CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

Paul A. Dennig, Jr.

Project Number

J0909

Project Title

Fusing a ZigBee Wireless Network with Sonar and Infrared Sensors in an Indoor Navigation System for Alzheimer's Patients

Abstract

Objectives/Goals

My objective is to identify the best way to build an indoor navigation system that can help Alzheimer's patients find their locations at home and receive cues for accomplishing daily activities. My research question was whether ZigBee (XBee) radios by themselves would be sufficient in measuring distances indoors or whether they would perform better when combined with Sonar and Infrared (IR) sensors. I predicted that the fusion method would be more accurate since the received radio signal strength (RSS) decays as log (1/r^2) and can be affected by environmental factors.

Methods/Materials

First, I studied the advantages and limitations of XBees, Sonar, and IR by testing them against six drawback factors, each with two or more levels. I hung a barrier corresponding to a drawback factor on a 5 ft by 5 ft plastic frame. Then, I tested each sensor over 6.5 meters in 0.5m increments, recording 30 measurements for each distance, then repeating the whole process for each barrier. I also did a control run with no barriers. I then compared my data to measurements based on mathematical formulae. Second, I took the best combination of sensors for each environment and implemented it in a 2-D prototype.

Results

Without barriers, RSS decayed from -30 dBm at 0.5 m to about -50 dBm at 6.5 meters, as predicted by my formula, and the accuracy was high at 95%. When metallic barriers were used, the accuracy dropped to 37% at 0.5 m. Reflective surfaces affected IR significantly and porous materials confused Sonar. The main problems for Sonar were from outliers in the data, which were caused by Sonar's wide beam catching side walls in the testing area.

Conclusions/Discussion

I correctly predicted the XBee control data based on my equations; however, I didn't expect XBees to be this robust in the absence of drawback factors. My hypothesis about the fusion method as being more effective is accurate. Each tool has its strengths that can be utilized in different areas of a building. Radios are best for long non-line-of-sight paths while Sonar is best for shorter, open, direct distances and is not affected by metal. IR is good for .5 m to 1.5 m but needs to be positioned away from shiny objects. In my prototype, I shifted my reliance from Sonar to XBee measurements between 2 m and 5 m. In the future, I will expand this system to 3-D and test it with Alzheimer's patients.

Summary Statement

My project examines the best way to fuse ZigBee radios with sonar and infrared sensors to build a navigation system for Alzheimer's patients.

Help Received

Dad introduced me to XBees and helped me with programming and math new to me, Mom edited my writing, and my science teacher, Mr. Hu, provided support and critical input.