An Adaptive Motion Estimation Algorithm For Irregular Motion Of Objects

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***Abstract*— In this paper, a novel motion estimation method is proposed in order to enhance the block based matching. The enhancement is achieved by eliminating the number of search points, which in turn will reduce the computation complexity of any block based matching method. Relying on the social force model, a predicted direction of the motion vectors can be estimated significantly.**

***Keywords*— Motion estimation, Diamond search, social force model, search points, surveillance, predicted motion vector**

I. Introduction

Motion estimation (ME) is a very active research topic and performs an efficient role in computer vision. Various algorithms for motion estimation have been proposed such as statistical model based method, frame difference, optical flow, and block based matching algorithm (BMA). Some have proposed using 3D information using focus measures too [1,2]. BMAs have been employed to generate the motion vectors of each moving block using distinct search techniques as well as several search points distribution around the center search point in order to eliminate the number of these search points[3,4]. Such algorithms share a common problem, where they are likely to trap into a local minimum problem. In order to overcome this difficulty, some researchers exploited the neighboring candidate blocks to predict the motion vector [5,6].

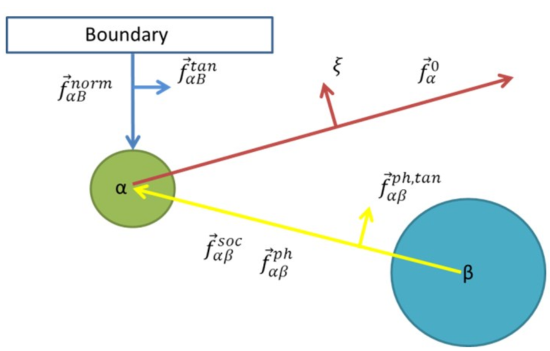

Fig 1. The Social forces of pedestrian α

Since such methods are highly dependent in their prediction procedure on the correlation between motion vectors, many irregular motion vectors which may exist in crowded scenes; the crowds avoiding obstacles or individuals passing through crowded street are common examples of such issue. In this paper, to estimate the complicated and irregular crowd motion more effectively, we used social force model (SFM) with the block matching method. Based on the concept of social force, each potential change in the direction of moving crowd influenced by different conditions can be predicted.

II. The Social Force model

This model has been developed primarily by D. Helbing and P. Molnár [7]. They noticed obviously that the social forces among pedestrians reflect no physical meaning, rather than the intents of pedestrians avoiding collision with each other or even with any obstacle. The general expression for this force can be written as:

$$\vec{f}_{\alpha} = \vec{f}_{\alpha}^{0} + \vec{f}_{\alpha\beta} + \vec{f}_{\alpha B} + \vec{f}_{att} + \vec{\xi}$$

Where $\vec{f}_{\alpha}^{0}$ refers to the driving force that describes each individuals desire to move to their intended destination. The $\vec{f}_{\alpha\beta}$ represents the interaction force between two pedestrian which Consist of a socio-psychological force and physical interactions. On the other hand $\vec{f}_{\alpha B}$ indicates the boundaries influence on each pedestrian. Many attractive events such as fighting or shops may have their influence on the crowd behavior and can be represented by $\vec{f}_{att}$. Finally, the individuality and random behavior fluctuations are referred to as ξ. In figure 1, illustrated these forces in detail.

III. Proposed Method

In our proposed method, the information of predicted direction of current motion vector is effectively exploited using the SFM of a pedestrian or even a crowd. This information is not only employed for deciding the next start search point, but also used to enhance the accuracy of the motion vectors by adding more information about the correct direction of each pedestrian. This process can significantly help avoid being trapped in local minimum. The social force model based block matching method adapts its searching point according to the predicted direction of motion vector. Flow chart of the proposed motion estimation search is displayed in Figure 2.

A. Step 1: Initial step:

Initially, we define a large diamond with 8 search points around the center search point. The search will start from the nearest point that is located close to the main direction of the pedestrian motion. Such direction is determined as mentioned previously by both driving and interaction forces.

B. Step2: The prediction of the motion:

When a group of pedestrians walk in a certain way with a smooth motion and far distances between them, the driving force becomes larger compared to the interaction force. That will lead to the fact that the predicted direction of each individual is controlled by the driving force. On the contrary, when there are a lot of obstacles as well as the pedestrians start colliding with each other, the interaction force will become larger than the driving force and the predicted direction can be estimated based on the direction of the interaction forces.

C. Step 3: Final Step:

According to different conditions, there is a small probability that the best match after comparing with a specific threshold will not exist directly in the predicted direction; therefore the proposed algorithm performs an alternative search which checks the next two search points closer to predicted direction.

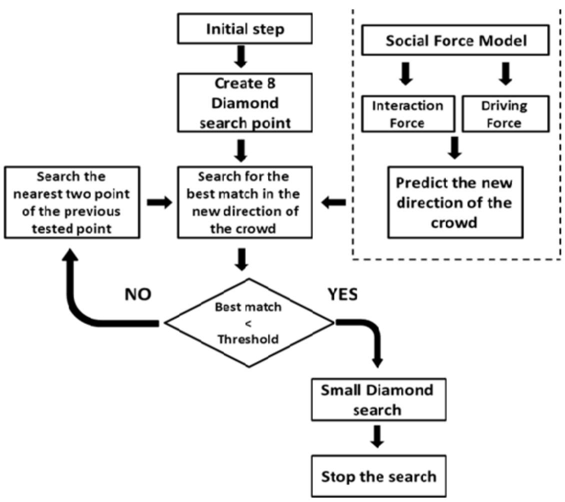

Fig 2. Flow chart of the proposed SFM based block matching method.

IV. RESULTS

In our implementation, we set the relaxation time to 0.5 s in addition to choose $A_{\alpha}^{1}= 0$ and $B_{\alpha}^{1} = 0.3$ m as suggested by Helbing [8]. The reason of this is to speed up the implementation process. Additionally we should take into account the form factor $F_{\alpha\beta}$ which account for the antistrophic action of the pedestrians and provides a higher influence for those pedestrians within the view of an individual compared to those out of the view. Once there is another pedestrian in direct direction of the movement that yields the maximum value of this factor ($F_{\alpha\beta} = 1$).

Figure 6 shows a comparison between our proposed method and different block based matching methods. This comparison demonstrates that the proposed method reduces the number of search points significantly, especially when the pedestrians tends to avoid collision between each other.

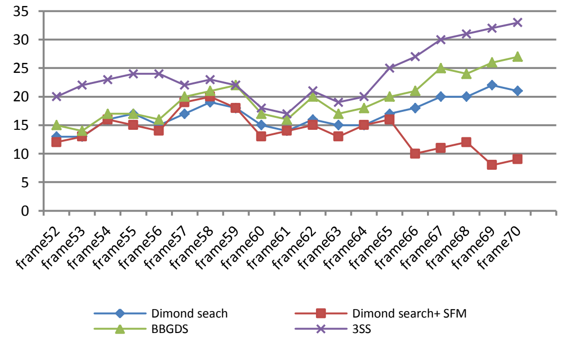

Fig 3. Number of search patterns of four block based matching algorithms.

Considering the reduction in the computational complexity, the quality degradation is very low. In all cases, the Full search algorithm outperforms the others in image quality. Compared to FS, average PSNR degradation of the proposed algorithm is only 0.11 as shown in Table 1.

TABLE 1. THE PSNR RESULT OF EACH METHOD FOR THREE SCENARIOS

Quality Degradation					
Scenario	***TSS PSNR***	***BBGDS PSNR***	***DS PSNR***	***DS+SFM PSNR***	***FS PSNR***
Simple Flow	25.24	27.05	28.31	29.16	29.35
Avoiding	22.81	24.03	24.37	25.38	25.49
Blocking	24.12	26.54	27.20	27.33	27.38

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