Measurability of Crowd Collectiveness in Dynamic Scenes

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1. Introduction

Collective motions are common in crowd systems and have attracted a great deal of attention in a variety of multidisciplinary fields [2]. Collectiveness, which indicates the degree of individuals acting as a union in collective motion, is a fundamental and universal measurement for various crowd systems. Quantitatively measuring this universal property and comparing it across different crowd systems are important in order to understand the general principles of various crowd behaviors. It plays important roles in many applications, such as monitoring the transition of a crowd system from disordered to ordered states, studying correlation between collectiveness and other crowd properties such as population density, characterizing the dynamic evolution of collective motion, and comparing the collectiveness of different crowd systems. One remarkable observation of collective motions in various crowd systems is that some spatially coherent structures emerge from the movements of individuals in the crowds, which are referred to as collective manifold of collective motion illustrated in Fig.1. Based on the structure of collective manifold, our work aims at analyzing the measurability of crowd collectiveness and formulating a new collectiveness descriptor for collective motions[1].

In our work, a descriptor of collectiveness and an efficient computation for the crowd and its constituent individuals are formulated. This descriptor first estimates the behavior consistency of individuals in neighborhood. Then it integrates the path similarities from different length scales on the graph of collective manifold to get the individual collectiveness ϕ. Then the crowd collectiveness Φ is estimated as the average of all the individual collectiveness. Based on the collectiveness descriptor, an algorithm called Collective Merging is then proposed to detect collective motions from random noises.

[1]Data and codes are available at
http://mmlab.ie.cuhk.edu.hk/project/collectiveness/

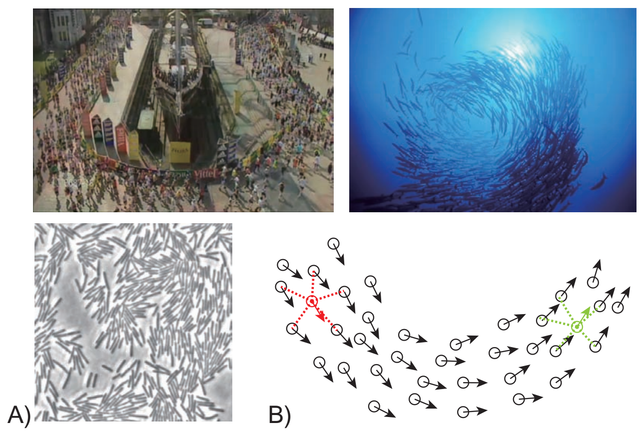

Figure 1. A) Collective motions of human crowd, fish shoal, and bacterial colony. B) Spatially coherent structures, *i.e.*, *Collective Manifold*, emerging in these crowds. Since individuals in a crowd system only coordinate their behaviors in their neighborhood, individuals at a distance may have low velocity correlation even though they are on the same collective manifold. An example of this is the red individual and the green individual. Thus, accurately measuring the collectiveness of crowd and its constituent individuals is challenging. Colored dash links represent neighborhoods.

2. Experimental Results

We first validate the effectiveness and robustness of the proposed collectiveness descriptor on the system of Self-Driven Particles [1], since SDP is widely used in crowd simulation. As shown in Fig.2A, collectiveness Φ records the emergence of collective motion in SDP. Further experiments on detecting collective motions and measuring their collectiveness in videos of pedestrian crowds and bacteria colony show the robustness and generalization of the collectiveness descriptor and the algorithm of collective merging. Some examples are shown in Fig.2B. Furthermore, We compare the collectiveness descriptor to human perception for collective motion on a new dataset called Collective Motion Database. This dataset consists of 413 video clips from

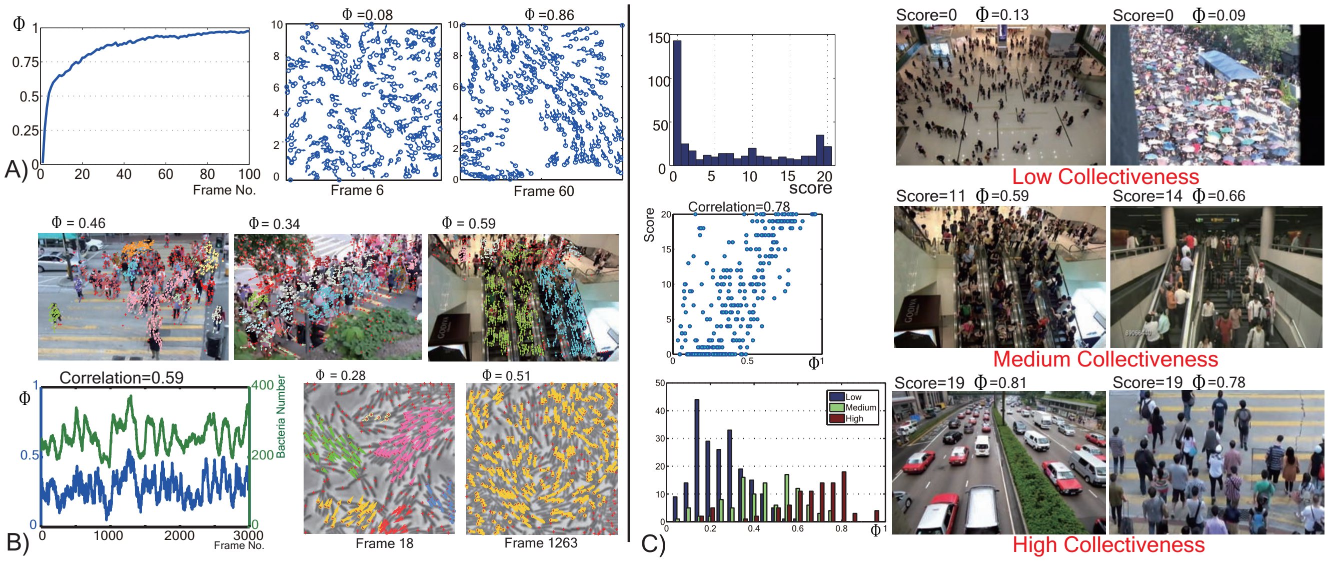

Figure 2. A) Evaluation of Φ on Self-Driven Particles. Φ accurately records the emergence of collective motion in SDP. B) Detecting collective motions and measuring their collectiveness in videos of pedestrian crowds and in bacterial colony. Keypoints with the same color belong to the same cluster of collective motion. Red crosses are detected outliers. The correlation between the number of bacteria and Φ is high. C) Comparing Φ with human perception for collective motion. The first diagram is the histogram of collective scores of all the videos in the Collective Motion Database given by 10 human labelers. The second diagram shows the high correlation between Φ and the collective scores. The third diagram is the histogram of Φ for the three categories of videos. Some example videos from three categories with their computed Φ are shown on the right-hand side.

62 crowded scenes; every clips are scored and labeled by 10 subjects into three categories of collectiveness according to the level of collective motions in the video. In Fig.2C, statistical analysis shows the high correlation between the estimated collectiveness descriptor and collective scores given by the subjects. Thus, the proposed collectiveness descriptor is consistent with human perception for collective motion.

As a new universal measurement for various types of crowd systems, the proposed crowd collectiveness descriptor and the algorithm of collective merging should inspire many interesting applications and extensions in future work.

This work has been published as oral presentation at CVPR 2013 [3].

References

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