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Autonomous Guide Robot

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Abstract- The aim of this research project is to develop a smart social robot showing sufficient intelligence to work as a tour-guide in different environments. In doing so, both a software and a hardware architecture are proposed, the different modules of which, such as a laser, cameras, platform, face, and voice, among others, control the different components of the robot. Those components are in turn used by other modules designed for navigation and interaction. A sensor fusion for the purposes of localization is implemented by means of an Extended Kalman Filter, which is one of the navigation module components, together with the proposed fuzzy controllers needed for path following. A fuzzy emotion system that controls the face and the voice modules also forms part of this architecture for assisting interaction. Finally, all the modules are controlled with a customized programming language that is a mixture of C, Pascal, and JavaScript. The modules are optimized for immediate execution to achieve realistic human–machine interaction.

1. Introduction-

This paper focuses on designing an autonomous indoor tour guide robot capable in assisting visitors by giving them a tour of the Engineering Labs and its facilities in the Universities across the country. The robot is not only aimed to be made low-cost, it is also expected to be highly reliable. This type of robot is suitable to be used in educational environments such as colleges and universities, as it helps new students have an understanding of what engineering is truly about before they embark into the journey. This robot will then serve the purpose of assisting visitors around the campus with ease. Besides using it in the educational field, the robot can also be used in the travel sectors to improve tourism of a country. It can be placed in various places of interests and be used to guide the tourists around the place. Such robots are popularly used in museums in some countries.

Ever since the Czech novelist Karelˇ Capek invented the term “robot”—whichwas later popularized by Isaak Asimov- the dream of building autonomous robots—willing, intelligent and human-like machines that make life pleasant by doing the typework we don’t like to do—has been an active dream in people’s minds. With universalpersonal robots still far beyond reach, we are currently witnessing a rapid revolution inrobots that directly interact with people and affect their lives. Thispaper describes one such robot, which is really just a step in this direction. Presented hereis the software architecture of an interactive robot, which has been built toassist and entertain people in public places, such as universities.Its primary task is to give interactive tours through an admission, providing multi-modalexplanations to the various exhibits along the way (verbal, graphical, sound).

2. Related Projects-

Most localization and mapping techniques involve running complex algorithms. These kinds of operations require powerful processors to analyze all the collected data. Consequently, those approaches might not be fully efficient because they often require considerable amount of time to accomplish the mappings . MacDougall & Tewolde8 suggested the implementation of a tour guide robot using the weighted centroid technique. The method consists of placing ZigBee modules at known location to provide reference information to the robot to locate itself. Unfortunately, the robot consistently missed the final destination by a distance of 3.3m up to 4.5m. When it comes to the human robot interaction, researches employed several approach. A tour guide robot that communicates with visitor through a touch screen was introduced by Yelamarthi et al11. Seok et al.10 proposed a different approach which consist of using android text to speech application to converts a string into audio and read it to visitors. Another low cost human machine interaction through voice recognition was presented by Haro et al.5 . The proposed system consists of using a Raspberry pi as the main processing unit to recognize up to 6 different languages using web applications services. Stefanovic et al13 introduced a voice control system based on android and Google speech recognition API. The recognition success rate of the system was estimated to be more than 50%. In another related work, btAripin et al14 implemented a voice recognition system via smart phone for controlling home appliances. The common challenge between all this applications using Google voice API is that it very sensitive to the environment noise and it is also highly depends on the internet.

3. Technichal components of the proposed system-

- An ultrasonic sensor- It is a device that emits and/or detects ultrasonic radiation in order to sense the objects in front of it. It is an electronic device. The range and angle of detection depends on the ultrasonic sensor specifications. Value sensed by ultrasonic sensor is independent of surrounding light and temperature. For this work. We are taking digital voltage output from the sensor.

- Raspberry pi- The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote teaching of basic computer science in schools and in developing countries.The original model became far more popular than anticipated, selling outside its target market for uses such as robotics. It now is widely used even in research projects, such as for weather monitoring because of its low cost and portability. It does not include peripherals (such as keyboards and mice) or cases. However, some accessories have been included in several official and unofficial bundles.The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python.

- Motor driver L293d - A motor driver translates the input to higher voltage while maintaining the promised current output, thereby acting as a current amplifier. This current is used to drive the motors, which usually require a larger current for their operation compared to the other peripherals. The motor driver uses L293D to drive 3 DC motors. It is a quadruple H-bridge and can provide bidirectional drive currents of up to 600 mA.

- Canny filtrer- The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. It was developed by John F. Canny in 1986. Canny also produced a computational theory of edge detection explaining why the technique works. Canny edge detection is a multi-step algorithm that can detect edges with noise supressed at the same time. Smooth the image with a Gaussian filter to reduce noise and unwanted details and textures.

- Audrino Uno - The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

- Audrino Mega - The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

4. Proposed Model-

The Raspberry pi minicomputer acts as the brain of the robot where most of the processing such as the image recognition takes place. It is like a bridge between the android tablet and the motors and sensors. The Ultrasonic sensors and the motors are all connected to an Arduino Mega microcontroller which uses I2C communication to exchange data with the Raspberry pi. The reason for this is that all the drivers and sensors are 5V logic while the Raspberry pi is a 3.3V logic device. The android tablet serves as a monitor to display the user interface of the robot and to execute the voice recognition. Hypertext Transfer Protocol (HTTP) which is a client server communication protocol is used to exchange information between the Pi (server) and the tablet (client).

The tour guide navigation system proposed is activated through voice commands such as “Show me the labs” or “Start navigation”. Once the robot receives the command, it first checks how far the right wall is situated from the sensors. If the wall is not in range, the robot executes the wall adjustment subroutine. In this subroutine, if the wall is found to be too far (distance > 30 cm), the robot move closer to the wall. Otherwise if the wall is too close (distance < 25 cm) the robot moves away from the wall. Next the robot checks for obstacles in its paths. If an obstacle is detected, the robot executes the obstacle avoidance subroutine. In the obstacle avoidance subroutine, when an obstacle is detected the robot waits for 3 seconds in case if it is a human passing by. Then, the robot checks again a second time. If the obstacle is still present, the robot assumes it is a static object and so it move away from the object. Next, after the obstacle avoidance subroutine the robot execute the image processing subroutine to check and see if any Lab is in range. Images with a black square and a white number will be placed in front of each Lab. This is what the robot will be continuously looking for in order to localize itself and identify the labs. If a match is found, the robot start talking and show a video presentation of the Lab it found to the visitors. After the presentation, the robots ask if the visitors have any question about that particular Lab. If a question is asked the robot looks for answers in its database and reply. Otherwise, the robot carries on with the tour.

In the image processing subroutine shown above, the Raspberry pi first captures an image. Then the image is smoothened to reduce noise before the edge is detected using the Canny filter. The contours in the image are found using the find contours function and the rectangular objects are isolated using the approxpolyDP function because rectangles have 4 sides. If a rectangle is found, it is compared against all the images stored in a database to find appropriate match using the bitwise XOR function and algorithm flowchart.

In normal condition, the robot achieves 100% of correct recognition. The algorithm performed well during the image recognition testing in the lab under normal lighting condition. However, the performance of the system considerably dropped as the environment illumination reduced. The recognition rate was below 20% when the test was performed in the corridor. The problem was due to the fact that the corridor had less light than the labs, thus creating a dark foreground with a bright background. Consequently, the problem was solved by reducing the brightness of the captured image pixels before it gets further processed for recognition. However after improvement of the algorithm, the system could successfully recognize the tags .

The distance at which the robot can correctly recognize the speech reduces as the noise increase. Currently, in order to address the robot the user has to be standing in less than 1m away from the robot. This has been tested in normal ambient places (60dB up to 70dB) whereby people were moving around and talking. At this point, the robot highly depends on the internet for the voice recognition. Google only provided the offline speech recognition for the android jelly bean version. The internet has nothing to do with the accuracy of the speech recognition. It only affect the time it takes for the robot to process queries.

5. Conclusion-

The low cost tour guide robot presented is the first of its kind to be powered with the Raspberry pi 2 which is a credit card size embedded minicomputer. The robot could successfully navigate through engineering labs and guide the visitors. Currently, the robot is configured to use 4 Omni wheels which require the use of four motors. This configuration is great for making the robot movement flexible. However, using four motors requires more power as the current robot can only run for 30 min. Future improvements would require building a robot which uses only two motorize wheels and a caster wheel. Also, since the tour guide application on the android phone is totally independent from the robot, this current project can be further enhanced. A virtual guide can be made out of the current android application running of the robot. This guide could be used by anyone running an android device. Furthermore, the current system recognize and understand users request based on keywords and is only limited to its one local database

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