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# TOWARDS UNDERSTANDING OF HUMAN BEHAVIOUR IN CROWDED SPACES USING VIDEO OBSERVATION ANALYSIS

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## ABSTRACT

Human behaviour in the real world is important information for developing human behaviour models and simulations. However, it is difficult to capture 'real' human behaviour since each human has unique characteristics. As part of the AUNT-SUE (**A**ccessibility and **U**ser **N**eeds in **T**ransports - **S**ustainable **U**rban **E**nvironments) project, this research is aimed at understanding individual human behaviour in crowded spaces based on video observation analysis. The video observation analysis employed a video observation method where a multi-mode transportation system in Malaysia was selected as a case study. The observation focus was at an exit door where considerable variety of human movement and behaviour could be observed. Six hours of video recording was conducted covering weekdays, weekends, peak and off-peak times. Almost 19,000 individual humans were observed and categorised into six different behaviours that were determined from the three major human movements of free, opposite direction and same direction movement.

Keywords: Human Behaviour, Video Analysis, Simulation

## 1 INTRODUCTION

Research related to human movement and behaviour in crowded spaces is of major interest in many areas such as engineering, architecture, psychology and ergonomics. The major concern is with the design and safety of crowded spaces for human beings. In general research related to crowded spaces can be divided into four major focuses which are crowd modelling, crowd simulation, crowd monitoring and crowd experimentation.

Crowd modelling research involves developing a model to represent the crowd based on mathematical equations or a set of rules. Most of the models have been simplified since a crowd is considered to be a complex area where the human movement are very variable. In crowd modelling, the humans in the crowd can be modelled to a microscopic or macroscopic scale. The microscopic scale treats every human in the crowd as an individual or particle and detailed analysis of movement and behaviour is considered and measured. On the other hand, the macroscopic scale treats the humans in a crowd as equivalent to the movement of fluids and humans are considered to be moving in the flow with average speed. Cellular automata (Schadschneider, 2001), social force (Helbing and Molnar, 1995) and agent-based (Pan, et al., 2006) are examples of crowd modelling.

Crowd simulation research focuses on developing software or tools that can be applied to evaluate the crowd and the environment. Crowd simulation can be considered as a research area that is interrelated with crowd modelling where the crowd simulation enhances crowd modeling by using virtual agents with a graphical interface. Crowd simulation provides many advantages such as the ability to evaluate the

crowd and the environment before real construction is undertaken. The best and worst case scenarios of crowd movement in a building (for example) can be predicted without using real human by carrying out the simulation many times (Gwynne, et al., 1999) . New theories or hypotheses on human movement in crowds also can be investigated using the software (Pan, et al., 2006).

Crowd monitoring research is focussed on the development of automated monitoring systems using computer vision to monitor the crowd. The development is due to the inability of human observers to monitor numerous cameras at one time using the Closed Circuit Television (CCTV). For example, computer vision is applied to estimate the crowd density in buildings (Rahmalan, et al., 2006). The crowd density estimation is important for controlling crowd safety and avoiding an over-crowded situation. Computer vision is also applied to detect and localize abnormal events/behaviours in a crowd (Andrade, et al., 2006) (Mehran, et al., 2009). In this research area, crowd behaviour is characterized by optical flow before abnormal events/behaviours are detected.

Crowd experimentation research is aimed at understanding crowd movement and behaviour using a laboratory situation. In crowd experimentation, predefined instructions are given to the participants based on the objective. For example, crowd experimentation is performed to understand human movement in a bottleneck situation (Daamen and Hoogendoorn, 2003). In this research, bottleneck designs were constructed in the laboratory and the crowd was required to move within the constructed area. The data from the experiment was applied to update planning guidelines for capacity estimation (Kretz, et al., 2006). In crowd experimentation, humans in the crowd are easily monitored and controlled. However, crowd experimentation need to deal with ethical issues and have difficulty in acquiring rarely occurring events or 'real' human behaviour since the movement is predefined.

The research described here concerned with the use of video observation as a method of understanding human movement and behaviour in crowds. The research has its origins in the major research project known as AUNT-SUE (**A**ccessibility and **U**ser **N**eeds in **T**ransport - **S**ustainable **U**rban **E**nvironments). This paper discusses the problems involved during applying the video observation method and the results achieved from the method.

## 2 THE OBSERVATIONAL STUDY

In this research, video observation is applied as a method to understand human movement and behaviour in crowded spaces. In this observation method, a video camera was used to capture and record human movement and behaviour. A multi-mode transportation system in Malaysia was selected as a case study, and more particularly the focus was on an exit door where considerable human movement and variety of behaviour could be observed. Detailed explanation of the observation area can be found in Mohamaddan and Case (2012).

Video observation was considered to be a good method of capturing human movement and behaviour, but issues of privacy and security required serious consideration. Compared to other methods (e.g. laboratory experiments and observing fire drills) video observation supplies 'real' human movement and behaviour where some of unpredictable or natural movements can be revealed. There is also no restriction on the time taken to record the human movement and behaviour in crowded spaces. The observation method is widely applied in ergonomics research. For example, in (Juul-Kristensen, et al., 2001) video observation data is applied with direct technical measurement to study human posture and movement during repetitive work in a poultry processing plant.

## 3 VIDEO OBSERVATION ANALYSIS

Video observation analysis is a process developed to analyse human movement and behaviour from the recorded video data. The process starts with recording the video of the crowd, developing the conceptual behaviours, applying the supporting software to analyse the video and developing the observation database. Detailed discussion about the process is given below.

### 3.1 Video Recording

Video recording is a process to record human movement in crowded spaces using a video camera. In total six hours of video recording were conducted and the recording time was divided into morning, afternoon and evening times. The morning time started at 7:30 am, the afternoon session at 12 pm and the evening session at 5 pm. Each session lasted for one hour and was repeated for weekdays and weekends.

The weekday session represented the peak time where people start using the transportation service in the morning, moving around for lunch in the afternoon and going back home in the evening. The weekend session represented the off-peak time where people were using the transportation service for 'leisure' activity. After the recording session, each video was viewed once to observe the overall activities and to understand the human movement and behaviour.

### 3.2 Conceptual Behaviour

The recorded video consists of a high volume of human movement displaying a variety of behaviours. It was difficult to understand human behaviour using the 'naked eye'. Therefore, conceptual behaviours were developed as foundations or guidelines to understand individual human behaviours within the recorded video. Conceptual behaviours are a set of rules acquired from major human movement and consist of free, opposite direction and same direction movements.

The major focus of the conceptual behaviours is on individuals and individuals in small groups and involved four different subjects; older people, disabled people, adults and others. Others here refers to children or workers moving around with trollies, cleaning devices and other equipment. There were six behaviours determined from the human movement which are Moving Through Behaviour, Move-Stop-Move Behaviour, Avoiding Behaviour, Passing Through Behaviour, Queuing Behaviour and Competitive Behaviour. A detailed explanation of the behaviours can be found in Mohamaddan and Case (2012).

### 3.3 Observation Supporting Software

In this research two supporting items of software were applied to analyse the individual human movements and behaviours. The observation supporting software as shown in Figure 1 is Windows Live Movie Maker (left) and Windows Media Player (right). Windows Live Movie Maker was selected since the software has a function to view the human movement frame-by-frame in slow motion. Windows Media Player is applied to check the movement since it offers a better view of the movement.

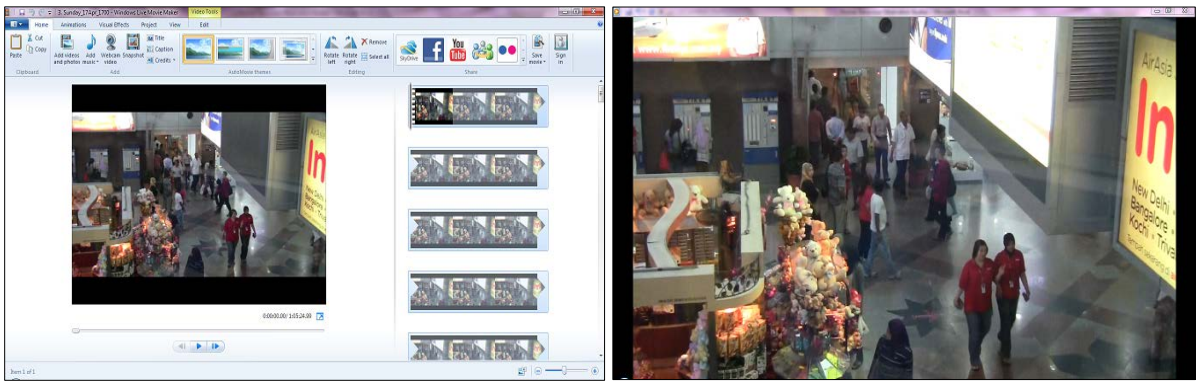

Figure 1: The Observation Software

During the analysis process human movement was observed for around 30 seconds for every video frame. The analysis focus was on the individual human movement (whether free, same direction or opposite direction movement) within the observation area and its comparison with conceptual behaviours to acquire the individual behaviour. The number of humans having that behaviour was entered manually into

the observation database and the total number of humans on a specific video frame was counted. The analysis showed that crowd density was different at several times during the observation session. Therefore, there was a need to analyse the same video frame many times. The software contains a slow motion button and a replay button to control the recorded video. Besides that, when the crowd density was considered high, the humans in the video frame performed more than one behaviour at one time within the observation area. In this case the behaviour was counted only once based on the first one that appeared in the video.

### 3.4 Observation Database

The observation database is a set of data consisting of detailed information regarding individual human behaviours analysed with the observation supporting software. Figure 2 shows an overview of the observation database. The database consists of recording session and behaviour sections. The behaviour section used a colour coding system (e.g. yellow and green) to differentiate different behaviours. Each behaviour section consisted of four different subjects; the older people, disabled people, adult and others.

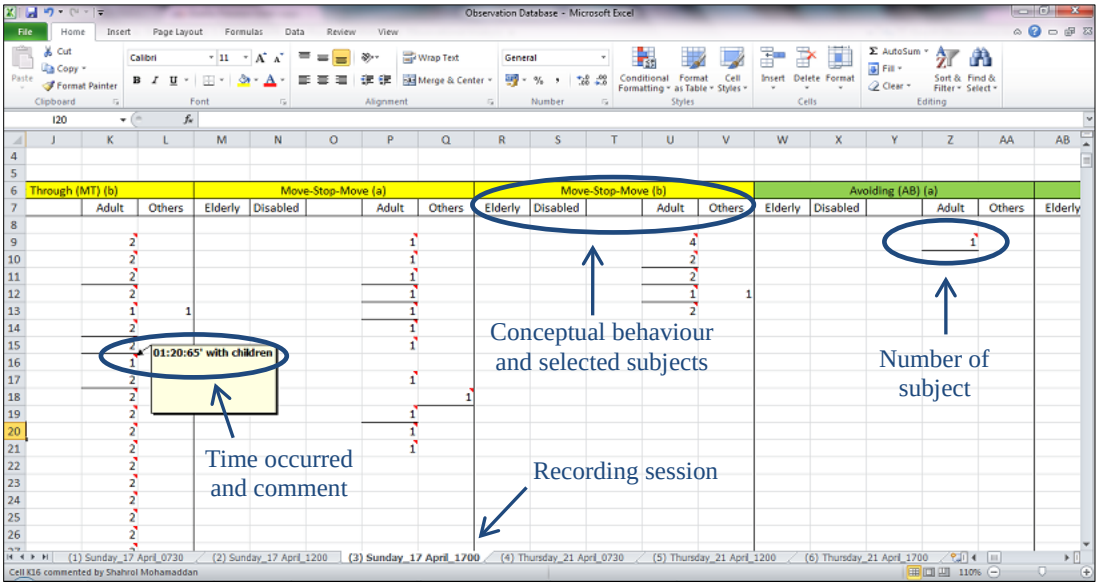


Figure 2: The Observation Database

The database also contains the number of subjects showing each behaviour with time occurred and a short comment on the subject. The process was conducted for all of the videos. After the database was completed, the individual human data was compared with the conceptual behaviours to evaluate the behaviours. In this process only selected behaviours were evaluated. Besides evaluating the behaviour, the process was conducted also to understand the factors affecting behaviour, differences between the subjects and other relevant findings.

## 4 OBSERVATION RESULTS AND DISCUSSION

The observation results are shown in Table 1. In total, 18,946 individuals were observed within the six hours video recording. Higher numbers were observed during weekdays (58.8% or 11,138 individuals) compared to weekends (41.2% or 7,808 individuals). In both recording sessions, greater numbers of individuals were observed during the afternoon (12 pm to 1 pm) than the morning (7:30 am to 8:30 am) especially during the weekend where only 1,152 individual humans were observed.

Table 1: The observational result

| Recording time | Number of subjects | |
|---|---|---|
| | 17 April 2011 (Weekend) | 21 April 2011 (Weekday) |
| 7:30 am – 8:30 am | 1,152 | 3,020 |
| 12:00 pm – 1:00 pm | 3,402 | 4,182 |
| 5:00 pm – 6:00 pm | 3,254 | 3,936 |
| Total subjects | 7,808 | 11,138 |
| Grand Total Subjects | 18,946 | |

Table 2 shows the human behaviours based on the subjects. Within the 18,946 humans observed, the majority of the human behaviours were free movement where 83.7% or 15,863 humans performed the Moving Through Behaviour and 10.2% or 1,929 humans performed the Move-Stop-Move Behaviour. Free movement was considered as a basic human movement from one point to another point of interest within the observation area (Mohamaddan and Case, 2012). The humans in the crowd were considered to have had enough space to move without facing any obstacle or constraint during the movement. The results show that, during the observation time the observation area is considered to have a low crowd density where the majority of the humans could maintain their personal space. Humans had a lot of time to avoid meeting with other humans during the movement.

Table 2: Human behaviours based on subjects

| No. | Behaviour | No. of Older People | No. of Disabled | No. of Adults | No. of Others | TOTAL |
|---|---|---|---|---|---|---|
| | ***Free Movement*** | | | | | |
| 1. | Moving Through (MT) | 268 | 15 | 15,192 | 388 | 15,863 |
| 2. | Move-Stop-Move (MSM) | 71 | 1 | 1,770 | 87 | 1,929 |
| | ***Opposite Direction Movement*** | | | | | |
| 3. | Avoiding Behaviour (AB) | 13 | 0 | 588 | 8 | 609 |
| 4. | Passing Through Behaviour (PT) | 14 | 0 | 248 | 18 | 280 |
| | ***Same Direction Movement*** | | | | | |
| 5. | Queuing Behaviour (QB) | 1 | 0 | 162 | 1 | 164 |
| 6. | Competitive Behaviour (CB) | 2 | 0 | 98 | 1 | 101 |
| **TOTAL** | | **369** | **16** | **18,058** | **503** | **18,946** |

Besides free movement, there was 3.2% or 609 humans performed the Avoiding Behaviour and 1.5% or 280 humans performed the Passing Through Behaviour. The Avoiding and Passing Through Behaviour were derived from the conceptual behavior of opposite direction movement. Another 0.9% or 164 humans

performed Queuing Behaviour and 0.5% or 101 humans performed Competitive Behaviour. The Queuing and Competitive Behaviour were derived from the conceptual behavior of same direction movement. The opposite direction movement and same direction movement show that, within the observation area, there are still times when human density was considered high and when humans had to consider other humans during the movement.

## 5 CONCLUSION

This paper describes the application of a video observation method in understanding individual human movements and behaviours in a crowd. The behaviour of nearly 19,000 individuals in the video recording have been analysed using the observation supporting software based on the conceptual behaviours. Most of the subjects were observed during the weekday especially during the afternoon. An observation database was developed to record the observation analysis. The observation database is an important information to conclude the finding. However, the result was only based on three different recording times. For the future work, human behaviour will be analyzed to understand the factors affecting the behaviours and simulation software will be applied to simulate the human behaviour within a virtual environment.

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