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Investigating density effects on the “awareness” area of pedestrians using an eye tracker

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Abstract

Understanding behaviour of pedestrian is important for planning and/or design of large public transport facilities. The presented research looks at the “awareness” area, the area where the pedestrian is aware of other oncoming pedestrians. The research focuses on how the size and shape of this area changes according to the density. Employed in the research is an eye tracker, with which we can locate where the pedestrian fixates. Experiment will be performed to examine how fixation patterns change according to the density. The results will be of use for more sophistication of representation of collision avoidance in pedestrian simulations.

Key Words

awareness area, collision avoidance, density, eye tracker, pedestrian simulation

Definition of words

- ***awareness area***: the area in front, side, and back of the pedestrians where he/she scans/monitors presence/behaviour of other pedestrians
- ***collision avoidance***: the phenomenon where two (or more) pedestrians, who are walking toward each other, avoid collision against each other

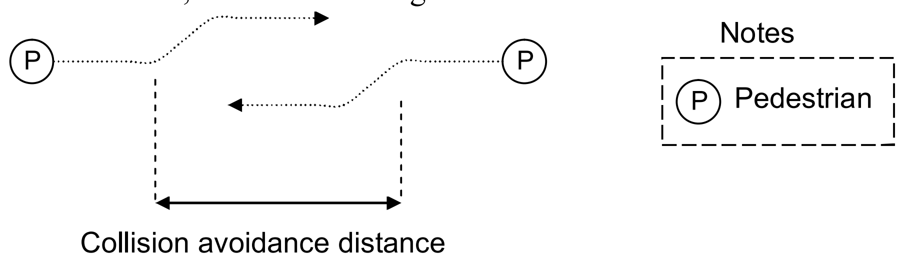

Fig.1 collision avoidance

- ***collision avoidance distance***: the distance between two pedestrians when two pedestrians (or one pedestrian) start avoiding collision with each other (an oncoming pedestrian)

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1. Introduction

Understanding use of space of pedestrian is important for planning and/or design of large public transport facilities. Without detailed knowledge on this, it is impossible to create appropriate and comfortable space for pedestrians.

Such understanding is also of great use for development of pedestrian simulations. With this pedestrian simulation, planners and designers can predict movement of pedestrians as a result of installation or modification of facilities, for example locating a new coffee shop in a railway station. Because of usefulness, pedestrian simulations are largely involved in various planning processes as an essential planning or design tool.

In pedestrian simulations, collision avoidance, the phenomenon where pedestrians avoid each other, is an essential part because how to avoid other pedestrians affects how much space the pedestrians uses. In order words, collision avoidance largely affects the output of the simulation, i.e. how many pedestrians can use a certain space. Researchers and developers have spent considerable efforts to develop collision avoidance algorithms and to represent collision avoidance in the simulation as it takes place in the real world.

Pedestrian simulations have been used mainly to represent an eccentric situation, such as evacuation inside the building or in the event venue, where it is very crowded and pedestrians avoid each other at the very last moment (before colliding with each other) or after colliding with each other. The simulation algorithms, some of which are based on fluid dynamics theories, are capable to represent such situations. However, as pedestrian simulations are employed in more and more situations, simulations are now required to represent also less crowded situations. Problems here are that, firstly there has been little research on how characteristics of collision avoidance (i.e. collision avoidance distance) changes according to the density, and secondly the current simulations are not always capable to represent collision avoidance in non-dense situations.

It has been already known that, in less crowded spaces, pedestrians avoid each other at an earlier stage than in crowded space (Wolff, 1973; Collett and Marsh, 1981; Burgess, 1983). However, these studies are qualitative (and observational). On the other hand, a quantitative approach is desirable in order to provide data of collision avoidance characteristics for pedestrian simulations.

There have been a good number of studies on the territory of people, and this research topic is called "Proxemics". The results of these studies offer interesting knowledge about the area where man is aware of other people (See Fujiyama, 2005). However, most of these studies have been on stationary participants, and it is envisaged that pedestrians, who are walking, show different results.

In order to investigate alteration of collision avoidance of pedestrians according to the density, it would be of use to start off with looking at how pedestrians perceive other pedestrians and how this changes in a variety of densities. Cepolina and Tyler (2002) proposed the notion of the "awareness area" that each pedestrian has a certain sensory area, and if another pedestrian comes into this area, the pedestrian perceives this new-oncoming pedestrian and takes an appropriate action (i.e. changing the direction to avoid collision with the oncoming pedestrian). We base our investigation on this notion and examine how the awareness area of pedestrians changes according to the density.

The purpose of the research set out with this paper, is to examine how the size and shape of the awareness area changes according to the density. The results would be of great use for development of collision avoidance algorithms of pedestrian simulations in various densities, and thus aid further sophistication of pedestrian simulations.

2. How do we carry out the research?

It is impossible to totally understand the size and shape of the awareness area because even the state of the art neurological science cannot fully explain the whole human perception system of space or environments. However, as the first step of investigation of the awareness area, this research concentrates on fixation patterns of pedestrians in collision avoidance, and employs an eye tracker, with which it is possible to locate where pedestrians fixate.

Eye tracker is the device developed to analyse fixation of people. The device consists of two cameras; one looks at the scenery view of the participant and the other scans and analyses movement of an eyeball of the participant. Synchronising the eyeball movement data with the scenery video images allows us to locate, on the scenery video image, where the participant fixates. In this research, we use the IView X system manufactured by SMI (See reference section). Advantages of the IView X system are that cameras are mounted on a bicycle helmet, and that scenery video images and eyeball movement data are ratio-transmitted to a computer. Because the bicycle helmet fits well to the head of the participant and the participant only needs to carry a small battery pack (rather than whole recording device), the participant becomes, after a few minutes of exercise, less conscious about the system and his/her fixation being examined.

It is important “to distinguish the retinal image and what man perceives.” (Hall, 1966). This means that, although an object is situated just in front of a pedestrian, the pedestrian doesn’t always perceive the object. It is often observed that an absent-minded pedestrian falls over a gap, which is obviously situated on his/her way but he/she may not have been aware of. In this sense, it may be not appropriate to assume that the pedestrian is all time aware of the objects situated in a certain area, say, within 5 meter front of him/her. Examining where to place fixation certainly would help to investigate where the pedestrian is aware of.

It should be noted that pedestrians perceive environment not only by fixating but also by other visual recognition systems, for instance, peripheral vision. In peripheral vision, “the ability to see colour diminishes… (, whereas) the perception of movement is enhanced” (Hall, 1966). This means that, if the pedestrian doesn’t fixate an oncoming pedestrian in front (but not in straight-front), this pedestrian doesn’t necessarily ignore the pedestrian. (Fig. 2 shows the structure of the retina and how people see objects.)

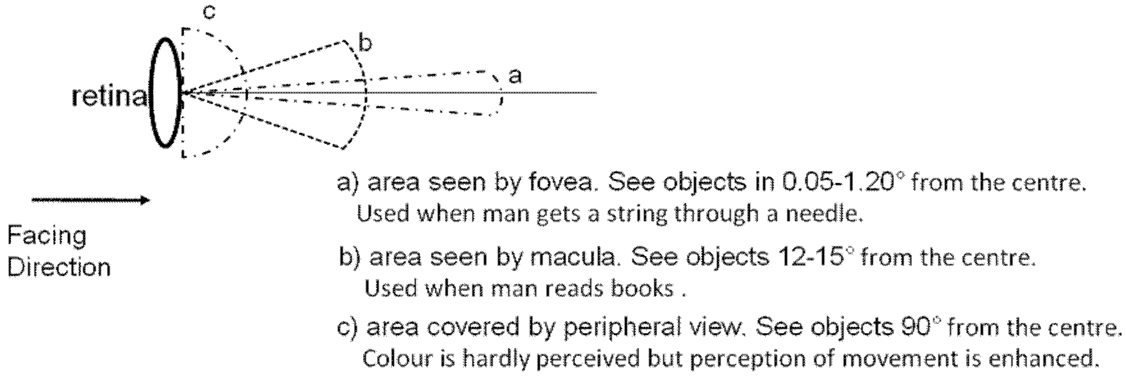

Fig. 2 How does the retina see? (made by the author based on descriptions in Hall, 1966)

Also, we know the sound plays an important role of perception of other pedestrians. People can perceive an oncoming person on the back side by hearing noises. Also, "the ability to localise sound sources … will indicate the appropriate direction to direct visual attention" (Moore, 1982), which infers that it may be inappropriate to separate sound perception from visual perception.

Unfortunately, eye tracker doesn't tell us about peripheral vision nor the area where the pedestrian is audiologically aware of. Nevertheless, it would be interesting to see how fixation behaviour, which may be a basic behaviour in human visual perception system, differs according to the density. We could say that, as long as a pedestrian fixates an oncoming pedestrian, this pedestrian is aware of the oncoming pedestrian. Investigating alteration of fixation patterns according to the density may help us understand more about alteration of the size and shape of the awareness area according to the density.

3. Conclusion

This research will investigate how fixation patterns of pedestrians alter according to the density. It is impossible to determine the size and shape of the awareness area only by the eye tracker, yet examining alteration of fixation behaviour of pedestrians according to the density may provide us with further insights about density's effects on the awareness area. Such insights help us to understand alteration of collision avoidance according to the density, and thus to represent collision avoidance more sophisticatedly in pedestrian simulation models.

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