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Hardware Prototype of a Mirror Array-Based Optical Intelligent Reflecting Surface

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Background

- Visible light communication (VLC) leverages the broad bandwidth of the visible spectrum for high-speed data transmission, offering advantages such as immunity to electromagnetic interference and physical layer security.
- Optical intelligent reflecting surface (OIRS) has been explored to enlarge the coverage area and enhance the received signal by dynamically controlling the direction of reflected light.
- Currently, the mainstream OIRS implementations include hypersurface, liquid crystal, and mirror arrays, among which the mirror array scheme is simple in structure, flexible in control, and high in reflection efficiency, which has obvious potential for engineering applications.

System Model

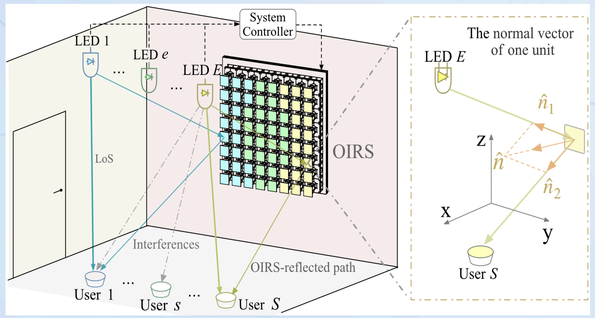

Fig.1 The VLC system aided by OIRS

Hardware Prototype

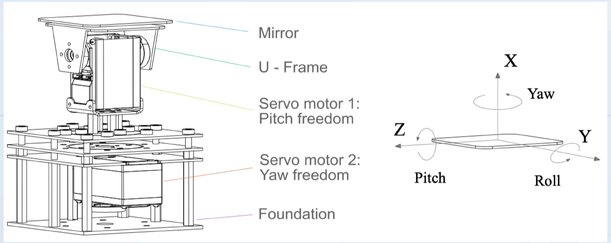

Fig.2 The architecture of a single OIRS unit.

- This demo adopts the yaw-pitch dual-degree-of-freedom design scheme to realize the precise adjustment of optical signals in two-dimensional space.

Array Arrangement

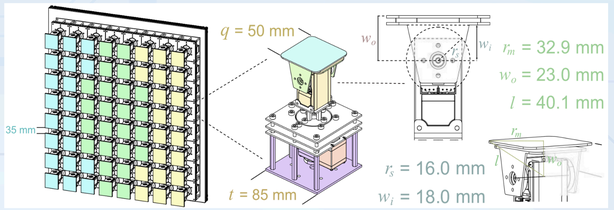

Fig.3 The OIRS array

- The array arrangement avoids mechanical interference and collision between reflection units by reasonably controlling the unit spacing. Ultimately, it realizes stable operation under high-density arrangement.

Controller Protocol

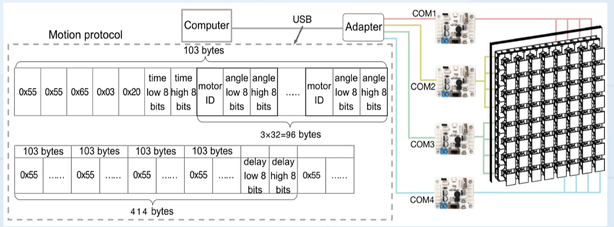

Fig.4 The controller Protocol

- A distributed architecture is utilized, where four boards are employed to control the 64-unit array, making the system scalable and efficient. The boards are coordinated by a central computer, which synchronizes their operation.

Experimental Results

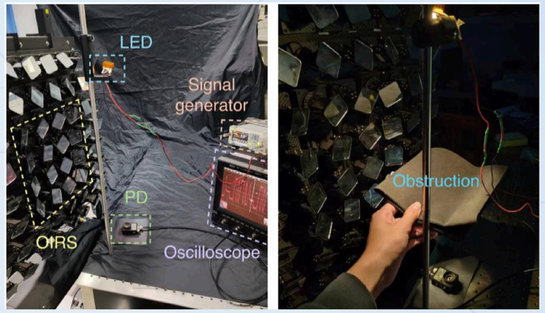

Fig.5 The experimental platform

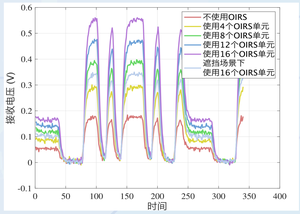

Fig.6 The received signals

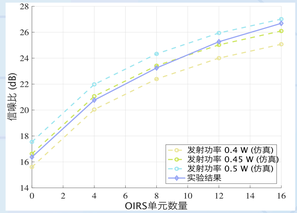

FIg.7 The SNR

- With the increase of the number of OIRS units, the received signal amplitude is significantly enhanced. Besides, the SNR shows a significant increase with the number of OIRS.
- The OIRS can still maintain stable signal transmission under occlusion conditions, which proves that it has good occlusion resistance.
- This technical solution not only fills the gap in the field of OIRS hardware realization, but also offers a solid foundation for future applications in visible light communication systems, with extensive application prospects.