Motivation

Coherent motions widely exist in natural phenomena

- Bacteria
- Fish shoal
- Pedestrian crowd

Objectives:
1. revealing the prior underlying coherent motions;
2. proposing the algorithm of coherent motion detection.

The Prior: Coherent Neighbor Invariance (CNI)

Illustration of CNI in K nearest neighbor (K=7)

Two key properties:
- Invariance of spatiotemporal relationships: the neighborhood of individuals with coherent motions tends to remain invariant over time.
- Invariance of velocity correlations: the velocity correlations of neighboring individuals with coherent motions remain high when being averaged over time.

Studying CNI through Random Dot Kinematogram

We define two ratios to quantify CNI in K nearest neighbor:

\[ p_{\text{inv}} = \frac{|M_{\text{inv}}|}{k} \]

\[ R_{\text{inv}} = \frac{|C_{\text{inv}}|}{|M_{\text{inv}}|} \]

Pairwise velocity correlations averaged from time t to t+1:
we can remove incoherent dots by thresholding the pairs.

Algorithms of Coherent Filtering

Algorithm 1: detecting coherent motion patterns at one frame

1. For \( v \) in \( t \) to \( t+d \):
   01: search \( k \) nearest neighbor set as \( M \) for each dot \( v \) in \( t \).
   02: search the invarient neighbor set as \( M_{\text{inv}} \).
   03: Compute the averaged velocity correlations \( v_{\text{inv}} \).
   04: include \( v \) in \( R \) if \( v_{\text{inv}} > \lambda \).
   05: Build a graph from \( g \). Remove incoherent moving individuals as the isolated node.

Algorithm 2: associating continuous coherent motion over time relying on the overlap between clusters detected at consecutive frame.

Experimental Results & Applications

3D Motion Segmentation

Comparison with the ground truth

Coherent Motion in Synthetic Data

Checkboard Traffic Articulated

Average Time

Checkboard All sequences

Motion Segmentation

GPCA

Articulated

3D Motion Segmentation

Hopkins155 Database

More information at http://zhoubolei.com