AssistMe robot, an assistance robotic platform

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***Abstract*—this paper presents the design and implementation of a full size assistance robot. Its main purpose it to assist a person and eventually avoid a life threatening situation. Its implementation revolves around a chipKIT Arduino board that interconnects a robotic base controller with a 7 inch TABLET PC and various sensors. Due to the Android and Arduino combination, the robot can interact with the person and provide an easy development platform for future improvement and feature adding. The TABLET PC is Webcam, WIFI and Bluetooth enabled, offering a versatile platform that is able to process data and in the same time provide the user a friendly interface.**

I. Motivation

The smart house had long been a concept that fascinated us, as its job is to assist us and make us more comfortable and safe. An important part of this smart house is the smart robot [1] that can assist us when we need help and even have some medical features. These personal assistant robots must be designed in order to offer assistance especially to high degree risk persons: children, elderly [2] or even disabled people.

Our motivation was to create a robot that can do exactly that: offer assistance and telepresence services for elderly, disabled people and children. We wanted to create a robotic platform that is modular and can be easily be upgraded or modified in order to incorporate the latest features.

II. The Personal Assistant Robot Project

The personal assistant robot project consists of a modular telepresence robot. The hardware design is presented in Fig. 1. The robot is created from three major components:

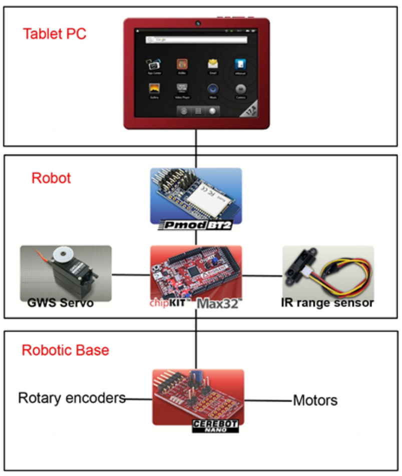

Figure 1. The hardware design

1. The robotic base
2. The core microcontroller
3. The TABLET PC

Since the robot is built mainly around two well-known platforms: Arduino and Android, it creates a very popular robotic development platform. Since both platforms are open source, hardware or software, the development and upgrade is highly encouraged.

III. The Robotic Base

The robotic base is responsible for the robots movements. It is completely modular as it receives commands from the robots core processor and translates those commands into movements. The modularity comes from the fact that the interface chosen for communication is a UART connection at 4800 baud rate ant the command list is reduced. In table 1 a list of all command supported by the robotic base are presented. In order to completely replace the robotic base, the behavior described in this table must be recreated. The robot is not necessary to be aware how the system archives movement only how to interface with the robotic base subsystem in order to obtain the desired movement.

The hardware components that make up the robotic base are:

- The motors
- The rotary encoders
- The Atemga168 board (Cerebot Nano)

TABLE I.
Robotic Base Interface Commands

Sent character	Command to be executed
F	Move forward.
B	Move backward.
L	Rotate Left.
R	Rotate Right.
S	Stop.
H	Halt (stop + brake).
(	Decrease move speed by a factor of 5.
)	Increase move speed by a factor of 5.
[	Decreases turn speed by a factor of 5.
]	Increases turn speed by a factor of 5.
T	Set turn speed between 0 and 255. Second parameter is expected.
M	Set move speed between 0 and 255. Second parameter is expected.
+	Increase move and turn speed by a factor of 5.
-	Decrease move and turn speed by a factor of 5.

A. *The motors*

The motors of our choice were two 36:1 planetary reduction gears with torque limiter. They offer a good rotation speed (550 rpm) versus maximum torque (5.5-6.0 Nm). The motors are controlled by PWM with the help of two 20A h-bridges in order to ensure a variable speed and a correct movement.

B. *The rotary encoders*

The optical rotary encoders are of type RJGSEP-2112 and they use optical disks attached directly to the hub of the motors. Since the optical disks are coded with a single track [3], there is no way of determining the direction of rotation, problem resolved by the software that runs on the ATmega168 microcontroller.

C. *ATmega168 microcontroller*

The microcontroller chosen is an ATmega168 that is a part of a Cerebot Nano board. This board was chosen because of its small size, being perfect for embedding in the robotic platform. This microcontroller has relative modest resources: 1KB SRAM, 16KB Flash, and 512B EEPROM, but is enough for controlling the two motors.

It receives commands from the core microcontroller via a UART interface with two wires, and transforms those commands into movements. It does this by receiving data from the encoders and adapting the current speed in order for the robot to have a correct motion. The programming of this microcontroller was done in C language, in the Atmel AVR Studio IDE and WinAvr library.

The software realizes the data acquisition from the rotation sensors and based on these data adapts the speed. This process of adapting speed is meant to overcome movement error generated by small difference in motors or terrain imperfections. Fig. 2 shows the software diagram for the ATmega168 microcontroller.

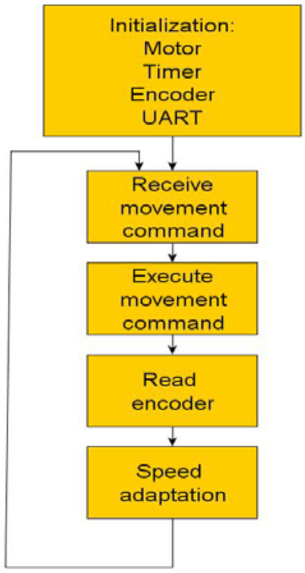

Figure 2. The simplified software diagram for the robotic base microcontroller

The two motors are controlled by Pulse-Width-Modulation, the signal being generated by one of the internal counter of the ATmega168. The commands that are received are under the form of one character, all thought there are commands that have parameters, meaning that the command character is follow by a single value from 0 to 255. Since the data acquisitions from the rotation sensors are not done via interrupts, some values may be missed as the microcontroller is busy processing some data. In order to overcome this problem, all the functions have been designed in order not to interfere with the data acquisition.

IV. CORE MICROCONTROLLER

The main controller has multiple components connected to a central processing microcontroller:

1. The sensors
2. The actuators
3. The microcontroller
4. The Bluetooth module

The sensors are used to detect at what distance is the robot from an obstacle, or to follow a user. The sensors used are two Sharp 2Y0A21 IR distance sensor that can measure distance up to 80 cm, beginning at 10 cm. The sensors are placed at a certain angle on the tilt able TABLET PC support in order to be able to shift the declination on which the measurements are done. These two sensors are used for preventing the robot from doing any harm to a person, to the environment or to himself. Also these sensors are used for allowing the robot to follow the persons that are in front of him.

The actuator used is a servo motor of 0.23 sec/60 deg. rotation. It tilts the TABLET PC up or down in order for the built in camera to better see the environment. Due to the fact that the sensors are placed on the tilt able support that holds the TABLET PC , them to are being tilted in order to measure the distance from the robot to nearby objects. The one servo motor supports the weight of the small TABLET PC chosen very well, but if a heavier one is chosen, the servo motor is to be replaced either by one more powerful or with two servo motors.

The microcontroller chose is a chipKit Max32 board that contains a PIC32MX795F512 microcontroller. Since the operating frequency is very high, 80 MHz, it's perfect for bridging all the components together. Since it has plenty of resource: 128K RAM, 512K Flash and 83 I/O ports that are available. This board is effectively a high performance Arduino clone that is fully compatible with the Arduino software and hardware. This microcontroller was programmed with the MPIDE but because it has a Microchip microcontroller, the board can be also programmed with the MPLAB IDE.

The Bluetooth module is the interface between the TABLET PC and the core microcontroller. We used a RN-42 Roving Network module that was configured to a UART interface of 19200 baud rate.

The software diagram is presented in Fig. 3.

ISSN 1844 – 9689

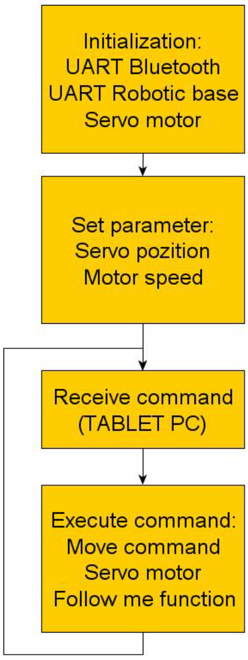

Figure 3. The simplified software diagram for the core microcontroller

V. THE TABLET PC

The TABLET PC was chosen because of the rich user interface, touchscreen, and because the application development for the ANDROID OS is fast. Most TALBET PCs have many built-in sensors and modules:

- Accelerometer
- GPS
- GSM
- Webcam
- Bluetooth

This creates a perfect device for development since ones of the most used modules are already installed and controllable by software.

The TABLET PC chosen has a 1.2 GHz Cortex A8 Kernel Processor, 512 MB DDR3 RAM. With its internal memory of 4Gb it can store the OS, programs and many user files without problem. The TABLET PC runs a modified Android version 2.3 in order to introduce support for external USB Bluetooth module, since this TABLET PC doesn't have a built in Bluetooth module.

The software that runs on the Android operating system manages:

- The transmission of a live video stream from the built in Webcam via the internet to a client software
- Receiving command from the client software via internet
- Sending command to the core microcontroller
- Enable a speech recognition module
- Enable the control of the robot by voice.
- Enable a text to talk module
- Make small conversation with the user
- Enable a basic diagnostics system by voice
- Enable a follow me function

The TABLET PC is able to transmit a live video feed to a client that is connected to it. This feed is used for telepresence and to permit the user to control the robot safely in the remote environment. In the same time the TABLET PC receives commands from the client software about the movements that the robot must execute. So a direct link exists between the two components in server-client architecture.

In order for the robot to move, the TABLET PC sends commands to the core microcontroller. After some processing and verification, the commands are retransmitted to the robotic base. The volume of processing that is done on the core microcontroller can be easily increase, in order to contain more failsafe locks, in case of software failure on the TABLET PC side.

Due to the speech recognition software module, the robot is able to understand basic words in English and permits the user to control the robot with voice commands. This sub module combined with the text to speech sub module creates a robot that can talk and listen. So the user can have a basic conversation, and even a diagnostics conversation.

The follow me function is a method making the robot navigate from one point to another, by following the user. The robot remains at a safe distance behind the user and follows him with the help of the two range sensors.

The software is composes of one Android activity and 3 threads, as shown in Fig. 4.

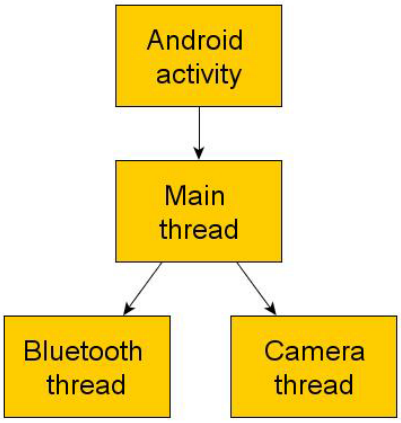

Figure 4. The simplified software diagram for the TABLET PC

The software was created using the Eclipse IDE and ADP Eclipse plug-in.

VI. SOFTWARE CLIENTS

The software clients are written in JAVA using the Slick 2D game library. The client connects to the TABLET PC and enables the user to control the robot and in the same time to view the live feedback from the Webcam. The user controls the robot by certain keys on the keyboard; the mapping of the controls is presented in table 2. For security reasons, in the current implementation, the TABLET PC connects to 1 client.

TABLE II.
ROBOTIC BASE INTERFACE COMMANDS

Keyboard key	Action performed by the robot
UP key	The robot moves forward until stopped by the user.
Down key	The robot moves backward until stopped by the user.
Left key	The robot turns left backward until stopped by the user.
Right key	The robot turns right backward until stopped by the user.
Space key	Sudden burst of speed-nitro
Q key	Tilt the robots head up(TABLET PC)
A key	Tilt the robots head down(TABLET PC)

VII. RESULTS AND CONCLUSION

The robot that illustrates the concept presented has been physically created. It is presented in Fig. 5. It has been created in order for the components to be easily changed and upgraded. It is primary a telepresence robot, a robot that can assist an elderly or disabled people 24/7. Due to relative low power consumption and high amps lead based rechargeable battery the robot has a good operating time before it needs recharging. In order to further decrease power consumption, the motors (that are the largest power consumption units) must be replaced with a high efficiency and low power version.

Figure 5. The AssistMe robot

One of the most important features of the robot is the diagnostics mode. The robot starts a basic diagnostics conversation in which it tries to determine the user's problem. If a problem is detected, the robot will give the user an answer or even place an emergency SKYPE call.

The robot can be fully controlled remotely. The user can transmit commands to the robot, from any location via an internet connection. The movements that the robot can do are: move forward, move backward, turn left, turns right.

As the TABLET PC can be removed from the robot, the user can use it in order to manually control the robot, similar to a remote control.

The robot supports control by voice; the robot will move a predefined distance or rotate a predefined angle when a voice command is detected.

In order to have a better view of the remote environment, the user can tilt the robots head up or down, as the robot's head contains the Webcam. The user is able to see the live video feed transmitted from the robot via an intranet or internet.

The robots two range sensor are used in order to avoid any obstacles or people. If an object is in front of the robot, than the robot cannot move forward anymore, but it can move backward, or turn left or right.

A follow me function permits the user to easily control the robot and to rapidly change its location. The robot will remain at a safe distance behind the user, and follow him.

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ISSN 1844 – 9689