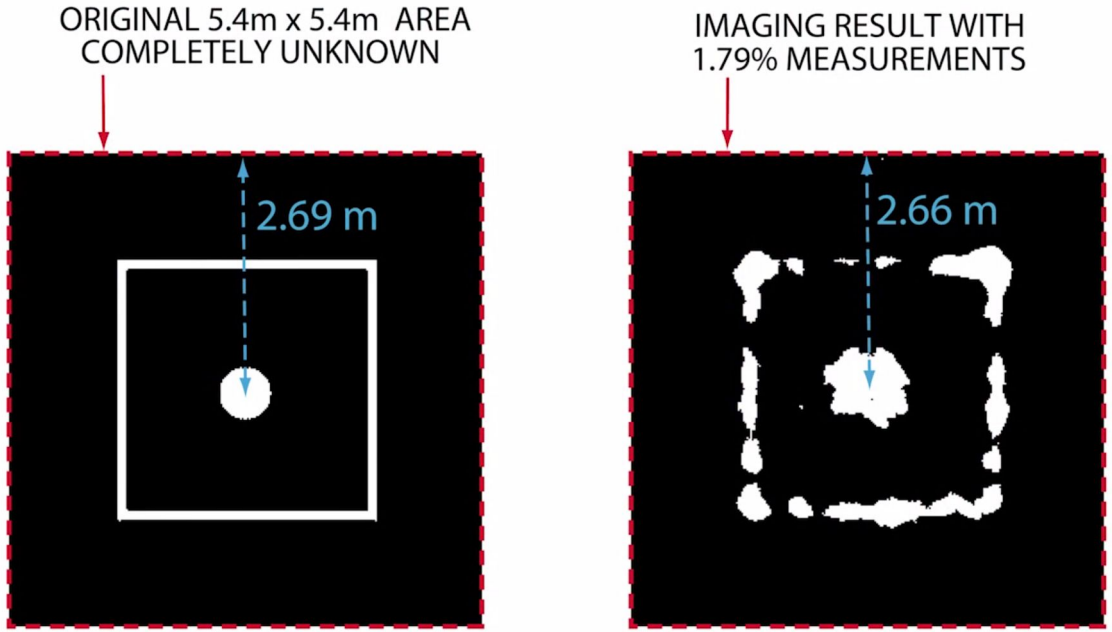
X-Ray Vision with WiFi

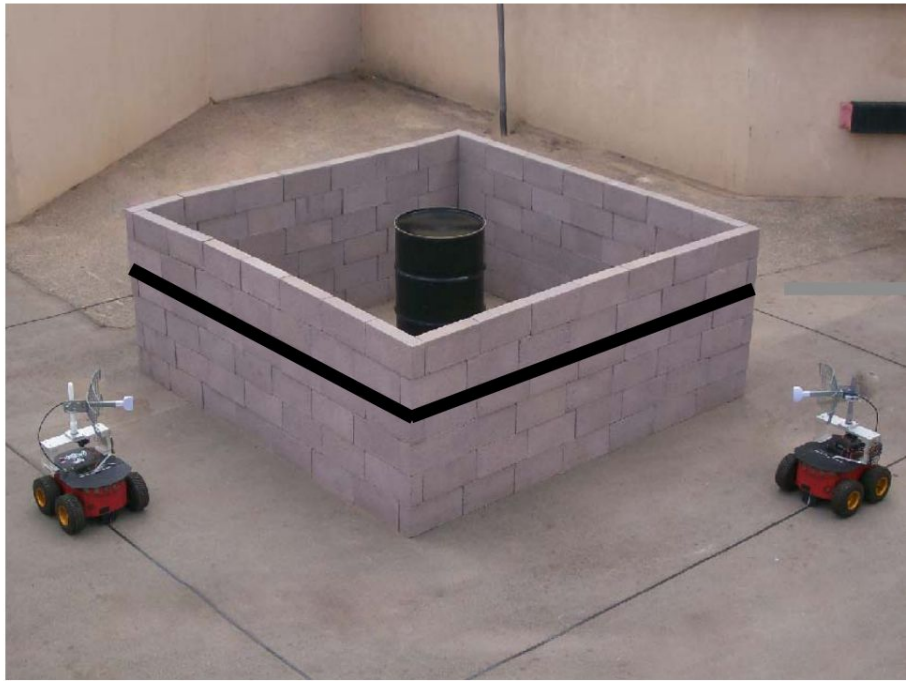


George Baier

Art 185GL - S17

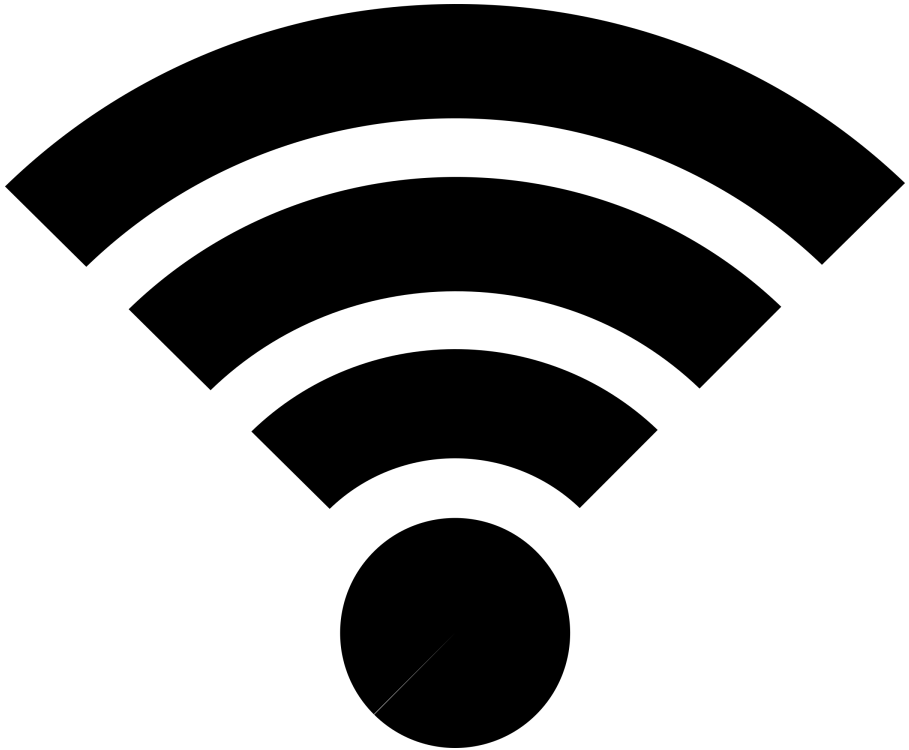
Overview

- WiFi
- Math
- Robots
- Experiment
- Results
- Future Uses



WiFi

- What is it?
  - Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards
  - 2.4GHz
- How does it work?
  - Transmitter
  - Receiver
  - Waves (3-5 inches crest to trough)
  - Crest = 1
  - Trough = 0

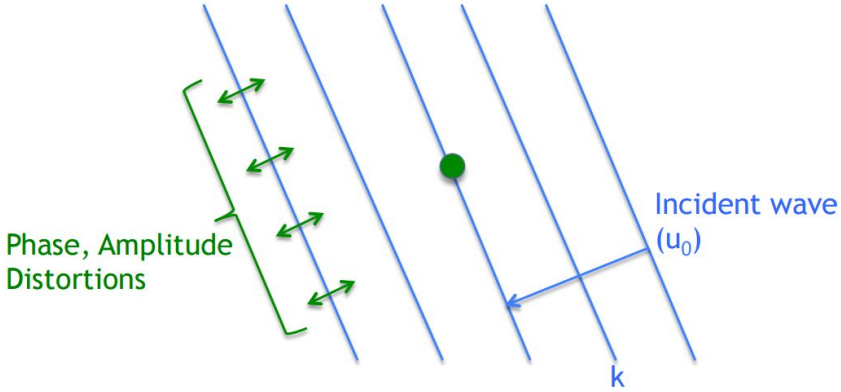


Math

$$u = e^{i(kz-\omega t)} e^{\Xi(\mathbf{x}_\perp, z, \omega)}$$

$$\Xi(x_\perp, Z, \omega) = \frac{k^2}{2\pi^2} \int_0^Z \iint \tilde{G}(k_\perp, Z-z, \omega) \xi(k_\perp, z) e^{-ik_\perp x_\perp} dk_\perp dz$$

- Rytov Approximation
  - Linearization
  - Scattering
  - Filter
  - Imaging based on received signal power
- Line of Sight (LOS) Approximation
  - Integral of line joining the positions of the transmitter and receiver



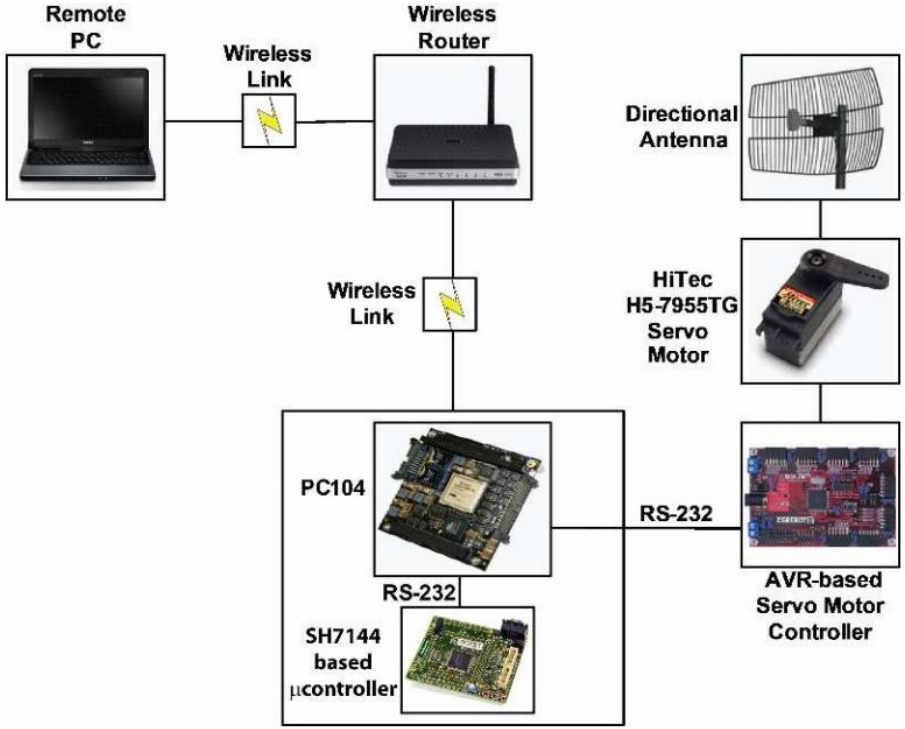
$$P_r(\mathbf{r})(\text{dBm}) = P_{inc}(\mathbf{r})(\text{dBm}) - 10\log_{10}(e^{-2})\omega \int_{\mathbb{L}_{T\to R}} \text{Imag}(\alpha(\mathbf{r}'))\, d\mathbf{r}'$$

Robots

- Components
  - Pioneer 3-AT mobile robots
  - Onboard PC
  - IEEE 802.11g (WLAN) card
  - Renesas SH7144-based micro-controller
    - Motors
    - Actuators
    - Sensors
      - Gyroscopes
      - Encoders
  - Directional antennas
  - Digilent Cerebot II micro-controller
  - Hitec HA-7955TG digital servo
  - D-Link WBR-1310 wireless router

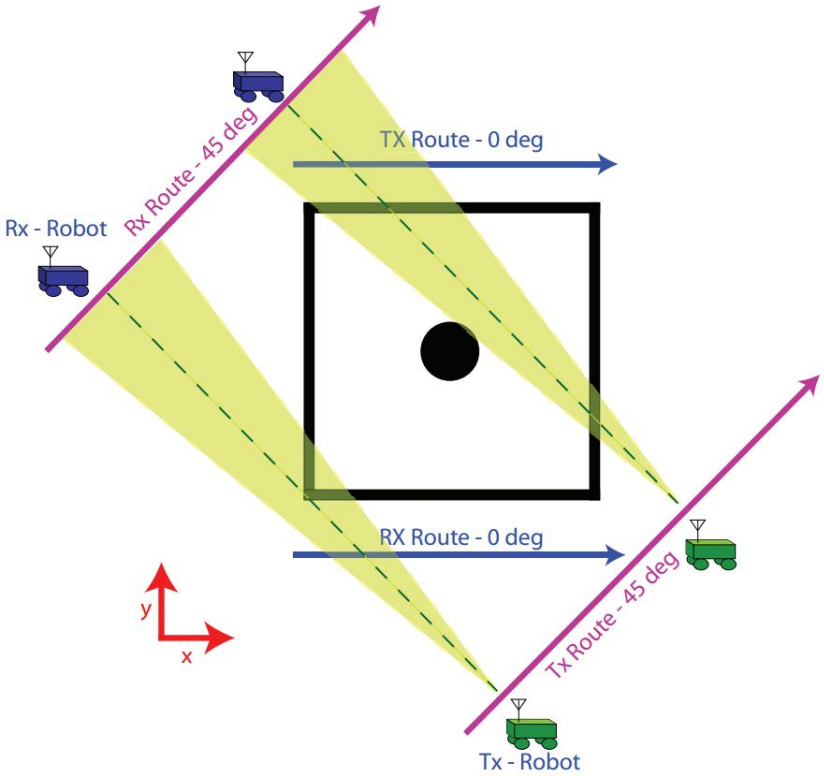
Robots

- Code
  - C++ using the ARIA library
  - four separate in-software threads
    - antenna control
    - signal strength
    - motor control
    - main thread
  - designed for autonomy and precision



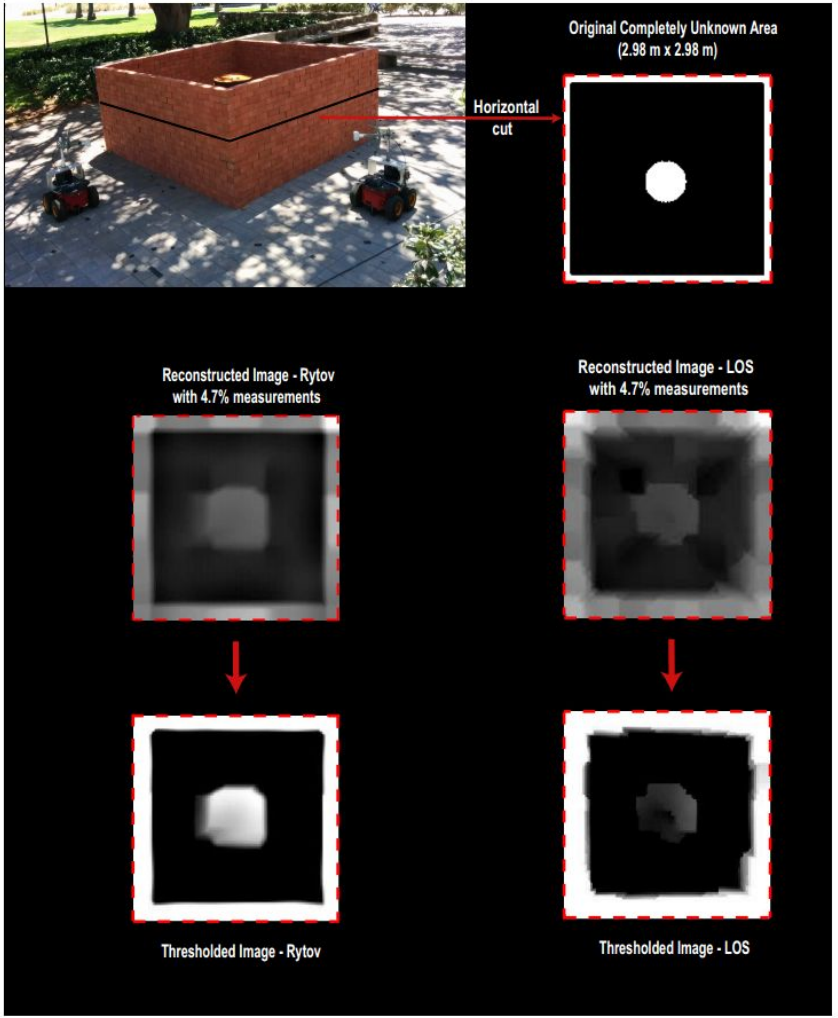
Experiment

- 4 passes
  - Vertical
  - Horizontal
  - 45 degrees
  - 135 degrees
- Parallel Routes
- Record signal strength
- Apply Rytov and LOS approximations



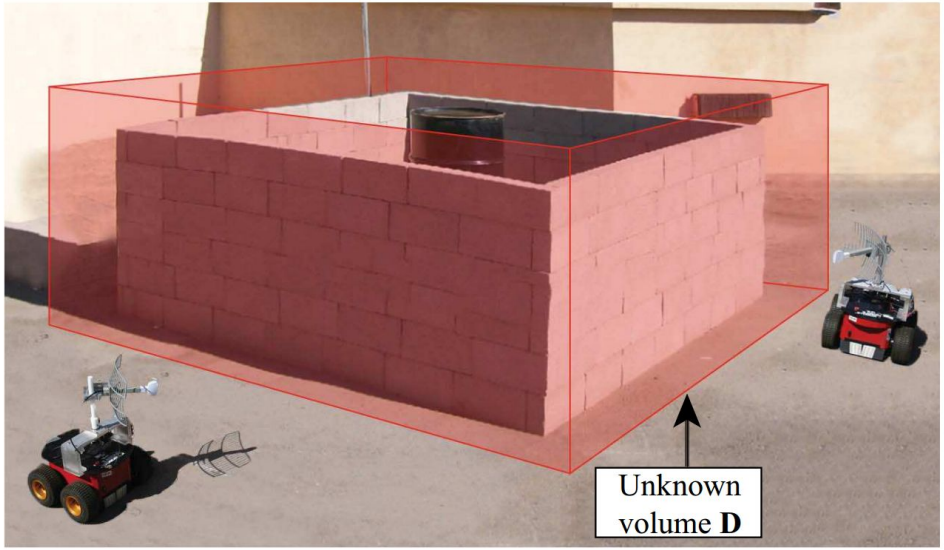
Results

- 4.7% of signal measured
- Rytov outperforms LOS
- Thresholding applied to images
- Rytov faster than LOS
- Errors
  - Route Length
  - Antenna Misalignment



Summary

- WiFi
- Math
- Robots
- Experiment
- Results
- Future Uses
  - Search and Rescue
  - Tracking the elderly



Questions?

Sources

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