HUMAN MOVEMENT REPRESENTATION IN VIRTUAL ENVIRONMENT USING GAMING SOFTWARE

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Graphical abstract
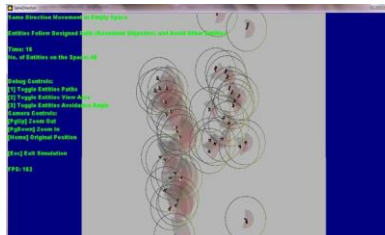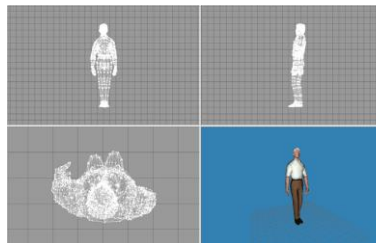
Abstract

Human movement in crowd can be considered as complex and unpredictable. In this research, image analysis, video observation and conceptual behaviour was developed as a method to understand the human movement in crowd. Based on the method, human movement was represented or converted into the virtual environment using gaming software called DarkBASIC Professional (DBPro). The developed program using DBPro was applied as a tool to simulate and predict human movement in different building layout. Two subjects (adult and older people) were selected as the virtual entities. Human movement at the bottleneck and non-bottleneck layout was presented in this paper as example of case study.

Keywords: Human movement; virtual; gaming software; darkbasic; simulation

Abstrak

Pergerakan manusia di dalam keadaan yang sesak adalah kompleks dan sukar dijangka. Di dalam penyelidikan ini, analisa imej, pemerhatian video dan konsep tabiat manusia telah dibangunkan sebagai kaedah untuk memahami pergerakan manusia di dalam keadaan yang sesak. Berdasarkan kaedah tersebut, pergerakan manusia telah ditukar ke dalam persekitaran maya menggunakan perisian permainan yang dikenali sebagai DarkBASIC Professional (DBPro). Program yang telah dibangunkan menggunakan perisian tersebut telah digunakan sebagai alat untuk melakukan simulasi dan meramal pergerakan manusia di dalam susunatur bangunan yang berbeza. Dua subjek iaitu orang dewasa dan orang tua telah digunakan sebagai entiti maya. Pergerakan manusia di susunatur sempit dan kurang sempit telah digunakan sebagai contoh di dalam risalah ini.

Kata kunci: Pergerakan manusia; maya; perisian permainan, darkbasic; simulasi

1.0 INTRODUCTION

A crowd can be defined as a large group of individuals in the same physical environment and sharing a common goal [1]. Crowds can occur in many places including for example train stations, shopping mall and stadium. Human movement in crowd can be considered as complex and unpredictable. In this research, emphasize is placed on gaining knowledge of some of the characteristics of human movement in the real world and model the humans in the virtual environment.

There are many significant issues related to crowds that can be considered such as how humans move and behave within the high density crowds. Do they tolerate or ignore each other during the movement, or do they move more slowly than they would in a low density crowd? If the focus is more towards the older and those with disabilities, there are significant issues such as how an elderly man might maintain his balance and choose his movement direction when people around move at faster speed or how a disabled person with a wheelchair reacts when faced with a movement path containing obstacles (or bottlenecks).

Understanding of human in the real crowd is important in order to gather information on the difficulties that they are facing and the factors affecting movement to minimize these difficulties. In this research, several methods including image analysis, video observation and conceptual behaviour were developed to understand human movement in crowd. Based on that, human movement was represented or converted into virtual environment using gaming software, DarkBASIC Professional (DBPro). The main objective is to develop a tool to simulate and predict the effect of human movement in different layout.

DBPro was developed based on the BASIC computing language. The language has been enhanced specifically to aid the creation of games programs [2] and contains none of the complexity of other commonly used computer languages for commercial games such as Microsoft Visual and C++ [3]. The language has many unique commands for displaying graphics, controlling images and creating 2D and 3D images. Programs can be developed for low development costs [4], while all games created using the language are license and royalty free.

DBPro software is widely used for the games application. However, the software is also used in other applications as it is able to simulate a graphical scene in 2D and 3D design. For example, Park and Calvert [5] applied DBPro for criminology research as shown in Figure 1. The research was developed under Crime Prevention Through Environmental Design (CPTED), a multidisciplinary research that determined criminal behaviour using environmental design. The objective was to reduce the occurrence and fear of crime whilst improving quality of life.

Figure 1 Example of virtual environment in DBPro [5]

DBPro was also used by Watcharasukarn *et al.* [4] to develop a survey tool that collect the travelling behaviour data and monitor behaviour adaptation. The developed tool was based on the virtual reality role-playing game known as Travel Activity Constraint Adaptation Simulation (TACA SIM). The objective was to investigate the adaptability of human travelling behaviour under the simulated scenario of rapid fuel price increases.

This research has its origin in the AUNT-SUE (Accessibility and Users Needs in Transport – Sustainable Urban Environments) project which emphasized the need to accommodate the largest possible range of humans with diverse abilities and aspirations [6]. The AUNT-SUE research did not explicitly consider the issues of human movement in crowded areas which is the focus of the research described in this paper.

2.0 METHODS

2.1 Human Movement Motion Detection

The motion detection system using periodic background estimation subtraction method was conducted to measure the human speed of movement. The speed of movement is important input or parameter in developing the virtual humans. Two subjects, adult and older people were selected for this research.

Two different pedestrian pathways were selected as the analysis area. Normal movement with adult subjects and experimental movement with adult and older people subjects were conducted at those areas. The experiment with older people was approved by the Jabatan Kebajikan Masyarakat, Sarawak, Malaysia. Blobs as shown in Figure 2 were created for each motion objects taken from video camera using MATLAB software.

Figure 2 Blob for motion detection [7]

The images were converted into binary by auto threshold and enhanced using dilation and erosion.

Lastly, the images were luminance normalize before background subtraction to acquire the speed of movement. Detailed discussion of the applied method is stated in Cheong [7]. Based on the analysis, an adult subject is walking at 1.2m/s while the older people subject at 0.8m/s. The walking speed data is applied as one of the parameters for the virtual humans.

2.2   Video Observation and Conceptual Behaviour

Besides human speed of movement, there is a need to understand the human movement and behaviour in the real world. The movement and behaviour is other important parameters that need to be considered before represent the humans into the virtual environment. Observational study was conducted by Mohamaddan [8], where an exit door at multi-mode transportation area was selected as the observation area. Video camera was used to record the movement and conceptual behaviour was developed to detail up the human movement and behaviour. The step involve is shown in Figure 3.

Figure 3 Video observational analysis

Based on the study conducted by Mohamaddan [8], it was concluded that six factors affecting humans movement and behaviour including the personal objectives, visual perception, speed of movement, personal space, crowd density and avoidance angle or distance. The six factors were then applied in the DBPro coding to design and model the software.

2.3 DBPro Coding: Software Design and Modelling

Since human movement in the real world is considered complex and unpredictable, there is a need to simplify or modify the movement. The factors affecting human movement and behaviour in the real world are considered as the parameters for each entity in the virtual environment. The parameters play important roles in developing different types of simulation that utilize different movement scenarios in the real world. The parameters were coded accordingly as shown in Table 1.

The personal objectives refer to selected movement for this research such as free, same and opposite directions. Two commands were used to represent the movement; *Position Object* and *AI Entity Go to Position*. The visual perception refers to the view arc and view range that applied for the virtual entities. In DBPro the value of the view arc is in the range of 1 to 360 degrees.

Figure 4 shows an overview of visual perception in DBPro. The speed of movement refers to the movement speed of the entity in DarkBASIC units per second. Different entity was designed with different speed of movement. Personal space as shown in Figure 4 refers to the space available around the entities.

Table 1 Individual parameters in virtual environment [8]

| No	Parameters	Representation in Virtual Environment (Coding)
1.	Personal Objectives	*Position Object*
		AI Entity Go to Position
2.	Visual Perception	*AI Set Entity View Arc*
		AI Set Entity View Range
3.	Speed of Movement	*AI Set Entity Speed*
4.	Personal Space	*AI Set Radius*
5.	Crowd Density	Based on number of humans over floor size
6.	Avoidance Angle or Distance	Based on Dark AI from the software
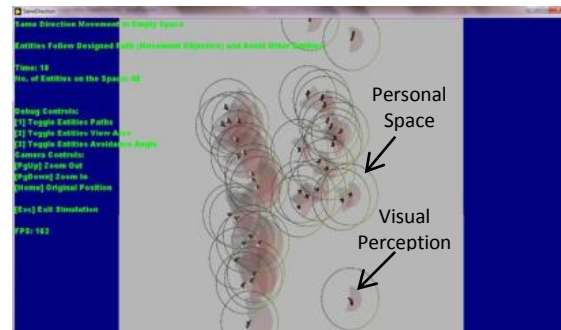
Figure 4 Personal space and visual perception in virtual environment [8]

Crowd density refers to the total number of entities within the floor area. In this research, the floor area is designed recognizing that the maximum number of entities in order to ensure viable simulation is limited to 90. The size of floor area was designed to be 600 unit pixels × 600 unit pixels (30 m × 30 m). Lastly, the avoidance angle or distance refers to the situation where the entities in virtual entities avoid each other during the movement. The avoidance angle or distance used the uncontrollable command from the software that based on the artificial intelligent. However, the command is also affected by the Personal Space and Visual Perception parameters.

2.4 DBPro Coding: Virtual Entities Design

Two subjects, adult and older people were selected as the entities for virtual environment simulation. Both entities were designed with the three dimensional (3D) design based on the work of [7] to provide more realism for the simulation. Table 2 shows the entity source codes for the simulation. Based on [7], 1 unit pixel (DarkBASIC unit) is equal to 5 cm in the real world.

Therefore, within the source code the speed of movement for adult entity is set to be 24 unit pixels or 1.2 m/s. The view arc is set between 160 to 210 degrees with the view range of 40 unit pixels or 2 meters. The adult entity is also design with blue colour based on DarkBASIC RGB (Red, Green and Blue) colour spectrum.

On the other hand, the older entity as shown in Figure 5 is set to have 16 unit pixels per second or 0.8 m/s speed of movement. The view arc is set between 140 to 190 degrees with the view range of 20 unit pixels or 1 meter. Lastly, the older entity is designed with red colour based on the DarkBASIC RGB colour spectrum. The selection of the speed, view arc and range was based on the work of [7], [9], [10] and assumption of the author.

Table 2 Adult and older entity source codes in virtual environment [8]

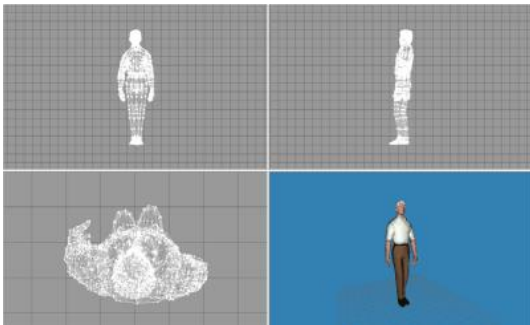| Adult Entity	Older Entity
AI Set Entity Speed I, **24**	*AI Set Entity Speed I,* **16**
AI Set Entity View Arc I, **160, 210**	*AI Set Entity View Arc I,* **140, 190**
AI Set View Range I, **40**	*AI Set Entity View Range I,* **20**
Color Object I, RGB **(0, 0, 255)**	*Color Object I, RGB* **(255, 0, 0)**

Figure 5 Older entity in 3D design [7]

3.0 RESULTS AND DISCUSSION

3.1 Low Level Validation

Low level validation was conducted to confirm that the modelling and simulation in the virtual environment have some kind of agreement with the real world. It includes the advantages and limitations of the simulation and the similarities and differences of the virtual entity movement based on the different parameters compared to human in the real world.

For example, the observation study shows that the crowd density effected the human movement in the real world. Besides, human shows the potential of queuing or compete with each other in the same direction movement or in the opposite direction

movement, they avoid or passing through each other depending on the situation of the crowd.

Figure 6 shows the example of low level validation that had been conducted. The simulation consists of high density crowd (90 entities) with 18 adult and 72 older entities. The result indicated that only 9 adult entities or 50% of the total adult entities manage to arrive at the end point earlier than (or faster than) the older entities. Another adult entity was observed moving in between (or slower than) the older entities and the arrival sequence is shown using red arrow in Figure 6.
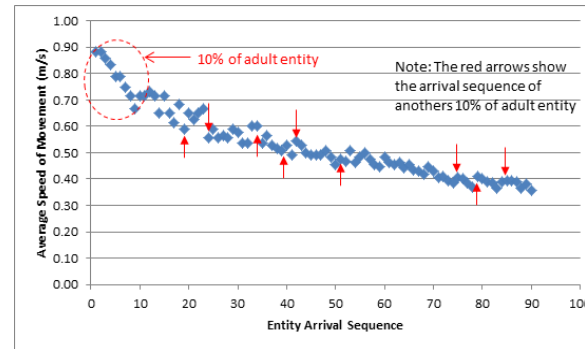

Figure 6 Arrival sequences of 18 adult entities in high density crowd

The simulation and observation results indicate that in the virtual environment during movement in low density crowd, when there is enough space to move towards the end point (personal objective parameter), the entities will move faster. The entities will compete with other entities. However, when a high density is encountered and where the space is limited for movement of competition with other entities, the adult entity will follow the crowd or even queuing with the crowd.

3.2 Example of Case Study

The case study of evacuation at bottleneck and non-bottleneck layout was conducted using the simulation as shown in Figure 7. The simulation was conducted to understand the evacuation process at different building layout. 90 adult entities were randomly allocated within the layout and simulated to move towards the exit door marked by red circle. The evacuation time for each entity was recorded and the evacuation time results were compared.

The result for the case study is shown in Figure 8. The result shows that the total evacuation time at the bottleneck layout is higher compared to the non-bottleneck. The entities in bottleneck layout needed a total of 51 seconds to evacuate from the area while only 36 seconds was needed to evacuate the non-bottleneck layout. Additionally, the linear regression line indicates that entities evacuate in a more structured manner from the non-bottleneck layout

when compared to evacuation from the bottleneck layout.

The result shows that the simulation is applicable to provide information on crowd evacuation from different layout. The simulation indicates that a non-bottleneck layout provides a safer environment in term of human movement in crowded areas. The simulation is also useful to predict how human evacuate if there is only one exit door available for the evacuation process.

Bottleneck layout

Non-bottleneck layout

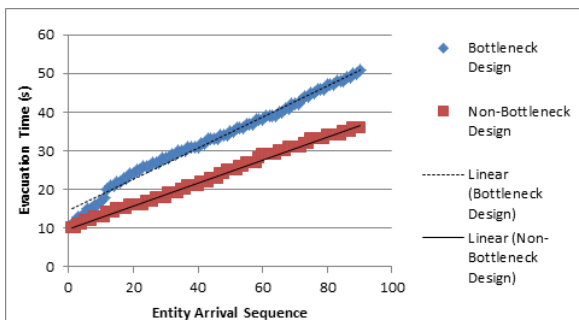**Figure 7** Evacuation of entities at bottleneck and non-bottleneck layout

Figure 8 Evacuation time from bottleneck and non-bottleneck layout

4.0 CONCLUSION

This paper discussed the method applied to represent human movement in the real world into the virtual environment using gaming software, DBPro. Motion detection method was applied to acquire the human speed of movement in the real world. Besides, video observation and conceptual behaviour were developed to understand human movement and behaviour in the real world. The important part of this paper is on how to model the movement in the real world using DBPro coding.

Since DBPro is gaming software, the coding need to be developed carefully in order to reflect the research objective. Lower level validation need to be conducted in order to analyze the software. The effectiveness and usefulness of the simulation software was observed through the simulation of bottleneck and non-bottleneck layouts. The simulation software was considered to be beneficial in visualizing different possible layouts in the virtual environment before real construction or modification is conducted in the real world.

Acknowledgement

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