Moving Domestic Robotics Control Method Based on Creating and Sharing Maps with Shortest Path Findings and Obstacle Avoidance

Utilization of Place Indentifier: PI

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***Abstract*—Control method for moving robotics in closed areas based on creation and sharing maps through shortest path findings and obstacle avoidance is proposed. Through simulation study, a validity of the proposed method is confirmed. Furthermore, the effect of map sharing among robotics is also confirmed together with obstacle avoidance with cameras and ultrasonic sensors.**

Keywords-domestic robotics; obstacle avoidance; place identifierl ultrasonic sensor; web camera

I. INTRODUCTION

Domestic robotics utilizing services are available in hospitals, group homes, private homes, etc. Domestic robot has camera image acquisition and voice output capability. Patients in hospitals wear a single Head Mount Display: HMD and an eye looking camera mounted glass. Camera acquired their eye image is transmitted to mobile phone through Bluetooth communication interface. Many robot helpers have been investigated by researchers. The ARM9-based Car controlled remotely has been developed by Wang Shaokun et all [1]. The embedded Linux system was installed under ARM9-structure processor for real time robot operation. It also optimized and improved the versatility and rapid data transmission of wireless remote car. The robots collected the data sensor and relay it to main PC station over WIFI network. Another robot also has been developed by Ding Chengjun et all [2].

Based on embedded WinCE5.0 operating system, they created remote control for mobile robot. The low power consumption and perfect real-time controller is the main goal of this. The data was sent using TCP/IP protocol over WIFI network. Another research concern in remote robot has been developed by Niu Zhigang and Wu Yanbo [3]. They developed a wireless remote control special design for Coal Mine Detection Robot. They investigated the embedded motion control system and apply it for Coal Mine Detection Robot's control system and wireless remote control.

The scenery around the robot in coal mine environment was transmitted to the main station, used it for controlling the robot movement such as forward, backward, turning left, turning right and tipping over the front arm. Ofir H et all have evaluated the telerobotic interface components for teaching robot operation [4]. They evaluated the control method of the robotic arm and the use of three alternative interface designs for robotic operation in the remote learning. Another system has been proposed by He Qingyun et all [5]. They created an embedded system of video capture and the transmission for monitoring wheelchair-bed service robots remotely. The embedded linux, S3C2410AL microprocessor, AppWeb 3.0 server, and block-matching motion estimation were taken into account for obtaining better video compression data. The remote control robot system with a hand-held controller has been proposed by Dmitry Bagayev et all [6]. The dog robot for accompanying the elderly has been proposed by Wei-Dian Lai [7]. The improved interaction technique between users and the robot has been developed for making elderly easy to use.

Application software of the mobile phone allows estimation of line of sight of their eye when they are looking at a certain location of a key in the keyboard which is displayed on the HMD screen. Thus they can create sentences and can communicate with the surrounding peoples of the robot because voice output capability is implemented on the robot. Also the patients select functions, move forward, turn right, turn left and the other functions by looking at the function keys.

At the same time, acquired image with the mounted at the tip of the robot is transmitted to the mobile phone through WiFi networks. Therefore, they can look at the outside scenery of the robot which is displayed on HMD screen. Such this domestic robot is designed and developed. Using this robot, patients enjoy virtual trip in the hospital, communication with the surrounding peoples, make orders to nurses, medical doctors, etc.

Domestic robots have to be moved safely with avoiding obstacles and have to find a shortest pass. This paper deals with the methods for obstacle avoidance, and finding a shortest pass based on Dijkstra algorithm [8]. The following section describes the proposed domestic robot followed by the methods for obstacle avoidance and finding a shortest pass. Then experiments and simulation study is described followed by conclusion with some discussions.

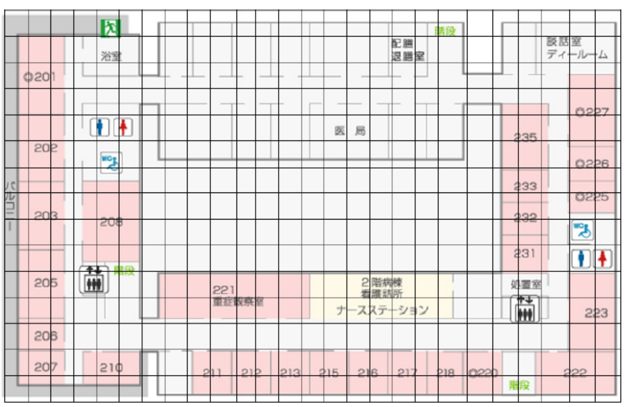
II. PROPOSED DOMESTIC ROBOT HELPING HOSPITALIZED PATIENTS

A. Fundamental Ideas of the Proposed Robot

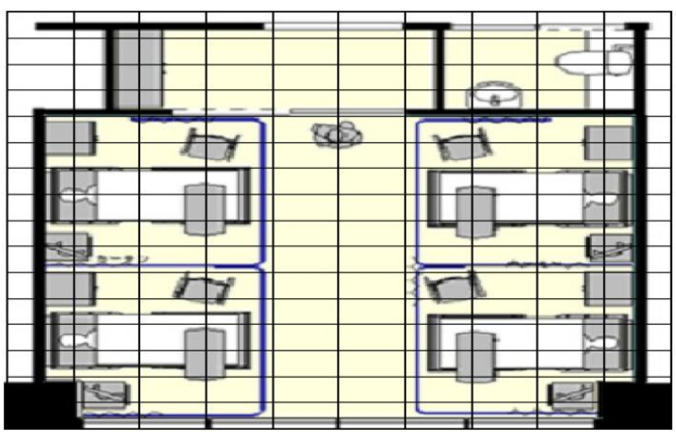
There is a concept of Place Identifier: PI. One of the examples shown below,

tag:hospital.net,2009:pi/2floor/31-2/view1/flag/hh.mm.ss

This is a kind of tag expressions which is known as tag scheme (RFC4151)[1] which allows identifying spatial reference coordinate system with DNS representations. Tag information says, the name of the hospital, floor, room, interior, the data acquisition time and so on as shown in Figure 1. Figure 1 (a) shows an example of floor layout of the floor in the hospital while Figure 1 (b) shows an example of room layout. Therefore, any specific piece of the items in the interior, in the room, on the floor in the hospital can be identified with PI. These examples have mesh. Every cross points of the mesh has the spatial reference coordinate system. Therefore, DNS representation of tag scheme is on the corresponding spatial reference coordinate system.



(a)Floor Layout



(b)Room Layout

Fig. 1. Examples Of Floor And Room Layout

B. Process Flow of the Proposed Robot Control

Figure 2 shows the process flow of the proposed helper robotics control.

1 http://www.ietf.org/rfc/rfc4151.txt

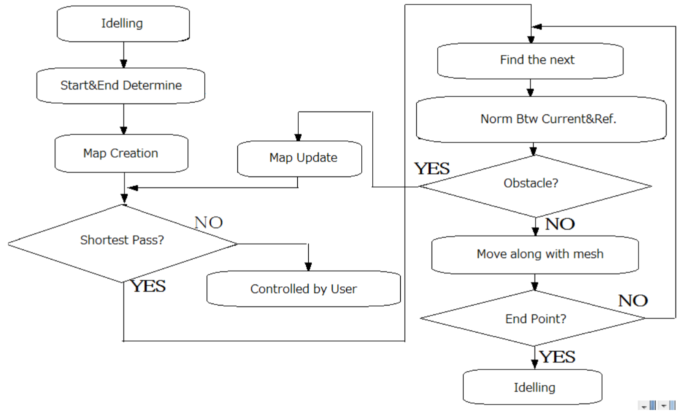
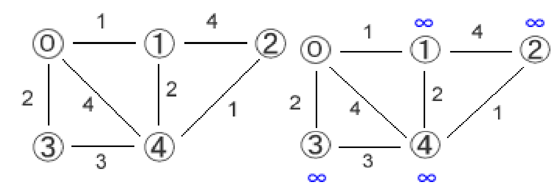


Fig. 2. Process Flow Of The Proposed Helper Robotics Control

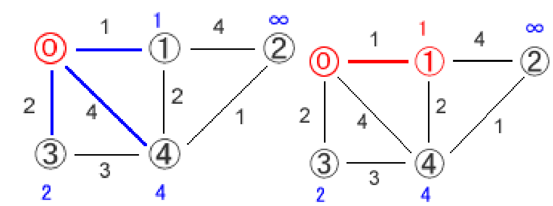
Along with the mesh which is shown in Figure 1, robotics are controlled and moved from the start point to the end point (destination). Shortest pass can be found based on Dijkstra algorithm and obstacles are detected by the norm image between the current and the reference images. All the robots on the same floor and room has shared map which is composed with the mesh data. Using floor and room layout, static obstacles are found and stored in the map database in a real time basis. Therefore, collision may not be happened.

C. Shortest Pass Finding with Dikstra Algorithm

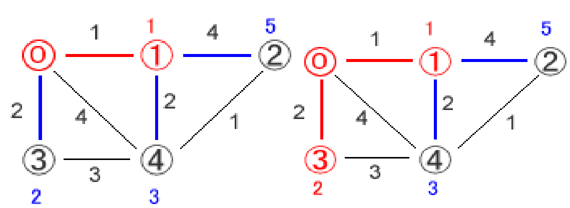
Djikstra algorithm can be illustrated as shown in Figure 3.In the Figure 3, there are just five nodes. Pass lengths are indicated between the adjacent nodes. From Figure 3 (a) to (h), the shortest pass is found subsequently. Thus the shortest pass, from node No.0 to node No.2 through node No.1 and No.4 can be found.



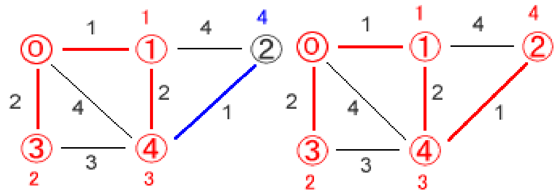
(a)Step #1 (b) Step #2



(c) Step 3# (d) Step 4#



(e) Step 5# (f) Step #6



(g) Step #7(h) Step #8

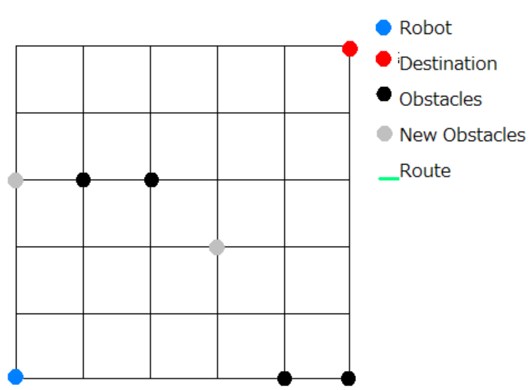
Fig. 3. Dijkstra Algorithm For Shortest Path Findings

D. *Method for Obstacle Avoidance*

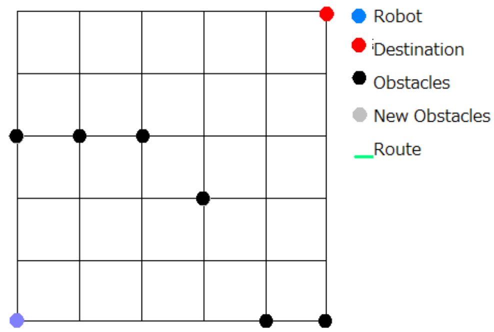
Using camera acquired image which are mounted at the tip of the domestic robot, patients can identify obstacles. One of the examples of the acquired images with camera is shown in Figure 4 together with the outlook image which is taken from the hand held camera tracing to the robot.

Fig. 4. Acquired Image with the Camera Mounted At the Tip of Helper Robot and the Image of Helper Robot from the Hand Held Camera

Patients can avoid the obstacles which are found by looking at the camera acquired image through finding a route for avoiding the obstacles. It is also possible to avoid obstacles because robots are sharing their own created map as shown in Figure 5.



(a)The first robot finds new obstacles



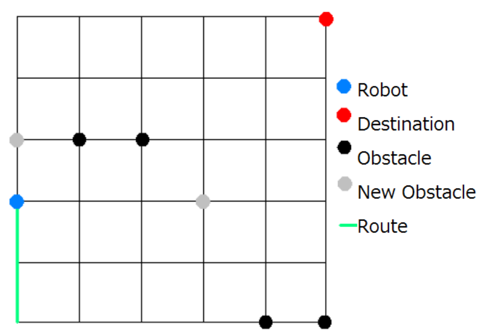
(b)The second robot may avoid the obstacles found by the first robot with the map sharing among the robots

Fig. 5. Obstacle Avoidance with Map Sharing Among Robots

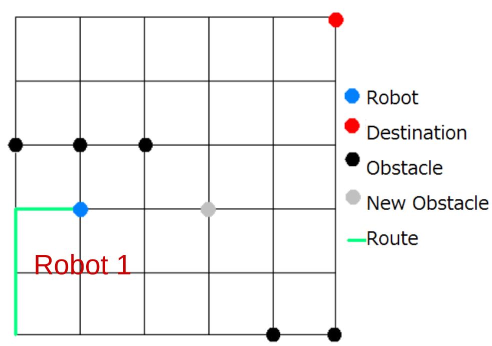
III. EXPERIEMENTS

A. *Preliminary Experiment*

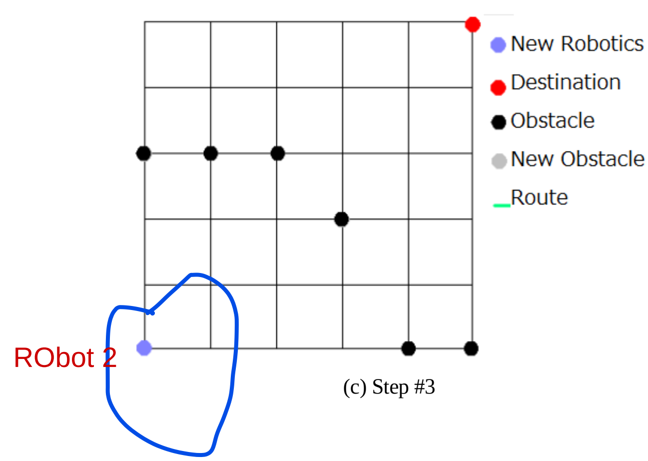
Figure 6 shows the example of process flow for obstacle avoidance.



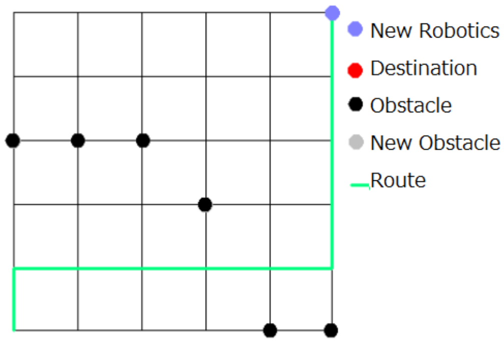
(a)Step #1



(b) Step #2



(c) Step #3



(d) Step #4

Fig. 6. Example Of Process Flow For Obstacle Avoidance.

Original situation is shown in Figure 5 (a). Starting from the bottom left corner, robot moves to the destination which is situated at the top right corner. Two robots share floor and room layout maps. At the step #1 and #2, the first robot creates a map. The map is shared by the second robot. Therefore, the second robot can avoid transient obstacles because the first robot meet the transient obstacles then the maps are updated with the location of the transient obstacles.

At the step #1, new obstacles (grey colored objects) appear. There are three types of obstacles, static, dynamic, and transient obstacles. Wall, door, interior, etc. is a kind of static obstacle while moving obstacles such as walking nurse, medical doctor, and patient is a dynamic obstacle. Suddenly appeared and disappeared obstacles, on the other hands, are transient obstacles. In the step #1, transient obstacles appear suddenly. Therefore, the robot has to change the route for avoiding static and transient obstacles in accordance with the Dijkstra algorithm.

At the step #2, the first robot meet the another obstacle. Then the robot changes route in accordance with Dijkstra algorithm. At the step #3, the second robot departs from the start point for the same destination of the top right corner in accordance with the updated maps. Therefore, the second robot can determine the shortest pass as shown in Figure 6 (d) of the step #4.

B. *Obstacle Finding and Avoidance*

Obstacles can be found by comparing between current and the reference image without obstacle. At the cross points of location, of meshed data of floor and room layout, forward looking images are acquired a prior basis as reference images. Therefore, obstacle can be identified when the norm between the current and the reference images is greater than zero. Reducing influences due to illumination condition changes, shadows and shades by using Near Infrared: NIR camera, the current and the reference images are acquired. Also influence due to geometric distortion on the calculation of norm can be eliminated with image matching (or template matching) between the current and the reference images. In the image matching process, Affine transformation is assumed for geometric distortion.

Figure 7 (a) and (b) shows the reference and the current images which are acquired with the forward looking NIR camera mounted at the tip of the robot. There is an obstacle in the current image. Also Figure 8 shows norm image between Figure 7 (a) and (b). Obstacle can be detected as shown in Figure 8. Figure 8 shows the norm image between the current and the reference images at the cross point of the meshed data for floor and room layout.

(a)Reference image

(b)Current image

Fig. 7. Examples of the Reference and the Current Images

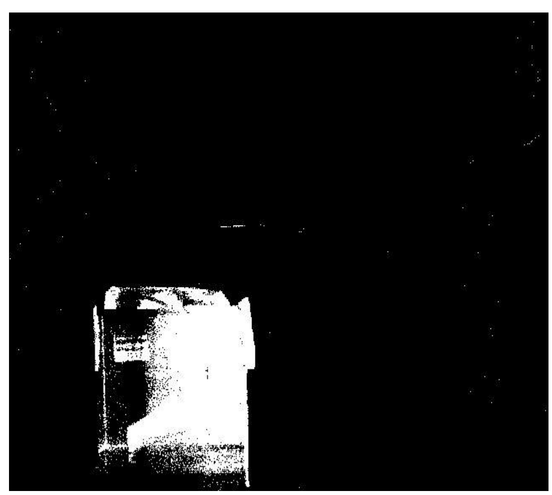


Fig. 8. Norm Image between the Reference and the Current Images Results in Obstacle Finding.

In Euclidean geometry, an affine transformation or affinity (from the Latin, affinis, "connected with") is a geometric transformation that preserves lines and parallelism, but not necessarily Euclidean distances and angles.

C. Realistic Simulation

Much realistic situation is taken into account with the following simulation parameters,

Mesh size: 30 by 20

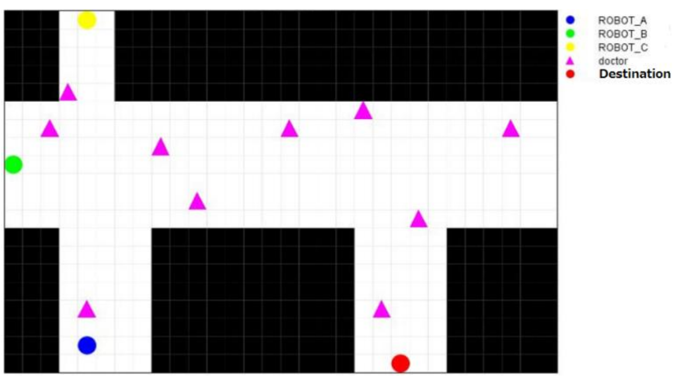
The number of robotics: 3

The number of moving obstacles: 0 to 15

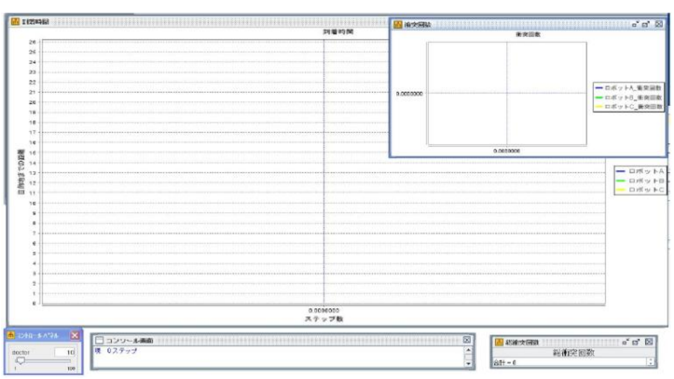
Floor and room layout, initial location of robotics, moving obstacles (medical doctors, nurses, patients) start and end points (destination) is shown in Figure 9. The simulations are taken place with a variety of initial conditions of the initial location of robotics and moving obstacles. Floor and room layout as well as mesh size and the number of robotics are fixed. The initial locations are determined with uniformly distributed random number. The number of trials is set at 10 times.

Figure 9 (a) and (b) shows situation and location of robotics as well as log data of three robotics locations at the initial situation while Figure 9 (c) and (d) shows those at the intermediate situation. Meanwhile, Figure 9 (e) and (f) shows those for the final situation.

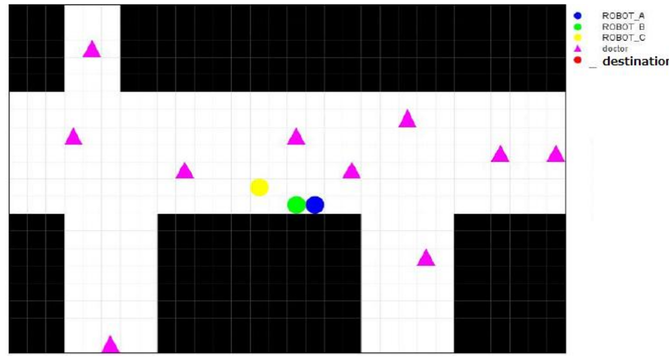
When collision occurs between or among the robotics, then it is assumed to be delayed 10 unit steps for recovering from the collision situation. A comparative study on the required number of steps (time) for getting the destination from the start point is conducted between with and without map sharing among robotics.



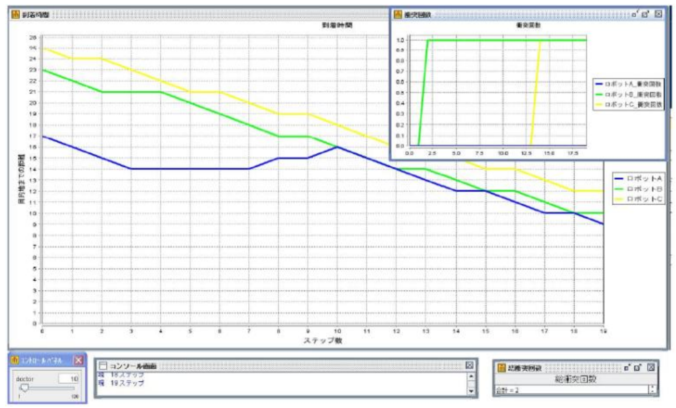
(a)Initial situation of robotics and moving obstacles



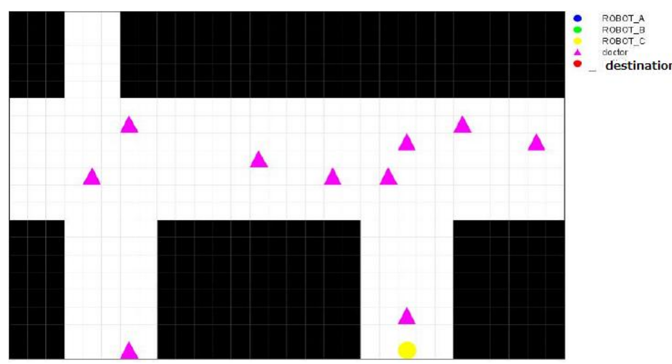
(b)Log data of the location of three robotics as function of the number of steps



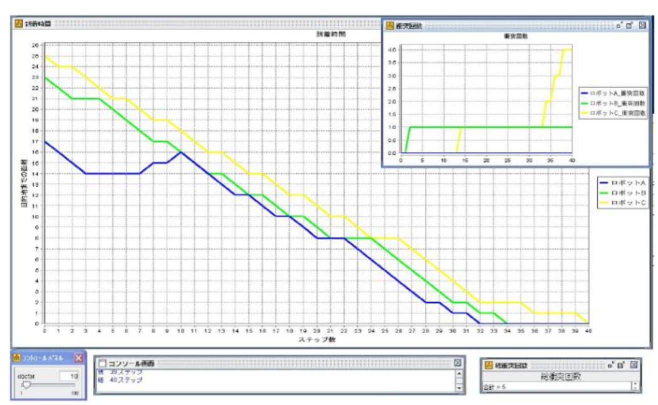
(c)Intermediate situation



(d)Log data of three robotics location at intermediate situation



(e)Final situation



(f)Log data of three robotics locations at the final situation

Fig. 9. Situation and Location of Robotics at the Initial, Intermediate, and Final Situations

Simulation results show that the number of collision increased with increasing of the number of moving obstacles as shown in Figure 10. Also, a relation between the number of moving obstacles and the number of unit time steps for getting the destination from the start point is shown in Figure 11. It is obvious that the number of unit time steps required for getting the destination is increased in accordance with increasing the number of moving obstacles because the number of collisions increased with increasing of the number of moving obstacles.

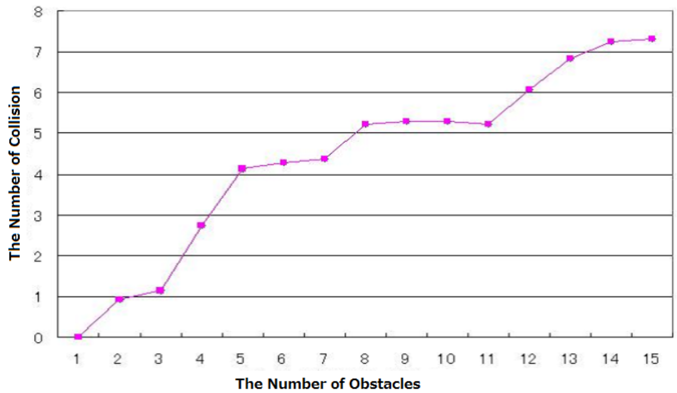


Fig. 10. Relation Between The Number Of Collision And The Number Of Moving Obstacles

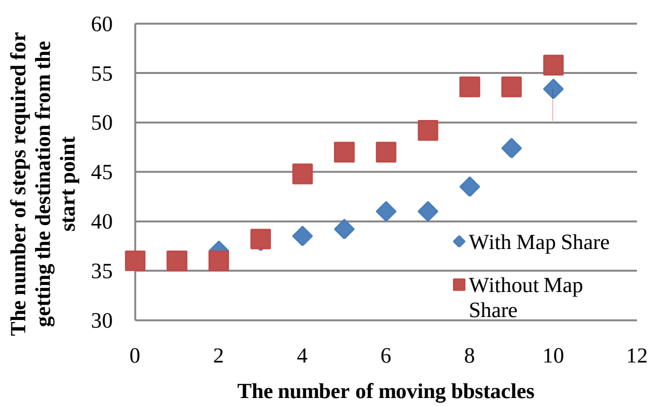


Fig. 11. Relation Between The Number Of Moving Obstacles And The Number Of Steps Required For Getting The Destination From The Start Point.

As shown in Figure 11, the effect of map sharing for reducing the time required for reaching the destination from the start point is quite obvious. In this simulation study, the time required for reaching the destination from the start point is almost same at the number of moving obstacle of 10. Because that the routes is getting complex in accordance with the number of moving obstacles, the effect of the map sharing is saturated is the number of moving obstacles is greater than 10 in this case.

IV. Conclusion

Control method for moving robotics in closed areas based on creation and sharing maps through shortest path findings and obstacle avoidance is proposed. Through simulation study, a validity of the proposed method is confirmed. Furthermore, the effect of map sharing among robotics is also confirmed together with obstacle avoidance with cameras and ultrasonic sensors.

For the small size simulation cell such as 30 by 20, the effect of the map sharing for reducing the time required for reaching the destination from the start point is significant and is saturated in accordance with the number of moving obstacles.

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