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Experimental Study Efficiency of Robust Models of Lucas-Kanade Optical Flow Algorithms in the Present of Non-Gaussian Noise

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***Abstract*— This paper presents experimental efficiency study of noise tolerance model of spatial optical flow based on Lucas-Kanade (LK) algorithms such as original LK with kernel of Barron, Fleet, and Beauchemin (BFB), confidence based optical flow algorithm for high reliability (CHR), robust motion estimation methods using gradient orientation information (RGOI), and a novel robust and high reliability for Lucas-Kanade optical flow algorithm using median filter and confidence based technique (NRLK) under several Non-Gaussian Noise. These experiment results are comprehensively tested on several standard sequences (such as AKIYO, COASTGUARD, CONTAINER, and FOREMAN) that have differences speed, foreground and background movement characteristics in a level of 0.5 sub-pixel displacements. Each standard sequence has 6 sets of sequence included an original (no noise), Poisson Noise (PN), Salt&Pepper Noise (SPN) at density (d) = 0.005 and d = 0.025, Speckle Noise (SN) at variance (v) = 0.01 and v = 0.05 respectively which Peak Signal to Noise Ratio (PSNR) is concentrated as the performance indicator.**

I. INTRODUCTION

LK is local intensity gradient based optical flow algorithm that is applied in many areas such as image segmentation, motion estimation, motion tracking, video encoding, video compression & reconstruction, image stabilization and super resolution reconstruction because of its simplicity and fast computation. But under the noisy conditions, the quality of LK decreases. Several models of noise tolerance under the LK based algorithm were proposed to increase the performance of the motion vector (MV). This paper concentrates on the performance of classical spatial optical flow of LK algorithm [1] and its advance models such as BKB kernel [2], CHR [3], RGOI [4], and NRLK [7] when they are applied over Non-Gaussian noises sequences.

In 1994, Barron, Fleet, and Beauchemin (BFB) [2] adjusted the kernel model on density of velocity for increasing the performance of original LK. In 2008, CHR was proposed to increase performance by using bidirectional symmetry with consideration on reliability rate. In 2009, RGOI [4] was proposed by using median filter to increase noise tolerances. In 2010, D. Kesrarat and V. Patanavijit have performed performance evaluation on many optical flow algorithms which LK, CHR, and ROGI are included [5-6] on Additive White Gaussian Noise (AWGN). Then, we continue to investigate the accuracy in performance of the CHR, RGOI, and NRLK when they are applied on LK based optical flow in this experiment over several non-Gaussian noises.

Finally, we evaluate the performance by comparing these reconstruction image frames with their corresponding original sequence by using PSNR in which the better of estimated result in MV lead to the higher dB in PSNR. In this paper, we address the studying of the effects introduced by totally 4 optical flow for motion estimation on LK based algorithms (LK, CHR, RGOI, and NRLK) when they applied to sub-pixel displacement on multiple non-Gaussian noise sequences.

This paper is organized as follow. Section II explains the motion estimation algorithm based on considered optical flow algorithm. Section III introduces the experiment results that assess the quality of the estimated motion. Section IV concludes the experiment result.

II. OPTICAL FLOW MOTION ESTIMATION ALGORITHMS

This section presents optical flow algorithms for motion estimation that we references in our experimental.

A. Local Intensity Gradient Based Optical Flow (Lucas - Kanade) Algorithm (LK) [1]

In 1981, B.D. Lucas and T. Kanade proposed this algorithm that it is based on differential technique of local gradient intensity. It used intensity for gradient constraint and applied weight least-squares as constant model in each small spatial neighborhood which iterative process is repeated to minimize and to obtain final image velocity.

Firstly, Estimated MV is obtained under differential technique by using gradient constraint with a global smoothness defined as:

$$\begin{aligned} Ix &= \tfrac{1}{4}\{I_{x,y+1,k} - I_{x,y,k} + I_{x+1,y+1,k} - I_{x+1,y,k} + I_{x,y+1,k+1} - I_{x,y,k+1} \\ &\quad + I_{x+1,y+1,k+1} - I_{x+1,y,k+1}\} \\ Iy &= \tfrac{1}{4}\{I_{x+1,y,k} - I_{x,y,k} + I_{x+1,y+1,k} - I_{x,y+1,k} + I_{x+1,y,k+1} - I_{x,y,k+1} \\ &\quad + I_{x+1,y+1,k+1} - I_{x,y+1,k+1}\} \\ It &= \tfrac{1}{4}\{I_{x,y,k+1} - I_{x,y,k} + I_{x+1,y,k+1} - I_{x+1,y,k} + I_{x,y+1,k+1} - I_{x,y+1,k} \\ &\quad + I_{x+1,y+1,k+1} - I_{x+1,y+1,k}\} \end{aligned} \tag{1}$$

After those weight least-squares are applied in each spatial neighborhood for MV.