AFFRO-BOT Autonomous Forest Fend Robot Paper ID- 44

Subhajit Dutta
Department of Electrical Engineering,
Guru Nanak Institute of Technology,
Kolkata, India.

Achinta Das
Department of Electrical Engineering,
Guru Nanak Institute of Technology,
Kolkata, India.

Ayan Nandi
Department of Electrical Engineering,
Guru Nanak Institute of Technology,
Kolkata, India.

Dr. Barnali Kundu
Department of Electrical Engineering,
Guru Nanak Institute of Technology,
Kolkata, India.

Abstract— In the recent few years' wildlife has decreased rapidly in spite of having conservation and preservation zones due to lack of maintenance due to wild animals and dense and vast vegetation as well as natural and man-made catastrophes. With advancement in technology Robots can act as great first responders reaching difficult parts of the wildlife vegetation without interrupting the ecosystem and maintaining the biodiversity of the environment with different sensors to detect the change of climatic conditions, it can also be used for surveillance for illegal trespassing as well as poaching in the wildlife vegetation. The collected data is transmitted in cloud database to keep a record of changes in the wildlife ecosystem, species populations and vegetation over a certain period of time, based on which quick response can be provided to prevent any damage from happening and ensuring safety and healthy growth for our biodiversity.

Index word: - Cloud database, surveillance, poaching, illegal trespassing, quick response

1. INTRODUCTION

A flourishing life on land is the foundation for our life on this planet, people directly depend on forests for their livelihood and forest are home to more than 80% of all terrestrial species of animals, plant and insects. Although being a part of the planet's ecosystem and we have caused severe damage to it through deforestation, loss of natural habitats and land degradation. Although we all are part of the planet's ecosystem and we have caused severe damage to it through deforestation, loss of natural habitats and land degradation, trespassing as well as poaching of wildlife and vegetation for our desire and needs. These actions still continue in deep and dense vegetation even in the conservation and preservation zones due to lack of supervision of the areas which results in loss of flora and fauna . It is not only important to protect the wild habitat but also to put a stop the wildlife trafficking as well as preventing catastrophes before it even spreads. Robots can reach dense part of the forest and can act as a great first responders without disturbing the ecosystem due to its size.

There are more than eight million different species. It is important to measure and keep records of the change in diversity to monitor and conserve. Robot can collect and store data of the change in climatic condition based provide information, calamities can be prevented from spreading and causing huge damages to the biodiversity, it also provides information about illegal trespassing, poaching and interference of human with the wildlife without interfering or disturbing the ecosystem and avoiding any harm to the biodiversity of the ecosystem.

The practical significance of the work lies in the fact that a working functional prototype of the robotic platform has been developed, thus allowing its future development in the direction of a full industrial prototype.

2. FUNCTION OF THE FORESTER ROBOT

These following functions of the robot, based on the current literature on the subject are as follows:

a. Movement with the help of both caterpillars and pacing mechanism
b. Navigation and orientation of the robot
c. Provide information about the climate and weather change
d. Provides data in change of in the biodiversity of the place
e. Counting the number of trees in the forest area and their classification (determining the type of each tree)
f. Can also acts as surveillance for human trespasses and interference
g. Can withstand harsh weather and animal attack as well human attacks
h. Eco-friendly (does not disturbs the ecosystem or harm as animals

3. LITERATURE SURVEY

3.1 *IMPORTANCE OF BIODIVERSITY*

Biodiversity is the most important factor to all the living organisms as well as the health of the ecosystem. It provides foods and other materials and also contributes to our economy, and the most important part of it that it make life on earth possible which include cleaning of water , cycle of life and many more, it also allows the ecosystem to adjust to disturbances like fire, flood, etc. and also helps the species to adapt to the changes in their environment. There are several levels of biodiversity, each indication how diverse the genes, species and resources are in a region. There are diversities in between

- Individual
- Subspecies
- Species
- Biological communities
- Ecosystem

The diversities are: -

- Species Diversity
- Genetic Diversity
- Ecosystem Diversity
- Functional Diversity

3.2 THREATS TOWARD BIODIVERSITY

With time, all habitat that existed on the face of earth has undergone evolution and extinction gradually over time due to natural shifts of their surroundings that occurred over a long period of time. At present time extinction has rapidly accelerated at a dangerous rate due to natural as well as non-natural change of ecosystem caused by human activities. Some of the activities have direct effect on the ecological biodiversity such as loss of habitat, degradation, over exploitation, spread of invasive alien species) and diseases while some activities have indirect but wide-reaching impact on biodiversity such as climate change and pollution.

These threats imposes a serious strain on the biodiversity, about one third of the species are endangered which includes 29% of amphibians, 21% of mammals and 12% of birds, in spite of having preservation and conservation zones, illegal trespassing and poaching of wildlife still occurs in dense vegetation, these threats also puts a possibility of another mass extinction with dire consequences to the ecosystem, human health and livelihood as well as loss of national property and treasure.

3.3 IMPLEMENTATION OF TECHNOLOGY TOWARDS BIODIVERSITY

Every ecosystem has its own unique biodiversity which is a key measure of the health of any ecosystem and of our entire planet. There are several levels of biodiversity, each indication how diverse the genes, species and resources are in a region. In order to observe and conserve biological diversity, it is important to collect data about every factors involving the biodiversity of a place at every level of diversity in different parts of the world. With advancement in technology robots can replace humans in order to collect and store data as well as provide information about calamities as well as illegal trespassing, poaching and interference of human with the wildlife without interfering or disturbing the ecosystem and avoiding any harm to the biodiversity of the ecosystem

.

The robot uses different sensor to collect data of its surrounding like the weather condition, such as temperature, humidity, precipitation, air quality, which is helpful in predicting the upcoming disasters like low precipitation, low humidity, high temperature is a sign of possible fire break out if this conditions are satisfied with traces of smoke in the air and alarm from the heat sensor then a fire has broken out, then again like with high precipitation, with raise of water level can also be a possible sign of flood, the robot collects the data without disturbing the ecosystem. The robot is also equipped with a camera so it can act as a surveillance, looking out for trespassers as well as animals needing help with the proper information and location of the place, the collected data is sent to the receiver's end, to the user and stored in a cloud database for future use. Robots have the potential to be a means to solve the problems of conventional monitoring methods and to construct a huge monitoring system. Table 1 shows the positioning of the environmental monitoring robot. The author is aiming to propose a monitoring method that is safer and more mobile (more flexible) than the conventional methods. It is not necessary for a human to take the trouble to go to the observation point if mobile robots can be used.

Table 1: Comparison of different methods

	Trace by human	**Biologging**	**Spot Sensor**	**Trace by human Biologgi Spot sensor Mobile rob with sensor (This study)**
Human labor	Need continuous monitoring	Finding animals and installation	Only at installation	Only at installation
Safety	Needed to stay in the danger area	Danger in dense forest	Needed to stay in the danger area	No danger faced by human body
Flexibility	Flexible to change the location	Rely on animal behavior	Unable to measure except the fixed place	Flexible to change the location

4. ROBOT DESIGN AND SOFTWARE

Every ecosystem has its own unique biodiversity which is a key measure of the health of any ecosystem and of our entire planet. There are several levels of biodiversity, each indication how diverse the genes, species and resources are in a region. In order to observe and conserve biological diversity, it is important to collect data about every factor involving the biodiversity of a place at every level of diversity in different parts of the world. On basis of which Autonomous forest fend also known as AFFRO-Bot is designed it uses ATmega1280 microprocessor controlled by a proprietary Robot C language software developed by the author.

The robot uses different sensor to collect data of its surrounding like the weather condition, such as temperature, humidity, precipitation, air quality, which is helpful in predicting the upcoming disasters like low precipitation, low humidity, high temperature is a sign of possible fire break out if this conditions are satisfied with traces of smoke in the air and alarm from the heat sensor then a fire has broken out, then again like with high precipitation, with raise of water level can also be a possible sign of flood, the robot collects the data without disturbing the ecosystem.

The robot has two modes of control manual mode when it is controlled by the user with the help of a radio frequency controlled controlling from a distance and providing command to the robot to act on, while in autonomous mode it detects obstacle with the help of a camera and ultrasonic sensor approximating the distance between itself and the obstacle is improvises its path avoiding the obstacle , equipped camera is mounted on a pivoting mechanism so it can act as a surveillance, looking out for trespassers as well as animals needing help with the proper information and location of the place, and also used for navigation and orientation. the collected data is sent to the receiver's end, to the user and stored in a cloud database for future use.

By directing the camera, it selects some tracking points from each received frame received and compares the same points in all the adjacent frames to determine its position according to the its starting point, the algorithm is:

4.1 Collision Avoidance

It is important for the robot to have the ability to avoid collision with trees or other objects , animals while moving in the real environment, it is also important that it should high responsiveness, not only for dynamic obstacles but also for obstacles suddenly invading its path as well as its observation range of its vision system while it is moving. . Therefore, a collision avoidance behavior was designed as reactive motion using the following two parameters.

• Object Ratio N_{np} - A number of points existing in the vicinity where there is a possibility of contact with the robot among the three-dimensional point set acquired from the depth sensor.

• Space Ratio ρ_{sr}- A ratio of points number other than neighborhood points to whole points number.

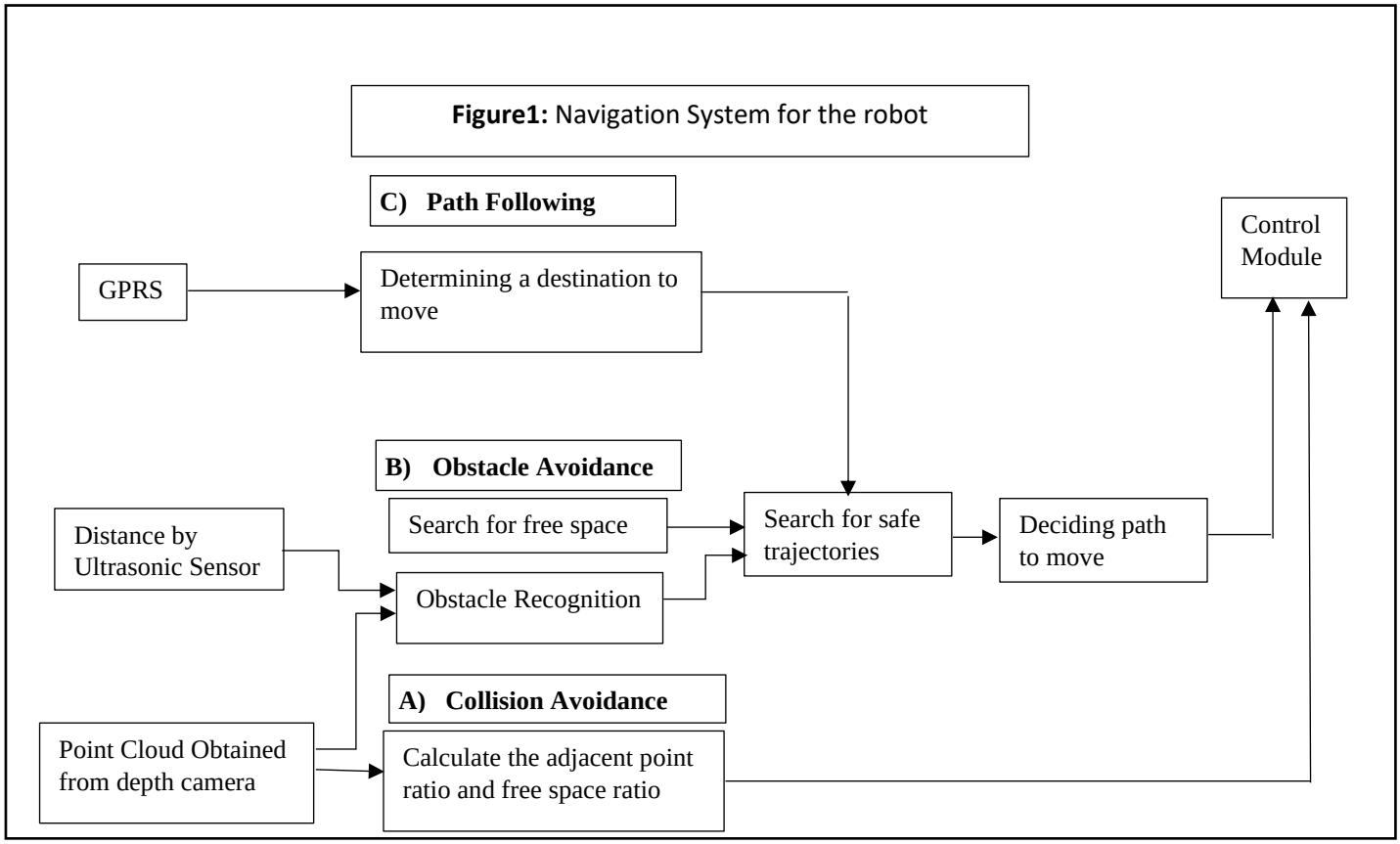

Figure1: Navigation System for the robot

If there is an object in the neighborhood of the robot and there is a possibility of collision, there will be many scanning points on its surface, and considering occlusion of the sensor, the points other than those in the neighborhood will be low. Therefore, expression of the collision avoidance behavior is determined by these parameters and threshold values N np and ρ sr. The condition that decides output collision avoidance behavior is when Nnp > N np ∩ ρsr < ρ sr, and whereas other conditions allow the robot to move forward. This behavior was designed such that the robot could move backward after forward progress was no longer possible.

4.2 Obstacle Avoidance

A motion planning for obstacle avoidance is performed based on State Space Sampling [10]. State Space Sampling method generates a set of feasible actions derived by sampling in the surrounding state space. In the system, from this action set, a secure trajectory and control input capable of avoidance for obstacles will be able to found. The system generates a lookup table by state space sampling method after startup.
While moving autonomously, at first, recognition of obstacles is performed by the procedure. The point cloud representing the external situation will be collected via the depth sensors. After removing the noise contained in the raw point cloud, points are projected to the xz-plane and performing the clustering process based on the distance of each point. Finally, the boundaries of each obstacle are computed. Then the state vector and the control input corresponding it without obstacle collision will be extracted from the lookup table To detect collision the robot with an object, it checks that contacting of the circle of radius r with a boundary of the obstacle for every constant interval on the calculated trajectory Finally, the set of terminal state and control input that providing the safety trajectory will be output from the subsystem of obstacle avoidance.

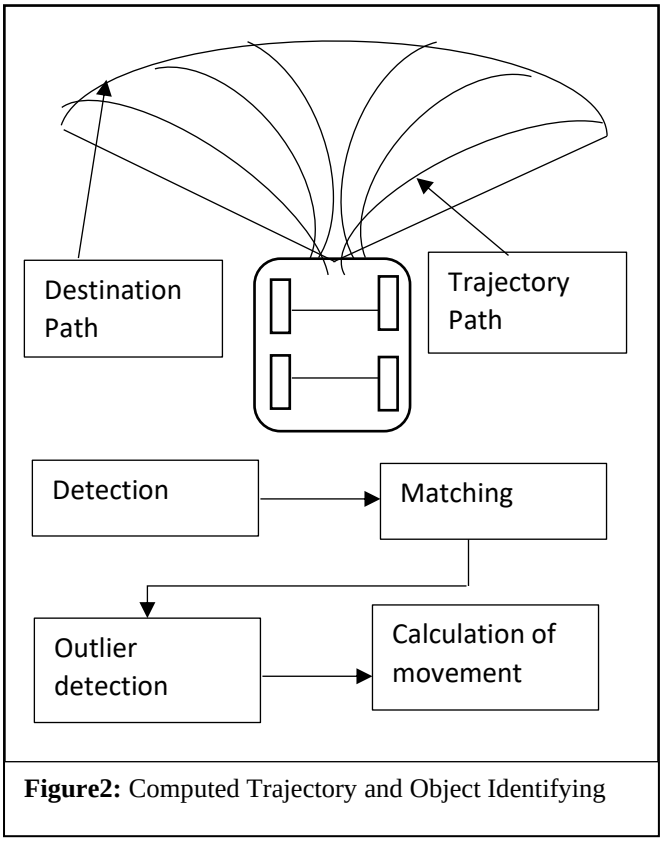

Figure2: Computed Trajectory and Object Identifying

4.3 Path Following

For following of paths generated by a path planning subsystem. The path planning subsystem would generate the set of vertices and edges to traverse entire the area. The relative positions of the objects in this area that might impede the movement of a robot determined by GPS. The positive directions and oriented true north and true east, respectively. Based on the dimensions and the width of the path between the trees, an undirected graph was developed, the adjacencies represent pairs of trees at a line-of-sight distance from each other, however, the behavior that both of the obstacle avoidance and path tracking were carried out, the robot reached point B. The robot can also find its way back to the path or to its hub while it is lost or it is running on a low battery level. In the real environment such as an artificial forest constructed in a forest mountain, there is a possibility of falling to a cliff or others existing near a work area. To solve the problem, it is necessary to improve the motion planning including the backward movement of the robot to solve them.

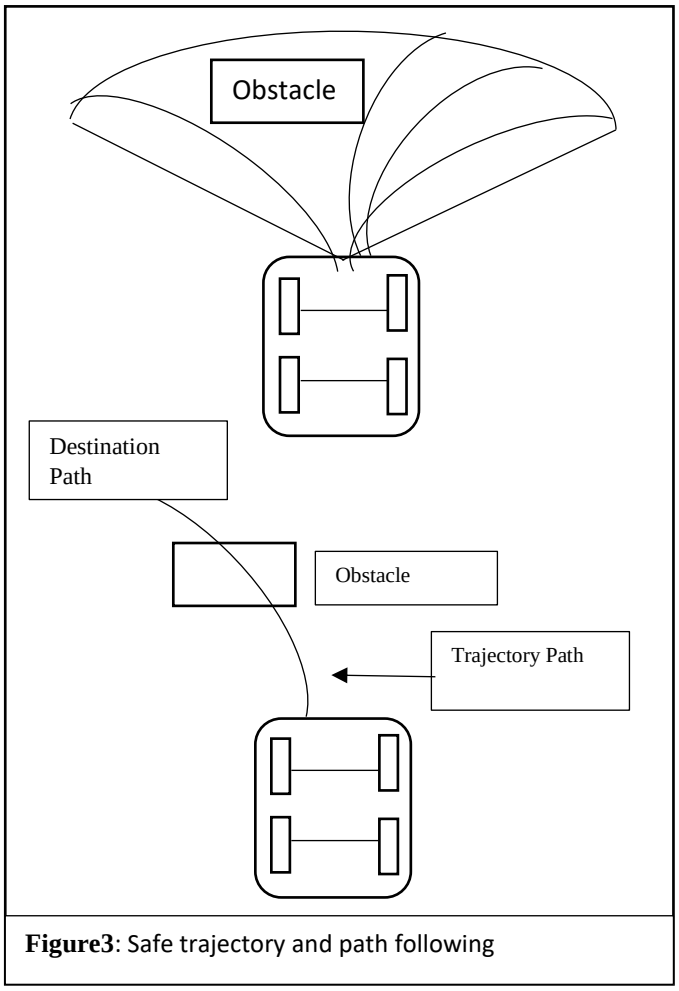

Figure3: Safe trajectory and path following

4.4 Model

It's a prototype mode based on the researches above and some common materials found and electronics such as Atmega1280 and some sensors and components as follows: -

4.4.1 Chassis

The model is made with hard plastic for the time being which forms the base of the robot which holds all the components and takes all the weight of the robots. The chassis is a cuboidal enclosure with components properly shielded from fire, water, dust and foliage. It is connected together using detachable connectors to keep the robot modular. It should be able to withstand hush climatic condition as well as animal attacks

4.4.2 Drive train

Forest are a difficult terrain, where tracked wheel mechanism is best suited since it has high traction and a good max slip angle for this environment. But for the time being we are using wheels to move although we will be upgrading to tracked wheels in the nearby future, because with tracks, the weight of the robot gets distributed over a wider area so that ground sink age is low and traction increases. It is powered by 4 motors 2 at each side to move around.

4.4.3 Power Management System

The robot cannot rely on tethered power supplies and so must carry batteries. The battery voltages, current and power requirements are dependent on the exact hardware to be used. For the hardware selected for this robot, two 12V li-ion battery is used to powered the model for the sensor and other electronics 5V is required which Is drawn from the battery as well

4.4.4 Sensors

The major electronic components on the robot are the sensors, drivers and microcontroller. There are sensors, such as humidity and temperature sensor, fire sensor, ultrasonic sensor, motion detecting sensors, water level and gas sensors which collects the data of its surrounding and measure the change in the climatic conditions around it, it also has a navigation sensor like GPRS, Only the sensing unit of the sensors will remain outside, the rest of the circuitry will be placed inside the box

Components	Quantity	Specifications
Es32 cam module	**1**	**5v**
Esp32 node MCU	**1**	**3.3v**
Atmega328P	**1**	**5v**
L298n H-Bridge motor driver	**1**	**12v,5v**
Servo motor	**1**	**5v**
Ultrasonic sensor	**1**	**5v**
PIR motion detector sensor	**1**	**5v**
Smoke sensor	**1**	MQ11, 5v
Flame detector Sensor	**1**	**5v**
Relay	**1**	6v
motors	**4**	6v 200rpm
Wheels	**4**	
Li-Po battery	**1**	12v 1500mah
Buzzer	**1**	
SMD BOD board	**1**	4v
Solar panels	**1**	
Water level sensor	**1**	

Table 2: List of components

PROTOTYPE:

Figure4(a): Side view

Figure4(a): Front view

4.5 Test result and Discussion

During testing the robot is placed in a small local area to collect some data over a short period of time. The robot continuously collects the data of its surroundings such as temperature, humidity as well as the carbon absorption. Few data have been collected by the prototype over a short period of time like temperature, humidity and air quality of its surroundings as shown in Figure 5(a), Figure 5(b) and Figure 5(c) respectively. The collected data show the variation of the temperature, humidity of the place over a period of time. The robot has also been tested with smokes to check the amount of carbon dioxide present in the air. Although the robot is able to withstand harsh climatic conditions as well as animal attack, it is threatened by human attacks due to which it can be damaged severely and due to its small size, it can be carried away. The robot body camouflages to prevent its detection so that human attacks can be prevented to a certain extent.

5. CONCLUSION

With the current prototype we can collect the data, provide video as well as it can move in rough terrains manually as well as automatically over a certain range of area. It's still under development and with some more upgrades it can save some extent of our wildlife ecosystem. With the collected data it is only possible to prevent destruction from calamities up to

a certain extent. With the help of this robot the most dense parts of the vegetation can also be guarded to ensure safety of our wildlife habitat from poaching and trespassers, with the information provide about these illegal trespassers like the location of their hideout and the equipment they have, so we can act immediately in order to put a stop in this illegal wildlife black market to ensure safety and healthy growth of the biodiversity and help in maintaining proper ecosystem to help them grow.. Upgrading to a radio frequency-based microcontroller so that it can operate without network issues and provide data and feeds of its surroundings. Installing a powerful motor to move in tough terrains and hard body to withstand harsh weather and attacks and installing return home feature so that it can return home on its own when it is low on battery

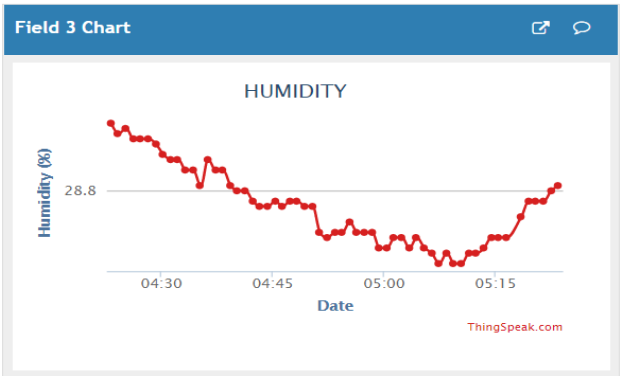

Figure 5(a)- variation in Humidity

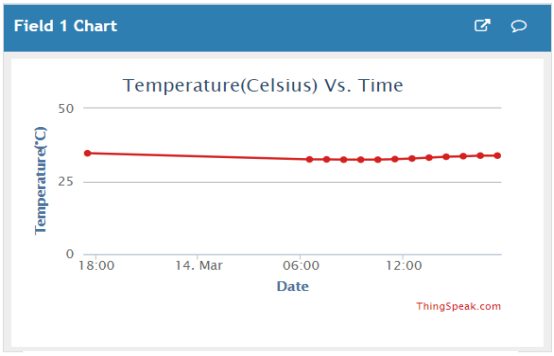

Figure 5(b)- variation in Temperature

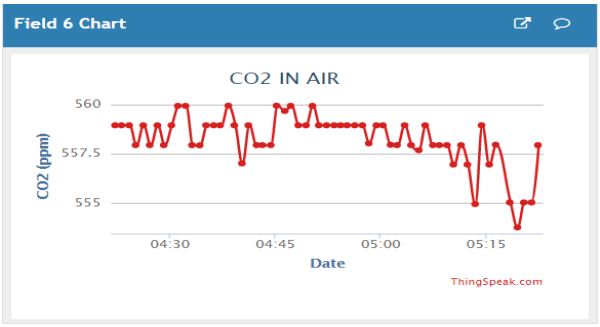

Figure 5(c)- Amount of CO_2 in air

6. REFERENCE

1. László FÖLDI, Rajmund KUTI, "Characteristics of Forest Fires and their Impact on the Environment", Academic and Applied Research in Military and Public Mgmt. Sc. , vol.1, pp. 5-17, 2016.
2 P. Forsman, A. Halme, "3-D mapping of natural environments with trees by means of mobile perception", IEEE Transactions on Robotics, Vol.21, No.3, pp.482 □ 490, 2005.
3. Wildlife Protection Society of India, (2003) *The Wildlife (Protection) Act, 1972* . Professional Book Publishers, New Delhi
4. http://www.wii.gov.in/nwdc/(2005)
5. http://www.wii.gov.in/envis/activities.html(2005)
6. http://www.unesco.org/mab/nutshell.htm(2005)
7. http://gov.ua.nic.in/conres/asan.pdf(2005)