Design and Development of efficient algorithm for sensor based monitoring of medicinal plants.

REPORT SUBMITTED FOR PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF

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<u>CERTIFICATE</u>

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1. Introduction :

"Plant a tree, save a life"- a very common saying. Trees are as much important to our life as food and water. Life becomes very difficult without trees or we can say that life would be finished because trees are most important aspect of giving us healthy and wealthy life.
Agriculture is the process of producing food, feed, fiber and many other desired products by the cultivation of certain plants and the raising of domesticated animals (livestock).The study of agriculture is known as agricultural science. Agricultural productivity is the backbone of India's economy.
Among various plants or trees the variety referred to as medicinal plants include various plants which are considered as a rich resource of ingredients which can be used in drug development and synthesis. Mostly medicinal plants are not widely available due to unfulfilled growth conditions. There are various parameters which affects the growth and development of medicinal plants like –

1.1. Light:

Light is the only external source of energy for the continuation of life of the plant. It influences photosynthesis, opening and closing of stomata, plant movements, seed germination, flowering and vegetative growth like tuber formation. Dry sunny weather increases the proportion of glycosides in digitalis and of alkaloids in belladonna.

1.2. Temperature:

Temperature is the major factor influencing the cultivation of the medicinal plant. The sudden decrease in temperature caused the formation of the ice crystals in intercellular spaces of the plant. As a result, water comes out of the cells and ultimately plants die due to drought and desiccation. The ice crystals also mechanical injury to the cells temperature stimulates the growth of seedlings. Water absorption decreases at low temperatures. The rate of photosynthesis is affected by change in temperature. The rate of respiration increases with increase in temperature. Examples: Cinchona- 58-73°F; Tea- 75-90°F and coffee- 55-70°F.

1.3. Atmosphere humidity:

It is present in the form of water vapours. This is called atmospheric humidity. Clouds and fog are the visible forms of humidity. The major sources of water vapours in the atmosphere are evaporation of water from earth surface and transpiration from plants the major effect of humidity on plant life and climate. Evaporation of water, its condensation and precipitation depends upon relative humidity and humidity affects structure, form and transpiration in plants.

1.4. Altitude:

The altitude is the most important factor influencing of cultivation of medicinal plants. The increase the altitude, the temperature and atmospheric pressure decreases while the wind velocity, relative humidity and light intensity increases.

Thus, as the climatic conditions change with height, they also produce change in the vegetation pattern. The bitter constituents of Gentiana lutea increase with altitude, whereas the alkaloids of Aconitum nacelles and lobelia inflate and oil content of thyme and peppermint decrease. Pyrethrum gives the best yield and Pyrethrum at high altitude. Examples: Tea- 9500-1500 meters; cinnamon- 300-1000 meters and saffron- up to 1250 meters.

1.5. Rainfall:

The rainfalls are most important factor influencing of cultivation of medicinal plants. The main source of water for the soil is rain water. Rainfall and snowfall have a large effect the climate condition. The water from rainfall flows into the rivers and lakes percolates into the soil to form ground water and remaining is evaporated. The minerals in the soil get dissolved in water and are then absorbed by plants. Water influences morphological and physiology of plant. Examples: continuous rain can lead to a loss of water- soluble substance from leaves and root by leaching; this is known to apply to some plants producing glycoside and alkaloids.

1.6. Soil:

Soil is defined as surface layer of the earth, formed by weathering of rocks. The soil is formed as a result of combined action of climate factors like plants and microorganisms. The soil should contain appropriate amounts of nutrients, organic matter and other elements to ensure optimal medicinal plant growth and quality. Optimal soil conditions, including soil type, drainage, moisture retention, fertility and pH, will be dictated by the selected medicinal plant species and/or target medicinal plant part. Plants depend on soil for nutrients, water supply and anchorage. Soil influences seed germination, capacity of plant to remain erect, form, vigour and woodiness of the stem, depth of root system, number of flowers on a plant, drought, frost, etc.

From the above mentioned factors, our project focuses on two factors, namely, Temperature and Humidity for the study of growth and development of **Krishna** Tulsi(*Ocimum tenuiflorum*).

2. Problem Definition:

In Ayurveda,Tulsi is titled as the "Queen of all herbs" a most powerful and adaptive herb that can be applicable and morphable to almost any condition just like a queen does. There are about 50 to 150 species of Ocimum genus' herbs and shrubs that are found in the tropical regions of Asia. The scientific name of **Krishna** Tulsi is *Ocimum tenuiflorum.* Unlike most species of Tulsi, Krishna Tulsi is not widely available due to it's nature which does not allows easy spreading and germination of pollen grains with the help of air as it requires rich soil, proper sunlight and a temperate climate.
To address this problem, our project will have two sections –

a. Design and development of algorithm to acquire data, temperature and humidity using agro-sensor.
b. Design and development of algorithm for data prediction.

The predicted data would help in determining any mishap that might happen in the process of growth and development of Krishna Tulsi due to temperature and humidity changes and take precautions accordingly.

3. Literature Survey:

3.1. Introduction to WSN:

Self-configured and infrastructure less wireless networks that can be used to monitor environmental or physical conditions, such as temperature, vibration, sound, pressure, motion or pollutants and cooperatively pass the data through the network, from a source to a main location or sink where the data can be observed and analysed, is known as Wireless Sensor Networks (WSNs) . Here the sink or base station acts as an interface between the users and the network. As wireless sensor networks grows rapidly, so the need for effective security mechanisms also shows an upward curve. Wireless sensor networks are potentially low cost solutions to a variety of real-world challenges and hence they are gaining a higher popularity these days. The main aspects of Wireless Sensor Network Security can be classified into four major categories: the obstacles to sensor network security, the requirements of a secure wireless sensor network, attacks, and defensive measures. [1]
The three main components of a Wireless Sensor Network are Nodes, Gateways and Software. Up to Gateway the acquired data is transmitted wirelessly. The gateway provides a connection to the wired world where the data can be processed, analysed and measured using Software. A Wireless Sensor Network contains hundreds of thousands of sensors nodes. Radio Signals are used as communication medium among the sensor nodes. [2] Each node of WSN consists of sensing and computing devices, radio transceivers and power components and are inherently resource constrained that is they have limited processing speed, storage capacity, and communication bandwidth. These are actually low cost devices that specifically perform sensing tasks and are deployed densely to monitor some specific type of events.

3.1.1. Structure of a Wireless Sensor Network:

Structure of a Wireless Sensor Network includes different topologies for radio communications networks like Star network (single point-to-multipoint), Mesh network & Hybrid star. Four basic components are used to make typical sensor node. [3] They are sensing unit, processing unit, transceiver unit and a power unit which is shown in Fig. 2.

Its additional components include a location finding system, a power generator and a mobilizer which are application dependent in nature. The major subunit of a sensing unit is: sensors and analogue to digital converters (ADCs).The analogue signals produced by the sensors are converted to digital signals by the ADC, which are then fed into the processing unit. The processing unit is generally associated with a small storage unit. Processing unit manages the procedures and collaborates the sensor nodes with the other nodes to carry out the assigned sensing tasks. The node is connected to the network by a transceiver. One of the most important components of a sensor node is the power unit. Power units can be supported by solar cells. The other subunits, of the node are application dependent. A functional block diagram of a wireless sensing node is provided in Fig. 1.

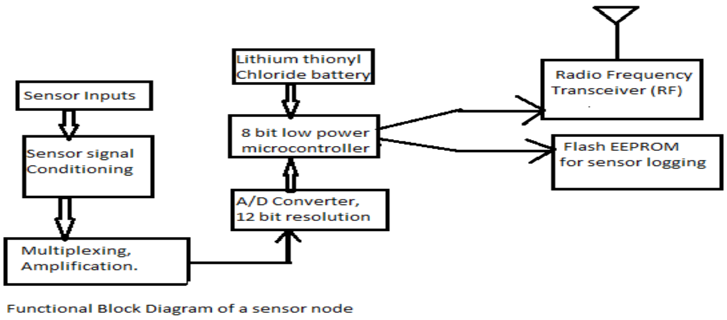


Fig. 1 : Functional Block Diagram of a Sensor Node.

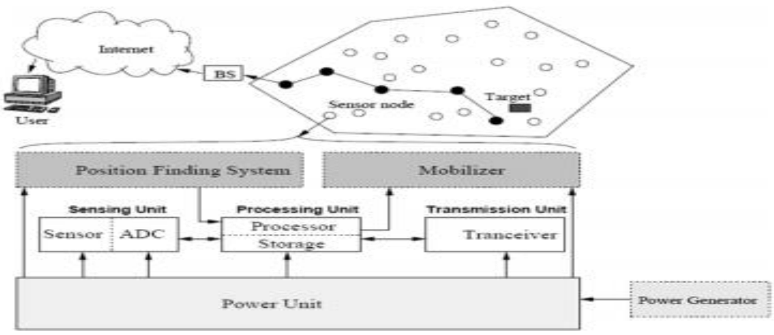


Fig. 2 : Basic Components of a Sensor node.

3.1.2. Communication process in WSN:

Communication is the most important part in a WSN. Every sensor node has the pre-defined task to sense its immediate environment and sends it to the gateway, if the gateway is directly in the range of the node otherwise it uses active multi-hoping algorithm to send the data to the gateway. [4]
While communicating with the gateway some points should always be kept in mind :

- Less replication of data should be in the gateway side.
- Communication algorithm should be highly power saving.
- Critical data must reach securely within its deadline.

3.1.3. Sensor Network Applications:

Sensor networks may consist of many different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic and radar, which are able to monitor a wide variety of ambient conditions that include the following:

- temperature,
- humidity,
- vehicular movement,
- lightning condition,
- pressure,
- soil makeup,
- noise levels,
- the presence or absence of certain kinds of objects,
- mechanical stress levels on attached objects, and
- the current characteristics such as speed, direction.

Sensor nodes can be used for continuous sensing, event detection, event ID, location sensing, and local control of actuators. The concept of micro-sensing and wireless connection of these nodes promises many new application areas. We categorize the applications into military, environment, health, home and other commercial areas. It is possible to expand this classification with more categories such as space exploration, chemical processing and disaster relief.

3.1.4. Major Obstacles of WSN Security:

Compared to a traditional computer network, a wireless sensor network has many constraints. Existing security approaches cannot be directly deployed to the area of wireless sensor networks. In order to develop useful security mechanisms by taking the ideas from current security techniques, we need to know and understand these constraints of deploying security by traditional method in WSN first. A certain amount of resources is required for the implementation, which includes data memory, energy to power the sensor and code space. For tiny wireless sensor, however, these resources are limited in current conditions.

Limited Memory and Storage:

A sensor contains a small amount of memory and storage space for the code. Hence code size of the security algorithm should be limited to make it an effective one. For example, one common sensor type (TelosB) has a 16-bit, 8 MHz RISC CPU with only 10K RAM, 48K program memory, and 1024K flash storage. Hence the software for the sensor must also be very small for such a limited space. The total code space of TinyOS, the de-facto standard operating system for wireless sensors, is approximately 4K, and the core scheduler occupies only 178 bytes, which indicates that the code size for the all security related code must also be very small being compatible with the storage space. [6]

Power Limitation Energy:

This is the biggest constraint to Wireless Sensor Network system. Once sensor nodes are deployed in a sensor network, they cannot be easily replaced or recharged .If they are to be replaced or recharged then high cost operating system or high cost sensors are to be deployed. Therefore, the charge of battery of the sensors taken to the field must be conserved. Hence the life of the individual sensor node and the entire sensor network is extended. The extra power consumed by sensor nodes due to security can be related to the processing required for encryption, decryption, signing data, verifying signatures, initialization vectors needed for encryption/decryption and cryptographic key storage.

Unreliable Communication:

This is another threat to sensor security. The security of the WSN runs on a defined protocol, which in turn depends on communication. Unreliable Transfer, Conflicts, Latency all are the parts of unreliable communication. Unreliable Wireless communication channel results in damaged packets whereas the communication may still be unreliable even if the channel is reliable. If packets meet in the middle of transfer, the transfer itself will fail and thereby conflict is produced. In a crowded sensor network, this is a major problem. The multi-hop routing, network congestion, and node processing leads to greater latency in the network. Synchronization among sensor nodes within that network has to be achieved with difficulty.

Unattended Operation:

If sensor nodes remain unattended for long periods of time, the three main threats which occur to them are Exposure to Physical Attacks, Managed Remotely and No Central Management Point. If a sensor is deployed in an environment open to bad weather the sensor suffers a physical attack in such an environment. Remote management of a sensor network makes it nearly impossible to detect physical maintenance issues (e.g., battery replacement). Hence the network organization turns difficult, inefficient, and fragile.

3.1.5. Security Requirements:

The hardware and energy constraints of the sensors add difficulty to the security requirements of ad hoc networks concerning availability, integrity, confidentiality, freshness, authentication, access control, and non-repudiation. [7]

Availability:
the availability gives insurance over the reactivity and time of response of the system to transmit information of one source to the good destination. It also means that the services of network are available to the authorized parts if necessary and ensures the services of network in spite of denies of service attack (DoS).

Integrity:
it is a service which guarantees that data are not be modified during the transmission. Integrity protects the network against the injection or the modification of messages.

Confidentiality:
is the guarantee that the information of a node is not available or revealed only with its recipient.

Freshness:
WSNs provide some measurements in time; we must ensure that each message is fresh. The freshness of data implies that the data are recent, and it ensures that no adversary replay the old messages.

Authentication:
For authentication the receiver makes sure that the data used have come from the correct, trusted source. Authentication is necessary for many other tasks in WSN also.

Access control:
This helps to detect the messages coming from external sources of the network.

Non-repudiation:
This ensures that the message has been originated and cannot deny having sent the message.

3.2. Agricultural Aspects:

Agriculture is the cultivation and breeding of animals, plants and fungi for food, fiber, bio-fuel, medicinal plants and other products used to sustain and enhance life. Agriculture was the key development in the rise of sedentary human civilization, whereby farming of domesticated species created food surpluses that nurtured the development of civilization. The study of agriculture is known as agricultural science. [8] Many aspects affect agriculture:

3.2.1. Climate :

Climate is one of the most important factor that influences agricultural practices. Based on the geographical location, climate varies and based on the climate, types of crops or plants that can be grown varies. In a broad sense, climate can be classified into:

a. **Tropical :**

An area can be classifies as tropical if it has an average temperature which is above 18 degrees Celsius (64 degrees Fahrenheit) and witnesses a considerable amount of rainfall during a specific part of the year. These areas are basically non-arid and are in conformity with general equatorial climatic conditions.

Crops grown in tropical climate areas are- Rice, sugar, bamboo, taro, coconut, pineapple etc.

b. **Temperate :**

An area can be classified as temperate if it lies between the tropics and the polar regions. These areas have relatively moderate temperatures i.e. neither too hot nor too cold and the change of weather from summer to winter or vice-versa is also moderate in nature. Crops grown in temperate climate areas are- Wheat, Corn, Oats, Barley, Rye, Millets etc.

3.2.2. Water Requirement :

Water is the most important component for plant survival and growth. The water requirement of crops is the amount of water that is required to meet the evapo-transpiration rate so that crops may thrive. The evapo-transpiration rate is the amount of water that is lost to the atmosphere through the leaves of the plant, as well as the soil surface.

Crops can be classified based on the requirement of water into –

a. **Hydrophytes** :

These plants are naturally adapted to grow in water or water logged soil. They may grow entirely or partly submerged, or floating on the water surface, or with their roots anchored to the ground in swamps or beside bodies of water.

Crops belonging to this category include – Gabi or taro, lowland rice, mangrove etc.

b. **Mesophytes** :

These are moist loving plants which are terrestrial in nature. These plants prefer moderate conditions. These conditions are describes as neither too dry nor too wet.

Crops belonging to this category include –

Corn , many fruit trees and vegetables.

c. Xerophytes :

These are plants growing in extremely dry regions. They are adapted to areas which have scant or no water and are extremely hot. Their natural habitats include arid and semi-arid regions.

Crops belonging to this category include – Cactus.

d. Halophytes :

These are salt loving plants. They are adapted to grow under saline conditions or in natural habitats which are rich in salt.

Crops belonging to this category include – Coconut, Cashew, Jackfruit etc.

3.2.3. Soil

Almost every one of us has faced a scenario in which we have planted a seed, watered it properly and allowed ample sunlight but the plant never survived. This is due to the simple fact i.e. incompatible soil type for that very species of plant. This discussion makes it pretty clear about the importance of soil. Soil type (texture) is defined by the percentage of clay, silt and sand it contains. These three ingredients form a 'loam'.Soil can be classified into –

a. **Clay Soil** :

The main composition of clay soil includes lots of tiny mineral particles which allows very less air space within the soil. This results in greater retention of water and are well compacted. It is sticky, heavy and easily moulded. These kind of soil are generally very fertile. [9]

Crops growing in this type of soil include – Rice, Lettuce, broccoli etc

b. **Silt Soil** :

The particles comprising of silt soil are slightly bigger that clay soil. As a result, they are having more air space and are less compacted. They are smooth in nature and drain more effectively.

Crops growing in this type of soil include – Shrubs, climbers, grasses, willow etc.

c. **Sandy Soil** :

The particles comprising of sandy soil are bigger and are very drainable due to the bigger air spaces within the soil. Their textures are light and gritty and are not moldable. They dry out very easily and have very poor fertility.

Crops growing in this type of soil include – Potatoes, raspberries, asparagus, rye etc.

d. **Peaty Soil** :

These kind of soil are dark brown or black in color, soft and are easily compressed due to its high water content. Although they tend to be heavily saturated with water , once drained , it turns out into a good growing medium. Peat contains acidic water, but growers use it to regulate soil chemistry or pH levels as well as an agent of disease control for the soil. Crops growing in this type of soil include –

Camellia, Rhododendron, Vegetable crops such as Brassicas, legumes, root crops etc. [10]

e. **Saline Soil** :

The soil in extremely dry regions is usually brackish because of its high salt content. Known as saline soil, it can cause damage to and stall plant growth, impede germination, and cause difficulties in irrigation. Crops growing in this type of soil include – Cotton, alfalfa, cereals, grain sorghum, sugar beets etc.

Table 1: District-wise soil fertility status in West Bengal [11]

District	Rice area (x 1000 ha)	Rice yield (t/ha)	Avail N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)
S. Paraganas	395.97	2.13	Low	M	Medium
Nadia	265.41	2.76	L	M	M
Burdwan	639.01	3.08	L	M	M
Hoogly	310.32	2.74	M	M	M
Howrah	125.55	2.28	M	M	M
Midnapur	654.03	2.49	M	M	M
Bankura	386.94	2.62	M	M	M
Purulia	266.98	1.98	M	M	M
Birbhum	368.55	3.03	M	M	M
Murshidabad	404.26	2.94	L	M	H
Malda	218.61	2.91	L	M	M
West Dinajpur	280.11	2.47	L	M	M
Darjeeling	34.52	1.70	L	M	M
Jalpaiguri	248.53	1.59	M	M	M
Cooch Bihar	280.49	1.95	M	M	M

3.2.4. Other aspects :

Biotic involvement in order to maintain certain nutrient content which in turn maintains the production level is one of the basic concept involved in pest management system. But not every pest is beneficial. And as a matter of fact agricultural crops face a great havoc due to pests and diseases. So, agriculturists are required to take care of any kind of unwanted pests and insects that might affect the normal growth and production of crops.

In a broad sense, pests can be classified as follows:

a. **Soil related pests** :

These kind of pests infect the soil which in turn infests the plants growing on it. As example: Springtails and fungus gnats.

b. Leaf and stem related pests :

These kind of pests mainly infect the leaves and the stem . for example,

- Aphids, mealybugs, mites, scales, whiteflies - sucking type
- Thrips - rasping type
- All feed on sap

3.3. West Bengal specific agriculture:

The Royal Commission on agriculture in India as early as 1928 recognised the value of Soil Resource Inventories for viable land use planning. Soil Survey Programmes were initiated from 1956 for implementing specific projects. Based on a low intensity, rapid reconnaissance survey, a soil map of **West Bengal** was prepared by the State Department of Agriculture. This was followed by the publication of soil maps at National Level showing soil units of higher categories, Great Groups/Sub Groups. Since these attempts were based on limited field surveys with 50 percent of delineations by extrapolations, these maps didn't prove very effective for the planning process as the mapping units were of higher categories(suborders) instead of lower categories, like soil families which are appropriate, f analogous transfer of agro-technology . The knowledge of oils in respect of their extent, distribution and characteristics as well as their potential are extremely important for optimising land use. Since we paid little attention to the wise use of these finite resource , these were subjected to the low and gradual processes of degradation. In this regard, it was unanimously decided in a National Workshop held at Nagpur in 1987, to take up Soil Resource Mapping of all states in India, on 1:250,000 scale delineating different soils, assessing their problem and potential for optimising land use at Regional level. The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) undertook this gigantic task in cooperation with the State Department of Agriculture for mapping soil resources of the state for generating soil data-base useful for optimising land use on sustainable basis.

The major objectives of the project were:

- Preparation of a soil resource map on 1:250,000 scale with soil families as the basic mapping units.
- Preparation of several kinds of thematic maps depending on the need of different land- user agencies.
- Identification of the nature and extent of different soils.
- Characterization and classification of different soils.
- Interpretation of different soil mapping units for determining their capability/ suitability classes for alternative land uses.
- Conducting research on established Benchmark soils for generating soil based agro-technology transfer.
- Creation of database for storage and retrieval of data as and when desired by any user agency.
- Monitoring health of soil resources for sustained agricultural productivity.

3.3.1. Climatic conditions:

The climate of West Bengal experiences hot and wet tropical monsoon climate. [12] The seasonal characteristics of various climate West Bengal is summarized below :

- **Dry Summer climate of West Bengal :**
  March to mid June is the hottest season. Day lengthen, heat increases, air pressures falls. The hot air on land rises to make room for the refreshing cool sea-breeze at dusk in South Bengal.Areas far away from the sea are hotter. The dry rocky surface of the western plateau fringe runs hottest around 40°C. After a hot oppressive afternoon, a Norwester of Kalbaishakhi appears, uprooting trees and blowing down huts. But the Norwester, rains and hails bring about cool evenings and are very useful for early paddy (aus) cultivation, summer -vegetables and jute. May is cooler than April due to more Norwesters. People from the plains flock to Darjeeling hills where, because of the height summer is as cool around 15° as winter in Kolkata.

- **Wet Summer Monsoon Climate of West Bengal :**
  The climates of West Bengal are influenced most by the gigantic wet monsoon air stream coming from the south and south-east. Mid-June to September is a rainy spell. To quench the thirst of dry summer, a gigantic air-stream with rain-bearing low black clouds arrives and bursts with a heavy downpour. Very often they are cyclonic with high wind speeds. The Bay cyclones are the most furious of all cyclones. In Bengal the wet monsoon current comes mainly from the south and south-east. For 3.5 months moderate to heavy rains occur, with sunny breaks and cyclonic bursts. Sometimes it continues for a week.The monsoon giant is very moody and irregular in its arrival and departure. If it in a bad mood, it gives too much water and causes floods or gives too little and causes a drought. If it is in a good mood, it gives just the sufficient amount of water in time Rain is most frequent and heavy on the southern slopes of the Himalayas. The Himalayas acts as barrier to the monsoon current and give birth to mighty rivers. The mean monsoon rainfall in the State is more than 175 cm.

- **The Autumn in West Bengal :**
  In October and November the dry monsoon current treats from land to sea. From 22nd September, days shorten and tropical Bengal cools; but over the southern seas, more sunlight makes more heat and pressure falls. The low pressure draws out the cool air under the high pressure over land. The autumn skies are blue with patches of silvery clouds. But for a few cyclonic storms coming from the Bay and dashing the coastal areas. Autumn brings fine weather everywhere.

- **The Winter climate of West Bengal :**
  Winter is from December to February in the plains and up to mid-March in Darjeeling Himalayas. The cold is mild over the plains (15°c-18°c) but bitter in nearly freezing points in Darjeeling. The winds are light and variable in the plains but strong in Darjeeling. Sometimes western disturbances coming from the Mediterranean make

light drizzles on the plains and sleet and snow on the mountains followed by a chilly cold wave from the north. This cold water, called pachhia, is as terrible as the summer hot wave, called ‘Loo’.

Fig. 3 : Agro-climatic zones of West Bengal.

3.3.2. Land features:

West Bengal can be broadly divided into three physiographic regions: [13]

• Eastern Himalayas (in the north).

• Eastern plateau or Chhotanagpur plateau (in west and south west), that is extended outliers of Peninsular mass.

• Alluvial and Deltaic plains (in the east and south).

The Eastern Himalayas include mountainous terrain of Darjeeling and northern fringe of Jalpaiguri districts, comprising foot-hills of Bhutan Himalayas. The inner terrain of Darjeeling Himalayas, extending to Sikkim and Nepal, include several lofty peaks of world attraction, such as Kanchenjunga, Nandaghunti, etc. The mean elevation of the Darjiling district is 2000 m above the mean sea level (MSL) and the inner terrain, including peaks, has an elevation of 4000 m or more above the MSL. The area is characterised by very rugged relief. Almost all the side slopes of the ridges are virtually vertically steep and break abruptly near foot slope encompassing the northern fringe of Jalpaiguri district (IaW) with elevation ranging between 100 and 66 m above MSL. The subdued foothills encompassing northern fringe of Jalpaiguri district end abruptly on level Tista Alluvial Plain (llu.aI.s.) forming southern part of the district. 2.2.2 Eastern or Chhotanagpur Plateau The Eastern Plateau comprising Peninsular mass, known as Chhotanagpur Plateau, is a Tertiary and Post-Tertiary peneplain surface. The eastward outliers extend aeros the north-western part of Barddra man, Medinipur, Bankura, Birbhum and whole of Purulia districts. The subdued spurs obliterate formation are 5 frequently observed in the western part of Bankura, part of Medinipur and Purulia districts. The outlier toward a t having laterite base are covered by old alluvium of Penin ular river , like Subarnarekha, Mayurakshi, Damodar and Ajay laid in early Pleistocene period (Pascoe, 1964) as observed in Bankura , Hugl i and Barddhaman district . 2.2.3 Alluvial and Deltaic Plains The extensive stretch of alluvial and deltaic plains in the east and south of the State are called as Bengal Basin. The Bengal Basin comprL es ea tward extension ofIndo-Gangetic alluvial plain. The alluvial plain comprises older and newer alluvium, although it is difficult to draw a distinct line of separation between the two. The river Ganga bifurcates into two main tributary viz. Padma and Bhagirathi, in the area between Rajmahal in Bihar and Murshidabad in West Bengal and start developing the Bengal Basin. The basin formation extends southward progressively by further branching off the tributaries into a number of sub-tributaries to meet Bay of Bengal. The Ganga river system with its tributaries and sub-tributaries meander severely leaving meandering scars (dead channel) in the flood plain and/or deltaic plain. The drainage pattern in general is dendritic while it is mostly subdendritie in northern part comprising the Ganga-Ti to alluvial plain. Thus, the Ganga Alluvial Plain can be broadly divided into two part , viz. Ganga-Tista or Ti t0 Alluvial Plain in north/northeast, known locally as D.u..ars and Ganga Deltaic Plain, known as Bengal Basin.

3.3.3. Farming Techniques:

Primitive subsistence farming :

Primitive subsistence agriculture is practiced with small patches of land with the help of primitive tools like hoe, Dao and digging sticks, and family/community labour. This type of farming depends upon monsoon, natural fertility of the soil and suitability of other environmental conditions to the crop grown. It is a mode of agriculture used since the beginning of the civilization. A patch of the forest is cut down and burnt to get a piece of agricultural land. The ashes of the burnt down trees provides manure for the crop. The farmer grows crops which is necessary for the daily use of their family. The family members help him in cultivation and the crops are not meant for sale. So in this type of agriculture food crops necessary for the family were only grown and many crops are grown in the same piece of land. When the fertility of the soil decreases farmer leaves the land and takes up another piece of land for cultivation. This allows nature to replenish itself and there is no need for farmer to use manures for the cultivation. It is known by different names in different parts of the country.

Intensive subsistence farming :

The main characteristics of the intensive subsistence agriculture are as follows:

(i) Very small holdings: Farms have been subdivided through many generations so they have become extremely small and often uneconomic to run. An average farm in Japan is approximately 0.6 hectare (about 1.5 acres) but in India and elsewhere in Asia farms may be even smaller. Individual peasants grow crops mainly to support their own families, though there is some surplus for sale in some areas. In China, however, rapid agricultural changes took place after the agrarian revolution of 1949 when the tiny farms were consolidated, under communist rule, into large collectives.

(ii) Farming is very intensive: In Monsoon Asia, the peasants are so ‘land hungry’ that every bit of tillable land is utilized for agriculture. The fields are separated only by narrow, handmade ridges and footpaths by which the farmers move around their farms. These are kept very narrow to save space. Additional land is made available for cultivation by draining swampy areas, irrigating drier areas and terracing hill slopes to produce flat areas that are suitable for paddy cultivation. Only the steepest hills and the most infertile areas, irrigating drier areas and terracing hill slopes to produce flat areas that are suitable for paddy cultivation. Only the steepest hills and the most infertile areas are left uncultivated. Farming is so intensive that double- or treble- cropping is practised , that is, several crops are grown on the same land during the course of a year. Where only one crop of paddy can be raised, the

fields are normally used in the dry season to raise other food or cash crops such as sugar, tobacco or oil-seeds.
(iii) Much hand labour is entailed: Traditionally, much hand labour is required in wet paddy cultivation. Ploughing is done with the aid of buffaloes, the fields are raked by hand, the paddy is planted painstakingly in precise rows by the women, harvesting is done with sickles and threshing is done by hand. Farm implements are often still very simple. The basic tools are simple ploughs, the cangkul , a kind of spade, and hoes. Nowadays machinery has been developed which is capable of working in the flooded fields and separate machines can plough, plant and harvest the paddy.
(iv) Use of animal and plant manures: To ensure high yields and continued fertility farmers make use of every available type of manure including farm wastes, rotten vegetables, clippings, fish wastes, guano, animal dung (especially those from the pig sties and poultry yards) and human excreta .Increasing amounts of artificial fertilizers are now being used in Japan, India and China, usually with government advice or assistance. The basic fertilizers applied include phosphates, nitrates and potash, which help to replenish vital plant nutrients in the soil.

Commercial farming :
Commercial agriculture is a large-scale production of crops for sale, intended for widespread distribution to wholesalers or retail outlets. In commercial farming crops such as wheat, maize, tea, coffee, sugarcane, cashew, rubber, banana, cotton are harvested and sold in the world markets. Commercial agriculture includes livestock production and livestock grazing. Due to the expensive nature of capital formation and implementation of technological processes, the landowners of such farms are often large agricultural corporations. Large-scale commercial farming, in terms of some of its processes, may be conceptually not very different from large industrial enterprises; United Fruit Company is an example. Commercial farming is most commonly found in advanced industrialized nations. The harvested crop may be processed on-site and then sold to a wholesaler as a complete product, or it may be sold as-is for further processing elsewhere. Commercial agriculture differs significantly from subsistence agriculture, as the main objective of commercial agriculture is achieving higher profits through economies of scale, specialization, introduction of capital-intensive farming techniques, labour-saving technologies, and maximization of crop yields per hectare through synthetic and natural resources.

3.4. A note on precision agriculture:

In modern agriculture, it is needed to modern technologies that will enable to increase the efficiency of production and quality of crops while protecting the environment. For this purpose, many parameters that vary with time and location, such as plant/soil characteristics and meteorological conditions, should be kept under control by monitoring them in real time and responding quickly to unexpected changes. To increase the effectiveness of control, the precision farming techniques are used instead of conventional methods. Precision agriculture is a management strategy that uses information technologies to take decisions associated with crop production.
In precision agriculture, one of the popular research topics is the irrigation scheduling and water quantity control for increasing water use efficiency. Seasonal water demand and peak daily use vary considerably from crop to crop and from one field to the next. Deciding when to irrigate and how much water to apply are the two most difficult decisions to make in managing irrigation systems. To measure the water content in the active root zone, the soil

moisture sensor is connected to the controller. The key factor is not to add a drop of water more than required and not a drop less than needed for adequate plant growth.
In agricultural fields, the establishment of the cabling infrastructure for energy and data transmission is often not possible. Therefore, when a central control system is to be formed to build a network that enables data transfer between the sensors and the actuators, the wireless communication becomes inevitable. Recent researches show that the wireless sensor networks (WSNs) are the most suitable technology for monitoring and agricultural fields. [14]

3.5. Role of WSN in agriculture:

The Wireless Sensors Network (WSN) is nowadays widely used to build decision support systems to solve many real-world problems. One of the most interesting fields having an increasing need of decision support systems is agricultural environment monitoring. Agricultural environment monitoring has become an important field of control and protection, providing real-time system and control communication with the physical world. An intelligent and smart WSN system can collect and process large amount of data from the beginning of the monitoring and manage air quality, soil conditions, to weather situations.
A typical WSN is a passive data acquisition system which consists of a large number of sensor nodes (SNs). WSNs can help the farmers to monitor soil parameters.
The next step in the evolution of WSNs is wireless sensor/actuator networks (WSANs) . WSANs are comprised of networked SNs and actuator nodes (ANs) to perform distributed sensing and control tasks. From a viewpoint of control theory, traditional WSNs are open-loop systems that only detect the physical world, whereas WSANs are closed loop systems that can further interact with it automatically. The nodes are equipped with low-power radio frequency (RF) transceiver and low-cost microcontroller together with an energy source, usually a battery. In SNs, several sensors are connected to the node to provide necessary monitoring function. Besides, in ANs, actuators are attached to trigger control functions.

Sensors are devices that produce a measurable change in output to a known input stimulus. This stimulus can be a physical stimulus like temperature and pressure or a concentration of a specific chemical or biochemical material. The output signal is typically proportional to the input variable, which is also called the measurand. In today’s world, sensors play a vital role in agriculture. The ever increasing need of agricultured products to keep the pace with the ever increasing population has led to the usage of various kind of sensors which effectively minimises the human effort. The use of sensors helps to exploit all available resources appropriately and to apply hazardous products moderately. [15]

Types of sensors applicable in agriculture are:

- **Light Intensity Sensor :** These kind of sensors are also referred as photodetectors or photosensors. In agricular practices, light plays a major role in allowing plants or crops to complete the process of photosysnthesis. Light sensor are basically used to control the intensity or time of exposure of the crops to light. Light sensors are mainly involved in detecting light density but they do not record images.

- **Temperature Sensor :** Temperature Sensors measure the degree of hotness or coldness that is generated by an object or a system. In agriculture, temperature plays a role in determining the types of crop that can be grown in a specific region.

- **Humidity Sensor :** Humidity is the presence of water in air. The amount of water in air can affect the growth of certain crops leading to lesser production than the optimal amount.

4. Background Study :

4.1. A note on Krishna Tulsi

Tulsi is a Sanskrit word which means "matchless one," in English Tulsi is known as Holy Basil.There are about 50 to 150 species of Ocimum genus' herbs and shrubs that are found in the tropical regions of Asia.Ocimum tenuiflorum is the scientific name of Krishna Tulsi. In Ayurveda,Tulsi is titled as the "Queen of all herbs" a most powerful and adaptive herb that can be applicable and morphable to almost any condition just like a queen does. It is a magical herb that can be used in many ailments such as in lung conditions, asthma, including bronchitis, congestion and colds. Part of this plant used are – seeds, roots and leaves. Krishna Tulsi looks purple it does have an aroma and peppery flavour a live Ram Tulsi. Chemical constituents of Krishna Tulsi include Essential Oils, Carbohydrates, Flavonoids, Proline, Linalool, Methyl Chavicol, Nerol, Geraniol, Citral and Ursolic Acid. Krishna tulsi grows slower than other varieties, which may contribute to its spicy, pungent flavor and odor. Purple leaf basil is also less bitter and astringent than other tulsis. Krishna Tulsi or purple leaf Tulsi grows in many parts of India, but this dark purple variety is harder to find than the greener. It is especially useful for curing respiratory infections, ear infections and skin problems.

Growing of Krishna Tulsi :

Krishna Tulsi seeds germinate after a while,so one needs to be patient to sow them. The seeds are mainly sown in the spring season. They are watered from time to time and germinated in one to two weeks. Tulsi prefers rich soil for its growth. It requires full sunlight. It is mainly grown in the temperate climate. [16]

Soil Variety for Krishna Tulsi :

The plant is sufficiently hardy and it can be grown on any type of soil except the ones with highly saline, alkaline or water-logged conditions. However, sandy loam soil with good organic matter is considered ideal. For propagating basil through seeds, they are to be sown in the nursery beds. The nursery should be located preferably in partial shade with adequate irrigation facilities. Soil is worked upto a depth of about 30 cm. Well rotten farm yard manure (2 kg/sq.m) is applied to the soil and prepared to a fine tilth and seed beds of 4.5x1.0x0.2 m size are prepared. As the seeds are minute, the required quantity of seeds are mixed with sand in the ratio of 1:4 and sown in nursery bed, 2 months in advance of the onset of monsoon. They germinate in 8-12 days and seedlings are ready for transplanting in about 6 weeks' time at 4-5 leaf stage.Vegetatively it can be propagated by terminal cuttings with about 90-100 per cent success during October-December months. For this purpose, cuttings with 8-10 nodes and 10-15 cm length are used. They are so prepared that except for the first 2-3 pairs of leaves the rest are trimmed off. Later, they are planted in the well-prepared nursery beds or polythene bags. In about 4-6 weeks time the rooting is complete and they are ready for transplanting into the main field. The plants are transplanted at a spacing of 40 cm between the row and 40 cm within the row. The crop is harvested at full bloom stage by cutting the plants at 15 cm from ground level to ensure good regeneration for further harvests. The first harvest is done after 90 days of planting and subsequently it may be harvested at every 75 days interval. Harvest the crop on bright sunny days to get good yield and oil quality. On an average, Krishna Tulsi gives about 10,000-15,000 kgs of fresh herbage per hectare per year. As the herb contains about 0.1 to 0.23 per cent oil, commensurating to it we may obtain about 10-23 litres of essential oil per hectare.

Climate:

Krishna Tulsi requires moderate annual rainfall and humid conditions for better yield. It can even thrive in partially shaded conditions with low oil content. Long days with high temperature are best for its growth with good oil content.

Soil and soil pH:

Rich sandy loam soils with good internal drainage are ideal for Tulsi cultivation. Avoid alkaline, saline and water-logged soils. Soil pH of 5.5-7.0 is ideal for better yield of Krishna Tulsi.

Fig. 4 : Sample Krishna Tulsi Plant.

4.2. WMSN (Wireless Multimedia Sensor Networks):

It is the wireless network of scalar sensor nodes in combination with multimedia nodes like cameras and audio acquisition system. Increasing demand of WSN and the availability of low cost, low energy consumer CMOS Cameras have led the way for WMSN. WMSN is definitely advancement in the direction of WSN but raised some complexity issues in the system too. When there were only scalar sensors attached to the system then the processor capacity and network load was not a great issue due to very small amount of data trafficking in the system. The inclusion of multimedia nodes has definitely increased the overhead and data traffic of the system and has opened many areas for research in this field. Besides, many applications like-Precision Farming, Seismic Monitoring, Oceanic Activity Survey, Remote Vital Health Sign Check, Volcanic Eruption Prediction, Environmental Pollution Control and many more have got the modernization with a greater extent of ease through the WMSN technology. To keep all these in mind we have further stepped towards the development of such a device which is capable of retrieving of multimedia data and can efficiently operate in a WMSN environment. Not only this, it is also useful for active researchers working in broad area of experimental multi-hop wireless networking such as mobile ad hoc networks, wireless sensor networks, wireless mesh networks, vehicular networks, and ad hoc computing systems.

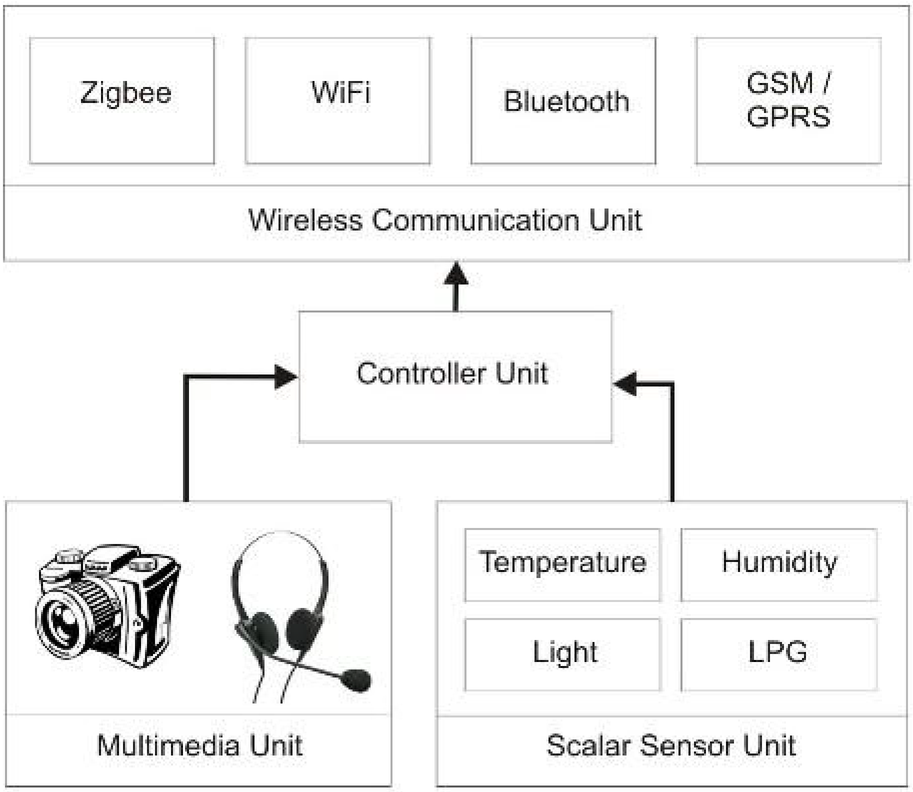


Fig. 5 : Block diagram of WMSN.

A WMSN consists of a collection of Scalar Sensors Unit, Some Multimedia Nodes, Computing Unit, Controller Unit, Wireless Communication Unit and a network management protocol for the efficient communication of messages in the network. Scalar Sensor Unit senses continuously the real world environment and sends the data at a regular interval to the computing unit. The microprocessor unit further processes these data according to the programming logic and delivers it to the wireless unit for the transmission of the required data. Multimedia nodes also send the data to the computing unit either in a triggered or periodic form. The central station has some software to record the important databases of every local station within its controlling range and take real time actions as needed depending on the situation.

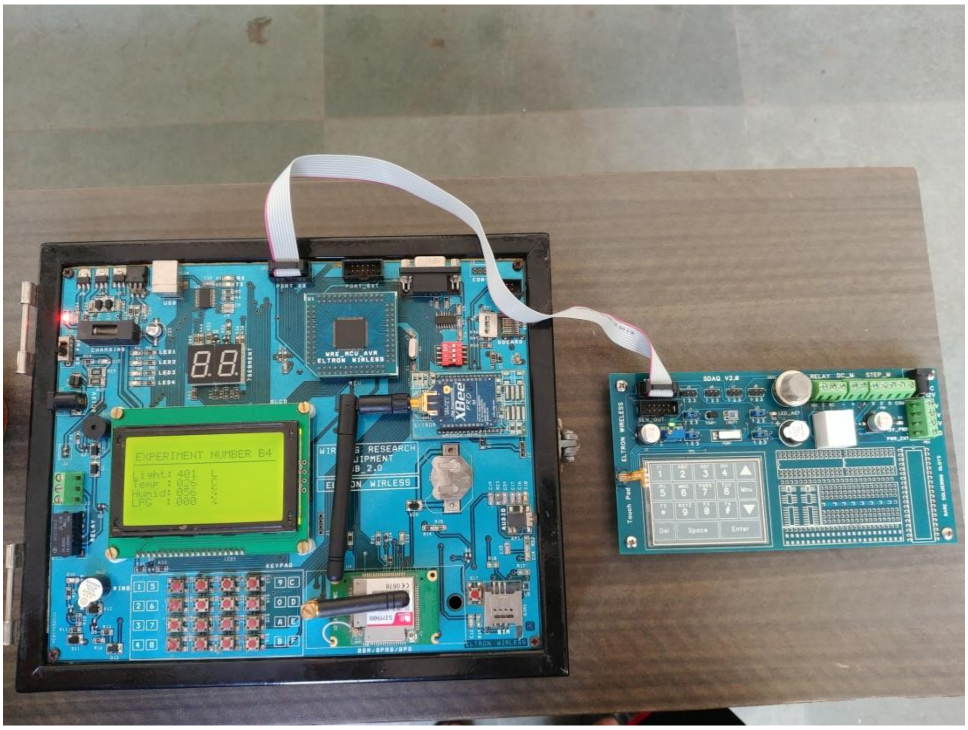


Fig. 6 : Snapshot of WMSN development kit with SDAQ board.

The WMSN Universal Board provides the following features –

- Multiple wireless networking device interface in a single board (**WiFi, Zigbee, Bluetooth, GSM, and GPS)**
- 2On board **camera** interface
- On board **data logging** through external memory and several I/O interface (e.g. Relay, Buzzer, display etc.)
- Flexibility to attach **external sensors** as required by researchers for specific application
- Wide scope for students/ researchers to use this wireless development board to create novel firmware and software
- Facilitate creation of novel embedded solutions in various industry domains such as Mining, Transport, Agriculture, Environment, Energy, retail, Health etc.

Sensors for our consideration:

- **Low Voltage Humidity Sensors :** The HIH-5030/5031 Series Low Voltage Humidity Sensors operate down to 2.7 V dc, often ideal in battery-powered systems where the supply is a nominal 3 V dc.
  The HIH 5030/5031 complements our existing line of 5 V dc SMD (Surface Mount Device) humidity sensors. SMD packaging on tape and reel allows for use in high volume, automated pick and place manufacturing, eliminating lead misalignment to printed circuit board through-holes.
  The HIH-5030/5031 Series Humidity Sensors are designed specifically for high volume OEM (Original Equipment Manufacturer) users.

- **Precision Centigrade Temperature Sensors :** The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy).

Fig. 7 : SDAQ board with Temperature and Humidity sensors.

4. Planning:

Our project can be divided into steps as follows :

1. a. Familiarization with the agro-sensor kit.
   b.Study related to precision agriculture.

2. a. Design and development of algorithm required to acquire data.
   b.Data acquisition using sensor kit.
   c. Comparison with standard data.

3. Study of effect of different parameters on Krishna Tulsi.

4. Design and development of algorithm for data prediction.

5. Result generation and analysis.

5. Design :

Code for data acquisition – Temperature and Humidity:

```
#define OFF 0
#define ON 1

//Defining Ports for LCD Backlight
#define Lcd_bklt_dr_out DDRB.F4=1
#define Lcd_bklt_ON PORTB.F4 = 1
#define Lcd_bklt_OFF PORTB.F4 = 1

//Declaration of the ports for graphic display
char GLCD_DataPort at PORTA;
char GLCD_DataPort_Direction at DDRA;

sbit GLCD_CS2 at PORTE2_bit;
sbit GLCD_CS1 at PORTE3_bit;
sbit GLCD_RS  at PORTE5_bit;
sbit GLCD_RW  at PORTE6_bit;
sbit GLCD_EN  at PORTE7_bit;
sbit GLCD_RST at PORTE4_bit;

sbit GLCD_CS2_Direction at DDE2_bit;
sbit GLCD_CS1_Direction at DDE3_bit;
sbit GLCD_RS_Direction  at DDE5_bit;
sbit GLCD_RW_Direction  at DDE6_bit;
sbit GLCD_EN_Direction  at DDE7_bit;
sbit GLCD_RST_Direction at DDE4_bit;

const char test[1024];
```

```
int key1=OFF,key2=OFF;

void Init_uart(unsigned long);
void Transmit_uart_pc(unsigned char);
void Transmit_uart_pc_string(unsigned char*);

void Glcd_Write_String(char*, char , char);
void EraseDisp(unsigned short, unsigned short, unsigned short, unsigned short);

void Initialize_sensor_ports(void);
unsigned int Read_adc(unsigned char);
unsigned int Read_ADC_Average(unsigned char);

unsigned char scount_pc=1,sdata_pc[50];
int ubrr_val;


void main()
{
     unsigned char lux[5],centigrade[5],humidity[5],lpg_con[5],p;//Sensor[5];
     unsigned int light,cent,hum,lpg;
     unsigned char key,temp,d0,d1,d2,d3,d4,to_write[25],address;
     float temp_float;
    //unsigned char cur_pos=0;
    unsigned int sens1,prev,sens2,sens3,sens4;
    unsigned char uart_data[25];

     Lcd_bklt_dr_out;;            //LCD Bklt direction output

     Lcd_bklt_ON;
     Glcd_init();
     Glcd_Fill(0x00);
     Delay_ms(50);
     Glcd_Image(eltron);
     Glcd_Write_Text("Welcome To", 5, 1, 2);          // Write string
     Delay_ms(2000);

     Glcd_Fill(0x00);
     Glcd_Write_Text("EXPERIMENT NUMBER B4", 3, 1, 2);
     Glcd_H_Line(1, 125, 18, 1);
     Delay_ms(500);
     Glcd_Write_Text("device rdy 4 SENSING", 1, 3, 2);
     Delay_ms(3000);
     EraseDisp(1,3,127,3);

     Glcd_Write_Text("Light:", 1, 3, 2);
     Glcd_Write_Text("L", 70, 3, 2);
     Glcd_Write_Text("Temp :", 1, 4, 2);
     Glcd_Write_Text("C", 70, 4, 2);
```

```
    Glcd_Write_Text("Humid:", 1, 5, 2);
    Glcd_Write_Text("%", 70, 5, 2);
    Glcd_Write_Text("LPG  :", 1, 6, 2);
    Glcd_Write_Text("%", 70, 6, 2);
    Initialize_sensor_ports();
    Init_uart(9600);


    while(1)
    {
       sens1=Read_ADC_Average(0);
       temp_float=((5*sens1)/(float)1020);
       temp_float=133.3*temp_float;
       light=temp_float;
       d0=light%10;light=light/10;d1=light%10;light=light/10;d2=light%10;
       lux[0]=0x30+d2;lux[1]=0x30+d1;lux[2]=0x30+d0;lux[3]=0;
       Glcd_Write_String(lux,40,3);
       //if(IN1_LOW || IN2_LOW || IN3_LOW || IN4_LOW) break;

       sens2=Read_ADC_Average(3);
       temp_float=0.4*(float)sens2;
       cent=temp_float;
       d0=cent%10;cent=cent/10;d1=cent%10;cent=cent/10;d2=cent%10;

centigrade[0]=0x30+d2;centigrade[1]=0x30+d1;centigrade[2]=0x30+d0;centigrade[3]=0;
       Glcd_Write_String(centigrade,40,4);

       //if(IN1_LOW || IN2_LOW || IN3_LOW || IN4_LOW) break;

       sens3=Read_ADC_Average(2);
       temp_float=((5*sens3)/(float)1020);
       temp_float=(((temp_float/5)-0.1515)/.00636);
       hum=temp_float;
       d0=hum%10;hum=hum/10;d1=hum%10;hum=hum/10;d2=hum%10;
       humidity[0]=0x30+d2;humidity[1]=0x30+d1;humidity[2]=0x30+d0;humidity[3]=0;
       Glcd_Write_String(humidity,40,5);

       //if(IN1_LOW || IN2_LOW || IN3_LOW || IN4_LOW) break;

       sens4=Read_ADC_Average(4);
       temp_float=0.098*sens4;
       lpg=temp_float;
       if(lpg>=15) lpg=lpg-15;
       else
       lpg=0;
       d0=lpg%10;lpg=lpg/10;d1=lpg%10;lpg=lpg/10;d2=lpg%10;
       lpg_con[0]=0x30+d2;lpg_con[1]=0x30+d1;lpg_con[2]=0x30+d0;lpg_con[3]=0;
       Glcd_Write_String(lpg_con,40,6);

       p=0;
```

```
        uart_data[p]='L';p++;
        uart_data[p]=lux[0];p++;
        uart_data[p]=lux[1];p++;
        uart_data[p]=lux[2];p++;

        uart_data[p]='T';p++;
        uart_data[p]=centigrade[0];p++;
        uart_data[p]=centigrade[1];p++;
        uart_data[p]=centigrade[2];p++;

        uart_data[p]='H';p++;
        uart_data[p]=humidity[0];p++;
        uart_data[p]=humidity[1];p++;
        uart_data[p]=humidity[2];p++;

        uart_data[p]='G';p++;
        uart_data[p]=lpg_con[0];p++;
        uart_data[p]=lpg_con[1];p++;
        uart_data[p]=lpg_con[2];p++;
        uart_data[p]=';';p++;
        uart_data[p]=0;

        Transmit_uart_pc_string(uart_data);
        Transmit_uart_pc(13);

        Delay_ms(1000);
    }
}


void Init_uart(unsigned long baud)
{
    switch(baud)
    {
     case 2400: ubrr_val =  287;
             break;
     case 4800: ubrr_val =  143;
             break;
     case 9600: ubrr_val =  71;
             break;
     case 14400: ubrr_val = 47;
             break;
     case 19200: ubrr_val = 35;
             break;
     case 28800: ubrr_val = 23;
             break;
     case 38400: ubrr_val = 17;
             break;
     case 57600: ubrr_val = 11;
             break;
```

```
        case 76800: ubrr_val = 8;
                break;
        case 115200: ubrr_val = 5;
                break;
        case 230400: ubrr_val = 2;
                break;
        case 250000: ubrr_val = 2;
                break;
        default    : break;
       }
       SREG.F7=0;          // Global Interrupt disable

       UBRR0L = ubrr_val;
       UBRR0H = (ubrr_val>>8);
       UCSR0B.F7=1;
       UCSR0A.F7=1;
       UCSR0B.F4=1;
       UCSR0B.F3=1;

       SREG.F7=1;          // Global Interrupt enable
       Delay_ms(200);
}

void Transmit_uart_pc(unsigned char tdata)
{
     while ( !( UCSR0A & (1<<UDRE0)) ); // Wait for empty transmit buffer
     UDR0 = tdata;                     // Put data into buffer, sends the data
}


void Transmit_uart_pc_string(unsigned char* str)
{
     unsigned char i;
     i=0;
     while(str[i] != 0) {Transmit_uart_pc(str[i]);i++;Delay_ms(1);}
}

void Initialize_sensor_ports(void)
{
      ADMUX=0x40   ;   //ADC Initialization, Internal Vcc Voltage Reference with external
capacitor at AREF pin
      ADCSRA=0x87;        //Clock is devided by 128
}
unsigned int Read_adc(unsigned char adc_input)
{
      /*
         ADC0 light
         ADC1 vibration
         ADC2 humidity
         ADC3 temperature
```

```
        ADC4 gas
    */
    unsigned char LB,HB;
    ADMUX=adc_input | (0x40);
    Delay_ms(20); // Delay needed for the stabilization of the ADC input voltage
    ADCSRA|=0x40;  // Start the AD conversion
    while ((ADCSRA & 0x10)==0); // Wait for the AD conversion to complete
    ADCSRA|=0x10;
    LB=ADCL;
    HB=ADCH;
    return(HB*256+LB);
}

unsigned int Read_ADC_Average(unsigned char channel)
{
     float avg;
     unsigned int adctotal,adc;
     unsigned char i;
     adctotal=0;
     for(i=0;i<10;i++) {adctotal+=Read_adc(channel); Delay_ms(20);}
     avg=adctotal/10.0;
     adc=adctotal/10;
     if((avg-adc)>0.6) adc++;
     return(adc);
}


void Glcd_Write_String(char* str, char xpos, char line)
{
    char i,j;
    for(i=0,j=0;;i++,j+=6)
    {
      if(str[i]==0) break;
      Glcd_Write_Char(str[i], xpos+j, line, 1);
    }
    return;
}

void EraseDisp(unsigned short start_x, unsigned short start_y, unsigned short last_x,
unsigned short last_y)
{
   unsigned short i;
   for(i=start_x;start_y<=last_y;i++)
   {
      if(i>127) {start_y++; i=0;}
      Glcd_Write_char(' ',i,start_y,1);
   }
   return;
}
```

Data Analysis:

Table 2: Daily Collected Data

Date	Time	Temperature		Humidity	
		Measured	Actual	Measured	Actual
1st Nov,17	01:00 P.M	29°C	27°C	68%	60%
2nd Nov,17	12:15 P.M	24°C	26°C	67%	55%
3rd Nov,17	11:25 P.M	22°C	23°C	64%	66%
6th Nov,17	10:18 P.M	23°C	23°C	68%	64%
7th Nov,17	04:15 P.M	31°C	30°C	52%	48%
8th Nov,17	10:35 A.M	26°C	22°C	67%	67%
9th Nov,17	12:45 P.M	29°C	28°C	42%	50%
10thNov,17	10:10 A.M	29°C	25°C	48%	67%
13thNov,17	10:15 A.M	23°C	23°C	78%	60%
14thNov,17	12:05 P.M	29°C	28°C	49%	54%
15thNov,17	05:10 P.M	24°C	22°C	80%	96%
16thNov,17	02:45 P.M	22°C	22°C	72%	89%
17thNov,17	02:10 P.M	24°C	24°C	68%	89%
18thDec,17	10:40 A.M	18°C	18°C	80%	84%
19thDec,17	10:30 A.M	19°C	17°C	89%	89%
20thDec,17	12:30 P.M	22°C	20°C	74%	67%
21stDec,17	03:45 P.M	24°C	22°C	68%	66%
22ndDec,17	03:30 P.M	24°C	24°C	51%	51%
8th Jan,18	11:00 A.M	17°C	18°C	70%	78%
9th Jan,18	12:10 P.M	19°C	19°C	48%	46%

10th Jan,18	10:10 A.M	17°C	15°C	64%	67%
11th Jan,18	10:15 A.M	15°C	13°C	75%	79%
12th Jan,18	12:30 P.M	21°C	20°C	45%	58%
15th Jan,18	11:00 A.M	15°C	15°C	70%	84%
16th Jan,18	01:10 P.M	20°C	20°C	54%	49%

Date	Time	Temperature		Humidity	
		Measured	Actual	Measured	Actual
17th Jan,18	01:05 P.M	21°C	22°C	40%	40%
19th Jan,18	11:10 A.M	15°C	16°C	74%	74%
25th Jan,18	12:45 P.M	23°C	23°C	54%	38%
29th Jan,18	03:05 P.M	27°C	26°C	50%	32%
30th Jan,18	11:30 A.M	22°C	22°C	62%	65%
31st Jan,18	12:05 P.M	26°C	25°C	50%	42%
1st Feb,18	03:55 P.M	26°C	26°C	42%	39%
2nd Feb,18	01:05 P.M	25°C	24°C	48%	40%
5th Feb,18	02:10 P.M	27°C	27°C	52%	57%
6th Feb,18	01:30 P.M	26°C	28°C	58%	31%
7th Feb,18	10:15 A.M	21°C	22°C	54%	54%
9th Feb,18	12:10 P.M	26°C	28°C	62%	60%
10thFeb,18	10:55 A.M	24°C	26°C	42%	55%
12thFeb,18	10:30 A.M	23°C	24°C	52%	55%
14thFeb,18	11:45 A.M	24°C	24°C	57%	57%
15thFeb,18	12:05 P.M	27°C	26°C	68%	61%
16thFeb,18	04:10 P.M	26°C	27°C	70%	56%

19th Feb,18	12:30 P.M	28°C	30°C	52%	40%
20th Feb,18	01:55 P.M	30°C	30°C	48%	45%
21st Feb,18	11:30 A.M	29°C	28°C	72%	71%
22nd Feb,18	11:25 A.M	29°C	30°C	70%	71%
23rd Feb,18	11:15 A.M	32°C	32°C	75%	68%
26th Feb,18	02:35 P.M	34°C	33°C	38%	35%
27th Feb,18	10:15 A.M	30°C	29°C	56%	78%
28th Feb,18	11:10 A.M	30°C	30°C	73%	80%

Date	Time	Temperature		Humidity	
		Measured	Actual	Measured	Actual
1st Mar,18	12:25 P.M	28°C	29°C	52%	47%
5th Mar,18	03:10 P.M	36°C	36°C	48%	36%
6th Mar,18	10:50 A.M	29°C	28°C	49%	46%
7th Mar,18	01:10 P.M	30°C	32°C	39%	25%
8th Mar,18	02:25 P.M	36°C	34°C	28%	23%
9th Mar,18	01:05 P.M	33°C	31°C	56%	31%
10th Mar,18	10:35 A.M	30°C	30°C	68%	51%
12th Mar,18	04:55 P.M	34°C	33°C	42%	39%
13th Mar,18	05:10 P.M	32°C	34°C	48%	30%
14th Mar,18	05:25 P.M	33°C	34°C	40%	19%
15th Mar,18	12:15 P.M	33°C	32°C	43%	57%
16th Mar,18	01:05 P.M	33°C	30°C	49%	45%
17th Mar,18	10:30 A.M	30°C	30°C	60%	47%
19th Mar,18	02:30 P.M	35°C	36°C	45%	23%

20th Mar,18	11:35 A.M	32°C	30°C	43%	65%
21st Mar,18	10:26 A.M	30°C	29°C	80%	71%
22nd Mar,18	11:10 A.M	31°C	31°C	71%	75%
23rd Mar,18	12:35 P.M	32°C	32°C	60%	60%
24th Mar,18	10:15 A.M	30°C	28°C	72%	73%

- **Weekly Collected Data-**

Table 3: Week-1: 11:00 A.M – 12:00 P.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
30th Oct,18	27°C	27°C	80%	83%
31st Oct,18	26°C	25°C	62%	70%
1st Nov,18	29°C	27°C	68%	60%
2nd Nov,18	24°C	26°C	67%	55%
3rd Nov,18	22°C	23°C	64%	66%
4th Nov,18	26°C	26°C	69%	66%
5th Nov,18	26°C	24°C	64%	66%

Table 4: Week-2: 12:00 P.M – 1:00 P.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
6th Nov,18	28°C	30°C	37%	48%
7th Nov,18	28°C	28°C	56%	48%
8th Nov,18	31°C	30°C	62%	49%
9th Nov,18	29°C	28°C	42%	50%

10th Nov,18	31°C	31°C	42%	43%
11th Nov,18	31°C	29°C	46%	48%
12th Nov,18	30°C	30°C	48%	43%

Table 5: Week-3: 10:00 A.M – 11:00 A.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
17th Dec,18	23°C	22°C	64%	53%
18th Dec,18	18°C	18°C	89%	80%
19th Dec,18	18°C	17°C	70%	89%
20th Dec,18	24°C	21°C	68%	64%
21st Dec,18	20°C	19°C	83%	83%
22nd Dec,18	20°C	21°C	69%	64%
23rd Dec,18	21°C	22°C	55%	65%

Table 6: Week-4: 01:00 P.M – 02:00 P.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
8th Jan,18	19°C	20°C	60%	46%
9th Jan,18	20°C	21°C	50%	43%
10th Jan,18	22°C	22°C	42%	38%
11th Jan,18	23°C	22°C	43%	41%
12th Jan,18	22°C	22°C	55%	53%
13th Jan,18	21°C	20°C	68%	53%
14th Jan,18	21°C	21°C	72%	60%

Table 7: Week-5: 01:00 P.M – 02:00 P.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
15th Jan,18	25°C	23°C	32%	47%
16th Jan,18	23°C	24°C	48%	41%
17th Jan,18	23°C	23°C	37%	36%
18th Jan,18	26°C	24°C	35%	39%
19th Jan,18	17°C	19°C	30%	56%
20th Jan,18	23°C	26°C	54%	32%
21st Jan,18	23°C	26°C	40%	32%

Table 8: Week-6: 02:00 P.M – 03:00 P.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
29th Jan,18	29°C	27°C	30%	28%
30th Jan,18	28°C	27°C	28%	28%
31st Jan,18	28°C	28°C	36%	30%
1st Feb,18	27°C	26°C	50%	37%
2nd Feb,18	28°C	27°C	33%	34%
3rd Feb,18	31°C	30°C	38%	29%
4th Feb,18	31°C	31°C	42%	38%

Table 9: Week-7 : 11:00 A.M – 12:00 P.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
5th Feb,18	26°C	26°C	57%	58%
6th Feb,18	27°C	28°C	36%	35%

7th Feb,18	27°C	28°C	39%	26%
8th Feb,18	26°C	26°C	33%	34%
9th Feb,18	28°C	29°C	33%	33%
10th Feb,18	27°C	27°C	32%	34%
11th Feb,18	29°C	26°C	38%	37%

Table 10: Week-8 : 02:00 P.M – 03:00 P.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
26th Feb,18	35°C	34°C	39%	32%
27th Feb,18	32°C	33°C	47%	46%
28th Feb,18	33°C	33°C	37%	36%
1st Mar,18	34°C	33°C	44%	44%
2nd Mar,18	35°C	36°C	50%	32%
3rd Mar,18	37°C	37°C	26%	29%
4th Mar,18	32°C	36°C	31%	32%

Table 11 : Week-9 : 12:00 P.M – 01:00 P.M

Date	Temperature		Humidity	
	Measured	Actual	Measured	Actual
12th Mar,18	34°C	34°C	45%	41%
13th Mar,18	36°C	35°C	40%	41%
14th Mar,18	34°C	37°C	30%	19%
15th Mar,18	32°C	33°C	40%	52%
16th Mar,18	30°C	30°C	42%	46%
17th Mar,18	32°C	34°C	39%	36%
18th Mar,18	36°C	34°C	43%	44%

- **Day Wise Collected Data-**

Table 12 : 26th March,2018 :

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
11:20 A.M	30°C	31°C	65%	70%
11:30 A.M	31°C	31°C	72%	70%
11:40 A.M	32°C	31°C	72%	70%
11:50 A.M	32°C	32°C	73%	70%
12:00 P.M	32°C	32°C	64%	70%
12:10 P.M	32°C	32°C	63%	62%
12:20 P.M	33°C	32°C	63%	62%

Table 13 : 27th March,2018 :

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
12:50 P.M	31°C	33°C	58%	58%
01:00 P.M	33°C	34°C	60%	55%
01:10 P.M	33°C	34°C	59%	55%
01:20 P.M	34°C	34°C	59%	55%
01:30 P.M	34°C	34°C	58%	55%
01:40 P.M	34°C	34°C	58%	55%
01:50 P.M	34°C	35°C	57%	49%

Table 14 : 28th March,2018

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
02:10 P.M	33°C	34°C	42%	45%
02:20 P.M	35°C	35°C	42%	45%
02:30 P.M	36°C	35°C	55%	52%
02:40 P.M	34°C	35°C	58%	52%
02:50 P.M	34°C	35°C	42%	52%
03:00 P.M	33°C	35°C	42%	52%
03:10 P.M	33°C	36°C	42%	52%

Table 15 : 29th March,2018 :

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
02:10 P.M	34°C	35°C	46%	55%
02:20 P.M	36°C	35°C	46%	55%
02:30 P.M	35°C	35°C	37%	55%
02:40 P.M	38°C	35°C	33%	55%
02:50 P.M	34°C	35°C	42%	55%
03:00 P.M	32°C	35°C	42%	55%
03:10 P.M	36°C	35°C	36%	55%

Table 16 : 2nd April,2018 :

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
11:40 A.M	26°C	28°C	64%	58%
11:50 A.M	28°C	30°C	63%	52%
12:00 P.M	28°C	30°C	61%	54%
12:10 P.M	32°C	30°C	59%	54%
12:20 P.M	31°C	27°C	58%	60%
12:30 P.M	28°C	27°C	58%	60%
12:40 P.M	29°C	27°C	57%	60%

Table 17 : 3rd April,2018 :

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
12:55 P.M	30°C	32°C	62%	43%
01:05 P.M	30°C	32°C	56%	40%
01:15 P.M	33°C	32°C	52%	40%
01:25 P.M	32°C	32°C	60%	40%
01:35 P.M	30°C	32°C	60%	40%
01:45 P.M	31°C	32°C	58%	40%
01:55 P.M	33°C	32°C	61%	40%

Table 18 : 4th April,2018 :

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
12:00 P.M	32°C	31°C	60%	49%
12:10 P.M	33°C	31°C	65%	49%
12:20 P.M	33°C	33°C	63%	49%
12:30 P.M	32°C	33°C	63%	47%
12:40 P.M	34°C	33°C	60%	47%
12:50 P.M	34°C	33°C	58%	47%
01:00 P.M	35°C	34°C	50%	47%11

Table 19 : 5th April,2018 :

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
10:30 A.M	32°C	32°C	48%	59%
10:40 A.M	32°C	32°C	49%	59%
10:50 A.M	33°C	32°C	52%	59%
11:00 A.M	33°C	33°C	46%	56%
11:10 A.M	34°C	33°C	52%	56%
11:20 A.M	35°C	34°C	55%	56%
11:30 A.M	35°C	34°C	53%	53%

Table 20 : 6th April,2018 :

Time	Temperature		Humidity	
	Measured	Actual	Measured	Actual
11:20 A.M	30°C	33°C	73%	54%
11:30 A.M	30°C	33°C	66%	54%
11:40 A.M	31°C	33°C	62%	54%
11:50 A.M	33°C	34°C	62%	52%
12:00 P.M	33°C	34°C	61%	52%
12:10 P.M	35°C	34°C	60%	52%
12:20 P.M	33°C	32°C	59%	56%

Moments Captured during the working process:

Fig. 8 : Krishna Tulsi Pots.

Fig. 9 : Ongoing Analysis.

Algorithm for data prediction :

Step 1: Take matrix “CD” of last seven days for current year’s data of size 7xn.
Step 2: Take matrix “PD” of fourteen days for previous year’s data of size 14xn.
Step 3: Make 8 sliding window of size 7xn each from the matrix “PD” as W1,W2,......,W8.
Step 4: Compute the Euclidean distance of each sliding window with the matrix “CD” as ED1,ED2,.......,ED8.
Step 5: Select matrix Wi as

Wi = Corresponding _Matrix(min.(Edi)).

∀ i ∈ [1,8].

Step 6: For k = 1 to n

a. For WC_k compute the variation vector for the matrix “CD” of size 6x1 as “VC”.
b. For WC_k compute the variation vector for the matrix “PD” of size 6x1 as “VP”
c. $Mean_1$= Mean(VC)
d. $Mean_2$= Mean(VP)
e. Predict variation “V” = $(Mean_1+Mean_2)/2$
f. Add “V” to the previous day’s weather condition in consideration to get the predicted condition.

Step 7: End.

Matrix CD(Current data) holds the data of the previous 7days of the current year.
Matrix PD(Previous data) holds the data of the previous 7days and next 6days including the date that is to be predicted of the previous year.
Following are the parameters used in our algorithm :

a. Mean : Mean of day’s weather conditions, that is, temperature and humidity. After adding each separately, divide by total number of days.
b. Variation : Calculate day by day variation after taking difference of each parameter. This shows how the next day’s weather is related to previous day’s weather.
c. Euclidean Distance : It compares data variation of current year and previous year.

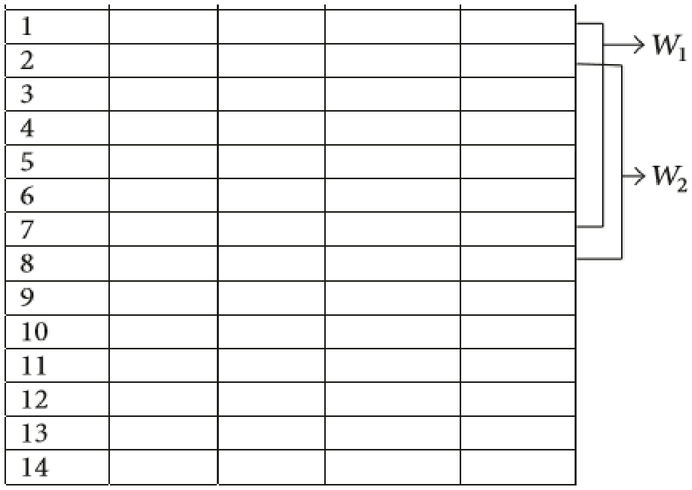
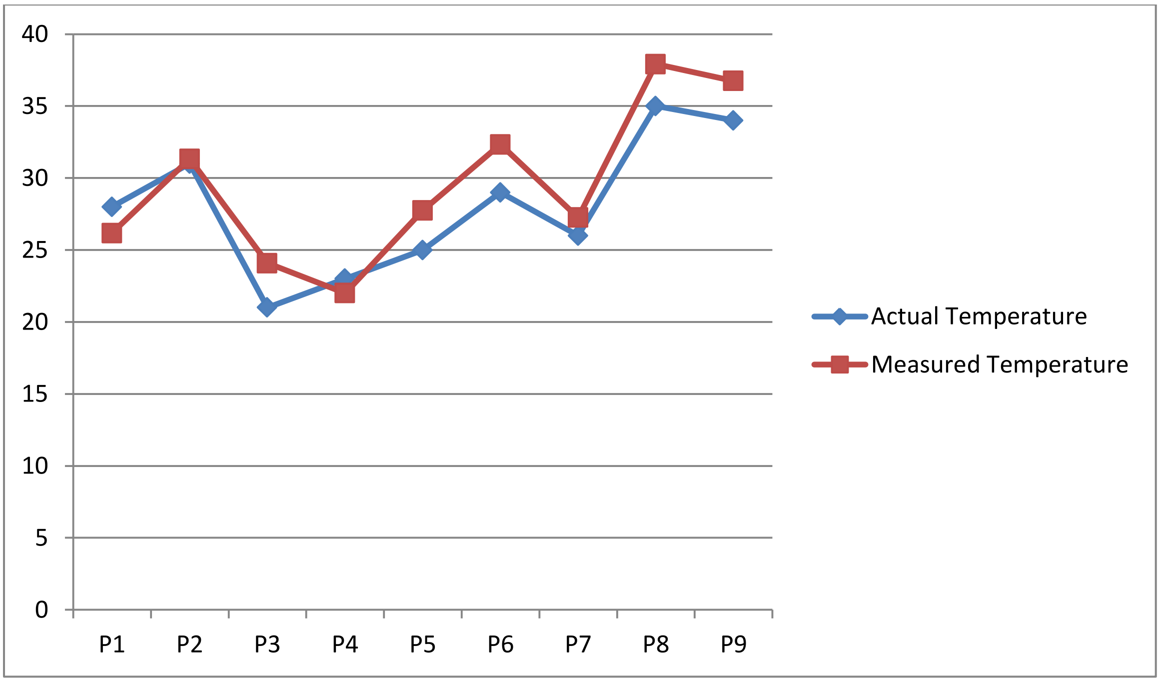


Fig 10 : Sliding Window concept where W_1 represents window 1 and W_2 represents window 2.

6. Results and Discussion

The previous algorithm is tested on several data out of which we present the results obtained from applying it on 9 weeks data between the month of November,2017 to March,2018 in the form of a graph.

Graph 1:



Along the x-axis temperature in °C is represented.
Along the y-axis predicted days as P1,P2,.........,P9 are represented.
The Above graph clearly shows the least variation of the actually and the predicted data.

Table 21 : Shows the date and the accuracy of the predicted data.

Sl No.	Date	Accuracy
P1	6th Nov,2017	93.46%
P2	13th Nov,2017	98.94%
P3	24th Dec,2017	85.33%
P4	15th Jan,2018	95.65%
P5	22nd Jan,2018	89%
P6	5th Feb,2018	88.51%
P7	12th Feb,2018	95.19%
P8	5th Mar,2018	91.66%
P9	19th Mar,2018	91.91%

7. Conclusion

Sensor based monitoring can be useful in more accurate data acquision when compared to already available data about weather conditions as a result more accurate prediction about future weather conditions can be made. The more accurate the data is, the easier it will be to grow and maintain plants like Krishna Tulsi. The comparison of weather condition variation using sliding window approach has been found to be highly accurate except for the months of seasonal change where conditions are highly unpredictable. The results can be altered by changing the size of the window. Accuracy of the unpredictable months can be increased by increasing the window size to one month.

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