A Study of Performances on An Automatic IEEE 802.11g Wireless-Standard Robot Using Infrared Sensors

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Abstract - This paper presents a study of performances on an automatic wireless robot using IEEE 802.11g standard and infrared sensors. The robot acts a personal computer (PC) controlling equipments (e.g. motors) through a printer port. Window XP is setup on the PC robot which is received a command from notebook (only Start / Stop commands) linked through the use of a wireless router and a real-time streaming protocol (RTSP) program. The study of performances on the automatic wireless robot is tested in three patterns of obstacles i.e. \( \alpha \), \( \beta \) and \( \Pi \). In the results, the robot can avoid a hindrance when infrared sensors detect the obstacles, then it will move backward direction in the length of 60 cm and move forward direction in the angle of 45\(^\circ\). The sensors can detect colors (except black color) and opaque but they cannot detect clear glass. In addition, the delay time and the maximum distance of transmitting and receiving images are approximately at 0.1s and 40m, respectively.

Index Terms – automatic wireless robot, IEEE 802.11g standard, infrared sensors, real-time streaming protocol (RTSP)

I. INTRODUCTION

Nowadays, applications of telerobotics can benefit from Wireless Local Area Network (WLAN) technology. The development of teleoperated systems has gained considerable attention in recent years due to the new potential applications, such as remote production monitoring, remote exploration and manipulation in inhospitable environments, telesurgery, and remote training etc [1]. Important issues concerning communication channels, random propagation delays, bandwidth limitations, fault-tolerance, synchronization, telepresence, and the stability of the robotic systems involving human operators have all been taken into account in different works across the literature. Most of them consider Internet as the interconnection network between telecontrolled systems and control stations [1].

IEEE 802.11 Wireless standards can be utilized for many applications depending on characteristics of duties [2]. In this way, there are three wireless standards of IEEE 802.11 (IEEE 802.11a/b and IEEE 802.11g) which are typically popular in existing days. Each type of wireless standards can summarize advantages and disadvantages as follows. For the IEEE 802.11a standard, the operating frequency and the maximum speed of transferred data are at 5 GHz and 54 Mbps, respectively, however: the working radius is a short length and the cost is high expensive, therefore it is less popular [3]. The IEEE 802.11b standard employs the operating frequency at 2.4 GHz and it has the maximum speed of transferred data at 11 Mbps. For the IEEE 802.11g standard using orthogonal frequency-division multiplexing (OFDM) [4], the operating frequency and the maximum speed of transferred data are at 2.4 GHz and 54 Mbps, respectively, as well as the working radius is also higher than that of two previous standards.

A Related research has proposed a wireless robot using IEEE 802.11b [1], however: the radius is short for working area and it is not an automatic robot. Recently, a study of performances on a wireless robot has been presented based on various brands of IEEE 802.11g standard and controlled by notebook [5], however: it is unable to control by automation and the delay time of transmitting images is a relatively high approximately at 0.5 ms due to the use of web server [6]. In the well open literature, no other researches have been reported for a study of performances on an automatic wireless robot using IEEE 802.11g standard and infrared sensors.

In this paper, a study of performances on an automatic wireless robot is presented through the use of IEEE 802.11g standard and infrared sensors. The robot acts a personal computer (PC) controlling equipments (e.g. motors) through a printer port. Window XP is setup on the PC robot which is received a command from notebook (only Start / Stop commands) linked through the use of a wireless router and a real-time streaming protocol (RTSP) program [6]. The study of performances on the automatic wireless robot is tested in three patterns of obstacles i.e. \( \alpha \), \( \beta \) and \( \Pi \). In the results, the robot can avoid a hindrance when infrared sensors detect the obstacles, then it will move backward direction in the length of 60 cm and move forward direction in the angle of 45\(^\circ\). The sensors can detect colors (except black color) and opaque but they cannot detect clear glass. In addition, the delay time and the maximum distance of transmitting and receiving images are approximately at 0.1s and 40m, respectively.
II. PROPOSED METHODS

A. Hardware Structure

Figure 1 shows hardware structure for communication between a notebook (client) and an automatic robot (server). The start command (Auto On) is sent from the notebook and then the robot will move automation whilst it will send the images from a webcam camera to display on the notebook. Finally, it will not move when the stop command is sent to it.

The automatic robot consists of:

1) A webcam camera is used for receiving images and sending them to the notebook, as shown in Fig. 2 (a).
2) A computer is a central processing unit which is used for display of images, as shown in Fig. 2 (b).
3) A router wireless LAN on the automatic robot is used for transmitting the image data to display the notebook, as shown in Fig. 2 (c).
4) Four Motors are utilized for driving four wheels of the automatic robot, as shown in Fig. 2 (d).
5) Relay circuits are exploited for controlling functions of the four motors. They will receive signals from infrared sensor circuits, as shown in Fig. 2 (e).
6) Circuits for infrared sensors are used for detecting objects and sending signals through the relay circuits to the notebook, as shown in Fig. 2 (f).
7) Figures 3 (a) and (b) show a physical model of infrared sensors and four positions of infrared sensors, respectively.

B. Software Structure

Figure 4 shows software structure for controlling the automatic robot. The start command (Auto On) is sent from the notebook. After the robot will move forward direction and will receive images which are transmitted and displayed on the notebook. Then it also will check and detect signals from four infrared sensors which are transmitted and sent to the notebook. Finally, it will not move when the stop command is sent to it.

It can be seen from Fig. 4 that the diagram of processing for moving directions will be described in Fig. 5. Figure 5 shows the moving directions for the automatic robot when four sensors detect obstacles between its movements. The process of four infrared sensors can be described as follows. If the front of left sensor is on (Yes) for working, then the robot will move backward, turning right and forward directions. If the front of right sensor is on (Yes), then it will move backward, turning left and forward directions. If the back of left sensor is on (Yes), then it will move forward direction whilst if the back of right sensor is on (Yes), then it also will move forward direction.

![Figure 1](image1.png)  
Fig. 1 Hardware structure for communication between a notebook and an automatic robot (server).

![Figure 2](image2.png)  
Fig. 2 The automatic robot consisting of (a) web camera, (b) main board computer, (c) router wireless LAN, (d) motors, (e) relay circuits and (f) circuits of infrared sensors.

![Figure 3](image3.png)  
Fig. 3 Infrared sensors (a) a physical model of infrared sensors and (b) four positions of infrared sensors.
III. CONDITIONS OF THE STUDY OF PERFORMANCES ON AN AUTOMATIC IEEE 802.11G WIRELESS-STANDARD ROBOT

Conditions of the study of performances on an automatic robot are considered from transmitting and receiving data in terms of end-to-end i.e. the robot is the server as well as the notebook is a display unit including a controller for the Start or Stop commands. This study will focus topics as follows:

1) Strength of the transmitted signals on the air is measured in terms of distances depending on the received data (no loss).
2) Delay time of transmitting and receiving images is considered from the robot to display on the notebook.
3) Distances of the detected signals can be received from four infrared sensors which are displayed on screen.
4) The automatic robot testing will be tested in three patterns of obstacles i.e. $1$, $1'$ and $\Pi$, as shown in Fig. 6.
5) Comparisons of performances to previous works are proposed.

Other performances such as errors of transmission and stability of controlling robot will be studied by transmitting images from the robot and transferring commands to the robot where data will transfer no loss packets of information. The robot testing will considered under the conditions as follows:

1) Speed of the robot is approximately at 10 cm/s for all movement. (Sometimes, the robot is stop.)
2) Surroundings are emptiness and obstacle of rooms. The air is normal. (Having disturbance of 1 or 2 wireless LAN signals)
3) A rate of transferred images is at 30 frames per second.

Fig. 4 Software structure for controlling the automatic robot.

Fig. 5 The moving directions for the automatic robot.
IV. EXPERIMENTAL RESULTS

The experiment is to study performances of the automatic wireless robot under the conditions of section III. For testing the robot, it tries to run on flat floor, it includes the USB camera having two motor for turning left, right, top and down, as well as, it also includes four sensors to detect the objects. There are 4 tests in this study as follows:

A. Three patterns of the obstacles

Figure 7 shows the results of moving directions for the automatic wireless robot in three patterns of obstacles. It can be seen from Fig. 7 that three movements in three patterns i.e. 1, 2 and 3 are shown in Figs. 7 (a), (b) and (c), respectively. The robot can avoid a hindrance when infrared sensors are worked for detecting objects, then it will be backward direction in the length of 60 cm and move forward direction in the angle of 45º.

B. Distances of the detected signals from 4 infrared sensors and a capable usage of infrared sensors

Table I shows the results of distances of detected objects from four infrared sensors (between the robot and objects). It can be seen from Table 5 that status of sensors is correctly work in the range of distances (~1–10 cm) and the sensors are not completely work in the larger than 10 cm. In addition, a capable usage of the infrared sensors can detect colors (except black color) and opaque, but they cannot detect clear glass.

<table>
<thead>
<tr>
<th>Distances (cm) between the robot and objects</th>
<th>Status of infrared sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>~1–10</td>
<td>Work</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>No</td>
</tr>
</tbody>
</table>

C. Delay time for transferred images to the notebook

Table II shows the results of delay time for transmitting and receiving images depending on distances. It can be seen from Table 4 that delay time is approximately at 0.5 second in the range of distances (~1–40 m) and the wireless signal are faded in the larger than 40 m.

<table>
<thead>
<tr>
<th>Distances (m)</th>
<th>Delay time (second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>~1–40</td>
<td>~ 0.5</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>Fading</td>
</tr>
</tbody>
</table>

D. Capable period time of the automatic wireless robot

Capable period time of the wireless robot is not less than 20 minutes and not more than 30 minutes. Power supply and UPS will provide the electrical power for 200 watt and 1,200 watt, respectively.
E. Comparisons of performances to previous works (Focusing on IEEE 802.11 wireless-standard robots)

Table III shows comparisons of performances to previous works focusing on IEEE 802.11 wireless standard robots. It can be seen from Table III that the delay time and the maximum distance in this work are approximately at 100ms (or 0.1s) and 40m, respectively, for transmitting and receiving images. This work also is the automatic wireless robot whilst previous works have not been presented for the automatic wireless robot.

<table>
<thead>
<tr>
<th>References Performances</th>
<th>This work</th>
<th>[1]</th>
<th>[5]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A rate of transferred images</td>
<td>Frame/second (fps)</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Delay time for transmitting and receiving images considered at a rate of transferring images</td>
<td>millisecond (ms)</td>
<td>-100</td>
<td>-70</td>
</tr>
<tr>
<td>Maximum distances</td>
<td>meter (m)</td>
<td>-40</td>
<td>-</td>
</tr>
<tr>
<td>Automatic robot</td>
<td>-</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

V. CONCLUSION

The study of performances on an automatic wireless robot has been presented through the use of IEEE 802.11g standard and infrared sensors. The robot acts a personal computer (PC) controlling equipments (e.g. motors) through a printer port. Window XP is setup on the PC robot which is received a command from notebook (only Start / Stop commands) linked through the use of a wireless router and a real-time streaming protocol (RTSP) program. The study of performances on the automatic wireless robot has been tested in three patterns of the obstacles i.e. Ⅰ, Ⅱ and Ⅲ. In the results, the robot can avoid a hindrance when infrared sensors detect the obstacles, then it will move backward direction in the length of 60 cm and move forward direction in the angle of 45°. The sensors can detect colors (except black color) and opaque but they cannot detect clear glass. In addition, the delay time and the maximum distance of transmitting and receiving images are approximately at 0.1s and 40m, respectively.

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