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Three – Dimensional Reconstruction of Surfaces with Analog Sensors

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Abstract
3D Reconstruction of surfaces in simulation software like MATLAB, Unity 3D and WebGL with analog sensors is a major area of growing interest. Existing and improving technology like AR core and other Artificial Reality/Virtual Reality technologies work with computer visionprocessors and motion tracking cameras with other depth sensors are the go-to technologies now to map surfaces or terrains. The problem is that this kind of technology is still in its initial stages and is not economically viable. Google's Project Tango is a project to develop a consumer device via which they could map the environment is an example of such technologies. This paper deals specifically in applications which can use analog sensor arrays to map the surroundings around them to create a 3D map of their surroundings and execute their application pertaining to a certain logic defined by the designer. This paper proposes a novel cost-effective method of immediate surface mapping which can be integrated into diverse technological applications. Proposed methodology is validated by a design validation prototype experimental setup. Paper also proposes how the proposed methodology can be used in an autonomous quadcopter landing application. This method will serve as a very cost-effective alternative to traditional mapping techniques.

Keywords – Autonomous, Sensor array, Three-Dimensional, Quadcopter, Project Tango, Artificial Reality, Virtual Reality.

1. INTRODUCTION

1.1 Problem Statement

In the normal world, mapping of surrounding for autonomous bodies have become atedious task to reduce which comes in the implementation of the automation techniques.The objective for us in this regard was to implement a three-dimensional map for theproximity data of the surroundings hence implementing a terrain mapping system.

1.2 Existing Methodology

The current system has either accuracy or cost being at extremities for which the mappingprocedure is followed upon. Hence a parallel conclusion with either method to befollowed by a normal individual is the major issue. Also, laser optical rays cannot beused at every point if energy conservation is a growing demand in this world. Hence asan alternative to it comes infrared rays which may not be accurate up to the respectivewavelength but can be used as a substitute to combat cost criteria for usage.

2.EXPERIMENTAL METHODS OR METHODOLOGY

In this paper, we will be using analog sensors like an ultrasonic sensor, IR sensors and Time of flight

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sensors to map the environment around us and can be extended to map the terrain. The environment around the sensor can be mapped efficiently but mapping the terrain would be a challenging task. Analog sensors are the type of sensors which will give a continuous output in one form or other depending on the sensor. Robotics, navigation, localization, mapping are some of the principal fields this type of technology can be applied. The design would be receiving the sensor values from the sensors pointed towards the terrain and simultaneously mapping these values using simulators to create a 3-dimensional structure of the environment and a rough terrain map. This sort of technology is already being practiced by the military in combat and rescue helicopters to comprehend the terrain height in their presence. Employing analog sensors which have a very pinpointed field of vision(range) for this sort of approach and successfully executing this would be an immeasurable headway in this field. By developing this project, we can introduce a novel way of surface modelling and rough terrain mapping with low-cost analog sensors.

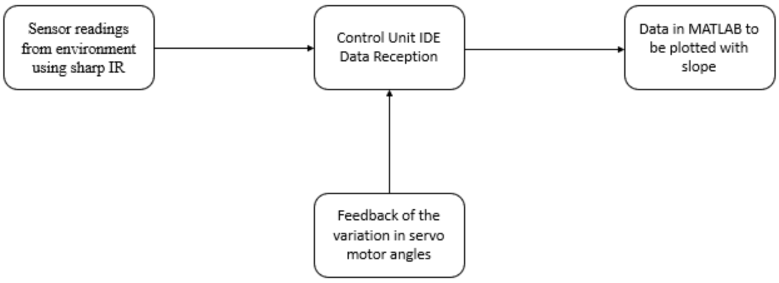

Fig 1.1 Brief Steps in Plotting the surfaces in Simulator

Fig 1.1 shows how the flow of the Surface simulation occurs.

3. SYSTEM DESIGN

3.1 Model Setup

The hardware unit shown in Fig 3.1 of the entire system contains mounting an array of Sharp IRsensors upon a servo motor to acquire the position and angle upon its motion.These raw values obtained from the IR sensors were fed to a microcontroller to be converted intodistance of the surface being measured at that instant and the setup. Setup contains sensors with an accuracy range between 20 meters to 150 meters and 120-degree rotating servo motor being used as a rotor. The basic model requires the Sharp Infrared Rays (IR) sensors to direct their rays to nearby surrounding and use the reflected rays for the 3D map accordingly.This hasbeen achieved by mounting the array on top of a bot (in case the structure isa wheeled body) or sometimes in the bottom of the body (in case of a flying structure).The model includes an individual power supply given to the sensors with a powersupply of 5V/2A which is subjected to a better level for safety and proper fidelity. Theservo motor used for it also needs an implementation over a height for wheeled bodies and given power supply from the controller board. This helps in reducing an excessivepower utility and hence clearly serves the purpose of being used in real world.

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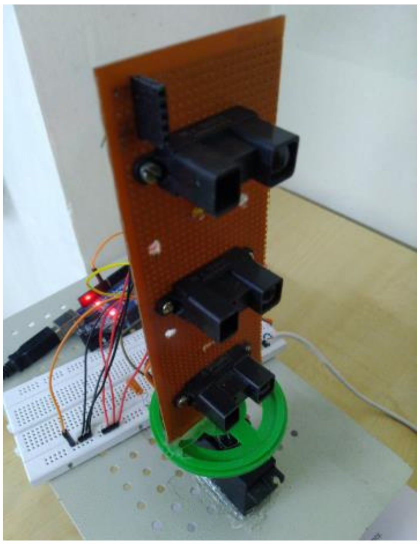

Fig 3.1 Design verification Prototype Setup

3.2 Simulation

The code has two different units being connected to each other. The first onebeing the Arduino IDE which helps in controlling the servo motor and its feedback,hence helping the direction and angular projections it works on with. At the same timethe other unit comprises of MATLAB where the proximity distances are compared andstitched together with in order to find the compatibility of the surrounding and mappingit thereafter if executed. Raw values from each sensor are stored in a string and then these strings are rounded off and plotted in the simulator which in this case is MATLAB. After which the slopes between the parallel points of two consecutive sensors is calculated and plotted which gives us an approximation of the surface.

Slope= (y2-y1)/(x2-x1)

where x, y being strings of rounded values of the values from each sensor. Executing logics with this data will lead to a new application for example Autonomous Quadcopter Landing.

4. RESULTS AND DISCUSSION

To verify the design, the design verification prototype has been placed in-front of a surface bent at a 120-degree angle which will be reflected in the graph as well.

Fig 4.1 Test Setup while plotting a surface

The accuracy of the surface is dependent on the frequency of the values being measured in one sweep of 120-degree of the servo motor. To achieve maximum efficiency, the servo is programmed to rotate 2-degree per cycle. Each cycle contains time taken by servo to go to that angle and the time taken by the control unit to take the values from the sensors.
After completing one whole sweep, the following graph was plotted.

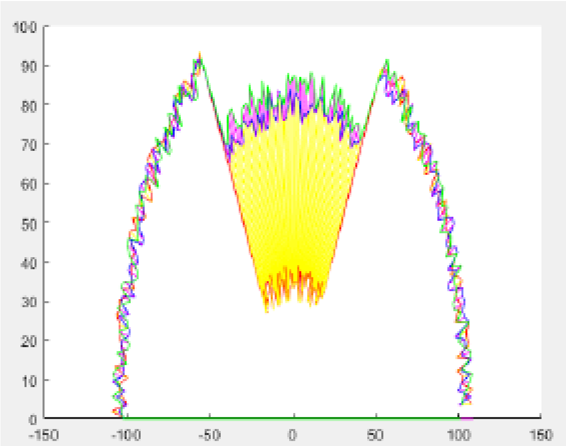

Fig 4.2 Surface Plotted using slope equations

After plotting such immediate surfaces, executing decisions based on these surfaces will lead to an application specific technology.
Using this technique, if the same method was implemented under a quadcopter, the sensor array will map the immediate landing area. Then the control unit checks whether the slope calculated between sensor 1 and 2 and the slope between 2 and 3 is same and checks if both slopes are of flat with respect to the sensor array deployment. If the Control unit concludes that the surface scanned satisfies all these conditions, then this will send a message to the quadcopter that it is a safe area to land. This suggests that this methodcan be used in an emergency landing assistance application for such small copters and in autonomous drone landing applications.

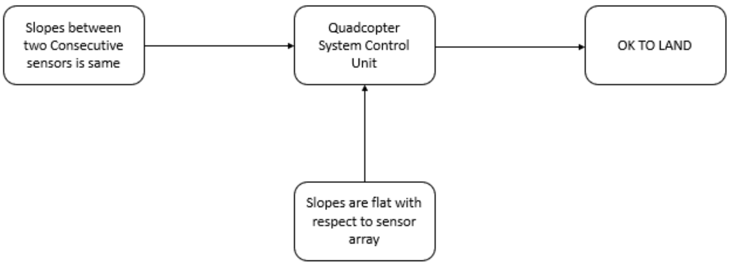

Fig 4.3 Application flow of proposed methodology

Fig 4.3 shows utility of the proposed methodology in emergency quadcopter landing application.

5. CONCLUSION

The conclusion of this entire experiment upon working was found that we can implementa more accurate result with the sensors and the range they have. However,implementing an infrared is not always an alternative nor can only implementation ofLight Amplification and Stimulated Emission

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of Rays (LASER) ray a solution. It alldepends on which kind of environment they are being deployed into. There can be alarge conclusion for what kind of system using this method for itself as this will affectthe landing and movement of the body.Sometimes rotating may have some delays in the angular projection and hence arequirement of the sensor module in a well aligned way is another major requirement.The power supply may vary as per the sensor's requirement and the controller ifreduced in size may lead to a need of using an external supply for the servo. Therecan be fidelity issues with the sensors upon environmental effects like rains or humidityat times, but not necessarily affect the proximity data to an extreme level and henceinfrared reflected rays may be affected.The overall achievement of the project needed the map of surrounding plotted insuch a way that the data can be used for navigation has been achieved yet demonstratedto a restricted area's implementation only.

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