Evaluating data transmission through VLC/OCC systems applied to mobile devices

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1. Context

- The increasing demand for secure wireless communication has driven interest in **Visible Light Communication (VLC)** and **Optical Camera Communication (OCC)** as alternatives to traditional RF systems. These light-based technologies offer reliable data transmission, especially in RF-restricted environments, while providing enhanced security and efficiency for diverse applications.[1]

2. VLC/OCC Testbed

- We evaluated a **mobile phone** Flutter-based transmitter (see https://flutter.dev/ for more info) that modulates data through four color channels. For reception, a **laptop camera** using Python/OpenCV receiver captures and decodes these optical transmissions.
- To ensure robust performance, the design implements **preamble synchronization and guard times** between frames.

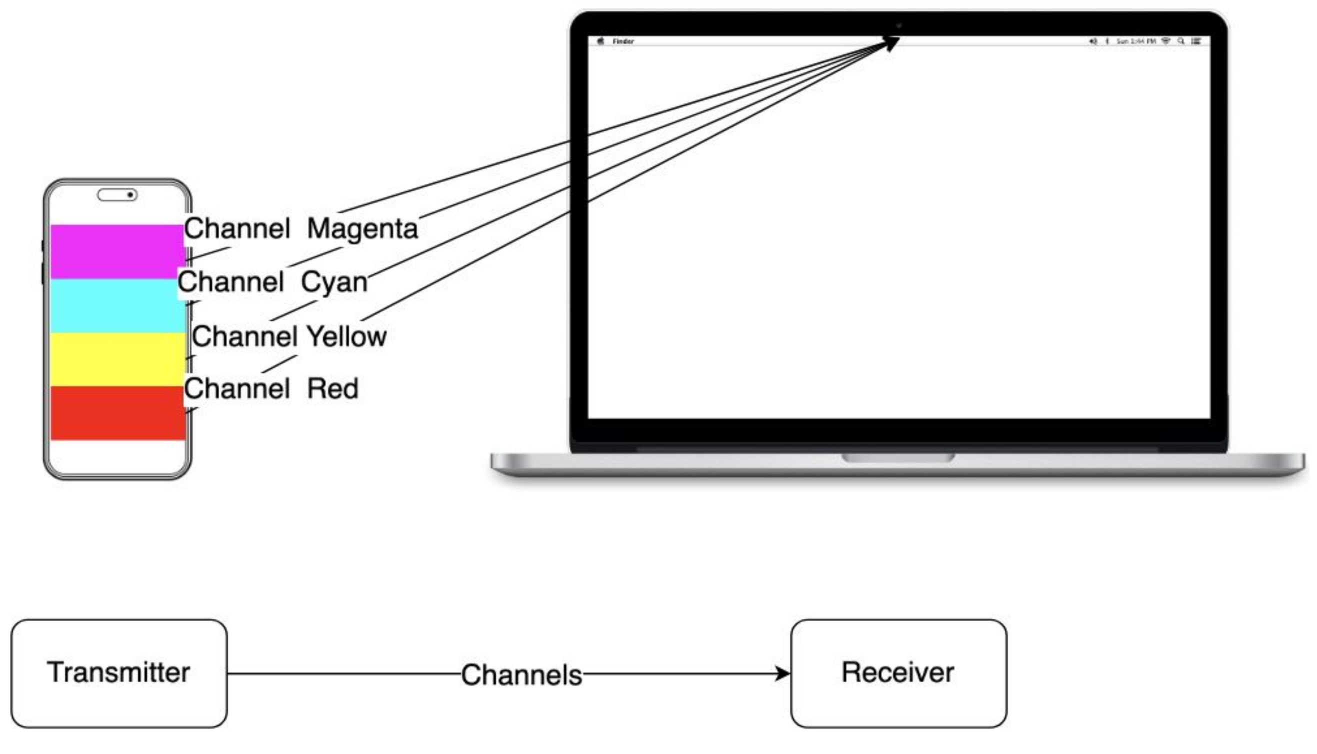

Fig. 1 - Schematic diagram of the developed VLC/OCC system.

3 Synchronization scheme

- The preamble serves as a **synchronization marker,** consisting of a specific bit pattern that enables the receiver to detect and align with incoming transmissions. This critical timing mechanism prevents data misalignment errors while improving decoding accuracy.[2
- Positioned before each data frame, **the preamble** ensures reliable operation even under challenging conditions like fluctuating ambient light or signal latency.
- Strategically placed **guard intervals** between frames provide buffer periods for system resynchronization.

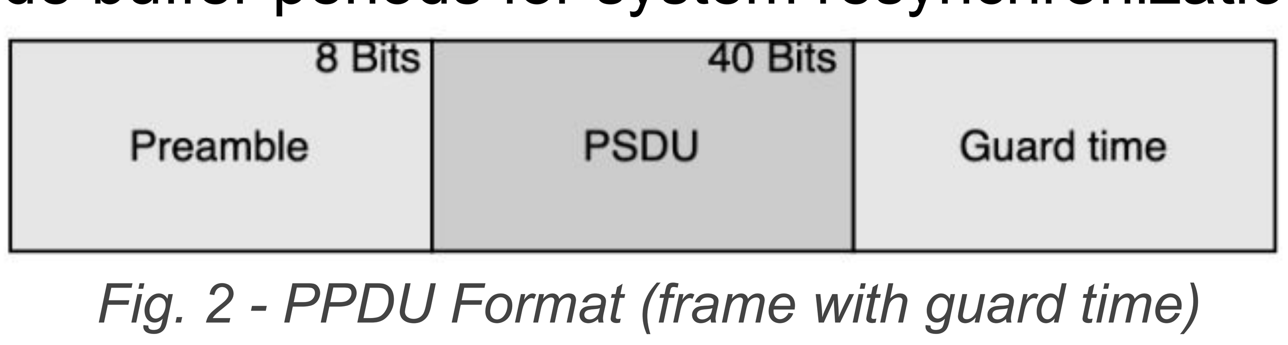

Fig. 2 - PPDU Format (frame with guard time)

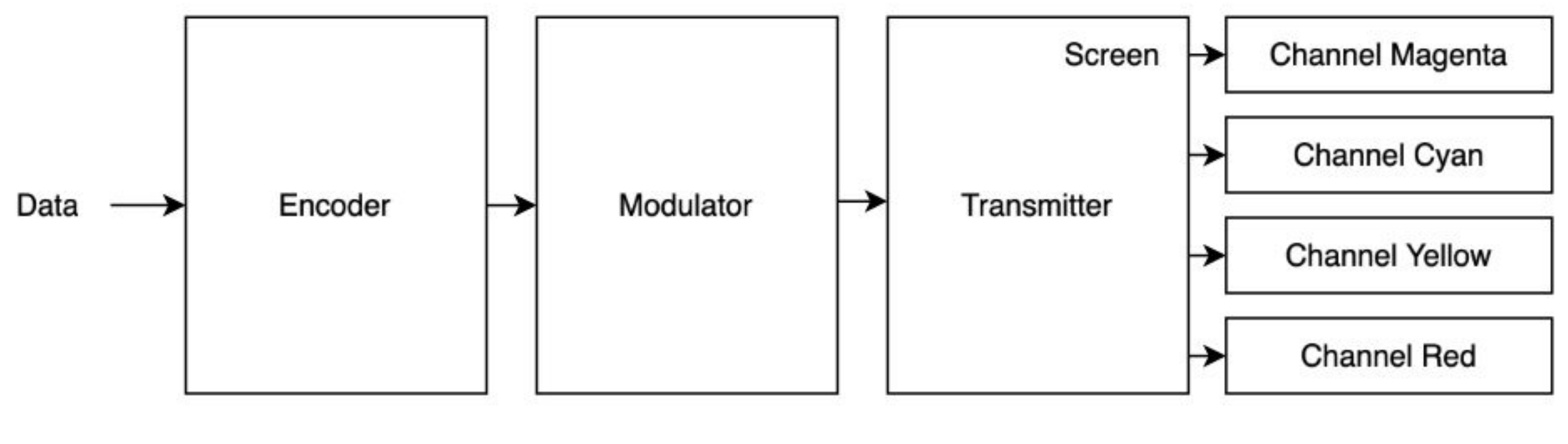

Fig. 3 - Transmitter block diagram.

3. Evaluation

- The **VLC/OCC system** underwent rigorous testing across critical metrics, achieving a BER of 0.275 at optimal conditions but degrading to 0.491 at maximum tested distances (150cm).
- The **synchronization system** proved robust against environmental variables, with preamble detection and guard intervals effectively maintaining signal integrity during light fluctuations.
- These findings highlight the **system's effectiveness** for short-range applications while identifying distance limitations that guide future optimization efforts.
- The results particularly emphasize the crucial role of synchronization mechanisms in unstable lighting conditions.

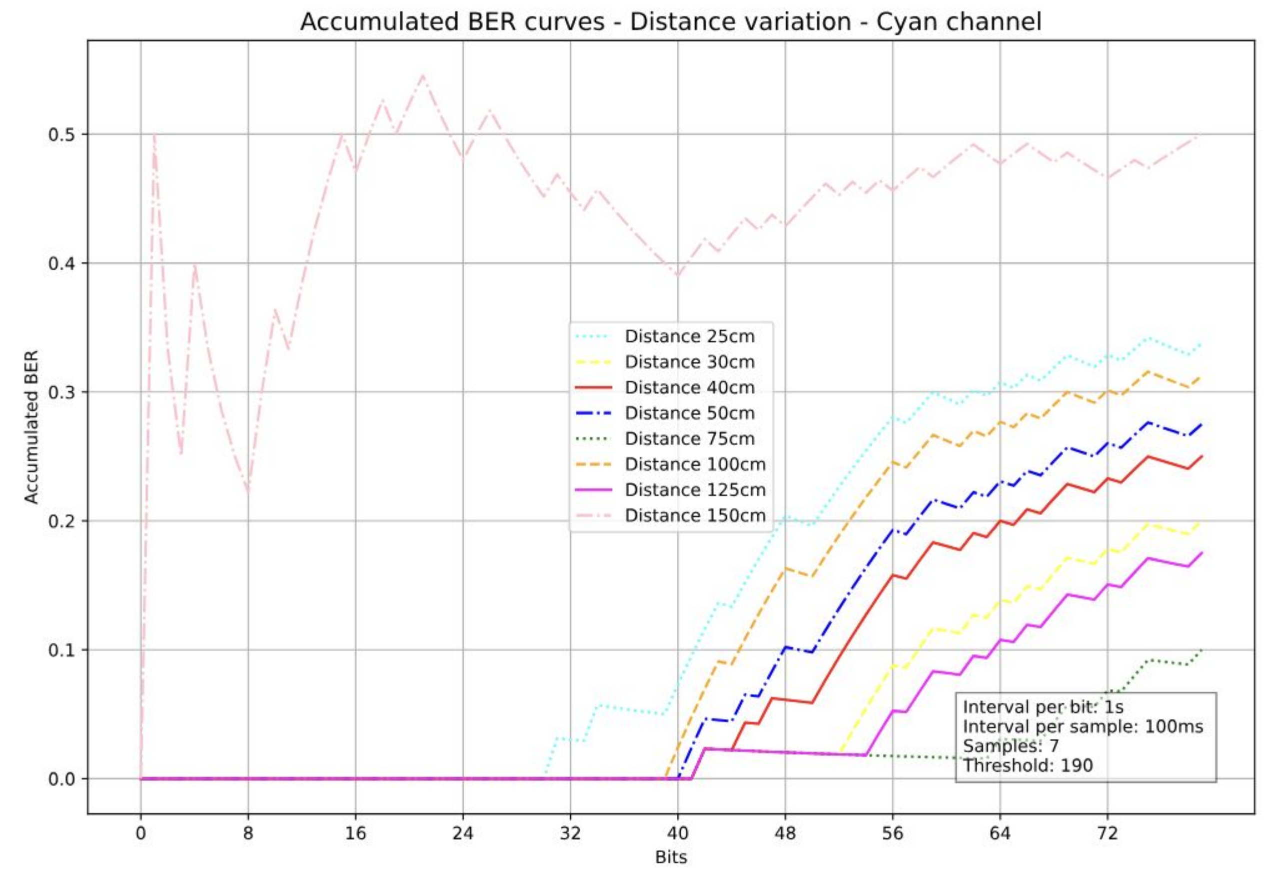

Fig. 4 - BER with Distance Variation for yellow channel

4. Summary & Conclusions

- The VLC/OCC system successfully demonstrated secure data transmission capabilities using mobile devices as both transmitters and receivers. By employing **multiple color channels and robust preamble-based synchronization,** the system achieved reliable communication performance.
- Dynamic **threshold adjustments** and carefully implemented guard times enabled stable operation across varying lighting conditions.
- While the technology shows significant promise as an alternative to traditional wireless methods, certain **technical challenges remain to be addressed in future** iterations to further enhance its reliability and practical applicability.

5. References

[1] Zeng, Y.; Chen, Y.; Feng, S.; Zhou, K.; Sun, X.; Mao, T.; Shi, L.; Lei, B.; Wang, F.; Yan, X.; et al. Visible light communication system for mobile device. In Proceedings of the 2014 Sixth International Conference on Ubiquitous and Future Networks (ICUFN), 2014, pp. 26–28. https://doi.org/10.1109/ICUFN.2014.6876742.
[2] Nguyen, D.T.; Park, S.; Chae, Y.; Park, Y. VLC/OCC Hybrid Optical Wireless Systems for Versatile Indoor Applications. IEEE 2019. DOI:10.1109/ACCESS.2019.2898423