Image Stabilization Algorithm for Video with Large Image Fluctuation.

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***Abstract*-- We propose an image stabilization system for video with large image fluctuation by estimating and correcting translation and rotation from the video. The fluctuation is handled ,separately ,as ,relative ,inter-frame ,motion ,and ,absolute intra-frame information, in order to suppress large fluctuation in the video sequence efficiently.**

I. INTRODUCTION

People often take a video following the object while walking, without checking the viewfinder. In such occasions, the videos often contain large image fluctuations that are extremely annoying when watching, and what is worse, it could cause visually induced motion sickness sometimes. Therefore, it is desirable to suppress large image fluctuations in a video. Fig.1 shows frequency analysis of image fluctuations caused by handling and walking[1]. Image fluctuations in walking are generally much larger than in handling, and it is hard to suppress such large image fluctuations just by applying conventional method like Optical Image Stabilizer (OIS).

To solve this issue, we developed a new algorithm featuring both inter-frame and intra-frame information, not only to reduce the fluctuation level in each frame, but also to prevent errors from accumulating over the video sequence.

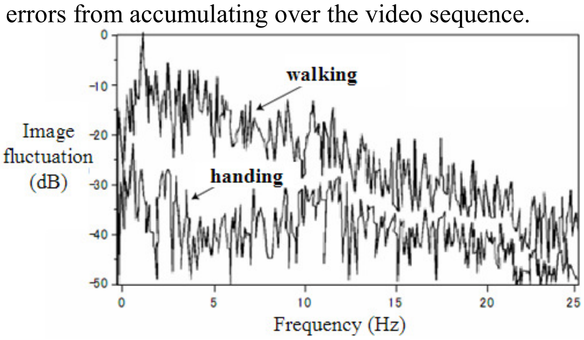

Fig.1 Frequency analysis of f image fluctuation

II. PROPOSED APPROACH

Proposed algorithm is composed of four units, "frame extraction", "motion estimation", "slant estimation" and "image correction" units as shown in Fig.2. The function of each unit is explained as follows: Frame extraction unit extracts frame images from the video sequence frame by frame. Slant estimation unit requires one frame image as an input, and estimates absolute slant angle ($roll_A$) of the one frame image. Motion estimation unit accepts successive two frame images as input, and detects relative rotation and translation motion ($roll_R$, x, y) between the two images. Image correction unit

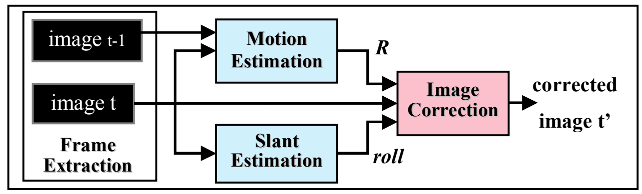

Fig.2 Overview of Proposed algorithm

corrects the frame image(t) by using the detected parameters ($roll_R$, x, y) and ($roll_A$).

As explained above, both slant estimation unit and motion estimation unit outputs similar angular information such as ($roll_A$) and ($roll_R$). The reason why we need these two outputs in image correction unit is explained as follows:

Since motion estimation unit estimates relative motion between frame(t-1) and frame(t), frame(t) should be corrected so as to match the position of frame(t-1) as in Fig.3(a). Therfore, frame(t-1) must be located at the right position to correct frame(t) properly. However, errors are often inevitable in motion estimation, and once the error occurs, the position of frame(t-1) could be in the wrong position. Especially if estimation error occurs in roll, corrected frame(t) will slant as in Fig.3(b). This is why we need slant estimation unit as well. With the ability of detecting the absolute slant angle independently for each frame, the slant estimation unit helps to correct the wrong roll angle in motion estimation unit and prevent errors to be accumulated. By combining these two units properly, not just a relative fluctuation between two frames is reduced, but also large image fluctuations in the video sequence are minimized being free from error accumulation in roll angle. As estimation errors in x or y, have relatively little impact on image correction, we do not require further correction on these values.

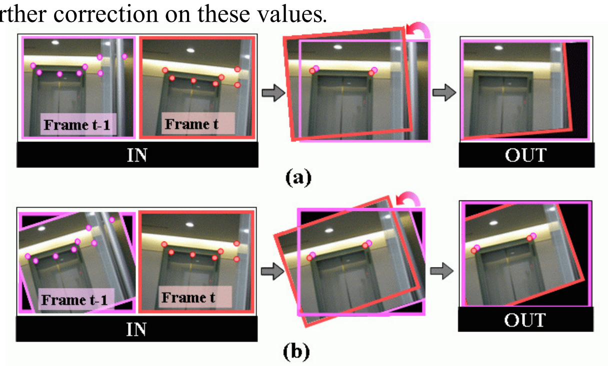

Fig.3 Effect of Slant Estimation

III. DETAILS OF EACH UNIT

A. Slant Estimation Unit

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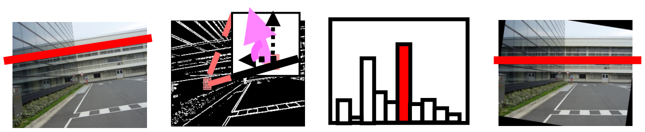
Fig. 4 shows the concept of slant estimation. In this unit, the absolute slant angle $roll_A$ is estimated from an input frame image by using the clue like line segments originated from architectural structures such as buildings. The key idea of this algorithm is based on the following: Typically, general architectural structures stand uprights against the ground. Therefore, the line segments from architectural structures should have information about absolute slant angle of the image. As line segments appear as changes in luminance level, the unit can estimate an absolute slant angle by measuring the direction of luminance change within the image. These luminance changes then create a histogram having frequency of luminance changes as horizontal axis and angles as vertical axis. Finally, the angle with the highest frequency in the histogram is estimated as the absolute slant angle $roll_A$.



(a)original image (b)Concentration gradient from edge (c) Concentration gradient histogram (d) Slant estimation

Fig.4 Concept of Slant Estimation

B. Motion Estimation Unit

We assume that inter-frame relative motion of video camera is expressed as a three-dimensional rotation matrix R (roll, pitch and yaw). The motion estimation unit calculates rotation matrices by matching method in feature points of adjacent frames using the estimation method called RANSAC (RANdom SAmple Consensus), within assigned time as illustrated in Fig.5. After the calculation, the rotation matrix with the highest goodness of fit is estimated as the true rotation matrix that represents inter-frame motion[3]. The inter-frame distances of roll, pitch and yaw represented by the true rotation matrix are converted into inter-frame distances of roll, x and y.

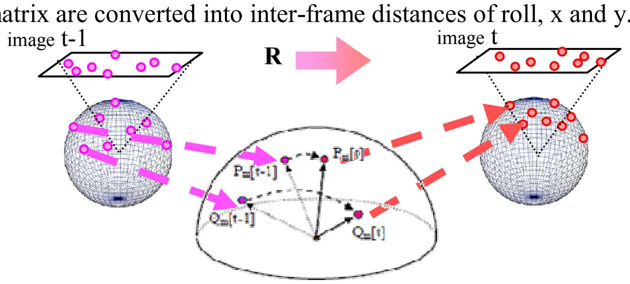


Fig.5 Algorithm for Motion Estimation

C. Image Correction Unit

By using both the absolute slant angle, and the relative rotation and translation, image correction unit transforms input image to obtain image sequence in which the large fluctuations in each frame should be suppressed.

IV. EXPERIMENTAL RESULTS

To evaluate the performance of the propose algorithms, we have conducted experiments as follows:

A. System Performance Test

Table.1 shows remaining error angles in proposed system, for four different magnitudes of simulated fluctuations, and OIS on this system, when four types of artificial image fluctuation are added into frame images.

Table.1 Result of Proposed System

	Proposed System				OIS
Added Level	5%	10%	15%	20%	–
Max Fluctuation	±0.281	±0.562	±0.843	±1.125	±0.319
Error Remaining	±0.004	±0.010	±0.006	±0.023	±0.061

It is confirmed that image fluctuation was reduced from 1.125 degrees in angle (20 percent in amplitude) to small as 0.023 degrees. In comparison, in OIS, maximum image fluctuation allowed is 0.319 degrees at most, with remaining error of 0.061 degrees[2]. This means the image-stabilizing performance in proposed method is effective even for large image fluctuations as high as 20 percent in the amplitude, suppressing the remaining errors to acceptable levels.

B. Evaluation for Rotaion

We also conducted the experiment to confirm the performance for rotation. Fig.6 shows transitions of error roll angle of frame images with or without slant estimation unit. The true value of roll angle is always 0.0, as the video clips used in this experiment have no roll movement.

In motion estimation unit, the inter-frame relative motion is estimated for every adjacent frame. However, as estimation error sometimes occurs, and once estimation errors were accumulated over frames, angle information given from motion estimation would be diverted from the true angle. On the contrary, the error in roll angle is always kept low as shown in Fig.6 owing to the absolute slant information.

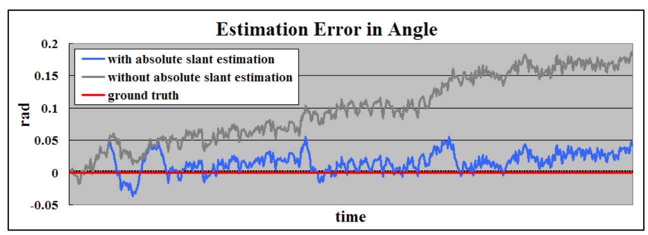


Fig.6 Estimation Errors in Roll Angle

V. CONCLUSIONS

We have tackled with the problem to suppress large image fluctuations contained in the video taken while walking. It is shown that the proposed algorithm makes it possible to suppress large image fluctuations effectively, being free from error accumulation in processing the video sequence.

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