Calibration of Video Cameras Frame Rate based on Onsets Tracking Technique

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***Summary* – This paper presents a calibration method developed at the Standards and Calibration Laboratory (SCL) for calibration of the frame rate of a video camera. The measurement setup includes a signal generator, a flashing light source and an in-house developed intensity analysis program. The calibration principle is based on analysing the intensity variation of a flashing light source recorded by a video camera under test. The onsets tracking technique is applied to track the glowing onsets instance of the flashing light source at particular frames, which offers traceable reference for frame rate setting of a video camera. Frame rates of a high speed camera calibrated by the proposed method are presented and discussed in this paper.**

Keywords – Calibration; Video Camera; Frame Rate; Onset

I. INTRODUCTION

Video cameras are ubiquitous in our everyday life such as mobile phones, IP cameras, CCTV system, etc. The frame interval of a calibrated video camera can be used to determine the elapsed time of a recorded video, which could be useful information for legal enforcement investigation [1] - [2]. The frame rate of a video camera can be calibrated by capturing the glowing pattern of a flashing light source. As illustrated in Fig. 1, a light source is flashing on and off periodically with frequency of F_S. When two successive glowing onsets are observed at frames 0 and N of a recorded video, the frame rate of the video camera, F_C, can be calculated from F_S and N. In practice, the captured light glowing onset could happen any time within a particular video frame. So, the measurement uncertainty could become significant particularly at slow frame rate. Recently, several methods [3] - [5] were proposed for measuring the frame rate of a video camera. These methods utilized the video camera under test to record videos of a reference light source array with a very accurate flashing frequency. The frame rate and other timing parameters of the video camera can then be determined by analysing the on/off characteristics of the light source.

In this paper, a proposed method to calibrate the frame rate of a video camera by recording a video of a single reference flashing light source. As illustrated in Fig. 2, for a 50 % duty cycle square wave signal, the light source is flashing at a frequency which is slightly less than half of the frame rate of the video camera. According to the feature of exposure, the light source intensity captured by each frame relates to the captured duration of the growing light. If a recorded frame contains most of the off duration and a very short glowing onset, it can be observed that this frame starts to capture light from the reference

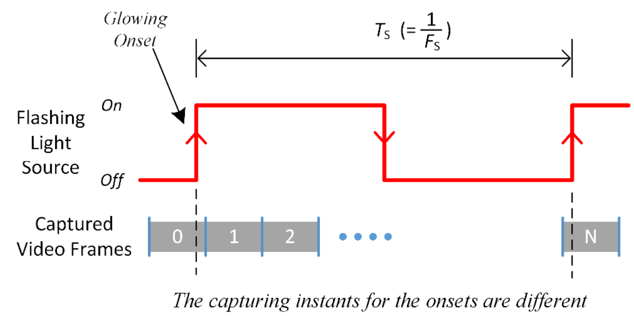

Fig. 1. Imbalanced capturing instants for the glowing onset instants.

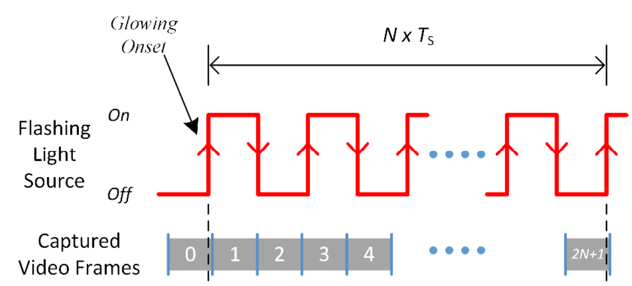

Fig. 2. Onsets tracking technique.

light source and is treated as our reference point. This reference point will repeat in every N flashing cycles of the light source. This reference point of glowing onsets can be used as an accurate reference in determining the frame rate of the video camera under test. By tracking the onsets instance, the duration of N flashing cycles of the light source will be approximately equal to $(2N + 1)$ frames at frame rate of the video camera, which gives

$$(2N+1)\frac{1}{F_C} \approx N\frac{1}{F_S} \tag{1}$$

By representing the captured video frame reference point cycle $(2N + 1)$ as N_R, the camera frame rate can be formulated as

$$F_C \approx \frac{2F_S N_R}{N_R - 1} \tag{2}$$

II. MEASUREMENT SETUP

The measurement setup for the calibration of the video camera frame rate is illustrated in Fig. 3. A signal generator is phased locked to the Laboratory's Caesium reference standard to generate square wave signal to the LED board and a power supply is connected to the LED board. The LED flashes at the same frequency as the square wave frequency. The video camera under test is configured to record a video of the flashing LED. The recorded video is analysed frame-by-frame to locate the reference point frame numbers and to determine the frame rate.

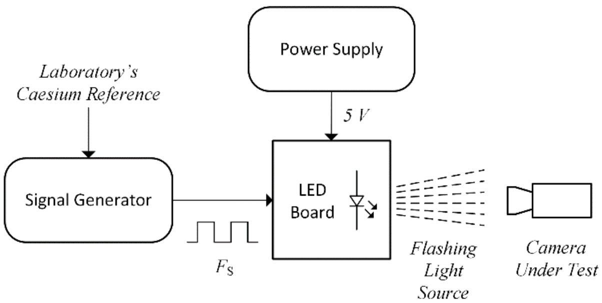

Fig. 3. Bock diagram of the measurement setup.

III. Measurement Results

The developed calibration method was used to calibrate the frame rate of a high speed camera which is illustrated in Fig. 4. The camera was focused on the flashing LED to emphasize the light intensity in the recorded video. A flashing frequency of 499 Hz was applied in the calibration for video camera frame rate setting of 1000 fps. 10 consecutive recorded video frames are shown in Fig. 5, which illustrated the variation of LED intensity in every alternate frames (i.e. 2, 4, 6, 8 and 10). SCL had developed a software tool to analyse the light intensity of captured video frames [6]. The light intensity versus frame was plotted in Fig. 6. The average reference point cycle was 519 frames, while the frame rate determined by the proposed method was 999.926 6 fps. For a video camera frame rate setting of 50,000 fps, the frame rate determined by the proposed method was 49,999.713 6 fps. Calibration results together with the measurement uncertainties, which were evaluated in accordance with JCGM 100:2008 [7], are summarized in TABLE I.

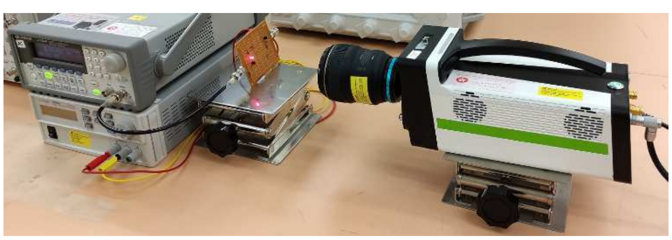

Fig. 4. Measurement setup for the camera frame rate calibration.

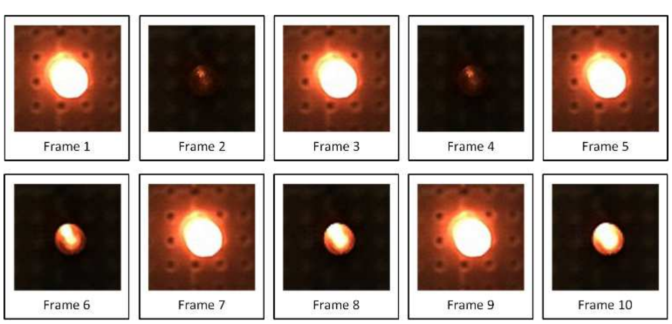

Fig. 5. Captured LED glowing status in 10 consecutive frames.

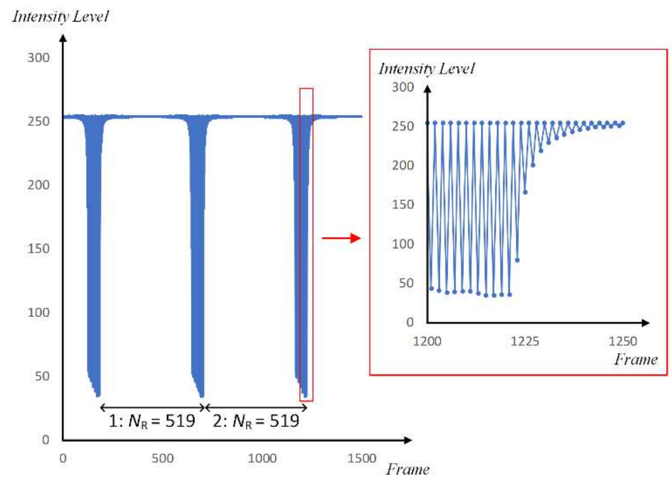

Fig. 6. Plot of light intensity level versus frames.

TABLE I. Frame rate calibration results

Camera Frame Rate Setting (fps)	Applied F_s (Hz)	Measured Frame Rate (fps)	Expanded Measurement Uncertainty (fps)
1,000	499	999.926 6	0.005 6
50,000	24,999	49,999.713 6	0.001 4

IV. Conclusion

SCL has developed a video camera frame rate calibration method based on onsets tracking technique. The method offers the advantage of obtaining precise time reference of recorded video frames using a single light source. Software tool was developed in-house for the effective analysis of the large amount of video frames and the evaluation of measurement results.

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