

Construction of Collision Avoidance Behavior Model Induced by Visual Motion

Norifumi Watanabe

Brain Science Institute

Tamagawa University

6-1-1 Tamagawa-gakuen, Machida-shi
Tokyo, Japan

Email: norifumi@lab.tamagawa.ac.jp

Hiroaki Mikado

Graduate School of Engineering

Tamagawa University

6-1-1 Tamagawa-gakuen, Machida-shi
Tokyo, Japan

Email: mkdhi6ec@engs.tamagawa.ac.jp

Takashi Omori

Brain Science Institute

Tamagawa University

6-1-1 Tamagawa-gakuen, Machida-shi
Tokyo, Japan

Email: omori@lab.tamagawa.ac.jp

Abstract—We decide and execute our action from many types of environmental information in our daily lives even if we are not conscious of being guided. The human action induced from the oncoming person's movement is the collision avoidance of passing each other. In collision avoidance, we chiefly judge the avoidance direction from visual information. Especially, it is important to get the information from oncoming person's body part and avoidance timing in each other. Then, we make an experiment to judge the avoidance direction by watching the masking movie of oncoming person's body part. By evaluating this judgment time, it was clarified oncoming person's body part is leg in collision avoidance. Next, it especially paid attention to oncoming person's leg, and the relation between the walking cycle and leg position in avoidance judgment is evaluated. From this result, the avoidance judgment is possible because the traveling direction can be controlled by the leg when the leg is lifting and landing. It was clarified that oncoming person's walking cycle is important in the action decision during collision avoidance. So we propose the action decision model based at the walking cycle.

Index Terms—action decision model, collision avoidance, visual motion, walking cycle

I. INTRODUCTION

As for us, a safe walking is possible in the crowded situation. We plan not to collide with the other person, and the purpose of this is to execute it the decision of the action. However, it is difficult in the situation very crowded at the event site and the disaster, etc. to walk safely [1]. Attention is distributed in the inducement by the emergency light and the arrow when trying to head for a target place in such a place and the situation, and consideration is not turned by the inducement presentation thing. Then, it is important to make a unconscious inducement system thought that the congestion situation doesn't influence us easily, and our safety is kept direction where it should walk by controlling person's flow.

We examine the use of the galvanic vestibular stimulation (GVS) as a device of such an unconscious inducement. GVS behave on the vestibular apparatus, and change the perception of the direction of gravitational force. The movement related in the direction of center of gravity undertakes the influence of unconsciousness by this action. For example, it is reported that the direction of walking changes right and left into giving the illusion that posture has collapsed to the pedestrian by giving GVS, and the unconscious correction of the posture [2-3].

Up to now, the possibility that the effect of the inducement is achieved in a consecutive periodic motion has been pointed out from the walking [4] and minion [5-6] inducement by GVS.

On the other hand, we are generating the walking rhythm by using CPG (Central Pattern Generator) [7-8] that exists in the spinal cord while walking. Therefore, a smooth, steady walking is achieved in the place where it walks the plain, the stairs, the crowd, and for the first time. It is thought that the rhythm of CPG is related to the timing generation in various processes included in walking of perception and the action decisions and the motion executions etc. It is necessary to stimulate drawing out the effect of the inducement on the pedestrian by GVS to its maximum in the appropriate timing based on the walking cycle. Then, we construct a model of pedestrian's action decision process based on a walking cycle to optimize the intervention effect to walking with the device such as GVS. Concretely, the scene of passing each other of the one to one is taken up as a daily walking. We presume the influence specifying oncoming person's body necessary for the action decision at the time of passing each other. And, the influence of the self-movement when passing each other on generation is discussed.

II. ACTION DECISION PROCESS OF PASSING EACH OTHER

In this study, we targets an action of passing each other to which the others observation, the self-decision making and motion generation for the action decision by walking. In addition, to make the model simple, the pedestrian goes straight, and the situation in which the direction is that oncoming person may evade the collision with the pedestrian. In this case, the pedestrian observes others, judges the direction of evasion from information in other's body site, decides own evasive action based on it, and is executing his movement (Fig. 1).

As for the judgment of others' evasion directions, the body site that seems to be important. So we evaluated to the judgment by using movie of passing each other by making others' body sites. From the result of the using others' body sites, we consider the influence of own evasive action. Finally, we measure the body site thought to receive the influence by using the motion capture system and evaluate whether the motion generation based on the self action decision gives the

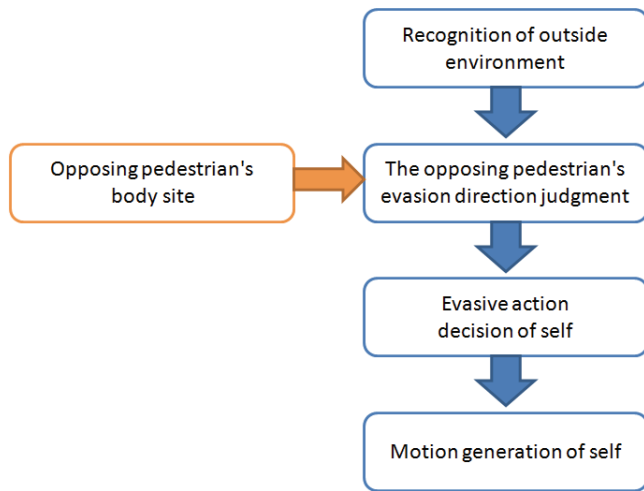


Fig. 1. Pedestrian's Action Decision Process



Fig. 2. Masking Movie of Passing Each Other Used by Experiment

effect to own body site.

A. Gazing Body Part in Passing Each Other

When passing each other with the person, we judge own direction of evasion from body features of those who oppose it by obtaining from the sight. Then, we measure the time that hangs to the judgment when the movie that does oncoming person's body site in masking is presented, and presume the body site necessary for the judgment.

1) *Method*: Subjects see the movie that those who oppose it projected onto the projector pass each other leaving the screen by about three meters in standing position, and judges oncoming person's direction of evasion. And subjects were stepping to image walking, and push the button in oncoming person's direction of evasion momentarily at the time of understood oncoming person's direction of evasion. However, the correction in the direction of evasion is no object.

The movie used by the experiment masked the specific body site all of about 300 frames, and integrated it again (Fig. 2). Oncoming person's body was classified into three (head, body, and foot), and the either was masked because the pedestrian had gazed at oncoming person's foot and breast by using eye track camera. Information obtained from the body site is limited by using the masked movie, and an important body site is specified from delay of the judgment by the limitation for the estimation of the direction of evasion.

2) *Results*: Figure 3 is a result of having totaled the number of judgments of body sites where the evasion judgment is delayed ($N=3$). The result that the judgment time became long when it had the foot in masking was shown. Then, it is thought that we do the evasion judgment by using information on our feet when passing each other. However, the delay has been generated by not only one's feet but also the masking of the head and the upper-body. It is thought that the head and the upper-body are seen and judged when the judgment is difficult only by oncoming person's feet. Thus, we examined the possibility that the body site where the evasion judgment

was done according to the walking phase (position of the foot when walking) is different (Fig. 4).

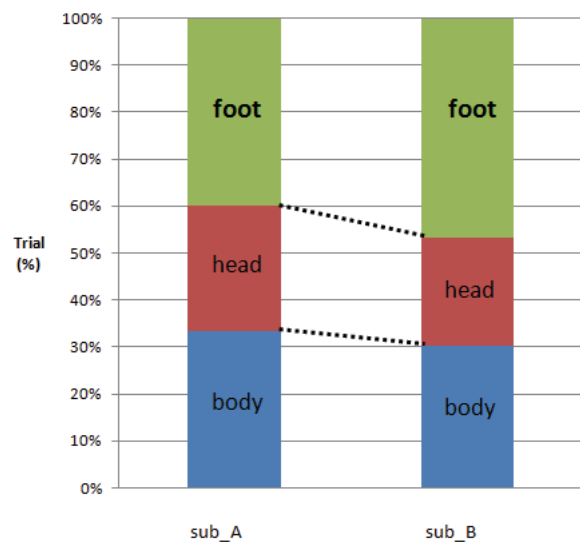


Fig. 3. Body Site Where the Delay of Judgment by Masking

B. Walking Phase in Evasion Judgment

We make a hypothesis with different body site at which it gazed when the evasion judgment is done according to oncoming person's walking phase at the time of passing each other. Next, how the walking phases of the body site and those who opposed it by the gaze influenced was examined.

1) *Method*: The subjects stand leaving the screen by 3 meters, step to image walking. They push the button in the direction momentarily at the time of understood oncoming person's direction of evasion. However, the correction in the direction of evasion is no object.

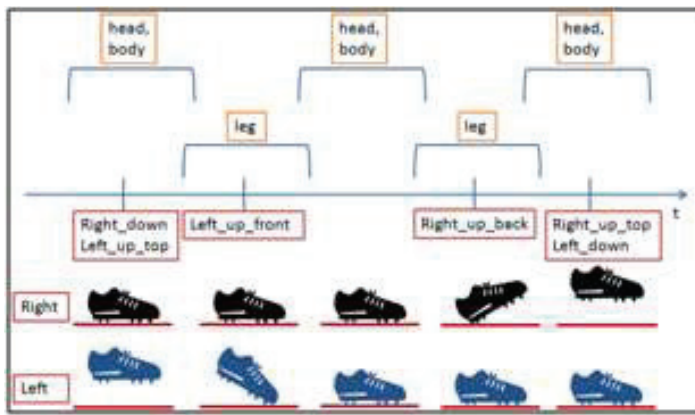


Fig. 4. Conceptual Chart of Walking Cycle and Evasion Judgment Body Part

The movie used took the situation of passing each other of the one to one from the other subject side. Four of those who opposed it directed the right and left foot stepped forward, and walked ten times of left evasion ten times of right evasion. In addition, to evaluate the walking phase, the movie of the side foot position was recorded synchronizing with movie of passing each other.

2) *Results*: Four subjects saw 378 animations a day in the experiment, the evasion judgment was done, and it experimented on it for five days. Average judgment timing of each movie was calculated from the experiment, and the walking phase when judged that was analyzed. The walking phase classified a foot right and left respectively in four states “Landed phase”, “Before swing phase”, “Swing phase”, and “After swing phase”.

Figures 5 and 6 are graphs where the number of judgments of walking phases of a momentary each foot that the evasion judgment was done was shown dividing into four oncoming pedestrians. In the graph, the phase is shown, “L: Landing, BS: Before Swing, S: Swing, AS: After swing”. Figure 5 is distribution of the phase in the judgment trice when stepping forward from the left leg. The judgment result has concentrated for the period of AS for the period of BS in the right leg in the left leg. Figure 5 is distribution of the phase in the judgment trice when stepping forward from the right leg. The judgment result is Figure 5, the oncoming phase, and has a lot of judgments in the period of BS in the left leg in AS in the right leg. As a result, it is suggested that a lot of evasion judgments be done in “Before swing phase” and “After swing phase” in the walking phase in operation of passing each other.

C. Walking Phase in Generating Evasion Motion

As for pedestrian’s action decision process, it has been understood that there is a judgment process of depending on oncoming person’s walking phase in addition to the process of others observation and decision of self-action and execution of self-movements. Not only these factors however but also in own motion generation, it is possible to a distance of self and oncoming pedestrian and the influence of own walking phase. Then, the moved distance of subject’s body (especially, feet)

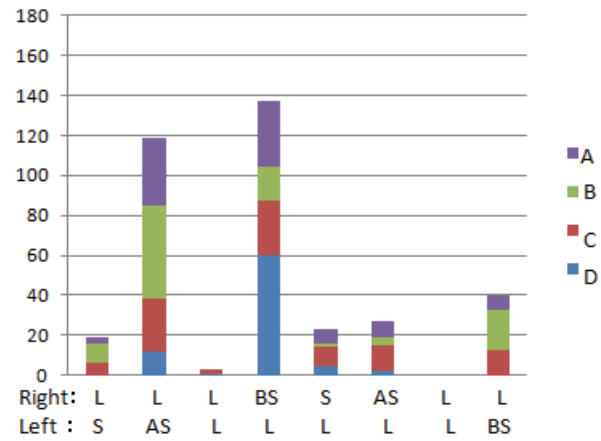


Fig. 5. Evasion judgment distribution when left leg is stepped forward. L: Landing, BS: Before Swing, S: Swing, AS: After swing.

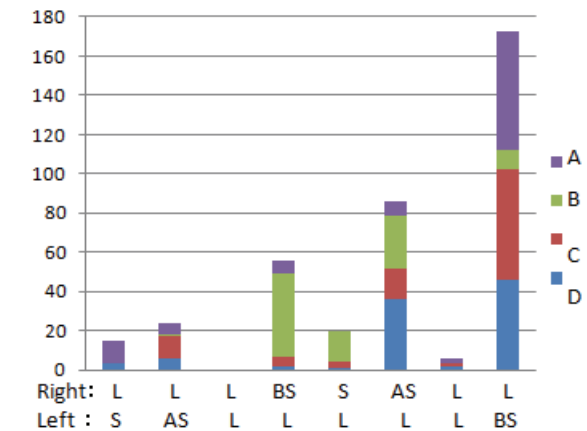


Fig. 6. Evasion judgment distribution when right leg is stepped forward. L: Landing, BS: Before Swing, S: Swing, AS: After swing.

at the time of passing each other is measured by using the motion capture system, the physical exertion for passing each other is begun, and timing is examined.

1) *Method*: The distance between oncoming pedestrian and subject is about 5.2 meters, and they start at time when the oncoming pedestrian put down his hand both simultaneous. At this time, both oncoming pedestrian and subject go straight. The subject evades to the right and left directed beforehand, and the oncoming pedestrian goes straight and passes each other. The evasion distance was directed to avoid it when seeming to collide with subject with oncoming pedestrian.

The subject threaded 13 point in total marker of head 3 points, shoulder 2 points, waist 2 points, knee 2 points, and ankle 4 points, and oncoming pedestrian threaded 8 points of waist 2 points, knee 2 points, and ankle 4 points in total. The subjects walked ten times respectively in right evasion and left evasion. The motion capture device used the one of made of Motion Analysis, 12 cameras, and the sampling rate 250Hz.

2) *Results*: A right and left rate vector greatly changes into straight advancement so that the subject may evade right and left so as not to collide with the oncoming pedestrian. We analyzed the moment when a right and left speed of the ankle had greatly changed into the right and left as 0.16m/second or more as for the threshold as motion generation timing. Figures 7 and 8 show the frequency of the walking phase when the motion of each subject being tested is generated. In the graph, the phase is shown, “L: Landing, BS: Before Swing, S: Swing, AS: After swing”. Figure 7 is a momentary walking phase with which subjects generated the evasion motion left, and the motion generation is often done in the section where the left leg has landed. Figure 8 shows a momentary walking phase in which the evasion motion to the right side is generated, and subjects generate the motion with both of right legs when landing and the left leg have landed. As a result, the timing at the motion generation is suggested that the foot in the direction of evasion landed. However, when the left leg had landed, the motion was generated about right evasion. Here, the motion generation tends to do generally by own working foot. The tendency to generate the motion when the foot in the direction of evasion had landed was suggested from experimental result at left evasion. On the other hand, the motion that moved at half cycle is generated in the direction of evasion by the left leg at right evasion. As a result, we assume whether subject’s working foot influences.

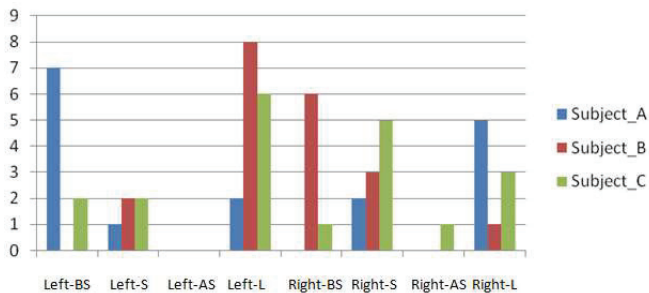


Fig. 7. Walking Phase at Motion Generation When the Left Side is Evaded

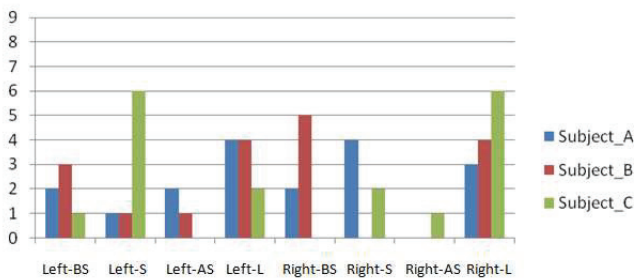


Fig. 8. Walking Phase at Motion Generation When the Right Side is Evaded

III. DISCUSSION

A. The pedestrian’s action decision based on walking cycle

From these experiments, it was shown that we have been influenced when passing each other at the action decision and the motion generation according to an oncoming pedestrian and own walking cycle.

Oncoming person’s body site is observed and the direction of evasion is judged the start when the pedestrian passes each other (Fig. 9-1). Concretely, the direction of evasion is judged from information on oncoming person’s feet in “Before swing phase” and “After swing phase” by which those who oppose it can control the direction of the foot. In L and S that the control of the foot is difficult, it is thought that the direction of the upper-body and the face is seen, and the direction for which the oncoming person’s heads is judged.

The pedestrian action decision after the direction of evasion is judged undertakes the influence of oncoming person’s walking phase (Fig. 9-2). Because the pedestrian has decided it the action according to the body site (especially, walking cycle) at which it gazed by the evasion judgment, the influence is undertaken from oncoming person’s walking phase though it only has to do the evasion judgment according to arbitrary timing.

This timing at the motion generation depends on own walking phase though the exercise is generated after the decision of the self action. That is, the motion is generated when the foot in the direction of evasion can be controlled, and a lot of the timing occurs to after swing phase (Fig. 9-3).

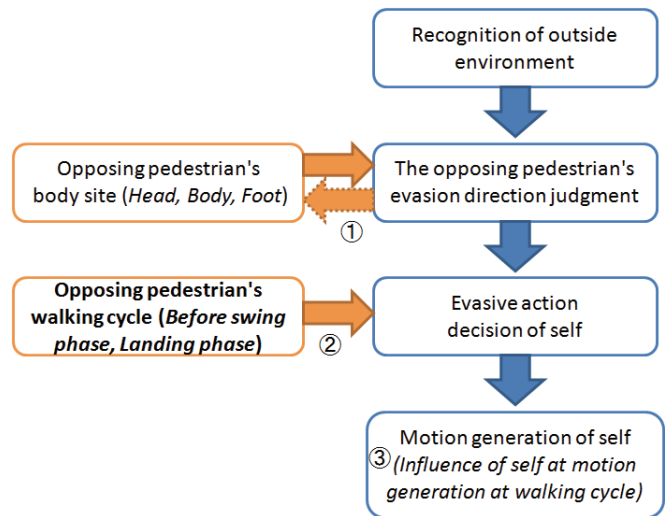


Fig. 9. Pedestrian’s Action Decision Process Model in Passing Each Other

B. Possibility of Inducement of Pedestrian Based on Action Decision Model

In this study, we have experimented the understanding of the action decision process at the time of person’s passing each other based on the hypothesis that an effective inducement by aiming at human action inducement under unconsciousness,

and putting out the inductive stimulus according to the walking cycle according to appropriate timing.

It is thought that we observe others' body sites and presume others' directions of evasion. However, there is a possibility of correcting the evasion judgment that the self decided when inducing it here with the sight device etc. so that the self may do the evasion judgment. Therefore, it is improper as the timing of the inducement presentation.

On the other hand, self decides the action according to others' walking cycle (3.2). Because the action decision timing has synchronized with the others' behavior, there is a possibility that it is caused to the inducement by inducing the pedestrian before the action decision. It is expected that the action decision of unconsciousness is performed by the inducement as for this method because there is no correction feedback by own intention. In addition, the action decision causes a high effect of the inducement because it influences the motion generation that the self controls. It is thought that it is the most effective before own evasive action is decided to induce it under such consideration.

IV. CONCLUSION

In this study, it experimented passing each other of the one to one for the clarification of the decision process of the walking action that aimed at the action inducement of unconscious. As a result, it was suggested that an oncoming pedestrian and own walking cycle influence at an action decision of the self and own motion generation. However, it is necessary to increase the number of subjects so that the possibility that the motion generation is influenced by the working foot may remain.

In addition, it wants to examine the inducement device including GVS, and to examine the inducement experiment.

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