Wireless Signal Characterization

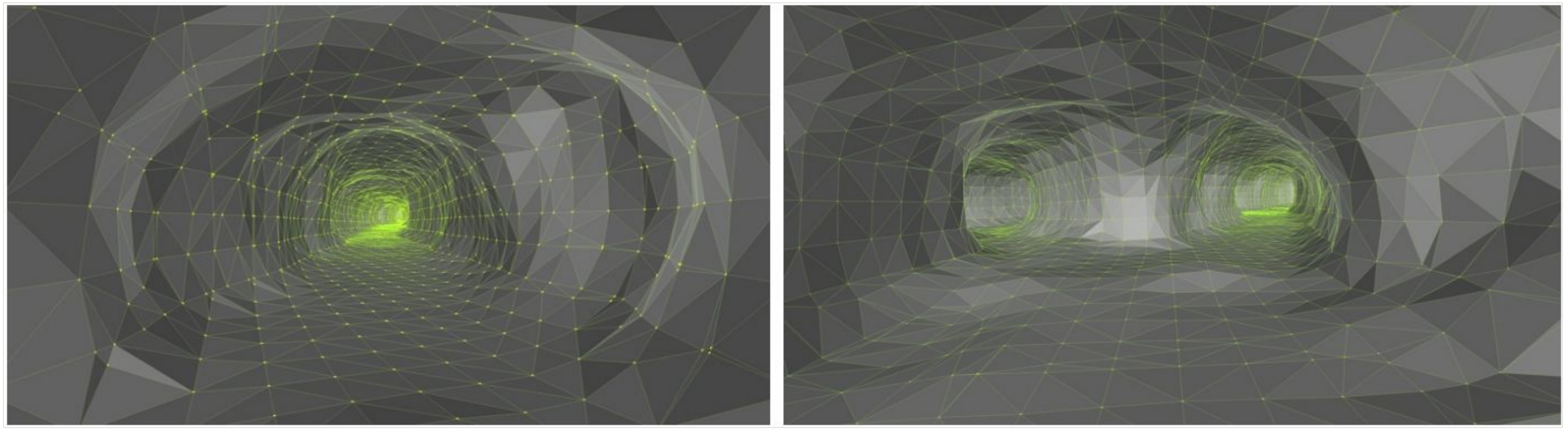
Nick Daly and Huanjia Liu

Advised by Dr. Branislav Notaros and Stephen Kasdorf

Department of Electrical and Computer Engineering, Colorado State University, Fort Collins, CO, USA

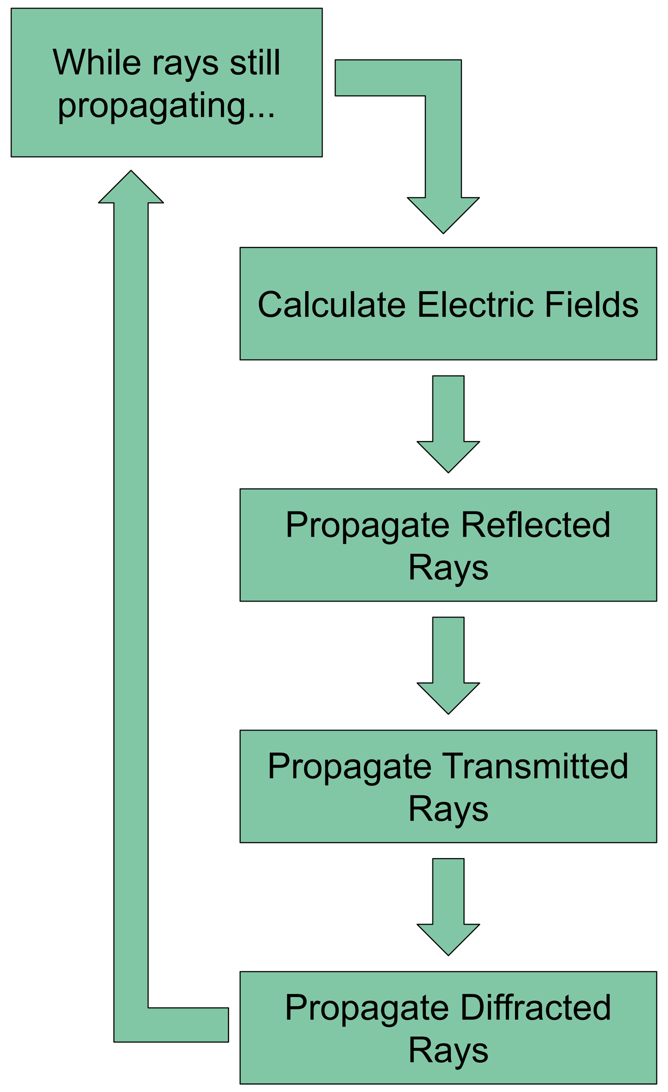
Modelling EM Radiation in Indoor Environments

- As the use of wireless technology continues to expand, this project focuses on developing a simulation tool designed to model electromagnetic radiation.
- This tool will be used for the design of wireless communication systems in complex areas such as underground mines or other large and complex indoor environments like hospitals.
- This tool seeks to improve upon existing technologies by:
  - Accounting for different materials in the environment
  - Reducing site survey overhead to enable quick construction of the model to be simulated
  - Maintaining high levels of simulation accuracy with improved efficiency
- The Shooting-and-Bouncing Rays (SBR) ray tracing technique is utilized in this design to accomplish each of the above priorities.

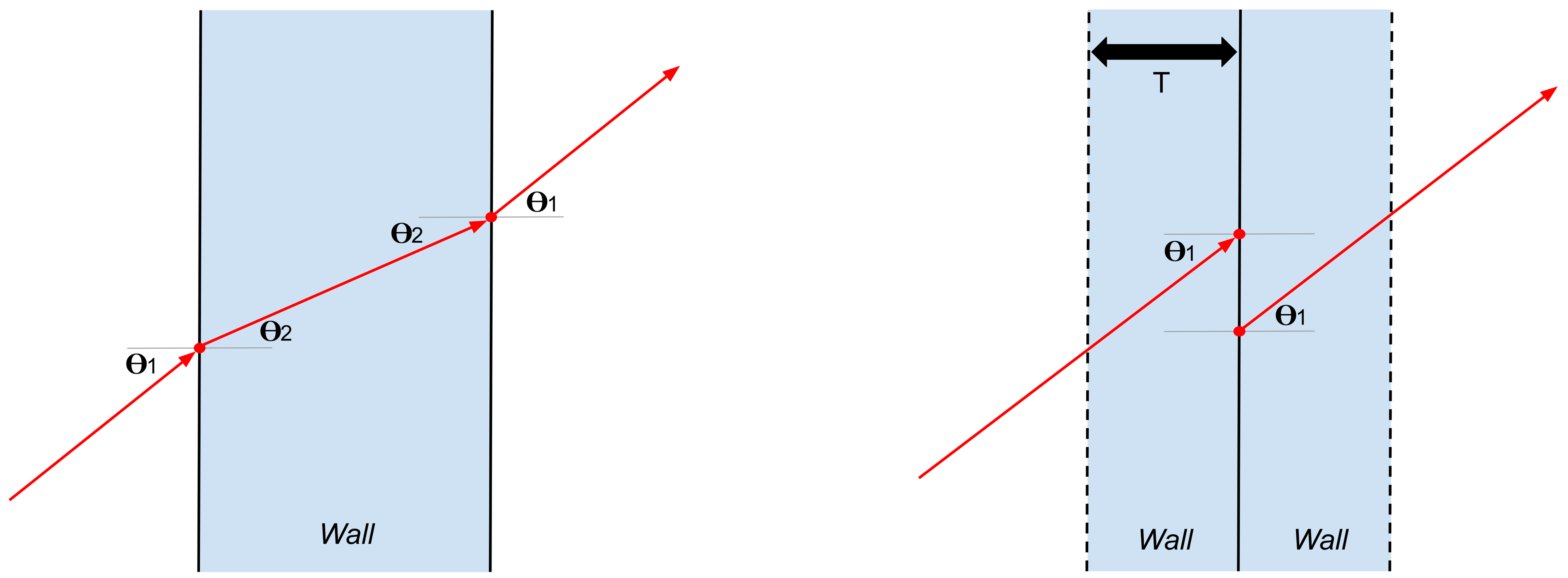


Project Progress

- Reflected Rays
  - Designed structure capable of being used for reflected, transmitted, and diffracted rays
  - Reimplemented large portion of reflected ray code to fit this structure
- Transmitted Rays
  - Implemented a thin wall approximation method to improve computational efficiency of transmitted rays
  - Derived correction term necessary for simulation accuracy when ray travels through different materials
  - Began implementation of backend methods to fully support transmitted ray simulation
- Miscellaneous
  - Created python script to automate “kill box” creation to clean up unnecessary rays
  - Documented critical path of code by creating a flowchart to assist with onboarding of future teams



Thin Wall Approximation



- Traditional calculations on transmitted rays include two steps: finding the ray transmitting through the wall and finding the ray which will propagate beyond the wall.
- Thin wall propagation eliminates the need for two steps by modeling a wall as a single plane.
- This strategy makes modeling environments significantly easier and is computationally more efficient.

Custom .mtl File Use

- The SBR code makes use of .obj files to model environments.
- For accurate calculations, it is necessary to account for the materials of objects and how EM radiation interacts with those materials
- The custom use of .mtl files along with .obj files to allows the team to natively handle materials through the Optix package without having to develop additional solution to represent material data

Current Achievements and Future Improvements

- Current Achievements
  - Ray generation from both icosahedron (dipole antenna) and plane wave transmitter
  - Simplified code structure for reflected, transmitted, and diffracted electromagnetic rays
  - Python script to automatically generate a “kill box” for removing unnecessary rays to improve algorithm efficiency
  - Custom material parsing allowing material assignment for each face in .obj file
- Future Improvements
  - Accuracy verification for transmitted rays and bistatic radar cross section measurements
  - Algorithm optimization to minimize copy operations between CPU and GPU
  - User interface design to limit need for complex configuration file

Acknowledgements

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Source

D. Didascalou, T. M. Schafer, F. Weinmann and W. Wiesbeck, "Ray-density normalization for ray-optical wave propagation modeling in arbitrarily shaped tunnels," in IEEE Transactions on Antennas and Propagation, vol. 48, no. 9, pp. 1316-1325, Sept. 2000, doi: 10.1109/8.898764.