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Conference Paper

Room Searching Performance Evaluation for the JagaBot^{TM} Indoor Surveillance Robot

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Abstract

This paper reports the evaluation of the performance of room searching capability for the JagaBot^{TM} Indoor Surveillance Robot. The ultimate objective of the JagaBot^{TM} is to be applied as an event actor, inspecting the secured environment automatically and feeding the dynamic view of the surrounding to remote user. It can also be used to communicate with persons inside the monitored area. A web service based instruction panel was used to command the JagaBot^{TM} to designated rooms. The JagaBot^{TM} then navigates itself to the room automatically, scanning for the QR code marker attached to room door, tracking a designated trail of lines through its QR code and line tracking camera. The result of this room's searching procedure shows that the JagaBot^{TM} achieved its objective of correct room finding in favorable time. A 100% correct search result was obtained with an average velocity of 0.1748 m/s under the current setting.

Keywords: Indoor Surveillance Robot, QR code, and web service

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Received: 1 August 2016
Accepted: 18 August 2016
Published: 6 September 2016

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICoSE Conference Committee.

1. Introduction

Automated Ground Vehicle (AGV) type robot has been used in many applications including surveillance. The Smart Engineering System Research Group (SESRG) has successfully designed an AGV type robot, called the JagaBot^{TM}, for surveillance application. The robot is tasked with monitoring the environment dynamically, going from room to room and also to act as an actor, one which is commanded remotely to inspect a particular room upon detection of an anomalous event from that room (for example, from Closed Circuit Television (CCTV) observation manually or automatically).

There are several AGV robot developed for surveillance system, for example [1] presented a prototypical multi-robot surveillance system that is able to monitor an outdoor environment autonomously and visual surveillance system mounted on the mobile robot as developed by [2]. A navigation architecture for autonomous mobile robot was developed by [3] to run in environment based on stereo vision camera utilizing the Binocular Stereo Vision Based Obstacle Avoidance technique. A robot for intruder detection and surveillance task was developed by [4] and [5] demonstrated a surveillance robot capable of capturing and transmitting video on rough terrains. [6] has incorporated unique feature of surveillance robot, which is travelling capability on both land and water.

2. JagaBo TM Infrastructure

The JagaBot^{TM} infrastructure is shown in Fig. 1 (b). The web service based command mechanism of JagaBot^{TM} is shown in Fig.1 (a). The instruction panel can be replaced by desktop instruction panel or android device based instruction panel. However, the web service act as the main communication hub for JagaBot^{TM}. Several versions of the JagaBot was developed. The version shown in Fig. 1 (b), which is the JagaBot-J03, is the latest version of the JagaBot^{TM} **[7]**.

It uses an Intel NUC mini PC as the main controller, connected with a web cam for Quick Response (QR) code reading, a downward pointing line tracking camera, and two forward pointing wireless Internet Protocol (IP) camera for monitoring purposes. It also has two main screen, the larger one is used to display the Graphical User Interface (GUI) and the remote telecommunication module while the smaller one is used as a control panel. A Teensy microcontroller act as a field controller, connecting the NUC Mini PC to the sensor and actuator and all the instrumentation circuit below. The JagaBot^{TM} is move by two Direct Current (DC) motor and powered by 2 12V sealed lead acid battery.

3. Objective of Study

The objective of the study is to establish the performance of the JagaBot^{TM} in achieving targeted room for inspection and to derive a mathematical model depicting the target to arrival time with JagaBot^{TM} current location.

Figure 2 shows JagaBot^{TM} path in detecting the desired room. JagaBot^{TM} will go through the red line track for straight movement. When the green line marker is detected, JagaBot will make a turn based on the side detected and scan the QR code provided. If the QR code gives correct room reading, JagaBot^{TM} will enter the room.

4. Experiment Design

From the X_S starting point, the robot were assigned to move to any of the rooms (room 1 (D1), 2 (D2), 3 (D5), 4 (D3), 5 (D4), 7 (D7)) using the web service based command panel. The experiment were repeated for several times. The floor plan of the experiment location is shown in Fig. 3 below.

Figure 4 shows the sequence of JagaBot^{TM} movement. It started from identifying the command for the room to be searched. Then, JagaBot^{TM} will move forward and find the room markers. Once JagaBot^{TM} detect the marker, it will turned to identify the room using QR code displayed in front of the door. If the QR code shows the wrong room, JagaBot^{TM} will turn back and continuously move forward to find the correct room. If the identified QR code shows the correct room, JagaBot^{TM} will enter the room for inspection. We have also develop a model to estimate the arrival time ($T_{Target)}$ to destination.

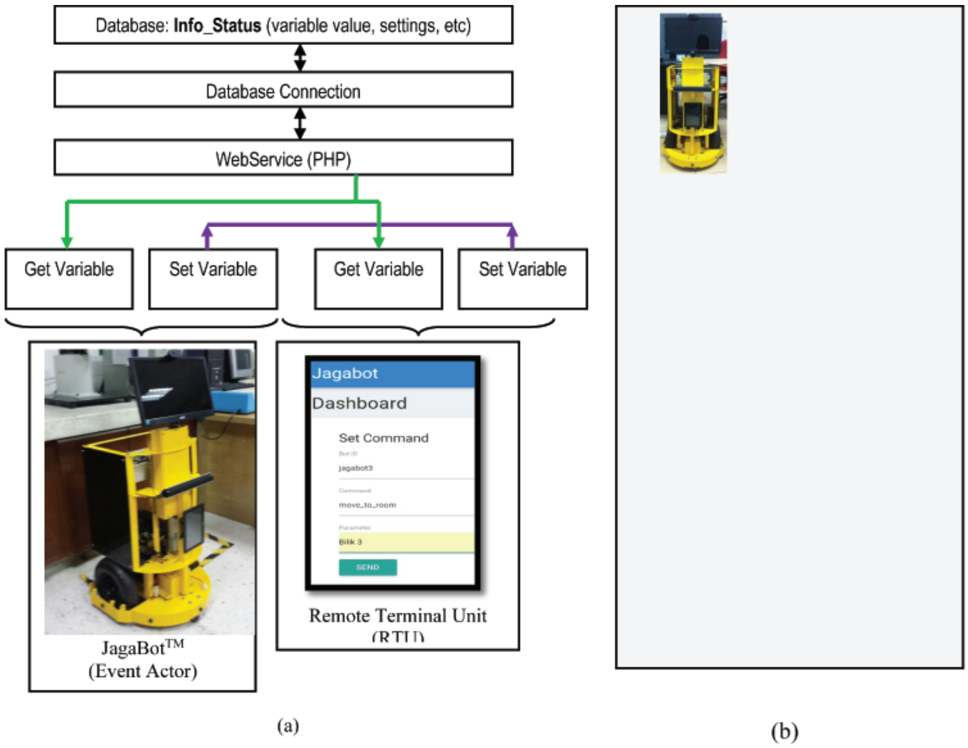

Figure 1: Jagabot TM, (a) Jagabot TM Web service Based Command, (b) Closeup of the Jagabot TM [7].

5. Results

Table 1 shows the JagaBot^{TM} performance evaluation. The time taken for each target is measured using Eq. 1.

$$T_{Target} = T_{straight} + T_{QRC} + T_{QRI} * N + T_{Initial} \tag{1}$$

Where,

T_{Target}: Estimated time for JagaBotT^{M} to reach target room.

T_{QRC}: Time spent when scanning correct QR code (Measured experimetally).

T_{QRI}: Time spent when scanning incorrect QR code (Measured experimetally).

$T_{straight}$: Time taken to move in a straight line from X_s (shifted by $T_{Initial}$) to targeted door

Marker (Measured experimentally).

N : Number of turn.

$T_{Initial}$: Pick up time required for the JagaBot^{TM} motor to ramp up to nominal speed.

5.1. Accuracy

Both T_{Target} and $T_{Measured}$ depends on N and the distance from starting point. The T_{Target} is estimated using Eq. 1 and measured experimentally ($T_{Measured}$). The results of the experiment shows that all room were identified and reached succesfully. The average

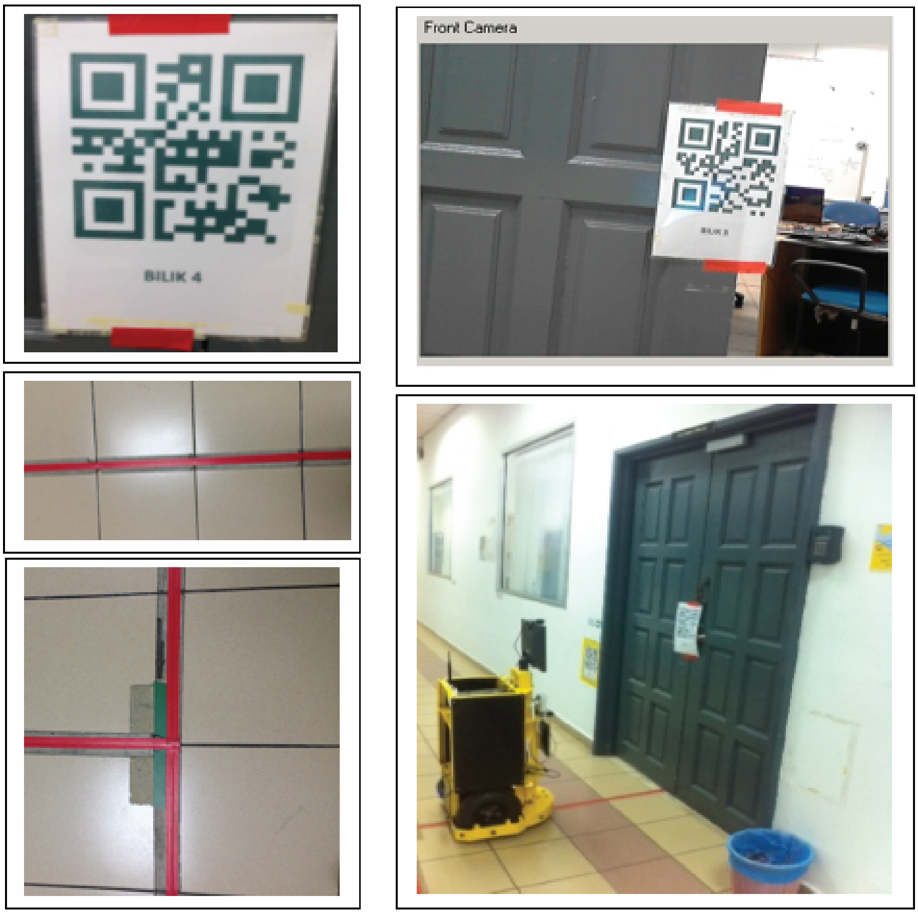

Figure 2: QR-Code Depicting The Door (Left,Top), The lines Tracked (left, Middle), Door Marker (Left , Bottom), JagaBot TM Inspecting the Door (Right Bottom), Doors are opened automatically and JagaBot TM Enters (Right Top).

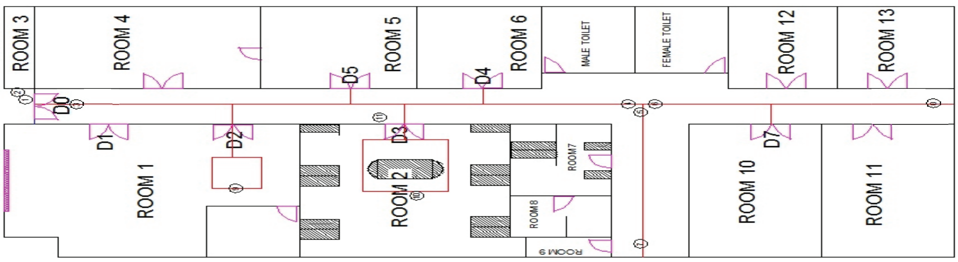

Figure 3: Design Floor Plan.

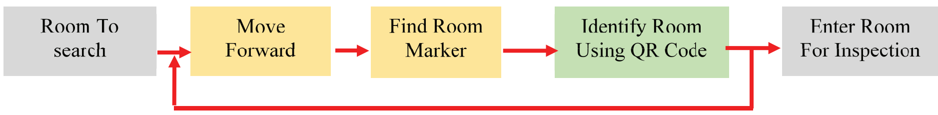

Figure 4: Sequence of Jagabot Movement.

percentage of error between T_{Target} and $T_{measured}$ is 3.14% only, which indicates that the model is in good agreement with the real system behaviour.

Room	Distance (m)	Turn	Test Run 1	Test Run 2	Test Run 3	Estimated Time (T_{Target})	Actual Time ($T_{Measured}$)	Error	Error (%)	Speed (m/s)
room 1	1.07	0	8	9	8	13.26	13.62	0.0275	2.75	0.128
room 2	6.18	1	44	46	44	47.56	44.53	0.0680	6.80	0.138
room 5	10.08	2	73	73	74	74.94	77.43	0.0332	3.32	0.140
room 3	12.78	3	98	95	94	95.45	93.97	0.0157	1.58	0.134
room 4	15.38	4	120	121	124	115.39	119.3	0.0338	3.38	0.126
room 7	27.18	5	196	194	193	187.98	192.82	0.0257	2.57	0.140
Average percentage of error = 3.14%										

Table 1: JagaBo TM performance evaluation.

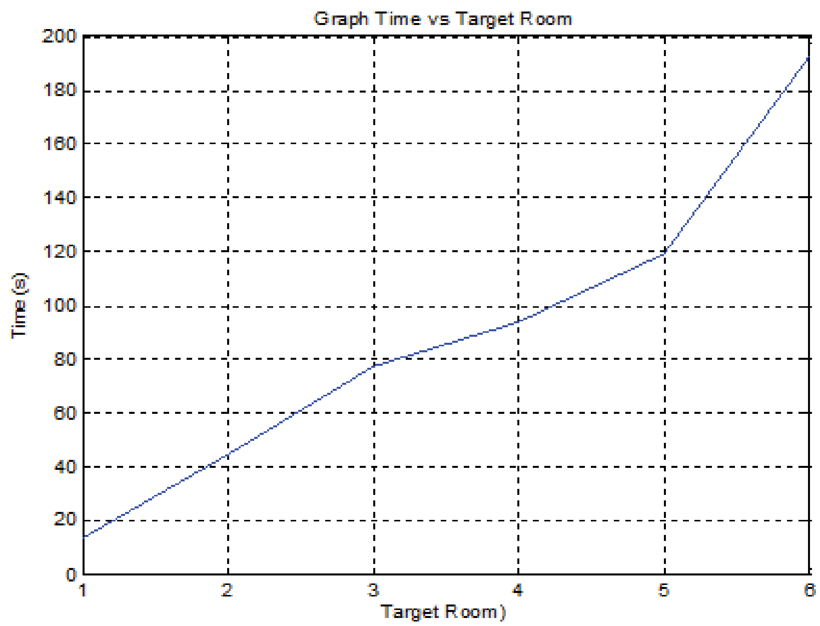

Figure 5: Time taken by JagaBot to reach target room.

5.2. Speed of Detection and Reach

The average measured value of $V_{Straight}$ ($V_{Straight}$ = Distance / $T_{straight}$) is 0.1748 m/s. However, $T_{Measured}$ and T_{Target} depends on the room distance and number of verification it has to do before reaching the correct target. Figure 5 shows speed and time performance of JagaBot^{TM}

6. Conclusion

The JagaBot^{TM} was proven to be able to detect all room using QR code accurately. Good agreement was obtained between predicted arrival time to target room (T_{Target}) and the measured arrival time($T_{Measured}$), with an average percentage of error of 3.14%. Using this model, it would be possible to accurately estimate the arrival time based on JagaBot^{TM} current location. In future, the JagaBot^{TM} will be integrated into our smart environment system, Sekitar. We will also work on various improvement to the JagaBot^{TM} system to improve the speed and the detection accuracy.

7. Acknowledgement

The authors would like to express their gratitude to the Government of Malaysia and National University of Malaysia for financing this research via the DPP-2015-011 research grant.

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