論 文 の 要 旨

題 目 A Study on High-Speed-Vision-Based Visible Light Communication System for Real-Time Video Streaming
（リアルタイムビデオストリーミングのための高速ビジョンベースの可視光通信システムに関する研究）

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This study develops a projector–camera-based visible light communication (VLC) system for real-time broadband video streaming, in which a high frame rate (HFR) projector can encode and project a color input video sequence into binary image patterns modulated at thousands of frames per second and an HFR vision system can capture and decode these binary patterns into the input color video sequence with real-time video processing. For maximum utilization of the high-throughput transmission ability of the HFR projector, we introduce a projector–camera VLC protocol, wherein a multi-level color video sequence is binary-modulated with a gray code for encoding and decoding instead of pure-code-based binary modulation. Gray code encoding is introduced to address the ambiguity with mismatched pixel alignments along the gradients between the projector and vision system. Our proposed VLC system consists of an HFR projector, which can project 590 x 1060 binary images at 1041 fps via HDMI streaming and a monochrome HFR camera system, which can capture and process 12-bit 512 x 512 images in real time at 3125 fps; it can simultaneously decode and reconstruct 24-bit RGB video sequences at 31 fps, including an error correction process.

In this study we also proposed a novel method for synchronizing a high frame-rate (HFR) camera with an HFR projector, using a visual feedback-based synchronization algorithm for streaming video sequences in real time on a visible-light communication (VLC)-based system. The frame rates of the camera and projector are equal, and their phases are synchronized. A visual feedback-based synchronization algorithm is used to mitigate the complexities and stabilization issues of wire- based triggering for long-distance systems. The HFR projector projects a binary pattern modulated at 3000 fps. The HFR camera system operates at 3000 fps, which can capture and generate a delay signal to be given to the next camera clock cycle so that it matches the phase of the HFR projector. To test the synchronization performance, we used an HFR projector–camera-based VLC system in which the proposed synchronization algorithm provides maximum bandwidth utilization for the high-throughput transmission ability of the system and reduces data redundancy efficiently. The transmitter of the VLC system encodes the input video sequence into gray code, which is projected via high-definition multimedia interface streaming in the form of binary images 590 x 1060. At the receiver, a monochrome HFR camera can simultaneously capture and decode 12-bit 512 x 512 images in real time and reconstruct a color video sequence at 60 fps. The efficiency of the visual feedback-based synchronization algorithm is evaluated by streaming offline and live video sequences, using a VLC system with single and dual projectors, providing a multiple-projector-based system. The results show that the 3000 fps camera was successfully synchronized with a 3000 fps single-projector and a 1500 fps dual-projector system.