

Human Behaviour Simulation Using Gaming Software Based On Video Observation Analysis

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1. Introduction

Computer simulation is one of the techniques applied by engineers and architects to evaluate building designs before real construction is undertaken. Computer simulation is also applied in crowd research to evaluate the safety of building designs for human evacuation during emergency situations. By using computer simulation, the best and worst-case scenarios during emergency evacuation can be predicted without using real humans by carrying out the simulation many times (Gwynne, et al., 1999). This provides many advantages compared to experimental methods (e.g. fire drills) when dealing with the ethical issues and rarely occurring events. Besides that, the simulations can be applied to investigate the outcome of different evacuation strategies (Hsiung, et al., 2009) and to investigate emergent behaviour based on new theories or hypotheses (Pan, et al., 2006).

In this research, computer simulation is applied to develop a 'toolkit' or computer program that is able to model and simulate human movement and behaviour in crowded spaces. The research has its origin in the AUNT-SUE (Accessibility and User Needs in Transport - Sustainable Urban Environment) project that emphasized the need to accommodate the largest possible range of humans with different abilities and aspirations (Marshall, et al., 2008) based on the philosophy of 'inclusive design', 'design for all' or 'universal design'.

A video observation method was used in this research to record 'real' human movement and behaviour in crowded spaces. Once analysed, the recorded video is considered as input data for the human behaviour simulation. The simulation focuses on the microscopic scale where each individual character within the crowd is considered. Additionally, heterogeneous characters or different types of humans such as older people, disabled people, young and able-bodied are also considered. However, the simulation only focuses on the normal situation where there is no panic condition. The gaming software DarkBASIC Professional was applied after the video observation analysis.

2. Video Observation Analysis

Video observation analysis is a process conducted to understand human movement and behaviour within crowded spaces. The process starts with recording the crowd at the largest transportation hub in Malaysia (The Stesen Sentral Kuala Lumpur) as a case study area. The focus is at the exit door where a considerable variety of human movement and behaviour can

be observed. Six hours of video recording was conducted to capture the human movement and behaviour covering weekdays, weekend, peak and off-peak times.

The recorded video was viewed once after the recording session to gain an overall understanding of the crowd. There are difficulties in understanding human movement and behaviour due to the high volumes of humans within the recorded video. Therefore, conceptual behaviours were developed as a guideline to assist the observation through video recording. The conceptual behaviours focused on six different behaviours, namely Moving Through Behaviour, Move-Stop-Move Behaviour, Avoiding Behaviour, Passing Through Behaviour, Queuing Behaviour and Competitive Behaviour. The idea is based on observing major human movements of free movement, opposite direction movement and same direction movement.

To assist in the detailed analysis of the video two supporting pieces of software, Window Live Movie Maker Project and Windows Media Player were used. Both allow viewing of the humans in the crowd in frame-by-frame and slow motion movement. The human movement and behaviour observed using the software was entered manually into an observation database. The database consisted of detail information about the behaviour, time occurred, number of subjects and other relevant information about individual humans observed within the recorded video. The observation database was used for analysis and simulation purposes. A detailed discussion on the video observation analysis can be found in (Case, et al., 2011) and (Mohamaddan & Case, 2012).

3. Factors Affecting Human Behaviour

Almost 19,000 humans were observed during the six hours of the video recording. Based on the observation database, individual human behaviour was analysed to understand the factors that affect the behaviours. The analysis was based on events or similarities that occur at individual levels during the movement in crowded spaces. Six factors were detected affecting the human behaviour, and in this section each factor is discussed.

3.1 Personal objective



Figure 1: Example of personal objective

Personal objective refers to the goal that humans have during the movement. Based on the video observation analysis, personal objective is considered as the main factor affecting human behaviour in crowded spaces. The personal objective is considered to be interrelated with other factors. Although there was no direct communication between the observer and the individual humans during the recording of the video, personal objectives can be observed based on the physical appearance of the individual.

Figure 1 show an example of picture taken from the recorded video. The image shows that each individual had a different behaviour and it is clear that there were individuals walking either in groups or separately and individuals who were waiting or stopping during the movement. Examples of stationary behaviour can be seen in the man with a red bag talking on a mobile phone and buying a ticket at the ticket machine and the cleaner performing the cleaning job within the crowd. These are examples of each individual human having their own personal objective during the movement.

3.2 Field of view (FOV)

Field of view (FOV) refers to the extent of the observable range seen by a human at any given moment, and this is typically 120 to 180 degrees. FOV is important since humans develop their perception of the environment during the movement primarily from visual data (Sukhatme, 2011). Figure 2 shows an example where an individual human has stopped in the middle of walking path and is looking around. There are moments when the individual is looking at the information at the distant end of the observed area, and this is considered to be the Move-Stop-Move Behaviour. The behaviour leads the man to slow his movement or to stop for several seconds. In general, older people have a lower FOV compared to the young and able-bodied due to reduced physical abilities.



Figure 2: Example of the field of view affect

3.3 Speed of movement

Speed of movement refers to the walking speed of humans, classified into slow, average, fast and extra fast (Case, et al., 2011). Slow and average speed of movement can typically be observed when humans are slowing down as seen in Figure 2 or are moving in a 'leisure' condition. Fast and extra fast speed of movement can be observed when individual humans are running or trying to move more quickly than other humans at the front queue.

3.4 Personal space

Personal space refers to the invisible surrounding/territory or spaces around human beings. Personal space is considered as a social condition that affects communication or contact between humans. In general, older and disabled people have a larger personal space compared to the young and able-bodied. Figure 3 shows an example of a worker moving with a trolley. The worker performed avoiding action (refer section 3.6) to maintain the personal space and avoid collision with two other people that have stopped in front of the movement path. The new movement path is shown as a yellow dashed line.



Figure 3: Personal space and avoidance angle

3.5 Crowd density

Since humans need space (personal space) to move from one area to another, it is notable that space plays an important role in human movement and behaviour. Crowd density refers to the number of people per square meter for a stationary or moving crowd. According to (Thompson & Marchant, 1995) the human speed of movement is decreased when crowd density is increased. This scenario can be seen clearly in the recorded video especially during the peak time of the recording session. Individual human movement and behaviour become difficult to observe when crowd density is increased. Humans performed different types of behaviour within the observation area. In video observation analysis, more replays have to be conducted using the observation software to understand the human movement and behaviour.

3.6 Avoidance angle and distance

Avoidance is an action performed by humans to keep away from something. In the case of crowd behaviour, avoidance most frequently occurs when humans try to avoid collision with other humans. There are two types of movement that can be described by an avoidance angle and distance; Avoidance Behaviour where humans are avoiding each other when moving in opposite directions and Competitive Behaviour where humans are moving in the same direction at different speeds. Figure 3 shows an example where humans need considerable angle and distance to avoid others.

4. The Simulation

Figure 4 shows an example of a simulation conducted using the gaming software, DarkBASIC Professional. The simulation consists of 80 entities (60 young people or adults and 20 older people) moving in opposite direction movement. The simulation set 40 entities (30 adult and 10 older people) moving from right to left and another 40 entities moving from left to right of the area as the moving objective. Entities representing older people have a lower speed of movement compared to the adult entity. When both sides meet at the middle of the area, the entities will avoid each other with different avoidance angles. At the same time, each entity will maintain their personal space. In the simulation, the field of view of the entity is set in the simulation algorithm.

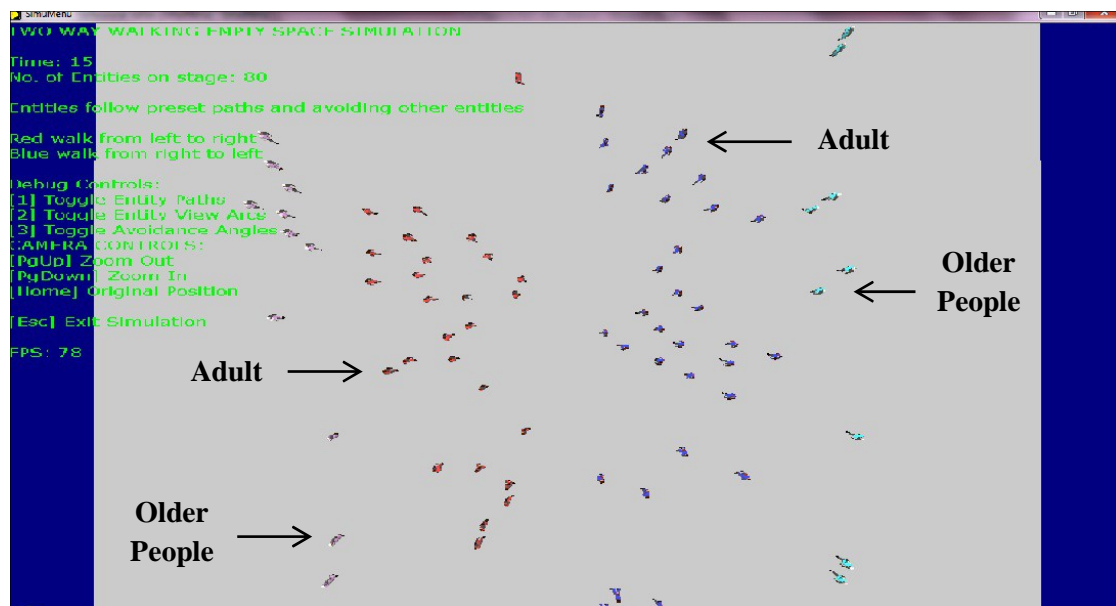


Figure 4: Example of opposite direction movement

5. Conclusion and Future Work

This paper discusses the factors affecting human behaviour during movement in crowded spaces. The factors affecting human behaviour were determined based on events or similarities that occurred at individual levels during the movement in crowded spaces. Six hours of recorded video was used as an input and video observation analysis was developed to assist the process. Gaming software DarkBASIC Professional was applied to simulate the human movement and behaviour. The simulation was based on input from the factors affecting human behaviour in crowded spaces. As a future work, a relevant case study will be developed to test the simulation. This includes simulation of the largest transportation hub in Malaysia.

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