Zigbee-based Location System for Forest Search and Rescue Missions

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***Abstract* - This paper presents the framework of a ZigBee based rescue robot for missing people in forest environment. We will give RFID tag to each and every person who will enter into the forest and will give GSM, fire sensor, GPS, and ZigBee modules to all nearby trees in forest. If microcontroller detects the persons tag then it will send the information about location of particular person to ROBO through GPS module and RFID reader receives information: forest's name, longitudinal and latitudinal coordinates from the tag on the closest tree. ROBO will send that information to the control unit through ZigBee. In control unit we operate all this by using lab view and we only manually operate the ROBO in the forest. Finally, the missing victim is localized, and we present a power supply solution using solar energy.**

***Keywords*- LPC1768, ATMEGA 644, GSM module, RFID module, Fire sensor, RF Camera, GPS module, ZigBee module.**

I. INTRODUCTION

The RFID wireless module and ZigBee modules are added to an already existing mobile robot used as a skeleton [1] to improve the robot's ability to detect human bodies. In addition, a solar charger is used to increase the use life of the robot's battery, hence allowing the robot to work continuously without wasting time in the detriment of people's lives.

The critical choice of the location technology to be used in this work depends on the technology suitability for the application. In this case, the technology selected should be the user could easily reach victims thanks to the plans given by the RFID tags and directions [2].The robot developed is intended for indoor use, in case of building failures and it uses millimeter wave radar sensors and thermal cameras to
help the first-aid staffs by giving them a picture of a place that is difficult to reach [3] [4]. Another team from Kobe University in Japan: the utility vehicle for search (UVS) is focusing its research on the coordination of small robots to form a large robot able to climb large obstacles in the case of earthquake aftermaths [5]. The Kohga University of Tokyo is currently developing snake robots for exploration of small spaces in disaster sites. Rescue robotics is also investigated in industry [6].The iRobot project is financed by the US government; the robots are equipped with cameras, microphones, laser range finders, and IR sensors to explore urban and outside places [7]. Inuktun designs robots to be used inside tubes and in wet environments [8].RFID technology allows storing information onto tags placed on devices by radiofrequency and recovering it. Some advantages of RFID technology include that multiple tags can be read simultaneously and can be used in harsh environments. They can have all-weather capabilities, allowing them to be read through water, surrounding metal, or dirt [9], [10]. ZigBee is used to give the information about missing people to the control unit.

II. LOCATION-BASED WIRELESS TECHNOLOGIES

We can use RFID, ZIGBEE, GSM, GPS wireless technologies and inorder to generate power supply we used solar energy [25]

A. radio frequency identification

Active and passive RFID are different technologies but are usually evaluated together Active RFID makes use of battery within tag for providing continuous power to tag and radio frequency power circuitry. Passive RFID on the other hand, relies on energy of radio frequency transferred from reader to tag for powering it. The information stored in the tags is the forest name and the longitudinal and latitudinal coordinates of each specific tree**.** Prior to the tags installation, location data can be provided by the High Commissariat for Water, Forests and Desertification Control of Morocco [11].The RFID reader and tags are chosen based on low price and the models for this work will be: Parallax 125 MHz RFID model (40.00$) and Parallax 12 MHz transponder (62.00$) [12].

Passive RFID needs strong signals from reader but signal strength bounced from tag is at low levels. Active RFID receives low level signals by tag but it can create higher level signals to readers. Thus, the coverage is maximized with an enhanced positioning capability [13].

B. ZIGBEE

ZigBee is the only standards-based wireless technology designed to address the unique needs of low-cost, low-power wireless sensor and control networks. Using the networking system Zigbee Technology can connect machines and control through one connection whiles consuming less power. So Zigbee is the cost-effective wireless technology for controlling and monitoring. Applications of Zigbee Technology is not limited to a certain level but because of being cost effective, low-power battery and wireless connectivity, this Zigbeetechnology is used in almost every appliance.

Zigbee Modules:

Tracker is a fully web-based system for tracking the people whom we want to track according to their willing.

It provides:

Tracking– Tracking the people who are in need.

Dataflow– Automatic routing and notification to the user.

Process enforcement– Managing and enforcing the path to be followed to the destination.

Status – Up-to-the-minute path tracking and future path guidance mechanism for providing safety to the user.

Communication– Capturing distances towards the destination according to on path obstacles.

Accountability– History and make it for future purposes. The footsteps do not represent the precise location of a person. A Markov chain Monte Carlo method is a promising tracking algorithm for pedestrian models.

C. global positioning system (GPS)

The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 24 satellites and many number of ground stations. A GPS tracking device calculates its position by measuring distances between itself and other GPS satellites. In return, the signals emitted by the satellites carry information about the GPS carrier's location.

Gps tracking map:

GPS and GIS technology is widely used for determining the position of an object and measuring distance. However, the whole technology is based on maps. The GIS technology generally uses digital information with the help of digitized data creation methods. Any particular place is marked by its longitudes, latitude and elevation by co-ordinate points. In this way digital satellite images are analyzed and the data in map form represents real world objects with digital form.

D. The Global System for Mobile communication

The Global System for Mobile communication, usually called GSM, Telecommunications Standards Institute (ETSI) to describe protocols for second generation (2G) digital cellular networks used by mobile phones. The GSM standard was developed as a replacement for first generation (1G) analog cellular networks, and originally described a digital, circuit switched network optimized for full duplex voice telephony. This was expanded over time to include data communications, first by circuit switched transport, then packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS). Further improvements were made when the 3GPP developed third generation (3G) UMTS standards followed by fourth generation (4G)LTE Advanced standards. "GSM" is a trademark owned by the GSM Association.

III. SYSTEM DESCRIPTION

A. transmitter *section*

In transmitter section we interface different modules and sensors to microcontroller. The microcontroller used here is LPC1768 (cortex-M3). PIR sensor, Fire sensor, Battery, and GPS are given input to the microcontroller.

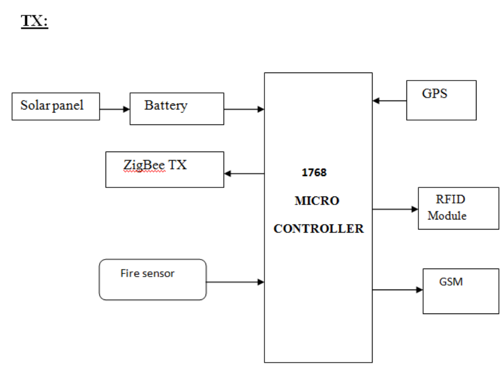

Fig1. Transmitting section block diagram

Several batteries are currently available in the market and the selection of the appropriate device type for this application is crucial. Nickel-Cadmium (NiCd), Nickel Metal Hydride (NiMH), Lithium Ion (Li-Ion), Sealed LeadAcid (SLA) and Lithium Polymers (Li-Po) are examples of batteries that are commonly used for solar energy storage [20].Although these batteries are efficient power source, they are poisonous to the environment and can lead to sulfuric acid leakage that causes acid rains [21]. This battery is regulated to 5V in order to power supply the wireless module together with the robot sensory system [22]. Photovoltaic technology is characterized by high reliability and long life cycle [23].Fire sensor for detection of fire, Battery is for giving supply to the microcontroller and GPS is used to give the location of the missing person. ZigBee and RFID modules are given output to the controller, if controller detects the RFID tag then RFID reader receives information: forest's name, longitudinal and latitudinal coordinates from the tag on the closest tree and all this information is received as a message to control section through GSM. ZigBee TX sends that information to the ROBO section ZigBee.

B. *receiver section*

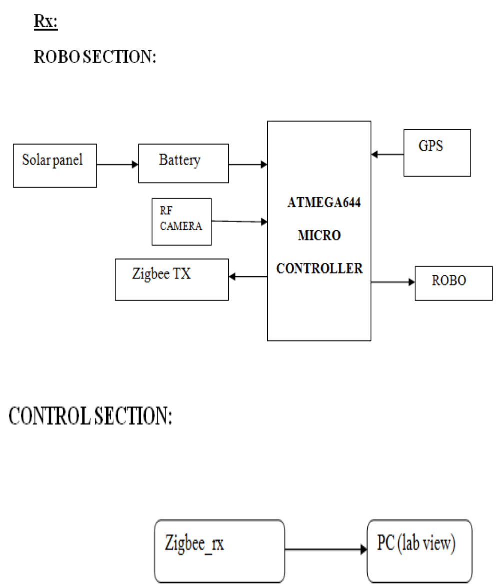

Fig2. Receiving and control section block diagram

In receiver part we have ROBO section and control section. In ROBO section the controller we used is ATMEGA644 and we interface ZigBee and ROBO as output to controller and battery, GPS as inputs. ZigBee RX receives the location of particular person and gives that information to the control unit. RF Camera is used to display the persons view in the control section. The literature presents different types of cameras: linear camera, color camera, stereo vision and infrared camera [14]-[18].In control unit ZigBee RX receives that information and displays that in a computer through lab view software. During rescue missions, it is not tolerated that the robot returns to the operator for a change of batteries as time is very valuable in these situations. In other words, the power supply should allow the robot to work uninterruptedly for hours [19].Also, the small size of the robot is to be taken into consideration while designing the solar system. In order to locate victims in the areas of entrapment in which they are concealed, the robot should be small enough to fit and thread through any tree holes or narrow spaces encountered on its path [24].

C. *lab view sotware*

LABVIEW (short for **Lab**oratory **V**irtual **I**nstrumentation **E**ngineering **W**orkbench) is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, LAB VIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavors of UNIX, Linux, and Mac OS X. The latest version of LAB VIEW is version LAB VIEW 2011. The code files have the extension ".vi", which is an abbreviation for "Virtual Instrument". LABVIEW offers lots of additional Add-Ons and Toolkits.

Dataflow programming

The programming language used in LAB VIEW, also referred to as G, is a dataflow programming language. Execution is determined by the structure of a graphical block diagram (the LV-source code) on which the programmer connects different function-nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available. Since this might be the case for multiple nodes simultaneously, G is inherently capable of parallel execution.

Graphical programming

LAB VIEW ties the creation of user interfaces (called front panels) into the development cycle. LAB VIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector panel. The last is used to represent the VI in the block diagrams of other, calling VIs. Controls and indicators on the front panel allow an operator to input data into or extract data from a running virtual instrument. However, the front panel can also serve as a programmatic interface. The graphical approach also allows non-programmers to build programs simply by dragging and dropping virtual representations of lab equipment with which they are already familiar. The LAB VIEW programming environment, with the included examples and the documentation, makes it simple to create small applications. This is a benefit on one side, but there is also a certain danger of underestimating the expertise needed for good quality "G" programming. The most advanced LAB VIEW development systems offer the possibility of building stand-alone applications. Furthermore, it is possible to create distributed applications, which communicate by a client/server scheme, and are therefore easier to implement due to the inherently parallel nature of G-code.

Benefits

One benefit of LAB VIEW over other development environments is the extensive support for accessing instrumentation hardware. Drivers and abstraction layers for many different types of instruments and buses are included or are available for inclusion. These present themselves as graphical nodes. The abstraction layers offer standard software interfaces to communicate with hardware devices. The provided driver interfaces save program development time. The sales pitch of National Instruments is, therefore, that even people with limited coding experience can write programs and deploy test solutions in a reduced time frame when compared to more conventional or competing systems.

IV. MICROCONTROLLERS

A. *LPC1768 controller*

The LPC17xx is an ARM Cortex-M3 based microcontroller for embedded applications requiring a high level of integration and low power dissipation. The ARM Cortex-M3 is a next generation core that offers system enhancements such as modernized debug features and a higher level of support block integration. The ARM Cortex-M3 CPU incorporates a 3-stage pipeline and uses Harvard architecture with separate local instruction and data buses as well as a third bus for peripherals. The ARM Cortex-M3 CPU also includes an internal pre-fetch unit that supports speculative branches.

The peripheral complement of the LPC17xx includes up to 512 kB of flash memory, up to 64 kB of data memory, Ethernet MAC, a USB interface that can be configured as either Host, Device, or OTG, 8 channel general purpose DMA controller, 4 UARTs, 2 CAN channels, 2 SSP controllers, SPI interface, 3 I2C interfaces, 2-input plus 2-output I2S interface, 8 channel 12-bit ADC, 10-bit DAC, motor control PWM, Quadrature Encoder interface, 4 general purpose timers, 6-output general purpose PWM, ultra-low power RTC with separate battery supply, and up to 70 general purpose I/O pins.

Features:

• ARM Cortex-M3 processor, running at frequencies of up to 120 MHz on high speed versions (LPC1769 and LPC1759), up to 100 MHz on other versions. A Memory Protection Unit (MPU) supporting eight regions is included.

• ARM Cortex-M3 built-in Nested Vectored Interrupt Controller (NVIC).

• Up to 512 kB on-chip flash program memory with In-System Programming (ISP) and In-Application Programming (IAP) capabilities.

• Up to 64 kB on-chip SRAM includes:

– Up to 32 kB of SRAM on the CPU with local code/data bus for high-performance CPU access.

– Up to two 16 kB SRAM blocks with separate access paths for higher throughput. These SRAM blocks may be used for Ethernet, USB, and DMA memory, as well as for general purpose instruction and data storage.

• Eight channel General Purpose DMA controller (GPDMA) on the AHB multilayer matrix that can be used with the SSP, I2S, UART, the Analog-to-Digital and Digital-to-Analog converter peripherals, timer match signals, GPIO, and for memory-to-memory transfers.

B. *ATMEGA644 controller*

Features

• High-performance, Low-power Atmel® AVR® 8-bit Microcontroller
• Advanced RISC Architecture
– 131 Powerful Instructions – Most Single-clock Cycle Execution
– 32 × 8 General Purpose Working Registers
– Fully Static Operation
– Up to 20 MIPS Throughput at 20MHz
• High Endurance Non-volatile Memory segments
– 64 Kbytes of In-System Self-programmable Flash program memory
– 2 Kbytes EEPROM
– 4 Kbytes Internal SRAM
– Write/Erase cyles: 10,000 Flash/100,000 EEPROM
– Data retention: 20 years at 85°C/100 years at 25°C
– Optional Boot Code Section with Independent Lock Bits
In-System Programming by On-chip Boot Program
True Read-While-Write Operation
– Programming Lock for Software Security
• JTAG (IEEE std. 1149.1 Compliant) Interface
– Boundary-scan Capabilities According to the JTAG Standard
– Extensive On-chip Debug Support
– Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
• Peripheral Features
– Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
– One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture
Mode

– Real Time Counter with Separate Oscillator
– Six PWM Channels
– 8-channel, 10-bit ADC
Differential mode with selectable gain at 1x, 10x or 200x
– Byte-oriented Two-wire Serial Interface
– One Programmable Serial USART
– Master/Slave SPI Serial Interface
– Programmable Watchdog Timer with Separate On-chip Oscillator
– On-chip Analog Comparator
– Interrupt and Wake-up on Pin Change
• Special Microcontroller Features
– Power-on Reset and Programmable Brown-out
• I/O and Packages
– 32 Programmable I/O Lines
– 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
• Speed Grades
– ATmega644V: 0 - 4MHz @ 1.8V - 5.5V, 0 - 10MHz @ 2.7V - 5.5V
– ATmega644: 0 - 10MHz @ 2.7V - 5.5V, 0 - 20MHz @ 4.5V - 5.5V
• Power Consumption at 1MHz, 3V, 25·C
– Active: 240µA @ 1.8V, 1MHz
– Power-down Mode: 0.1µA @ 1.8V.

V. RESULTS AND DISCUSSIONS

In control section we will all the details about the transmitter and receiver section GPS values and we compare that GPS values and move the robo according in lab view. We also observe the missing person latitude and longitude information and also observe the fire occurring information in control section through lab view. We manually operate the robo based on comparison of transmitter and receiver section GPS values. Those results are as shown below:

Missing person information

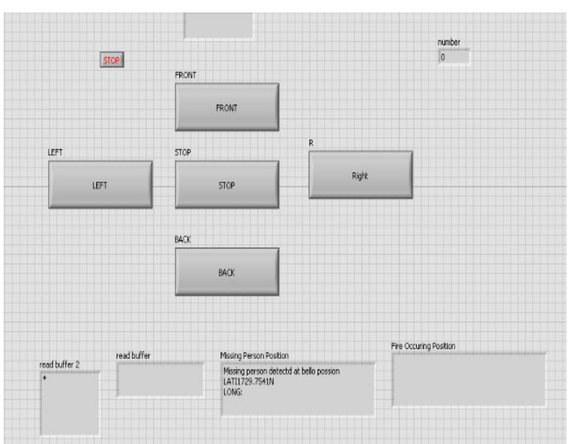

Fig3. Missing person result in labview

Fire occurring information

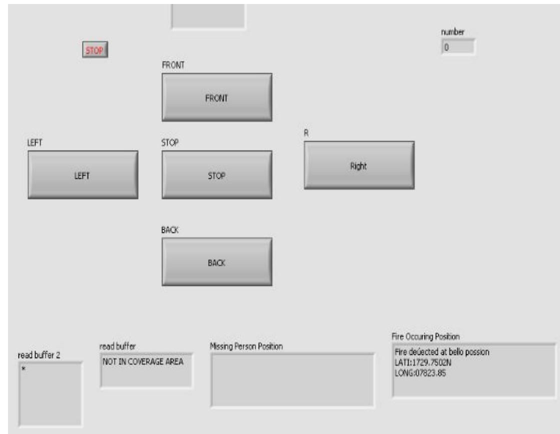

Fig4. Fire occurring result in lab view

VI. CONCLUSION AND FUTURE WORK

This paper dealt with a Zigbee based tag design for rescue purposes. It presented the improvement of an already existing rescue robot through the addition of Zigbee location technology. The latter was selected among other different technologies taking into account various aspects, mainly the cost and the efficiency to operate in though environment. We used GSM and GPS in order to send the message to control section and also knows the latitude and longitude information about the missing person. The IR camera replaced the RF Camera existing in the initial robot for cost purposes and ability to detect human heat using focal plane array sensor. Introducing the solar power supply system added a value to the rescue robot as it prevents the interruption during the rescue operation due to low battery.

In virgin forests where the branches are very dense, the efficiency of the solar powered rescue robot is limited because of the shadow effect. Therefore, future research can tackle the problem of the power supply system efficiency. Other limitations of the suggested robot is we manually operate the robo based on latitude and longitude values of the missing person in future we design automatically operated robo

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