論文の要旨

題 目　A Study on Real-time Video Mosaicking and Stabilization Using High-speed Vision
（高速ビジョンを用いたリアルタイムビデオ モザイキングと 安定化に関する研究）

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In this study, the novel approach of high-speed vision-based video mosaicking and stabilization are realized by sensing frame-to-frame displacements and motion anomalies available in the video sequences. The feature point-based frame-to-frame displacements is conducted using the high-speed vision system. Hence, by stitching the images based on their estimated frame-to-frame changes in global movements and orientations, mosaicked images can be composed for visualizing a panoramic image of a wide area. However, the undesired motion due to shaking or rapidly moving camera observed while rolling the shutter is known as jitters, which are often introduced by various external sources. The presence of jitter in the video sequences leads to unpleasant visual effects. The jitter sensing method is derived by calculating displacements in the consecutive frames, resembling the global motion of the camera. By compensating the associated motion anomalies in the global displacement of a camera, image stabilization can be achieved for visualizing smooth video sequences. The computationally viable and efficient high-frame-rate (HFR) vision system increases the temporal redundancy in feature extraction, which reduces the search range of neighboring features required for sensing, even when a camera moves rapidly over a scene. In this system, the feature point extraction is accelerated by implementing parallel processing circuit module for Harris corner detection on field-programmable gate array (FPGA); the hundreds of selected feature points in the current frame can be simultaneously corresponded with those in their neighbor ranges in the previous frame, assuming that frame-to-frame image displacement becomes smaller in the HFR sequences. The proposed system consists of a high-speed vision to extract and track the feature points in gray-level 512×496 pixel-size image sequences at thousands of frames per second (fps). The high-speed camera when mounted on terrain robots or vehicles, it functions as displacement and jitter sensing device to measure the apparent displacements and jitter movement of the system. It can compose a mosaic of 512×512 color images at 500 fps as a single synthesized panoramic image in real-time as well as assist the stabilization applications at 1000 fps. Applications such as video stabilization of high-resolution camera of 2048×2048 pixel-size can be assisted by the proposed HFR-based jitter

sensing to overcome the shortcoming in image-space resolution and brightness of an HFR camera. The hybrid approach can solve trade-off between the tracking accuracy in real-time motion estimation and the spatial resolution in composing a compensated video sequence. The efficiency of video mosaicking is verified by conducting experiments: (a) capturing an indoor scene using a camera mounted on a fast-moving two-degrees-of-freedom pan-tilt system, (b) capturing an outdoor scene using a hand-held camera that was rapidly moved in a periodic fashion by hand. Whereas, the effectiveness of hybrid-camera-based digital video stabilization is demonstrated by conducting several experiments such as, (a) verification when the hybrid-camera system oscillates in the pan direction in front of a checkered pattern, (b) stabilization in video shooting a photographic pattern when the system moved with a mixed-displacement motion of jitter and constant low-velocity in the pan direction, and (c) stabilization in video shooting a real-world outdoor scene when an operator holding hand-held hybrid-camera module while walking on the stairs.

The thesis is summarized in six chapters; chapters are explained as follows,

In chapter 1, The problems associated with photography and videography are described observed in various applications. This chapter also explains the related works on feature tracking and jitter estimation methods that have been investigated and implemented by the researchers as well as research on various applications of high-speed vision systems in object tracking, mosaicking, and in numerous fields where hyperactive vision systems are required.

In Chapter 2, the concept of high-speed vision-based video mosaicking and stabilization using a feature point-based approach is proposed, including the fundamentals of global displacement and jitter sensing using an HFR vision system.

In Chapter 3, the algorithms for displacement and jitter sensing are explained along with a description of panoramic image composition and stabilized video composition.

In Chapter 4, the resources used for implementing the proposed method are explained with a detail clarification of the hardware and software components. The multithreaded approach for real-time synthesis is also specified in this chapter.

In Chapter 5, the experiments conducted for verifying the effectiveness of digital video stabilization and video mosaicking are demonstrated including verification and the outdoor demonstration to show the feasibility of the proposed method in a real-world scene as well as discusses the experiments conducted for composing panoramic images at indoor and outdoor scenes. In this chapter, the computational

efficiency of our proposed system is also discussed and compared with the various conventional methods for jitter sensing and video stabilization.

Finally, Chapter 6, concludes the contributions of this study and discusses the futuristic improvements to achieve more robust results as well as the real-time implementation of video stabilization and mosaicking in various applications of the real-world.