LABORATORY INVESTIGATIONS ON BLACK COTTON SOIL USING LIME AND FLY ASH

Award Of The Degree Of

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IN

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DEPARTMENT OF CIVIL ENGINNEERING

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Project report submitted in fulfillment of the requirements for the degree of

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IN

CIVIL ENGINEERING

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CERTIFICATE

This is to certify that the project entitled **LABORATORY INVESTIGATIONS ON USING LIME AND FLYASH** being submitted by **MADICHERLA RAMA SURYA SAI TEJA (18MH5A0120)**

In fulfillment of the requirements for the award of Bachelor of Technology Degree in Civil Engineering at Aditya college of engineering is an authentic work carried out by them under my supervision and guidance.

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ABSTRACT:

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For any type of structure , foundation plays a crucial role and it become strong to support the entire structure. In order for the strong foundation the surrounded soils plays a crucial role. In case of expensive soil it become difficult for foundation purpose due to good compressive strength but weak in tension. To overcome these problems many researches are done. Our main objective is to investigate the effect of lime and fly ash in Geo-technical applications and to investigate the properties over treated soils and also to improve the properties of black cotton soil and finally use them for construction of structures. Eventually the bearing capacity of the soil will improves and thus it helps the structure to construct upon it.

It covers nearly 30% of the land in India and includes approximately the entire Deccan Plateau. Andhra Pradesh, Karnataka, Maharashtra, Parts of Gujarat and Western Madhya Pradesh. The name “Black Cotton” as an agricultural origin. Irrespective of the building structures these Black Cottons soils offers to lay roads on it. Any type of road construction needs a muscular sub-grade to offer resistance against the loads which are transmitting from the moving vehicles. To bear those loads the soil has to be well prepared. We are trying to strengthen the soil (Black Cotton Soil) to perform at it best in taking stresses, loads from structures and offers safety against settlement.

CHAPTER -1

INTRODUCTION OF STABILIZATION

1.0 GENERAL:

Generally, the concept of stabilization can be dated to 5000 years ago. McDowell (1959) reported that stabilized earth roads were used in ancient Mesopotamia and Egypt, and that the Greek and the Romans used soil-lime mixtures. Kézdi (1979)mentioned that the first experiment on soil stabilization were achieved in the USA with sand/clay mixtures round1906. In the 20th century, especially in the thirties, the soil stabilization relevant to road construction was applied in Europe.

Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations.

1.01 IMPORTANCE AND AFFECTS ON STRUCTURES:

Stabilization makes soil more stable by reduction in the permeability, compressibility and with increase in shear strength; it makes the soil more stable thusenhancing bearing capacity of soil. Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations.

Structures need a stable foundation for their proper construction and life long durability. Foundation needs to rest on soil ultimately, transferring whole load to the soil. If weak soil base is used for construction, with passage of time it compacts and consolidates, which results in differential settlement of structure. It may result in cracks in structure which can have catastrophic affect too. To avoid these future problems in weak soil, stabilized soil should be considered.

1.1 METHODS OF STABILIZATION:

1.1.1 Mechanical Method :

In this category, soil stabilization in achieved by physical process such as alteration and mechanical machines .By grading of soil particles i.e. changing composition of soil by adding or removing different soil particles. By compaction using devices such as rollers, tempers, rammers.

1.1.2 Chemical Stabilization:

In this category, soil stabilization depends on chemical reaction between stabilizer and soil mineral. It is done to reduce permeability of soil, increase shear strength and enhance bearing capacity by using chemical agents such as, calcium chloride, sodium silicate, cement, lime, bitumen.

- **Calcium Chloride** – It is mainly used in road construction work for stabilizing base and sub base course.
- **Sodium Silicate** – It is mainly used for fine and medium sands. Sodium silicate together with water and calcium chloride is injected for stabling
- soil deposit which improves the shear strength of soil.
- **Cement** – Cement being the oldest binding agent, is also considered as a primary stabilizing agent and is used to stabilize a wide range of soils. Stabilization process starts when cement is mixed with water, which results in hardening phenomena (hydration of cement). Setting of cement will enclose soil as glue, without changing the structure of soil.
- **Lime** – lime is an economic way of soil stabilization, used mainly in black cotton soils which are highly unstable. Quicklime when mixed with wet soil, immediately takes up water from surrounding to form hydrated lime, generates heat which causes loss of water which in turn results into increased plastic limit of soil.
- **Fly ash** – fly-ash is by product of electric generation plants based on coal fire. These are cheaper, environment friendly and easily available. It has little cementitious property compared to that of lime and cement. But in presence of activator (sodium-based solution) it can react chemically and improve strength in soft soil.

1.1.3 Geo synthetics:

Geo synthetics are latest techniques used to stabilize soil strata, made from various types of polymers (Polyethylene, Polypropylene, Polyester, Nylon, Poly-vinyl Chloride)

- GEOTEXTILES are flexible, textile like fabrics of controlled permeability used to provide reinforcement in soil.
- GEOGRIDS are grid like sheets used primarily as reinforcement of unstable soil.
- GEOCELLS are honey combed shape sheets used as a sub base support in soil.

1.2 TYPES OF STABILIZATION:

1.2.1 In Situ Stabilization :

The method involves on site soil improvement by applying stabilizing agents without removing the soil. This can be used for deep foundation, shallow foundation, and contaminated sites. This is done by using techniques like grouting and injecting. Grouting isa process in which stabilizers either in the form of a solution or suspension are injected into

soil. The choice to either use dry or wet mix depends on in situ soil conditions, in situ moisture content, effectiveness of binders, and nature of construction. Depending on depth of stabilization it may be deep mixing or mass stabilization.

1.2.2 Ex Situ Stabilization:

It involves removing of the soil or sediments from the original position and moved to other places. These can be encountered during dredging of river channel and ports. It is normally not done for common structures. Stabilization of soil isvery important as ultimately, it is soil which bears the complete load (dead, live, seismic, wind). A structure is finally safe if its foundation is safe. Stabilization of soil may cost you, though it's beneficial to improve the quality of soil if required, rather than to play with the safety of structure and feel guilty for the settlement of structure in near future.

1.3 INTRODUCTION OF BLACK COTTON SOIL

1.3.1 Introduction:

India Black Cotton soil also known as „Regurs" are found in extensive regions of Deccan Trap. They have variable thickness and are underlain by sticky material locally known as "Kali Mitti". In terms of geotechnical Engineering, Black Cotton soil is one which when associated with as engineering structure and in presence of water will show a tendency to swell or shrink causing the structure to experience moments which are largely unrelated to the direct effect of loading by the structure. Black cotton soil is not suitable for the construction work on account of its volumetric changes. It swells and shrinks excessively with change of water content. Such tendency of soil is due to the presence of fine clay particles which swell, when they come in contact with water, resulting in alternate swelling and shrinking of soil due to which differential settlement of structure takes place, so the stabilization is being done for the Stabilization of black cotton soil has been done in this project work by using recron-3s fibre as an admixture.

1.3.2 Distribution in India:

In India, an area about one-six is occupied by black cotton soil. The area covers mostly the Deccan Trap plateau, between 73°80" East longitude and 15° to 24° north, latitude. Thus, most of soil in and around Mumbai, Madras, Gwalior, Khandwa, Indore, Nagpur and even some on the river banks is Black cotton .That means these soils are predominant in Deccan trap plateau region, i.e., in states of Andhra Pradesh, Western Madhya Pradesh, Gujarat, Maharashtra, Northern Karnataka and Tamilnadu.

1.3.3 CHARACTERISTICS OF B.C. SOIL:

Black cotton soils are generally reddish brown to black in colour and occur from 0.5m to 10m deep and have high compressibility.The generally observed characteristics of black cotton soils are recorded in table below :

S.NO	PROPERTY	VALUE
1	Dry Density (γd)	1300 to 1800 kg/m
2	Fines (<75μ)	70 to 100%
3	2μ Fraction	20 to 60 %
4	Liquid Limit (L.L.)	40 to 120%
5	Plastic Limit (P.L.)	20 to 60%
6	Activity	0.8 to 18%
7	Soil Classification	CH or MH
8	Specific gravity	2.60 to 2.75
9	Proctor Density	1350 to 1600 kg/m3
10	Max. Dry Density	20 to 35 %
11	Free Swell Index	40 to 180%
12	Swelling Pressure	50 to 800 kN/m
13	C.B.R. (Soaked)	1.2 to 4.0
14	Compression Index	0.2 to 0.5

1.3.4 Problem associated with B. C. soil:

Black Cotton soils are problematic for engineers everywhere in the world, and more so in tropical countries like India because of wide temperature variations and because of distinct dry and wet seasons, leading to wide variations in moisture content of soils. The following problems generally occur in black cotton soil.

1.3.4.1 High Compressibility:

Black Cotton soils are highly plastic and compressible, when they are saturated. Footing, resting on such soils under goes consolidation settlements of high magnitude.

1.3.4.2 Swelling:

A structure built in a dry season, when the natural water content is low shows differential movement as result of soils during subsequent wet season. This causes structures supported by such swelling soils to lift up and crack. Restriction on having developed swelling pressures making the structure suitable.

1.3.4.3 Shrinkage:

A structure built at the end of the wet season when the natural water content is high, shows settlement and shrinkage cracks.

1.4 CHEMICAL COMPOSITION OF B. C. SOIL:

Black cotton soil are made of varying properties of clay minerals like Montmorrilonite, Illite and Kaolinite, chemicals like iron oxide and calcium carbonate (in the form of kankars), and organic matter like humus. Montmorrilonite is the predominant mineral of Black cotton soils. The swelling and shrinkage behaviour of black cotton soil originate mainly from this mineral are hydrous silicates of aluminium and magnesium .They are made of sheets of silica (tetrahedral) and alumina (octahedral) stacked on above the other forming sheet like of flaky particle. Montmorrilonite has a three sheeted structure with expanding lattices. The structure carries negative charge, due to isomorphic substitution of some aluminium ions by magnesium ions and minerals becomes chemically active.

The black cotton soils are found to have the following chemical compositions

S.NO	Property	Range
1	PH Value	>7(Alkaline)
2	Organic Content	0.4 to 204 %
3	CaCO3	5 to 15 %
4	SiO2	50 to 55 %
5	SiO2 , Al2O3	3 to 5 %
6	Montmorrilonite Mineral	30 to 50 %

1.5 ENGINEERING PROPERTIES OF B. C. SOIL:

The Engineering properties of soil are permeability, plasticity, compaction, compressibility and shear strength.

1.5.1 Permeability:

The permeability is defined as the property of a porous material which permits the passage or seepage of water through its interconnecting voids.

1.5.2 Plasticity:

It is defined as the property of a soil which allows it to be deformed rapidly, without elastic rebound, without volume change.

1.5.3 Compaction:

Compaction is a process by which the soil particles artificially rearrange and packed together into a closer state of contact by mechanical means in order to decrease the

porosity of the soil and thus increase its dry density.

1.5.4 Compressibility:

The property of soil mass pertaining to its susceptibility to decrease in volume under pressure is known as compressibility.

1.5.5 Shear Strength:

This is the resistance to deformation by continuous shear displacement of soil particles or on masses upon the action of a shear stress.

1.5.6 Specific Gravity:

It can be classified as the ratio of the weights of a given volume of soil solid at a given temperatures of the weight of an equal volume of distilled water at that temperature both weight being taken in air.

$$G=\gamma s/ \gamma w$$

The density bottle method is most accurate and is suitable for all types of soil the flask or pycnometer method is suitable for coarse grained soil. The range of specific gravity of coal ashes varies from 1.46 to 2.66 the low values of specific gravity is because of hollow particles chemo sphere the Sp. gravity of soil solids is determined by –

1. 50 ml density bottle or
2. A 500 ml flask or
3. A pycnometer the density bottle method is most accurate and is suitable for all types of soil the flask or pycnometer method is suitable for coarse grained soil.

1.6 INDEX PROPERTIES OF B. C. SOIL:

The properties of soil, which are not of primary interest to the geotechnical engineering, but are indicative of the engineering properties are called index properties. This includes –

1.6.1 Particle Size Analysis:

This is method of separation soils into different fraction bases on particles present into soils. It can be shown graphically on a particle size distribution curve. The coal ashes can be classified as sandy silt to silt sand as per this classification.

1.6.2 Atterberg's Limit:

The water content at which the soil changes from one state to other state are known as consistency limits or Atterberg's limit .The Atterberg's limit which are useful for engineering purposes are; Liquid limit, plastic limit and shrinkage limit. These limits are expressed as percent water content.

1.6.3 Liquid limit:

It is defined as the minimum water content at which the soil is still in liquid state but has a small strength against flowing which can be measured by standard available means.

1.6.4 Plastic limit:

It is defined as minimum water content at which soil will just begin to crumble water rolled into a thread approximately 3mm in diameter, Plasticity index is determined as difference of L.L.and P.L.

1.6.5 Shrinkage limit:

It is defined as the maximum water content at which a reduction in water content will not cause a decrease in the volume of soil mass.

1.7 INTRODUCTION OF MATERIALS

1.7.1 Black cotton soil:

We collect the soil from rangampeta village Andhra pradesh at cotton fields at below depth of 3 feet. We used this soil for stabilization by adding lime and fly ash. Due to its fine textured and clayey in nature. It has high amounts of lime, iron, magnesium and generally low quantities of phosphorus, nitrogen and organic matter. It has up to 50% clay content and therefore is highly retentive of water.

1.7.2 fly ash (class –F)

It is collected from thermal power plant at Vijayawada. Fly ash is a fairly divided residue which results from the combustion of powdered bitumen or sub-bituminous coal like ignite.

Chemical properties of fly-ash include chemical composition, PH values, and cation exchange capacity. In general the chemical composition of fly-ash are silicon dioxide, aluminium oxide, ferric oxide, calcium oxide, magnesium oxide composition compounds differ with sources of production of fly-ash.

Test Value	**Test Value**
Type	Type
Class F	Class F
Specific Gravity	Specific Gravity
1.975	1.975
Water content (%)	Water content (%)

1.7.3 Lime

It is taken from Rajahmundry, Andhra Pradesh.It is a colourless or white powder and is obtained when calcium oxide is mixed , slaked with water.

CHAPTER -2

LITERATURE REVIEW

2.1 GENERAL:

In this chapter, a brief description of lime and fly ash and also a note on black soil which it is call it as a expansive soil as a stabilizing material are given under.

2.2 INTRODUCTION

Lime and fly ash are the major materials which are easily available, if lime it have high properties which is strengthen the black cotton soil, the cost of lime also more , in that perspective view we are both lime and fly ash also. Fly ash is a easily available material and cheaper also, so that we are using lime and fly ash as a stabilizing agents in black cotton soil.

2.3 PROPERTIES OF LIME AND FLY ASH

Parameter	*Percent of composition*
SiO_2 (silicon dioxide), %	0.01
Al_2O_3 (aluminum oxide), %	0.01
Fe_2O_3 (iron oxide), %	0.11
CaO (calcium oxide), %	65.25
MgO (magnesium oxide), %	0.50
K_2O (potassium oxide), %	0.01
Na_2O (sodium oxide), %	0.01
S (sulfur, 1000°C), %	0.13
C (carbon), %	4.50
Loss on Ignition, %	33.25

Physical property	
Characteristics	Fly Ash
Specific Gravity (Le-Chatelier's flask)	2.07
Fineness (Blaine's Air permeability), m^2/kg	290
Bulk Density, kg/m^3	1100-1200
Colour (Visual observation)	Light grey
Chemical composition (%)	
pH	10.21
CaO (Calcium Oxide) w/w %	12.34
SiO_2	72.08
Al_2O_3	5.15
Fe_2O_3	0.57
MgO	4.04
Loss of Ignition (%)	0.76

2.4 OBJECTIVES OF THE STUDY :

The experimental work consists of the following steps:

- Determination of soil index properties & Specific gravity of soil
- Compaction characteristics, CBR Value of fibre stabilized black cotton soil.

Mr. Jaya Rao et al in 2020 Review on Index and Strength Properties of Stabilized Soils.Pavements need a stable subgrade as the wheel load is directly transferred to the soil through the pavement layers. With the passage of time, weak soil base compacts and consolidates, resulting in the differential settlement of the pavement. To avoid this problem, proper soil stabilization is to be carried out not only to enhance the engineering properties but also to achieve durability. The purpose of this literature review is to summarize the soil stabilization techniques that been done so far. This paper provides various soil stabilizers such as Sodium Hydroxide (NaOH), fly ash, geopolymeric binders, lime, alkali treated coir fibres, and ground granulated blast furnace slag (GGBS) that has been used in the previous works. The various tests conducted on these stabilized soils and their results are discussed keeping in view the strength, cost and efficiency along with the environment suitability.

With the rapid urbanization and the growing traffic, there is a need to satisfy the increasing travel demand by providing the proper infrastructure. The existing roadway facilities are not sufficient to fully cater the mobility needs which leads to traffic congestion. Thus to cater the capacity, new road segments are being constructed or the existing road sections are widened. To do so, the road construction is also carried out on the poor soils, whose bearing capacity is low also consolidates with time. Solution to such problem is to stabilize the soil which enhances the properties such as load

bearing capacity, thus increasing the strength of the soil to support the heavy wheel loads and overall performance. Soil stabilization can be used for roads, parking facilities, construction sites where the sub-soil strength is not sufficient to bear the load. This techniques is used for a variety of soils including expansive soils, granular soils etc. The properties such as plasticity, permeability, seeping etc., can be improved if the weak soil is stabilized with proper and suitable additives. Most commonly used additives are lime, fly ash, GGBS and others. Soil Stabilization can be done in two ways viz., insitu soil stabilization and ex-situ soil stabilization.In-situ soil stabilization is a soil improvement technique by adding stabilizers to the soil without removing it from the field. Such stabilization process involve grouting and injecting techniques and can be used for contaminated sites, deep and shallow foundations. On the other hand, when the soil is removed from the original site for stabilization, it is termed as ex-situ soil stabilization. This is normally done for common structures and also during dredging. Also there are three main stabilization techniques such as mechanical stabilization, chemical stabilization and polymer stabilization. Mechanical stabilization is considered as one of the oldest technique where the soil is stabilized

mechanically using rollers, tamping, compacting and blending different soils to improve the gradation. Chemical stabilization involves the addition of stabilizer or chemical that will react with the soil and improve its properties. These include lime, cement, fly ash and others. When these chemicals are added to the soil, there will be pozzolanic reaction and the soil strength is improved. Polymer stabilization refers to the addition of polymers such as geopolymers and synthetic polymers.

Dr. A.I. Dhatrak et al in 2015 after reviewing performance of plastic waste mixed soil as a Geo-technical material, it was observed that for construction of flexible pavement to improve the sub grade soil of pavement using waste plastic bottles chips is an alternative method. In his paper a series of experiments are done on soil mixed with different percentage of plastic (0.5%, 1%, 1.5%, 2 % & 2.5%) to calculate CBR. on the basis of experiments that he concluded using plastic waste strips will improve the soil strength and can be used as sub grade . It is economical and eco-friendly method to dispose waste plastic because there is scarcity of good quality soil for embankments and fills.

Kumar (2015) conducted a study on use of construction and demolition waste. The study concludes that construction and demolition wastes like bricks, concrete, tiles etc. may be used for mechanical stabilization of very poor soils, by adding extra cementitious materials or commercial stabilizers accredited by IRC as per IRC:SP:89. The C&D waste material shall have gradation as per IRC: SP: 89. Alternatively, it may be used partly as soil after doing testing on leach ability, durability in addition to unconfined compressive strength. After satisfactory trial results, this type of mixed material may be used for stabilization of poor soil alone or by mixing with some good soils and/or with suitable additives. The unconfined compressive strength obtained shall be 0.8 MPa for sub base and
1.75 MPa for base course as per revised MORTH and IRC: SP: 89.

Gullu (2015) detailed the stabilization of fine grained soil with bottom ash, lime and super plasticiser. The effective dosages are between 1% and 2% for super plasticisers, 15% for bottom ash and 4% for lime, when the additives are used separately. Similar proportions were used when combined together. Lime induced more brittleness in clay than bottom ash. Combinations of lime, bottom ash and super plasticiser proved to be better combination against disintegration of specimens under vertical loading for both pre and post freeze thaw tests. Super plasticizer used either separately or in combination with bottom ash and lime improved the strength of native clay.

Fattah et al. (2015) focused on the improvement of bearing capacity of footing resting on soft clay through grouting. Initially soil was mixed with lime at varying percentages of 2, 4, 6 at optimum moisture content and unconfined compression strength (UCS) test was conducted. Similarly the same was carried out with silica fume at 2.5%, 5% and 10%. Finally with optimum dosage of silica fume with varying percentages of lime was added. Based on UCS results, lime and silica fume at 4% and 5% was chosen as grouting mixture. Four series of test was conducted to find the improvement in bearing capacity and for each series, testing was done before and after construction of footing.

It was found that soft clay grouted below the footing and around the footing improved the bearing capacity of footing. Also as the depth of grout increased, bearing capacity also increased.

Kayal Rajakumaran (2015) experimentally analyzed the stabilization of expansive soil with steel slag and fly ash. In this paper, the stabilization of expansive soil on experimental basis.The stabilization of expansive soil is required because their volume canbe change due to the variation in moisture content on it, which leads to either shrink or swell while the soil is in dry or wet condition respectively. The stabilization of expansivesoil is assessed by the presence of different percentage of steel slag and fly ash on the expensive soil and the performance of modified expansive soil is evaluated using index properties test, permeability test, compaction test and unconfined compressive strength test.

Based on this performance tests, optimum amount of steel slag and fly ash on expensive soil is also determined.

Muthu Kumar M. Tamil arasan V. S. (2015) [6] had added marble waste. They study the behaviour of the soil using marble powder by adding marble powder with clay 0% - 25% at an interval of 5%. As a result of that the maximum unconfined compressive strength of the clay is 215 KN/m2 a 15% of marble powder. The Marble Powder is added about 15% to the soil as strength point of view.The expansive soil was modified in to low plasticity and silt behaviour.

H. Venkateswarlu et al. (2015) [7] had studied the effect of black cotton soil after treated with Quarry dust and observed that the liquid limit and plastic limit decreasing irrespective of the percentage of addition of Quarry Dust. It was found that the MaximumDry Density attained at 10% Quarry Dust and OMC goes on decreasing with increase in percentage of Quarry Dust and noticed that the UN-soaked CBR goes on increasing with increase in percentage of addition of Quarry Dust. It was found that cohesion goes on decreasing with increase in percentage of quarry dust. From the experimental analysis it is found that Quarry Dust up to 10% can be utilized for strengthening the expansive soil with a substantial save in cost of construction

Bjesh Mishra, Ravi Shankar Mishra (2015) [8] had added some percentage of fly ash with Black Cotton Soil and find its behaviour and also Mix some percentage of ferric chloride and some percentage of sand dust with Black Cotton Soil and it was observed that the liquid limit was decreased by 22.41% with addition of 2.5%, FeCl3, 15% fly ash and25% stone dust. Plastic limit of black cotton soil was increased by 9.58% for 2.5%, FeCl3, 15% fly ash and 25% stone dust addition to black cotton soil and the results show that there was a increase in maximum dry density of black cotton soil from 1.624 g/cm3 to 1.915 g/cm3 for 2.5%, FeCl3, 15% fly ash and 25% stone dust addition to black cotton soil. It was observed that C.B.R. value was increase by 170.83% for 2.5%, FeCl3, 15% fly ash and 25% stone dust addition to black cotton soil. The increase in C.B.R. value is an indication of improvement of soil properties and its strength to counter the resistance to penetration resulting in a decrease in pavement thickness and reduction in cost of construction of pavement

Vivek Singh et al. (2015) has studied that Addition of cement kiln dust into the black cotton soil has changed the proctor compaction parameters. The OMC of the BCS has decreased and Maximum dry density (MDD) increased with the addition of cement kiln dust. There is significant decrease in swelling characteristics of the soil. The DFS (Differential Free Swell) values are reduced from 31% to 5%, indicating that the degree of expansiveness has reduced from high to low. Soaked CBR values have also increased with the addition of cement kiln dust content. The addition of 25% cement kiln dust into the black cotton soil , increases the CBR value from 1.514% to 3.54%. There is a gradual increase in permeability

from 4.80 × 10−4 cm/s to 1.43 × 10−3 cm/s which leading to the pervious material property. Addition of cement kiln dust also increased the unconfined compressive strength (UCS). The UCS stabilized samples significantly increased from 142 KN/m2 to 178 KN/m2.

P. Sowmya Ratna et. al. (2016) studied the performance of Recron-3s fibre with lie in expansive soil stabilization. They used lime content from 0% to 13% with black cotton soil and for the results of compaction with addition of 5% or more lime content to clay's. They also reported an increase in the optimum moisture content till 3% lime content and decreased with the increase in lime content with Recron-3s fibre. From the results, it has observed that black cotton soil with lime and Recron-3s fibre the strength parameters can be improved and the main disadvantage of lime is brittle nature which is overcome by the inclusion of fibre which gives ductility to the soil.

Achmad Fauzi et al in 2016 calculated the engineering properties by mixingwaste plastic High Density Polyethylene (HDPE) and waste crushed glass as reinforcement for sub grade improvement. The chemical element was investigated by Integrated Electron Microscope and Energy-Disperse X-Ray Spectroscopy (SEM-EDS). The engineering properties PI, C, OMC values were decreased and ϕ, MDD, CBR values were increased when content of waste HDPE and Glass were increased.

Sharma & Siva pullaiah (2016) evaluated the potential of using a mixture of fly ash and ground granulated blast furnace slag (GGBS) as stabilizers for stabilizing an artificially mixed expansive soil consisting of 80% clay and 20% sodium bentonite. The stabilizer was prepared in 70:30 ratio of fly ash and GGBS respectively. Varying percentagesof stabilizer from 10%-40% in increments of 10% was used with and without lime content (1%) for activation of chemical reaction. Results showed that both liquid limit and Plasticity Index reduced with increasing stabilizer content. Also there was a reduction in optimum moisture content with increase in maximum dry unit weight. Unconfined compression strength increased with increase in stabilizer content and curing period.SEM and XRDrevealed the formation of calcium silicate hydrate and Ca(OH) 2.

Minde et. al. (2017) have shown, In India, Black cotton soil covers over one-fifth of the entire land area. These are mostly found in and around the Deccan plateau. Black cotton soil is an expansive soil which proves problematic for the engineering work. Black cotton soil has low bearing capacity, high compressibility and swelling and shrinkage properties. To overcome on these engineering problems soil stabilization is the best solution. In our research we used the concept of chemical stabilization. We used fly ash and rice husk straw ash in different proportion with black cotton soil. The present paper briefly describes the experimental investigation carried out by adding fly ash and rice husk straw ash to black cotton soil for improving its engineering properties.

Krichphon singh & V.K. Arora " STABILIZATION OF BLACK SOIL USING LIME STONE, RICE HUSK AND FLY ASH" ICRTESM-2017. An environment friendly and cost effective way of soil stabilization is with the help of industrial waste. Unsuitable highway sub-grade, foundation soil of heavy building or water reservoirs etc. requires stabilization to improve its engineering properties. Large areas are covered with highly plastic soil, which is not suitable for construction purpose. In urban areas, borrow earth is noteasily available which has to be hauled from a long distance. Instead of borrowing a suitable soil from long distance it is economical to use locally available plastic soil after stabilization with cost effective and easily available industrial wastes. In this present study, components used are lime stone which is an industrial waste product, fly ash and rice husk which are agricultural waste products. The project is planned to conduct various Geo-technical lab test like unconfined compressive strength test, shrinkage test, swelling test, permeability test, Atterberg's limit and shear strength test. The objective of this study is to evaluate the effectof materials used to enhance the properties of plastic soil by comparing with the results andgraphs of various mixes. This stabilization technique is cost effective and has an additional benefit of providing an environmental friendly way to deal with industrial waste product.

Uma G. Hullur (2018) conducted a study in which different admixtures were used with black cotton soil with varying percentages. Proctor test was done in order to assess the compaction behaviour. Black cotton soil was mixed with 10%, 20% and 30% of admixtures such as cement, Fly Ash, Ground Granulated Blast Furnace Slag, Silica Fume, Metakaolin and Rice Husk Ash (RHA). The results showed, 10% FA gave maximum Max Dry Density(MDD) ,10% SF gave maximum MDD,20% RHA gave maximum MDD,30% GGBFS gave maximum MDD,30% Metakolin gave maximum MDD and similarly 30% cement gave maximum MDD. Hence for stabilization the above percentages can be considered as the optimum values of admixtures with black cotton soil.

CHAPTER -3

METHODOLOGY

3.1 MATERIALS USED:

- Black cotton soil.
- Lime
- Fly ash

3.11 stages of work

100% BC soil

90% BC soil + 10% lime

85% BC soil + 15% fly ash

3.2 EXTRACTION:

We collect the soil from rangampeta, AndhraPradesh at below depth of 3 feet at cotton fields. Physical and Geo-technical properties of the soil samples were studied in the laboratory. The tests conducted were grain size analysis, specific gravity, liquid limit, standard Proctor compaction test. Results as obtained were compared with the Indian standard code. Further, relationships of plasticity index with liquid Limit and optimum moisture content were also derived. The test results have shown that increase in the clay content in the black cotton soil attributes an increase in the plasticity index. Beside this, with the increase in optimum moisture content, an increase in the plasticity index, liquid limit were also observed.. The empirical models with the help of regression analysis were also suggested for the benefit of field engineers for prediction of Geo-technical properties of black cotton soil.

3.2.1 BASIC PROPERTIES OF BLACK COTTON SOIL:

As such Black cotton soil (BC soil) has very low bearing capacity and high swelling and shrinkage characteristics. Due to its peculiar characteristics, it forms a very poor foundation material for road construction. Rich proportion of ***montmorillonite*** is found in *Black cotton soil* from mineralogical analysis. High percentage of montomorillonite renders high degree of expansiveness. These property results ***cracks in soil*** without any warning. These cracks may sometimes extent to severe limit like ½" wide and 12" deep. So building to be founded on this soil may suffer severe damage with the change of atmospheric conditions.

we have already noticed that black cotton soils of different region show considerable variation of properties. So while explaining any property, we will try to mention region where the tests were conducted.

SNO	Description of properties	values
1	Shear strength	Soaked CBR only 1.5%
2	Residual strength parameter	12*
3	permeability	10^-10cm/sec
4	Liquid limit	40 -100%
5	Free swell index	Sometimes less than 50%

In Hyderabad, the formation of this soil is similar to lentil seed; their subsurface structure takes shape like double-convex lens.A study on African soil (Sudan) shows such aggregated structure is a consequence of variation of pressure exerted under swelling shrinkage process due to seasonal change.

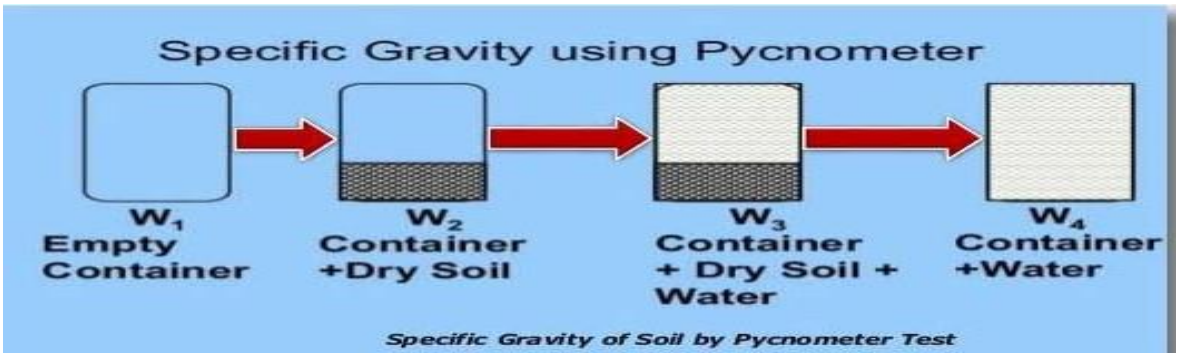
As ***plasticity index*** and linear shrinkage decreased with the increase of lime content, a mixture of both lime and cement is necessary for adequate stabilization of road bases for heavy wheel loads on the black cotton soils. Previously derived results from African and Indian black cotton soils are also matched with these results.

3.3 TESTS ON BLACK COTTON SOIL:

- Specific gravity.
- Liquid limit.
- Plastic limit.
- Differential swell Index
- Modified compaction test.
- California Bearing Ratio (with pure black cotton soil)
- California Bearing Ratio (with different percentages of lime and fly ash different water contents).
- Vane shear test.

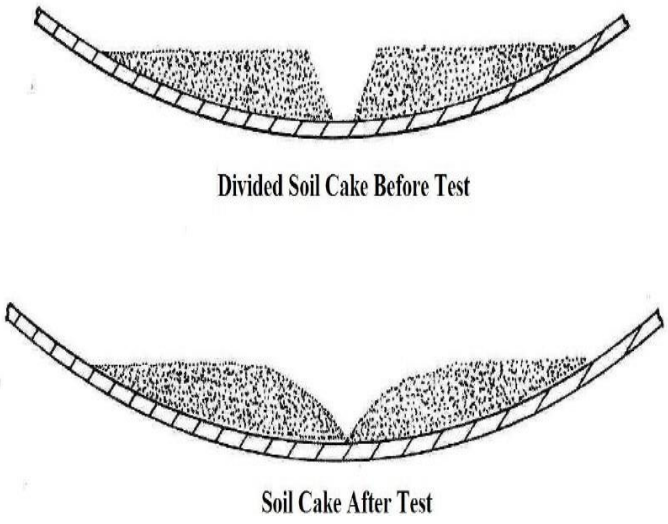
3.3.1 SPECIFIC GRAVITY:

- Specific Gravity Test was carried as per IS: 2720 (Part 3)-1980.
- Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air.
- The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc.



3.3.2 LIQUID LIMIT :

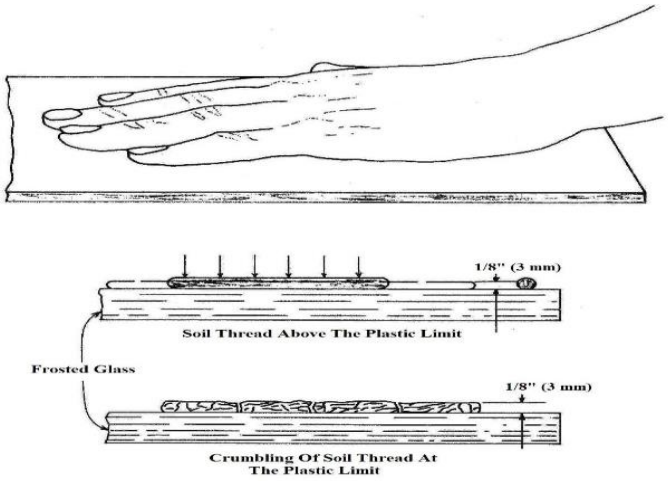
The liquid limit of a soil is the moisture content, expressed as a percentage of the weight of the oven-dried soil at the boundary between the liquid and plastic states of consistency. The moisture content at this boundary is arbitrarily defined as the water content at which two halves of a soil cake will flow together, for a distance of ½ in. (12.7 mm) along the bottom of a groove of standard dimensions separating the two halves, when the cup of a standard liquid limit apparatus is dropped 25 times from a height of 0.3937 in (10 mm) at the rate of two drops/second.



3.3.3 PLASTIC LIMIT:

The plastic limit of a soil is the moisture content, expressed as a percentage of the weight of the oven-dry soil, at the boundary between the plastic and semisolid states of consistency. It is the moisture content at which a soil will just begin to crumble when rolled

into a thread ⅛ in. (3 mm) in diameter using a ground glass plate or other acceptable surface.



3.3.4 DIFFERENTIAL SWELL INDEX:

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water. To determine the free swell index of soil as per IS: 2720 (Part XL) – 1977. Free swell or differential free swell, also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence inwater.

3.3.5 STANDARD & MODIFIED COMPACTION TEST:

It is a pretest of CBR test because if i conduct CBR test before that it is to know the optimum moisture content (OMC) in this test , so this test is to be conducted to know the optimum moisture content

3.3.6 CALIFORNIA BEARING RATIO:

The **California bearing ratio** (**CBR**) is a penetration **test** for evaluation of the mechanical strength of natural ground, sub-grades and base courses beneath newcarriageway construction. It was developed by the California Department of Transportation before World War II. The California bearing ratio test is penetration test meant for the evaluation of sub-grade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement. This instruction sheet covers the laboratory method for the determination of C.B.R. of undisturbedand remould-ed /compacted soil specimens, both in soaked as well as un soaked state. It is the ratio of force per unit area required to penetrate a soil mass with standard circular pistonat the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. The test may be performed on undisturbed specimens and on remoulded specimens which may be compacted either statically or dynamically.

C.B.R. = Test load/Standard load

CHAPTER -4

RESULTS AND DISCUSSIONS

4.1.GENERAL:

Details of laboratory experiments carried out with Recron-3S sub-bases with expansive soil sub-grade on the results have been discussed in the previous chapter. In this Chapter a detailed discussion on the results obtained from various laboratory tests are presented. Further, the results of the track constructed on the expansive soil sub-grade are also discussed.

4.2 PRELIMINARY LABORATORY TEST RESULTS:

4.2.1 GENERAL:

In the laboratory, we conducted many tests to estimate the index properties of soils like Atterberg's limits, specific gravity, moisture content, permeability, differential swell index, hydrometer and also we calculate the CBR and HEAVY COMPACTION test results by using different percentages of Recron-3S fibers with a view to find the optimum moisture contents.

4.2.2. ATTERBERG LIMITS TEST RESULTS:

4.2.2.1 LIQUID LIMIT TEST RESULTS:

The liquid limit (LL) is conceptually defined as the water content at which the behaviour of a clayey soil changes from plastic to liquid. However, the transition from plastic to liquid behaviour is gradual over a range of water contents, and the shear strength of the soil is not actually zero at the liquid limit. This test is done by adding different samples of water contents in soil. The Results are shown in below table

For 100% black cotton soil

S.NO	Number of blows	Liquid limit value **(%)**
1	11	66%
2	38	76%
3	22	57%

For 90% BC soil +10% lime

S.NO	Number of blows	Liquid limit value (%)
1	11	64
2	38	75
3	22	55

For 85% BC soil +15% fly ash

S.NO	Number Of Blows	Liquid limit value (%)
1	11	60
2	38	73
3	22	52

4.2.2.2. PLASTIC LIMIT TEST RESULTS:

The Plastic Limit (PL) is determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface. The procedure is defined in ASTM Standard D 4318. If the soil is at a moisture content where its behaviour is plastic, this thread will retain its shape down to a very narrow diameter. The sample can then be remoulded and the test repeated. As the moisture content falls due to evaporation, the thread will begin to break apart at larger diameters.

The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2 mm (about 1/8 inch). A soil is considered non-plastic if a thread cannot be rolled out down to 3.2 mm at any moisture possible. The result is given in below table,

S.NO	Water percentage	Moisture content	Plastic limit value (%)
1	5%	40%	38%

4.2.2.3 PLASTICITY INDEX:

The plasticity index (PI) is a measure of the plasticity of a soil. The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL). Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay. The result is given in below table

S.NO	Liquid limit	Plastic limit	Plasticity index
1	76%	38%	38%

4.2.3 SPECIFIC GRAVITY:

Specific Gravity Test was carried as per IS: 2720 (Part 3)- 1980.Specific gravity (G) is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air. The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc**.** The results are shown in below table

s.no	Soil sample	values
1	100% BC soil	2.04
2	90%BC soil + 10% lime	2.12
3	85% BC soil + 15% fly ash	2.05

4.2.5 DIFFERENTIAL SWELL INDEX:

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water. We done this experiment by using 425 micron IS sieve and two Graduated glass cylinders 100 ml capacity (IS: 878 -1956) and the result is given in below table

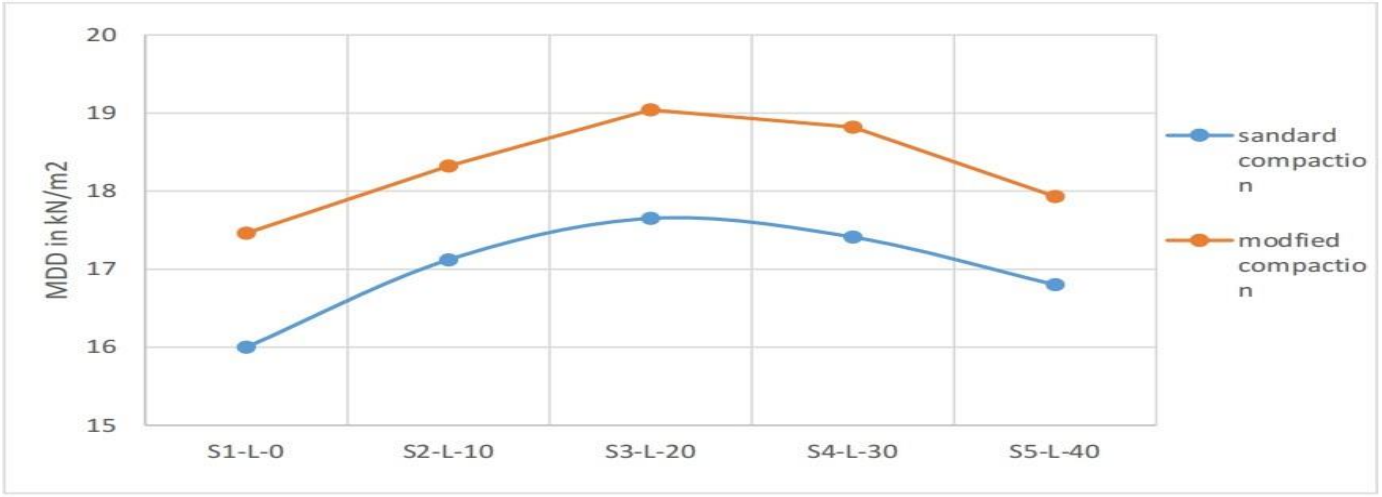
s.no	Soil sample	Differential swell index
1	100% BC soil	61%
2	90% BC soil + 10% lime	35%
3	85% BC soil +15% fly ash	40%

4.2.6. STANDARD & MODIFIED COMPACTION TEST RESULTS:

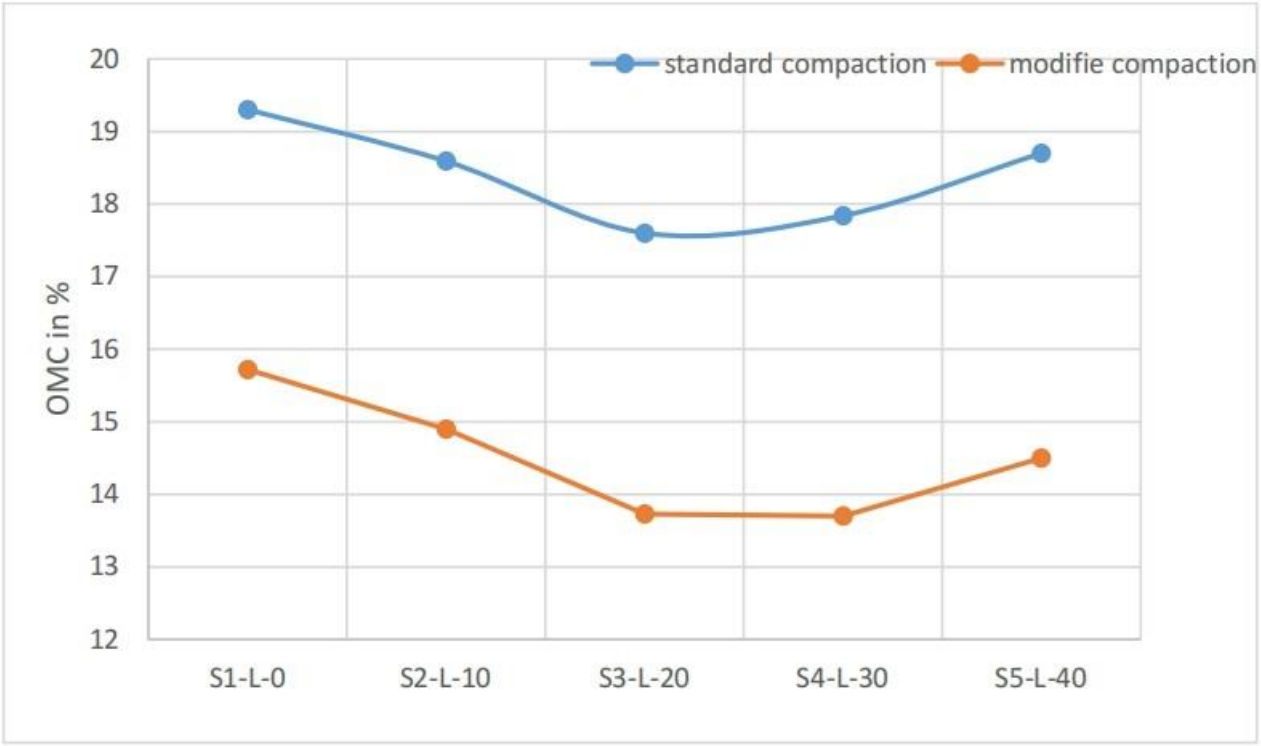
Compaction characteristics have been studied by replacing fly ash in different percentages to with the soil and optimum lime content mix. It has been observed that, optimum moisture content increases and maximum dry density decreases with fly ash content increases. The variation in compaction characteristics of with fly ash content and the results are tabulate in below Table.

Soil Mix	IS Standard Compaction		IS Modified Compaction	
	OMC (%)	MDD (KN-mt)	OMC (%)	MDD (KN-mt)
S0-0-0	17.3	17.07	13.6	18.5
S1-L-0	19.3	16	15.72	17.46
S2-L-10	18.59	17.12	14.9	18.32
S3-L-20	17.6	17.65	13.73	19.04
S4-L-30	17.84	17.41	13.7	18.82
S5-L-40	18.7	16.8	14.5	17.93

With increased fly ash content the clay mass effectively fills the voids formed by the relatively coarse fly ash, giving rise to a compact structure and hence increased density. However when the fly ash quantity is relatively high (i.e. more than 30%) the fly ash forms a cluster-like structure (Murthy et al., 1985) that effectively resists the compaction. As a result, there is not much improvement in the overall density of the expansive soil- fly ash mix. Hence, it can be concluded that 20% is the optimum FA content that gives maximum density for ES-FA mixes



Variation of dry density with different fly ash content for the soil



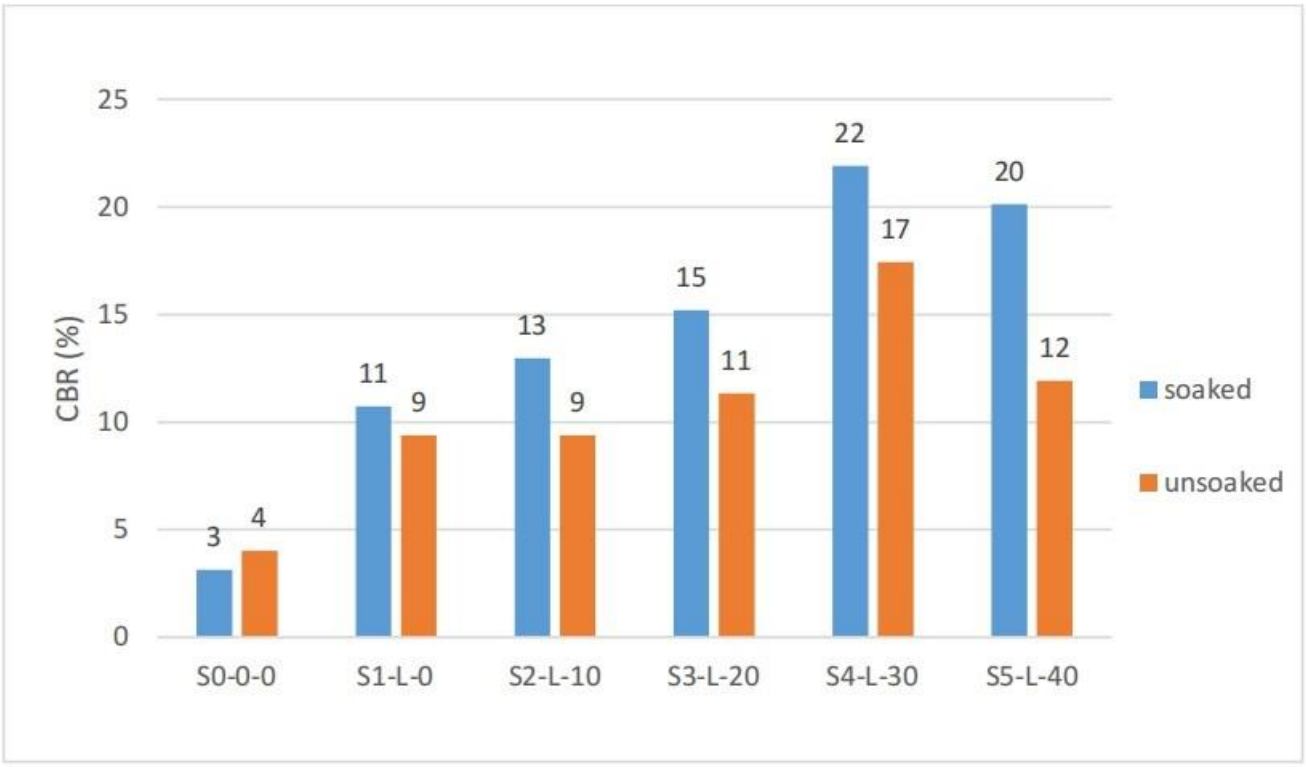
Variation of water content with different fly ash content for the soil

4.3 CALIFORNIA BEARING RATIO (CBR) TEST RESULTS:

CBR tests were conducted by black cotton soil and the results are presented in the following table.

Soil Mix	Standard compaction		Modified compaction	
	soaked	Un soaked	soaked	Un soaked
S0-0-0	3	4	7	13
S1-L-0	11	9	16	17
S2-L-10	13	5	25	21
S3-L-20	15	11	34	25
S4-L-30	22	17	37	30
S5-L-40	20	12	35	26

The results of soil-lime-fly ash mix are presented in below fig. and 4.10.it was observed that there was 600% increment for 30%fly ash-lime- soil Mix than the clayey soil.



Variation of CBR results with different fly ash for Standard compaction

CHAPTER-5

CONCLUSIONS

Some clayey sand mixes with determined gradations, abundant in northern India, was stabilized with different lime contents and then subjected to Bearing strength, Shrinkage property, and CBR tests. Materials were reconstituted in the laboratory and the fine content of mixes was provided from Kaolinite clay to reach a constant plastic characterization for all specimens. Results of this investigation are as below: At finally we perform the all properties of the soil which we taken. And after the all laboratory test we found that our soil is a highly clay content and sat that black cotton soil. We found the value of liquid limit and plastic limit and which is very high and high content of water so we cannot use directly for the construction or highway pavement purpose. In the test of proctor of soil we found that their is high value of optimum moisture content and as well as low dry density of soil. And more air voids in the soil. So, soil loose their strength. In the test of C.B.R. we found the value of the C.B.R. is less and high value of the swelling pressure and due to low C.B.R. value soil has no high strength and no stabilization. So we require the stabilize the black cotton soil and increase the strength of soil and decrease the swelling pressure and decrease the liquid limit and Plastic limit. Some mechanical properties of clayey sands were investigated and the behaviour of these materials was expressed in simple mathematical equations based on test results on soil samples provided from the Northern areas of India. These functions are applicable for materials that have the same or close gradations to those, which were used in this investigation.

The effect of lime and fly ash on soil samples were studied by conducting tests with various percentages of lime and fly ash the following conclusions were drawn.

- Strength of soil can be increased to the certain extent by using additive materials in soil. Especially lime when mixed with soil gives a wonderful result..
- From the arrangement of standard delegate tests directed, we found that the OMC of the strengthen soil increments with the pickup of the lime and fly ash content.
- From the series of standard proctor tests conducted, we found that the OMC of the reinforce soil increases with the gain of the fly ash content.
- The new technique of soil stabilization can be effectively used to meet the new challenges of society, producing useful material from non-useful waste materials...
- The MDD of BC soil increases with the addition of lime with corresponding increase in OMC. The adhesion between the water and soil particles increases with the increase.

CHAPTER -6

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A Project Report on

Automatic Identification of Ayurvedic Medical Plants Leaf Using KNN Classifier

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

In

ELECTRONICS AND COMMUNICATION ENGINEERING

By

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ADITYA COLLEGE OF ENGINEERING

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Department of Electronics and Communication Engineering

CERTIFICATE

This is to certify that the Project report entitled.

"Automatic Identification of Ayurvedic Medical Plants Leaf Using KNN Classifier."

Being submitted by

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In partial fulfillment of the requirements for the award of the Degree of **BACHELOR OF TECHNOLOGY in Electronics & Communication Engineering.** It is record of Bonafede work carried out by them under esteemed guidance and supervision of DR.G. JAFFINO.

Signature of Project Guide

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Signature of Head of the Department

Dr. G. RAMAKRISHNA, M. Tech, Ph.D.

Professor,
Department of ECE

DECLARATION

we hereby declare that the entire project work embodied in this dissertation entitled has been independently carried out by us. As per our knowledge, no part of this work has submitted for any degree in any institution, university, and organization previously. we hereby boldly state that to the best of our knowledge our work is free from plagiarism.

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Finally, we acknowledge sincerely the effective services rendered by one and all involved directly and indirectly in the entire project work.

Your Sincerely,

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ABSTRACT

Plant identification is an important field of biological and medical sciences. Medicinal plants must be classified and recognized with high accuracy. Classification errors can lead to high costs and losses. For example, if a poisonous plant is classified as medicinal plant, this can lead to fatal cases. Also, it can be dangerous, if a plant that has no medicinal property is classified as a medicinal plant. The classification is done normally manually and based on the experience of the human classifier. In this case the classification process is limited by the experience and the knowledge of the human expert. On the other hand, exploiting the accuracy and speed of the computer technology can be very useful in creating high performance plant leaf classification system based on the leaf recognition. Based on this idea, this project proposes an Automatic Identification of Ayurvedic Medicinal Plants Leaf System using KNN Classifier

The use of Machine learning algorithm in science has seen a huge revolution in the last decades. This Project uses KNN classifier for Leaf recognition. The images of different plants are acquired and pre-processed using averaging filter. In the next stage the edge details of the leaf image are extracted by using canny edge detection Algorithm. The statistical features such as Boundary Points, connected components, Object Area, Major axis Length, filled area of the object, Perimeter, Eccentricity, Equivalent diameter, and Mean Intensity are extracted from the edge detected images. The KNN classifier is used to recognize the medical plant leaves. This KNN classifier is tested by using 669 medical plants leaf. The system achieved 98% of accuracy. The Ayurvedic medicine field is commercialized, and this project work is useful for Ayurvedic medicine field.

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CHAPTER 1
INTRODUCTION TO IMAGE PROCESSING

1.1 Image Processing

Image Processing is a technique to enhance raw images received from cameras/sensors placed on satellites, space probes and aircrafts or pictures taken in normal day-today life for various applications. Various techniques have been developed in Image Processing during the last four to five decades. Most of the techniques are developed for enhancing images obtained from unmanned spacecrafts, space probes and military reconnaissance flights. Image Processing systems are becoming popular due to easy availability of powerful personnel computers, large size memory devices, graphics software's etc. Image Processing is used in various applications such as: Remote Sensing, Medical Imaging, Non-destructive Evaluation, Forensic Studies, Textiles, Material Science, Military, and Film industry. The common steps in image processing are image scanning, storing, enhancing and interpretation.

There are two types of methods used for image processing namely, analogue, and digital image processing. Analogue image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. Digital image processing techniques help in manipulation of the digital images by using computers. The three general phases that all types of data must undergo while using digital technique are pre-processing, enhancement, and display, information extraction.

1.2 Analog Image Processing

Analog image processing is done on analog signals. It includes processing on two dimensional analog signals. In this type of processing, the images are manipulated by electrical means by varying the electrical signal. The common example include is the television image. The digital image processing deals with developing a digital system that performs operations on a digital image. An image is nothing more than a two-dimensional signal. It is defined by the mathematical function f(x, y) where x and y are the two co-ordinates horizontally and vertically. The value of f(x, y) at any point is gives the pixel value at that point of an image.

1.3 Relationship between a digital image and a signal

In physical world, any quantity measurable through time over space or any higher dimension can be taken as a signal. A signal is a mathematical function, and it conveys some information. A signal can be one dimensional or two dimensional or higher dimensional signal. One dimensional signal is a signal that is measured over time. The common example is a voice signal. The two-dimensional signals are those that are measured over some other physical quantities. The example of two-dimensional signal

is a digital image. We will look in more detail in the next tutorial of how a one dimensional or two-dimensional signals and higher signals are formed and interpreted. Since anything that conveys information or broadcast a message in physical world between two observers is a signal. That includes speech or (human voice) or an image as a signal. Since when we speak , our voice is converted to a sound wave/signal and transformed with respect to the time to person we are speaking to. Not only this , but the way a digital camera works, as while acquiring an image from a digital camera involves transfer of a signal from one part of the system to the other.

1.3.1 Digital Image Formation

Since capturing an image from a camera is a physical process. The sunlight is used as a source of energy. A sensor array is used for the acquisition of the image. So, when the sunlight falls upon the object, then the amount of light reflected by that object is sensed by the sensors, and a continuous voltage signal is generated by the amount of sensed data. In order to create a digital image , we need to convert this data into a digital form. This involves sampling and quantization. (They are discussed later on). The result of sampling and quantization results in a two-dimensional array or matrix of numbers which are nothing but a digital image.

1.4 Basic Principles In Object Recognition

Generic object recognition systems do not include any information about specific objects. Rather, they learn to recognize arbitrary objects by inspecting a set of training images and train a model on these [1].This model is then used to recognize the objects in unseen images. In the training phase, for all objects to be recognized, training images containing the objects need to be passed to the system. For detection, which is a special case where images are to be classified according to whether they contain a given object or not. Normally, the images are preprocessed for further use.

After preprocessing, for each of the training images a set of features is derived. Each feature describes properties of either the whole image (global feature) or a part of the image (local feature).Usually; local features are more successful in capturing the content of complex images. To reliably recognize objects under varying circumstances (for example, objects appearing at different scales, rotation, and translation) the features ought to be chosen such that they are invariant with respect to these aspects. From the features of the training images, the parameters of an underlying statistical model are estimated. Using these features and the trained model the object recognition system outputs which of the trained objects is contained

in the image or not.

Once trained, the performance of object recognition systems is measured on a set of test images. The recognition rate on this set denotes the ratio of correctly classified images to all images in the test data set.

1.5 Application Areas For Image Object Recognition

Automatic image analysis and object recognition in images is an important task in many real-world applications, for example the recognition of handwritten characters and digits, enabling the automatic reading of bank cheques and postal envelopes.

Medical applications such as the automated evaluation of medical image data for instance the counting of cells in a medical probe, the diagnosis of skin lesions as malignant or benign, or the retrieval of a similar image from a database; image and video indexing in large database; robot vision, including the use in autonomous vehicles or driver assistance systems that warn the driver of a car about pedestrians that are about to cross the path of the vehicles entering and leaving a car park or passing toll roads; industrial applications such as quality control , for example the matching of solar cells wafers before and after processing to allow for an biometric applications, such as fingerprint or face recognition These applications are widely a assumed to be crucial for the successful implementation of modern security systems

1.6 Applications Of Image Processing

1.Intelligent Transportation Systems – This technique can be used in Automatic number plate recognition and Traffic sign recognition.

2. Remote Sensing – For this application, sensors capture the pictures of the earth's surface in remote sensing satellites or multi – spectral scanner which is mounted on an aircraft. These pictures are processed by transmitting it to the Earth station. Techniques used to interpret the objects and regions are used in flood control, city planning, resource mobilization, agricultural production monitoring, etc.

3.Moving object tracking – This application enables to measure motion parameters and acquire visual record of the moving object. The different types of approach to track an object are Motion based tracking and Recognition based tracking.

4.Defense surveillance – Aerial surveillance methods are used to continuously keep an eye on the land

and oceans. This application is also used to locate the types and formation of naval vessels of the ocean surface. The important duty is to divide the various objects present in the water body part of the image. The different parameters such as length, breadth, area, perimeter, compactness is set up to classify each of divided objects. It is important to recognize the distribution of these objects in different directions that are east, west, north, south, northeast, northwest, southeast and southwest to explain all possible formations of the vessels. We can interpret the entire oceanic scenario from the spatial distribution of this object.

5.Automatic Visual Inspection System – This application improves the quality and productivity of the product in the industries. Automatic inspection of incandescent lamp filaments – This involves examination of the bulb manufacturing process. Due to no uniformity in the pitch of the wiring in the lamp, the filament of the bulb gets fused within a short duration. In this application, a binary image slice of the filament is created from which the silhouette of the filament is fabricated. Silhouettes are analyzed to recognize the non-uniformity in the pitch of the wiring in the lamp. This system is being used by the General Electric Corporation

6. Automatic surface inspection systems – In metal industries it is essential to detect the flaws on the surfaces. For instance, it is essential to detect any kind of aberration on the rolled metal surface in the hot or cold rolling mills in a steel plant. Image processing techniques such as texture identification, edge detection, fractal analysis etc. are used for the detection.

7. Faulty component identification – This application identifies the faulty components in electronic or electromechanical systems. Higher amount of thermal energy is generated by these faulty components.

CHAPTER 2

Medical Plant Leaf Processing

2.1 INTRODUCTION

Ayurveda is an ancient system of medicine practiced in India and has its roots in the Vedic times, approximately 5000 years ago. The main constituents of ayurvedic medicines are plant leaves and other parts of plants like root, bark etc. More than 8000 plants of Indian origin have been found to be of medicinal value. Combinations of a small subset amounting to 1500 of these plants are used in Herbal medicines of different systems of India. Specifically, commercial Ayurvedic preparations use 500 of these plants. Over 80% of plants used in ayurvedic formulations are collected from the forests and wastelands whereas the remaining is cultivated in agricultural lands [1].

In the ancient past, the Ayurvedic physicians themselves picked the medicinal plants and prepared the medicines for their patients. Today only a few practitioners follow this practice. The manufacturing and marketing of Ayurvedic drugs has become a thriving industry whose turnover exceeds Rs 4000 crores. The number of licensed Ayurvedic medicine manufacturers in India easily exceeds 8500. This commercialization of Ayurvedic sector has brought in to focus several questions regarding the quality of raw materials used for Ayurvedic medicines.

Today the plants are collected by women and children from forest areas; those are not professionally trained in identifying correct medicinal plants. Manufacturing units often receive incorrect or substituted medicinal plants. Most of these units lack adequate quality control mechanisms to screen these plants. In addition to this, confusion due to variations in local name is also rampant. Some plants arrive in dried form, and this make the manual identification task much more difficult. Incorrect use of medicinal plants makes the Ayurvedic medicine ineffective. It may produce unpredictable side effects also. In this situation, strict measures for quality control must be enforced on Ayurvedic medicines and raw materials used by the industry in order to sustain the present growth of industry by maintaining the efficacy and credibility of medicines .

A trained Botanist looks for all the available features of the plants such as leaves flowers, seeds, root, and stem to identify plants. Except for the leaf, all others are 3D objects and increase the complexity of analysis by computer. However, plant leaves are 2D objects and carry sufficient information to identify the plant. Leaves can be collected easily, and image

acquisition may be carried out using inexpensive digital cameras, mobile phones or document scanners. It is available at any time of the year in contrast to flowers and seeds. Leaves acquire a specific color, texture, and shape when it grows, and these changes are relatively insignificant. Plant recognition based on leaves depends on finding exact descriptors and extracting the feature vectors from it. Then the feature vectors of the training samples are compared with the feature vectors of the test sample to find the degree of similarity using an appropriate classifier

2.2 Pattern Classification in Plant leaf

Pattern classification is the organization of patterns into groups of patterns sharing the same set of properties. Given a set of measurements of an unknown object and the knowledge of possible classes to which an object may belong, a decision about to which class the unknown object belongs could be made. For example, if information about the length of sides of an unknown triangle is extracted, a decision on whether the unknown triangle is an equilateral, isosceles or scalene triangle can be made. Similarly, if a set of features/measurements is extracted from a leaf, a decision about the possible class of the leaf can be made. Pattern classification may be statistical or syntactic. Statistical classification is the classification of individual items into groups based on quantitative information of one or more features/measurements of the item and based on a training set of previously classified items. An example of this type of classification is clustering; this study uses clustering for pattern classification.

Syntactic classification (Structural classification) is the classification of individual items based on a structure in the pattern of the measurements. Items are classified syntactically only if there is a clear structure in the pattern of the measurements. Pattern recognition possesses the following features:

- Pattern recognition system should recognize familiar pattern quickly and accurate.
- Recognize and classify unfamiliar objects.
- Accurately recognize shapes and objects from different angles
- Identify patterns and objects even when partly hidden.
- Recognize patterns quickly with ease, and with automaticity.

2.3 Training and Learning in Pattern Recognition

Learning is a phenomenon through which a system gets trained and becomes adaptable to give result in an accurate manner. Learning is the most important phase as how well the system performs on the data provided to the system depends on which algorithms used on the data. Entire dataset is divided into two categories, one which is used in training the model i.e., Training set and the other that is used in testing the model after training, i.e., Testing set.

2.3.1Training set:

Training set is used to build a model. It consists of the set of images that are used to train the

system. Training rules and algorithms used give relevant information on how to associate input data with output decision. The system is trained by applying these algorithms on the dataset, all the relevant information is extracted from the data and results are obtained. Generally, 80% of the data of the dataset is taken for training data.

2.3.2 Testing set:

Testing data is used to test the system. It is the set of data which is used to verify whether the system is producing the correct output after being trained or not. Generally, 20% of the data of the dataset is used for testing. Testing data is used to measure the accuracy of the system. Example: a system which identifies which category a particular flower belongs to, is able to identify seven categories of flowers correctly out of ten and rest others wrong, then the accuracy is 70 %.

A pattern is a physical object or an abstract notion. While talking about the classes of animals, a description of an animal would be a pattern. While talking about various types of balls, then a description of a ball is a pattern. In the case balls considered as pattern, the classes could be football, cricket ball, table tennis ball etc. Given a new pattern, the class of the pattern is to be determined. The choice of attributes and representation of patterns is a very important step in pattern classification. A good representation is one which makes use of discriminating attributes and also reduces the computational burden in pattern classification.

An obvious representation of a pattern will be a vector. Each element of the vector can represent one attribute of the pattern. The first element of the vector will contain the value of the first attribute for the pattern being considered.

2.4 Advantages and Disadvantages of Pattern Recognition

The main advantages of pattern recognition are as follows.

- Pattern recognition solves classification problems.
- Pattern recognition solves the problem of fake bio metric detection.
- It is useful for cloth pattern recognition for visually impaired blind people.
- It helps in speaker diarization.
- We can recognize particular object from different angle.

The main disadvantages of pattern recognition are as follows.

- Syntactic Pattern recognition approach is complex to implement, and it is very slow process.
- Sometime to get better accuracy, larger dataset is required.
- It cannot explain why a particular object is recognized.

- Example: my face vs my friend's face.

2.5 Applications of Pattern Recognition

Some applications of computer vision are face recognition, fingerprint recognition, image-based searching, optical character recognition, remote sensing, and number plate recognition. This project is highly inspired by the real-world applications of computer vision. The key idea of most of these technologies is automation. Automation is an interdisciplinary concept that uses technologies in the computer world to simplify complex issues in other disciplines or in everyday life. This research focuses on using image processing to automate classification and perform plant recognition based on the images of the leaves. Automatic plant classification and recognition can assist botanists in their study as well as help laymen in identifying and studying plants. Different shape related features were extracted from these images using image processing algorithms. Depending on these features, a statistical classification of plants was conducted. The classification scheme was then validated using a set of test images.

1) Image processing, segmentation, and analysis

Pattern recognition is used to give human recognition intelligence to machine which is required in image processing.

2) Computer vision

Pattern recognition is used to extract meaningful features from given image/video samples and is used in computer vision for various applications like biological and biomedical imaging.

3)Seismic analysis

Pattern recognition approach is used for the discovery, imaging, and interpretation of temporal patterns in seismic array recordings. Statistical pattern recognition is implemented and used in different types of seismic analysis models.

4) Radar signal classification/analysis

Pattern recognition and Signal processing methods are used in various applications of radar signal classifications like AP mine detection and identification.

5) Speech recognition

The greatest success in speech recognition has been obtained using pattern recognition paradigms. It is used in various algorithms of speech recognition which tries to avoid the problems of using a phoneme level of description and treats larger units such as words as pattern.

6)Fingerprint identification

The fingerprint recognition technique is a dominant technology in the biometric market. A number of recognition methods have been used to perform fingerprint matching out of which pattern recognition.

CHAPTER 3

LITERATURE REVIEW

3.1 Machine learning in medicinal plants recognition: a review

The Medicinal plants are gaining attention in the pharmaceutical industry due to having less harmful effects reactions and cheaper than modern medicine. Based on these facts, many researchers have shown considerable interest in the research of automatic medicinal plants recognition. There are various opportunities for advancement in producing a robust classifier that has the ability to classify medicinal plants accurately in real-time. In this paper, various effective and reliable machine learning algorithms for plant classifications using leaf images that have been used in recent years are reviewed. The review includes the image processing methods used to detect leaf and extract important leaf features for some machine learning classifiers. These machine learning classifiers are categorized according to their performance when classifying leaf images based on typical plant features, namely shape, vein, texture, and a combination of multiple features. The leaf databases that are publicly available for automatic plants recognition are reviewed as well and we conclude with a discussion of prominent ongoing research and opportunities for enhancement in this area.[2].

Modern medicine is massively produced for medical treatment, but many first world countries are now opting for traditional medicine due to the limitation of synthetic drugs in controlling and curing chronic diseases (WHO 1999). Traditional medicines are used extensively in the pharmaceutical industry, as claimed in where a quarter of the globally prescribed drugs are extracted from medicinal plants. This is due to the benefits of medicinal plants that offer substantially lower adverse reactions and more cost effective as compared to synthetic drugs. Furthermore, bioactive compounds such as phenolics, carotenoids, anthocyanins and tocopherols that can be extracted from medicinal plants serve as antioxidants, anti-allergenic, anti-inflammatory, antibacterial and also anti-hepatotoxic. Nonetheless, the task of identifying medicinal plants manually is complicated and time consuming, similar to other plant recognition and this is due to the availability of expert opinions. Inspired by these problems, researchers introduced numerous automatic plants or leaf recognition systems, where most of them utilized Machine learning approaches.

Machine learning is a branch of artificial intelligence which allows machines to identify patterns and make decisions with minimal human intervention. Machine learning has been

used to obtain impressive recognition, prediction and filtration results on many problems such as medical diagnosis, financial analysis, predictive maintenance, and image recognition. Currently, there are various types of machine learning algorithms, and these algorithms can be classified into three categories, namely supervised, unsupervised, and semi supervised. In supervised learning, the algorithm makes decisions based on the labeled input data, where the training process continues until the classifier able to achieve the highest accuracy. There are also machine learning algorithms that can be trained without labeled data and these algorithms are categorized under unsupervised learning. In some cases, there is a need for semi-supervised learning, where the algorithms are trained using both labelled and unlabeled data.

In this paper, various effective and reliable machine learning algorithms such as Multilayer Perceptron, Support Vector Machine (SVM), K-Nearest Neighbor (k-NN), Nearest Neighbor Generalized Exemplar, Fuzzy Lattice Reasoning, Naive Bayes Classifier, K-Star Instance Based Classifier, Hyper Pipes Classifier, Random Committee, Random Forest (RF), Bagging Classifier, Voting Feature Intervals, and Random Tree that are commonly utilized for plant or leaf classifications in recent years are reviewed.

The ultimate goal of performing leaf detection is to determine the presence and location of leaves in images. The detection process involves image pre-processing, image segmentation, image enhancement and localization. The implementation of pre-processing is crucial to substantially reduce computation time and noise, which subsequently leads to higher accuracy. This is proven by Nasir et al. (2014), where the authors demonstrated 99% detection rate when detecting the enhanced Ficus Delto idea leaf images using Principal Component Analysis (PCA). The authors used 345 images from 5 variations of Ficus Delto idea. In another example, Gao and Lin (2018) achieved 99% detection rate as well but the authors applied OTSU method, which is an optimal segmentation approach that measures adjacent marked edge point of leaf accurately in pre-processing stage. The OTSU method adopts maximum between-class variance as criterion and selects optimal segmentation threshold. Gao and Lin (2018) used two datasets where the first dataset consists of 440 images comprising of 88 different species and the second dataset has 232 images comprising of 70 different species. The images from both datasets were captured with complex background.

3.2 Computer Vision Based Leaf Identification.

Plants are considered as one of the greatest assets in the field of Indian Science of Medicine called Ayurveda. Some plants have its medicinal values apart from serving as the source of food. The innovation in the allopathic medicines has degraded the significance of these therapeutic plants .People failed to have their medications at their doorstep instead went behind the fastest cure unaware of its side effects. One among the reasons is the lack of knowledge about identifying medicinal plants among the normal ones. So, a Vision based approach is being employed to create an automated system which identifies the plants and provides its medicinal values thus helping even a common man to be aware of the medicinal plants around them. This paper discusses about the formation of the feature set which is the important step in recognizing any plant species.

The plants which are around us play a major part in framing our ecosystem. Some gives us edible eatables either above or beneath the ground whereas there are a wide variety of plants that has found its use in Indian system of medicine called Ayurveda. These plants are different from the normal ones. In earlier days, people were good enough to identify the medicinal aspects of these plants in curing various diseases. These plants were the ones that normally grow in our backyards or the ones that we find along the roadsides. As the days pass it is becoming difficult for the people to identify the existence of the medicinal plants. Many are unaware of these plants. So, to identify a plant first we consider the leaves of that plant to classify them. Leaves can be classified based on various features like texture, shape, and color .The texture-based feature classification has been discussed in a paper, where a statistical approach has been used which gives the quantitative measure of the pixel arrangements in a region. So, the GLCM method has been used and the dissimilarity between the leaves has been found and leaves are classified[3].

This algorithm works on different herbal leaves namely Thulasi, Omavalli, Neem, Vana Thulasi, Thudhuvalai and nochi. In some cases, color and shape features has been used to get the feature vectors from where the classification is done. There are various classification algorithms used to classify the plants based on the feature vectors. Some of the papers discuss about Support Vector Machine (SVM) and Artificial Neural Network algorithm. E.Sandeep Kumar and Viswanath Talasila has discussed about the Gaussian distribution of the leaf features that serves as the effective classifier. In this paper, survey on various algorithms like Probabilistic Neural Network, Support Vector Machine, Principal Component Analysis, and the texture base analysis.

The leaves are considered as a dominant feature for identifying a plant type. The digital image of the leaf part of any plant is given as an input data. This image undergoes preprocessing steps in order to remove any kind of external noises present in an image. The main idea of preprocessing is to enhance the image details so that features are clearly found for further processing. The noise removed leaves are then converted from color to grayscale image which will be easy for feature extraction process. The contour of the leaf is then detected using the edge detectors.

3.2.1 Probabilistic Neural Network

Probabilistic neural networks are a type of classification algorithm that is derive from the from Radial Basis Function (RBF) Network. The major advantage of PNN is its time complexity. It takes lesser time to train the data. The working of PNN includes three layers namely input layer, Radial Basis Layer, and competitive layer. The input layer is the first layer through which the input vectors are fed. As the input is given the distance of the input vectors are calculate with respect to the vectors in the training dataset. A vector value is got as a result that shows how similar s the input vector to that of training data. The values of each input class are summed in the second layer thus giving an output vector. The distance between the row weight vectors of the weighted matrix and the input vectors re calculated by the Radial Basis Layer which then scales these distance values nonlinearly. Here the weight values are assigned instead of training. The new vectors can be added into the weight matrix without altering the existing ones. The competitive layer is the last layer that decides to which class the input data belongs to base on the probabilities. The one whose probability is maximum takes the value 1 and the remaining classes takes 0.

3.3 Identification of Ayurvedic Medicinal Plants

Identification of the correct medicinal plants that goes into the preparation of a medicine is very important in ayurvedic medicinal industry. The main features required to identify a medicinal plant is its leaf shape, color, and texture. Color and texture from both sides of the leaf contain deterministic parameters to identify the species. This paper explores feature vectors from both the front and back side of a green leaf along with morphological features to arrive at a unique optimum combination of features that maximizes the identification rate. A database of medicinal plant leaves is created from scanned images of front and back side of leaves of commonly used ayurvedic medicinal plants. The leaves are

classified based on the unique feature combination. Identification rates up to 99% have been obtained when tested over a wide spectrum of classifiers. The above work has been extended to include identification by dry leaves and a combination of feature vectors is obtained, using which, identification rates exceeding 94% have been achieved.

Parag Bhandarkar, Rizwan Ahmed et al. decomposed the morphology of leaf edges using predefined structural elements and extracted a structural signature which quantifies the leaf shape feature. They used the root mean square error between the feature vectors of the input image and the image in the database for computing the identity. The database created by the authors consists of 40 leaf samples of 10 different species. They achieved an overall classification rate of 67.5%, which is independent of leaf size and orientation. The identification rate is comparatively low to be of use in practical implementations. T. Sathwik, R. Yasaswini developed a plant identification method using texture features alone. They extracted 10 textural features from GLCM of the leaf image and used these for classification using least dissimilarity method. The system was trained with 63 and tested with 33 leaves and achieved an accuracy of 95%. When they used a combination of inverse difference moment, entropy, sum average and difference variance, accuracy of 91% is achieved. The method was tested only on a limited number of samples and was not fully invariant to rotation of leaf.

Nuril Aslina, Nursuriati Jamil used Scale Invariant Feature Transform (SIFT) as a shape descriptor and color moments. The image is decomposed in to HSV planes and each plane is divided into 9 grids. Color moments are calculate for each grid of every plane and used as feature vector. Least Euclidean distance between test and training sets are used for identification. Database is created by the authors by acquiring 40 leaf images of Malaysian herbs from natural habitat in natural light. An accuracy of 87.5% is obtained independent of scaling and rotation of images. SIFT is computationally intensive when used to extract key point features. Itheri Yahiaoui, Olfa Mzoughi used five geometrical features and a boundary descriptor named as Directional Fragment Histogram for identification. They used 3070 scanned and 897 scan-like images of Plant Leaves dataset for experiment. For scanned images, accuracy of 77.83% and for scan like images an accuracy of 67.47% is obtained.

3.3.1 Classification tools

Human beings make mistakes during analysis of large amounts of data and when trying to figure out relationships between multiple features of a data set. This makes solving the

problem manually time consuming and difficult. Machine learning techniques can often be effectively applied to these problems, improving the efficiency of systems. Weka is a collection of machine learning algorithms for data mining tasks written in Java . It is developed by University of Waikato and is open-source software. The algorithms can either be applied directly to a dataset or called from a Java code. Weka contains tools for data pre-processing, classification, regression, clustering, association rules, feature selection and visualization. It is also well-suited for developing new machine learning schemes. The functions can be accessed by a graphical user interface. The attribute selection panel provides algorithms for identifying the most predictive attributes in a dataset. The visualization panel shows a scatter plot matrix, where individual scatter plots can be selected and enlarged, and analyzed further using various selection operators. It contains different classifiers for classification. Some of the classifiers are explained below.

3.3.2 Support vector machine

Support vector machines contains an algorithm, which deducing a function from given data. This method is used for classification and reverting analysis of the data. Decision boundaries are defined by decision planes. These planes separate set of objects in different classes. SVM is working based on these planes. They are performing the linear classification. The main property of SVM is Duality.

3.3.3 Multilayer perceptron

A multilayer perceptron (MLP) is a kind of feed forward artificial neural network. It routes the input data in one set to appropriate outputs in another set. Directed graph consisting of many nodes. A MLP contain many layers of this node. Specialty of these layers is that they are connected to one another. We can consider each node in a layer as a neuron. For training the network MLP utilizes a back propagation technique, and this technique is a supervised learning method. Data that are not linearly separable can be distinguished by MLP. The system has two stages of operation: training phase and testing phase. In the training phase, the images in the leaf database are given as input to the system one by one. The pre-processing step ensures that all the images have same standard resolution. The next step is to convert the color image to grayscale and then to binary image. The binary image passes through a morphological erosion and dilation process that removes small imperfections like dots and cracks. The largest

component of the binary image is selected for finding morphological features. The feature extraction stage extracts morphological, color and texture features from binary and color images respectively and stores these values in another database.

This is repeated for all the leaves in the leaf database. A classifier is trained with selected feature values from the feature database. In the testing phase, query image is presented to the system on a white background. It goes through all the stages that each training image has passed through, and selected features are extracted from it. When these values are given as input to the classifier, it decides whether the test sample matches with any of the classes with which it was trained earlier. The name of the class that the leaf belongs is the output of the classifier. The features are analyzed with the help of Weka classifier tool to find out the optimum combination of geometrical, color and texture features that maximizes the identification rate using green leaves. Similarly, minimum feature set that maximizes the identification rate using dry leaves is also carried out.

3.4 Detection of Unhealthy region of plant leaves

Plant diseases have turned into a dilemma as it can cause significant reduction in both quality and quantity of agricultural products. Automatic detection of plant diseases is an essential research topic as it may prove benefits in monitoring large fields of crops, and thus automatically detect the symptoms of diseases as soon as they appear on plant leaves. The proposed system is a software solution for automatic detection and classification of plant leaf diseases. The developed processing scheme consists of four main steps, first a color transformation structure for the input RGB image is created, then the green pixels are masked and removed using specific threshold value followed by segmentation process, the texture statistics are computed for the useful segments, finally the extracted features are passed through the classifier. The proposed algorithm's efficiency can successfully detect and classify the examined diseases with an accuracy of 94%. Experimental results on a database of about 500 plant leaves confirm the robustness of the proposed approach.

Images form important data and information in biological sciences. Digital image processing and image analysis technology based on the advances in microelectronics and computers has many applications in biology and it circumvents the problems that are associated with traditional photography. This new tool helps to improve the images from microscopic to telescopic range and also offers a scope for their analysis. It, therefore, has many applications in biology. Since the effects of plant diseases were devastating, some of the crop cultivation has been abandoned. It is estimated that 2007 plant disease losses in Georgia

(USA) is approximately $653.06 million (Jean, 2009). In India, no estimation has been made but it is more than USA because the preventive steps taken to protect our crops are not even one-tenth of that in USA. The naked eye observation of experts is the main approach adopted in practice for detection and identification of plant diseases. But this requires continuous monitoring of experts which might be prohibitively expensive in large farms. Further, in some developing countries, farmers may have to go long distances to contact experts, Plant diseases cause periodic outbreak of diseases which leads to large scale death and famine.

It is estimated that the outbreak of helminthosporiose of rice in northeastern India in 1943 caused a heavy loss of food grains and death of a million people. Automatic detection of plant diseases is an important research topic as it may prove benefits in monitoring large fields of crops, and thus automatically detect the diseases from the symptoms that appear on the plant leaves. This enables machine vision that is to provide image based automatic inspection, process control and robot guidance. Comparatively, visual identification is labor intensive, less accurate and can be done only in small areas. Kim et al. have classified the grapefruit peel diseases using color texture features analysis. The texture features are calculated from the Spatial Gray-level Dependence Matrices (SGDM) and the classification is done using squared distance technique. Grapefruit peel might be infected by several diseases like canker, copper burn, greasy spot, melanose and wind scar. Helly et al. (2003) developed a new method in which Hue Saturation Intensity (HIS) - transformation is applied to the input image, then it is segmented using Fuzzy C-mean algorithm. Feature extraction stage deals with the color, size, and shape of the spot and finally classification is done using neural networks .Real time specific weed discrimination technique using multilevel wavelet decomposition was proposed by Siddiqil et al. In this histogram equalization is used for preprocessing. Features are extracted from wavelet decomposition and finally classified by Euclidean distance method.

Al-Bashish et al. developed a fast and accurate method in which the leaf diseases are detected and classified using k-means based segmentation and neural networks-based classification. Automatic classification of leaf diseases is done based on high resolution multispectral and stereo images .Sugar beet leaves are used in this approach Segmentation is the process that is carried out to extract the diseased region and the plant diseases are graded by calculating the quotient of disease spot and leaf areas. An optimal threshold value for segmentation can be obtained using weighted Parzen-window. This reduces the computational burden and storage requirements without degrading the final segmentation results.

CHAPTER 4

PROPOSED METHODOLOGY

4.1 BLOCK DIAGRAM

The flow chart of the proposed method is shown in Fig4.1. The input image is reprocessed by using average filter. The histogram operation is performed on the preprocessed image. After preprocessing the Edge details of the leaf image is obtained using Canny edge detector algorithm. The Statistical features such as statistical features such as Boundary Points, connected components, Object Area, Major axis Length, filled area of the object, Perimeter, Eccentricity, Equivalent diameter, and Mean Intensity are extracted from the edge detected images. The extracted features are used by KNN Classifier to classify the leaf images.

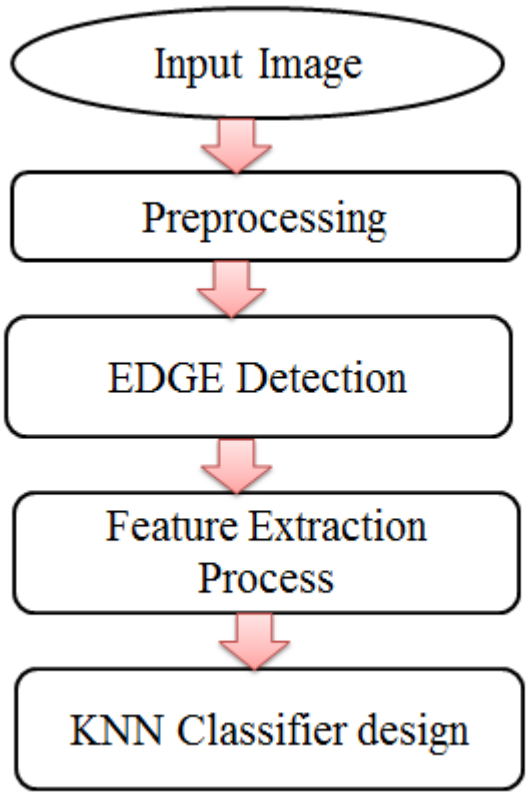

Fig4.1. Block diagram of Proposed method.

4.2 Preprocessing of Image

As a Machine Learning Engineer, data pre-processing or data cleansing is a crucial step and most of the ML engineers spend a good amount of time in data pre-processing before building the model. Some examples for data pre-processing include outlier detection, missing value treatments and remove the unwanted or noisy data. Similarly, Image pre-processing is the term for operations on images at the lowest level of abstraction. These operations do not increase image information content, but they decrease it if entropy is an information measure. The aim of pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis task.

There are 4 different types of Image Pre-Processing techniques, and they are listed below.

- Pixel brightness transformations/ Brightness corrections
- Geometric Transformations
- Image Filtering and Segmentation
- Fourier transform and Image restauration.
- Let us discuss each type in detail.

4.2.1 Pixel brightness transformations (PBT)

Brightness transformations modify pixel brightness, and the transformation depends on the properties of a pixel itself. In PBT, output pixel's value depends only on the corresponding input pixel value. Examples of such operators include brightness and contrast adjustments as well as colour correction and transformations. Contrast enhancement is an important area in image processing for both human and computer vision. It is widely used for medical image processing and as a pre-processing step in speech recognition, texture synthesis, and many other image/video processing applications.

There are two types of Brightness transformations, and they are below.

1. Brightness corrections
2. Gray scale transformation

The most common Pixel brightness transforms operations are,

1. Gamma correction or Power Law Transform
2. Sigmoid stretching
3. Histogram equalization

Two commonly used point processes are multiplication and addition with a constant. Gamma correction is a non-linear adjustment to individual pixel values. While in image normalization we carried out linear operations on individual pixels, such as scalar multiplication and addition/subtraction, gamma correction carries out a non-linear operation on the source image pixels and can cause saturation of the image being altered.

4.2.2 Histogram equalization

Histogram equalization is a well-known contrast enhancement technique due to its performance on almost all types of images. Histogram equalization provides a sophisticated method for modifying the dynamic range and contrast of an image by altering that image such that its intensity histogram has the desired shape. Unlike contrast stretching, histogram modelling operators may employ non-linear and non-monotonic transfer functions to map between pixel intensity values in the input and output images.

4.2.3 Geometric Transformations

The earlier methods in this article deal with the color and brightness/contrast. With geometric transformation, positions of pixels in an image are modified but the colors are unchanged. Geometric transforms permit the elimination of geometric distortion that occurs when an image is captured. The normal Geometric transformation operations are rotation, scaling and distortion (or undistortion) of images.

4.2.4 Image Filtering and Segmentation

The goal of using filters is to modify or enhance image properties and/or to extract valuable information from the pictures such as edges, corners, and blobs. A filter is defined by

a kernel, which is a small array applied to each pixel and its neighbors within an image Some of the basic filtering techniques are.

Low Pass Filtering (Smoothing) : A low pass filter is the basis for most smoothing methods. An image is smoothed by decreasing the disparity between pixel values by averaging nearby pixels.

High pass filters (Edge Detection, Sharpening) : High-pass filter can be used to make an image appear sharper. These filters emphasize fine details in the image – the opposite of the low-pass filter. High-pass filtering works in the same way as low-pass filtering; it just uses a different convolution kernel.

Directional Filtering : Directional filter is an edge detector that can be used to compute the first derivatives of an image. The first derivatives (or slopes) are most evident when a large change occurs between adjacent pixel values. Directional filters can be designed for any direction within a given space.

Laplacian Filtering : Laplacian filter is an edge detector used to compute the second derivatives of an image, measuring the rate at which the first derivatives change. This determines if a change in adjacent pixel values is from an edge or continuous progression. Laplacian filter kernels usually contain negative values in a cross pattern, centered within the array. The corners are either zero or positive values. The center value can be either negative or positive.

4.3 Edge Detection

Edges are significant local changes of intensity in a digital image. An edge can be defined as a set of connected pixels that forms a boundary between two disjoint regions. There are three types of edges: Horizontal edges, Vertical edges, and Diagonal edges.

Edge Detection is a method of segmenting an image into regions of discontinuity. It is a widely used technique in digital image processing like pattern recognition, image morphology, and feature extraction. Edge detection allows users to observe the features of an image for a significant change in the gray level. This texture indicating the end of one region in the image and the beginning of another. It reduces the amount of data in an image and preserves the structural properties of an image.

Edge Detection Operators are of two types:

Gradient – based operator which computes first-order derivations in a digital image like, Sobel operator, Prewitt operator, Robert operator.

Gaussian – based operator which computes second-order derivations in a digital image like, Canny edge detector, Laplacian of Gaussian.

4.3.1 Sobel Operator

: It is a discrete differentiation operator. It computes the gradient approximation of image intensity function for image edge detection. At the pixels of an image, the Sobel operator produces either the normal to a vector or the corresponding gradient vector. It uses two 3 x 3 kernels or masks which are convolved with the input image to calculate the vertical and horizontal derivative approximations, respectively. The filter shown in the below equation.

$$M_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad M_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

The advantages of Sobel operator are,

- Simple and time efficient computation
- Very easy at searching for smooth edges.

The Limitations of Sobel Operator

- Diagonal direction points are not preserved always,
- Highly sensitive to noise
- Not very accurate in edge detection
- Detect with thick and rough edges does not give appropriate results.

4.3.2 Prewitt Operator

This operator is almost like the Sobel operator. It also detects vertical and horizontal edges of an image. It is one of the best ways to detect the orientation and magnitude of an image. It uses the kernels or masks.

$$M_x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \quad M_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

The advantages of Prewitt Operator are

- Good performance on detecting vertical and horizontal edges.
- Best operator to detect the orientation of an image.

Limitations

- The magnitude of coefficient is fixed and cannot be changed.
- Diagonal direction points are not preserved always:

4.3.3 Laplacian of Gaussian (LoG):

It is a gaussian-based operator which uses the Laplacian to take the second derivative of an image. This really works well when the transition of the grey level seems to be abrupt. It works on the zero-crossing method i.e., when the second-order derivative crosses zero, then that particular location corresponds to a maximum level. It is called an edge location. Here the Gaussian operator reduces the noise, and the Laplacian operator detects the sharp edges.
The Gaussian function is defined by the formula:

$$G(x,y) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp - \left(\frac{x^2+y^2}{2\sigma^2}\right)$$

And the LoG operator is computed from.

$$\text{LoG} = \frac{\partial^2}{\partial x^2}G(x,y) + \frac{\partial^2}{\partial y^2}G(x,y) = \frac{x^2+y^2-2\sigma^2}{\sigma^4} \exp\left(-\frac{x^2+y^2}{2\sigma^2}\right)$$

The advantages are,

- Easy to detect edges and their various orientations.
- There is fixed characteristics in all directions.

Limitations:

- Very sensitive to noise
- The localization error may be severe at curved edges.
- It generates noisy responses that do not correspond to edges, so-called “false edges.”

4.3.4 Canny Operator

It is a gaussian-based operator in detecting edges. This operator is not susceptible to noise. It extracts image features without affecting or altering the feature. Canny edge detector has advanced algorithm derived from the previous work of Laplacian of Gaussian operator. It is widely used an optimal edge detection technique. It detects edges based on three criteria:

- Low error rate
- Edge points must be accurately localized.
- There should be just one single edge response.

The Advantages of the algorithm are.

- It has good localization.
- It extracts image features without altering the features.

- Less Sensitive to noise

Limitations:

- There is false zero crossing.
- Complex computation and time consuming

4.4 Feature Extraction

In real life, all the data we collect are in large amounts. To understand this data, we need a process. Manually, it is not possible to process them. Here is when the concept of feature extraction comes in. Suppose you want to work with some of the big machine learning projects or the coolest and popular domains such as deep learning, where you can use images to make a project on object detection. Making projects on computer vision where you can work with thousands of interesting projects in the image data set. To work with them, you have to go for feature extraction procedure which will make your life easy. Feature extraction is a part of the dimensionality reduction process, in which, an initial set of the raw data is divided and reduced to more manageable groups. So, when you want to process it will be easier. The most important characteristic of these large data sets is that they have a large number of variables. These variables require a lot of computing resources to process them. So, feature extraction helps to get the best feature from those big data sets by select and combine variables into features, thus, effectively reducing the amount of data. These features are easy to process, but still able to describe the actual data set with the accuracy and originality.

4.4.1 Why Feature Extraction is Useful?

The technique of extracting the features is useful when you have a large data set and need to reduce the number of resources without losing any important or relevant information. Feature extraction helps to reduce the amount of redundant data from the data set. In the end, the reduction of the data helps to build the model with less machine's efforts and also increase the speed of learning and generalization steps in the machine learning process. The statistical features extracted from the images are,

- Boundary Points
- Connected components.
- Object Area
- Major axis Length
- Filled area of the object.

- Perimeter
- Eccentricity
- Equivalent diameter
- Mean Intensity

4.4.2 Boundary Points

Basically, boundary detection algorithms could be classified into three categories: gradient-based, machine learning-based, and saliency-based methods. In the gradient-based methods category, the ultimate classical and well recognized edge detector is the Canny edge operator. Regardless of its initial prominence and success, the results obtained from this technique majorly depend on the scale parameter, which is possibly not easily customizable and whose parameters are not feasibly tuned. Bergholm investigated the problem of selecting the scale using the approach of focusing on edges, leading to the integration of multiple-scale information. Both Canny edge detection and edge focusing algorithms were planned to identify local edges; however, this led to a problem because the method could detect not only true images boundaries but also false positive texture edges. Therefore, to reduce texture edge detection, Grigorescu et al. as well as Papari and Petkov designed a model called the surround suppression model, which was based on gradient image features. Specifically, the design of suppression model in was inspired by the "non-classical receptive field" concept from biology. Essentially, this approach can be seen as a filter operating in the gradient space. As pointed by the authors, the method had two problems: unwanted self-inhibition and undetermined inhibition levels. Even on using a more sophisticated steerable filter, the self-inhibition problem still could not be completely resolved.

4.4.3 Connected components.

Connected components labeling scans an image and groups its pixels into components based on pixel connectivity, i.e., all pixels in a connected component share similar pixel intensity values and are in some way connected with each other. Once all groups have been determined, each pixel is labeled with a gray level or a color (color labeling) according to the component it was assigned to. Extracting and labeling of various disjoint and connected components in an image is central to many automated image analysis applications. Connected component labeling works by scanning an image, pixel-by-pixel (from top to bottom and left to right) in order to identify connected pixel regions, i.e., regions of adjacent pixels which share the same set of intensity values V. (For a binary image V={1}; however, in a gray level

image V will take on a range of values, for example: V={51, 52, 53, ..., 77, 78, 79, 80}.)

Connected component labeling works on binary or gray level images and different measures of connectivity are possible. However, for the following we assume binary input images and 8-connectivity. The connected components labeling operator scans the image by moving along a row until it comes to a point p (where p denotes the pixel to be labeled at any stage in the scanning process) for which V={1}. When this is true, it examines the four neighbors of p which have already been encountered in the scan (i.e., the neighbors (i) to the left of p, (ii) above it, and (iii and iv) the two upper diagonal terms). Based on this information, the labeling of p occurs as follows:

If all four neighbors are 0, assign a new label to p, else,

if only one neighbor has V={1}, assign its label to p, else

if more than one of the neighbors have V={1}, assign one of the labels to p and make a note of the equivalences.

After completing the scan, the equivalent label pairs are sorted into equivalence classes and a unique label is assigned to each class. As a final step, a second scan is made through the image, during which each label is replaced by the label assigned to its equivalence classes. For display, the labels might be different gray levels or colors.

4.4.4 Object Area

It estimates the area of all of the on pixels in an image by summing the areas of each pixel in the image. The area of an individual pixel is determined by looking at its 2-by-2 neighborhood. There are six different patterns, each representing a different area:

- Patterns with zero on pixels (area = 0)
- Patterns with one on pixel (area = 1/4)
- Patterns with two adjacent on pixels (area = 1/2)
- Patterns with two diagonals on pixels (area = 3/4)
- Patterns with three on pixels (area = 7/8)
- Patterns with all four on pixels (area = 1)

4.4.5 Major axis Length

The major axis is the (x,y) endpoints of the longest line that can be drawn through the object. The major axis endpoints (x1,y1) and (x2,y2) are found by computing the pixel distance between every combination of border pixel in the object boundary and finding the pair with the maximum length. The major-axis length of an object is the pixel distance between the major-axis endpoints and is given by the relation:

$$\text{major-axis length} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

The major-axis angle is the angle between the major-axis and the x-axis of the image:

$$\text{major-axis angle} = \tan^{-1}\left(\frac{y_2 - y_1}{x_2 - x_1}\right)$$

The angle can range from 0° to 360°. The result is a measure of object orientation.

4.4.6 Filled area of the object.

The Number of on pixels in Filled Image is estimated by using this feature. The feature value is extracted by using region props function in MATLAB.

4.4.7 Perimeter

A pixel is part of the perimeter if it is nonzero, and it is connected to at least one zero-valued pixel. Distance around the boundary of the region returned as a scalar. Region props computes the perimeter by calculating the distance between each adjoining pair of pixels around the border of the region. If the image contains discontinuous regions, region props return unexpected results.

4.4.8 Eccentricity

Eccentricity of the ellipse that has the same second-moments as the region, returned as a scalar. The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The value is between 0 and 1. (0 and 1 are degenerate cases. An ellipse whose eccentricity is 0 is a circle, while an ellipse whose eccentricity is 1 is a line segment.)

4.4.9 Equivalent diameter

Diameter of a circle with the same area as the region, returned as a scalar. Region props computed as sqrt(4*Area/pi).

4.4.10 Mean Intensity

It measures Image Intensity measures the total intensity in an image by summing all the pixel intensities (excluding masked pixels). The extracted features are used KNN classifier to do classification task.

4.5 KNN Classifier

K-Nearest Neighbors (k-NN) is a supervised machine learning algorithm i.e., it learns from a labelled training set by taking in the training data X along with it is labels y and learns to map the input X to it is desired output y. The k-NN algorithm is arguably the simplest of the machine learning algorithms. The model only consists of the training data, that is, the model

simply learns the entire training set and for prediction gives the output as the class with the majority in the ‘k’ nearest neighbors calculated according to some distance metric.

The working in a little more detail is as follows: After the model has stored the training set for prediction, it takes a test image to be predicted, calculates the distance to every image in the training set and obtains the ‘k’ training images closest to the test image. It then outputs the class according to some voting procedure from the labels of these ‘k’ neighbors , generally a majority vote. The distance metric used to calculate distances may differ, such as a L1 distance function which is the summation of the differences between the pixels of the images.

$$d1(I1, I2) = \sum p|Ip1 - Ip2|$$

L1 distance metric

An alternative distance metric may be the L2 distance or more commonly called the Euclidean distance.

$$d_2(I_1, I_2) = \sqrt{\sum_p (I_1^p - I_2^p)^2}$$

L2 distance metric

In other words, we would be computing the pixel-wise difference as before, but this time we square all of them, add them up and finally take the square root. It is interesting to note that due to the squared differences in the L2 distance, it is much more strict when the pixel difference is too large. Now, we move onto the practical considerations: Hyperparameters in k-NN and how they affect the performance. As k-NN is a very simple algorithm it does not really have a lot of hyperparameters to tweak, just the two: the distance metric and the value of ‘k’. So, what we can do is, run our model for various values of ‘k’ and get the model with the best validation accuracy, which will be used as our final model on the test set.

CHAPTER 5

EXPERIMENTAL RESULTS

5.1 Database used:

The plant leaves used in the project was obtained from medley Database. The details of plant leaf used in the project is mentioned below.

Sl.No	Name of the pant Leaf	Total number of Images
1	Alpinia Galanga (Rasna)	50
2	Amaranthus Viridis (Arive-Dantu	122
3	Artocarpus Heterophyllus (Jackfruit)	56
4	Azadirachta Indica (Neem)	60
5	Basella Alba (Basale)	103
6	Brassica Juncea (Indian Mustard)	34
7	Carissa Carandas (Karanda)	74
8	Citrus Limon (Lemon)	57
9	Ficus Auriculata (Roxburgh fig)	50
10	Ficus Religiosa (Peepal Tree)	63
Total images used		669

Table 5.1 Leaf database details

The samples images from the database are displayed in the Fig5.1

Alpinia Galanga (Rasna)

Amaranthus Viridis (Arive-Dantu)

Azadirachta Indica (Neem)

Brassica Juncea (Indian Mustard)

Fig5.1 Sample images from Database

5.2 Preprocessing using Average Filtering.

It is necessary to enhance the image and to remove unwanted distortions present in the image. In this project preprocessing step is used to create smoothness and to highlight the contours in the image using average filter Average (or mean) filtering is a method of 'smoothing' images by reducing the amount of intensity variation between neighboring pixels. The average filter works by moving the filter function through the image pixel by pixel, replacing each value with the average value of neighboring pixels. The Preprocessed image output is shown in Fig5.2

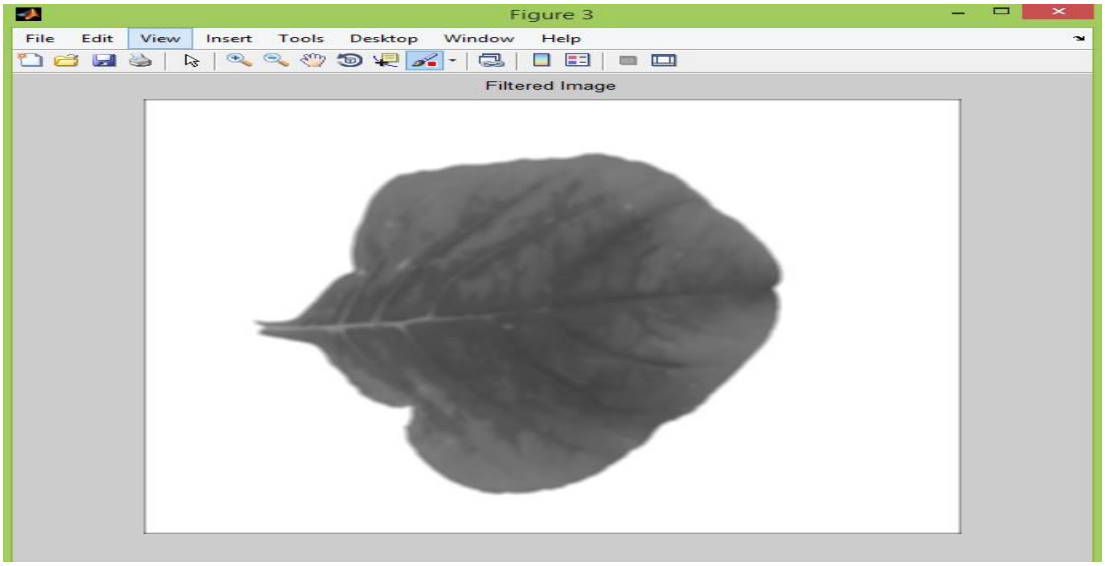

Fig5.2 Filtered Image.

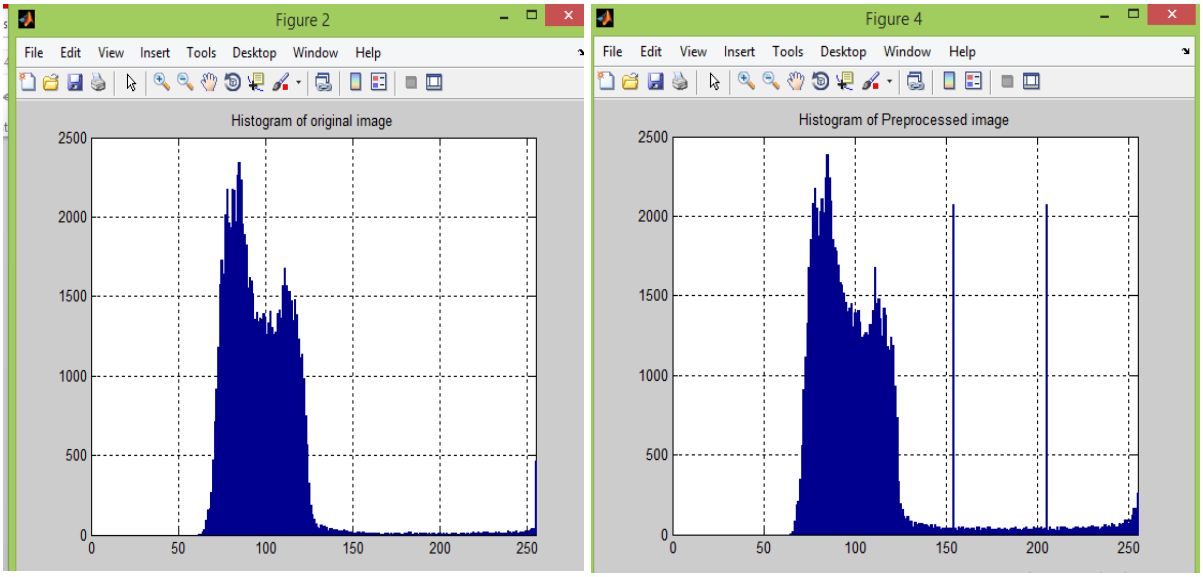

Fig5.3 histogram plot of original image and filtered image

5.3 Canny Edge Detection algorithm

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. The Canny filter is a multi-stage edge detector. It uses a filter based on the derivative of a Gaussian in order to compute the intensity of the gradients. It uses a filter based on the derivative of a Gaussian in order to compute the intensity of the gradients. The Gaussian reduces the effect of noise present in the image. Then, potential edges are thinned down to 1-pixel curves by removing non-maximum pixels of the gradient magnitude. The Edge detected image output image is shown in Fig5.4.The major steps involved are.

Step 1: Apply a Gaussian blur

Step 2: Find edge gradient strength and direction.

Step 3: Trace along the edges

Step 4: Suppress non-maximum edges.

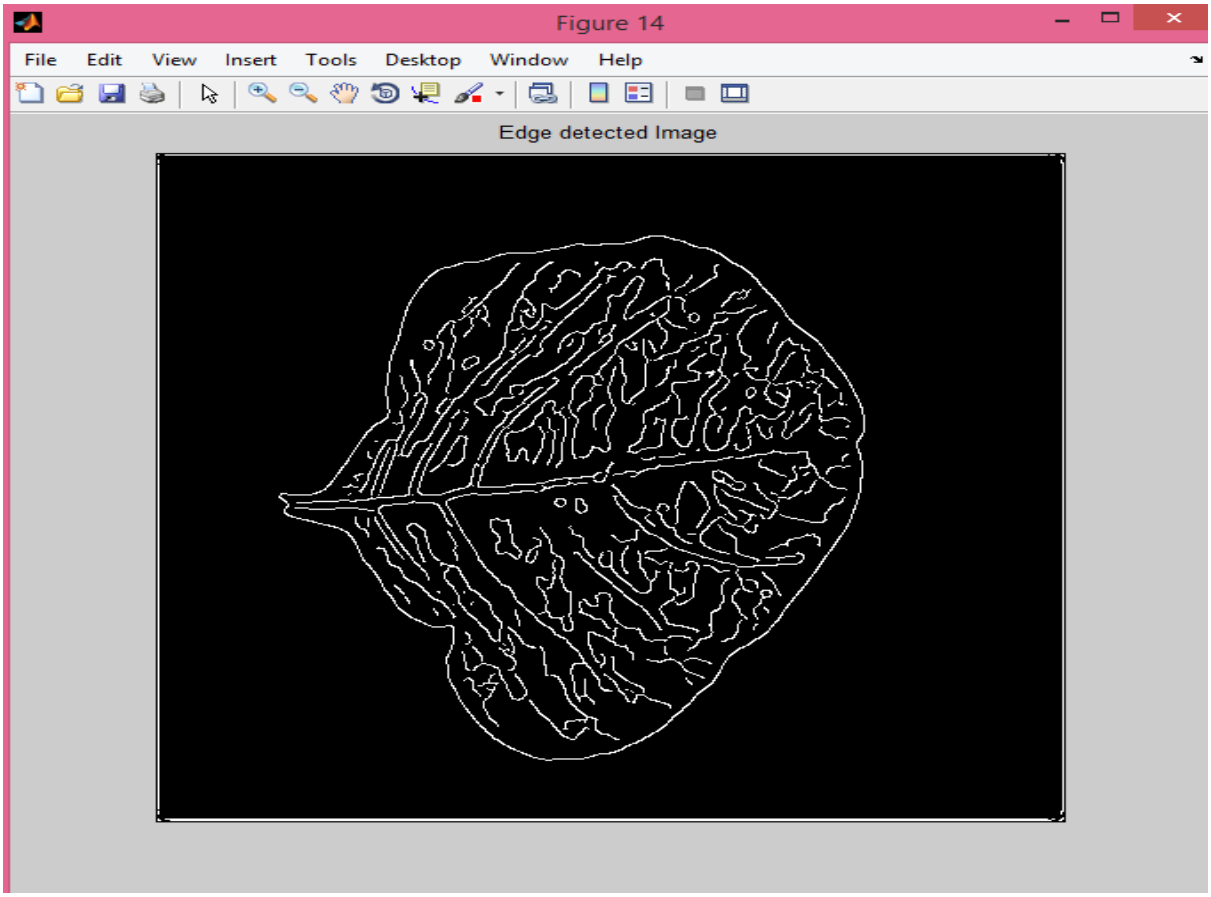

Fig5.4 Output Images of Edge detection Algorithm

5.4 Feature Extraction Process

Feature extraction is a type of dimensionality reduction where a large number of pixels of the image are efficiently represented in such a way that interesting parts of the image are captured effectively. The reduction of the data helps to build the machine learning model with less machine's efforts and also increase the speed of learning in the algorithm. The statistical features such as Boundary Points, connected components, Object Area, Major axis Length, filled area of the object, Perimeter, Eccentricity, Equivalent diameter, and Mean Intensity are extracted from the edge detected images. The sample features Extracted from the database images are shown in the below table.

F1	F2	F3	F4	F5	F6	F7	F8	F9
208	206	6	6.928203	6	10	0.98601	2.76395	221.6626
205	204	7	8.08290	7	12	0.98974	2.98541	212.288

			4			3	1	7
141	141	505	583.1238	505	1008.828	0.999998	25.35717	231.8259
208	205	503	580.7734	503	1002.828	0.999998	25.30691	210.8185
360	358	502	579.6186	502	1001.657	0.999998	25.28174	216.106
59	59	507	585.3789	507	1010.243	0.999998	25.40733	235.7985
269	269	1	1.154701	1	0	0	1.128379	219.6921
84	83	503	580.7324	503	1001.657	0.999998	25.30691	239.4124
139	138	502	579.6597	502	1002	0.999998	25.28174	227.6567
125	125	487	562.2968	487	970.8284	0.999998	24.90116	222.2551
133	133	506	584.2648	506	1010.243	0.999998	25.38226	224.6759
203	202	467	539.201	467	930.8284	0.999998	24.38448	213.69
84	84	1	1.154701	1	0	0	1.128379	231.3019

Table 5.2 Sample features extracted from images.

5.5 KNN Classifier

k-nearest neighbors' algorithm (k-NN) is a non-parametric machine learning method. K-NN algorithm assumes the similarity between the new data and available data and put the new case into the category that is most similar to the available categories. K-NN algorithm stores all the available data and classifies a new data point based on the similarity. This means when new data appears then it can be easily classified into a well suite category by using K-NN algorithm.

The algorithm steps are mentioned below.

Step-1: Select the number K of the neighbors.

Step-2: Calculate the Euclidean distance of K number of neighbors.

Step-3: Take the K nearest neighbors as per the calculated Euclidean distance.

Step-4: Among these k neighbors, count the number of the data points in each category.

Step-5: Assign the new data points to that category for which the number of the neighbor is maximum.

Step-6: Final Classification result

The performance of KNN classifier is measured based on accuracy. The accuracy obtained is tabulated in the below table. It is defined as

$$Accuracy = \frac{correctly\,\mathrm{det}ected\,Leaf\ \mathrm{Im}ages}{total\ number\ of\ \ Leaf\ \mathrm{Im}ages}$$

Total Number of images	Correctly Classified images	Accuracy
669	657	98.0597

Table 5.3 Performance table

5.6 Graphical User Interface (GUI)

Graphical user interfaces (GUIs), also known as apps, provide point-and-click control of your software applications, eliminating the need for others to learn a language or type commands in order to run the application. You can share apps both for use within MATLAB and also as standalone desktop or web apps. You can choose from the following three ways to create an app in MATLAB: Convert a script into a simple app: Choose this option when you want to share a script with students or colleagues and allow them to modify variables using interactive controls. Create an app interactively: Choose this option when you want to create a more sophisticated app using a drag-and-drop environment to build the user interface. Create an app programmatically: Choose this option when you want to create an app's user interface by writing the code yourself. The GUI designed for this project is shown in Fig 5.5. The load image push button is used to load the image. The Preprocessing push button is used to enhance the quality of the image. The Features extraction push button is used to extract the statistical feature from the leaf image.

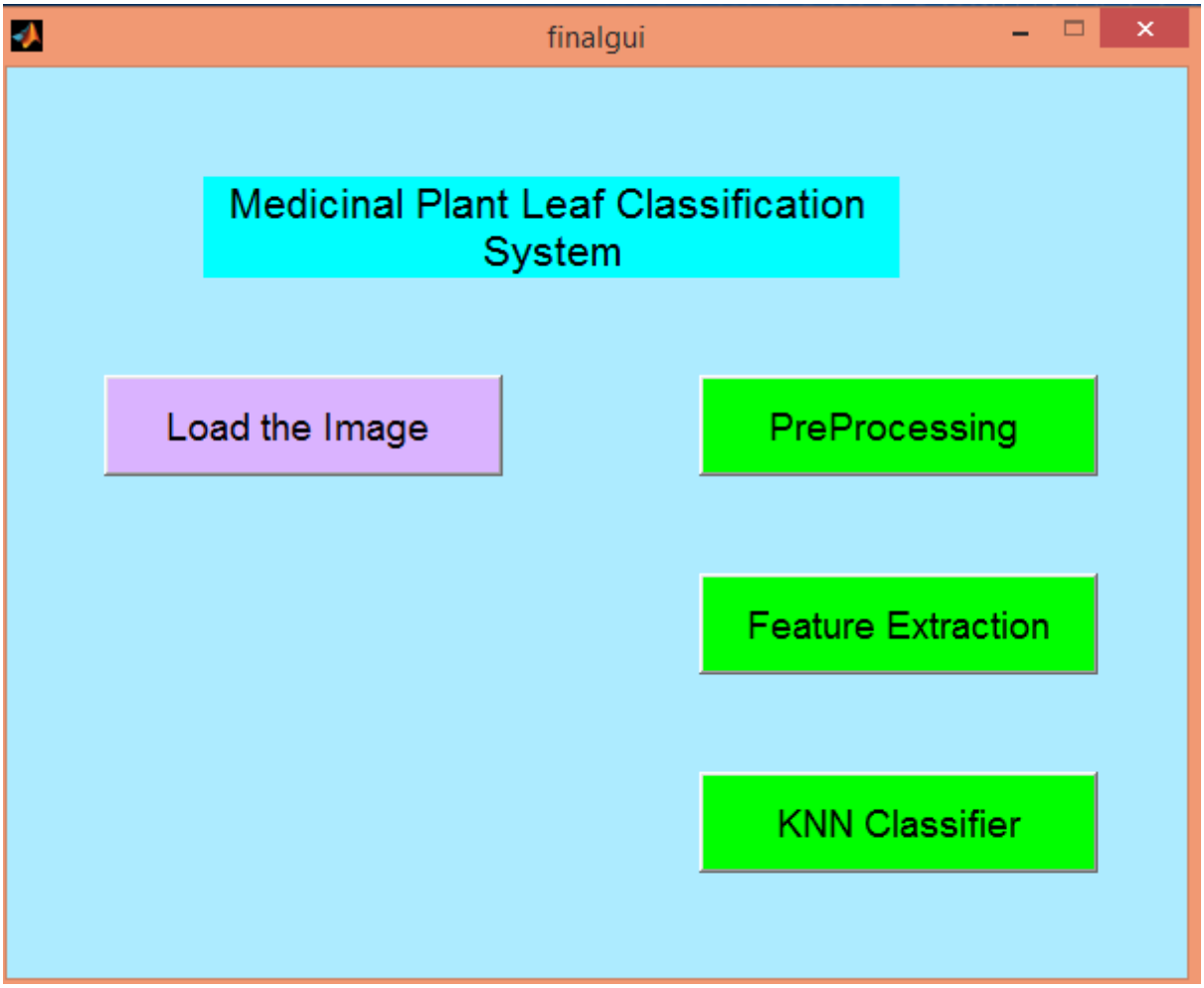

Fig5.5 GUI of the Project

CHAPTER 6
MATLAB SOFTWARE

6.1 INTRODUCTION TO MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. It provides an interactive environment with hundreds of built-in functions for technical computation, graphics, and animation .Best of all it provides easy extensibility with its own high level programming language. The name **MATLAB** stands for MATRIX LABORATORY.

MATLAB built in functions provide excellent tool for linear algebra computations ,data analysis ,signal processing, optimization ,numerical solution of ordinary differential equations (ODE), quadrature's and many other types of scientific computations. Most of these functions use state-of-the art algorithm .These are numerous functions for 2-D and 3-D graphics.

Typical uses include-

- Math and computation
- Algorithm development
- Data acquisition
- Modelling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics

The MATLAB platform is optimized for solving engineering and scientific problems. The matrix-based MATLAB language is the world's most natural way to express computational mathematics. Built-in graphics make it easy to visualize and gain insights from data. A vast library of pre-built toolboxes lets you get started right away with algorithms essential to your domain. The desktop environment invites experimentation, exploration, and discovery. These MATLAB tools and capabilities are all rigorously tested and designed to work together. MATLAB helps you take your ideas beyond the desktop. You can run your analyses on larger data sets and scale up to clusters and clouds. MATLAB code can be integrated with other languages, enabling you to deploy algorithms and applications within web, enterprise, and production systems.

Key Features:

- High-level language for scientific and engineering computing
- Desktop environment tuned for iterative exploration, design, and problem-solving.
- Graphics for visualizing data and tools for creating custom plots.
- Apps for curve fitting, data classification, signal analysis, control system tuning, and many other tasks
- Add-on toolboxes for a wide range of engineering and scientific applications
- Tools for building applications with custom user interfaces
- Interfaces to C/C++, Java®, .NET, Python, SQL, Hadoop, and Microsoft® Excel®
- Royalty-free deployment options for sharing MATLAB programs with end users.

The MATLAB system consists of six main parts:

- **DOVELOPMENT ENVIRONMENT:** This is the set of tools and facilities that help to use MATLAB functions and files. Many of these tools are graphical user interfaces. It includes the MATLAB desktop and Command Window, a command history, an editor and debugger, and browsers for viewing help, the workspace, files, and the search path.
- **THE MATLAB MATHEMATICAL FUNCTION LIBRARY:** This is a vast collection of computational algorithms ranging from elementary functions, like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix Eigen values, Bessel functions, and fast Fourier transforms.
- **The MATLAB LANGUAGE:** This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create large and complex application programs.
- **GRAPHICS:** MATLAB has extensive facilities for displaying vectors and matrices as graphs, as well as annotating and printing these graphs. It includes high-level functions for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level functions

that allow to fully customize the appearance of graphics as well as to build complete graphical user interfaces on MATLAB applications.

- **THE MATLAB APPLICATION PROGRAM INTERFACE (API):** This is a library that allows writing in C and FORTRAN programs that interact with MATLAB. It includes facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.
- **MATLAB DOCUMENTATION:** MATLAB provides extensive documentation, in both printed and online format, to help to learn about and use all of its features. It covers all the primary MATLAB features at a high level, including many examples. The MATLAB online help provides task-oriented and reference information about MATLAB features. MATLAB documentation is also available in printed form and in PDF format.

6.2 MATLAB TOOLBOX:

IMAGE PROCESSING TOOLBOX:

Image Processing Toolbox provides functions and apps to analyze, preprocess and extract features from uniformly and non-uniformly sampled signals. The toolbox includes tools for filter design and analysis, resampling, smoothing, detrending and power spectrum estimation. The toolbox also provides functionality for extracting features like change points and envelopes, finding peaks and signal patterns, quantifying signal similarities, and performing measurements such as SNR and distortion. We can also perform modal and order analysis of vibration signals. With the help of Signal Analyzer, we can preprocess and analyze multiple signals simultaneously in time, frequency, and time-frequency domains without writing code, explore long signals, and extract regions of interest. With the help of Filter designer, we can design and analyze digital filters by choosing from a variety of algorithms and responses.

CHAPTER-7
Conclusion

The identification of Ayurvedic medicinal plants leaf from images has been implemented in this Project. The images are preprocessed by using average filter and statistical features are extracted. The canny edge detection algorithm is used for edge detection. This project has successfully implemented the KNN classifier method on medicinal plant leaves and identify them into 10 classes of hypertensive medicinal plant leaves based on the closest value between the training data and test data. The project also developed a GUI Model for easy use of the project . The accuracy obtained in this method is 98.0 %.

CHAPTER-8

MATLAB CODE

```
function varargout = finalgui(varargin)
% FINALGUI MATLAB code for finalgui.fig
%      FINALGUI, by itself, creates a new FINALGUI or
raises the existing
%      singleton*.
%
%      H = FINALGUI returns the handle to a new FINALGUI
or the handle to
%      the existing singleton*.
%
%      FINALGUI('CALLBACK',hObject,eventData,handles,...)
calls the local
%      function named CALLBACK in FINALGUI.M with the
given input arguments.
%
%      FINALGUI('Property','Value',...) creates a new
FINALGUI or raises the
%      existing singleton*.  Starting from the left,
property value pairs are
%      applied to the GUI before finalgui_OpeningFcn gets
called.  An
%      unrecognized property name or invalid value makes
property application
%      stop.  All inputs are passed to
finalgui_OpeningFcn via varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose
"GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help
finalgui

% Last Modified by GUIDE v2.5 11-Jul-2021 14:33:41

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
```

```
                   'gui_OpeningFcn',
@finalgui_OpeningFcn, ...
                   'gui_OutputFcn',  @finalgui_OutputFcn,
...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State,
varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before finalgui is made visible.
function finalgui_OpeningFcn(hObject, eventdata, handles,
varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version
of MATLAB
% handles    structure with handles and user data (see
GUIDATA)
% varargin   command line arguments to finalgui (see
VARARGIN)

% Choose default command line output for finalgui
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes finalgui wait for user response (see
UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the
command line.
function varargout = finalgui_OutputFcn(hObject,
eventdata, handles)
```

```
% varargout  cell array for returning output args (see
VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version
of MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata,
handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version
of MATLAB
% handles    structure with handles and user data (see
GUIDATA)
[filename, pathname] = uigetfile('*.jpg', 'Load the Input
Image');
path=fullfile(pathname,filename);
a = imread(path);
figure;
imshow(a);
title('original Plant leaf Image');
handles.data=path;
guidata(hObject, handles);
guidata(hObject, handles);

% --- Executes on button press in pushbutton2.
function pushbutton2_Callback(hObject, eventdata,
handles)
% hObject    handle to pushbutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version
of MATLAB
% handles    structure with handles and user data (see
GUIDATA)
path=handles.data;
a=imread(path);
grayImage=rgb2gray(a);
originalimage=imresize(grayImage,[512 512]);
figure;
imshow(originalimage);
title('Gray Scale Image');
```

```
% Obtain and display the histogram
[pixelCount,greyLevels]=imhist(originalimage);
figure;
bar(pixelCount);
title('Histogram of original image');
xlim([0 greyLevels(end)]);
grid on;
% 5-by-5, averaging filter Design
h = ones(5,5)/25;
I2 = imfilter(originalimage,h);
figure
imshow(I2)
title('Filtered Image');

[pixelCount,greyLevels]=imhist(I2);
figure;
bar(pixelCount);
title('Histogram of Preprocessed image');
xlim([0 greyLevels(end)]);
grid on;
handles.data1=I2;
guidata(hObject, handles);
msgbox('PreProcessing Completed Sucessfully');

% --- Executes on button press in pushbutton3.
function pushbutton3_Callback(hObject, eventdata,
handles)
% hObject    handle to pushbutton3 (see GCBO)
% eventdata  reserved - to be defined in a future version
of MATLAB
% handles    structure with handles and user data (see
GUIDATA)
I2=handles.data1;
path=handles.data;
a=imread(path);
grayImage=rgb2gray(a);
originalimage=imresize(grayImage,[512 512]);


BW1 = edge(I2,'Canny');
figure
imshow(BW1);
title('Edge detected Image');

%determining the Centroid features
[labeledImage numberOfBlobs] = bwlabel(BW1, 8);
```

```
blobMeasurements = regionprops(labeledImage, 'Centroid');
xCenter = blobMeasurements(1).Centroid(1);
yCenter = blobMeasurements(1).Centroid(2);

%Determining the boundary features
boundaries = bwboundaries(BW1);
numberOfBoundaries = size(boundaries);
numberOfBoundaries1 =numberOfBoundaries(1);
cc = bwconncomp(BW1);
cc1=cc.NumObjects;

A = regionprops(cc, 'Area');
sum1=0;
for i=1:length(A)
    A1=sum1+A(i).Area
end


MA = regionprops(cc, 'MajorAxisLength');
sum1=0;
for i=1:length(MA)
    MA1=sum1+MA(i).MajorAxisLength
end

FA = regionprops(cc, 'FilledArea');
sum1=0;
for i=1:length(FA)
   FA1=sum1+FA(i).FilledArea
end

P = regionprops(cc, 'Perimeter');
sum1=0;
for i=1:length(P)
    P1=sum1+P(i).Perimeter
end

E = regionprops(cc, 'Eccentricity');
sum1=0;
for i=1:length(P)
    E1=sum1+E(i).Eccentricity
end

ED = regionprops(cc, 'EquivDiameter');
sum1=0;
for i=1:length(P)
    ED1=sum1+ED(i).EquivDiameter
end
```

```
MI = mean(mean(originalimage));
featureVector=[numberOfBoundaries1,cc1,A1,MA1,FA1,P1,E1,E
D1,MI];
handles.data2=featureVector;
guidata(hObject, handles);
msgbox('Feature Extraction process Completed
Sucessfully');
% figure
% imshow(BW1);
% title('EDGE Detected Image');

% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata,
handles)
% hObject    handle to pushbutton4 (see GCBO)
% eventdata  reserved - to be defined in a future version
of MATLAB
% handles    structure with handles and user data (see
GUIDATA)
featureVector=handles.data2;
load b;

feat=b(1:669,1:9);
t=b(1:669,10);

%out=knnclassify(featureVector,feat,t);
md1=fitcknn(feat,t);
out=predict(md1,featureVector);

disp(out);
if out==1
    msgbox('The recognized Leaf Image is Alpinia Galanga
(Rasna) (Database-1) ');
end
if out==2
        msgbox('The recognized Leaf Image is Amaranthus
Viridis (Arive-Dantu)(Database-2)');
end
if out==3
    msgbox('The recognized Leaf Image is Artocarpus
Heterophyllus (Jackfruit) (Database-3)');
end
if out==4
```

```
        msgbox('The recognized Leaf Image is Azadirachta
Indica (Neem) (Database-4)');
end
if out==5
    msgbox('The recognized Leaf Image is Basella Alba
(Basale)(Database-5)');
end
if out==6
        msgbox('The recognized Leaf Image is Brassica
Juncea (Indian Mustard)(Database-6)');
end
if out==7
    msgbox('The recognized Leaf Image is Carissa Carandas
(Karanda)(Database-7)');
end
if out==8
        msgbox('The recognized Leaf Image is Citrus Limon
(Lemon)(Database-8)');
end
if out==9
    msgbox('The recognized Leaf Image is Ficus Auriculata
(Roxburgh fig)(Database-9)');
end
if out==10
        msgbox('The recognized Leaf Image is Ficus
Religiosa (Peepal Tree)(Database-10)');
end
```

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A

Project report on

"IOT BASED CAR PARKING WITH EMPTY SLOT DETECTION SYSTEM"

Submitted in partial fulfilment of the Requirements for the award of the Degree of

BACHELOR OF TECHNOLOGY

In

ELECTRONICS & COMMUNICATION ENGINEERING

By

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ADITYA COLLEGE OF ENGINEERING

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CERTIFICATE

This is to Certify that the Main Project Report Entititled

IOT BASED CAR PARKING WITH EMPTY SLOT DETECTION SYSTEM

Being Submitted by

MUTHYALA KRISHNA SAILAJA	**17MH1A0479**
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In Partial Fulfilment of the requirements for the award of the Degree of the Bachelor of Technology in **ELECTRONICS & COMMUNICATION ENGINEERING**. It is Record of Bonafide work, Carried out by them under esteemed guidance and supervision of

Dr.R. RAMAN, M.Tech,PhD

Signature Of the Project Guide	**Signature Of the Head of the Department**
Dr. R. RAMAN, M.Tech,PhD	**Dr. G. RAMA KRISHNA, M.Tech, PhD**
Associate Professor	Associate Professor

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DECLARATION

We here By Declare that the discussion entitled "**IOT BASED CAR PARKING WITH EMPTY SLOT DETECTION SYSTEM**" being submitted by us towards the partial fulfilment of the degree of Bachelor of Technology in the Electronics & Communication Engineering is a Project work carried by us under the supervision of **Dr. R. Raman** and have not been submitted anywhere else.

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ABSTRACT

Vehicle parking place is one of the major problem in day to day life and it is indirectly leads to the traffic congestion. This paper presents the IOT based parking place detection using the mobile app. The user can able to check the nearest parking place availability and reserve the parking slot using mobile application. The mobile application will act as an interface between the end user and the system. Infrared sensor is placed at the parking slot along with the Arduino. Infrared sensor is used to detect whether the slot is occupied or empty and it is updated to the cloud using the Wifi based Internet Service. Arduino is used to track the number of vehicles parked in the parking area.

Internet of Things (IOT) is used to communicate with the devices. By using this devices could be controlled or monitored through the internet, IOT acts as a platform to store data from the remote locations. IOT consists of web enabled devices that collects the data from the surrounding environments using processors, sensors and other communication devices. The device could be monitored and tracked using computers connected through internet. There are different types of car parking system available to reduce the time and the traffic congestion.

With the latest proliferation of the vehicle availability finding the parking place availability is more difficult. Car parking is a main problem because of increasing in the vehicle number. Searching of a parking place around the cities is the routine work. In the smart parking system the parking space information is available at the real time. It consists of real time data collection, low cost sensors and mobile phone enabled systems

TABLE OF CONTENTS

1 INTRODUCTION

1.1 INTRODUCTION

A **car parking system** is a mechanical device that multiplies parking capacity inside a parking lot. Parking systems are generally powered by electric motors or hydraulic pumps that move vehicles into a storage position.There are two types of car parking systems: traditional and automated. In the long term, automated car parking systems are likely to be more cost effective when compared to traditional parking garages. Automatic multi-storey automated car park systems are less expensive per parking slot, since they tend to require less building volume and less ground area than a conventional facility with the same capacity. Both automated car parking systems and automated parking garage systems reduce pollution — cars are not running or circling around while drivers look for parking spaces.

Automated car parking systems use a similar type of technology to that used for mechanical parcel handling and document retrieval. The driver leaves the car inside an entrance area and technology parks the vehicle at a designated area. Hydraulic or mechanical car lifters raise the vehicle to another level for proper storing. The vehicle can be transported vertically (up or down) and horizontally (left and right) to a vacant parking space until the car is needed again. When the vehicle is needed, the process is reversed and the car lifts transport the vehicle back to the same area where the driver left it. In some cases, a turntable may be used to position the car so that the driver can conveniently drive away without the need to back up.

1.2 Internet of Things

The **Internet of things** (**IoT**) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as "the infrastructure of the information society." The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of themore general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the

existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020. Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a smart grid, and expanding to areas such as smart cities.

"Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, bio.chip transponders on farm animals, electric clams in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring or field operation devices that assist firefighters in search and rescue operations. Legal scholars suggest to look at "Things" as an "inextricable mixture of hardware, software, data and service".These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices. Current market examples include home automation (also known as smart home devices) such as the control and automation of lighting, heating (like smart thermostat), ventilation, air conditioning (HVAC) systems, and appliances such as washer/dryers, robotic vacuums, air purifiers, ovens or refrigerators/freezers that use Wi-Fi for remote monitoring.

As well as the expansion of Internet-connected automation into a plethora of new application areas, IoT is also expected to generate large amounts of data from diverse locations, with the consequent necessity for quick aggregation of the data, and an increase in the need to index, store, and process such data more effectively. IoT is one of the platforms of today's Smart City, and Smart Energy Management Systems.

2 LITERATURE SURVEY

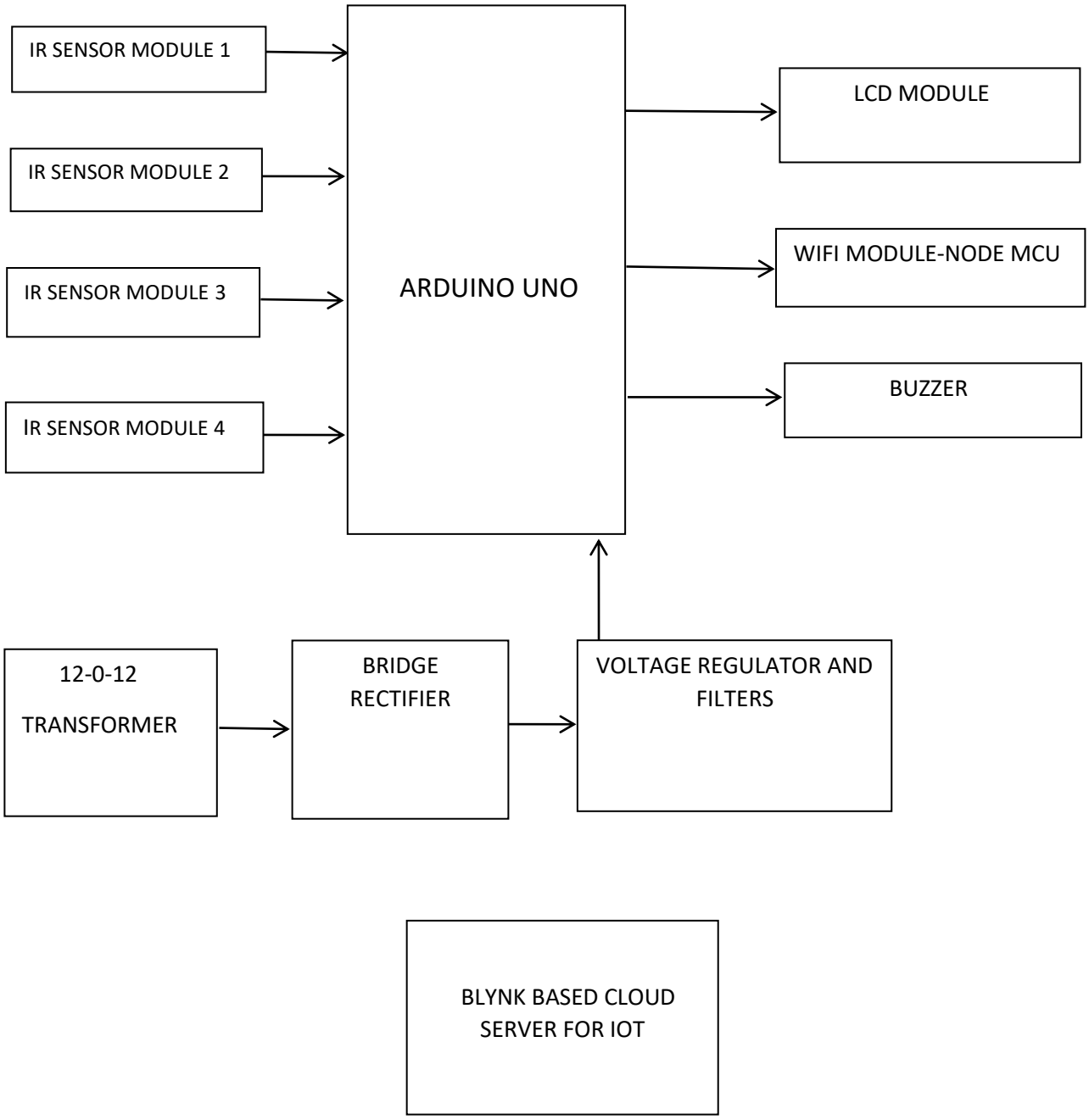
Various methods have been proposed for development of autonomous parking systems. Reference [1] is a smart parking system which allots users nearest parking slot. It considers only minimum driving distance as allocation criterion. Another proposed model based onIoT [2] uses Raspberry-pi and pi camera to continuously capture images of the parking slot to find empty ones. Another system [3] has been proposed by making use of Android application. In this system the car traces the path to the gate of the parking using the app. On the gate, the microcontrollers of the parking unit and the car communicate and availability of free parking slot is checked for. If a free slot is found, it is allocated and the car traces the path to the slot and gets parked. This system fails to find the best available parking slot for the car. In another paper that tells about RFID based parking [4], check-in and checkout is RFID based but it has no provision to automatically deduct parking charges. Also, user cannot choose a parking slot based on his preference. Another RFID based work [5] controls opening and closing of doors, and buzzer in case a person is drunk. Another work based RFID [6] takes care of permitting vehicles in the parking lot when any parking slot is available. Available parking slots are automatically incremented or reduced when a car leaves or enters. Both these models don’t consider automatic fee deduction or allocating best parking. In this paper [7], Automatic multilevel car parking, reduces time taken to find an empty slot using infa-red sensors. It again does not consider automatic fee-deduction.

3 PROPOSED WORK

The proposed smart parking system is implemented using mobile application and the system helps the user to know the parking space availability. System demonstrates a fully automated car parking system. For this purpose we use IR sensors along with motors, LCD display and microcontroller for controlling thesystem working. Our system consists of an LCD display that is used to demonstrate at a parking gate entrance display. Arduino UNO is connected with the IR sensor to find out the empty space in the Parking Lot.The LCD Module displays empty slots to new car arriving at gate of parking area. If slot is empty system, than guard allows car to enter the lot and displays empty slots where user can park. To detect vehicle slot occupancy the system uses IR sensors.
Wi-Fi Module is used as an interface between the Car Parking System Hardware and the Webpage. This Wi-Fi module is used to send the status of Parking Lot Empty Space to Blynk based cloud server over Internet. User can login to the Blynk account and can view the status of the Parking Lot. Further he can download the complete statics of the Parking Lot in Excel Sheet.

12-0-12 Transformer is used as a Primary source of this Notice Board. Bridge Rectifier is used to convert 12V AC to 12V Dc. Voltage Regulators & Filter Capacitors are used to produce regulated and constant DC Voltage.

3.1 BLOCK DIAGRAM



3.2 SOFTWARE REQUIREMENT

3.2.1 ARDUINO

Arduino is common term for a software company, project, and user community that designs and manufactures computer open-source hardware, open-source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices.[1]

The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can interface to various expansion boards (termed *shields*) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language named *Processing*, which also supports the languages C and C++.

The first Arduino was introduced in 2005, aiming to provide a low cost, easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio.

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages *Processing* and *Wiring*. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism to compile and load programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch".[21]

The Arduino IDE supports the languages C and C++ using special rules to organize code. The Arduino IDE supplies a software library called Wiring from the Wiring project, which provides many common input and output procedures. A typical Arduino C/C++ sketch consist of two functions that are compiled and linked with a program stub *main()* into an executable cyclic executive program:

- setup(): a function that runs once at the start of a program and that can initialize settings.
- loop(): a function called repeatedly until the board powers off.

After compiling and linking with the GNU toolchain, also included with the IDE distribution, the Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal coding that is loaded into the Arduino board by a loader program in the board's firmware.

3.2.2 BLYNK APPLICATION

Create a Blynk Project

Click the “Create New Project” in the app to create a new Blynk app. Give it any name.

Blynk works with hundreds of hardware models and connection types. Select the Hardware type. After this, select connection type. In this project we have select WiFi connectivity.

The ***Auth Token*** is very important – you’ll need to stick it into your ESP8266’s firmware. For now, copy it down or use the “E-mail” button to send it to yourself.

Widgets To The Project

Then you’ll be presented with a blank new project. To open the widget box, click in the project window to open.

We are selecting a button to control Led connected with NodeMCU.

1. Click on Button.
2. Give name to Button say led.
3. Under OUTPUT tab- Click pin and select the pin to which led is connected to NodeMCU, here it is digital pin 2, hence select digital and under pin D2. And Click continue.

Under MODE tab- Select whether you want this button as "push button" or "Switch".

You have successfully created a GUI for Arduino

Upload The Firmware

Now that your Blynk project is set-up, open Arduino and navigate to the ESP8266_Standalone example in the File > Examples > Blynk > Boards_WiFi> ESP8266_Standalone menu.

Execution

After the app has uploaded, open the serial monitor, setting the baud rate to 9600. Wait for the “Ready” message.

Then click the “Run” button in the top right corner of the Blynk app. Press the button and watch the LED

Then add more widgets to the project. They should immediately work on the ESP8266 without uploading any new firmware.

3.3 HARDWARE REQUIREMENTS

3.3.1 ARDUINO UNO - Details

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

Technical specs

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

3.3.2 ELECTROLYTE CAPACITOR

An electrolytic capacitor is a type of capacitor that uses an electrolyte to achieve a larger capacitance than other capacitor types. An electrolyte is a liquid or gel containing a high concentration of ions. Almost all electrolytic capacitors are polarized, which means that the voltage on the positive terminal must always be greater than the voltage on the negative terminal. The benefit of large capacitance in electrolytic capacitors comes with several drawbacks as well. Among these drawbacks are large leakage currents, value tolerances, equivalent series resistance and a limited lifetime. Electrolytic capacitors can be either wet-electrolyte or solid polymer. They are commonly made of tantalum or aluminum, although other materials may be used. Supercapacitors are a special subtype of electrolytic capacitors, also called double-layer electrolytic capacitors, with capacitances of hundreds and thousands of farads. This article will be based on aluminum electrolytic capacitors. These have a typical capacitance between 1µF to 47mF and an operating voltage of up to a few hundred volts DC. Aluminum electrolytic capacitors are found in many applications such as power supplies, computer motherboards and many domestic appliances. Since they are polarized, they may be used only in DC circuits.

Characteristics

Capacitance drift

The capacitance of electrolytic capacitors drifts from the nominal value as time passes, and they have large tolerances, typically 20%. This means that an aluminum electrolytic capacitor with a nominal capacitance of 47µF is expected to have a measured value of anywhere between 37.6µF and 56.4µF. Tantalum electrolytic capacitors can be made with tighter tolerances, but their maximum operating voltage is lower so they cannot be always used as a direct replacement.

Polarity and safety

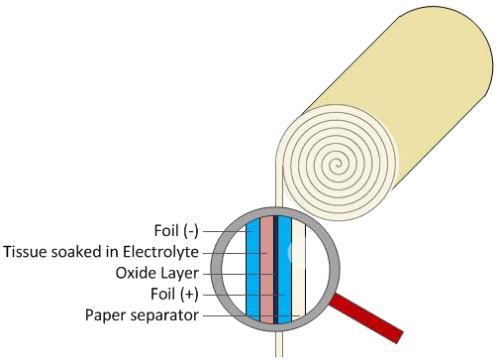
Due to the construction of electrolytic capacitors and the characteristics of the electrolyte used, electrolytic capacitors must be forward biased. This means that the positive terminal must always be at a higher voltage than the negative terminal. If the capacitor becomes reverse-biased (if the voltage polarity on the terminals is reversed), the insulating aluminum oxide, which acts as a dielectric, might get damaged and start acting as a short circuit between the two capacitor terminals. This can cause the capacitor to overheat due to the large current running through it. As the capacitor overheats, the

electrolyte heats up and leaks or even vaporizes, causing the enclosure to burst. This process happens at reverse voltages of about 1 volt and above. To maintain safety and prevent the enclosure from exploding due to high pressures generated under overheat conditions, a safety valve is installed in the enclosure. It is typically made by making a score in the upper face of the capacitor, which pops open in a controlled manner when the capacitor overheats. Since electrolytes may be toxic or corrosive, additional safety measures may need to be taken when cleaning after and replacing an overheated electrolytic capacitor.

There is a special type of electrolytic capacitors for AC use, which is designed to withstand reverse polarisation. This type is called the non-polarized or NP type.

Construction and properties of electrolytic capacitors

Aluminum electrolytic capacitors are made of two aluminum foils and a paper spacer soaked in electrolyte. One of the two aluminum foils is covered with an oxide layer, and that foil acts as the anode, while the uncoated one acts as a cathode. During normal operation, the anode must be at a positive voltage in relation to the cathode, which is why the cathode is most commonly marked with a minus sign along the body of the capacitor. The anode, electrolyte-soaked paper and cathode are stacked. The stack is rolled, placed into a cylindrical enclosure and connected to the circuit using pins. There are two common geometries: axial and radial. Axial capacitors have one pin on each end of the cylinder, while in the radial geometry, both pins are located on the same end of the cylinder.



Electrolytic capacitors have a larger capacitance than most other capacitor types, typically 1µF to 47mF. There is a special type of electrolytic capacitor, called a double-layer capacitor or a supercapacitor, whose capacitance can reach thousands of farads. The capacitance of an aluminum electrolytic capacitor is determined by several factors, such as the plate area and the thickness of the electrolyte. This means that a large capacitance capacitor is bulky and large in size.

It is worth mentioning that electrolytic capacitors made using old technology didn't have a very long shelf life, typically only a few months. If left unused, the oxide layer deteriorates and has to be rebuilt in a process called capacitor reforming. This can be performed by connecting the capacitor to a voltage source through a resistor and slowly increasing the voltage until the oxide layer has been fully rebuilt. Modern electrolytic capacitors have a shelf life of 2 years or more. If the capacitor is left unpolarized for longer periods, they must be reformed prior to use.

Applications for electrolytic capacitors

There are many applications which do not need tight tolerances and AC polarization, but require large capacitance values. They are commonly used as filtering devices in various power supplies to reduce the voltage ripple. When used in switching power supplies, they are often the critical component limiting the usable life of the power supply, so high quality capacitors are used in this application.

They may also be used in input and output smoothing as a low pass filter if the signal is a DC signal with a weak AC component. However, electrolytic capacitors do not work well with large amplitude and high frequency signals due to the power dissipated at the parasitic internal resistance called equivalent series resistance (ESR). In such applications, low-ESR capacitors must be used to reduce losses and avoid overheating.

A practical example is the use of electrolytic capacitors as filters in audio amplifiers whose main goal is to reduce mains hum. Mains hum is a 50Hz or 60Hz electrical noise induced from the mains supply which would be audible if amplified.

3.3.3 CRYSTAL OSCILLATOR

An electronic circuit or electronic device that is used to generate periodically oscillating electronic signal is called as an electronic oscillator. The electronic signal produced by an oscillator is typically a sine wave or square wave. An electronic oscillator converts the direct current signal into an alternating current signal. The radio and television transmitters are broadcasted using the signals generated by oscillators. The electronic beep sounds and video game sounds are generated by the oscillator signals. These oscillators generate signals using the principle of oscillation.

There are different types of oscillator electronic circuits such as Linear oscillators – Hartley oscillator, Phase-shift oscillator, Armstrong oscillator, Clapp oscillator, Colpitts oscillator, and so on, Relaxation oscillators – Royer oscillator, Ring oscillator, Multivibrator, and so on, and Voltage Controlled Oscillator (VCO). In this article, let us discuss in detail about Crystal oscillator like what is crystal oscillator, crystal oscillator circuit, working, and use of crystal oscillator in electronic circuits.

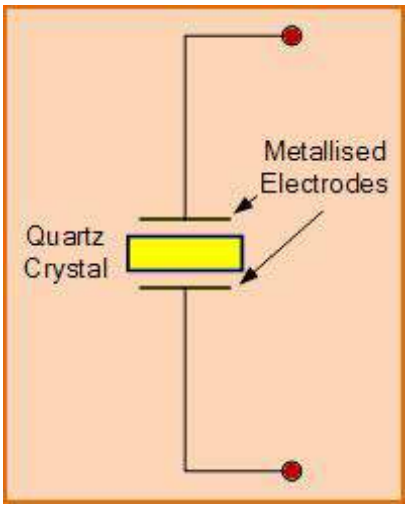
What is Crystal Oscillator?

Quartz Crystal Oscillator

An electronic circuit that is used to generate an electrical signal of precise frequency by utilizing the vibrating crystal's mechanical resonance made of piezoelectric material. There are different types of piezoelectric resonators, but typically, quartz crystal is used in these types of oscillators. Hence, these oscillator electronic circuits are named as crystal oscillators.

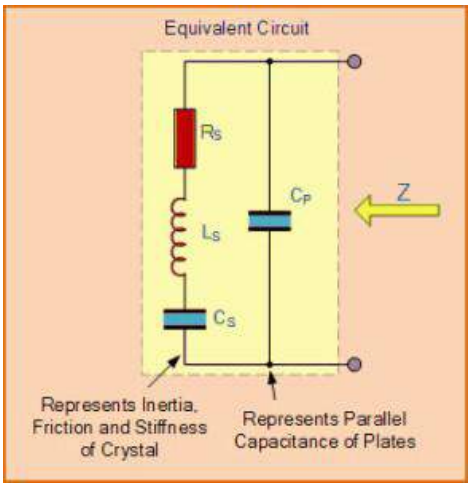
Crystal Oscillator Circuit Diagram

The quartz crystal oscillator circuit diagram can be represented as follows:



Electronic Symbol for Piezoelectric Crystal Resonator

The above diagram represents the electronic symbol for a piezoelectric crystal resonator which consists of two metalized electrodes and quartz crystal.



Equivalent Circuit Diagram of Quartz Crystal

The above figure shows the equivalent circuit diagram of quartz crystal in an electronic oscillator that consists of resistor, inductor, and capacitors which are connected as shown in the figure.

Use of Crystal Oscillator

In general, we know that, crystal oscillators are used in the microprocessors and microcontrollers for providing the clock signals. Let us consider AVR Microcontroller for which an external crystal oscillator circuit of 12MHz is essential, even though (based on model) AVR requires 12 clock cycles for one machine cycle, such . that to give effective cycle rate at 1MHz (considering 12MHz clock) to 3.33MHz (considering maximum 16MHz clock). This crystal oscillator is used to generate clock pulses required for the synchronization of all the internal operations.

There are numerous applications for crystal oscillator in various fields and a few crystal oscillator applications are shown below:

APPLICATIONS

Application of Crystal Oscillator in Military and Aerospace

The use of crystal oscillator in military and aerospace, is to establish an efficient communication system, for the navigation purpose, electronic warfare, in the guidance systems, and so on.

Use of Crystal Oscillator in Research and Measurement

The crystal oscillator is used in research and measurement for celestrial navigation, space tracking purpose, in the measuring instruments and medical devices, and so on.

Industrial Applications of Crystal Oscillator

There are a huge number of industrial applications of crystal oscillator such as in computers, digital systems, instrumentation, phase locked loop systems, marine, modems, sensors, telecommunications, disk drives, and so on.

Use of Crystal Oscillator in Automotive

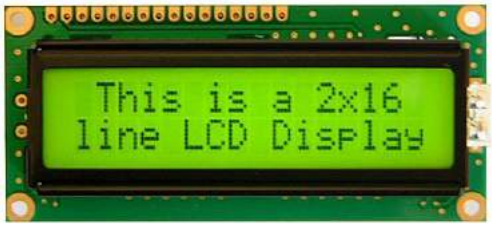
Crystal oscillator is used for engine controlling, stereo, clock and to trip computer, and in GPS system.

Consumer Applications of Crystal Oscillator

Crystal oscillators are used in many consumer goods such as cable television systems, personal computers, video cameras, toys and video games, radio systems, cellular phones, and so on.

3.3.4 LCD 2X16 MODULE

A **liquid-crystal display** (**LCD**) is a flat-panel display or other electronic visual display that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as DVD players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in nearly all applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they do not suffer image burn-in. LCDs are, however, susceptible to image persistence.



The LCD screen is more energy-efficient and can be disposed of more safely than a CRT. Its low electrical power consumption enables it to be used in battery-powered electronic equipment more efficiently than CRTs. It is an electronically modulated optical device made up of any number of segments controlling a layer of liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome.

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A **20x4 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

Pin Description:

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

VEE pin is meant for adjusting the contrast of the LCD display and the contrast can be adjusted by varying the voltage at this pin. This is done by connecting one end of a POT to the Vcc (5V), other end to the Ground and connecting the center terminal (wiper) of of the POT to the VEE pin.

The JHD162A has two built in registers namely data register and command register. Data register is for placing the data to be displayed , and the command register is to place the commands. The 16×2 LCD module has a set of commands each meant for doing a particular job with the display.

High logic at the RS pin will select the data register and Low logic at the RS pin will select the command register. If we make the RS pin high and the put a data in the 8 bit

data line (DB0 to DB7) , the LCD module will recognize it as a data to be displayed . If we make RS pin low and put a data on the data line, the module will recognize it as a command.

R/W pin is meant for selecting between read and write modes. High level at this pin enables read mode and low level at this pin enables write mode.

E pin is for enabling the module. A high to low transition at this pin will enable the module.

DB0 to DB7 are the data pins. The data to be displayed and the command instructions are placed on these pins.

LED+ is the anode of the back light LED and this pin must be connected to Vcc through a suitable series current limiting resistor. LED- is the cathode of the back light LED and this pin must be connected to ground.

16×2 LCD module commands.

16×2 LCD module has a set of preset command instructions. Each command will make the module to do a particular task. The commonly used commands and their function are given in the table below.

Command	Function
0F	LCD ON, Cursor ON, Cursor blinking ON
01	Clear screen
02	Return home
04	Decrement cursor
06	Increment cursor
0E	Display ON ,Cursor blinking OFF
80	Force cursor to the beginning of 1st line
C0	Force cursor to the beginning of 2nd line

38	Use 2 lines and 5×7 matrix
83	Cursor line 1 position 3
3C	Activate second line
08	Display OFF, Cursor OFF
C1	Jump to second line, position1
OC	Display ON, Cursor OFF
C1	Jump to second line, position1
C2	Jump to second line, position2

LCD initialization.

The steps that has to be done for initializing the LCD display is given below and these steps are common for almost all applications.

- Send 38H to the 8 bit data line for initialization
- Send 0FH for making LCD ON, cursor ON and cursor blinking ON.
- Send 06H for incrementing cursor position.
- Send 01H for clearing the display and return the cursor.

Sending data to the LCD.

The steps for sending data to the LCD module is given below. I have already said that the LCD module has pins namely RS, R/W and E. It is the logic state of these pins that make the module to determine whether a given data input is a command or data to be displayed.

- Make R/W low.
- Make RS=0 if data byte is a command and make RS=1 if the data byte is a data to be displayed.
- Place data byte on the data register.
- Pulse E from high to low.
- Repeat above steps for sending another data.

3.3.5 NON ELECTROLYTIC CAPACITOR

Non-Electrolytic capacitors are non-polarised, i.e they can be connected either way in a circuit without having to worry about + & -. The most common is the disc-type capacitor that we normally use in electronics. The other types are ceramic, mica etc. In almost all applications we use the disc-type capacitor which is brown in color and has the shape of a disc. Its value ranges between about a few pF to as high as 1uF. (You also get non-polarised capacitors of higher values and such capacitors have 'NP' written on them indicating Non Polarised)

The symbol for non-electrolytic capacitor is:

where the dark lines indicate the two plates, and the thin lines represent the two terminals.

Non-Electrolytic:

Some capacitors have their values printed in them. Unfortunately, there are various formats for printing the values and only a few can be discussed here:

1) If the printed value is like 101,102,103,204 etc then the value of the capacitor= (first 2 digits X 10 raised to the 3rd digit) pF.
For example if the value is 104 then capacitance = (10X 10e4) pF = 10e5 pF = 10e-7 F = 0.1uF
Remember a few of them: 104 = 0.1uF , 224=0.22uF , 103= 0.01uF, 102= 0.001uF

2) If the printed value is like 1K5, 100,220,10K etc,
Then capacitance = (printed value) pF
For example if the value is 10K then capacitance = 10K pF = 10X10e3 pF= 10e-8 F= 0.01uF
1K5 means 1.5K pF and so on.

ceramic capacitor

A **ceramic capacitor** is a non-polarized fixed capacitor made out of two or more alternating layers of ceramic and metal in which the ceramic material acts as the dielectric and the metal acts as the electrodes. The ceramic material is a mixture of finely

ground granules of paraelectric or ferroelectric materials, modified by mixed oxides that are necessary to achieve the capacitor's desired characteristics.

The electrical behavior of the ceramic material is divided into two stability classes:

- Class 1 ceramic capacitors with high stability and low losses compensating the influence of temperature in resonant circuit application. Common EIA/IEC code abbreviations are C0G/NP0, P2G/N150, R2G/N220, U2J/N750 etc.
- Class 2 ceramic capacitors with high volumetric efficiency for buffer, by-pass and coupling applications Common EIA/IEC code abbreviations are: X7R/2XI, Z5U/E26, Y5V/2F4, X7S/2C1, etc.

The great plasticity of ceramic raw material works well for many special applications and enables an enormous diversity of styles, shapes and great dimensional spread of ceramic capacitors. The smallest discrete capacitor, for instance, is a "01005" chip capacitor with the dimension of only 0.4 mm × 0.2 mm.

The construction of ceramic multilayer capacitors with mostly alternating layers results in single capacitors connected in parallel. This configuration increases capacitance and decreases all losses and parasitic inductances. Ceramic capacitors are well-suited for high frequencies and high current pulse loads.

Because the thickness of the ceramic dielectric layer can be easily controlled and produced by the desired application voltage, ceramic capacitors are available with rated voltages up to the 30 kV range.

Some ceramic capacitors of special shapes and styles are used as capacitors for special applications, including RFI/EMI suppression capacitors for connection to supply mains, also known as safety capacitors, X2Y® and three-terminal capacitors for bypassing and decoupling applications, feed-through capacitors for noise suppression by low-pass filters[and ceramic power capacitors for transmitters and HF applications.

Film capacitors

Film capacitors or plastic film capacitors are non-polarized capacitors with an insulating plastic film as the dielectric. The dielectric films are drawn to a thin layer, provided with metallic electrodes and wound into a cylindrical winding. The electrodes of film capacitors may be metallized aluminum or zinc, applied on one or both sides of the plastic film, resulting in metallized film capacitors or a separate metallic foil overlying the film, called film/foil capacitors.

Metallized film capacitors offer self-healing properties. Dielectric breakdowns or shorts between the electrodes do not destroy the component. The metallized construction makes

it possible to produce wound capacitors with larger capacitance values (up to 100 µF and larger) in smaller cases than within film/foil construction.

Film/foil capacitors or metal foil capacitors use two plastic films as the dielectric. Each film is covered with a thin metal foil, mostly aluminium, to form the electrodes. The advantage of this construction is the ease of connecting the metal foil electrodes, along with an excellent current pulse strength.

A key advantage of every film capacitor's internal construction is direct contact to the electrodes on both ends of the winding. This contact keeps all current paths very short. The design behaves like a large number of individual capacitors connected in parallel, thus reducing the internal ohmic losses (ESR) and ESL. The inherent geometry of film capacitor structure results in low ohmic losses and a low parasitic inductance, which makes them suitable for applications with high surge currents (snubbers) and for AC power applications, or for applications at higher frequencies.

The plastic films used as the dielectric for film capacitors are Polypropylene (PP), Polyester (PET), Polyphenylene sulfide (PPS), Polyethylene naphthalate (PEN), and Polytetrafluoroethylene or Teflon (PTFE). Polypropylene film material with a market share of something about 50% and Polyester film with something about 40% are the most used film materials. The rest of something about 10% will be used by all other materials including PPS and paper with roughly 3%, each.

3.3.6 RESISTOR

A **resistor** is a passivetwo-terminalelectrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. In electronic circuits, resistors are used to limit current flow, to adjust signal levels, bias active elements, and terminate transmission lines among other uses. High-power resistors, that can dissipate many watts of electrical power as heat, may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits.

Resistor units

The electrical resistance of a resistor is measured in **ohms**. The symbol for an ohm is the greek capital-omega: Ω. The (somewhat roundabout) definition of 1Ω is the resistance between two points where 1 volt (1V) of applied potential energy will push 1 ampere (1A) of current.

As SI units go, larger or smaller values of ohms can be matched with a prefix like kilo-, mega-, or giga-, to make large values easier to read. It's very common to see resistors in the kilohm (kΩ) and megaohm (MΩ) range (much less common to see miliohm (mΩ) resistors). For example, a 4,700Ω resistor is equivalent to a 4.7kΩ resistor, and a 5,600,000Ω resistor can be written as 5,600kΩ or (more commonly as) 5.6MΩ.

Types of Resistors

Resistors come in a variety of shapes and sizes. They might be through-hole or surface-mount. They might be a standard, static resistor, a pack of resistors, or a special variable resistor.

Termination and mounting

Resistors will come in one of two termination-types: through-hole or surface-mount. These types of resistors are usually abbreviated as either PTH (plated through-hole) or SMD/SMT (surface-mount technology or device).

Through-hole resistors come with long, pliable leads which can be stuck into a breadboard or hand-soldered into a prototyping board or printed circuit board (PCB). These resistors are usually more useful in breadboarding, prototyping, or in any case where you'd rather not solder tiny, little 0.6mm-long SMD resistors. The long leads usually require trimming, and these resistors are bound to take up much more space than their surface-mount counterparts.

The most common through-hole resistors come in an axial package. The size of an axial resistor is relative to its power rating. A common ½W resistor measures about 9.2mm across, while a smaller ¼W resistor is about 6.3mm long.

Surface-mount resistors are usually tiny black rectangles, terminated on either side with even smaller, shiny, silver, conductive edges. These resistors are intended to sit on top of PCBs, where they're soldered onto mating landing pads. Because these resistors are so small, they're usually set into place by a robot, and sent through an oven where solder melts and holds them in place.

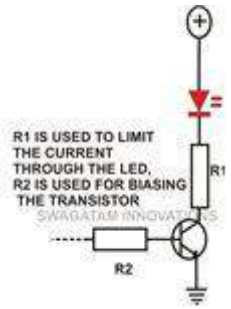
SMD resistors come in standardized sizes; usually either 0805 (0.8mm long by 0.5mm wide), 0603, or 0402. They're great for mass circuit-board-production, or in designs where space is a precious commodity. They take a steady, precise hand to manually solder, though!

Measurement

The value of a resistor can be measured with an ohmmeter, which may be one function of a multimeter. Usually, probes on the ends of test leads connect to the resistor. A simple ohmmeter may apply a voltage from a battery across the unknown resistor (with an internal resistor of a known value in series) producing a current which drives a meter movement. The current, in accordance with Ohm's law, is inversely proportional to the sum of the internal resistance and the resistor being tested, resulting in an analog meter scale which is very non-linear, calibrated from infinity to 0 ohms. A digital multimeter, using active electronics, may instead pass a specified current through the test resistance. The voltage generated across the test resistance in that case is linearly proportional to its resistance, which is measured and displayed. In either case the low-resistance ranges of

the meter pass much more current through the test leads than do high-resistance ranges, in order for the voltages present to be at reasonable levels (generally below 10 volts) but still measurable.

Applications of Resistors



In electronic circuits, resistors play an important role to limit the current and provide only the required biasing to the vital active parts like the transistors and the ICs. We will try to find out what is the function of a resistor in electronics through the following illustrations:

Transistor Biasing: Through one of my previous articles you must have acquired a good knowledge regarding transistors. A transistor basically needs a small base voltage (>0.6) to make a large voltage flow through its collector/ emitter terminals. But the base of a transistor is quite vulnerable to high currents, so a resistor is incorporated here to limit the current and provide a safe biasing voltage.
The value of the base resistor of a transistor may be calculated through the below given formula:

$R = (V – 0.6).Hfe / I,$

Here V = source voltage to the base resistor, I = the collector load current, Hfe = forward gain of a transistor (150 nominal) and 0.6 = minimum transistor biasing voltage.

LED Current Limit:

Just like transistors, LEDs too are very sensitive to high currents. A resistor when placed in series with the LEDs regulates a proper flow of current through them. To calculate the value of a series LED resistor, the following formula may be used:
$R = V –(N.V_{LED})/ I$

3.3.7 TRANSFORMER

A **transformer** is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. Electromagnetic induction produces an electromotive force across a conductor which is exposed to time varying magnetic fields. Commonly, transformers are used to increase or decrease the voltages of alternating current in electric power applications.

A varying current in the transformer's primary winding creates a varying magnetic flux in the transformer core and a varying magnetic field impinging on the transformer's secondary winding. This varying magnetic field at the secondary winding induces a varying electromotive force (EMF) or voltage in the secondary winding due to electromagnetic induction.

A Transformer takes in electricity at a higher voltage and lets it run through lots of coils wound around an iron core. ". A single-phase Transformer can operate to either increase or decrease the voltage applied to the primary winding. Because the current is alternating, the magnetism in the core is also alternating. Also around the core is an output wire with fewer coils. The magnetism changing back and forth makes a current in the wire. Having fewer coils means less voltage. When it is used to "decrease" the voltage on the secondary winding with respect to the primary it is called a **Step-down Transformer**. When a Transformer is used to "increase" the voltage on its secondary winding with respect to the primary, it is called a **Step-up Transformer**.

However, a third condition exists in which a transformer produces the same voltage on its secondary as is applied to its primary winding. In other words, its output is identical with respect to input. This type of Transformer is called an **"Impedance Transformer"** and is mainly used for impedance matching or the isolation of adjoining electrical circuits.

Types

Various specific electrical application designs require a variety of transformer types. Although they all share the basic characteristic transformer principles, they are customize in construction or electrical properties for certain installation requirements or circuit conditions.

- *Autotransformer*: Transformer in which part of the winding is common to both primary and secondary circuits.[88]
- *Capacitor voltage transformer*: Transformer in which capacitor divider is used to reduce high voltage before application to the primary winding.
- *Distribution transformer*, *power transformer*: International standards make a distinction in terms of distribution transformers being used to distribute energy from transmission lines and networks for local consumption and power transformers being used to transfer electric energy between the generator and distribution primary circuits.[88][89][q]
- *Phase angle regulating transformer*: A specialised transformer used to control the flow of real power on three-phase electricity transmission networks.

- *Scott-T transformer*: Transformer used for phase transformation from three-phase to two-phase and vice versa.[88]

Applications

Transformers are used to increase (or step-up) voltage before transmitting electrical energy over long distances through wires. Wires have resistance which loses energy through joule heating at a rate corresponding to square of the current. By transforming power to a higher voltage transformers enable economical transmission of power and distribution. Consequently, transformers have shaped the electricity supply industry, permitting generation to be located remotely from points of demand.[92] All but a tiny fraction of the world's electrical power has passed through a series of transformers by the time it reaches the consumer.[44]

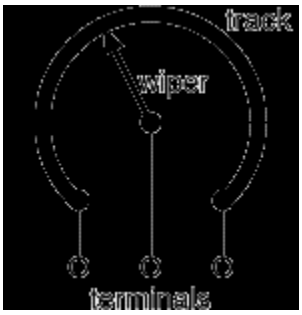
Transformers are also used extensively in electronic products to decrease (or step-down) the supply voltage to a level suitable for the low voltage circuits they contain. The transformer also electrically isolates the end user from contact with the supply voltage.

Signal and audio transformers are used to couple stages of amplifiers and to match devices such as microphones and record players to the input of amplifiers. Audio transformers allowed telephone circuits to carry on a two-way conversation over a single pair of wires. A balun transformer converts a signal that is referenced to ground to a signal that has balanced voltages to ground, such as between external cables and internal circuits.

VARIABLE RESISTOR

A variable resistor is a device that is used to change the resistance according to our needs in an electronic circuit. It can be used as a three terminal as well as a two terminal device. Mostly they are used as a three terminal device. Variable resistors are mostly used for device calibration.

As shown in the diagram below, a variable resistor consists of a track which provides the resistance path. Two terminals of the device are connected to both the ends of the track. The third terminal is connected to a wiper that decides the motion of the track. The motion of the wiper through the track helps in increasing and decreasing the resistance.



Variable Resistors

The track is usually made of a mixture of ceramic and metal or can be made of carbon as well. As a resistive material is needed, carbon film type variable resistors are mostly used. They find applications in radio receiver circuits, audio amplifier circuits and TV receivers. For applications of small resistances, the resistance track may just be a coil of wire. The track can be in both the rotary as well as straight versions. In a rotary track some of them may include a switch. The switch will have an operating shaft which can be easily moved in the axial direction with one of its ends moving from the body of variable resistor switch.

The rotary track resistor with has two applications. One is to change the resistance. The switch mechanism is used for the electric contact and non-contact by on/off operation of the switch. There are switch mechanism variable resistors with annular cross-section which are used for the control of equipments. Even more components are added onto this type of a variable resistor so as to make them compatible for complicated electronic circuits. A high-voltage variable resistor such as a focus pack is an example. This device is capable of producing a variable focus voltage as well as a screen voltage. It is also connected to a variable resistance circuit and also a fixed resistance circuit [bleeder resistor] to bring a change in the applied voltage. For this both the fixed and variable resistor are connected in series.

A track made in a straight path is called a slider. As the position of a slider cannot be seen or confirmed according to the adjustment of resistance, a stopping mechanism is usually included to prevent the hazards caused due to over rotation.

Variable Resistance Specification

Various parameters like size, type of track and also resistance is used to define a variable resistance. Usually the spindle diameter of a variable resistor is 6mm.
If the variable resistor has a straight track it is defined in the component by the short form

LIN representing a linear track. If it is a rotary track it is represented in short as LOG, as for a logarithmic track.

A common representation is given below.
5K6 LIN – 5.6 kilo ohm with a linear track.
2M LOG – 2 Mega ohm with a logarithmic track.

Application of Variable Resistors

There are mainly three types of variable resistors. They are

1. **Potentiometer**
2. **Rheostat**
3. **Presets**
4. Out of these **presets** are just smaller versions of a variable resistor. They can be easily placed on a PCB and can be adjustable when needed. The value of resistance is commonly adjusted with the help of a screw-driver. They are mostly used in applications like adjusting the frequency of an alarm tone or to adjust sensitivity of circuits. Since this device is the cheapest among all the three they are more commonly used amongst all of them. There are also highly precise presets which have multi turn options. In this type, the resistance will increase/decrease only slowly and hence the screw has to be rotated many times. Here also the basic slider and track mechanism is used. The track mechanism is always linear. Take a look at the preset symbol.
5. 
6. Preset Symbol

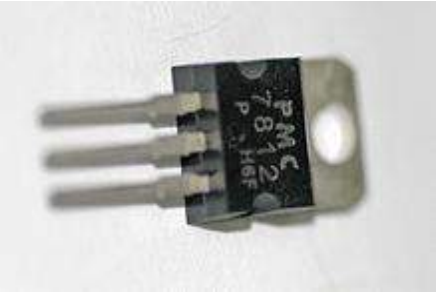
3.3.8 VOLTAGE REGULATORS

A **voltage regulator** is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedbackcontrol loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators

may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

The **78xx** (sometimes **L78xx**, **LM78xx**, **MC78xx**...) is a family of self-contained fixed linear voltage regulatorintegrated circuits. The 78xx family is commonly used in electronic circuits requiring a regulated power supply due to their ease-of-use and low cost. For ICs within the family, the *xx* is replaced with two digits, indicating the output voltage (for example, the 7805 has a 5-volt output, while the 7812 produces 12 volts). The 78xx line are positive voltage regulators: they produce a voltage that is positive relative to a common ground. There is a related line of **79xx** devices which are complementary negative voltage regulators. 78xx and 79xx ICs can be used in combination to provide positive and negative supply voltages in the same circuit.



78xx ICs have three terminals and are commonly found in the TO-220 form factor, although they are available in surface-mount, TO-92, and TO-3 packages. These devices support an input voltage anywhere from around 2.5 volts over the intended output voltage up to a maximum of 35 to 40 volts depending on the model, and typically provide 1 or 1.5 amperes of current (though smaller or larger packages may have a lower or higher current rating).

Advantages

- 78xx series ICs do not require additional components to provide a constant, regulated source of power, making them easy to use, as well as economical and efficient uses of space. Other voltage regulators may require additional components to set the output voltage level, or to assist in the regulation process. Some other designs (such as a switched-mode power supply) may need substantial engineering expertise to implement.
- 78xx series ICs have built-in protection against a circuit drawing too much current. They have protection against overheating and short-circuits, making them quite robust in most applications. In some cases, the current-limiting features of the 78xx devices can provide protection not only for the 78xx itself, but also for other parts of the circuit.

7805 is a **voltage regulator** integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The **voltage regulator IC** maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable

values can be connected at input and output pins depending upon the respective voltage levels.

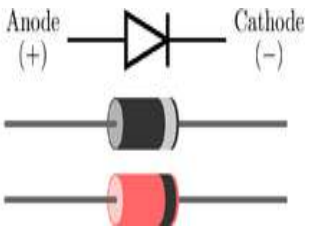
Pin Description:

Pin No	Function	Name
1	Input voltage (5V-18V)	Input
2	Ground (0V)	Ground
3	Regulated output; 5V (4.8V-5.2V)	Output

3.3.9 DIODE

A diode is an electronic component with two electrodes (connectors). It allows electricity to go through it only in one direction.

Diodes can be used to convert alternating current to direct current (Diode bridge). They are often used in power supplies and sometimes to decode amplitude modulation radio signals (like in a crystal radio). Light-emitting diodes (LEDs) are a type of diode that produce light.



Today, the most common diodes are made from semiconductor materials such as silicon or sometimes germanium.

Construction

Semiconductor diodes are made of two types of semiconductors connected to each other. One type has atoms with extra electrons (called the n-side). The other type has atoms that want electrons (called the p-side). Because of this, the electricity will flow easily from the side with too many electrons to the side with too few. However, electricity will not flow easily in the reverse direction. Silicon with arsenic dissolved in it makes a good n-side semiconductor, while silicon with aluminum dissolved in it makes a good p-side semiconductor, but other materials can also work.

The connector to the n-side is called the cathode, the connector to the p-side is called the anode.

Function of a diode

Positive voltage at p-side

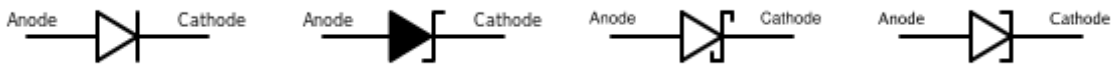
If you give positive voltage to the p-side and negative voltage to the n-side, the electrons in the n-side will want to go to the positive voltage at the p-side and the holes of the p-side will want to go to the negative voltage at the n-side. Because of this, current flow is able to exist, but it takes a certain amount of voltage to get this started (very small amount of voltage is not enough to get the electric current to flow). This is called the cut-in voltage. The cut-in voltage of a silicon diode is at about 0.7 V. A germanium diode needs a cut-in voltage at about 0.3 V.

Negative voltage at p-side

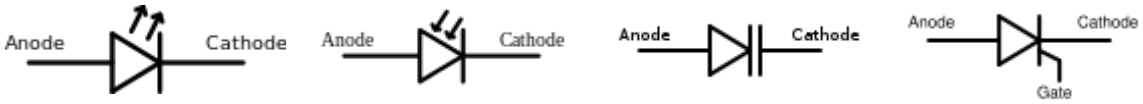
If you instead give negative voltage to the p-side and positive voltage to the n-side, the electrons of the n-side want to go to the positive voltage source instead of the other side of the diode. Same thing happens on the p-side. So, current will not flow between the two sides of the diode. Increasing the voltage will eventually force electric current to flow (this is the break-down voltage). Many diodes will be destroyed by a reverse flow but some are made that can survive it.

Types of diodes

Here are some common semiconductor diode symbols used in schematic diagrams:



Diode Zener Diode Schottky diode Tunnel diode



Light-emitting diode Photodiode Varicap Silicon controlled rectifier

Functions of Diodes

The most common function of a diode is to allow an electric current to pass in one direction (called the diode's *forward* direction), while blocking current in the opposite direction (the *reverse* direction). Thus, the diode can be viewed as an electronic version

of a check valve. This unidirectional behavior is called rectification, and is used to convert alternating current to direct current, including extraction of modulation from radio signals in radio receivers—these diodes are forms of rectifiers.

However, diodes can have more complicated behavior than this simple on–off action, due to their nonlinear current-voltage characteristics. Semiconductor diodes begin conducting electricity only if a certain threshold voltage or cut-in voltage is present in the forward direction (a state in which the diode is said to be *forward-biased*). The voltage drop across a forward-biased diode varies only a little with the current, and is a function of temperature; this effect can be used as a temperature sensor or as a voltage reference.

A semiconductor diode's current–voltage characteristic can be tailored by selecting the semiconductor materials and the doping impurities introduced into the materials during manufacture. These techniques are used to create special-purpose diodes that perform many different functions. For example, diodes are used to regulate voltage (Zener diodes), to protect circuits from high voltage surges (avalanche diodes), to electronically tune radio and TV receivers (varactor diodes), to generate radio-frequencyoscillations (tunnel diodes, Gunn diodes, IMPATT diodes), and to produce light (light-emitting diodes). Tunnel, Gunn and IMPATT diodes exhibit negative resistance, which is useful in microwave and switching circuits.

Applications of Diodes

- Radio demodulation
- Power conversion
- Over-voltage protection
- Logic gates
- Temperature measurementS

3.3.10 NODE MCU

NodeMCU is an open source LUA based firmware developed for ESP8266 wifi chip. By exploring functionality with ESP8266 chip, NodeMCU firmware comes with ESP8266 Development board/kit i.e. NodeMCU Development board. Since NodeMCU is open source platform, their hardware design is open for edit/modify/build.

NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. The **ESP8266** is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer ESP8266 WiFi Module.

There is Version2 (V2) available for NodeMCU Dev Kit i.e. **NodeMCU Development Board v1.0 (Version2)**, which usually comes in black colored PCB.

NodeMCU Dev Kit has **Arduino like** Analog (i.e. A0) and Digital (D0-D8) pins on its board.

It supports serial communication protocols i.e. UART, SPI, I2C etc.

Using such serial protocols we can connect it with serial devices like I2C enabled LCD display, Magnetometer HMC5883, MPU-6050 Gyro meter + Accelerometer, RTC chips, GPS modules, touch screen displays, SD cards etc.

NodeMCU Development board is featured with wifi capability, analog pin, digital pins and serial communication protocols.

To get start with using NodeMCU for IoT applications first we need to know about how to write/download NodeMCU firmware in NodeMCU Development Boards. And before that where this NodeMCU firmware will get as per our requirement.

There is online NodeMCU custom builds available using which we can easily get our custom NodeMCU firmware as per our requirement.

Difference in using ESPlorer and Arduino IDE

Well, there is a programming language difference we can say while developing application for NodeMCU using ESPlorer IDE and Arduino IDE.

We need to code in C\C++ programming language if we are using Arduino IDE for developing NodeMCU applications and Lua language if we are using ESPlorer IDE.

Basically, NodeMCU is Lua Interpreter, so it can understand Lua script easily. When we write Lua scripts for NodeMCU and send/upload it to NodeMCU, and then they will get executes sequentially. It will not build binary firmware file of code for NodeMCU to write. It will send Lua script as it is to NodeMCU to get executes.

In Arduino IDE when we write and compile code, ESP8266 tool chain in background creates binary firmware file of code we wrote. And when we upload it to NodeMCU then it will flash all NodeMCU firmware with newly generated binary firmware code. In fact, it writes the complete firmware.

That's the reason why NodeMCU not accept further Lua scripts/code after it is getting flashed by Arduino IDE. After getting flashed by Arduino sketch/code it will be no more Lua interpreter and we got error if we try to upload Lua scripts. To again start with Lua script, we need to flash it with NodeMCU firmware.

Since Arduino IDE compiles and upload/writes complete firmware, it takes more time than ESPlorer IDE.

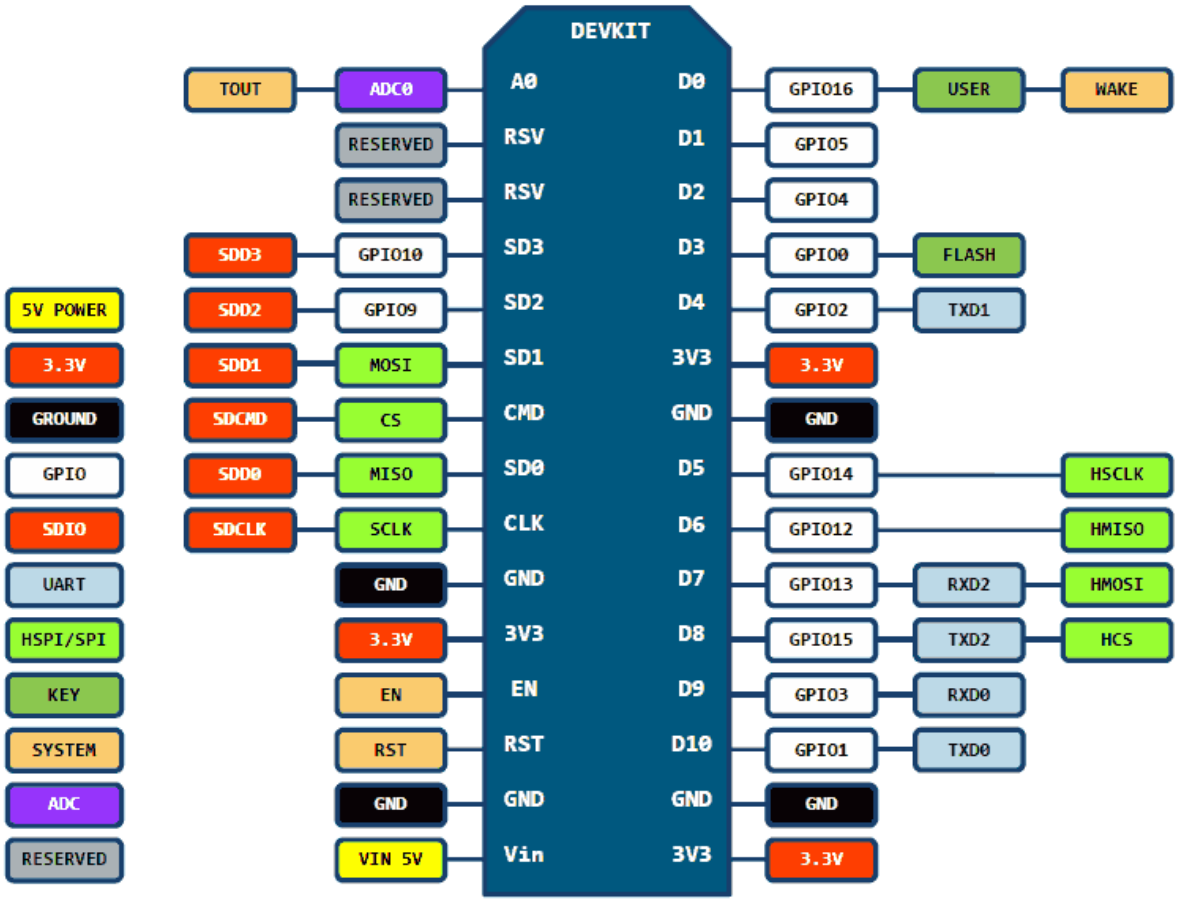
Development Board

NodeMCU Development Kit/Board consist of ESP8266 wifi chip. ESP8266 chip has GPIO pins, serial communication protocol, etc. features on it.

ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer ESP8266 WiFi Module.

The features of ESP8266 are extracted on NodeMCU Development board. NodeMCU (LUAbased firmware) with Development board/kit that consist of ESP8266 (wifi enabled chip) chip combines NodeMCU Development board which make it stand-alone device in IoT applications.

PIN DEFINITION



D0(GPIO16) can only be used as gpio read/write, no interrupt supported, no pwm/i2c/ow supported.

NodeMCU Dev Kit v1.0 pin descriptions

GPIO (General Purpose Input Output) Pins:

NodeMCU has general purpose input output pins on its board as shown in above pinout diagram. We can make it digital high/low and control things like LED or switch on it. Also, we can generate PWM signal on these GPIO pins.

ADC (Analog to Digital Converter) channel (A0):

NodeMCU has one ADC channel/pin on its board.

SPI (Serial Peripheral Interface) Pins:

NodeMCU based ESP8266 has Hardware SPI (HSPI) with four pins available for SPI communication. It also has SPI pins for Quad-SPI communication. With this SPI interface, we can connect any SPI enabled device with NodeMCU and make communication possible with it.

I2C (Inter-Integrated Circuit) Pins:

NodeMCU has I2C functionality support on ESP8266 GPIO pins. Due to internal functionality on ESP-12E we cannot use all its GPIOs for I2C functionality. So, do tests before using any GPIO for I2C applications.

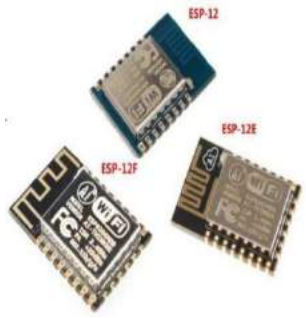
UART (Universal Asynchronous Receiver Transmitter) Pins:

NodeMCU based ESP8266 has two UART interfaces, UART0 and UART1. Since UART0 (RXD0 & TXD0) is used to upload firmware/codes to board, we can't use them in applications while uploading firmware/codes.

Difference in between 1st and 2nd version NodeMCU Board

We can make difference in 1st and 2nd version of NodeMCU Development board by their boards design and ESP modules on it.

- In 1st version of NodeMCU Dev Kit v0.9, CH341SER USB to Serial converter is used whereas in 2nd version of NodeMCU Dev Kit v1.0, CP2102 USB to Serial converter is used.
- 1st version uses ESP-12 and 2nd version uses ESP-12E (Enhanced version).
- Extra 6 pins (MTDO, MTDI, SD_3, MTMS, MTCK, SD_2) brought out on ESP-12E version of ESP-12 modules as shown in below figure. Though Quad SPI pins are brought out, they are internally used for flash memory access.Also, there slight antenna design difference in ESP-12 versions like ESP12-E & ESP-12F as.shown in fig below
-



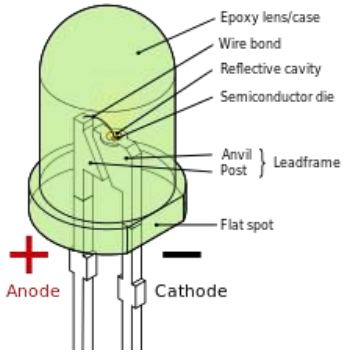
3.3.11 LED – Light Emitting diode

A **light-emitting diode** (**LED**) is a two-leadsemiconductorlight source. It is a p–n junctiondiode, which emits light when activated.[4] When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

An LED is often small in area (less than 1 mm^2) and integrated optical components may be used to shape its radiation pattern.[5]

Appearing as practical electronic components in 1962,[6] the earliest LEDs emitted low-intensity infrared light. Infrared LEDs are still frequently used as transmitting elements in remote-control circuits, such as those in remote controls for a wide variety of consumer electronics. The first visible-light LEDs were also of low intensity, and limited to red. Modern LEDs are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness.

Early LEDs were often used as indicator lamps for electronic devices, replacing small incandescent bulbs. They were soon packaged into numeric readouts in the form of seven-segment displays, and were commonly seen in digital clocks.



developments in LEDs permit them to be used in environmental and task lighting. LEDs have many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. Light-emitting diodes are now used in applications as diverse as aviation lighting, automotive headlamps, advertising, general lighting, traffic signals, camera flashes and lighted wallpaper. As of 2015, LEDs powerful enough for room lighting remain somewhat more expensive, and require more precise current and heat management, than compact fluorescent lamp sources of comparable output.

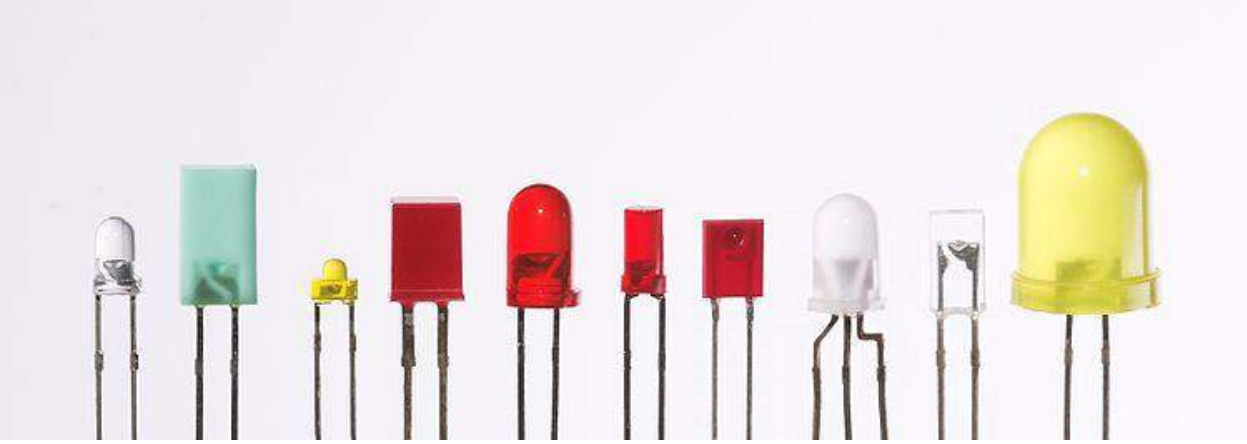
Working principle

A P-N junction can convert absorbed light energy into a proportional electric current. The same process is reversed here (i.e. the P-N junction emits light when electrical energy is

applied to it). This phenomenon is generally called electroluminescence, which can be defined as the emission of light from a semi-conductor under the influence of an electric field. The charge carriers recombine in a forward-biased P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes will be lesser than the energy levels of the electrons. Some portion of the energy must be dissipated in order to recombine the electrons and the holes. This energy is emitted in the form of heat and light.

The electrons dissipate energy in the form of heat for silicon and germanium diodes but in gallium arsenide phosphide (GaAsP) and gallium phosphide (GaP) semiconductors, the electrons dissipate energy by emitting photons. If the semiconductor is translucent, the junction becomes the source of light as it is emitted, thus becoming a light-emitting diode, but when the junction is reverse biased no light will be produced by the LED and, on the contrary, the device may also be damaged.

Types



The main types of LEDs are miniature, high-power devices and custom designs such as alphanumeric or multi-color

Miniture

These are mostly single-die LEDs used as indicators, and they come in various sizes from 2 mm to 8 mm, through-hole and surface mount packages. They usually do not use a separate heat sink. Typical current ratings range from around 1 mA to above 20 mA. The

small size sets a natural upper boundary on power consumption due to heat caused by the high current density and need for a heat sink.

Common package shapes include round, with a domed or flat top, rectangular with a flat top (as used in bar-graph displays), and triangular or square with a flat top. The encapsulation may also be clear or tinted to improve contrast and viewing angle.

Researchers at the University of Washington have invented the thinnest LED. It is made of two-dimensional (2-D) flexible materials. It is three atoms thick, which is 10 to 20 times thinner than three-dimensional (3-D) LEDs and is also 10,000 times smaller than the thickness of a human hair. These 2-D LEDs are going to make it possible to create smaller, more energy-efficient lighting, optical communication and nano lasers.[118]

There are three main categories of miniature single die LEDs:

Low-current

Typically rated for 2 mA at around 2 V (approximately 4 mW consumption)

Standard

20 mA LEDs (ranging from approximately 40 mW to 90 mW) at around:

- 1.9 to 2.1 V for red, orange, yellow, and traditional green
- 3.0 to 3.4 V for pure green and blue
- 2.9 to 4.2 V for violet, pink, purple and white

Ultra-high-output

20 mA at approximately 2 or 4–5 V, designed for viewing in direct sunlight

5 V and 12 V LEDs are ordinary miniature LEDs that incorporate a suitable seriesresistor for direct connection to a 5 V or 12 V supply.

Applications of LED

LED uses fall into four major categories:

- Indicators and signs
- Lighting
- Data communication and other signaling
- Sustainable lighting
- Energy consumption

3.3.12 SWITCH

A **Switch** is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another.[1][2] The most common type of switch is an electromechanical device consisting of one or more sets of movable electrical contacts connected to external circuits. When a pair of contacts is touching current can pass between them, while when the contacts are separated no current can flow.

Switches are made in many different configurations; they may have multiple sets of contacts controlled by the same knob or actuator, and the contacts may operate simultaneously, sequentially, or alternately. A switch may be operated manually, for example, a light switch or a keyboard button, or may function as a sensing element to sense the position of a machine part, liquid level, pressure, or temperature, such as a thermostat. Many specialized forms exist, such as the toggle switch, rotary switch, mercury switch, pushbutton switch, reversing switch, relay, and circuit breaker. A common use is control of lighting, where multiple switches may be wired into one circuit to allow convenient control of light fixtures. Switches in high-powered circuits must have special construction to prevent destructive arcing when they are opened.

A **push button** is a momentary or non-latching switch which causes a temporary change in the state of an electrical circuit only while the switch is physically actuated. An automatic mechanism (i.e. a spring) returns the switch to its default position immediately afterwards, restoring the initial circuit condition. There are two types:[1]

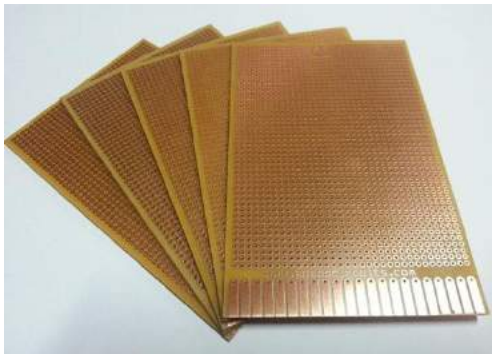
A **push to make** switch allows electricity to flow between its two contacts when held in. When the button is released, the circuit is broken. This type of switch is also known as a **Normally Open** (NO) Switch. (Examples: doorbell, computer case power switch, calculator buttons, individual keys on a keyboard)

- A **push to break** switch does the opposite, i.e. when the button is not pressed, electricity can flow, but when it is pressed the circuit is broken. This type of switch is also known as a **Normally Closed** (NC) Switch. (Examples: Fridge Light Switch, Alarm Switches in Fail-Safe circuits)

Many Push switches are designed to functions *both* **push tomake** *and* **push to break** switches. For these switches, the wiring of the switch determines whether the switch functions as a **push to make** or as a **push to break** switch.

3.3.13 PRINTED CIRCUIT BOARD (PCB)

A **printed circuit board** (**PCB**) mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it.



Printed circuit boards are used in all but the simplest electronic products. They are also used in some electrical products, such as passive switch boxes.

Alternatives to PCBs include wire wrap and point-to-point construction, both once popular but now rarely used. PCBs require additional design effort to lay out the circuit, but manufacturing and assembly can be automated. Electronic computer-aided design software is available to do much of the work of layout. Mass-producing circuits with PCBs is cheaper and faster than with other wiring methods, as components are mounted and wired in one operation. Large numbers of PCBs can be fabricated at the same time, and the layout only has to be done once. PCBs can also be made manually in small quantities, with reduced benefits.

PCBs can be single-sided (one copper layer), double-sided (two copper layers on both sides of one substrate layer), or multi-layer (outer and inner layers of copper, alternating with layers of substrate). Multi-layer PCBs allow for much higher component density, because circuit traces on the inner layers would otherwise take up surface space between components. The rise in popularity of multilayer PCBs with more than two, and

especially with more than four, copper planes was concurrent with the adoption of surface mount technology. However, multilayer PCBs make repair, analysis, and field modification of circuits much more difficult and usually impractical.

basic PCB consists of a flat sheet of insulating material and a layer of copper foil, laminated to the substrate. Chemical etching divides the copper into separate conducting lines called tracks or *circuit traces*, pads for connections, vias to pass connections between layers of copper, and features such as solid conductive areas for electromagnetic shielding or other purposes. The tracks function as wires fixed in place, and are insulated from each other by air and the board substrate material. The surface of a PCB may have a coating that protects the copper from corrosion and reduces the chances of solder shorts between traces or undesired electrical contact with stray bare wires. For its function in helping to prevent solder shorts, the coating is called solder resist or solder mask.

A printed circuit board can have multiple copper layers. A two-layer board has copper on both sides; multi layer boards sandwich additional copper layers between layers of insulating material. Conductors on different layers are connected with vias, which are copper-plated holes that function as electrical tunnels through the insulating substrate. Through-hole component leads sometimes also effectively function as vias. After two-layer PCBs, the next step up is usually four-layer. Often two layers are dedicated as power supply and ground planes, and the other two are used for signal wiring between components.

"Through hole" components are mounted by their wire leads passing through the board and soldered to traces on the other side. "Surface mount" components are attached by their leads to copper traces on the same side of the board. A board may use both methods for mounting components. PCBs with only through-hole mounted components are now uncommon. Surface mounting is used for transistors, diodes, IC chips, resistors and capacitors. Through-hole mounting may be used for some large components such as electrolytic capacitors and connectors.

3.3.14 IR SENSOR MODULE

Infrared technology addresses a wide variety of wireless applications. The main areas are sensing and remote controls. In the electromagnetic spectrum, the infrared portion is divided into three regions: near infrared region, mid infrared region and far infrared region.

The wavelengths of these regions and their applications are shown below.

- Near infrared region — 700 nm to 1400 nm — IR sensors, fiber optic
- Mid infrared region — 1400 nm to 3000 nm — Heat sensing
- Far infrared region — 3000 nm to 1 mm — Thermal imaging

The frequency range of infrared is higher than microwave and lesser than visible light.

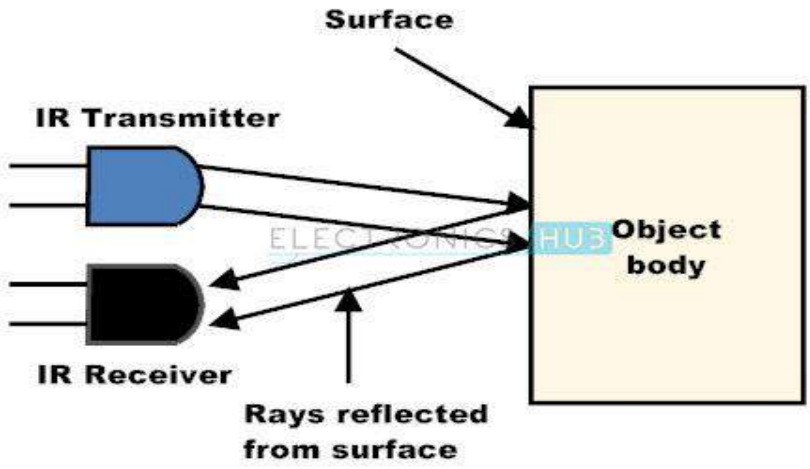
For optical sensing and optical communication, photo optics technologies are used in the near infrared region as the light is less complex than RF when implemented as a source of signal. Optical wireless communication is done with IR data transmission for short range applications. An infrared sensor emits and/or detects infrared radiation to sense its surroundings. Infrared sensors can be passive or active. Passive infrared sensors are basically Infrared detectors. Passive infrared sensors do not use any infrared source and detects energy emitted by obstacles in the field of view. They are of two types: quantum and thermal. Thermal infrared sensors use infrared energy as the source of heat and are independent of wavelength. Thermocouples, pyroelectric detectors and bolometers are the common types of thermal infrared detectors.

Quantum type infrared detectors offer higher detection performance and are faster than thermal type infrared detectors. The photosensitivity of quantum type detectors is wavelength dependent. Quantum type detectors are further classified into two types: intrinsic and extrinsic types. Intrinsic type quantum detectors are photoconductive cells and photovoltaic cells.

Active infrared sensors consist of two elements: infrared source and infrared detector. Infrared sources include an LED or infrared laser diode. Infrared detectors include photodiodes or phototransistors. The energy emitted by the infrared source is reflected by an object and falls on the infrared detector.

Principle of Working

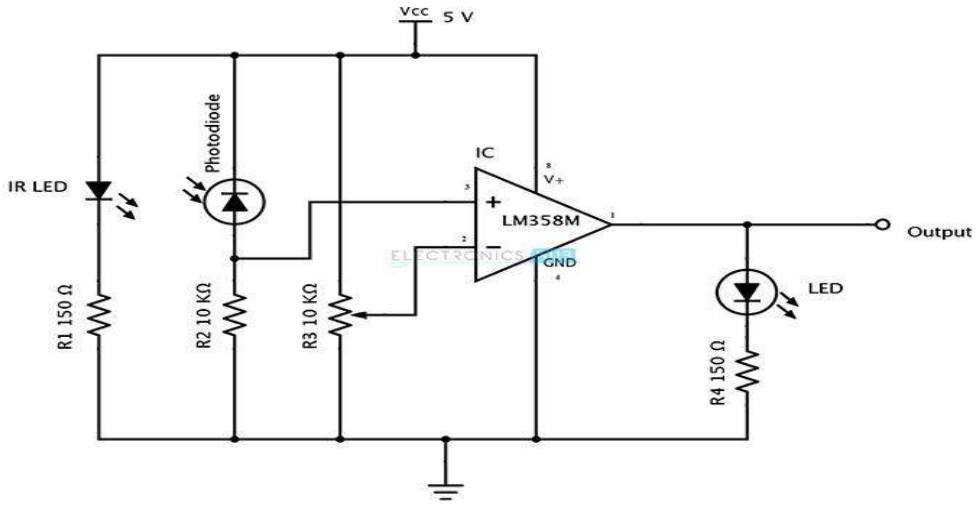
The principle of an IR sensor working as an Object Detection Sensor can be explained using the following figure. An IR sensor consists of an IR LED and an IR Photodiode; together they are called as Photo – Coupler or Opto – Coupler.



When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined.

IR SENSING CIRCUIT

A typical IR sensing circuit is shown below.



It consists of an IR LED, a photodiode, a potentiometer, an IC Operational amplifier and an LED.

IR LED emits infrared light. The Photodiode detects the infrared light. An IC Op – Amp is used as a voltage comparator. The potentiometer is used to calibrate the output of the sensor according to the requirement.

When the light emitted by the IR LED is incident on the photodiode after hitting an object, the resistance of the photodiode falls down from a huge value. One of the input of the op – amp is at threshold value set by the potentiometer. The other input to the op-amp is from the photodiode's series resistor. When the incident radiation is more on the photodiode, the voltage drop across the series resistor will be high. In the IC, both the threshold voltage and the voltage across the series resistor are compared. If the voltage across the resistor series to photodiode is greater than that of the threshold voltage, the output of the IC Op – Amp is high. As the output of the IC is connected to an LED, it lightens up. The threshold voltage can be adjusted by adjusting the potentiometer depending on the environmental conditions.

The positioning of the IR LED and the IR Receiver is an important factor. When the IR LED is held directly in front of the IR receiver, this setup is called Direct Incidence. In this case, almost the entire radiation from the IR LED will fall on the IR receiver. Hence there is a line of sight communication between the infrared transmitter and the receiver. If an object falls in this line, it obstructs the radiation from reaching the receiver either by reflecting the radiation or absorbing the radiation

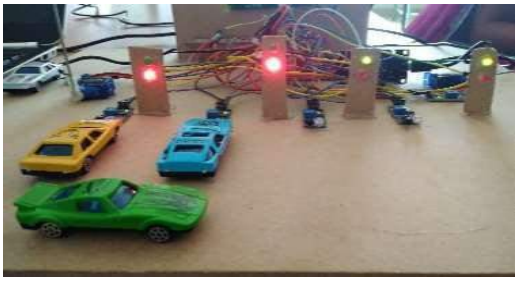
4 RESULT

When car enters the parking area IR sensor that is present before IN gate will detects the passing vehicle and the gate will be opened automatically.

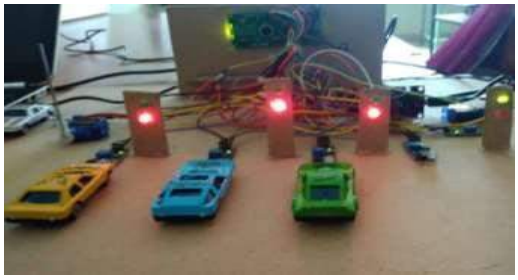
Before reaching to IN gate

After reaching to IN gate

The car will enter into the parking area at that time person doesn't know which slot is empty, for this there will be an indication of LED's for every slot when the Green light glows the slot is empty when the red light glows the slot was filled. By this the person easily know which slot is empty.

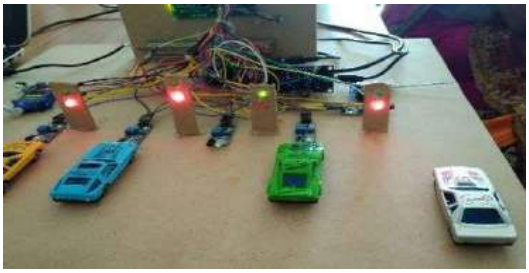


Before reaching to slot



After reaching to slot

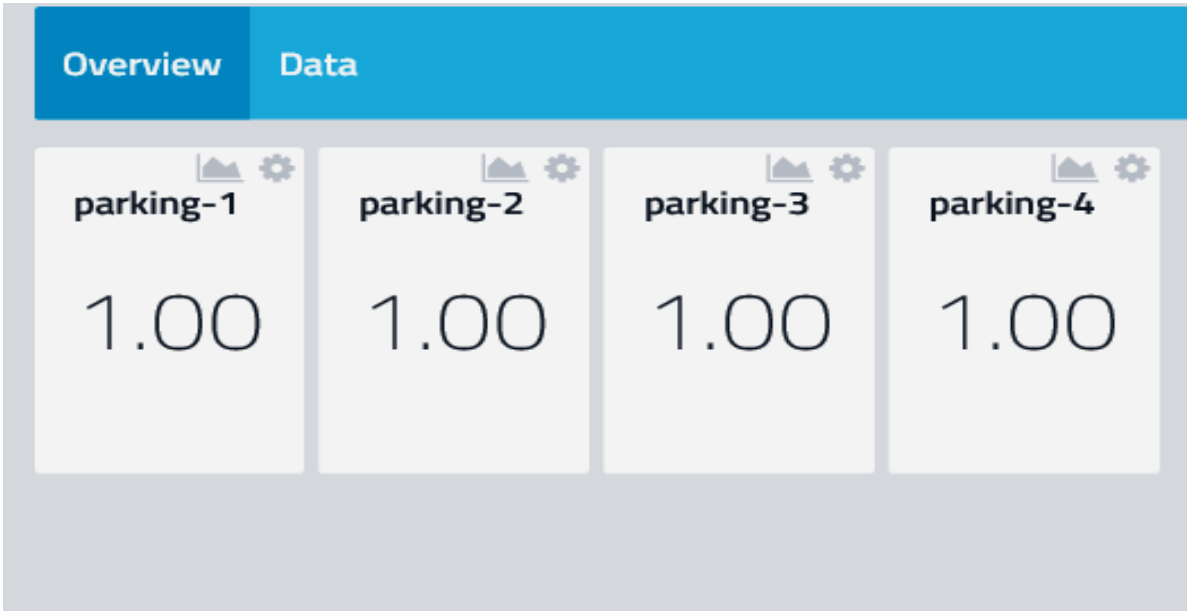
The operation of exit side will be same as that of the entrance. When the car is leaving the parking area, the IR sensor that is present before the OUT gate will detect the passing vehicle and the gate will be opened automatically.



In front of the parking area, there will be an LCD display that is used to show the status of the parking slots, whether the parking is available or not.

The main advantage of the current system is the user will register in application/website.

From this application/website also the user can see the status of parking area. In this application it will show the information of parking slots individually.



CONCLUSION

The concepts of smart cities have always been a dream. There have been advancements made from the past couple of years to make smart city dream to reality. The advancement of internet of things and cloud technologies has given rise to the new possibilities in terms of smart cities. Smart parking facilities have always been the core of constructing smart cities. The system provides a real time process and information of the parking slots. This paper enhances the performance of saving users time to locate an appropriate parking space. It helps to resolve the growing problem of traffic congestion. As for the future work the users can book a parking space from a remote location.GPS, reservation facilities and license plate scanner can be included in the future.

FUTURE SCOPE

A successful implementation of this project would result in less traffic and chaos in crowded parking spaces like malls and business buildings where many people share a parking area. The automated parking fee system would allow people to travel without cash. It provides drivers with Also, as it would reduce the waiting time, long queues, tension, stress and increase the efficiency of the parking system. As the Smart Car Parking System Requires minimal manpower, there are minimum chances for human errors, increased security in addition to a swift and friendly car parking experience for drivers

APPENDIX

```
#include <LiquidCrystal.h>


// initialize the library with the numbers of the interface pins

LiquidCrystal lcd(6, 7, 2, 3, 4, 5);


#include <SoftwareSerial.h>

#include <stdlib.h>

#define SSID        "carparking"

#define PASS        "12345678"


// LED

int ledPin = 13;

// LM35 analog input


unsigned int p1=0, p2=0, p3=0, temp=0, light=0;


String apiKey = "AEB0J2946L0MD1AH"; // API TO SEND DATA TO THINGSPEAK


// connect 10 to TX of Serial USB

// connect 11 to RX of serial USB
```

```
SoftwareSerial ser(10, 11); // RX, TX


void setup()
{
  // RELAY OUTPUT PIN DECLEARTION

  pinMode(A0,INPUT); // TEMP
  pinMode(A1,INPUT); // LDR
  pinMode(A2,INPUT); // P0
  pinMode(A3,INPUT); // P1
  pinMode(A4,INPUT); // P2

  // LCD 2X16 SETUP

  lcd.begin(16, 2);
  lcd.setCursor(0, 0);
  lcd.print("     PARKING    ");
  lcd.setCursor(0, 1);
  lcd.print("** Monitoring **");
  delay(2000);
  lcd.clear();
  lcd.setCursor(0, 0);
```

```
lcd.print("  ** Using **  ");

lcd.setCursor(0, 1);

lcd.print("   ** IOT **   ");

delay(2000);

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("Connecting ....");

lcd.setCursor(0, 1);

lcd.print("   ** WIFI **  ");

delay(1000);


// SERIAL COMMUNICATION BEGIN


Serial.begin(9600); // BEGIN SERIAL MONITOR WITH 9600 BAUDRATE


ser.begin(115200);


// WIFI CONNECTION SETUP


// reset ESP8266

ser.println("AT+RST");
```

```
 delay(3000);


 //connect to the wifi
 boolean connected = false;
 for (int i = 0; i < 5; i++)
 {
  if (connectWiFi())
  {
   connected = true;
   break;
  }
 }
 if (!connected) {
  while (1);
 }
 delay(1000);


}


void loop()
{
```

```
// READ VALUES OF SENSORS


p1=analogRead(A2);

p2=analogRead(A3);

p3=analogRead(A4);

light=analogRead(A1);

temp=analogRead(A0);

temp=temp/2;


// PRINT VALUES IN LCD


lcd.clear();

lcd.setCursor(0, 0);

lcd.print("P1");

lcd.setCursor(2, 0);

lcd.print(p1);

lcd.setCursor(7, 0);

lcd.print("P2");

lcd.setCursor(9, 0);

lcd.print(p2);

lcd.setCursor(0, 1);

lcd.print("P3");
```

```
lcd.setCursor(2, 1);
lcd.print(p3);
lcd.setCursor(7, 1);



delay(1000);



// TCP connection

String cmd = "AT+CIPSTART=\"TCP\",\"";
cmd += "184.106.153.149"; // api.thingspeak.com
cmd += "\",80";
ser.println(cmd);
delay(300);
if(ser.find("Error"))
{
  Serial.println("AT+CIPSTART error");
  return;
}

// prepare GET string
```

```
String getStr = "GET /update?api_key=";
getStr += apiKey;
getStr +="&field1="; // P1
getStr += String(p1);
getStr +="&field2="; // P2
getStr += String(p2);
getStr +="&field3="; // P3
getStr += String(p3);



// send data length
cmd = "AT+CIPSEND=";
cmd += String(getStr.length());
ser.println(cmd);
delay(1000);
if(ser.find(">"))
{
  ser.print(getStr);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("** DATA  SENT **");
```

```
  lcd.setCursor(0, 1);
  lcd.print("** TO  SERVER **");
  delay(1000);
 }
 else
 {
  ser.println("AT+CIPCLOSE");
  // alert user
  Serial.println("AT+CIPCLOSE");
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print(" DATA NOT SENT ");
  lcd.setCursor(0, 1);
  lcd.print("** TO  SERVER **");
  delay(1000);
 }

 // thingspeak needs 15 sec delay between updates
 delay(9000);
}

boolean connectWiFi()
```

```
{
 ser.println("AT+CWMODE=3");
 String cmd = "AT+CWJAP=\"";
 cmd += SSID;
 cmd += "\",\"";
 cmd += PASS;
 cmd += "\"";
 Serial.println(cmd);
 ser.println(cmd);
 delay(2000);
 if (ser.find("OK"))
 {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("      WIFI     ");
  lcd.setCursor(0, 1);
  lcd.print("   CONNECTED   ");
  delay(1000);
  Serial.println("OK, Connected to WiFi.");
  return true;
 }
 else
```

```
  {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("       WIFI     ");
    lcd.setCursor(0, 1);
    lcd.print("  NOT CONNECTED ");
    delay(1000);
    Serial.println("Can not connect to the WiFi.");
    return false;
  }
}
```

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