Design of a GPS-Enabled Multi-modal Multi-controlled Intelligent Spybot

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***Abstract*—*Intelligent* robots need to have the ability to adjust their actions, state and behavior (i.e., response), as per the inputs that could be influenced by their immediate environment and/or situation/s. Hence, intelligent robots have diverse applications in domains such as security, automation, industry and agriculture. Such robots when used for surveillance or spying operations by military or police forces are called *spybots*. This paper aims to highlight the need and importance of developing systems that have the ability to remotely control their functions, response and operation, using *multiple-controls* and commands given by *multiple-modalities*. As an example, to give a live physical demonstration of the proposed concepts, a *prototype smart spybot* is developed. The prototype spybot can be controlled using multi-modalities such as text, touch, speech and gestures. It can be remotely operated using an application running on an Android based smart-phone, or a website, or an interactive program running on a laptop. Each can be connected by wires or wirelessly. The prototype spybot also has decision making capability and obstacle-avoidance feature. It is GPS enabled, and can be used as a tracker also. This intelligent spybot can directly fetch the live-video feeds and the spied data to a website, along with GPS coordinates. Since the prototype spybot is speech and gesture-enabled, it can also be used effectively by the people having restricted physical abilities. The initial performance results and trials are encouraging. The prototype spybot can potentially be used for a range of applications.**

Keywords— intelligent spybot, multi-modal, multi-controls, intelligent robot, obstacle avoidance, GPS enabled

I. INTRODUCTION

With the technology advancing, robots have made their way into human life providing a comfortable living environment and ensuring safety in all the spheres. A robot is a primary part of intelligent devices. Spy robots, a category of robots, are those robots dedicated for spying or surveillance purpose. They are useful in remote locations where there is restricted human interference. With decision making capability they can also be utilized in military and army purposes. At the time of war spybot can be used for surveillance [1], [2] and rescue operations [3].

Intelligent spybots are the spy robots having decision-making capability. In addition to collision avoidance they also have the competency to judge the surrounding, with the help of sensors and camera, and act consequently. Various works have been done on accessing the intelligent spybots wirelessly [4] by using radio frequency [5], Wi-Fi, Internet [6] and Android App [7], [8], [9]. There are ongoing efforts to diversify the applications of such mobile spy robots such as in clandestine and covert missions, collecting spied data through a camera [10], traffic patrolling and many others [11].

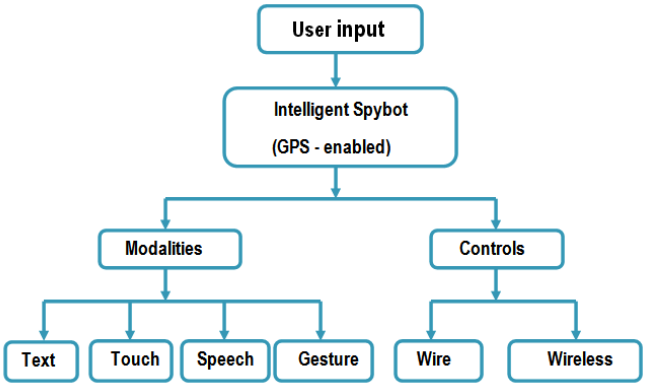

Fig. 1. *Modalities* and *Controls* of the Prototype

Furthermore, the intelligence of this spybot can be enhanced by acquainting it with multi-modal commands for the input [12], [13]. Several approaches have been developed to achieve gesture sensing and thus controlling a robot [14], [15]. Voice commands provide an articulate and natural way to control the automated devices using a microphone [16], [17]. A voice initiated personal robot, object tracking and obstruction avoiding robot has been already developed [18], [19]. GPS enabled robot is better off in an area under surveillance [20].With the advent of emerging technologies it is necessary to have several modalities and different access controls for an efficient surveillance. Nonetheless, combining a whole set of possible controls and modes in a single spy robot have yet not been touched upon.

A prototype, intelligent spy robot has been assembled with four modalities –text, touch, speech and gesture. Both wire and wireless access controls are amalgamated in this spybot, Fig. 1. With the text commands via a laptop based GUI or

wirelessly through a website, the spybot can be controlled. Touch mode has been incorporated via an android application. With the help of a microphone and Google speech-to-text API, speech recognition is collaborated along with the other modes. With GPS, in addition to the live feeds, the spybot can give exact location and a route can be made for surveillance. Lastly, gesture recognition is efficiently incorporated via a webcam. This camera streams live video and feeds it directly to the server which can be accessed by website or android app. The robot is intelligent for when it senses the obstacle it not only avoids collision but also reverses itself moving to the desired location.

Organization of the paper is as follows. Section 2 is concerned with the design and layout of our GPS-enabled multi-modal and multi-controlled intelligent spybot including the software and hardware details. The experiments and the observation are briefly discussed in Section 3. The inferences of the results are discussed in Section 4. A brief summary is given in Section 5 comprising of the future scope of this work.

II. Design of Intelligent Spybot

A. Key components

- Raspberry Pi 3, Modal B
- L298N H Bridge
- Webcam
- HC-SR04
- GPS/GPRS module
- Motors
- Batteries
- Sound card

B. Software and Hardware details

The hardware used in the spybot are Raspberry Pi 3 model B, L298N dual H-Bridge motor driver, ultra-sonic sensor HC-SR04, motors, microphone, camera. The heart of the system is Raspberry Pi- 3 having 1.2GHz, Quad-Core Broadcom BCM2837 64bit ARMv8 processor, which takes commands, processes them, captures data using camera and microphone, and communicates the data. Motor driver or the L298N H-Bridge is used to control the movements of the spybot. The processing unit gives the signal to the motor driver. The motor driver in turn runs the motors in a particular direction according to the signals received. It makes intelligent decisions using data captured via ultrasonic sensors like HC-SR04 and a camera.

The operating software of the Raspberry Pi is Raspbian. Other software used in the spybot are VNC server, 'putty', 'Python', 'Lighttpd', 'motion', etc. 'Putty' and 'VNC server' are used to control the spybot remotely using laptop by text commands. 'Lighttpd', a webserver, is used to host the website and 'motion' software is used for streaming camera's data. Google speech-to-text API is used for speech recognition in the spybot.

C. Operations

The control panel consists of a laptop based GUI, a website, an android app, speech and gesture controls. From the control panel the input signals are communicated to Raspberry Pi board, the processing unit which receives the commands by on-board Wi-Fi or Bluetooth module. After receiving the commands it interprets and processes the data and makes intelligent decisions for further actions.

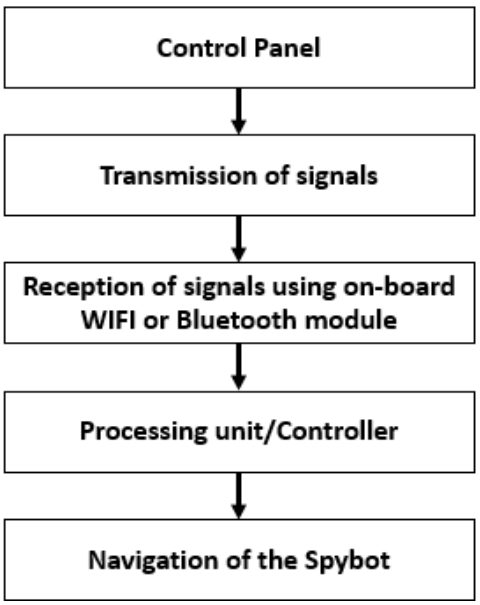

Fig. 2. Basic *Operations* of Intelligent Spybot

The spybot can be controlled by laptop using the software Putty which allows the user to access the Raspbian operating system running on the Raspberry Pi or can be wired to a display and keyboard. With the help of python codes, input is taken from the user by keyboard. The alphabet 'w' is used to move the bot forward, 's' to move it in reverse, 'd' to turn it right and 'a' to turn it left. The spybot with the aid of ultrasonic sensor detects the obstacle and measures the distance between the object ahead and itself. If this distance is less between the spybot and the obstacle then it will move backward and turn to avoid the obstacles thus making smart decisions.

The spybot can also be controlled via a website which can be used to operate the spybot remotely. Raspberry pi act as a server and the website can be accessed by any other device. The software used to make the Raspberry Pi a server is 'Lighttpd' which is designed and optimized for high performance, security, speed compliance and flexibility. With the arrows on the website, user can move the bot forward, left, right and reverse. This site has two versions, one is for the devices like laptops and PCs that interacts upon the mouse clicks and other is for the touch-based devices. The CGI script is executed on server when user interacts with the website. Raspberry Pi executes the CGI script and performs the related operations. The android application's graphical user interface is same as that of the website and can be used to operate in the same way. The Fig. 2 portrays the basic operations performed by the intelligent spybot.

The data is communicated to both control panels using Motion software. The camera used is a simple web camera that is connected to the Raspberry Pi by USB port. Pi cam can

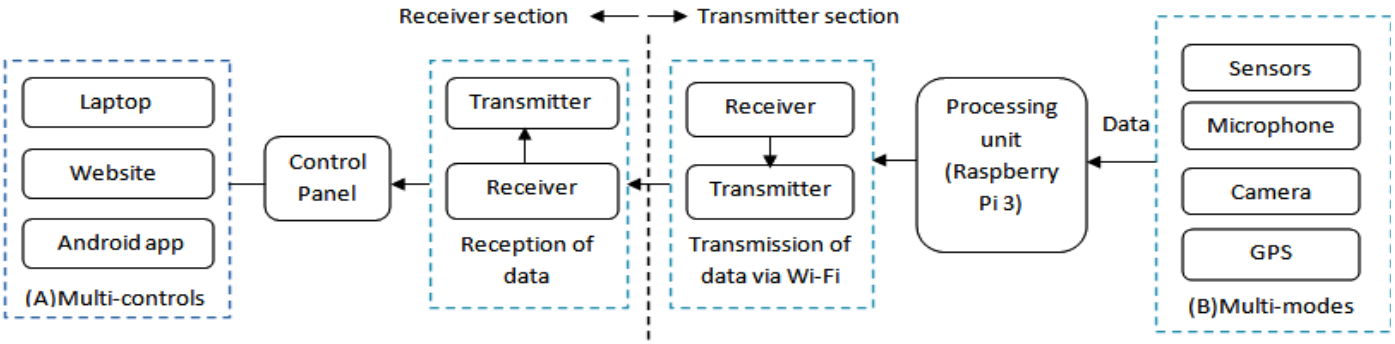

Fig. 3. Block diagram showing the *data communication*

also be used instead of web camera. The data is captured by the processing unit using camera and sensor and further processed to make intelligent decisions. Data i.e. video, audio and images can be transmitted to the website or android app as described in Fig. 3.

As a result, live video is streamed to the website and the app. The gesture commands are given through the number of fingers held up in front of the camera.

In case of speech commands, the spybot records the speech and process it using Google speech to text API and performs the operations according to the result processed. This mode is quite effective and makes controlling the spybot very easy.

III. Experiments and Observations

Development of 'intelligent robots' requires ability of making decision based on the surroundings or situations. For this purpose sensors are required to capture data which can be used in the decision making process. Ultrasonic sensor like HC-SR04 is used to measure distance in range of centimeters and meters to avoid any obstacles. The distance is calculated using the time-distance equation. An ultrasonic sensor records the time taken by the echo of the high-frequency sound pulse to reflect back. Therefore we calculate the distance between the obstacle and the spybot by using the relation between the distance and the time obtained. The comparison of the actual distance between the spybot and the obstruction and the distance measured by the sensor showed 0.03% error.

The second set of experiments was conducted for the accuracy and response time of the speech recognition implemented using the Google speech-to-text API. TABLE 1 shows the probability of the recognition of the speech and successful execution of the commands with the average probability of 0.822 while on the other hand the average response time is 3.2 seconds.

IV. Discussion on Results

From the results of the experiments conducted on the spybot it is evident that it can successfully detect the obstacle and respond effectively.

The ultrasonic sensor can measure the distance form a moving object accurately for every increment of 1.5 inches in distance. The efficiency of the ultrasonic sensor in measuring the distances is 97%. The efficiency of the sensor can be improved by using efficient algorithms and maintaining the surrounding heat around the sensor. The sensitivity of ultrasonic sensor can be tested upon by using various materials like metals, non-metals, plastics etc.

The spybot can also be controlled using speech commands. The spybot listens to the speech command for every 3 seconds and processes the command using google speech-to-text API whose average response time is 3.2 seconds. The efficiency of the speech recognition is 96.5% on an average for all speech commands for the direction of movements like forward, left, right, reverse and stop. The response time also depends on the speed of internet.

The gesture commands are given through the number of fingers that is 1, 2, 3 or 4 for forward, reverse, left and right respectively. More work need to be done upon for the removal of unwanted background images. With GPS, the route can be very well tracked down as the bot gives exact coordinates of the location.

V. Summary and Conclusions

With various input commands i.e. text, touch, speech or gesture commands an effective methodology to incorporate all the access controls and modalities in a single intelligent spy robot has been proposed in this paper. The prototype, spybot processes commands in both ways, wired and wirelessly. The spybot uses a single computer, Raspberry Pi 3, module B for the storage and processing of all the commands. A website and an android application are also developed to give commands to the spybot. The uniqueness lies in the fact that the spybot gives live video feed to the app and the website besides being controlled by speech and gesture alternatively. The bot is intelligent enough to detect the obstacle, avoid collision and henceforth take the decision depending upon the situation. Various experiments are compared practically and inferred. Communication distance is enhanced by using a Wi-Fi instead of Bluetooth.

Further, using a GPS module a track can be mapped for effective surveillance of the spybot. This can help in finding the location of our enemies. Work can be done upon the distance between the microphone and the speaker. Gesture commands can be upgraded by working upon the removal of background images by Image Processing by use of Matlab or Scilab. For increasing the Signal-to-Noise (SNR) ratio,

TABLE I. Efficiency of *speech recognition*: (a)Speech given as an input (b) Probability of recognition (c) Action performed by the spybot

Speech Command(a)	**Probability(b)**	**Output Action(c)**
Forward	0.83	Spybot moves forward
Left	0.8	Spybot turns left
Right	0.9	Spybot turns right
Reverse	0.75	Spybot moves backward
Stop	0.83	Spybot stop

signal processing can be done. Lastly smartness of the spybot can be increased by giving it a 'camera vision' rather than using ultrasonic sensors.

One of the prime applications of this robot is its usage in military and war-field purposes. It can be best used for covertly gathering intelligence inputs and surveillance. The gesture-control mode also enables the people with speech impediments to handle it. Furthermore, being speech-controlled it can be used by visually-impaired or handicaps effectively. In hazardous surrounding having less human intervention, spybot can be used for such operations. Spybot can effectively add up to the search and rescue operation by reducing the pressure on the human workforce. In this paper the prototype, intelligent spybot can be further enhanced in accordance to the desired applications. Having numerous potential applications, this paper will be helpful in showcasing the consolidation of different controls and modes for operation of a decision- making spy robot.

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