Poster: Multicamera Synchronization for Smartphones using Optimally Modulated Illuminations

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ABSTRACT

The paper describes a rapid and accurate time-synchronization technique for smartphones using their built-in cameras and its preliminary evaluations for application development.

Keywords

Smartphone, camera synchronization, LED illumination

1. INTRODUCTION

The proposed technique is applicable to a motion-capture, 3D video or a pseudo high-speed camera system using multiple smartphone built-in cameras by controlling their shutter timings. Existing time-synchronization techniques (e.g.[1]) are assumed to be run on a realtime OS, or need long time because of frequent message exchanges between devices. Achieving rapid and accurate time-synchronization is hence difficult. We reported a time-difference estimation technique between a LED light and a 60 fps camera, and achieved 0.0174 ms estimation errors at the 90th percentile using 4 frames (0.067 sec)[2]. We extended this technique and conducted preliminary evaluations using smartphones.

2. PROPOSED TECHNIQUE

An optimally modulated signal emitted from a LED and its time difference t_D $(0 \leq t_D < 1/f_S)$ from a camera is derived theoretically, if given the camera frame rate f_S, exposure time ratio η and intensity values of four consecutive frames (see [2] for details). The synchronization of a LED and a smartphone is conducted by first obtaining t_D, setting the camera frame rate to $f_S^{'} = 1/(2/f_S - t_D)$ $(f_S^{'} < f_S)$ and then returning to f_S. Synchronizing multiple smartphones is conducted individually in the same manner.

3. EXPERIMENTS AND FUTURE PLAN

Apple iPhone 6s and iPhone 7 Plus were used. A LED (OptoSupply OSB56A5111A) connected to a function generator (NF Corporation, WF1948) emitted an optimally modulated signal for a camera with parameters $\eta = 0.50$ and $f_S = 60$ (Hz). The time synchronization software was programmed with Swift3.0. Cumulative distribution functions (CDFs) of time synchronization errors in a no ambient light setting is shown in Figure 1 (a). The proposed technique using iPhone 6s and iPhone 7 Plus achieved 0.176 ms and 0.160 ms errors at the 90th percentile, respectively. From Figure 1 (b), errors and standard deviations did not change remarkably by repeating time synchronization calculations. Figure 1 (c) shows the time drifts of the smartphones after the completion of their synchronization were stable and different from each other, which must be considered in developing applications.

The following issues are to be investigated: (1) efficient methods for synchronizing heterogeneous smartphones (different models, vendors and camera parameters) and (2) useful applications. For example, a 120 fps pseudo high-speed camera was configured by using the two smartphones whose shutter release timing difference was adjusted to 1/120 sec (Figure 2).

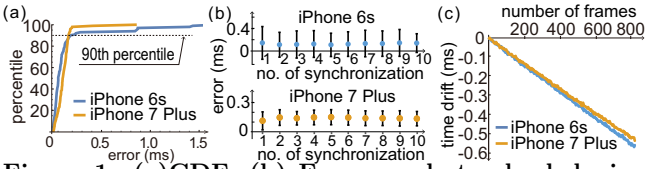

Figure 1: (a)CDFs (b) Errors and standard deviations ($n = 100$) and (c) Time drifts

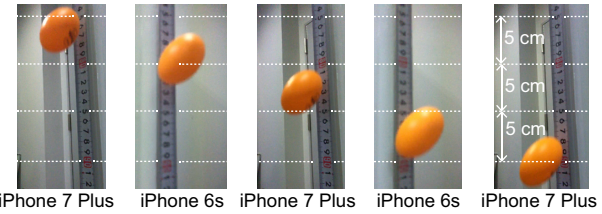

Figure 2: Pseudo high-speed camera capturing a falling ping-pong ball (1/120 sec intervals from the left)

4. REFERENCES

[1] R. Lim, B. Maag, and L. Thiele. Time-of-Flight Aware Time Synchronization for Wireless Embedded Systems. In *Proceedings of EWSN'16*, pages 149–158, Graz, Austria, 2016.

[2] M. Sugimoto, H. Kumaki, T. Akiyama, and H. Hashizume. Optimally Modulated Illumination for Rapid and Accurate Time Synchronization. *IEEE Transactions on Signal Processing*, 65(2):505–516, 2017.

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