



**CALIFORNIA STATE SCIENCE FAIR  
2017 PROJECT SUMMARY**

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**Project Title**  
**Detecting Gopher Tunnels Using Ground Penetrating Radar**

**Abstract**

**Objectives/Goals**  
This project attempts to use a Ground Penetrating Radar (GPR) system to detect the location of a gopher tunnel underground. The GPR sends electromagnetic waves into the ground. Objects in the ground (air, rocks) have properties (dielectric constant) that are different than the surrounding dirt, causing a reflection. The difference in dielectric properties causes the wave to reflect back towards the GPR. The goal is to use the strength of the returning signal to detect the tunnels underground.

**Methods/Materials**  
I used an Open Source RADAR designed by MIT for all of my experiments. This RADAR is a simple Doppler RADAR centered at 2.44 GHz. To characterize the signal from a gopher tunnel, I created an artificial tunnel and buried it in a six foot by three foot by two foot hole. After comparing a control (no tunnel) and the experiment (tunnel present), I confirmed I could distinguish the control from the experiment. Then I identified gopher holes in our front lawn and created two areas to scan with the RADAR. I took 176 RADAR measurements for each area by carefully moving the RADAR and controlling its orientation and distance to the ground. After analyzing the signals for tunnels, I dug up the front lawn to compare the GPR detected tunnels with the actual tunnels.

**Results**  
I compared the GPR detections with the presence of tunnels for two areas of the front lawn. I tracked the number of times the detection was correct and the number of times it was incorrect. The errors in detection were further separated into false positives (detecting a tunnel when one does not exist) and false negatives (not detecting a tunnel when one does exist). The false positive rate was:  $FP = 12 / 158 = 7\%$ . The false negative rate was:  $FN = 9 / 18 = 50\%$ .

**Conclusions/Discussion**  
My hypothesis was correct because in all three experiments the GPR could see the tunnel underneath the soil. The inexpensive MIT RADAR can be used as a GPR system. The MIT RADAR can be used to detect gopher tunnels as deep as 12 inches. The FP rate is relatively low. The FN rate indicates it missed many of the areas with tunnels. However, where the RADAR missed a tunnel, those areas are adjacent to areas that the RADAR did correctly identify a tunnel. Therefore if you dig in all the areas that indicate a tunnel you won't miss a tunnel because all the places that were missed by the RADAR are next to the areas you would be digging.

**Summary Statement**  
I showed that Ground Penetrating Radar can detect the difference between soil and air and correctly identify a gopher tunnel by the difference in dielectric constant in the different materials.

**Help Received**  
I showed that Ground Penetrating Radar can detect the difference between soil and air and correctly identify a gopher tunnel by the difference in dielectric constant in the different materials.