CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Daniel S. Yang

Project Number

S0922

Project Title

A New Radio Propagation Model at 2.4 GHz for Wireless Medical Body Sensors in Outdoor Environment

Abstract

Objectives/Goals

This project investigates the effect of antenna height, receive antenna on human body, and path distance on the loss of wireless signal power in order to systematically develop a radio propagation model for wireless body sensors. While many studies looked at only distance, this project is novel as it also examines the effect of antenna height and on-body antenna. Studying the effect of on-body antenna is central to wireless telemedicine sensors, which have notable healthcare benefits.

Methods/Materials

Received power in dBm was measured as a function of 4 independent variables: transmit (Tx) antenna heights of 1, 2, and 3m, receive (Rx) antenna heights of 1m (waist height) and 1.65m (head height), Rx antenna placed on-body and off-body, and 11 distances from 1 to 45m--resulting in 132 data points. For Tx unit, a home wireless router hung on a vertical plank was used. For Rx unit, a wireless USB device hung on a vertical stick, a laptop and spectrum analyzer software were used to measure received power.

Results

Multiple regression and t-test are used to analyze data. Significance of a variable is tested by comparing its p-value with alpha (5%); model fit is assessed using adjusted R^2 and standard deviation (sigma) of residuals. Experimental results support the 3 hypotheses that placing Rx antenna on-body and increasing distance would decrease received signal power; increasing antenna height would increase power--but only for Tx antenna. Rx antenna height has a surprising/opposite effect in on-body case, in which mean received power for waist-height antenna is significantly higher than that for head-height antenna, a phenomenon possibly due to a focusing effect in antenna pattern when Rx antenna is near the abdomen.

Conclusions/Discussion

Successive models improved as adjusted R^2 increased. Regression coefficients are incorporated in an extension of classical log-distance model to generate new on-body and off-body empirical propagation models. More accurate models allow lower Tx power margins, making devices more energy-efficient and saving battery--important in small wireless sensors. The final, off-body and on-body multiple regression models have respective sigma of residuals of 3.0 and 4.2dB (measures of model accuracy), as compared favorably to those of past studies (e.g., sigma=6 to 10dB reported). The new empirical model can be utilized to design more reliable wireless links for medical body sensors.

Summary Statement

This project collected field data on received power as a function of distance, transmit antenna height, receive antenna height, and antenna on/off the body to develop a new multivariate radio propagation model for wireless medical sensors.

Help Received

My teacher supervised the project and my parents helped me on the background research and field measurement setup.