Generation of Dynamic Moving Path for Autonomous Human Model

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EXTENDED ABSTRACT

These days computer graphics technology has developed rapidly and it can represent many things from artificial objects to natural scenes. Also, another technology called virtual reality has been improving with stereo view, haptic devices and so on. These technologies are used in many fields such as industrial, medical, educational, and entertainment fields. Especially in movies, representation of human beings is important but it takes huge time. Usually, there are some scenarios and humans can take actions according to the scenarios. On the other hand, there is crowd simulation, which predicts human behaviour based on behaviour related psychology. In the case of predicting human movement, there are usually some points that humans pass, and some of them are selected according to their movement. However, if those points are fixed in advance according to their actions, it is difficult to change the route by abrupt happing such as encountering friends, changing minds, and so forth. Also, if there are many points to pass, it takes much time to search for the best selection according to each action, while if there is little points, the selected path becomes unnatural. Also, in crowd simulation, there are some people who are on the way to move. In this case, the path should be changed to avoid the people automatically.

This paper describes an automatic generation method of dynamic moving path for autonomous human model. Humans are modelled based on behaviour related psychology so that they can take actions according to their minds. For instance, if one person encounters his/her friends on the way to a library, they might go to another place together. Also, when it is too late to go to a class room for taking a lecture, another person might change his/her mind and go to a restaurant for an early lunch. In these cases, the routes should be changed dynamically. In this paper, humans have only two points for their routes, and add a new point according to the environment change, although default points are added when nothing happens (Fig. 1 (a)). If many points are prepared for humans to move, variety of routes can be generated, but it takes huge time to select the best points among them. In this paper, the minimum set of points is prepared for movements, and some points are generated automatically from the minimum. For example, only one point is prepared for wide entrance of a building. Then, two end points and some intermediate points are generated automatically. People can select one of the generated points for the best route (Fig.1 (b)). Finally, when some people are on the way to move, humans have to avoid them. In this case, a new point is generated in order to avoid them, and humans can select it (Fig. 1 (c)).

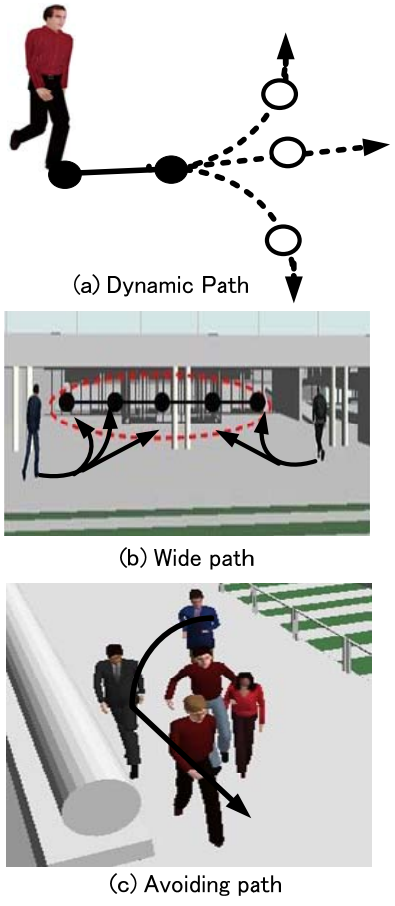

Figure 1. Path selection method. (a) Dynamic path, (b) Wide path, and (c) Avoiding path.

1. INTRODUCTION

Computer graphics has rapidly improved these days so that it can represent many things from artificial objects to natural phenomena such as vortex (Sadlo et al. 2006), advection (Kim et al. 2007a), and lighting (Kim and Lin 2007b). However, it is still difficult to generate various kinds of human behaviour. Usually motion capture is used to obtain the fundamental data of human motion, and the data is used to generate many actions such as emotion (Unuma et al. 1995a), motion transition (Rose et al. 1995), and kinematic motion (Nakamura and Yamane 2000).

Human motion or human action can be generated by changing the fundamental data captured with motion capture; however, it is very difficult to generate human behaviour, which is generated by human mind. Usually people have their schedules to make actions, but they are changed by the environment. For example, suppose that a student has a schedule to go to a class room to take a lecture. On the way to the class room, he/she happens to encounter his/her friend, who is elder than him/her. In this case, he/she might change his/her mind and go to another place together. There is another case that a person might change the schedule when it is too late to go to a class room. In movies, there is a scenario and human behaviour is directed according to the scenario (Maiocchi and Pernici 1990). It takes much time and work to generate many kinds of human behaviour for crowded case. Crowd simulation is used to simulate human behaviour for many people such as tourists (Itami 2003 and O'Connor et al. 2003).

Crowd simulation can simulate behaviour of huge amount of people, but it does not represent the detail action of human beings. Unuma et al. (1995b) and Miyoshi et al. (2000) proposed methods that can decide the direction of human behaviour by using attractiveness, and Kayahara et al. (2004) proposed a method, which can decide human motion to avoid other people in a crowded scene by using personal space and movement vector. Sakuma et al. (2005) proposed another idea that can control the flow of walking humans by using psychological model, which has human memory and personal space.

However, these methods can control the direction of human behaviour, but do not represent human interaction. For instance, when a person encounters another person whom he/she dislikes, he/she dares to avoid the person, while some friends approach each other. There is another case that when a person finds his/her friend on the way to go to a place. In this case, he/she calls the friend and the friend waits for him/her until he/she approaches. Then, they walk to go somewhere side by side. Therefore, we have proposed some methods, which can generate human behaviour for a group (Mukai et al. 2004a, Mukai et al. 2004b, and Honma et al. 2006).

This paper describes an automatic generation method of dynamic moving path and there are three main ideas (a) dynamic path, (b) wide path and (c) avoiding path. Dynamic path means that the human moving path can be changed dynamically. For example, if a person encounters his/her friend on the way to go to a library, he/she can change his/her mind and go to another place with the friend. Wide path means that the method can generate wide path automatically. In order to generate human moving path, route point data should be prepared in advance and some points are selected according to the route; however, if there are many points prepared, it takes much time to select the best points automatically. Then, in this paper, only the minimum points are prepared, and some points are generated automatically when they are needed. For instance, when there is a wide entrance in front of a building, people can enter the building through any point of the entrance. It is the best way to generate some points of the entrance automatically when the entrance is considered as the route selection. Finally, avoiding path means to generate a new point to avoid persons who are on the way. Some people are walking in front of a person, and their speed is slower than his/her. He/she makes a detour to avoid the people. This paper describes how to generate a new point in order to avoid them.

2. VIRTUAL HUMAN MODEL

In the human model of this paper, there are two types of behaviour, which are described as follows.

(I) **Personal behaviour**: single person based behaviour such as moving somewhere, taking a rest, or exercising. This behaviour is divided into two types.

  (a) **Scheduled behaviour**: moving behaviour to go somewhere in order to perform target actions such as walking to a class room to take a lecture, and moving to a restaurant to have lunch.

  (b) **Leisure time behaviour**: another moving behaviour to go somewhere when there is no schedule, such as walking to a designated area to smoke,

and moving to a vending machine to buy a coffee.

(II) **Interpersonal behaviour**: group based behaviour such as approaching each other for a chat, and avoiding a person who is not a friend.

The model has the following parameters in order to generate autonomous human behaviour.

Table 1.Properties of human model.

PARAMETERS	DETAILS
Name	Person's ID number
Character	Normalized in [-1.0, 1.0]
Strength	Normalized in [0.0, 1.0]
Social rank	Normalized in [0.0, 1.0]
Schedule	A list of scheduled behaviour
Leisure time	A list of unscheduled behaviour

Name is a person's ID, with which persons can be identified from each other. Character is personality of each person, which is defined with the result of Anderson's research (Anderson 1968), and the parameter is used to define friends. If these values of two persons are similar, they become friends. Strength is energy to perform an action. If the parameter is low, people does not want to take the scheduled behaviour. For example, a person does not go to a class room to take a lecture, but goes to a designated area to smoke when the parameter is very low. Social rank defines interpersonal relation such as professor and student, senior and junior and so on. Schedule is a list of scheduled behaviour, which is performed according to time. Leisure time is another list of behaviour, which is taken when there is no scheduled behaviour.

3. PATH SELECTION METHOD

In this section, an automatic generation method of dynamic moving path is described, and there are three types of path: (a) dynamic path, (b) wide path and (c) avoiding path.

3.1. Dynamic Path

In the previous section, scheduled behaviour is described as a moving behaviour to go somewhere in order to take actions. If an action is planed according to each person's schedule, the route to the place can be fixed (Fig.2 (a)). However, if the person happens to encounter his/her friend on the way to the destination, he/she might change his/her mind, and go to another place such as a restaurant to have lunch or a designated area to smoke. In this case, if the route is already fixed, it must be rearranged completely, and it takes much time. Then, in this paper, each person has only two points to generate the current path and adds another point dynamically as he/she moves to the destination (Fig. 2 (b)). This method makes the route flexible and generates any route dynamically and very fast without rearrangement. It is possible to have only one point for the current path; however, even though one more point is added to make the route, there are only two points on the route. Connection of two points makes a line instead of a curve so that the route is not smooth. On the other hand, this method has always two points for the current path and one point is added dynamically. Three points makes a curve instead of a line so that the route becomes smooth.

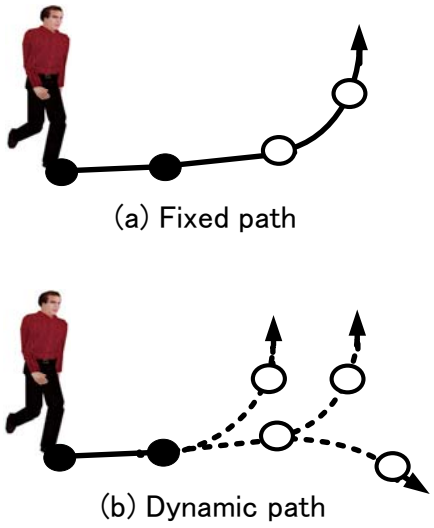

Figure 2. Dynamic path generation.

3.2. Wide Path

In this paper, the route of moving behaviour is generated by selecting some points among data prepared in advance. If there are many points in the data, variety of route can be generated; however, it takes much time to select the best points. Therefore, we propose a method that can generate additional points automatically. The data is the minimum set of points. For example, the

data has only one point in front of a building although there might be some points there. The first selection for the route uses the only one point. Once the point is selected, which means the person passes the entrance of the building, some points are generated automatically from the only one point. The algorithm is the following.

<**Wide path selection algorithm**>

(1) Two end point positions are calculated from the only one selected point and the wide length of the entrance (Fig. 3 (a) and (b)).

(2) Some intermediate points are generated by dividing the wide length uniformly considering that the length between points generated by this step can be reasonable (Fig. 3 (c)).

(3) One point is selected from the generated points according to the person's current position, and it is added to the path to generate the new route.

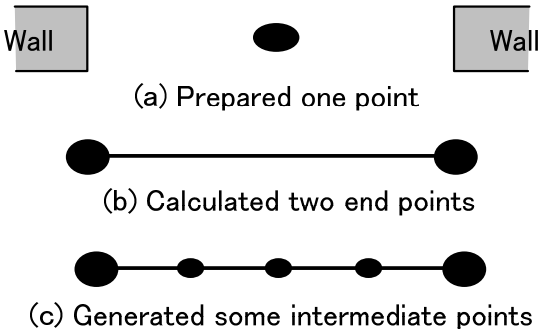

Figure 3. Wide path generation.

3.3. Avoiding Path

Suppose that there are people on the current route of a person. In this case, a new route must be generated in order to avoid them. The new route is generated as follows. First, the other person's position on the next step is estimated. If the position is still on the current rote, a new intermediate point is generated, which position has the right or left direction from the current route. Then, the new route is generated by connecting the current, the new intermediate and the next points (Fig. 4). However, there is another case that the new intermediate point cannot be generated because there are some obstacles at the position where a new intermediate point should be set. In this case, the person has to wait to avoid until he/she moves to an area enough for setting the intermediate point (Fig. 5).

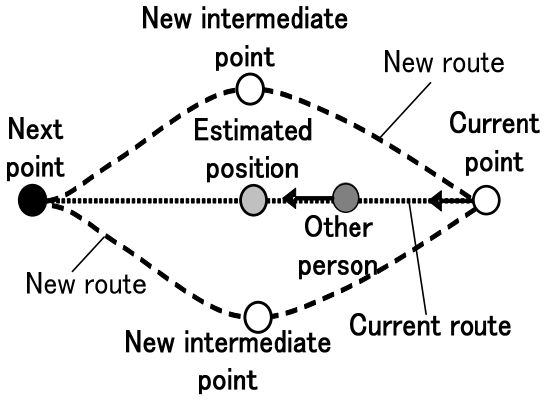

Figure 4. Avoiding path set.

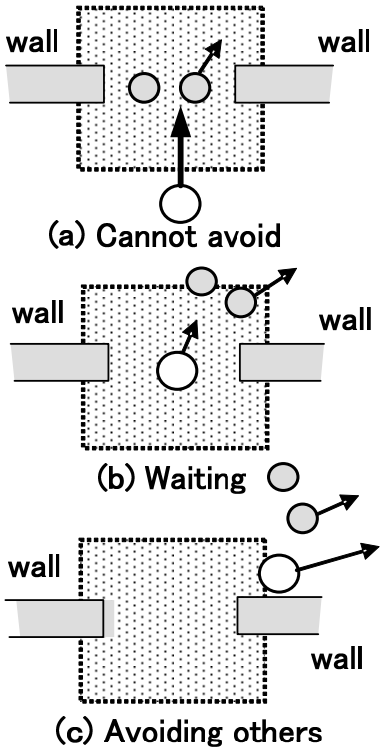

Figure 5. Wait and avoid others.

4. SIMULATION RESULTS

The simulation was performed with the following PC.

(1) PC: Dell DIMENSION 8200

(2) CPU: Pentium IV 2.2 GHz

(3) Memory: 512MB

(4) Graphics Board: nVIDIA GeForce 4 Ti 4600

(5) Language: Microsoft Visual C++ 6.0

(6) Library: OpenGL, DI-Guy SDK

Fig. 6 shows an example of human behaviour, which is generated by using dynamic moving path generation method. The scene has the time when a lecture is about to start so that many students start to move to a class room. Some persons (1 to 4) are moving to the class room by selecting some points for the route. However, one person (5) does not move to the class room and changes his route to take a rest at the bench although he has the schedule to take the lecture. For the point of the bench, there was only one point at first; however, when the person (5) approaches to the point, some points are generated automatically and one point from the generated points is selected by him.

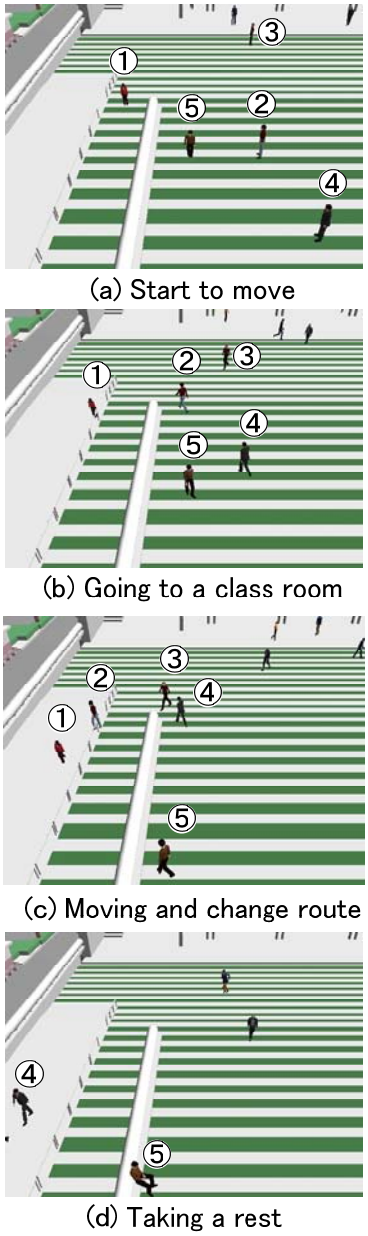

Figure 6. Scheduled behaviour and schedule change.

Fig. 7 shows another example of avoiding others. Some persons want to go to some place; however, there is a couple on their way so that additional point is set to change the route and they are avoiding the couple. If there is not enough space to avoid them, the last person waits to avoid the couple until he moves to a spacious area, and finally he can pass them.

Figure 7. Avoiding others.

5. CONCLUSION

This paper proposed an automatic generation method of dynamic moving path for autonomous human model. Each person has his/her own schedule and moves to the destination. Its route has only two points so that it can change easily for a new route. Also, for wide area, only one point is prepared at first in order to search the best route very fast; however when it comes to consider the plural points, some intermediate points are generated automatically and the best points are selected. Finally when there are others on the way, a new intermediate point is set to avoid them. Also, in the case that there is not enough space to avoid, the person waits to avoid until he/she moves to a spacious area. We have succeeded to generate dynamic moving path automatically with the proposed method. In the future, we plan to consider more complex situation such as cutting into a line.

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