Understanding Pedestrian Behaviors from Stationary Crowd Groups

Shuai Yi[1], Hongsheng Li[1,2], Xiaogang Wang[1]
[1]Department of Electronic Engineering, The Chinese University of Hong Kong.
[2]School of Electronic Engineering, University of Electronic Science and Technology of China.

Pedestrian behavior modeling and analysis is important for crowd scene understanding and has various applications in video surveillance. Stationary crowd groups are a key factor influencing pedestrian walking patterns but was largely ignored in literature. As shown in Figure 1 (d), the walking path of a pedestrian (black curve) is affected by a stationary crowd group. Without modeling the stationary crowd group, it is difficult to explain why the pedestrian detours when approaching the destination (Figure 1 (f)). Stationary crowd groups can serve as multiple roles (Figure 1 (e)) for different pedestrians, such as source, destination, or obstacle. Moreover, the spatial distribution of stationary crowd groups might change over time (Figure 1 (a)-(d)), which leads to the dynamic variations of traffic patterns. In our work, the factor of stationary crowd groups is introduced for the first time to model pedestrian behaviors.

The Proposed Pedestrian Behavior Model

A general energy map $\mathcal{M}$ is proposed to model the traveling difficulty of every location of the scene. It can be modeled with three channels calculated based on Scene Layout, Moving Pedestrians, and Stationary Groups. People might behave differently under the same situation, which is modeled by a personality parameter P in our model. Given the source and the destination, an optimal path is calculated based on the proposed energy map.

Based on our model, we can investigate the influence of stationary crowd groups on pedestrian behaviors. We observe that stationary crowd groups have greater influence on pedestrian walking paths than moving crowds, which shows the importance of monitoring stationary groups in traffic control system. Moreover, by the interactions among stationary groups and moving pedestrians, a personality attribute is proposed to classify pedestrians into different categories. This attribute is a key factor that makes each individual behave differently. One interesting observation is that people are more likely to behave in a conservative way when the scene is not that crowded. In contrast, a crowded scene leads to aggressive walking patterns because of the lack of space.

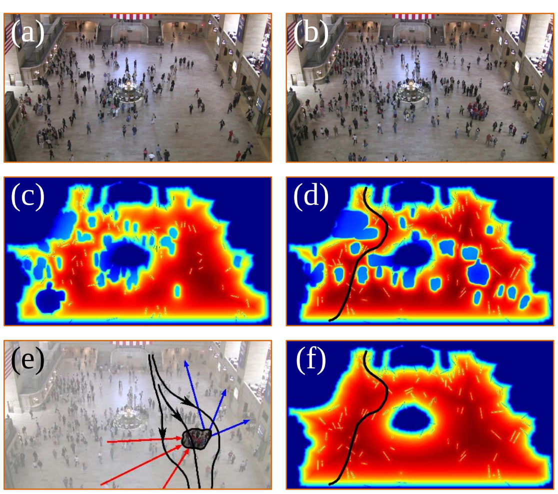


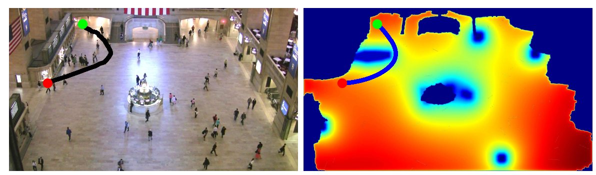
Figure 1: (a)-(b) Two input frames. (c)-(d) Energy maps calculated from (a) and (b) using the proposed model. Pedestrians are more likely to walk through regions with warm colors. (e) An illustration of multiple roles of a stationary crowd group. It can serve as source (blue lines), destination (red lines), and obstacle (black lines). (f) Energy map calculated from (b) without modeling the factor of stationary crowd groups.

This is an extended abstract. The full paper is available at the Computer Vision Foundation webpage.

Applications

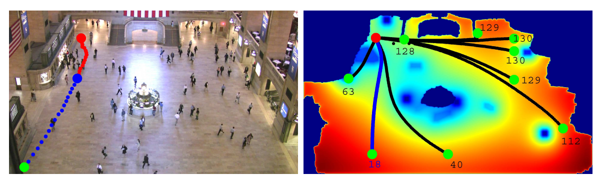
Based on our model, various applications can be implemented and interesting characteristics about human walking behaviors can be revealed.

- Prediction on pedestrian walking paths (Figure 2).
- Prediction of pedestrian destinations (Figure 3).
- Personality attribute estimation and analysis (Figures 4 and 5).
- Abnormal behavior detection based on walking path prediction, destination prediction, and personality estimation.



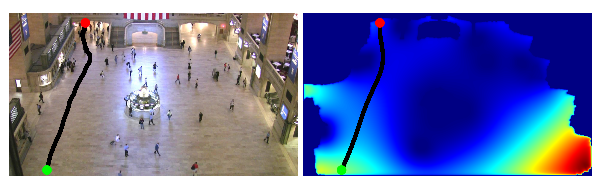
(a) Observation (b) Prediction result

Figure 2: An example of path prediction. Given a source (red) and a destination (green), we can predict an optimal walking route (blue curve).



(a1) Observation (b) Prediction result

Figure 3: An example of destination prediction. Given a source (red) and part of the walking path (red curve), we can predict the destination of this pedestrian. In (b), the predicted destination is chosen as the one with minimal value (blue curve).



(a) Observed walking path (b) Optimal walking path when $P = 1.5$

Figure 4: An example of personality estimation. Estimated personality minimizes the difference between observed path in (a) and optimal path in (b).

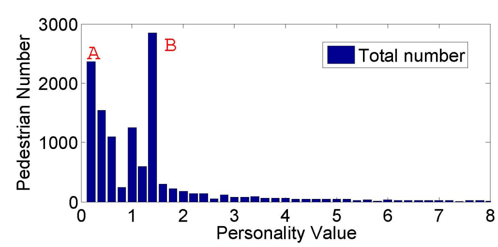


Figure 5: Personality value distribution. Different personality values may lead to different walking behaviors. All pedestrians can be classified into three categories based on their walking behaviors: aggressive, conservative, and abnormal. The peak A represents aggressive pedestrians who prefer to walk directly to their destinations. Conservative pedestrians are represented by the peak B. They prefer to walk a longer way to avoid close contact with others. The long tail of the distribution represents pedestrians that take a long route to their destinations. Conservativeness is no longer proper to describe these pedestrians and we define these behaviors as abnormal.