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Intelligent Robot Systems based on PDA for Home Automation Systems in Ubiquitous

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1. Introduction

Koreans occasionally introduce their country with phrases like, 'The best internet penetration in the world', or 'internet power'. A huge infra-structure for the internet has been built in recent years. The internet is becoming a general tool for anyone to exploit anytime and anywhere. Additionally, concern about the silver industry, which is related to the life of elderly people, has increased continuously by extending the average life span. In this respect, application of robots also has increased concern about advantages of autonomous robots such as convenience of robots or help from autonomous robots. This increase in concern has caused companies to launch products containing built-in intelligent environments and many research institutes have increased studies on home automation projects.
In this book chapter, we address autonomous systems by designing fusion systems including intelligent mobility and home automation. We created home oriented robots which can be used in a real home environment and developed user friendly external design of robots to enhance user convenience. We feel we have solved some difficulties of the real home environment by fusing PDA based systems and home servers. Wireless Lan attached PDAs can serve as small size and stable wireless environments. By sending states of robots using a home server, our system has the unique feature of remote control combined with 3D home monitoring. We have implemented a system that can adapt a mobile robot to home automation systems and confirm our proposal with experiments using a PBMoRo (PDA Based Mobile Robot).

2. Home Automation system using PDA based Intelligent Robot System (HAuPIRS)

2.1 Limitations and features of the home automation system

There are lots of home automation oriented researches being done together with the spreading of the internet and further development of communication technology. Innovative companies are making an effort to improve their business image through mass media. The main feature of these systems is centralization that roots on home servers and uses external devices to control home appliances.

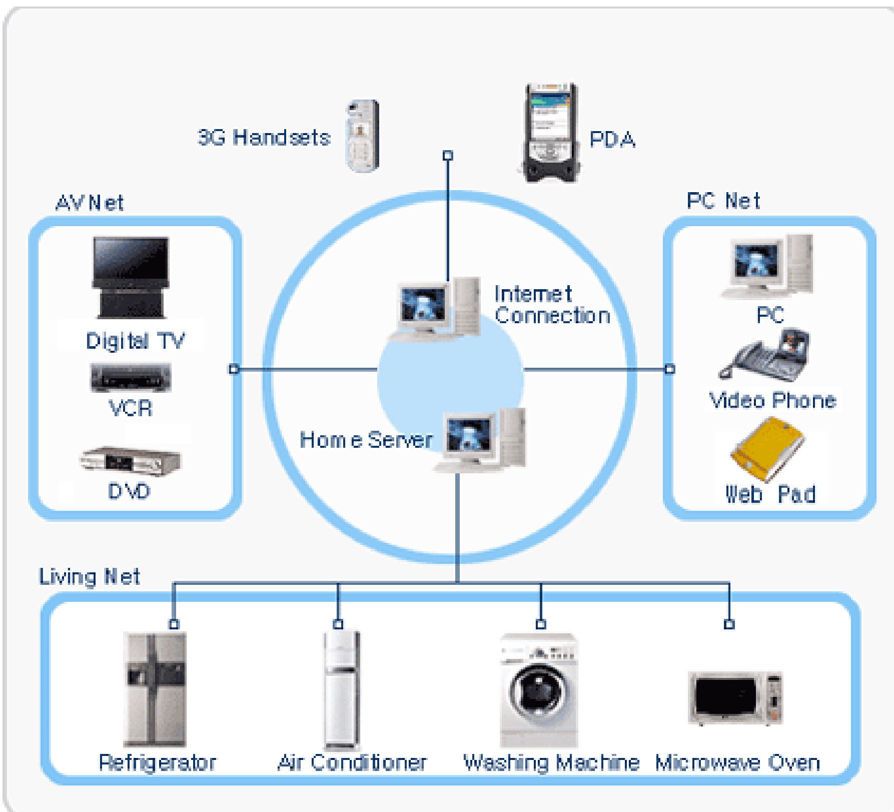


Fig. 1. Home Network concept.

Advantages	Remote control
	Security support
	Serving convince environment
Disadvantages	Consideration of system before construction
	Difficulty of adding and fixing extra home appliances
	Rising cost in proportion to size of home.
	Limitation of autonomous environment
	Passive system
	Simple UI based on text or 2D graphic
	Prerequisite learning for usage of system

Table 1. Advantages and disadvantages of home automation system.

Fig. 1 illustrated home automation system the intelligent home network & security structure (JongWhan Kim, 2002). Although it can serve a high level of security and ubiquitous functions, clients are able to connect anywhere and anytime. In Fig. 1, though they consider designing of home automation system should be done before construction, it is hard to add extra home appliances and fix them. In addition, it may increase building cost in proportion to the size of home. Another limitation exists as a view of system users. People who use this system should move to the right place in order to operate the system and learn about installation documents. Table 1 notes advantages and disadvantages of home automation system.

2.2 Limitations and features of intelligent robot system

Universities, companies and institutes studying robotics have changed their patterns by looking for huge markets such as welfare for elder or physically challenged people rather than factory industrial robots (Sebastian Thrun, 1999). Vacuum cleaning robot markets are already gradually forming (Vacuum cleaner robot from LG Electronics).
Service robot issues are a hot topic of the robotics filed (Ho Seok Ahn, 2008). Although there are many service robots, entertainment robots, escort robots, and medical robots, the common goal of these robots is to help people and increase convenience by actively giving information (Kuk-Jin Yoon, and In-So Kweon, 2001). Another feature of these robots is they are equipped with a PC based processing device, display system, and actuators.
Fig. 2 (Kyung-Sang Bukdo, 2004) shows an exhibition escort robot, another branch of intelligent robots. These robots have a PC based system that is easy to develop and expand. Thus, it has an efficient performance to process complex calculations and smart intelligence. The PC, however, should be running on the robot and it consumes a great amount of power because of the larger body size. Therefore, it is not suitable for home environments because the robot demands too much space and is too heavy (Koide Y., Kanda T., Sumi Y., Kogure K. & Ishiguro H. 2004).

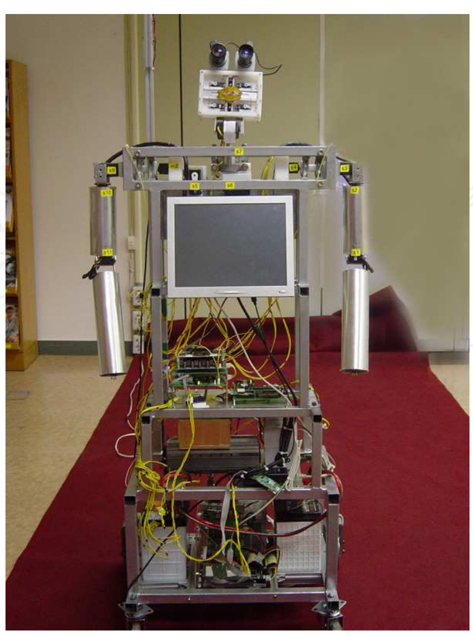


Fig. 2. Exhibition escort robot.

Some companies tried to combine home automation and intelligent systems in Fig. 3 (Most-itech). Despite the good idea to make home robot, they failed to form a market due to the limitation that relied on performance of the mobile phone (NEC personal robot PAPERO, Palm Pilot Robot kit from CMU). The boundary of incorporation of intelligent robot and home automation is displayed in Table 2.

Fig. 3. Home network robot of Most-itech.

Advantages	Convenient developing environment.
	Good expandability of developed modules.
	High performance.
Disadvantages	Difficulty of usage due to heavy shape.
	Much power consumption.
	High cost.
	Difficulty of building home automation.

Table 2. Critical points of combination of intelligent robot and home automation.

2.3 Home Automation system using PDA based Intelligent Robot System (HAuPIRS)

In this book chapter, we propose a system that overcomes the limitation of current difficulty; a fusion system combining home automation systems and intelligent robots. We focus on designing compact size of the robot in order to exploit the home environment and expand controllable area by adapting mobility and activity of the robot. Also, we discuss easy installation and repair of home appliances by RF communication.

To achieve our goal, we use PDA based environments rather than PCs. This gives us a lot of advantages. We could save power consumption by adapting to PDA and create a smaller shape for the body. It also allows a lower cost and higher operation efficiency. The fundamental differences of the HAuPIRS are that they specify a home environment, are easy to use and allow expandability.

Fig. 4 illustrates the system architecture of the HAuPIRS. The HAuPIRS are made up of 3 levels: the executive level, cognitive level and user level (Arkin R. C, 1987, 1998, 1999). The user level enables clients to connect a home server and send commands. Users can move the home robot and control home appliances. Client programs return current status to the home. The cognitive level is a pre-processing stage before execution of commands. It calculates command signals utilizing the information stored in the server, added to the robot input data. On this level, it accompanies artificial intelligent processing; SLAM (Simultaneous Localization and Mapping), image processing. We can not only add third party algorithms, but also recognition technology to the cognitive level. The executive level executes commands and returns sensor data obtained from cameras and ultrasonic range finders to the cognitive level (Brooks R, 1986).

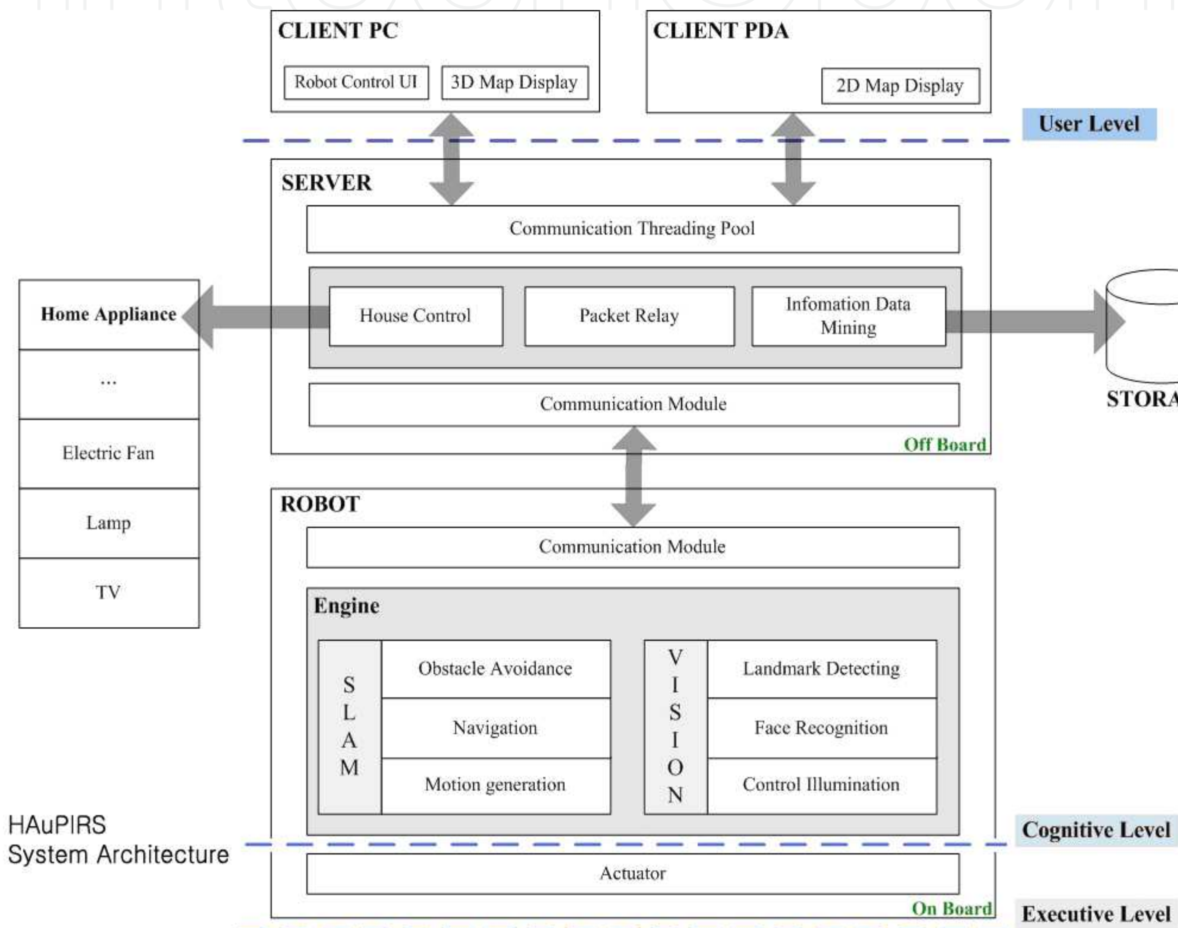


Fig. 4. Home Automation system using PDA based Intelligent Robot System (HAuPIRS).

Specifications of the HAuPIRS are shown in Table 3. HAuPIRS need a diversity of technologies to run the home automation system with the intelligent robot. In order to establish network environment, wide spread internet penetration, wireless technology, image streaming technology, and reliable packet command technology are highly demanded. Additionally, motor and sensor control technology, vision and voice processing technology, path planning, object avoidance, localization for freely navigation of robot, and well-organized scheduling technology are needed in aspects of the robot.

Main system	PDA (iPaq 6360). Home server equipped.
Power	Lithium-Polymer light weight notebook battery,. Guarantee 3 operating hours.
Size & Weight	Suitable size for home environment. Light weight.
Cost	Less expensive than PC. One camera and multi range finders.
Interface	Face detection and voice recognition technology support. Support additional devices; PC, PDA and mobile phone. Client System using 3D Display allows reliability for users. Intuitive user interface support.
Automation	Support mobility and active automation. Enable far distance watching by remote control.
Security	Secure home instead of human being. When it comes to crime, it can make evidence and identity of person.
System expandability	Easy expansion by altering robot instead of home. Easy to plug in or plug-out modules on home appliances.
Design	User friendly robot design. Prevent a wound by smooth design.

Table 3. Specifications of the Home Automation system using PDA based Intelligent Robot System (HAuPIRS).

3. PBMoRo System

In this book chapter, we implement the HAuPIRS Control Architecture system in order to evaluate its performances and refer it as the PBMoRo System (PDA Based Mobile Robot System). It is possible to add intelligence to the PBMoRo System and to recognize the module by adjusting the HAuPIRS. It has also been tested under the home automation conditions for house specified robots.

3.1 Structure of PBMoRo system

The PBMoRo System is consists of three parts, shown in Fig. 5. The first part of the system is a robot system based on the PDA. The second part is a server system that possesses all the data. Finally, a client system plays the role of interacting with the human through display devices and input devices.
To begin, the Robot system rooted on PDA can be divided into a PDA aspect and actuator aspect. The PDA aspect acquires images from cameras and communicates with the server using an Ethernet interface. The actuator aspect executes commands obtained from the

server. The server system plays an important role in spreading usage by supporting the PDA and acting as a home server.
The client system is made up of two systems as well, a PC oriented application and a PDA oriented application, and can run independently. In addition, this system sends commands locally or remotely to operate the PBMoRo system. Users are able to check the current status of the system as desired.

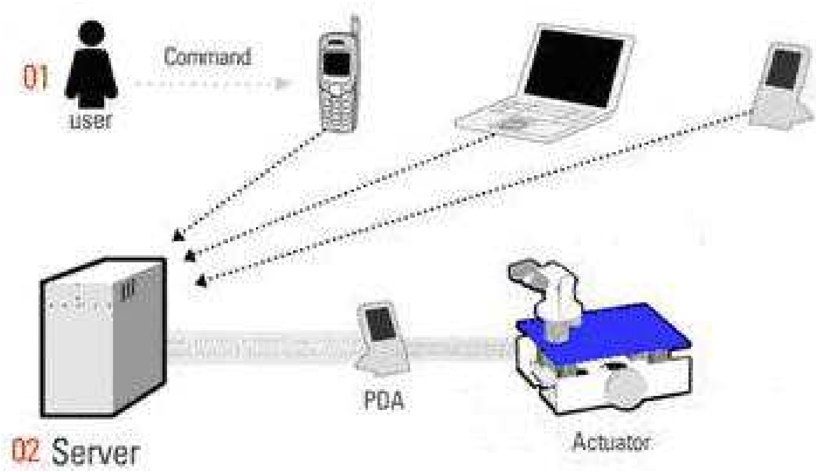


Fig. 5. Architecture of the PBMoRo System using the HAuPIRS.

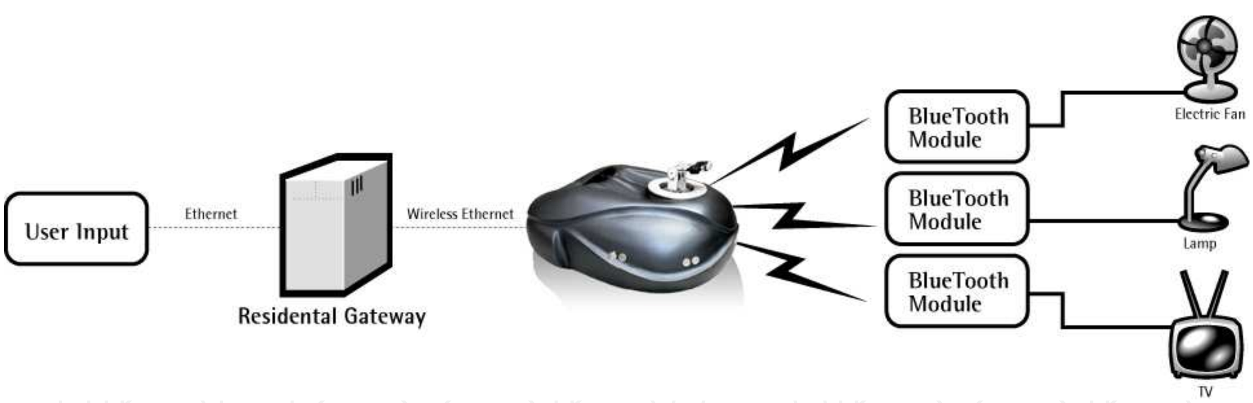


Fig. 6. Architecture of the PBMoRo System using the HAuPIRS with home appliances.

Fig. 6 denotes the architecture of the PBMoRo System using the HAuPIRS with home appliances. The main part of a home network server which plays a significant role in residential gateways sending commands to intelligent robots through a wireless network interface. The robot approaches home appliances in order to manage these with Bluetooth interface. Fig. 7 illustrates the control architecture of the PBMoRo system. Table 4 displays specifications of devices we employed.

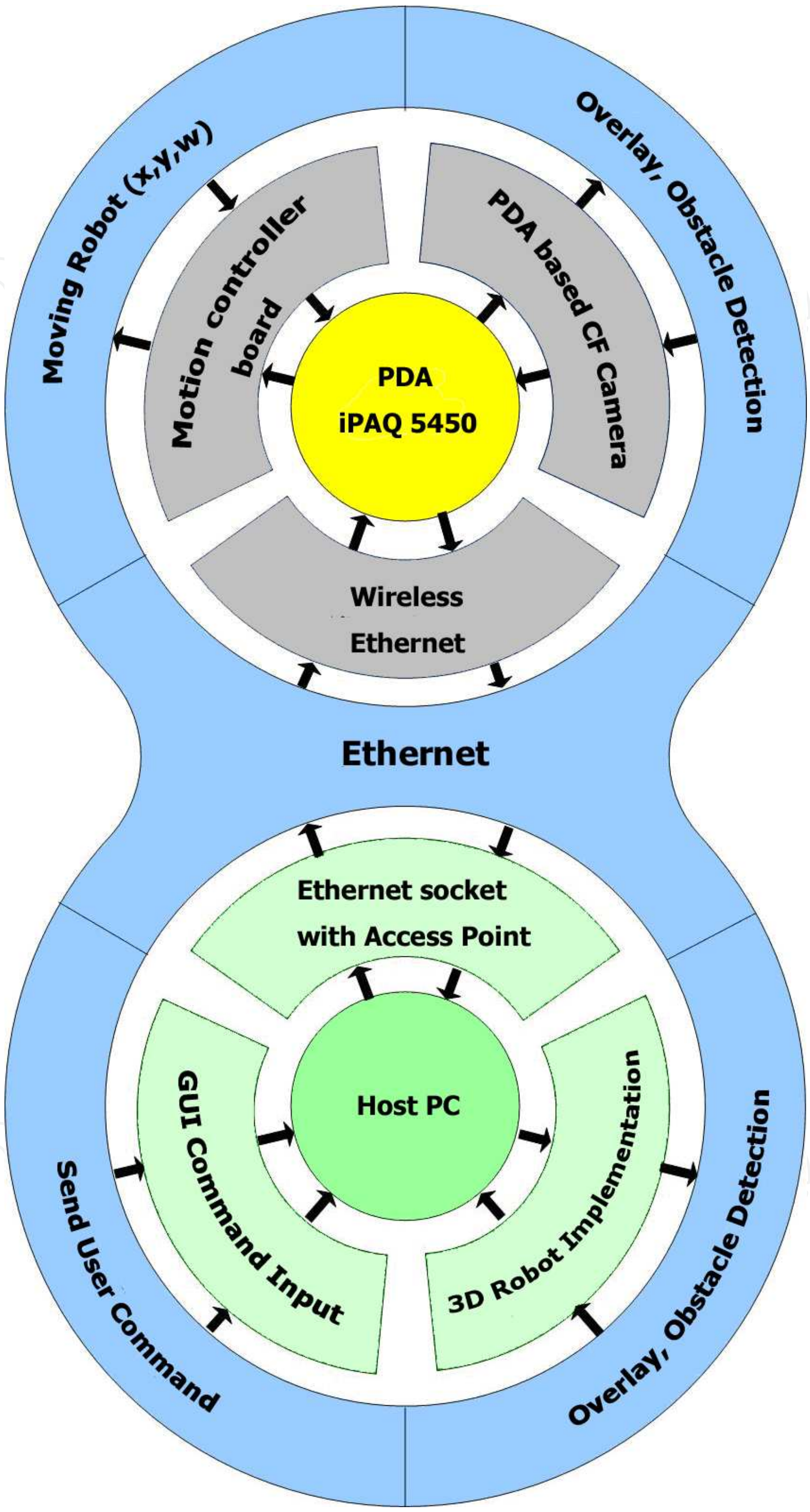


Fig. 7. Control Architecture of the PBMoRo System.

Dimensions	300 x 400 x 300 mm (w x d x h)
Weight	8 kg
PDA	HP iPAQ h5450
Body	Aluminum , acrylic
Motor	Actuators : DC motor x 2 , Pan-Tilt : DC motor x 2
Camera	CF COMS Camera (1.3M pixel, 30 Frame/sec)
Sensors	Ultra Sonic x 5 , CO2 Sensor x 1 , VOC Sensor x 1
Power	Notebook battery x 2 (6000mAh, 15V, 800g)

Table 4. Features of PBMoRo System.

3.2 Robot system of PBMoRo system

As we mentioned above, the robot system consists of two parts. One part is in charge of acquiring image frames, talking to the server, and sending motion commands. The other, the actuator, generates robot motion by commands. Fig. 8 denotes appearances of the robot we implemented.

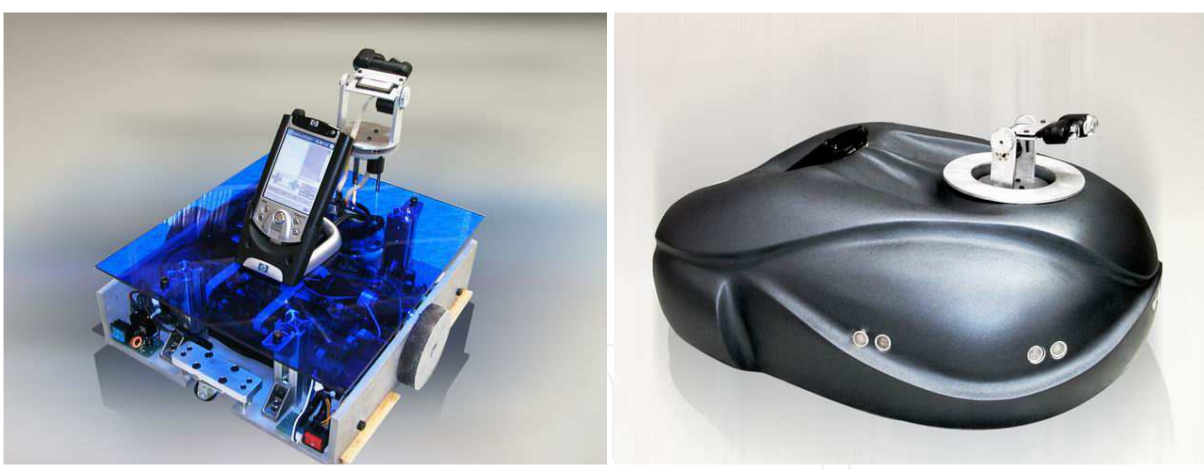


Fig. 8. Shape of the PBMoRo (Left image) before considering robot design, (Right image) after adapting robot design.

	PDA	Single Board Computer(SBC)
Power consumption	Low	High
Price	Low	High
Mobility	Good	Bad
Computational power	Low	High
Extension	Limited	Good

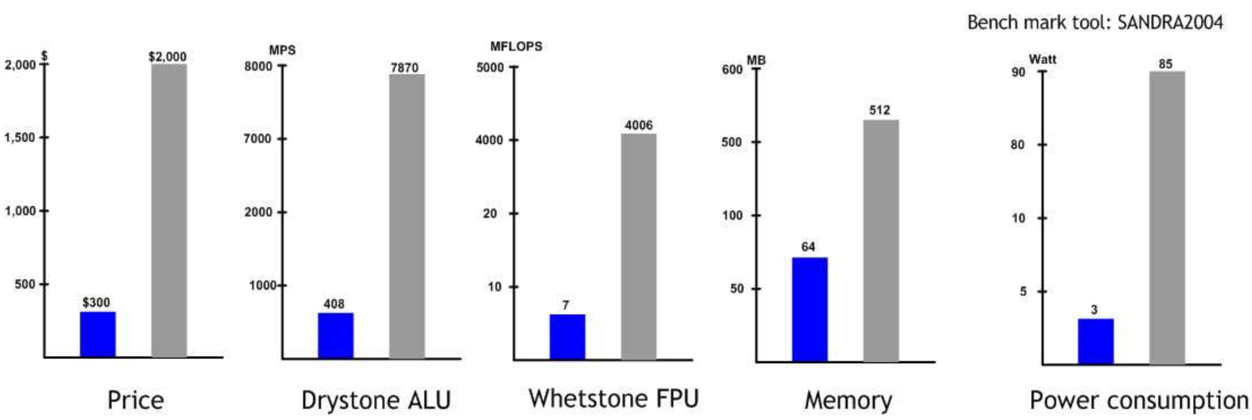


Fig. 9. Performances comparison between PDA and Single Board Computer.

As we see in Fig. 9, due to the fact that the PBMoRo system is rooted on a PDA, it shows a very severe experimental environment compared to primary PC based robots. The PDA is 10 times cheaper than an SBC and it consumes 30 times less energy. One disadvantage is that processing performance is far weaker than an SBC. To improve this aspect we need to optimize the general algorithms for the PBMoRo system.

Fig. 10 shows a conceptual diagram of our PDA program. At first, PDA investigates the current state of the robot through ultrasonic sensor data and motor encoder data. After that, it sends commands to the robot actuator using the data received from motion generators and target position information.

In order to approach the goal, we should control both the left wheel and right wheel velocities. Consequently, we need mathematical equations to evaluate the angle between robot and goal position. Fig. 11 shows the standard angular coordination (SAC) what we used in this robot system. θ_G denotes the goal angle related SAC and means robot angle oriented from SAC. We can say equation (1) in terms of above statement.

$$\theta_G - \theta_R = \theta_{GR} . \tag{1}$$

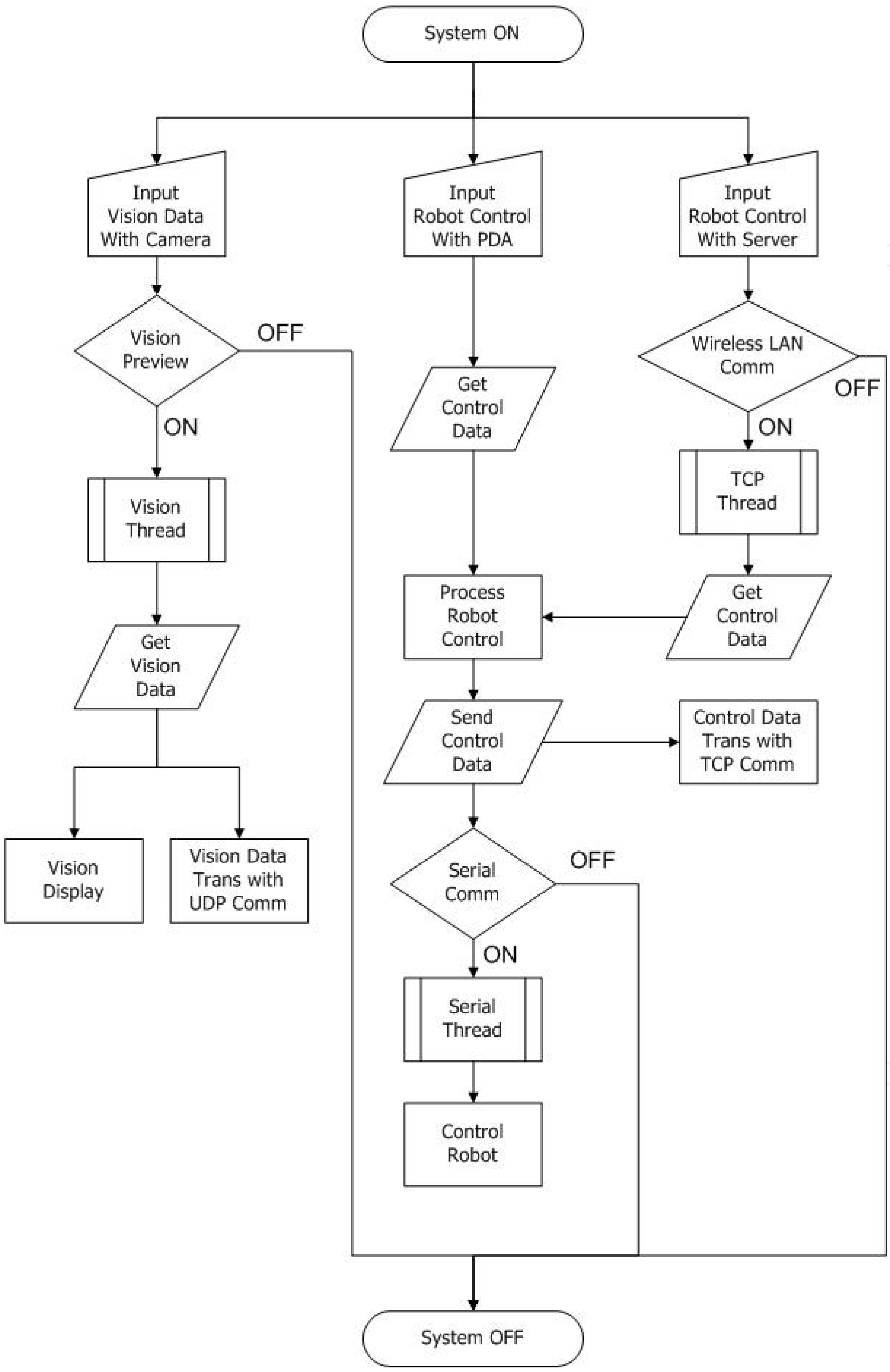


Fig. 10. Flow diagram of the PDA program.

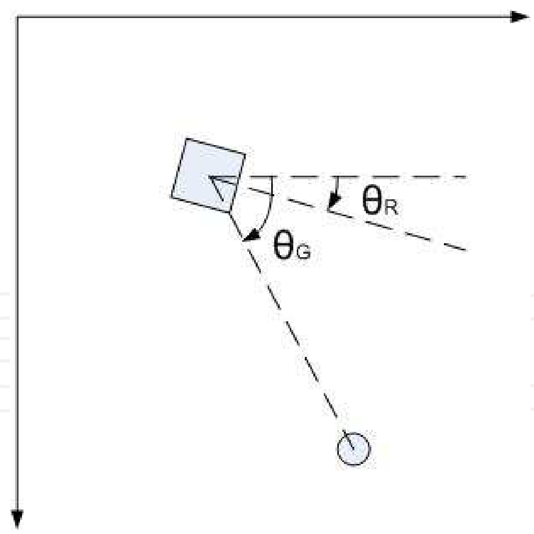


Fig. 11. Standard angular coordination in the PBMoRo System.

To find out the current robot position, many researchers have used odometry information from motor encoder and landmarks. Odometry based dead reckoning method employs encoder data to obtain the current robot speed. By implementing this method with our system, we can estimate current robot position by accumulating movement per sample time. First, we are able to calculate distance and velocity of the two wheels by encoder data during a sample time.

$$V_L = \frac{\delta_L}{T}, \tag{2}$$

$$V_R = \frac{\delta_R}{T}, \tag{3}$$

where, δ_L is movement of left wheel measured from the motor encoder per sample time, δ_R is movement of right wheel measured from the motor encoder per sample time, T is sample time, V_L is velocity of left wheel, and V_R is velocity of left wheel.
We can address linear velocity and angular velocity of robot from equation (2) and (3).

$$\delta_\theta = \frac{\delta_R - \delta_L}{\omega}, \tag{4}$$

$$V_C = \frac{V_R + V_L}{2} = \frac{\delta_R + \delta_L}{2T}, \tag{5}$$

$$V_\omega = \frac{\delta_\theta}{T} = \frac{\delta_R - \delta_L}{T \cdot \omega}, \tag{6}$$

where V_C is linear velocity of robot, V_ω is angular velocity of robot, and δ_θ is angular movement of robot during sample time.

Through equation (4), (5), and (6), we could estimate present robot position and orientation as shown in equation (7), (8), and (9).

$$ {}^{\omega}O_X(k+1) = {}^{\omega}O_X(k) + \frac{\delta_R+\delta_L}{2} \cdot \cos\left({}^{\omega}O_\theta(k) + \frac{\delta_\theta}{2} \right), \quad (7) $$

$$ {}^{\omega}O_Y(k+1) = {}^{\omega}O_Y(k) + \frac{\delta_R+\delta_L}{2} \cdot \sin\left({}^{\omega}O_\theta(k) + \frac{\delta_\theta}{2} \right), \quad (8) $$

$$ {}^{\omega}O_\theta(k+1) = {}^{\omega}O_\theta(k) + \delta_\theta . \quad (9) $$

Although users can control the PBMoRo System using a remote joystick, it is also able to operate automatically. If people input their desired goal position, the robot can navigate in a home environment freely by itself. To accomplish these kinds of jobs, a path planner should make the shortest path and avoid obstacles while a motion generator establishes suitable velocities for the two wheels. However, if the robot faces obstacles which don't exist on the map, collision and slippage problems occur simultaneously. In this case, the robot and home appliances might be damaged and systems could break out. Therefore, the robot should be able to avoid obstacles that are not the map.
In these respects, we suggest an obstacle avoidance algorithm for the PBMoRo System. The angular coordination can be divided into 4 sectors depending on the angle of the robot as illustrated in Fig. 12.

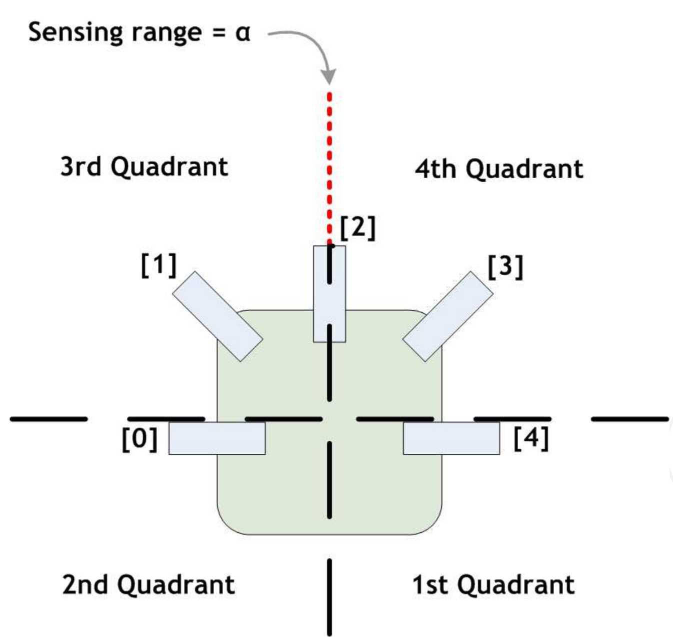


Fig. 12. Quadrant from view of robot.

If there are some obstacles near the robot, ultrasonic range sensors can detect them and transfer their data to a PDA (Beom H. R. and Cho H. S, 2000). The PDA recognizes locations of obstacles and makes a safe path to prevent collision. These processes are shown in Fig. 13.

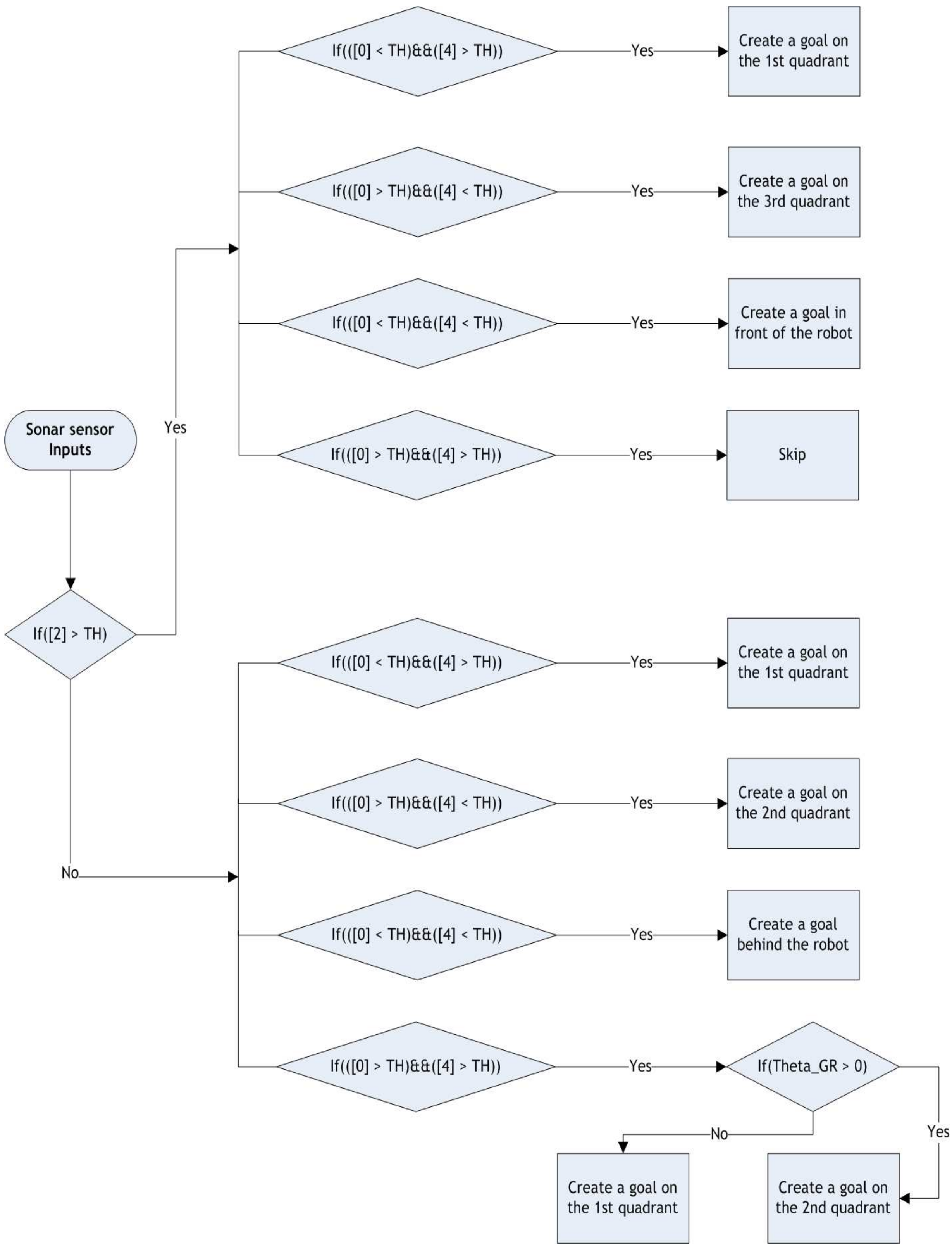


Fig. 13. Obstacle avoidance algorithm proposed by the PBMoRo System.

Because the PDA has a lower performance than the SBC, we exploited half of the ultrasonic sensor data, even filed and odd filed. By using this method, we could make an obstacle detection algorithm in real time. Fig. 13 illustrates even filed data processing using a zero index, two index and four index sensors.

Due to developing map building algorithms, overloading the PDA, we skipped a searching procedure surrounding the robot. Instead of map building on the PDA, the PBMoRo system updates map data into the server system and relies on current sensing data when non-existent obstacles appear in the way of the robot (Roland Siegwart, 2007). This method reduces errors and power consumption because it limits unexpected motion of the robot. In addition, it improves total system performance because it relieves unnecessary procedures. It needs to pay attention to implement intelligence and active sensibilities of the robot.

Fig. 14 shows map building algorithms running on a server system and position where sensors are arranged. In the PBMoRo Robot System, there are 5 ultrasonic sensors equipped. Each of them has a 45° gap between each other and has from 0 to 4 indexes on clockwise. As the illustration on the left of Fig. 14 shows, the front of the robot is designed at 0°, the left semi sphere has a range of from 0 to -179° and opposite side has range of from 0 to 180°. $\theta_{[n]}$ denotes an angle of nth sensors, each sensor possesses -90°, -45°, 0°, 45°, 90° separately. $\alpha_{[n]}$ denotes a length of nth sensors. If we suppose that θ_R is an angle of the robot, we can address the location of obstacles as shown in equations (10) and (11).

$$X_O = X_R + \alpha_{[n]} \cdot \cos\left(\theta_R + \theta_{[n]}\right), \tag{10}$$

$$Y_O = Y_R + \alpha_{[n]} \cdot \sin\left(\theta_R + \theta_{[n]}\right). \tag{11}$$

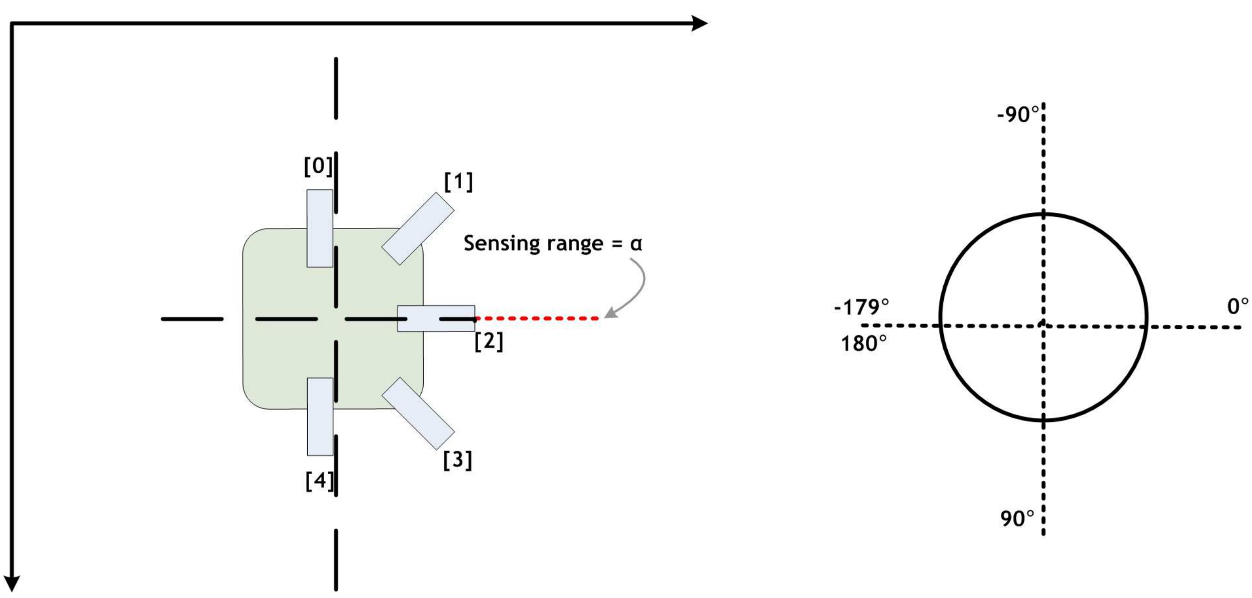


Fig. 14. Positions and angles of ultrasonic sensors.

Although the actuator part consists of 3 parts such as a sensor, moving and pan/tilt, the PDA only has one RS232 port. Thus, we should design a new data passage structure to communicate between PDA and actuator part. We developed multi sensors architecture as illustrated in Fig. 15.

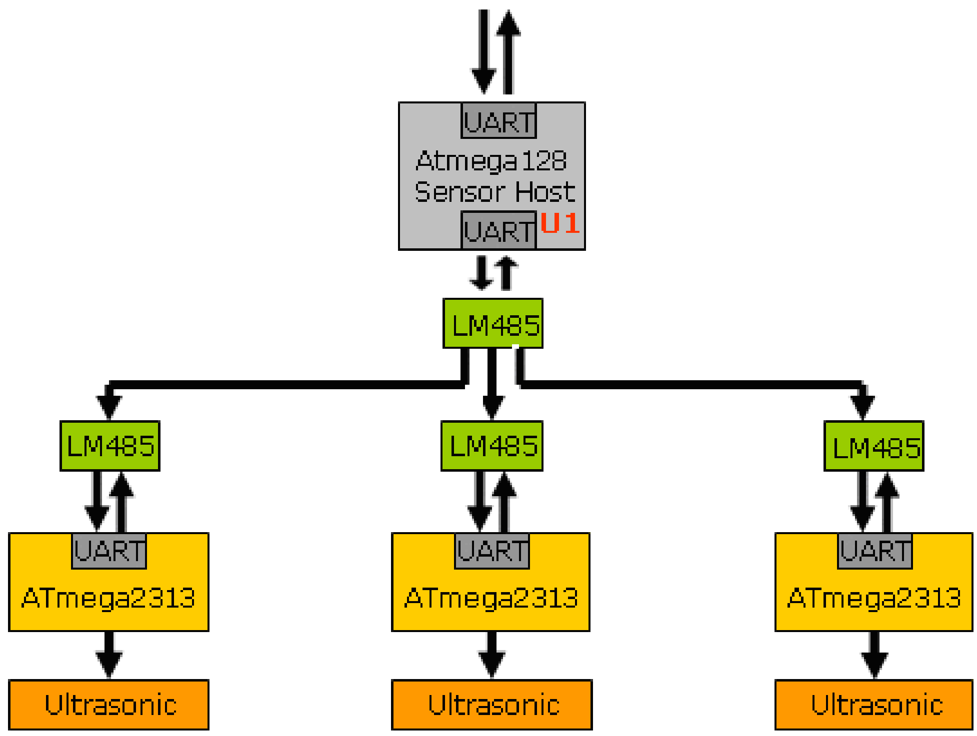


Fig. 15. The PBMoRo RS485 communication architecture.

In this book chapter, we developed an RS485 communication for the purpose of expanding the number of UART ports. Each slave device has a front end microchip to enable interaction with a master device.

3.3 Server system of PBMoRo system

The server system plays the role as an intermediary connecting client system and robot system according to the HAuPIRS. Thus, both robot system and client system should connect to the server system and have an important effect on the design of the entire system. Video streaming and robot information should pass through the server system due to a limit of PDA performances such as computational power and memory boundaries. In addition, we should consider the conditions of multi-connection and security when a number of user clients try to use the PBMoRo system. The dataflow diagram of our server system is shown in Fig. 16. Call flow structure of PDA-Server network system is illustrated in Fig. 17.
We adapted a UDP protocol when transferring video data and TCP protocol exploited the transaction of control signals. This is largely because UDP can reduce the load and TCP can guarantee high reliability.

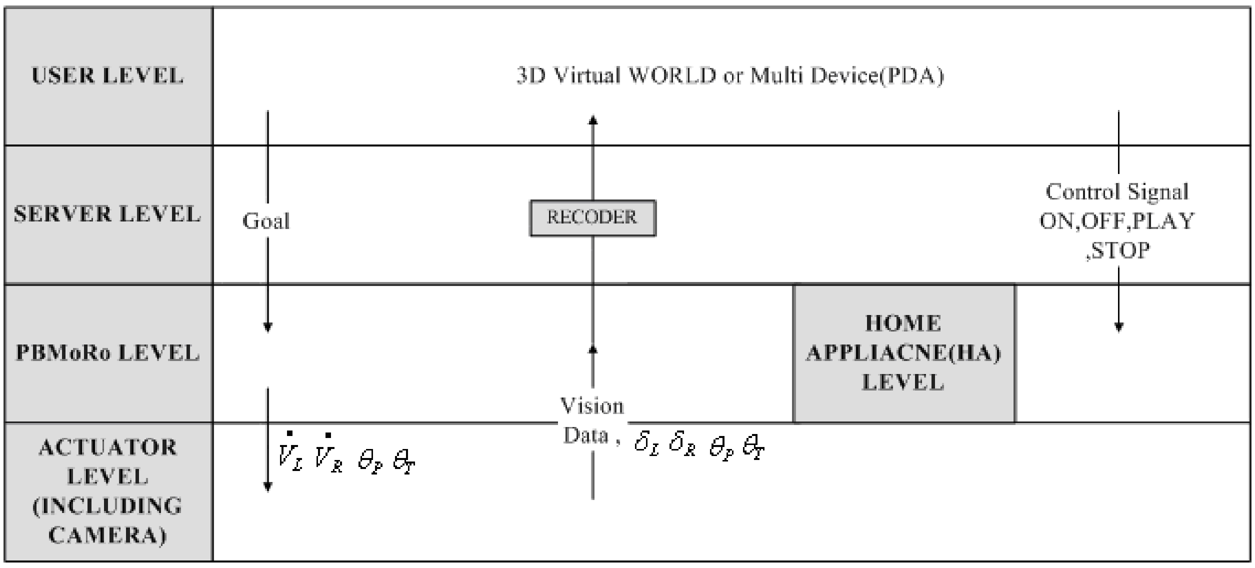


Fig. 16. Data flow of the server system.

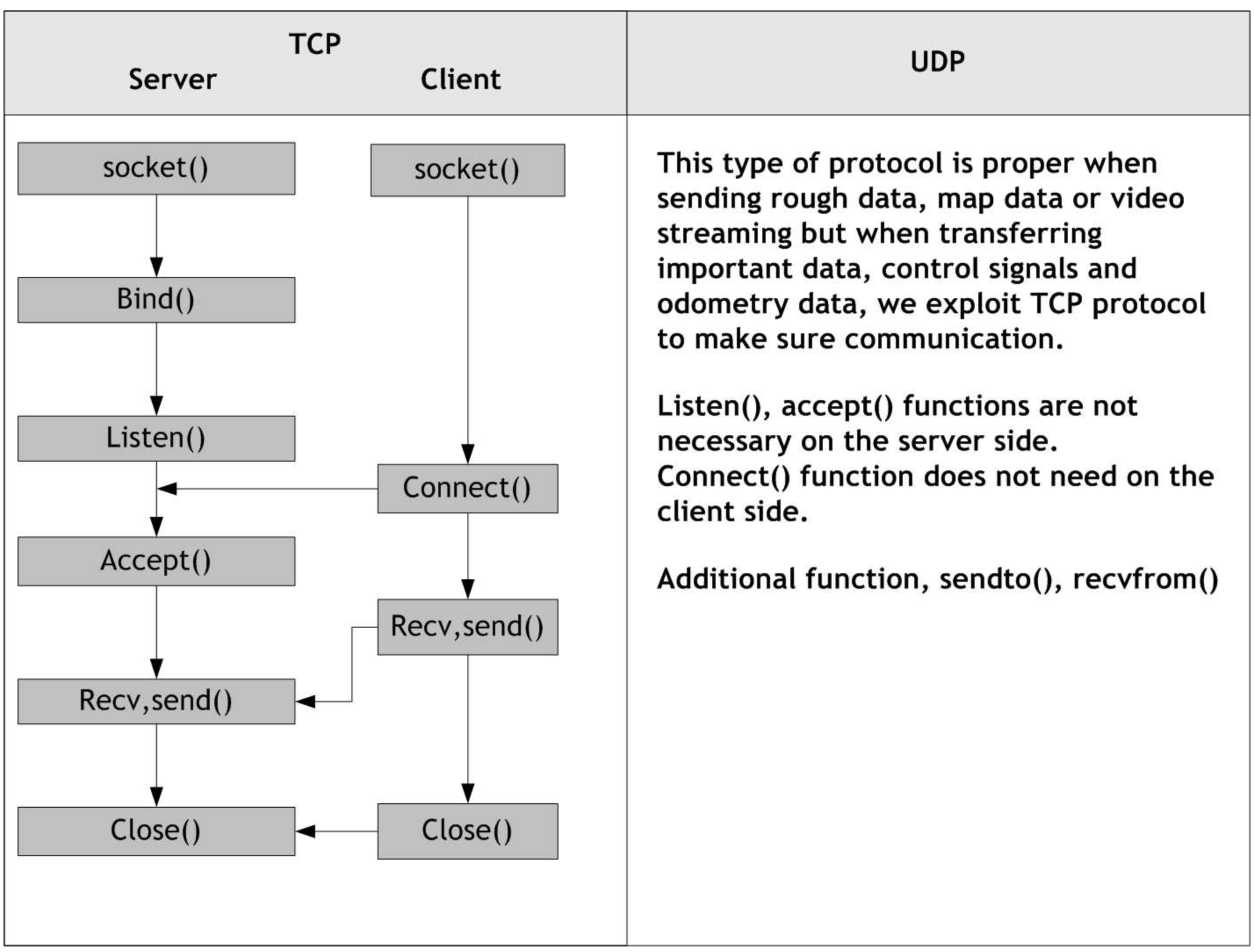


Fig. 17. Call flow of PDA-Server Network system.

3.4 Client system of PBMoRo system

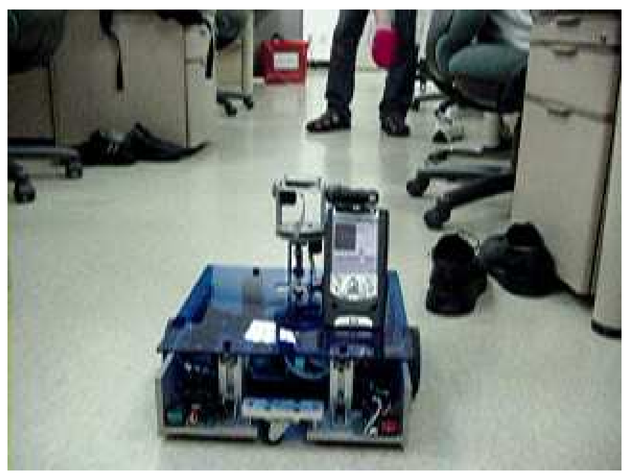
The client system consists of PC client programs and PDA client programs. PC client programs need more details and performances than the latter. We implemented this PC program using a 3D technology to give a better sense of reality. Additionally, designing of the system based on the HAuPIRS enables us to attach extra mobile devices.

4. Experimental Results

4.1 Tracking

The PBMoRo system detects a moving object and tracks it using security processes. When an object moves in security mode of the PBMoRo system, it follows the moving object keeping a suitable distance. The PBMoRo system calls to the owner and police using this function. Fig. 18 shows the experimental results of moving object tracking. In this experiment, the PBMoRo system followed the red glove keeping a suitable distance. We have proven that the PBMoRo system is capable of detecting and tracking a moving object.

(a) Turning left



(b) Turning right

(c) Approach

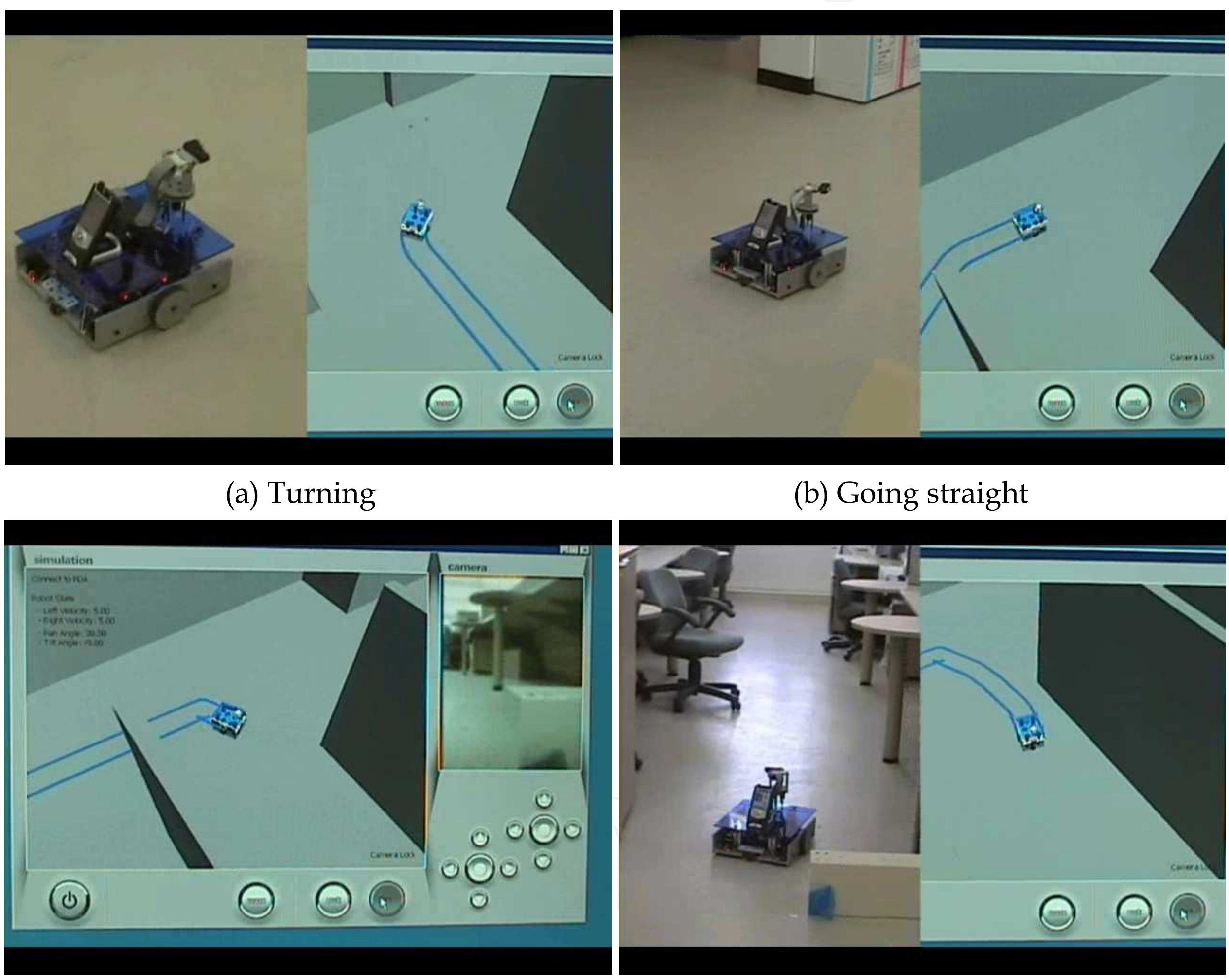
(d) Approach by turning left

Fig. 18. The experimental results of moving object tracking.

4.2 Path planning and localization

This experiment is for remote control and monitoring of the PBMoRo system. When a user sets the goal position of the robot, the robot should move to that position automatically. It should be possible for users to monitor the situation and the states of the robot from a location outside of the home. In this case, the experiment is important because the robot should synchronize the real-world position with the position of cyber-world.

Fig. 19 shows the experimental results of path planning and localization. In this experiment, the PBMoRo system made the path and moved to the goal position. In this process, the PBMoRo system negotiated the present position with the 3D monitoring program. We have verified that the PBMoRo system synchronizes the position of real-world and cyber-world as well as performing the path planning and localization functions effectively.



(a) Turning (b) Going straight

(c) Showing camera image (d) Getting goal position

Fig. 19. The experimental results of path planning and localization.

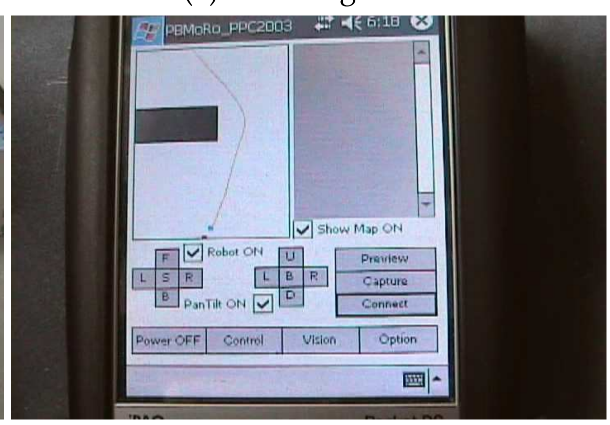
4.3 Obstacle avoidance and map building

When new obstacles are detected, the robot should make a new path to avoid the obstacle and update the map. As the PBMoRo system uses the PDA main system, we use the simplified algorithm for obstacle avoidance and map building based on the HAuPIRS architecture. Fig. 20 shows the experimental results of obstacle avoidance and map building. In this experiment, the PBMoRo system detected a new obstacle, made a new path, and updated the map. The bottom right figure in 20 shows the result of this map building.

(a) Detecting obstacles

(b) Avoiding obstacles

(c) Getting goal position



(d) Showing the results on PDA

Fig. 20. The experimental results of obstacle avoidance and map building.

4.4 Home appliances controlling

This experiment is for controlling home appliances automatically. When a user orders the robot to turn home appliances on or off, the robot moves to the appliances like human beings if the distance is too far to use Bluetooth or an IR sensor. If the robot is near the appliance, the robot controls those using Bluetooth or IR sensors without moving. Fig. 21 shows the experimental results of home appliances control. We tested three experiments: turning on/off a fan, lamp, and television. The PBMoRo system moved near each appliance and controlled them. Using this function, a robot can manage a home instead of human beings and a user can monitor by camera the process as well as the results. This remote controlling is most useful when a robot controls dangerous appliances such as a gas range.

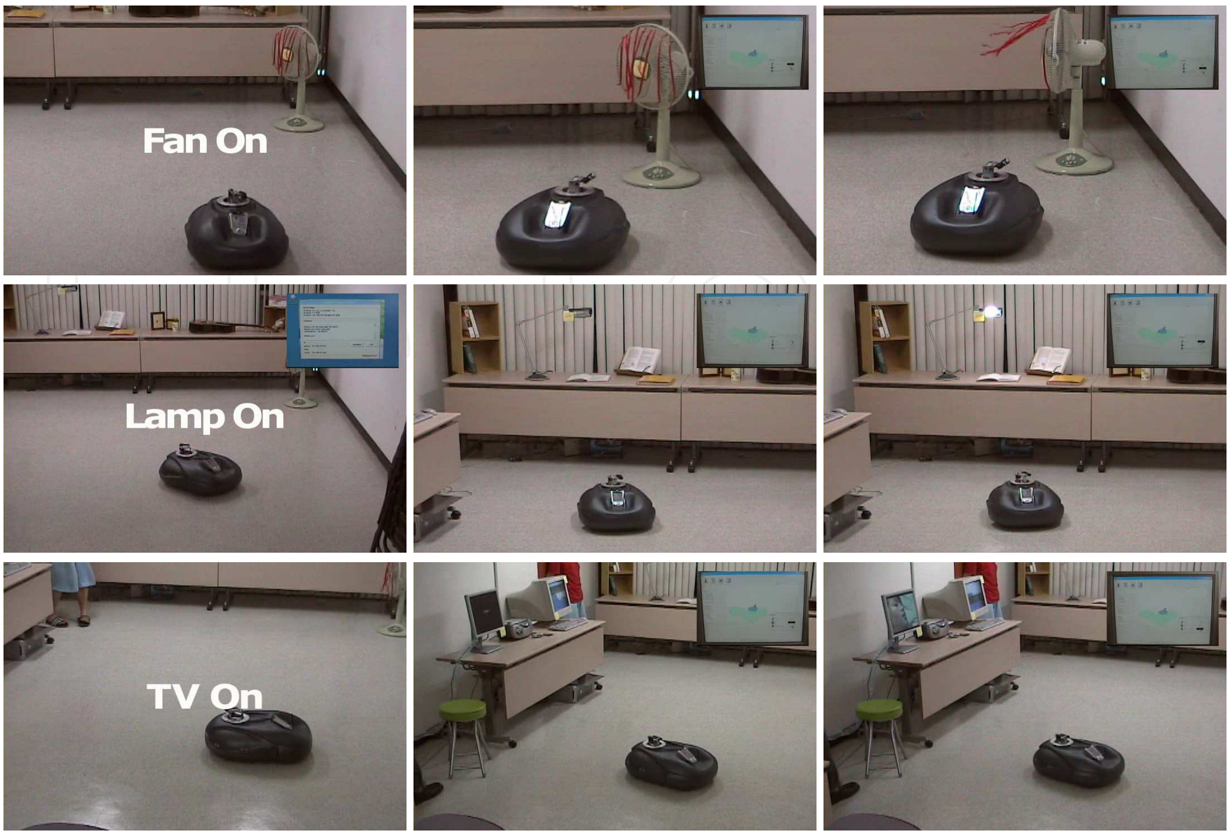


Fig. 21. The experimental results of home appliances controlling.

5. Conclusion

We have proposed the HAuPIRS architecture for organizing a more efficient and convenient home automation system which overcomes the limitations of conventional systems by using an intelligent service robot system. Intelligent service robot systems for the home environment should be designed to be human-friendly and should not draw unwelcome attention. The robot should also be light and small size for saving power and being conducive to an in home environment.

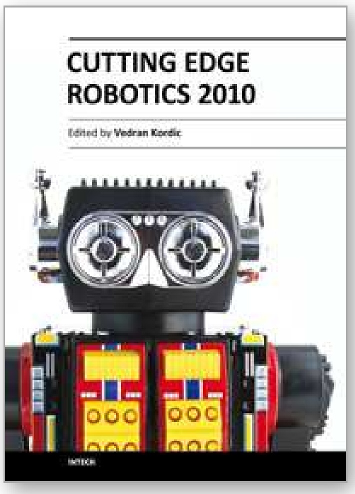
The HAuPIRS architecture solves the limitations of conventional home automation systems and intelligent robot systems for home environment using a PDA. Although a PDA has less performance than a PC which is used for conventional intelligent service robot systems, it is smaller and lighter while having long hours of operation. The robot system moves automatically as well as manually and users can control the robot system outside of home using a 3D monitoring system. The robot system also has a web camera and sends the streaming image to a 3D monitoring system.

Because the PBMoRo system uses a PDA, it is difficult to use the algorithms such as path planning and map building for conventional robot systems. To cure this problem, we simplified the algorithms and reduced the size of the streaming image. Service robots need many external ports for connecting hardware systems, but PDAs only have one external port and we used CAN communication.

We have tested many experiments: tracking, path planning, localization, obstacle avoidance, map building, and home appliance controlling. From these experiments, we verified that the proposed robot system can be one of the solutions for a home automation system.
In the future, we need to develop more efficient and robust algorithms with lower specification systems. The PBMoRo system can be a manager of any house and adapted to an apartment environment as well. It can also be more useful to control dangerous appliances using fire or water.

6. References

JongWhan, Kim (2002). Robot soccer technology, KAIST PRESS, ISBN, Place of Publication
Kuk-Jin Yoon, In-So Kweon. (2001). Landmark Design and real-time landmark tracking for mobile robot localization, SPIE2001, Sep, 2001, Korea
Kyung-Sang Bukdo (2004). Korea Intelligent Robot Contest 2004.
Ho Seok Ahn(2008), Advances in Service Robotics, InTech Education and Publishing.
Seung-Min Baek(2001), Intelligent hybrid control of mobile robotic system, The Graduate School of Sung Kyun Kwan University.
Arkin R. C. (1998), Behavior Based Robotics, The MIT Press.
Arkin R. C. (1989), Motor Schema Based Mobile Robot Navigation, International Journal of Robotics Research, vol. 8, no. 4, pp. 92-112.
Arkin R. C. (1987), Motor Schema Based Navigation for a Mobile Robot: An Approach to Programming by Behavior, Proceedings of the IEEE Conference on Robotics and Automation, pp. 264-71.
Beom H. R. and Cho H. S. (2000), Sonar-based Navigation Experiments on a Mobile Robot in Indoor Environments, Proceedings of the 15th IEEE International Symposium on Intelligent Control, July 2000, Greece.
Brooks R.(1986), A Robust Layered Control System for a Mobile Robot, IEEE Journal of Robotics and Automation, vol. RA-2, no. 1, pp. 14-23, 1986.
MostItech, http:// www.mostitech.com
NEC personal robot PAPERO, http://www.nec.co.jp/robot/english/robotcenter_e.html
Palm Pilot Robot kit from CMU, http://www.cs.cmu.edu/~pprk/
Vacuum cleaner robot from LG Electronics, http://www.lge.com/products/model/detail/v-r4000.jhtml
Sebastian Thrun (1999), et. Al., MINERVA: A second generation mobile tour-guide robot, Proc. of the IEEE International Conference on Robotics and Automation (ICRA'99), 1999.
Roland Siegwart (2007). Simultaneous localization and odometry self calibration for mobile robot, Autonomous Robots. Vol. 22, pp. 75–85.
Koide Y., Kanda T., Sumi Y., Kogure K. and Ishiguro H. (2004). An approach to integrating aninteractive guide robot with ubiquitous sensors, In Proceedings of the 2004 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2004), Vol. 3, pp. 2500-2505.



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Robotics research, especially mobile robotics is a young field. Its roots include many engineering and scientific disciplines from mechanical, electrical and electronics engineering to computer, cognitive and social sciences. Each of this parent fields is exciting in its own way and has its share in different books. This book is a result of inspirations and contributions from many researchers worldwide. It presents a collection of a wide range of research results in robotics scientific community. We hope you will enjoy reading the book as much as we have enjoyed bringing it together for you.