Compressive Signal Strength Mapping

in Various Fading Environments

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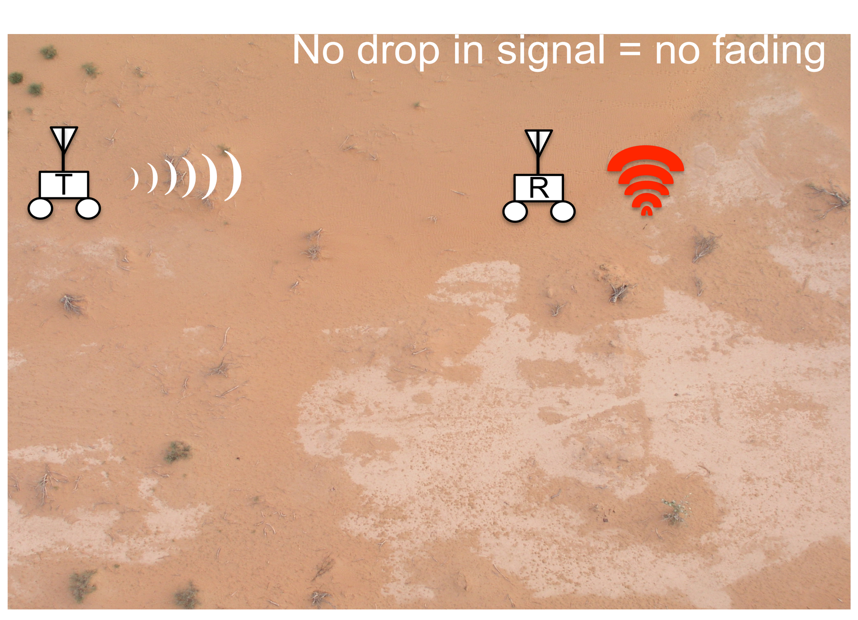
Abstract

In this project, we consider compressive signal strength mapping in various fading environments. While understanding past framework that allowed robots to build a map of an environment, we were able to analyze various environments signal strength with only Wi-Fi. By analyzing these various environments through MATLAB, we proved how each environment had a specific amount of measurements needed to produce a signal strength map. This work allowed the nodes to have prior signal knowledge of the environment before entering. Allowing nodes to avoid communication failures and ultimately accomplishing a task. Finding the right signal map for the job is the bottom line. The future of compressive signal strength mapping in various fading environments is highly evident in the progression of robot technology. The true gem is what it promotes. It promotes a safer, energy efficient and connected environment. Signal strength mapping assists us in our ability in multiple applications: search and rescue, see through wall imaging with only Wi-Fi and communication aware robotics. Overall, supplying the public and industries with an effective communication tool can inspire and motivate, leading them to explore new possibilities in the future.

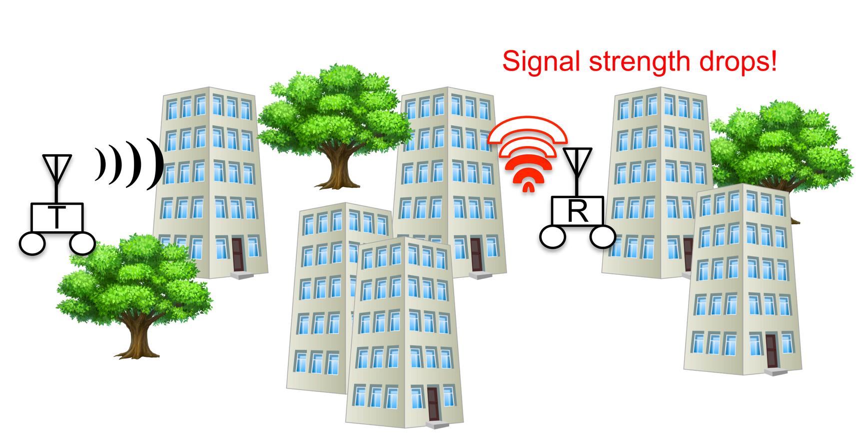
Methods

1. Signal strength is measured in power between a transmitting robot, which is the transmitter, and the receiver robot, which is the receiver. The transmitting robot transmits a known signal, which the receiving robot will receive. Since the receiving robot knows what the transmitting robot has transmitted, it can calculate the signal strength in various locations in an environment.

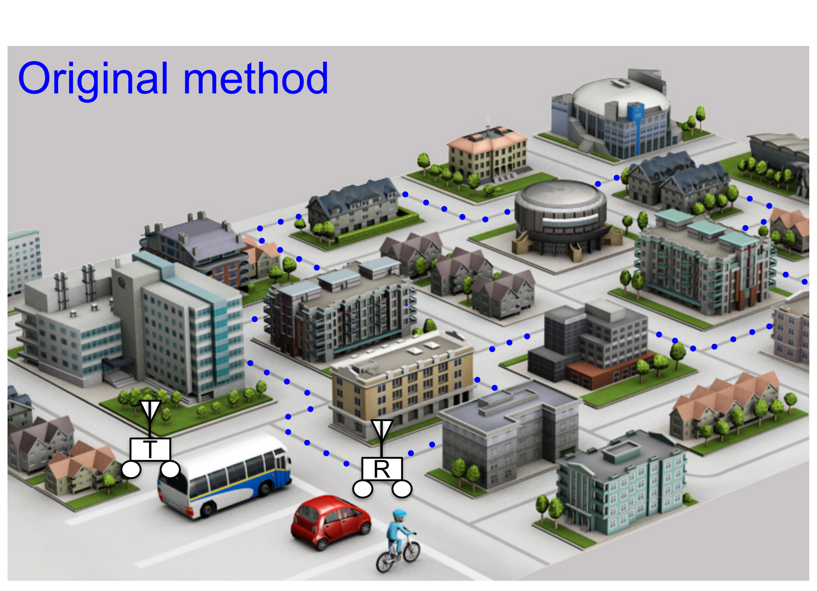
Robots Rely on Signal Strength

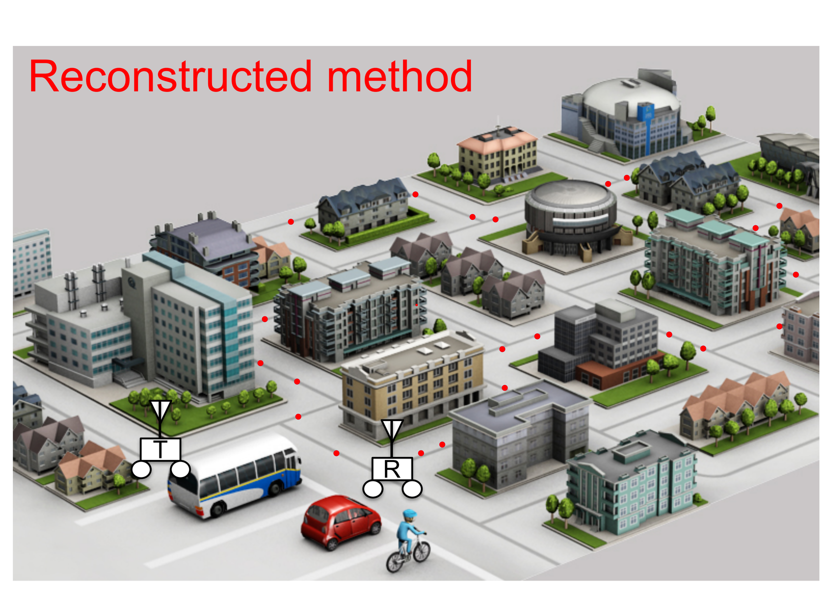


Obstacles Fade the Signal



2. Simulating this process through MATLAB we can measure the signal strength in various environments two ways: the original method by physically moving to every point which is very inefficient or the reconstructed method by compressive sensing which is measuring only a few points and then extrapolating those few points. Such signal strength is important because we need to know if two robots enter a building or an unknown area will be able to talk to each other.

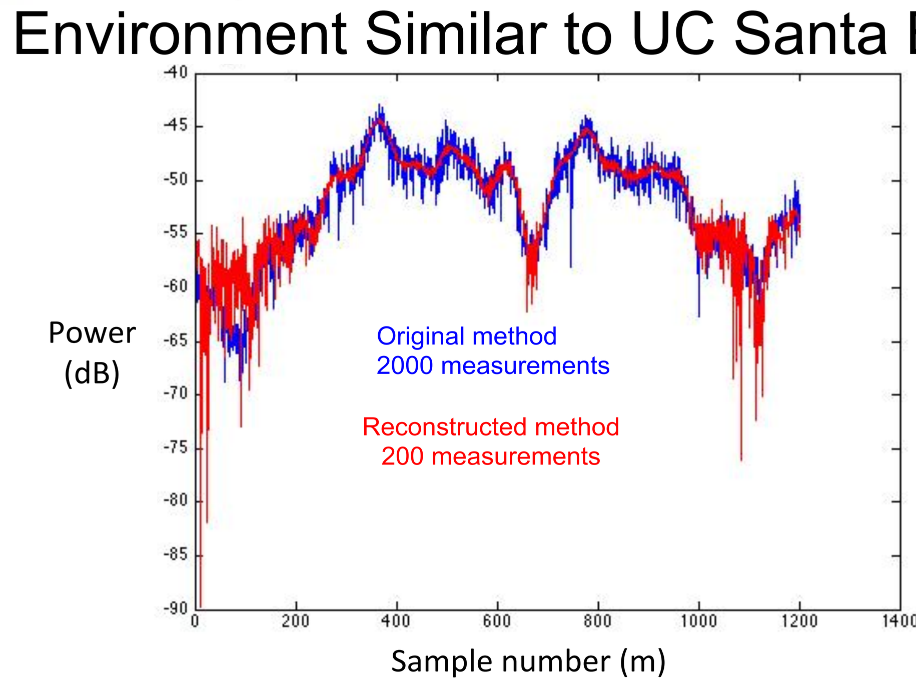




3. Motivated by the potential that we could find the least amount of measurements with a minimal amount of error for an environment. We expanded our search to find this number for various environments.

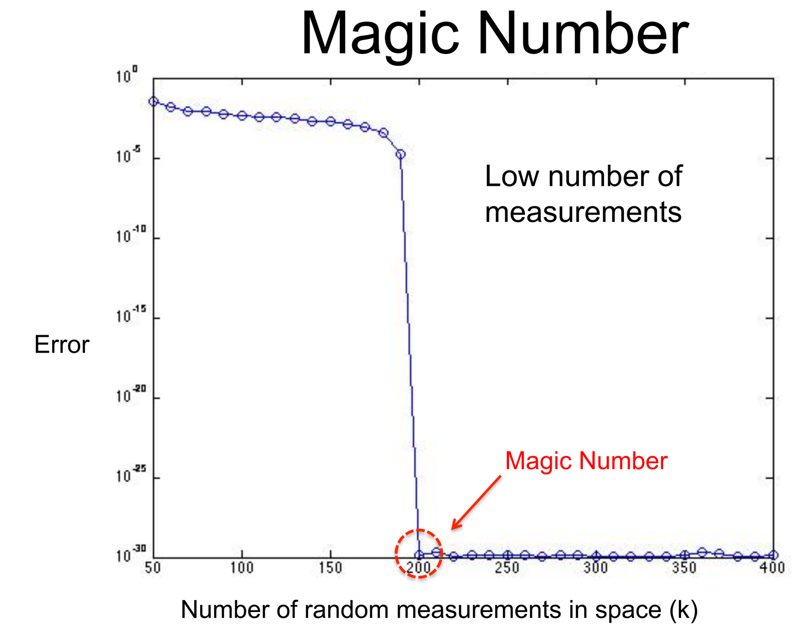
Data

Figure 1:
Environment Similar to UC Santa Barbara



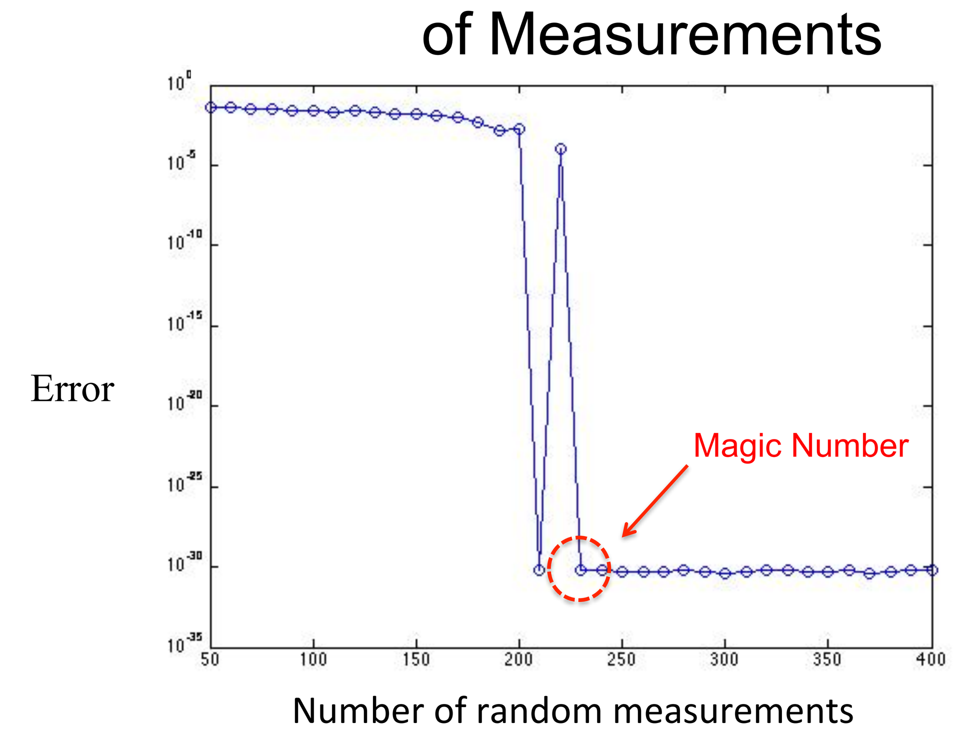
The signal between the transmitting and receiving robots is measured in power. The original method of collecting data at every possible location is inefficient. With this method, the same environment can be modeled with far fewer measurements. **Figure 1** compares the original with the reconstructed method for an environment similar to UC Santa Barbara; both providing similar signals.

Figure 2:
Every Environment has a Magic Number



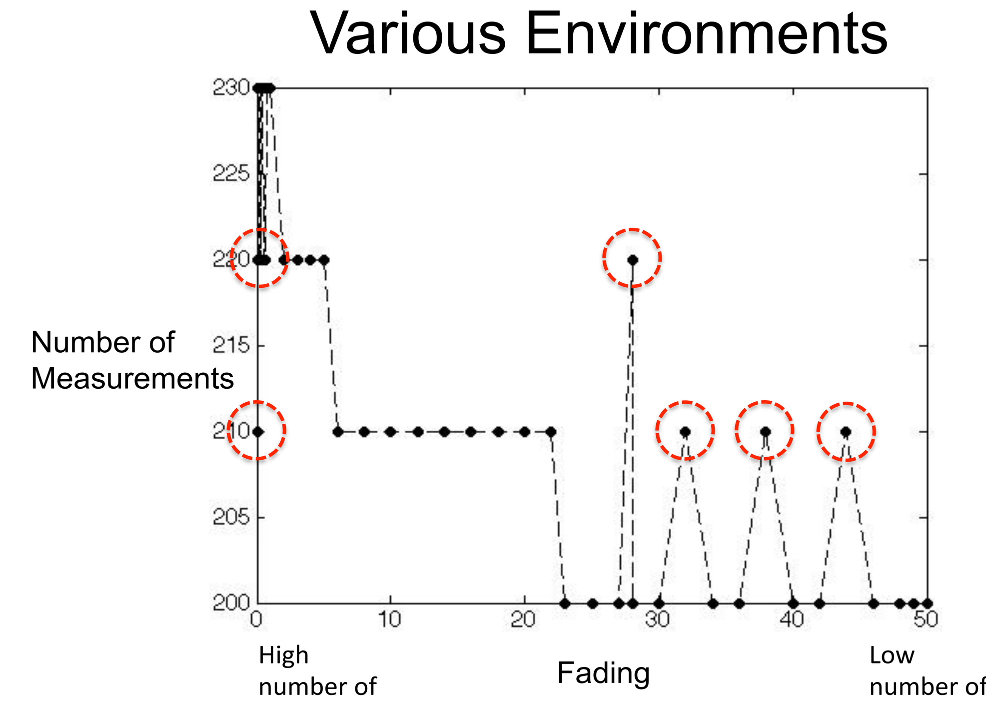
Therefore, we graphed its error to find out how accurate the reconstructed method actually was. This data is showed for a minimal amount of obstacles. The amount of measurements we needed was significantly smaller than expected. Bolstering our framework as well as motivating us to take more measurements for different environments. Ultimately providing signal strength data to the robots without the nodes having any prior knowledge of the environment. Referred to in our lab as the Magic Number.

Figure 3:
Environment with High Number of Measurements



The more obstacles we added to our environment we noticed something different. We noticed that we did not just have one significant drop in error but actually two, seen here. The reason for this still seems to be unknown. Similar to **Figure 1**, our measurement needed is still the value with the least amount of measurements with the greatest amount of accuracy.

Figure 4:
Found the Magic Number for Various Environments



The data shows in general the more obstacles in an environment the more measurements needed to produce an accurate yet energy efficient signal map. Theoretically, that was our assumption as well, but we realized our results were not consistent with our theory in a few cases. Circled in red in **Figure 4**, are the inconsistencies. These inconsistencies motivate future work to find out why our results deviated.

Conclusion

By plotting the error between the original and reconstructed method we were able to find the signal strength with the fewest amount of measurements while still being reasonably accurate, in various environments. In **Figure 4**, circled in red, you can see that our measurements oscillate around two areas. When there were a high number of obstacles present as well as a low number of obstacles. Since only our fading parameters accounted for obstacles; we came to the conclusion that there is more to characterizing signal strength in an environment than just fading. The simulation model used only fading parameters, and our research over the summer suggests that we need to incorporate extensive obstacle maps as well. This would be the scope of future research in the lab.

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Reference: Mostofi, Yasamin. "Compressive Cooperative Sensing and Mapping in Mobile Networks." IEEE Transactions on Mobile Computing IEEE Trans. on Mobile Comput. 10.12 (2011): 1769-784. Web.