CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
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Project Number
S1015

Project Title
Six Degree Positioning Based on Laser Plane Projection and Inertial Navigation

Abstract

Objectives/Goals
This project aims to provide 3D spatial orientation in an unknown space through the establishment of thermal patterns (beacons) on objects within the environment. Utilizing the skew, rotation, and size of the pattern, this method can derive six degree of freedom data (x, y, z, pitch, yaw, roll). The goal is to generate position and orientation accurate within 1 decimeter and 5 degrees.

Methods/Materials
The final design of the sensor unit used three 2 watt blue heating lasers. The lasers are powered until three spots are raised to a temperature 3, 6 or 9 degrees Celsius above the ambient temperature. A thermal camera mounted on a pan tilt roll servo mount track these dots. A thermometer, accelerometer and gyroscope unit mounted on the roll adjusting servo, provides the rotation and temperature data needed to filter the output of the camera. Comparing expected distances between spots to angular distance between spots produces a measurement of distance from the beacon. Viewing angle to the beacon is calculated using servo position. After conversion to Cartesian coordinates, noisy output data is passed through a dynamic filter that adjusts its parameters with accelerometer data.
To measure position accuracy, data was collected at 12 points within a 1m cube. To measure angular accuracy, data was collected at 18 points within the same cube.

Results
The engineering goal of sub decimeter accuracy was achieved and surpassed. Positional XYZ data was consistently accurate within 5 centimeters and degree data was accurate within 2 degrees. This prototype has shown higher accuracy of 1 centimeter and 1 degree within a 30 centimeter radius of the tracking dots. These results serve as a validation of the geometric principles used to conduct this project.

Conclusions/Discussion
Current indoor navigation systems use a pure inertial navigation unit (INU), Simultaneous Localization and Mapping (SLAM), stereo cameras, or a radio beacon. Combining the benefits of all current solutions, this system is self contained like an INU, light independent like LiDAR based SLAM, drift free like stereo cameras and accurate like a radio beacon. This technology enables various applications such as beacon free indoor mapping, geo referencing underground locations, and navigation in parking structures and tunnels.

Summary Statement
This project provides three dimensional position and direction by placing thermal patterns on nearby objects and measuring their movement.

Help Received
I designed, built, and tested my apparatus and algorithms myself after conducting internet research and consulting with my physics teacher.