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Vegetation Monitoring System-A Review

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Abstract*: *Vegetation Monitoring is important to understand the natural changes occur in the vegetation in different types of places. It is required to monitor changes in the vegetation because it affects the quality of life of animals, terrain stability and other environment components. Monitoring grasslands, crop height, forage mass, poaceae or grass species growth are the things which comes under the concept of vegetation monitoring. There are many techniques which has been used in the vegetation monitoring such as using manual mathematical modelling, Synthetic Aperture Radar (SAR), Unmanned Aerial Systems (UAS), ultrasonic sensors, image processing etc. In the same concern urban landscape which includes public parks, lawns, playgrounds, and golf courses are required to maintain for the city residents to look city beautiful. This idea coincides with one of the features of smart city concept. With the help of state of art technologies some initiatives can be taken for the betterment of the city. Internet of Things (IoT) is one of the state of art technology which can be used as a simplified technique to monitor the aesthetic management of the city.

Keywords: Synthetic Aperture Radar, Unmanned Aerial Systems, Image processing, mathematical modelling, Ultrasonic sensors, Internet of Things

I. INTRODUCTION

Vegetation is a generic term for all the plants or plant species. Monitoring relates to monitor or to keep record of something over a period of time or to have regular surveillance. Vegetation Monitoring is to monitor the growth of plants, grass on the basis of various parameters such as light, temperature, humidity etc [1]. It is important to provide feedback after the corrective actions have been taken based on the monitored assessments by the growth monitoring systems. This feedback points out the flaws in the actions and suggests further modifications if needed. What should be the measuring frequency it is all depends upon what is being measured [2]. For a land manager it is very much necessary to understand the requirement of vegetation monitoring because it helps to keep record of the current status of the vegetation, to determine the requirement of corrective actions to be taken which ultimately helps in developing a better vegetation management.

Preserving and developing open spaces is one of the prominent feature of Smart city concept — public parks, lawns, playgrounds, golf courses and recreational spaces in order to enhance the quality of life for the citizens of the city. This feature can be obtained by having a system for monitoring grass growth of the parks. Therefore, in order to maintain the visual appearance of the city, aesthetic management plays an important role in the smart city concept. Aesthetic management can be done by keeping record of the management of playgrounds, public parks through growth monitoring systems for grass [3] [4]. For a livestock manager, an essential concept of information is to have the Understanding of grass growth. Proper management of grass is extremely important to increase its productivity by proper defoliation i.e. grazing and mowing because grasses will grow back periodically throughout the season. In fact, occurrences of defoliation are very much necessary to happen in a right way at the right time for the grasses to be more productive and healthier [5]. After gaining knowledge, to enhance the productivity necessary methods should be applied appropriately to maximize the grass growth. Precision agriculture has been widely studied and adopted in many countries for grain and vegetable crop production, but grass or sod production has drawn relatively less interest. Cultivated Turf grass is a pervasive feature of the urban landscape in many developed countries providing recreational and ornamental benefits to human activities and also contributing to the sports field [6].

Mowing is one of the fundamental thing for maintaining lawn turf. To maintain the health and volume of the stand, it is essential to perform mowing at the right height and correct frequency. It is not advisable to cut the lawn grass too short because it will create an environment of an infestation by the weeds, pests and parasites [7] [8]. Therefore, one third rule for lawn mowing should be used. One third rule explains to remove one third part of the total grass surface in lawn mowing [7].

Table 1
One third rule for mowing

Height of cut	Mow when turf reaches	Growth between mowing
1.0''	1.50''	0.50''
2.0''	3.00''	1.00''
2.5''	3.75''	1.25''
3.0''	4.50''	1.50''
3.5''	5.25''	1.75''

There are different types of turf grasses available in India. Each one of them has a specific statistic in terms of their height is concerned. The Lawn Institute, an internationally recognised authority among turf professionals and scientists recommended Mowing height of turf grass [9].

Table 2
Recommended mowing height

SNo.	Type of grass	Mowing Height (inches)	Mowing Height (mm)
1.	Bermuda grass	0.75 - 2	19.05 – 50.8
2.	Kentucky grass	1.5 - 3	38.1 – 76.2
3.	Fine Fescue	2 - 3	50.8 – 76.2
4.	Tall Fescue	2 - 3	50.8 – 76.2
5.	Ryegrass	1.5 - 3	38.1 – 76.2

II. TECHNIQUES USED FOR VEGETATION MONITORING

There are many techniques which has been used for vegetation monitoring. Some of the techniques are discuss as follows:

A. Vegetation monitoring using Mathematical Modelling

Vegetation monitoring through mathematical modelling requires strong problem solving skills. To monitor growth of plant or grass species through this technique requires brainstorming which is quite complex and time consuming.

1) Medusahead, an undesirable, invasive grass specie which affects the function and health of rangelands has been differentiated from desirable annual grasses of rangeland through time and rate of phenological development. Therefore to control the growth of medusahead, Drichlet Regression and Multistate modelling has been used to determine the most suitable time for grazing and mowing of medusahead over vast rangelands across the western United States [10].

2) Sigmoidal equations has been used to measure crop height.

$$y = \frac{a}{1 + e^{-(\frac{x-c}{b})}}$$

Where
x represents the day after planting
y represents crop height
a,b,c are the 3 coefficients

These coefficients can be obtained by applying non-linear least square fitting algorithm to the discrete height measurement data. Along with this remote sensing has been done using UAS [11].

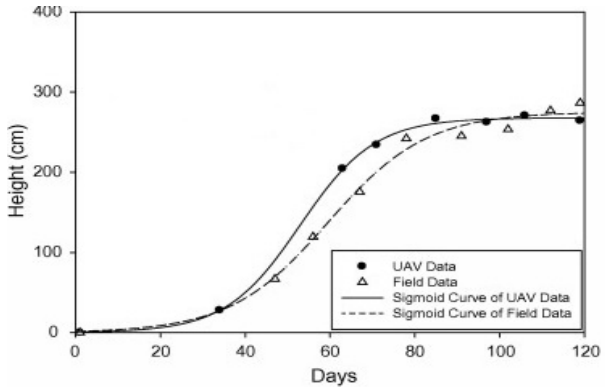

Figure 1 Growth height curve of crop from UAS and field data against days after

B. Vegetation monitoring using Remote sensing

Remote sensing is an attractive method used for the monitoring of vast area because it is capable of giving timely information

1) Synthetic Aperture Radar (SAR) is specifically useful due to two reasons in the field of grassland monitoring. First, SAR is sensitive to the plant structure, orientation and its water content. Second, SAR attainments are not dependent upon illuminations and weather conditions. Therefore, it has been used for the detection of grass cutting events over the grasslands by measuring polarimetric parameters such as HH/VV Polarimetric coherence and the scattering entropy [12].

2) Fusion of Drone and satellite images has been used to segregate the dense and sparse areas of the sugarcane field in the region of roorkee under district Haridwar, Utrakhand in India. Outcome result shows that this method was quite satisfactory with an accuracy of about 87% and 78% for testing and validation data respectively [13].

C. Vegetation monitoring using Sensors

Vegetation growth also depends on environmental factors such as temperature, humidity, soil moisture, light etc. effects of such factors can be determine using sensor network. Such kind of sensors has been used to determine the growth of plants. Apart from that, height measuring sensor is also available named as ultrasonic sensor. An ultrasonic sensor works on the principal of echolocation used by bats to identify nearby objects. It sends out a sound signal with a frequency higher than the human audible frequency and distance is measured by calculating the time taken for the sound signal to travel from transmitter to object and then get reflect from the object to the receiver.

1) A system has been proposed for the plant growth monitoring which comprised of the combination of sensor network along with microcontroller and output devices such as Liquid crystal Display or Motor. In this system Temperature and humidity sensor, soil moisture sensor and ultrasonic sensors has been used to sense the data and this data has been processed by the PIC16F877A Microcontroller and correspondingly message signal is generated through Global System for mobile to indicate the user [14].

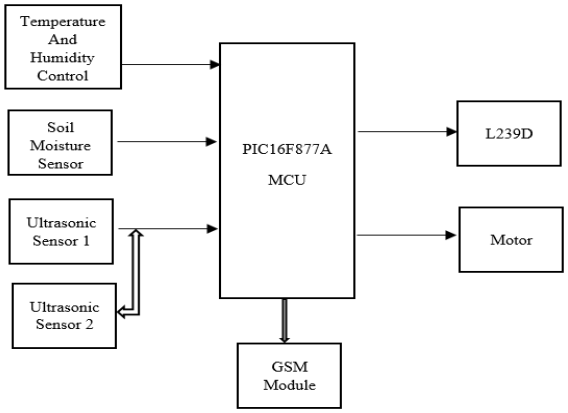

Figure 2 Block diagram of Plant growth Monitoring System

2) In the same way a tryout has been made where Ultrasonic sensor has also been used to measure the grass height to inspect forage mass in grass legume mixture under two experiments (i) Static measurement (ii) Mobile (on-the-go) measurement Figure 3. describes (A) operating principle of the ultrasonic sensor, (B) static application with measurement replications at five positions on each sample site and (C) on the-go application as a combined real time measurement of ultrasonic sward height and high precision GPS in movement. During measurement the reflected signal with the shortest distance inside the reflectance area is logged and other farther objects are ignored. Dimensions are given in cmIn the static measurement ultrasonic sensor has placed at a fixed position whereas in mobile test sensor has been mounted along with Differential Global Positioning System on a mobile vehicle for the forage assessment [15].

3) Ultrasonic sensor has also been used for the weed detection in cereal crops. To detect weeds, plants heights are measured using ultrasonic sensors. This method is based on the hypothesis that non- infested areas of weeds have lower quantity of biomass than the infested areas of weeds and this can be find out using the height measurement of the plants. This methodology also discriminates the weed infested areas, since the density of crop in the field areas will remain homogeneous whereas weeds spots are regularly distributed over the field which increases the

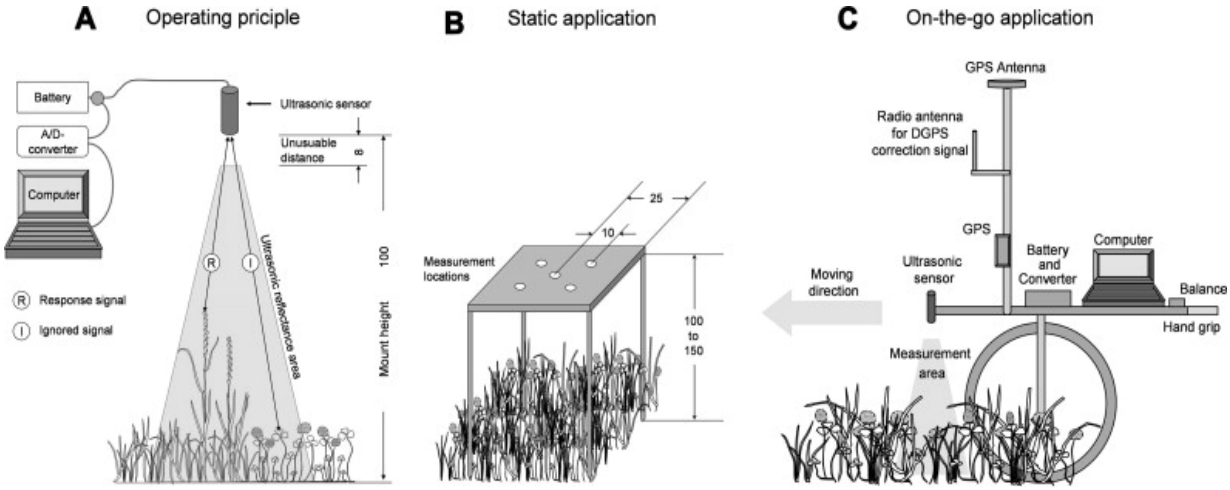

Figure 3 Experimental view of basic principal, static and mobile measurement

Plant density and this plant density is directly proportional to the energy of the reflected wave [16].

Figure 4. Shows a system view of ultrasonic sensor for weed detection in three different situations: (I) crops and broad-leaved weeds; (II) crop and mixture of grasses and broad-leaved weeds; and (III) crop and grasses. Static measurement is being done in this system. Vehicle was not moving while the samples were taken.

Data acquisition card was used for data processing and Robot Operating System was used as a framework for program writing.

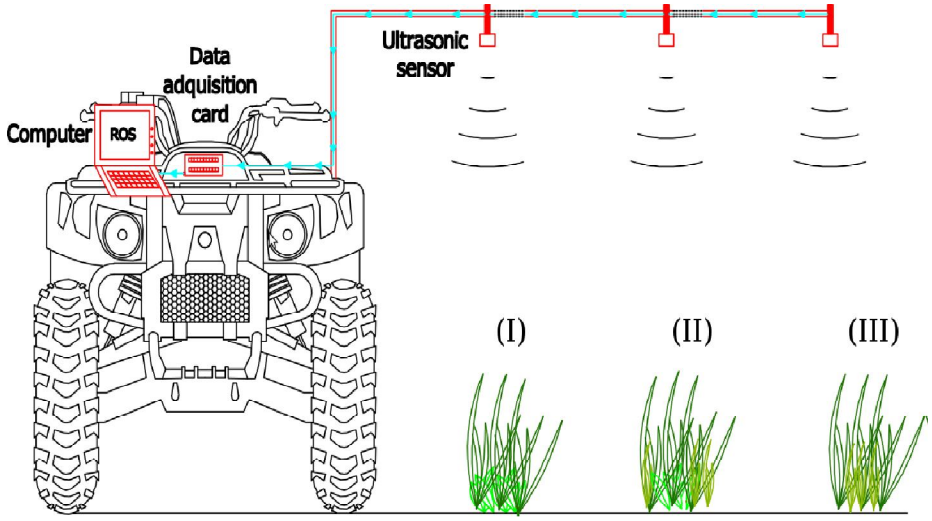

Figure 4 Schematic view of Weed Detection System

III. IOT BASED VEGETATION MONITORING SYSTEM

Internet of things, a state of art technology could be used as a simplified technique for the vegetation monitoring.

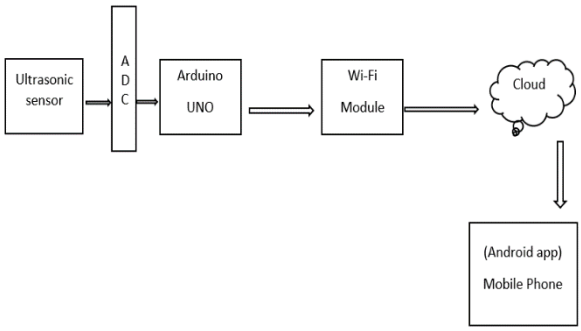

Figure 5IoT based vegetation monitoring system

In this proposed system, ultrasonic sensor is interfaced with Arduino UNO through analog to digital converter to check the height of the plants or grasses. The status of the vegetation level will be uploaded on the cloud and the data can be used for vegetation monitoring at a small scale. To avoid overgrowth, decision of cutting events can be taken by the user under the consideration of the stored data and specified threshold. The data will be stored on the cloud and that is nothing but an IoT platform [17]. There are many open source IoT platforms are available such as Thing speak [18] [19], Things view, Nimbits and kaa.

A. Benefits

1) This System can be used to maintain the aesthetic management of the city by applying it in public parks, playgrounds, lawns etc.
2) Graphical output results are easy to understand.
3) No need of skilled professionals to use this system.
4) Simple and less costly

B. Limitations

1) It will not perform well when used at large scale.
2) It will be no longer cheap when used at a large scale.
3) Skilled professionals are required for the large database management over the cloud.

IV. CONCLUSION

Grassland covers vast area therefore they are monitored at large scale through remote sensing techniques. However on a small scale these techniques will be very much complex as well as costly. Specifically, for the aesthetic management of the city a technique is required which is not as much complex and can be easily understood by the horticulture department authorities under municipal corporation. Internet of things technology in combination with embedded system could be a solution which can be used for the grass monitoring of the urban landscape which includes public parks, lawns, playgrounds and golf courses.

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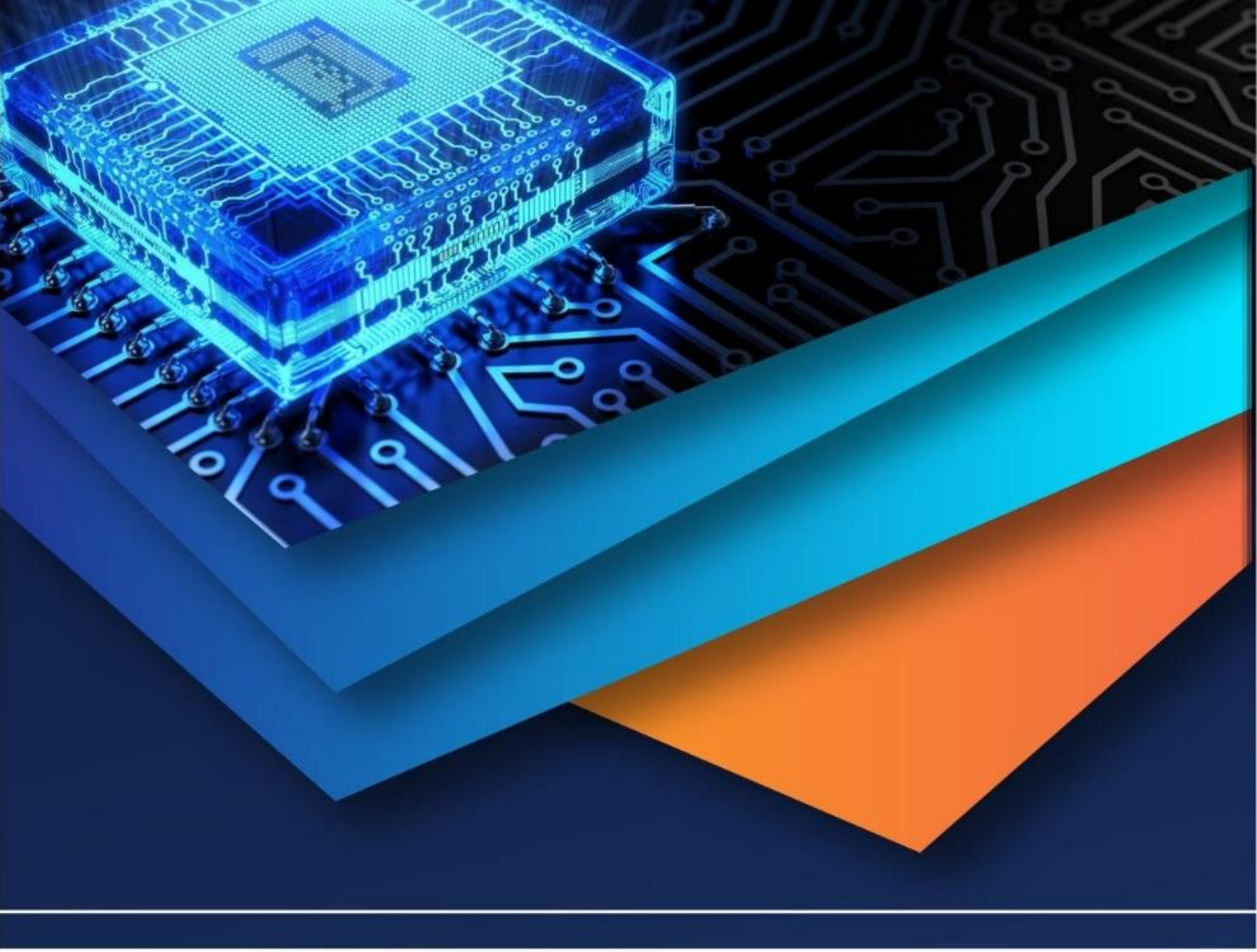

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