

# Preparation of Papers for IEEE Sponsored Conferences & Symposia

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**Abstract**—This electronic document is a live template.

## I. INTRODUCTION

### A. Shared Space and Movement Efficiency

In recent years, shared space, which is a kind of urban design has been increasingly introduced especially in some European urban areas. Compared to the conventional separated road, in shared space, all road users (e.g., pedestrians, bicycles, and cars) use the same space. Additionally, at the interactions of those road users, who has the priority is ambiguous. Thus far, the study of collision avoidance has been conducted in the context of merging at the highway or etc, however, the situation in the shared space is far different from the situation that previous studies have assumed. Therefore,

### B. Brake Index

In shared space, collision avoidance models developed by the previous studies might not be efficient because various road users coexist and there are no explicit rules for the priority.

### C. The Effects of Minority to the Whole Movement Efficiency

About the effects of minority movement to the whole movement efficiency, the authors revealed that increasing cooperative movement do not linearly increase the movement efficiency. In the experiment, the participants were instructed to either cooperatively reach their goal or in a hurry.

## II. OBJECTIVE

This study examined how the whole movements efficiency would change as the ratio of agents whose movement algorithms are different. We expected to find the threshold of the ratios of agents in the whole space that drastically change the movement efficiency. For example, considering the experiment carried by [2], one quarter of whole agents could be one of the bottleneck; namely, when the number of cooperative agents reached the one quarter of the whole agents, movement efficiency drastically increased. Otherwise, there is also possibility that the raise of movement efficiency follows the linear change and the movement efficiency and the ratio of cooperative agents are in proportion.

## III. METHOD

To achieve the objective of the study, we performed the computer simulation and measured the efficiency of the movements.

### A. Simulation Environment

The space of the simulation environment was set as a 500 by 500 pixel virtual space, where the simulation agents could move in two dimensions. Thus, the simulation environment was made to represent the shared space (Figure 1). The size of each agent was defined as the radius of 5 pixel circle. In one trial, all agents moved 500 steps. All agents' initial positions and initial velocities were randomized each time the simulation started.

### B. Avoidance Algorithms

Based on the collision avoidance algorithms, agents were classified into two types.

For one of types, simple avoidance agent, their avoidance vectors were generated to the opposite direction of the other agents which approached within a 50 pixel. The size of avoidance vectors were fixed as either 1, 2, 3, 4, or 5 pixel in one trial. We call this type of agents as the simple avoidance agents.

For another type of agent, which we call as the dynamic avoidance agent, their avoidance vector were generated based on the braking index. When an agent approach to another agent within 50 pixel, the braking rate was calculated based on their relative positions and velocities, and their avoidance vectors were determined from 1 to 3 pixel. This way of avoidance enabled agents to avoid other agents considering how much potential danger they are facing; in safer situations, agents avoid slightly, on the contrary, in more dangerous situation, agents avoid widely not to collide each other.

### C. Metrics of movement efficiency

The movement efficiency was measured from two perspectives: completion time and number of collisions. Completion times was calculated as the mean steps for each agent took to reach their goals, where each agent has goals to reach. After they reached their goals, another goal was set so that all agent always has the destination to go. Number of collisions is the mean of how many times each agent collided with other agents. When more than two agents approached each other at the distance of closer than 5 pixel, those agents' collision count was added. These two metrics were expected to be inverse-ratioal to each other because we assume that when agents avoid others more widely, their completion time should be longer and vice versa. Completion time and the number of collisions were calculated for each agent and all agents' values were averaged.

#### D. Change of the ratios of Dynamic Avoidance Agents

To verify how the change of ratios of dynamic avoidance agents affects the whole movement efficiency, we performed simulations varying the ratios of dynamic avoidance agents in the whole simulation environment. The variations of ratios were a range of 0 to 1. Therefore, when the ratio was 0, all agents in the environment move based on the simple avoidance algorithm, and when the ratio was 1, all agents in the environment moved based on the dynamic avoidance algorithm. We performed 20 trials of the simulation per ratio and all trials' completion time and number of collisions were averaged.

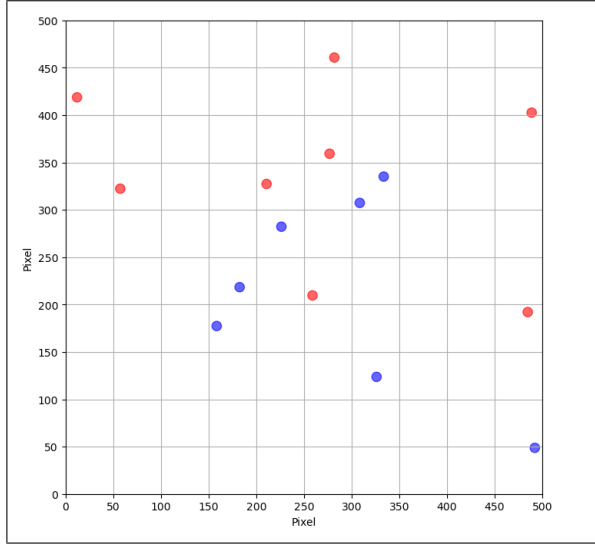


Fig. 1. Overview of the simulation environment

#### IV. RESULTS

Figure 2 shows the transition of the mean of all agents' completion time. In case of that simple avoid vec is smaller than 2 px, completion time increase as the proportions of the dynamic agent increases. For other cases, where the simple avoid vec is more than 3 px, the completion time decreases as the dynamic agent increases.

Figure 3 shows the transition of the mean of all agents' number of collisions. On the contrary to the completion time, when the simple avoidance vectors are smaller than 2 px, the number of collision decreases as the ratio of the dynamic avoidance agents increases; conversely, when the vectors are larger than 3 px, the number of collisions increased.

##### A. Transition of Movement Efficiency

##### B. Units

- Use either SI (MKS) or CGS as primary units.

#### V. DISCUSSION

As the results showed, the trade-off between the completion time and the number of collisions was observed when increasing the ratio of the dynamic avoid agents, except when the simple avoid vector is 2 px. For the simulation environment where the simple avoidance vector is small,

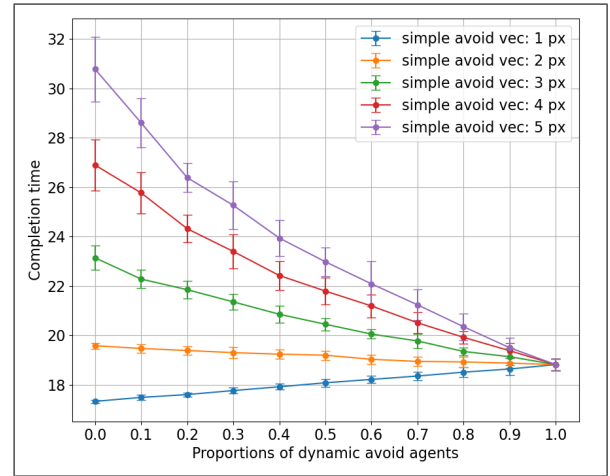


Fig. 2. Transitions of completion time as the ratio of dynamic avoidance agent increase. The error bars represent the standard deviation of 20 trials.

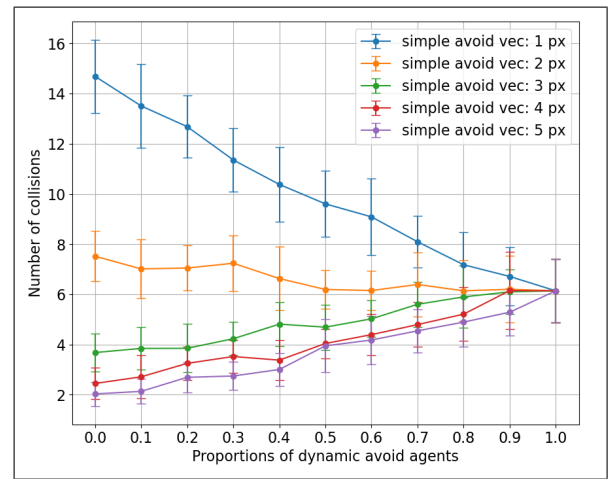


Fig. 3. Transitions of number of collisions as the ratio of dynamic avoidance agent increase. The error bars represent the standard deviation of 20 trials.

(i.e., 1 px) the increasing of the dynamic agents increased the completion time and decreased the number of collisions. While dynamic avoidance agents decreased the completion time and increased the number of collisions. Because we consider the dynamic avoidance agents as the cooperative movements in the environment, it is possible to say that these results imply that cooperative movements do not always beneficial to the movement efficiency, but there is the situation where the cooperative movements is beneficial to both the completion time and the number of collisions.

#### VI. TABLE

##### A. Equations

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$$z\alpha + \beta = \chi \quad (1)$$

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## B. Figures and Tables

Positioning Figures and Tables.

TABLE I  
AN EXAMPLE OF A TABLE

One	Two
Three	Four

Figure Labels: Use 8 point Times New Roman for Figure labels.

## VII. CONCLUSIONS

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

## APPENDIX

Appendixes should appear before the acknowledgment.

## ACKNOWLEDGMENT

The preferred spelling of the word on the first page. We cited [2].

## REFERENCES

- [1] G. O. Young, Synthetic structure of industrial plastics (Book style with paper title and editor), in *Plastics*, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 1564.
- [2] Matsubayashi, S., Miwa, K., Terai, H., and Ninomiya, Y. (2024). Index of braking behaviour in two dimensions within risk perception. *Transportation research part F: traffic psychology and behaviour*, 102, 164-176.