ROS BASED STEREO VISION SYSTEM FOR AUTONOMOUS VEHICLE

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***Abstract*—In this paper, we have designed a autonomus vehicle which is cost effective and powered by Robotic Operating System (ROS). The vehicle is capable of maintaining a constant speed and distance for monitoring or surveillance.**

ROS is implemented for trajectory tracking and telemetry. A low cost compact on-board embedded system powers the vehicle.Various image processing techniques are been implemented for navigation and obstacle detection. Artificial Neural Network which helps in finding the shortest path by using the acquired data from image processing.

Different controllers were implemented for movement and obstacle avoidance including PI and PID. The performance were compared and the results are also discussed in this paper.

***Keywords*—**

I. INTRODUCTION

While the field of robotics has been developing significantly in recent years, robots still have a very long way to go before autonomous systems are viable in complex real-world situations. Autonomous robots are intelligent machines capable of performing tasks in the world by themselves, without explicit human control. In controlled conditions, autonomous robots have proved to be extremely successful. The problems with autonomous systems in the real-world are numerous. A robot must have some way to perceive its environment, but it becomes difficult to logically process only the data that is relevant, while ignoring the mountains of data that is not. A robot must have some way to localize its own position, but must be prepared to maintain this state even if any given sensor may not work. A robot must have some way of changing its position, but must be able to perceive exactly how its position is actually shifting. A fully autonomous robot must be able to make decisions to change its position based on the world it perceives; it should be noted, however, that this project does not include artificial intelligence within its scope.

II. MECHANICAL DESIGN

The vehicle is fabricated in acrylic sheet for weight reduction . The vehicle is designed to accommodate a payload of 2Kg (Max.)

The modeling is carried out using Dassault systems-Solid Works (Fig. 1).

The vehicle is divided into three stages together measures 230 mm in height which is capable of accommodating the motors, motor drivers, camera's , battery, micro controller and single board computer.

Each stage of the vehicle has 80mm gap between them which is used to accommodate various components. All the three stages are connected with specially machined clamps.

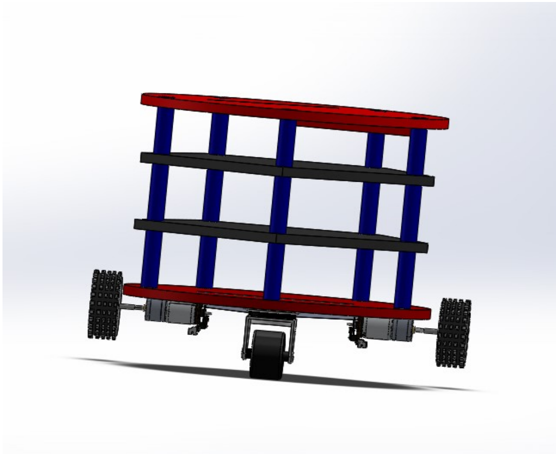

Fig.1 Model of the vehicle

The motor used is 100rpm DC geared motor with a torque of 20Kgcm.

The vehicle uses Differential drive system. Which allows the rear wheels to rotate in opposite direction thus making it turn left and right

The following is the equation for Differential drive system :

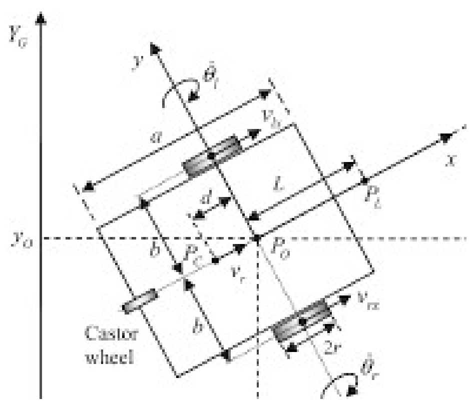

Fig.2 Differential Drive System

III. CONTROL SYSTEM

The vehicle is intended to have position lock and autonomous navigation for which a appropriate control system is to be developed. The control parameters are the acceleration of the vehicle.

The position of the vehicle is obtained through feedback from accelerometer mounted at the centre of the vehicle. The position feedback is split into x and y components using I2C protocol in the controller. After obtaining these values, the controller process the data and makes corrective actions using the feedback loop control.

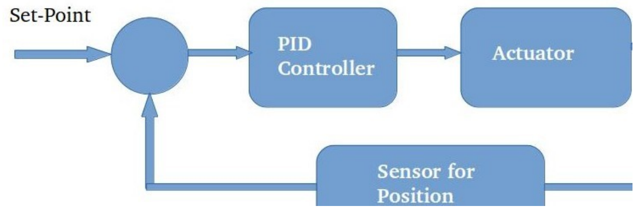

Fig.3 Block Schematic of Control System

The position feedback is obtained from the accelerometer and gyro. These values are compared with the set-point and appropriate error signal[4] is generated and fed to the PID controller. The PID controller[1] upon receiving the error signal, generated the correction signal and feeds it to the drive unit for acceleration. The error signal is generated using the PID algorithm:

$$u(t) = K_p e(t) + K_i \int e(T)\,dT + K_d \frac{d}{dt} e(t) \qquad (2)$$

The simulation of the above algorithm was carried out in Scilab Xcos for predicting the behavior of the system. It was found that PID controller[1] is more suitable for position lock and autonomous navigation compared to PD[6] and PI controller.

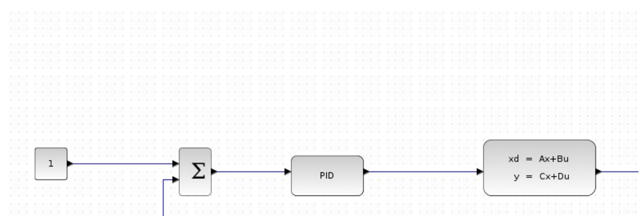

Fig.4 Simulation of PID controller in Scilab Xcos

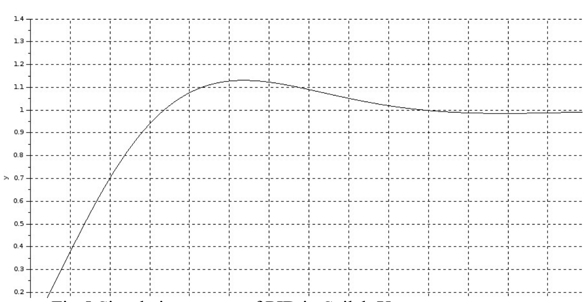

Fig.5 Simulation output of PID in Scilab Xcos

IV. ELECTRONIC INTEGRATION

The control signals from base station is transmitted to the on board computer via ROS (Robotic Operating System) using wireless communication. These signals are transferred by the single board computer to the micro-controller to initiate appropriate action sequence.

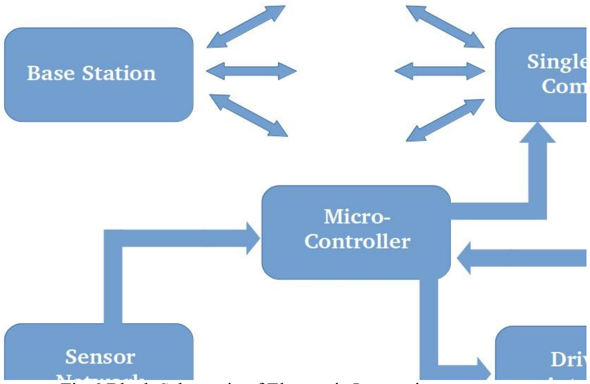

Fig.6 Block Schematic of Electronic Integration

A. Micro-Controller

The micro-controller, upon making decision based on the program/algorithm, initiates the driver unit for actuation. The actuation feed back is received by the controller via sensor network. This feedback is used for executing the PID controller[1] algorithm by the micro-controller.

The controller used is ATmega 2560 with a maximum operating voltage of 12 V. It has 54 digital input pins and 16 analog output pins with a flash memory of 256 KB. The clock speed is 16 MHz.

The sensor network also transfers other relevant data including position of the vehicle, visuals captured by the on-board camera etc. These data are transferred to the on-board computer and is transmitted to the base station.

The ESC used is 20 amps capable of withstanding up to 70000 rpm with a self weight of 0.021 Kg. The refresh rate of throttle signal is 50 Hz to 400 Hz.

Fig.7 Electronic Integration

B. Robotic Operating System

ROS is a unique open source platform for communication, data acquisition, image processing, modeling and other features required for robotic applications. It is highly reliable and has a impressive speed of response. In this application, the communication feature of ROS is utilized which makes it faster to communicate with the vehicle.

While transmitting control signals from base station to vehicle, the ROS in base station acts as a publisher and the ROS at on-board computer acts as a subscriber.

While transmitting sensor feedback from vehicle to base station, the ROS in base station acts as a subscriber and the ROS at on-board computer acts as a publisher.

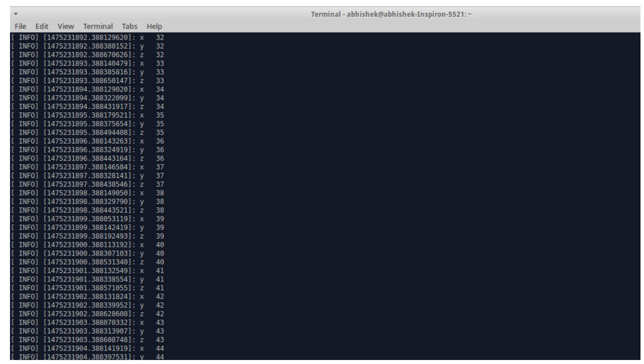

Fig.8 ROS at On-board computer acting as Publisher

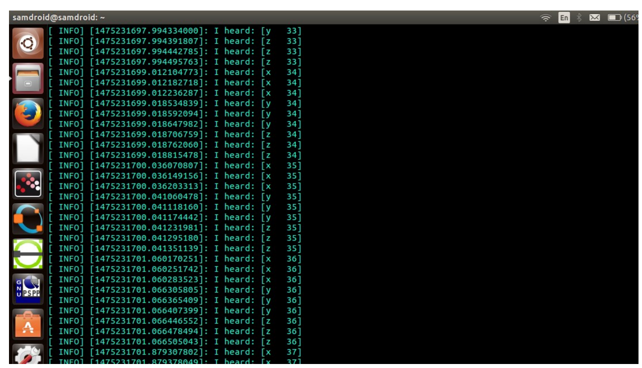

Fig.9 ROS at Base station acting as Subscriber

C. Image Processing

Image processing is done using OpenCV which is a open source software. Various image processing techniques such as pattern matching, edge detection and other morphological operations. Vision system also generates a map that can be used for future reference so that the Artificial Neural Network can use it to take decisions on which path to take in the future .Stereo vision system is used for finding distance between object and vehicle using triangulation method which gives us the feedback for navigation. The vision system uses two cameras in the same plane.

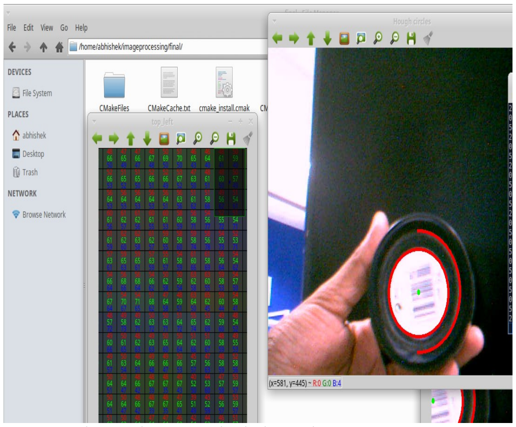

Fig.8 Distance calculation using opencv

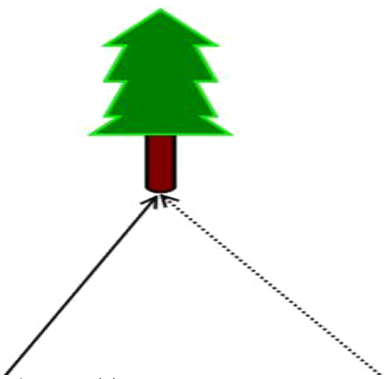

Fig.9 Stereo vision system

V. IMPLEMENTATION

The autonomous vehicle is successfully implemented with position lock and autonomous navigation. Use of ROS for communication enhanced better response between systems. Sensor data were accurate and was useful in achieving position lock and autonomous navigation.

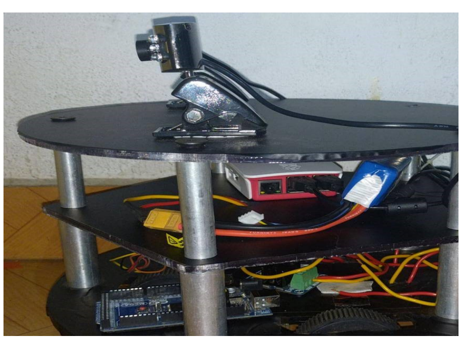

Fig.10 Implementation of Vehicle

VI. RESULTS AND DISCUSSION

The vehicle designed is capable of flying at the required altitude and the semi-autonomous navigation[2] is smooth.
It was observed that the PID controller[1] is more suitable for the vehicle for position lock and autonomous navigation. The performance was good.
Integrating ROS helped in smooth communication with base station and the testing with Scilab was successful and gave a good idea about the performance and was useful in manual tuning of PID controller.

VII. CONCLUSION

A ROS based semi-autonomous vehicle[3] with position lock and autonomous navigation is successfully developed and tested. The vehicle is cost effective as most of the components (hardware and software) used are pen source[3]. The vehicle may be used for surveillance, for medical applications like spine scanning, or for agricultural purposes.
In future, image processing may be integrated for a better performance and also may be utilized for autonomous navigation[2].

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REFERENCES