Skysong Innovations
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1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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Inventors

Ahmed Alkhateeb
Abdelrahman Taha
Muhammad Alrabeiah

Contact

Physical Sciences Team

Enabling Large Intelligent Surfaces Using Sparse Channel Sensors

Background

Large Intelligent Surfaces (LISs) are envisioned as intrinsic components of beyond-5G wireless systems. In its core design concept, an LIS realizes a continuous electromagnetically-active surface by stacking a massive number of radiating/sensing elements. These elements interact with the incident signals, for example by reflecting them, in a way that improves the coverage and data rate of the wireless systems. This concept is further motivated by the possible energy-efficient implementation using nearly passive elements such as analog phase shifters. Prior work has focused on developing efficient designs for the LIS reflection matrices and evaluating their coverage and rate gains assuming the existence of global channel knowledge. However, obtaining this channel knowledge (which is essential for operating the LISs and harvesting their gains) requires huge and possibly prohibitive training overhead as well as highly complex and expensive hardware. These factors represent a critical challenge for LIS operation.

Invention Description

Researchers at Arizona State University have developed a novel LIS architecture based on sparse channel sensors. In this architecture, all LIS elements are passive except for a few elements that are active (i.e., connected to the baseband of the LIS controller). Two approaches provide the key to designing LIS reflection matrices with negligible training overhead: In the first, compressive sensing tools are leveraged to construct the channels at all LIS elements from the channels seen only at the active elements. In the second, a deep learning method allows the LIS to dynamically optimize interactions with the incident signal given the channels at the active elements, which represent the current state of the environment and transmitter/receiver locations. Achievable rates of the compressive sensing and deep learning solutions were shown to approach the upper bound (assuming perfect channel knowledge) with negligible training overhead and less than 1% of the elements being active. This highlights a promising advancement for LIS systems from both energy efficiency and spectral efficiency perspectives.

Potential Applications

- Large intelligent surfaces (LISs)
- Smart reflect-array-aided 5G base stations

- Beyond-5G communication
- Massive multiple-input and multiple-output (MIMO) systems
- Millimeter wave and sub-terahertz communications and imaging systems

Benefits and Advantages

- Achieves high data rates with negligible training overhead and low-cost hardware
- Requires very few active elements for improved energy efficiency
- Enables practical LIS operation by combining deep learning and compressive sensing techniques
- Enables high-resolution and low-cost sensing and imaging applications

Related Publication (PDF)

Faculty Profile of Professor Ahmed Alkhateeb