Feasibility and Quality of a MATLAB Implementation for an Intelligent Reflective Surface

REU fellows: Garrett Fairbanks Faculty Mentors: Dr. Reza Amineh

Affiliation:[1.] Luddy School of Informatics, Computing and Engineering, Indiana University [2.] School of Engineering and Computing Science, NYIT

Emails: garrfair@iu.edu, rkhalaja@nyit.edu

ABSTRACT

This poster goes over the feasibility and overall quality of an Intelligent Reflective Surface (IRS) implementation in MATLAB. First, going over the general process and implementation, then giving multiple results demonstrating the level of control that model has over the field distribution when determining the reflection coefficients over the IRS surface.

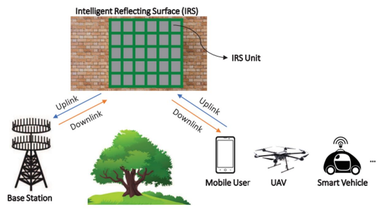
BACKGROUND

What is an Intelligent Reflective Surface (IRS)?

- An IRS is a 2-D surface that "reflects" electromagnetic radiation (ER). It does this according Maxwell's Equations, where ER induces a current in our IRS, then that induced current produces secondary ER propagated toward the users.

What is being tested?:

Essentially, what's being tested is the level of control over a specific field distribution we can maintain in this model. By looking at the leftmost figures in Figure 2, you can see the desired field distribution we want to maintain. The other figures show how accurate our IRS replicates it under various conditions. In Figure 3, a process called phase quantization was implemented, and accuracy was similarly tested.



PROBLEM & OBJECTIVE

Research problem:

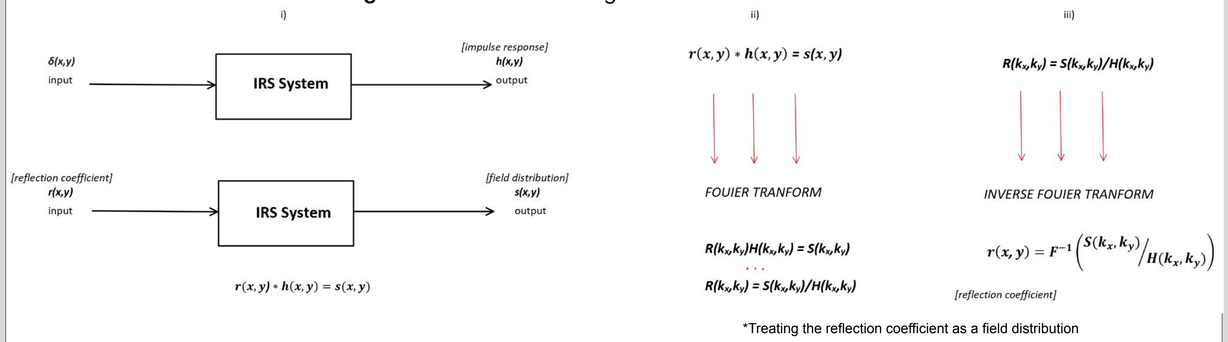
Experiment with simultaneous phase and magnitude control of the reflection coefficient over the IRS.

Objective:

Create a MATLAB implementation that replicates the behavior of an IRS that will aid in secure communication systems.

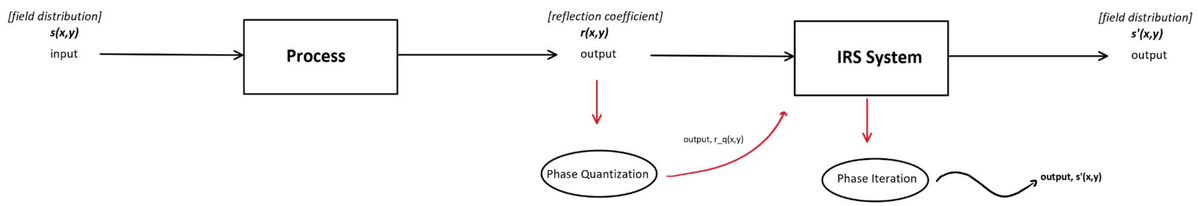
METHODOLOGY

Figure 1. Process of finding reflection coefficient



*Treating the reflection coefficient as a field distribution

Figure 4. Outline of how the model produces a field distribution



RESULTS

Figure 2. Fields Replicated by MATLAB

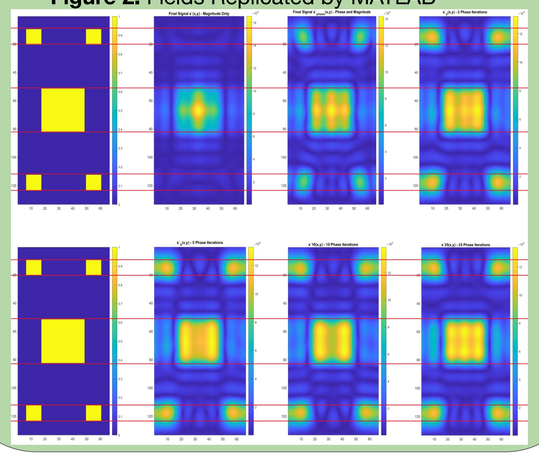
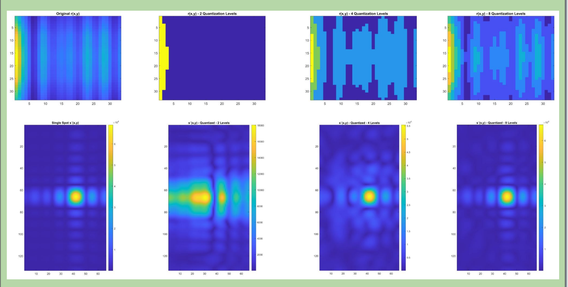


Figure 3. Results of Quantizing Phase in a Certain Field Distribution



DISCUSSIONS

- Figure 2. Improved replication of field distributions is achieved by multiple **phase iterations.**
  - **Phase iterating** - is the process of taking the updated phase values from the final field distribution, and incorporating those values with the initial distribution we wish to replicate.
  - This done because when making a field distribution phase was not initially included.
- Figure 3. Quantization of phase leads to degrading results
  - **Phase quantization** is the process of taking all the phase values present in the distribution and grouping them into a few different levels, in this case 2,4, and 8 levels.
  - This is done because an IRS will only have a limited number of values it can work with due to the Digital to Analog Converter (DAC) and varactor diodes.

FUTURE WORK

- Improving Upon the model as it stands currently; i.e. better quantization threshold
- More iterations could be experimented with in the model.
- Implementation of the model into the real world

CONCLUSIONS

- There's a certain iteration threshold such that performing more phase iterations would yield negligible results. This threshold can depend on position and size of the square "spots".
- There also exists a quantization threshold, where you cannot quantize phase anymore without misrepresenting the field distribution.

REFERENCES

[1] Zhao, Jun. "A Survey of Intelligent Reflecting Surfaces (IRSs): Towards 6G Wireless Communication Networks with Massive MIMO 2.0." (2019).

ACKNOWLEDGEMENT

This research was supported by the National Science Foundation (NSF) Research Experiences for Undergraduates (REU) program. We would like to thank all of the mentors and research fellows at the New York Institute of Technology who have provided their helpful insight and expertise that greatly assisted with our research.

We want to extend our thanks to the helpful graduate students.

This project is funded by National Science Foundation Grant No. CNS-1559652 and New York Institute of Technology.