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RESEARCH ARTICLE

Research on Design and Motion Control of a Considerate Guide Mobile Robot for Visually Impaired People

BIN ZHANG, (Member, IEEE), MIKIYA OKUTSU, RIN OCHIAI, MEGUMI TAYAMA, AND HUN-OK LIM, (Senior Member, IEEE)

Department of Mechanical Engineering, Kanagawa University, Yokohama, Kanagawa 221-8686, Japan

Corresponding author: Bin Zhang (zhangbin@kanagawa-u.ac.jp)

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ABSTRACT Guide mobile robot have been researched and developed for decades. However, current robot cannot guide the user to the destination considerately, since the status of the user and the properties of the obstacles are not considered, especially for the guiding work of servicing visually impaired people. In this paper, a guide mobile robot with an easy-to-hold handle is designed, a generation method of spatial risk map is proposed to evaluate the influences of potential spaces of objects and a motion control method based on spatial risk map considering potential occupied spaces of objects is proposed. The users are successfully guided to the destination naturally without influencing other pedestrians by avoiding entering the potential spaces of objects automatically, and they can adjust their moving status in their own will since the considerate robot can adaptively adjust its guide status to adapt to the user. Through comparing guiding experiments of different tasks for 10 blindfolded users, the proposed guide mobile robot is proven considerate by guiding the users adaptively and make other pedestrians feel comfortable by avoiding entering the potential spaces of objects automatically.

INDEX TERMS Intelligent robots, autonomous systems, robot control, assistive robots, autonomous robots.

I. INTRODUCTION

In recent years, there has been an overwhelming shortage of guide dogs to meet the demand for walking guides for the visually impaired people [1], [2]. For now, the number of guide dogs in working is 861, but the number of people who need a guide dog is about 3000 in Japan [3]. Therefore, means that can solve this problem is greatly needed, and re-search and development of autonomous guide mobile robots is being actively carried out [4], [5], [6]. However, existing guide mobile robots are often developed with a focus on guiding functions, and do not give sufficient consideration to the potential occupied spaces of objects and status of users, so that it is far from applying the robot to real life [7], [8]. For example, the robot may move in front of a person who is watching TV. Although the robot did not collide with obstacles, it still disturbed others. The social acceptance of guide mobile robot is still needed to be improved. A considerate robot that can not only avoid obstacles but also understand the potential occupied spaces of objects and status of users to move without disturbing any others is greatly needed to improve the social acceptance of guide mobile robots.

In this study, a considerate guide mobile robot is designed, and a motion control method is proposed based on a risk map that considers the potential occupied space of objects in the process of motion control. The developed robot can move naturally without disturbing others during moving and adaptively adjust its moving speed to adapt the motions of users. The risk map is defined as an environmental 2D map that not only reflects the occupancy status of objects and free spaces, but also shows the magnitude of risks around objects. The degree of danger in the area around the robot are expressed in stages according to the properties of objects. Specifically, areas where robots cannot pass such as walls and humans are

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set with high risk, and areas such as human personal space and potential occupied spaces where it is possible to pass but are better to be avoided are set with medium risk. Areas suitable for going through without obstacles and potentially occupied are set with no risk. A path with lowest risk is then generated, which can usually avoid entering potential occupied spaces of objects. Notice that the potential occupied spaces can still be chosen for passing through if there is no path without risk, and the robot will choose a comparatively better path, trying to make the disturbed people feeling less uncomfortable by keeping a certain distance with them and providing effective interactions such as making a waring sound or voice. The robot is controlled by using potential field method. In this method, goals or sub-goal are set with attractive potential to attract the robot and objects are set with repulsive potential to stop the robot moving close. The areas with risk are set with repulsive potential since they are familiar with obstacles. The moving speed and direction are controlled by using the integrated potential field. In addition, by detecting the distance between the user and the robot and setting attractive potential at the place with a certain distance in front of the user, the moving status of the robot is adjusted by keeping a fixed distance with user, which makes the robot possible to adapt to the motions of the user.

The contributions of this research are as follows. (1) Designed a wheeled guide mobile robot that is easy-to-hold for visually impaired users; (2) Proposed a spatial risk map generation method to evaluate the influences of potential occupied spaces of objects; (3) Proposed a motion control method based on integrated potential field method to control the guide mobile robot move considerately.

The remainder of this paper is organized as follows. Section II gives a brief review of the related work. Section III shows the design of the proposed guide mobile robot mechanism. Section IV presents the proposed method of mapping and generation of spatial risk map and section V presents the control system based on spatial risk map. Section VI shows the experiment results. Finally, Section VII concludes the paper.

II. RELATED WORKS

Guide dogs have been an important part of the life of visually impaired people. However, guide dogs require a considerable amount of effort to train and maintain. Moreover, not all visually impaired people can or want to own a guide dog. Thus, the development of an alternative solution such as a guide dog robot could be a good choice to assist visually impaired people in their daily lives. There are several types of guide mobile robots developed to meet the needs of different users. The first type is the wheeled robot, which uses a set of wheels to move around and navigate the environment [6], [7]. The wheeled robot is usually equipped with various sensors, such as cameras, LIDAR, and ultrasonic sensors, to detect obstacles, paths, and landmarks [8], [9], [10]. The robot also has a set of speakers and microphones to communicate with the user, recognizing their speeches and providing information for the users [3], [11], [12]. The other type of guide mobile robot is the quadruped robot, which uses four legs to move around and navigate the environment. The quadruped robot is designed to imitate the behavior and movement of a real dog, providing a more natural and intuitive interface for the user [4], [13]. The sensor systems of quadruped robot are similar with the wheeled robot [14], [15]. With the sensor system, the robot can understand the environment by mapping [16], [17], path planning [18], [19] and controlling the moving speed of the robot [20], [21] to move towards the destination along with the planned path without colliding with any obstacles. Moreover, current guide mobile robot can interact with the users by recognizing voices, gestures and learning the motion patterns of the users [22], [23], etc.

However, current guide mobile robots usually enter potential occupied space of objects, like the personal spaces of human beings and the area around a door [24]. The potential occupied space is an area that is potentially used by an object and a human, although there is no actual object in that area. Even if there is enough space to go through, it is normally needed to avoid entering for the robot, such as the area in front of a person who is watching the television or the area among people who are in conversation. Person-al space of human beings is a typical example of potential occupied spaces, where people may feel uncomfortable when someone gets into this special area [25]. People with good manners usually unconsciously avoid entering such spaces. It can be said that autonomous mobile robots that coexist with humans should also avoid moving into potential occupied spaces so that they can socially accepted. The guide mobile robot needs to generate a path that avoids the potential occupied spaces of objects on the way and move to the destination naturally. In addition, there are cases where the robot tries to enter under a desk or chair to get to the destination in a shorter way [26]. The robot may mistakenly think that it can pass through the places under the obstacles since there is enough space for the robot. As a result, when the robot does path planning, it may choose such a path and cause a collision between the user and the obstacles. Even if there is enough space for the user, it is still unnatural to pass through these kinds of areas.

Moreover, there are many limits for the user when using a guide mobile robot. Most of the currently developed guide mobile robots require the user to follow them by adjusting their speed or to control the moving speed of the robot by themselves [27], [28]. It is difficult to control the speed of the robot or adjust their own speed without knowing the surrounding situation, and it is very stressful for the visually impaired people if they enter potential occupied spaces of the objects or surrounding people together with the robot [29].

III. DESIGN OF THE GUIDE MOBILE ROBOT

The guide mobile robot developed in this research is shown in Fig. 1. This robot consists of a moving platform, a body frame with a handle, and a monitor. Mecanum Rover Ver2.1 made by Vstone Co. Ltd. is used as the moving platform, which has

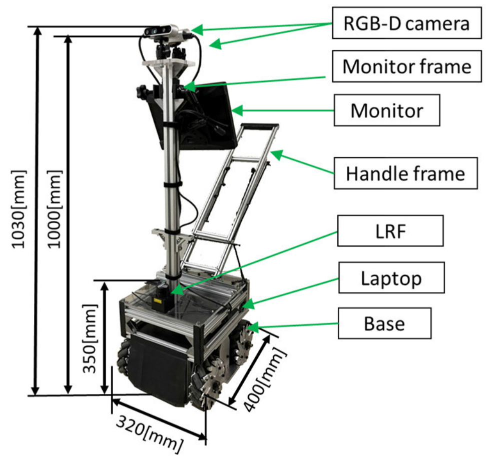

FIGURE 1. The overview of the developed guide mobile robot.

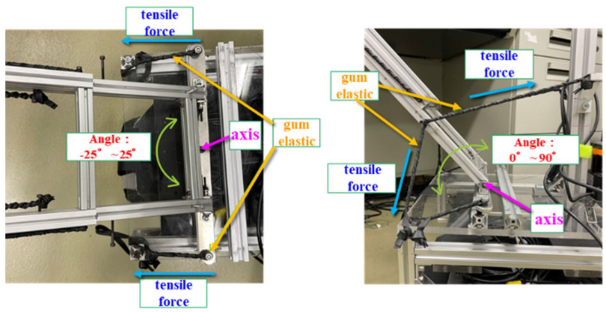

FIGURE 2. Frontal and side view of the easy-to-hold handle.

four Mecanum wheels with the function of moving towards all directions and is able to load 40 [kg]. The main body of the robot is made from materials like lightweight and strong polycarbonate and aluminum frames. This robot has a total weight of 27.6 [kg] (including the 20 [kg] weight of moving platform) and a maximum speed of 130 [cm/s]. In order to control the robot, two notebook PCs are mounted on the base of the robot. In addition, a two-dimensional range sensor URG-04LX-UG01 (LRF) is installed in front of the base. Two RGB-D cameras RealsenseD435 are attached to the monitor support bar 650[mm] above the base of the robot. The handle is designed to be easy to hold. The base of the handle is fixed to the base with screws and synthetic rubber. In addition, a telescopic lead is used to move the handle from 0° up and down to 90° and left and right by 25°, and it is fixed to the base, as shown in Fig. 2. Furthermore, the height of the handle can be adjusted from 60[cm] to 80[cm] considering the height of the user.

IV. MAPPING AND SPATIAL RISK MAP GENERATION

In order for the guide mobile robot to guide the users to the destination, it is necessary to understand the environment first. Therefore, using the distance information obtained by LRF, a two-dimensional map of the surrounding environment is generated by Simultaneous Localization and Mapping (SLAM) based on cartographer [30]. The map generation

(a)The scene of the environment (b) Generated map

FIGURE 3. Mapping result by using SLAM.

by SLAM in this re-search generates a two-dimensional occupancy grid map. An occupancy grid map divides the surrounding environment into grids and stochastically describes whether or not an object occupies each grid as an occupancy probability. All grids are shown in gray color in the beginning because the initial state is an unknown state before detection. After that, the environment is detected by LRF, and the probability that an object exists on the grid is high if the objects are detected, making these areas shown in black color. In addition, when the occupancy probability is low, it means that the probability of being an empty area on the grid is high, making these areas shown in white color. The unknown areas keep gray if the information about these places is not detected yet. For an indoor environment shown in Fig. 3 (a), the generated map is shown as Fig. 3 (b). The door of a room is open, and the robot is controlled manually to go around in the room and the passage until the working areas are all detected. This map generated in advance will be used as the global map for the guiding tasks in the experiments. The red triangle shows the position of the robot when the view in Fig. 3 (a) is taken. There is a room that keeps its door opening and the doors of other rooms are all closed. The end of a passage is not allowed to enter during the experiment. The map correctly reflected the shape of a room and passages. The white areas in the map show the places where the robot is able to pass through, and the black areas show the obstacles where the robot must avoid during moving around. The gray areas show the unknown places.

The spatial risk map is generated considering the potential occupied spaces of objects. The areas without obstacles but potentially used by objects are also evaluated by different risk levels so that the robot can avoid entering these places in general. The concept of potential occupied spaces is evaluated by the repulsive potential field, which will cause repulsive force to the robot so that the robot cannot get close to these areas unless the repulsive forces from other directions are lager. In that case, it means that the robot has no choice but go through the potential occupied spaces to get to the destination. It is still a good choice because human beings also do the same thing. For example, people usually avoid entering the areas in front of a person who is watching TV, which will disturb the person, but they still go through these areas when there is no another path. However, people may say sorry to

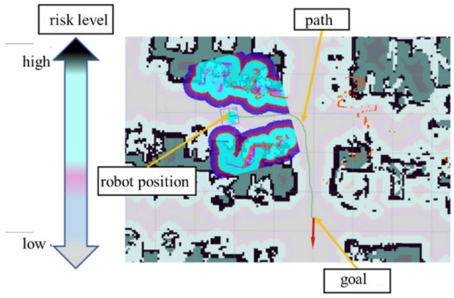

FIGURE 4. Generated spatial risk map.

the person who is disturbed, and it is usually allowed in daily life. The robot can be also controlled in that way. It is usually controlled to avoid disturbing other people, but it will also use effective interactions like saying "excuse me" to make the disturbed people feel better as well as finishing its task. The generated spatial risk map is shown in Fig. 4. It is observed that the areas around the obstacles are all evaluated by risk so that the robot find a path without risk to get to the goal. The closer to the obstacles, the risk level is bigger. When there is no path without risk, the path with lowest risk will be generated. It means that the potential occupied spaces are still passable when there is no better path.

V. CONTROL SYSTEM BASED ON SPATIAL RISK MAP

A motion control method is proposed based on spatial risk map. Using the global map generated in advance, the robot uses information from encoder and LiDAR for self-localization. The human beings in the environment are detected by OpenPose [31] by using RGB-D information from RealSense D435. The direction of the body can be calculated from the 3D coordinates of human shoulders. Here, the 3D coordinates are calculated by matching the shoulder positions in the RGB image, which are detected by OpenPose, to the point cloud. The visually impaired user is recognized by OpenCV ObjDetect Module Face Recognition (SFace) [32] and the status of the user is detected from the pose of user body. Most obstacles and their regions are recognized by Yolact [33] and some special obstacles that are easy to be interacted with humans (like posters on the wall) are marked in the map in advance. The influences of obstacles, pedestrians and user are all reflected to the robot, and the robot is controlled by using integrated potential field method, in which the potential occupied spaces are also considered. The flowchart of the proposed system is shown in Fig. 5.

A. DYNAMIC PATH PLANNING FOR THE GUIDE MOBILE ROBOT

The robot gives candidates of destinations to the user by sound instructions and the user can choose from the candidate by answering the number of the candidate of destination. The voice of the user is recognized by using Speech Recognition API [34]. After the destination of the guide mobile robot is set on the map, Dijkstra method is used to calculate the shortest path on the map [35]. This algorithm based on graph

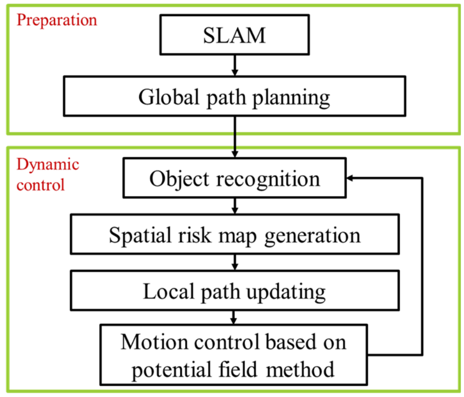

FIGURE 5. Control system.

theory that efficiently calculates the shortest path between two nodes, which are uniformly set on the free space areas in white color on the map. Considering the potential occupied spaces, the robot basically follows the shortest path to get to the destination, but the local path will be adjusted in real time according to the spatial risk map.

B. CONTROL METHOD BASED ON INTEGRATED POTENTIAL FIELD

The potential field method [36] is a real time robot motion controlling method, in which potential fields are generated according to the properties of places or objects that may influence the motion of robot. The goal or sub-goals that the robot should move towards are set with attractive potential field, and they will generate an attractive force to make the robot get close. The obstacles that the robot should avoid colliding with are set with repulsive potential, and they will generate a repulsive force to make the robot leave away. As for the visually impaired user, attractive potential field are set in a certain distance in front of the user, so that the robot will try to keep this certain distance with the user. The certain distance is usually set as social distance of a human being and can be adjusted by the user. Keeping a certain distance can make the robot more considerate since it can move faster when the user becomes faster and slow down or stop to wait for the user when the user slows down. Moreover, the robot can even follow the user to move around when the user moves by his/her own will. All of these motions are generated automatically, rather than designed by setting rules case by case. Particularly, potential occupied spaces are set with repulsive potential field, and the risk level of these places are generated according to the properties of objects. The generated repulsive potential field of potential occupied spaces is similar with that generated from obstacles but smaller. It can make sure the robot will try to avoid these places in common but still be able to pass through these places when there is no better path. The robot will move towards the gradient direction of integrated potential fields. When the goal is set and shortest path is generated, the robot starts to move towards the goal according to the generated attractive potential field. However, the final goal may far away from the robot, which can cause the robot stop at some local extremum values of integrated potentials. Instead, sub-goals are generated by sampling from the shortest path, and the robot will always move towards the nearest sub-goal. Equation (1) shows the value of attractive potential field from sub-goals and the position in front of the user, and Equation (2) shows the value of repulsive potential fields from obstacles and potential occupied spaces.

$$P_a = \frac{k_a}{2} \times d_a^2 \tag{1}$$

$$P_r = \begin{cases} \infty & (d_r \leq d_0) \\ \dfrac{k_r}{(d_r - d_0)} & (d_r > d_0) \end{cases} \tag{2}$$

Here, P_a means the generated attractive potential field, and P_r means the generated repulsive potential field. k_a and k_d mean the coefficients, which are defined according to experimental tests. d_a and d_r mean the distances between the robot and the targets. d_0 means the minimum distance that the robot is allowed to get close to the obstacles.

VI. EXPERIMENTS

To prove the effectiveness of the proposed method, several experiments of guiding 10 blindfolded users are conducted under indoor environment separately. When a user is guided by the robot, the others are shown as pedestrians randomly walking or talking with each other. The allowance distance of obstacles is set as 10 cm, same with the conventional method (potential field method without considering spatial risk map), and the allowance distance of special objects are set differently (20 cm for chairs). As for human beings, the personal space area of a person [37] is set as an egg shape, with 80 cm in width and 100 cm in length. During the environment, the shortest distance from the robot to different objects are calculated and compared. Questionnaire about social acceptance of the guide mobile robot is conducted after the experiments. The user and pedestrians are investigated to have a 5-level evaluation of effectiveness, acceptance rate, level of felling trustable to the robot or disturbed by the robot, comparing the conventional and proposed methods.

A. PERSONAL SPACE AVOIDANCE EXPERIMENTS USING THE GUIDE MOBILE ROBOT

The robot treats the pedestrians as obstacles based on conventional potential field method so that it can avoid colliding with the pedestrian. However, the robot may choose a path that gets very close to them or disturbs them by going in front of them. As shown in Fig. 6, the pedestrian is detected and treated as an obstacle (shown as the pink circle). The allowance area is also set to the person (circular blue area around the pink circle), and the shortest path is generated (the green line), which is very close to the allowance area. The robot (purple rectangle) then moves to the goal, following the designed path. A person is guided by the robot who walked blindfolded (pretending as the visually impaired user). As shown in Fig. 7, the robot successfully avoided to collide with the person, but got very close to him (with the shortest distance of 40 cm) so that the guided user slightly collided with the person (shown as (c) and (d) in Fig. 7). The robot disturbed the pedestrian and make both the user and the pedestrian feel sorry to collide with the other one.

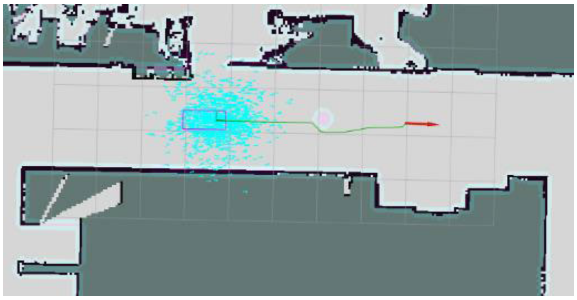

FIGURE 6. Path planning result when the user is guided to avoid colliding with a person by conventional potential field method.

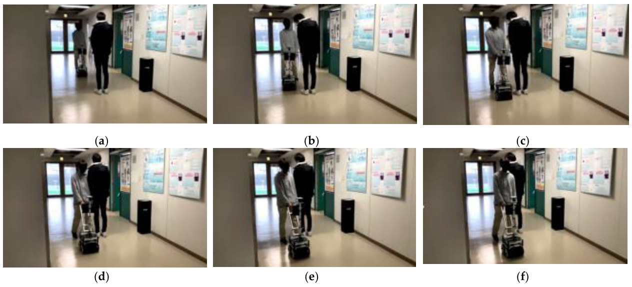

FIGURE 7. The scenes when the user is guided to avoid colliding with a person by conventional potential field method.

On the other hand, the robot treats the pedestrians as human beings based on the proposed potential field method considering spatial risk map so that it not only avoids colliding with the pedestrian but also avoids the potential occupied areas around the pedestrian (shown as the egg shape according to the concept of personal space), showing as adjusting the path before entering the personal space of the pedestrian. In this way, the robot and the guided user both avoided the pedestrian and kept a certain distance with him, preventing the pedestrian from feeling uncomfortable in advance. As shown in Fig. 8, the pedestrian is detected and treated as a person (shown as the circle with egg shape personal space). The risk level is set to the personal space according to the distance, and the path with lowest risk is generated (the green line), which is relatively far away from the pedestrian. The robot (purple rectangle) then moves to the goal, following the designed path. The same person is guided by the robot who walked blindfolded (pretending as the visually impaired user). As shown in Fig. 9, the robot successfully avoided to collide with the person (with the shortest distance of 40 cm), and the avoiding motion is held in advance (shown as (b) and (e) in Fig. 9). The pedestrian is not disturbed nether by the robot nor the user.

B. EXPERIMENTS OF AVOIDING PEOPLE IN CONVERSATION USING THE GUIDE MOBILE ROBOT

The robot treats the pedestrians in conversation as independent obstacles based on conventional potential field method

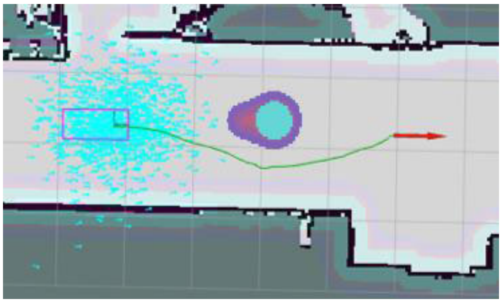

FIGURE 8. Path planning result when the user is guided to avoid colliding with a person by proposed potential field method considering spatial risk map.

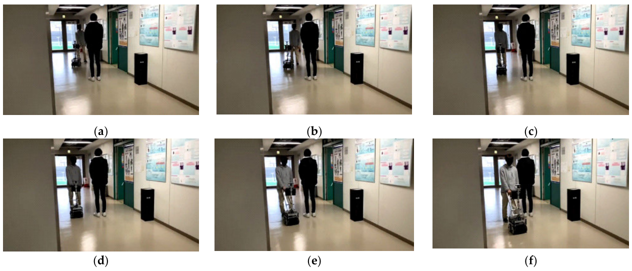

FIGURE 9. The scenes when the user is guided to avoid colliding with a person by proposed potential field method considering spatial risk map.

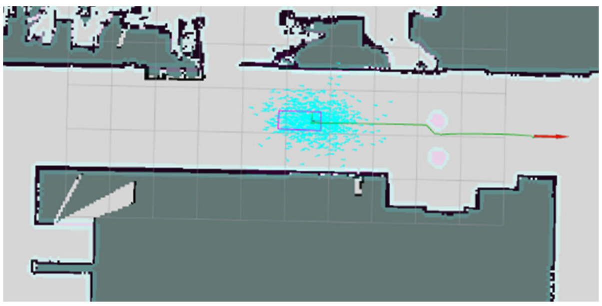

FIGURE 10. Path planning result when the user is guided to avoid colliding with two persons in conversation by conventional potential field method.

so that it can avoid colliding with the two pedestrians. However, the robot may choose a path that passes through the two pedestrians and gets very close to them. As shown in Fig. 10, the pedestrians are detected and treated as independent obstacles (shown as the pink circles). The allowance areas are also set to the persons (circular blue areas around the pink circles), and the shortest path is generated (the green line), which is very close to the allowance area of one pedestrian. The robot (purple rectangle) then moves to the goal, following the designed path. A person is guided by the robot who walked blindfolded (pretending as the visually impaired user). As shown in Fig. 11, the robot successfully avoided to collide with the pedestrians, but passed through the area between them and got very close to one of the pedestrians (shown as (c) to (f) in Fig. 11, with the shortest distance of 10 cm). The robot disturbed the pedestrians in conversation and make the pedestrians feel uncomfortable.

On the other hand, the robot treats the pedestrians as human beings based on the proposed potential field method considering spatial risk map so that it not only avoids colliding

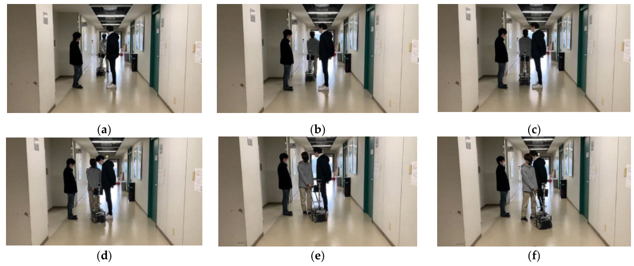

FIGURE 11. The scenes when the user is guided to avoid colliding with two persons in conversation by conventional potential field method.

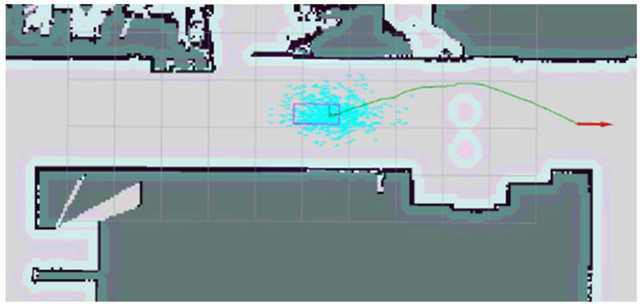

FIGURE 12. Path planning result when the user is guided to avoid colliding with two persons in conversation by proposed potential field method considering spatial risk map.

with the pedestrian but also avoids the potential occupied areas around the pedestrians (shown as the connected areas of two egg shape personal spaces), showing as adjusting the path to move on the other side of the two pedestrians instead of passing through of them. In this way, the robot and the guided user both avoided the pedestrians and kept a certain distance with them preventing the pedestrians from feeling uncomfortable in advance.

As shown in Fig. 12, the pedestrians are detected and treated as two persons with connected personal spaces (shown as the connected egg shapes). The risk level is set to the connected personal space according to the distance to the two pedestrians, and the path with lowest risk is generated (the green line), which is on the other side of the two pedestrians and relatively far away from them. The robot (purple rectangle) then moves to the goal, following the designed path. The same person is guided by the robot who walked blindfolded (pretending as the visually impaired user). As shown in Fig. 13, the robot successfully avoided to collide with the pedestrians by moving in the other side of them (shown as (a) to (f) in Fig. 13, with the shortest distance of 40 cm). The pedestrians in conversation are not disturbed nether by the robot nor the user.

C. OBJECT AVOIDANCE EXPERIMENTS USING THE GUIDE MOBILE ROBOT

The robot treats the chair as an obstacle with its special allowance based on the proposed potential field method considering spatial risk map so that it not only avoids colliding with the chair but also avoids the potential occupied areas around the chair (shown as the pink area with wider circular risk area), performing as adjusting the path to avoid colliding

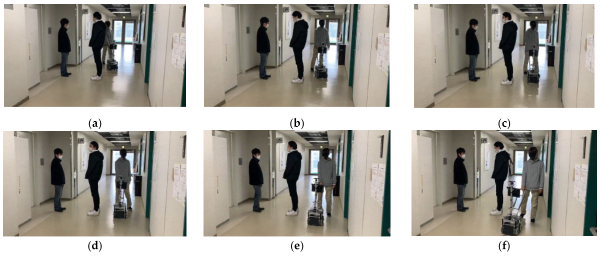

FIGURE 13. The scenes when the user is guided to avoid colliding with two persons in conversation by proposed potential field method considering spatial risk map.

FIGURE 14. Path planning result when the user is guided to avoid colliding with a chair by proposed potential field method considering spatial risk map.

with chair in advance. In this way, the robot and the guided user both avoided the chair and kept a certain distance with it, preventing the other pedestrians in the environment from worrying about the visually impaired user. As shown in Fig. 14, the chair is detected and treated as an obstacle with special risk areas shown as circular light blue area, which is generated according to the property of the object. It is a circle shape here, different from the egg shape of a person. The risk level is set to the potential occupied area according to the distance to the chair, and the path with lowest risk is generated (the green line), which is far away from the chair. The robot (purple rectangle) then moves to the goal, following the designed path. As shown in Fig. 15, the robot successfully avoided to collide with the chair by avoiding it in advance (shown as (a) to (f) in Fig. 15, with the shortest distance of 20 cm). It prevents the pedestrians around who are watching the user from feeling worried.

D. EXPERIMENTS OF AVOIDING MULTIPLE OBJECTS USING THE GUIDE MOBILE ROBOT

The visually impaired man (pretended by 10 different persons who walks blindfolded) is finally guided by the guide mobile robot to finish a task of getting through a passage with multiple objects. There are multiple chairs as obstacles and people who stand single or talk with each other in the passage, as shown in Fig. 16. The path with lowest risk is generated (shown as the purple line in Fig. 16).

The robot successfully guided the user to the goal, avoiding all of the pedestrians and obstacles without disturbing or worrying them. The scenes of the checkpoints ((a) to (i)

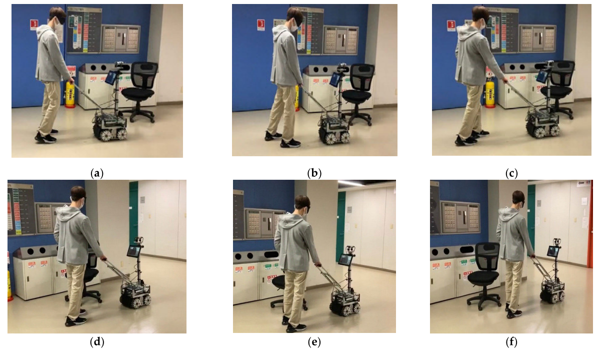

FIGURE 15. The scenes when the user is guided to avoid colliding with a chair by proposed potential field method considering spatial risk map.

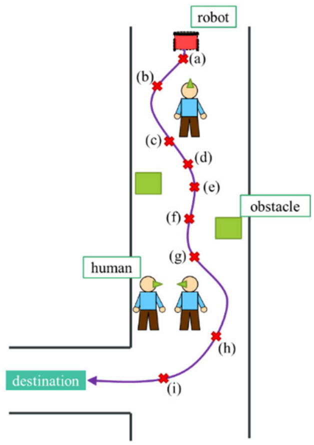

FIGURE 16. The guide task when the user is guided to avoid colliding with multiple objects by proposed potential field method considering spatial risk map.

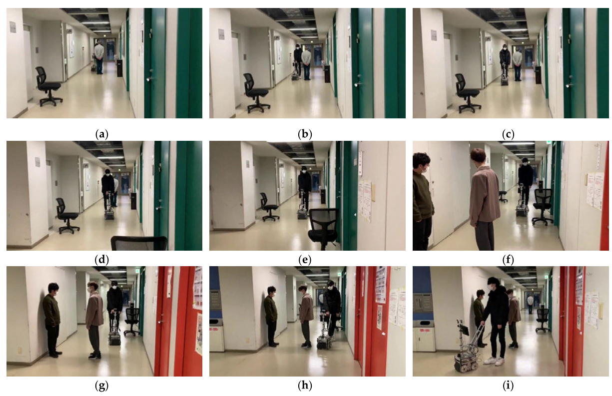

FIGURE 17. The scenes when the user is guided to avoid colliding with multiple objects by proposed potential field method considering spatial risk map.

shown in Fig. 16) are shown in Fig. 17. The robot avoids entering the personal space of a person who stands single as shown in Fig. 17 (a) to (c) with the user, with the shortest distance of 40 cm. It avoids the two chairs by moving in the relatively middle line of them to keep a certain distance (with the shortest distance of 20 cm) with both of them and prevented the user from colliding with them. The robot also guides the user to avoid the two pedestrians in conversation by moving in the right side (with wider space) of them, with the shortest distance of 40 cm.

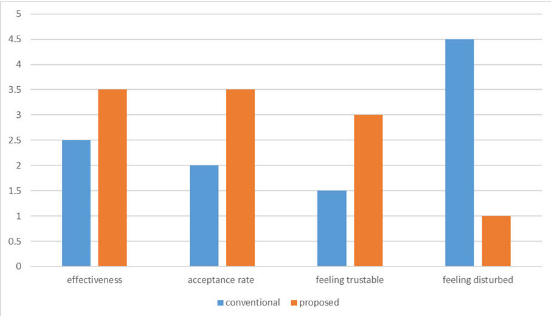

FIGURE 18. Questionnaire results by comparing the conventional and proposed methods.

According to the questionnaire results, the effectiveness of guide mobile robot and acceptance rate are improved by using the proposed method, but there is still a gap before application (got 3.5 scores in 5). Especially for the visually impaired user, they feel kind of trustable (got 3 scores in 5) to the robot but still in a medium level, even though the performance has improved a lot than the conventional method. It is inspiring that the level of feeling disturbed for pedestrians is greatly decreased by using the proposed method.

VII. CONCLUSION

In this research, a considerate guide mobile robot is designed. By considering the concept of risk map into the processes of path planning and motion control, it was possible to make the guide mobile robot move to the goal considering the conditions of surrounding people. The risk map is generated according to the potential occupied areas of objects, which can be adjusted by their properties. The robot can avoid disturbing or worrying people around and adjust its speed to maintain a certain distance from the user, while avoiding obstacles. The effectiveness of the proposed method was confirmed by experiments of guiding 10 users who walks blindfolded under different environments. Further testing experiments with real visually impaired people need to be conducted. Besides, the function of speech recognition is needed to be improved so that the robot can understand the intentions of the user and choose the destination with the concept of voice command. Scene instructions by voice will also be added so that the scenes around the user can be explained by the robot when the user tries to interact with the environment.

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BIN ZHANG (Member, IEEE) received the Graduate degree from the Department of Automation, Harbin Engineering University, in 2011, and the Doctorate (D.Eng.) degree from the Graduate School of Informatics and Engineering, University of Electro-Communications, in 2017. He is currently an Assistant Professor with the Department of Mechanical Engineering, Faculty of Engineering, Kanagawa University. He is also researching in intelligent robotics, signal processing, artificial intelligence, and human interaction. He is a member of RSJ, JSME, and IEEJ.

MIKIYA OKUTSU received the B.E. degree from the Department of Mechanical Engineering, Kanagawa University, Japan, in 2022. He is currently researching on robotics. He also works on robotics.

RIN OCHIAI received the B.E. degree from the Department of Mechanical Engineering, Kanagawa University, Japan, in 2022. He is currently researching on robotics. He also works on robotics.

MEGUMI TAYAMA received the B.E. degree from the Department of Mechanical Engineering, Kanagawa University, Japan, in 2022. She is currently researching on robotics. She also works on robotics.

HUN-OK LIM (Senior Member, IEEE) received the B.E. degree in electrical engineering from Hongik University, South Korea, and the M.E. and Ph.D. degrees in mechanical engineering from Waseda University, Japan. From 2000 to 2005, he was an Associate Professor with the Department of System Design Engineering, Kanagawa Institute of Technology. In 2005, he joined Kanagawa University as an Associate Professor, and he is currently a Professor with the Department of Mechanical Engineering, Kanagawa University. Since then, he has held several positions at Kanagawa University, including the Dean of the Faculty of Engineering (2014–2020), a Trustee on the Board of Trustees (2017–2020), the Dean of the Graduate School of Engineering (2020–2022), and has been the Director of the Center for Cooperation with Society, since 2022. Since 2000, he has been with the Humanoid Robotics Institute, Waseda University, where he is currently a Visiting Professor. He was also a Visiting Research Scientist with the Department of Mechanical and Industrial Engineering, University of Toronto, Canada, from 2009 to 2010. His research interests include humanoid robots, walking systems, human–robot symbiosis systems, human-centered robotics, human safety control, emotion-based control, compliance control, and mobile manipulator control. He is a member of the Robotics Society of Japan and the Japanese Society of Instrument and Control Engineers. Since 2010, he has been an Associate Editor of *International Journal of Humanoid Robotics*.