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BarBot: An Intelligent Carrier Robot

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Abstract— In this paper, an intelligent carrier robot, entitled "BarBot", is introduced for carrying loads in real-world environment such as industrial, hospital, official and domestic applications. The environment is allowed to have uncertain static and dynamic obstacles. The navigation system of BarBot has two distinguishing modes: Learning mode and Optimal Path Planning mode. In learning mode, user can arbitrarily navigate BarBot in the environment based on the desired tasks, and the robot can learn the user-defined path automatically. After the training process, BarBot makes a new map based on user-defined paths. In optimal path planning mode, user can define the map and static obstacles of the environment in the HMI software of BarBot, and then the robot intelligently finds the shortest paths between the defined source and destination points using an optimal path planning algorithm. Generally, BarBot benefits from an obstacle avoidance system to handle the problem of uncertain dynamic obstacles. The performance of BarBot has been evaluated in different real-world test environments.

Keywords— Intelligent Carrier Robot, Mobile Robot Navigation, Machine Learning, Optimal Path Planning, Obstacle Avoidance.

I. INTRODUCTION

Intelligent carrier robots can be widely used for the environments in which human cannot directly work there due to dangerous environmental conditions such as pollution, chemicals, injuries, etc. These robots are also applicable for carrying loads in industrial, hospital, official and domestic environments and other similar cases. Moreover, intelligent carrier robots can be effectively employed by disabled people as intelligent aid devices. Different carrier robots have been designed in the literature for various applications. Few of the most relevant ones are reviewed here.

Tomio et al. [1] designed a carrier mobile robot to work in official and domestic environments. The working path of the robot is defined by a black line in the environment and the robot is able to follow this pre-defined black line, like a line following robot, to move between source and destination. In [1], this robot has been used for carrying small objects such as a cup and official letters between the rooms of manager and secretary. In [2] and [3], different carrier robots were designed for agricultural applications, in which the robots are capable of carrying heavy agricultural tools that cannot be easily carried by farmers. In addition, depending on the sensors and processors embedded on the robot, the robot could collect some special information from the agricultural land. Forlizzi and Disalvo [4] discussed the functional importance of the domestic mobile robots in the real environment in which the relationship between robots and people plays a major role. Falcone et al. [5] designed an intelligent domestic mobile robot with the ability of climbing stairs. Their robot can uses environmental landmarks for navigation. This type of navigation is very useful for real-world applications and it is a significant way for increasing the robot autonomy. Similarly, another domestic mobile robot was designed in [6], but with a noteworthy advantage in contrast to the previous cases. Here, in addition to the base section that is a mobile robot with intelligent navigation system, the robot is equipped by a robotic arm which enables it to pick and place small objects. In fact, mobile manipulators are very beneficial in industrial and domestic applications. Lehtinen et al. [7] reviewed a number of applied carrier robots such as a driverless robotic truck that works in a factory for transporting large loads on a defined route. Also, real-world applications of carrier robots in manufacturing lines and forest environments have been studied in [7]. Mason et al. [8] designed a special mobile robot that can use its wheels for moving objects in addition to locomotion. This robot can be considered as a mobile manipulator. Other types of mobile manipulators, as applied carrier robots, were designed in [9], [10] and [11] for different applications such as helping disabled people. In [12], soft computing techniques and specifically neuro-fuzzy methods were employed for intelligent mobile robot navigation. This paradigm is very efficient and applicable because it enables the robot to simultaneously exploit human knowledge and learning from experimental data. Other methods were proposed in [13] and [14] for robust path planning of mobile robots in the presence of noise and uncertainty.

In this paper, we have designed and implemented an intelligent carrier robot, entitled "BarBot", that is able to carry load in different real-world environments such as industrial, domestic, hospital and official environments, which includes uncertain static and dynamic obstacles. In the next sections, the structure and capabilities of BarBot are explained and its performance is examined in a real-world test environment.

II. THE STRUCTURE OF BARBOT

Fig. 1 depicts different parts of BarBot. The Human Machine Interface (HMI) section includes a keyboard and LCD to provide an interactive user interface system. In this system, user can choose the type of navigation system, including Learning mode and Optimal Path Planning mode. Also, the trained or defined paths can be loaded and user can determine the source and destination points and generally program the robot for multi-path tasks. BarBot includes a wireless transceiver system that enables the user to navigate the robot in the environment to train the desired path in the learning mode. BarBot has an ultrasonic obstacle avoidance system for detecting uncertain static and dynamic obstacles. The locomotion system of BarBot is a four-wheeled mechanical system which is driven by three DC motors, two motors for driving back wheels and one for forward wheels that plays the role of steering wheel. BarBot can carry loads of maximum 40 Kg. The power system of BarBot consists of a chargeable 12 V battery (and an electronic charging circuit) that can supply the required power of the robot for at least 5 hours in normal working conditions. The speed of BarBot is above 1 m/s for full-scale load.

BarBot can operate in two different working phases: training and execution. Training phase can be done in two different modes: Learning mode and Optimal Path Planning mode. Each of these modes is explained in the next section. Training phase includes creating a new map or updating an existing map. Execution phase is the utilization phase, in which BarBot can carry load over the selected paths. During the execution phase, the obstacle avoidance system acts via the embedded sensors on the front of the robot. The operational procedure of BarBot is displayed in Fig. 2.

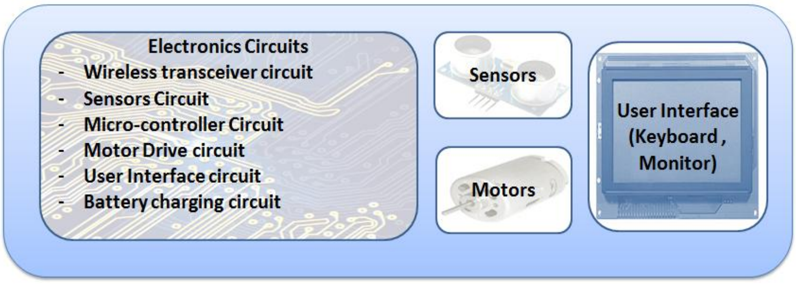

Figure 1. The different parts of BarBot.

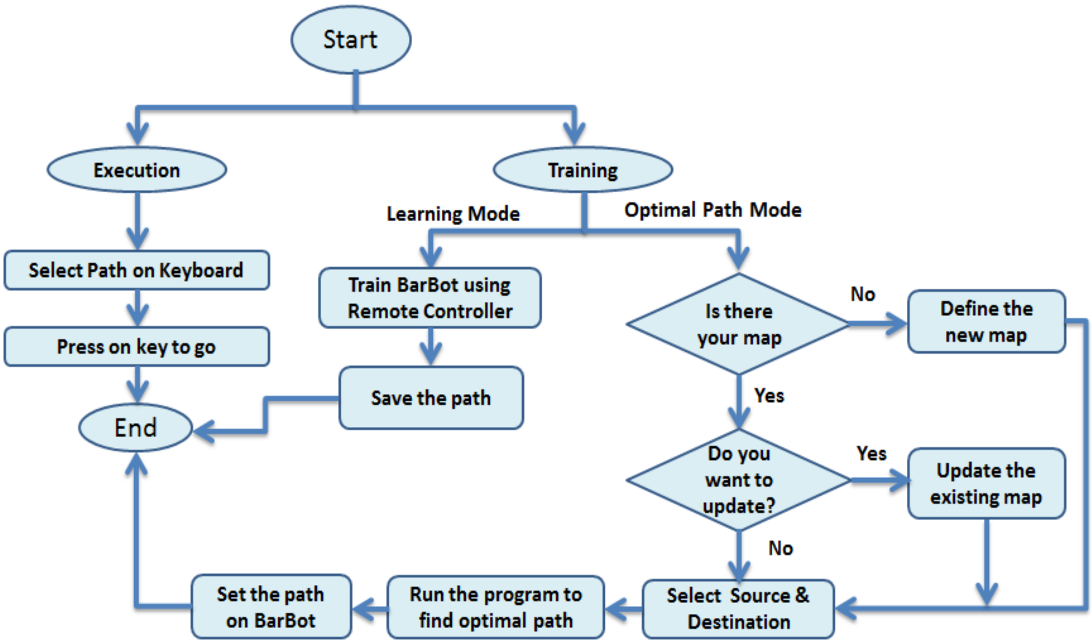

Figure 2. The operational procedure of BarBot.

III. NAVIGATION MODES

BarBot has two distinguishing navigation modes: Learning mode and Optimal Path Planning mode. In learning mode, user can navigate the robot arbitrarily according to the desired tasks by a remote controller. As shown in Fig. 3, user locates BarBot in an optional initial point (source) and navigates it toward a target point (destination) over a desired path. Source and destination points and paths are all allowed to be selected optionally by user. The robot can learn the user-defined paths automatically and it can load these learned paths again for further exploitation after the training process. In optimal path planning mode, user is able to easily define the map and static obstacles of the environment in the user-friendly HMI software of BarBot. There is no limitation in the map size and the number of obstacles. Different maps can be defined, loaded and restored when environmental changes are needed. This software benefits from Dijkstra's algorithm [15], [16] as an optimal path planning algorithm to find the shortest path. Dijkstra's algorithm has been used to find the shortest path in many applied problems such as robot path planning [17]. However, many different algorithms can be used for robot path planning such as ant colony optimization [18] and particle swarm optimization [19]. In this project, we have used Dijkstra's algorithm due to its simplicity and parallelism capability to faster execution [20]. Dijkstra's algorithm is one of the graph traversal algorithms that can find the shortest path from the source to all nodes of the graph. Original version of Dijkstra finds the shortest path between source node and all other nodes in graph, but a more common version can find the shortest path from a source node to destination node in the graph. In this version, the execution of the algorithm is stopped as soon as the shortest path is found from source to destination. Our software utilizes the second version of Dijkstra for rapid execution. For example, Fig. 4 shows a 5*10 map with 8 different static obstacles.

Figure 3. Learning mode.

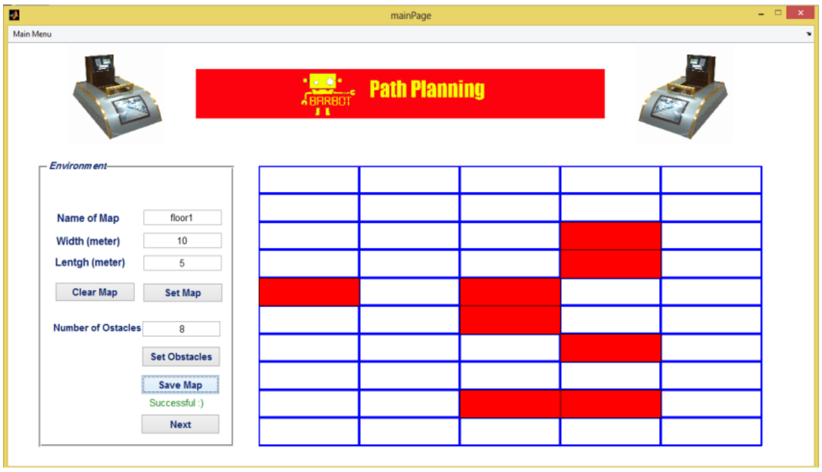

Figure 4. A 5*10 map with 8 static obstacles.

IV. EVALUATION

The performance of BarBot is evaluated for both of the above-mentioned navigation modes and in two working phases of training and execution. The test environment was Multi-scale Robotics Lab of University of Neyshabur that is a good example of an official environment. First, a desired path was given to BarBot by user through the remote controller in the learning mode. Then, the performance of BarBot was studied in terms of accuracy on path and dealing with static and dynamic obstacles during the execution phase. Second, a map of Multi-scale Robotics Lab was given to the BarBot software to automatically find the optimal paths between the desired source and destination points as depicted in Fig. 5. In both tests, when some dynamic obstacles emerge, BarBot can effectively detect them and react. Fig.6. demonstrates four different snapshots of the movement of BarBot in the execution phase. In Fig.6-d, a dynamic obstacle (a moving person) emerges in the environment and BarBot can detect it.

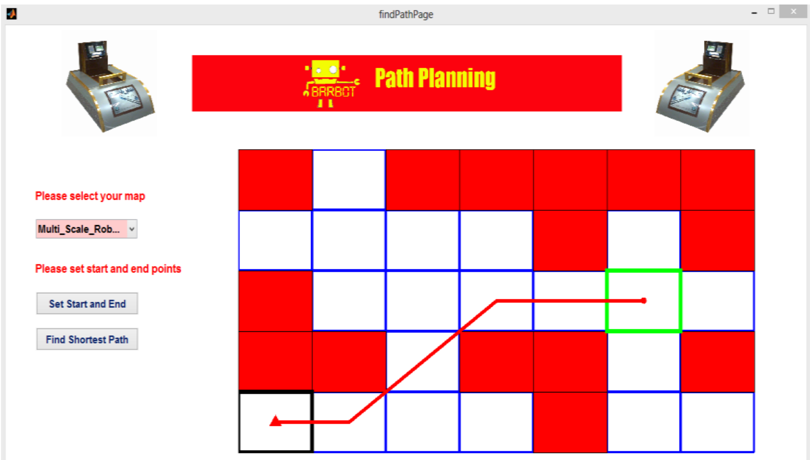

Figure 5. The map of Multi-scale Robotics Lab with 15 static obstacles. The optimal path planning algorithm could find the optimal path.

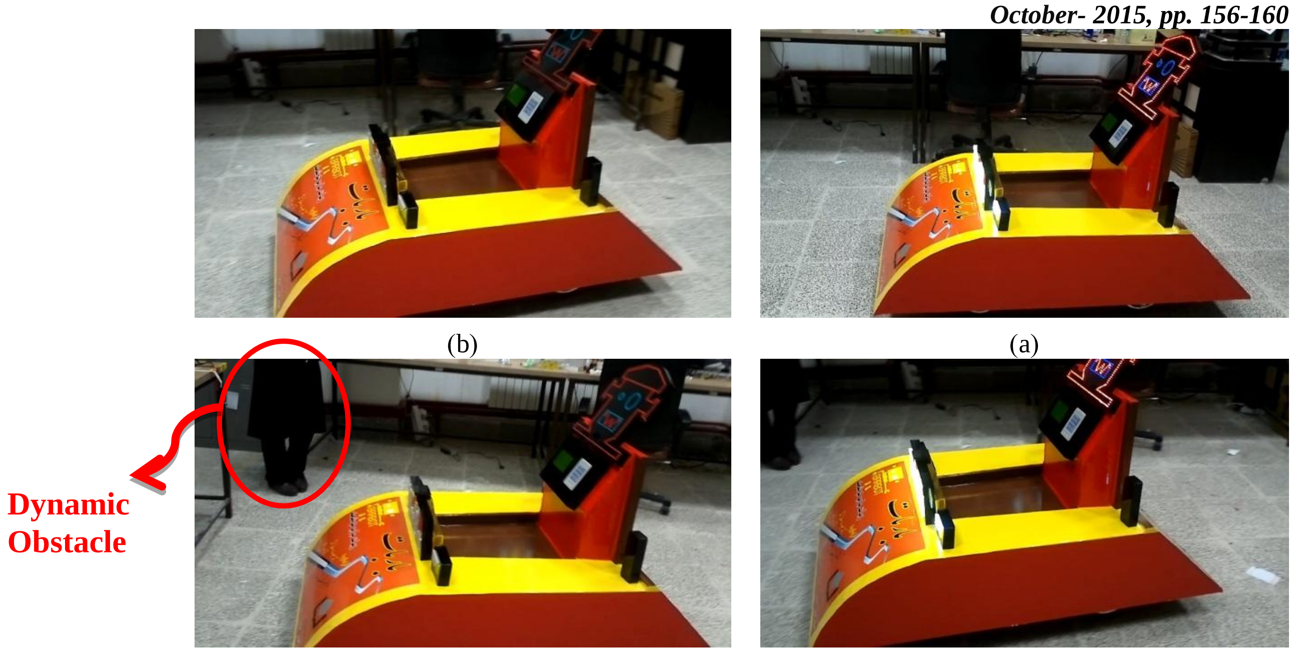

Figure 6. Four snapshots of BarBot movement in the presence of static and dynamic obstacles.

V. CONCLUSIONS

In this paper, we designed an intelligent carrier robot, entitled “BarBot”, for carrying loads in real-world environments such as industrial, domestic, hospital and official applications. The environment is allowed to have uncertain static and dynamic obstacles. The navigation system of BarBot has two modes including Learning and Optimal Path Planning modes. In the learning mode, user can navigate the robot in the environment arbitrarily according to the desired task, and the robot can learn the user-defined paths. After the training process, BarBot automatically makes a new map based on the user-defined paths. In optimal path planning mode, user can define the map and static obstacles of the environment in the HMI software of BarBot, and then the robot intelligently finds the shortest paths using an optimal path planning algorithm. In both cases, the robot benefits from an obstacle avoidance system to handle uncertain static and dynamic obstacles. The performance of BarBot was evaluated in a real-world test environment.

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REFERENCES

[1] K. TOMIO and e. al, "Designing of a Carrier Robot “CARREY” at Office," presented at the 6th Asian Design Conference, Japan, 2003.

[2] S. Nielsen, K. Jensen, A. Bøgild, O. J. Jørgensen, N. Jacobsen, C. L. Jæger-Hansen, *et al.*, "A low cost, modular robotics tool carrier for precision agriculture research," in *11th International Conference on Precision Agriculture*, 2012.

[3] R. RN Jorgensen, C. Sorensen, J. Maagaard, I. Havn, K. Jensen, H. Sogaard, *et al.*, "HortiBot: A system design of a robotic tool carrier for high-tech plant nursing," 2007.

[4] J. Forlizzi and C. DiSalvo, "Service robots in the domestic environment: a study of the roomba vacuum in the home," in *Proceedings of the 1st ACM SIGCHI/SIGART conference on Human-robot interaction*, 2006, pp. 258-265.

[5] E. Falcone, R. Gockley, E. Porter, and I. Nourbakhsh, "The Personal Rover Project:: The comprehensive design of a domestic personal robot," *Robotics and Autonomous Systems*, vol. 42, pp. 245-258, 2003.

[6] J. Stückler and S. Behnke, "Dynamaid, an anthropomorphic robot for research on domestic service applications," *Automatika–Journal for Control, Measurement, Electronics, Computing and Communications,* vol. 52, 2011.

[7] H. Lehtinen, P. Kaarmila, M. Blom, I. Kauppi, and J. Kerva, "Mobile robots evolving in industrial applications," in *INTERNATIONAL SYMPOSIUM ON ROBOTICS*, 2000, pp. 96-101.

[8] M. T. Mason, D. K. Pai, D. Rus, L. R. Taylor, and M. Erdmann, "A mobile manipulator," in *Robotics and Automation, 1999. Proceedings. 1999 IEEE International Conference on*, 1999, pp. 2322-2327.

[9] G. D. White, R. M. Bhatt, C. P. Tang, and V. N. Krovi, "Experimental evaluation of dynamic redundancy resolution in a nonholonomic wheeled mobile manipulator," *Mechatronics, IEEE/ASME Transactions on*, vol. 14, pp. 349-357, 2009.

[10] S. Chitta, B. Cohen, and M. Likhachev, "Planning for autonomous door opening with a mobile manipulator," in *Robotics and Automation (ICRA), 2010 IEEE International Conference on*, 2010, pp. 1799-1806.

[11] A. Jain and C. C. Kemp, "EL-E: an assistive mobile manipulator that autonomously fetches objects from flat surfaces," *Autonomous Robots,* vol. 28, pp. 45-64, 2010.

[12] J. B. Mbede, P. Ele, C.-M. Mveh-Abia, Y. Toure, V. Graefe, and S. Ma, "Intelligent mobile manipulator navigation using adaptive neuro-fuzzy systems," *Information Sciences,* vol. 171, pp. 447-474, 2005.

[13] D. H. Shin, B. S. Hamner, S. Singh, and M. Hwangbo, "Motion planning for a mobile manipulator with imprecise locomotion," in *Intelligent Robots and Systems, 2003.(IROS 2003). Proceedings. 2003 IEEE/RSJ International Conference on*, 2003, pp. 847-853.

[14] D. Kragic, "Object search and localization for an indoor mobile robot," *CIT. Journal of Computing and Information Technology,* vol. 17, pp. 67-80, 2009.

[15] S. Skiena, "Dijkstra 's Algorithm," *Implementing Discrete Mathematics: Combinatorics and Graph Theory with Mathematica, Reading, MA: Addison-Wesley,* pp. 225-227, 1990.

[16] M. Seraj and C. Y. Wong, "Lecturers' and Students' Perception on Learning Dijkstra's Shortest Path Algorithm Through Mobile Devices," *International Journal of Interactive Mobile Technologies (iJIM),* vol. 8, pp. 19-24, 2014.

[17] A. R. Soltani, H. Tawfik, J. Y. Goulermas, and T. Fernando, "Path planning in construction sites: performance evaluation of the Dijkstra, A∗, and GA search algorithms," *Advanced Engineering Informatics,* vol. 16, pp. 291-303, 2002.

[18] T. Guan-Zheng, H. Huan, and A. Sloman, "Ant colony system algorithm for real-time globally optimal path planning of mobile robots," *Acta Automatica Sinica,* vol. 33, pp. 279-285, 2007.

[19] M. Saska, M. Macaš, L. Přeučil, and L. Lhotská, "Robot path planning using particle swarm optimization of Ferguson splines," in *Emerging Technologies and Factory Automation, 2006. ETFA'06. IEEE Conference on*, 2006, pp. 833-839.

[20] N. Jasika, N. Alispahic, A. Elma, K. Ilvana, L. Elma, and N. Nosovic, "Dijkstra's shortest path algorithm serial and parallel execution performance analysis," in *MIPRO, 2012 Proceedings of the 35th International Convention*, 2012, pp. 1811-1815.

