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EXPERIMENTAL STUDIES ON WIRELESS SENSOR NETWORKS FOR THE DETERMINATION WELLNESS OF ELDERLY PEOPLE BY DESIGNING OF A MULTI-SENSOR BASED SYSTEM

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***Abstract*— Wireless Sensor Networks Application of Wellness Determination for elderly people involves functional assessment of daily activities. We reported a mechanism for estimation of elderly well-being condition based on usage of house-hold appliances connected through various sensing units. An intelligent home monitoring system based on ZIGBEE wireless sensors network has been designed and developed to monitor and evaluate the well-being of the elderly living alone in a home environment. Wellness of elderly can be evaluated for forecasting unsafe situations during monitoring of regular activities. The intelligent software, along with the electronic system can monitor the usage of different household appliances and recognize the activities to determine the well-being of the elderly. Also, the system interprets all the essential information about elder persons such as Heartbeat Rate, Temperature, Movement, lighting in the room. Basically, the system function based on the usage data of electrical and non-electrical appliances within a home. At the hardware level, wireless sensor network with ZigBee components are connected in the form of mesh topology, and a central coordinator of the sensing units collect data from the sensors connected to various appliances. In this system, a required number of sensors for monitoring the daily activities of the elderly have been used. A smart sensor coordinator collects data from the sensing units and forward to the computer system for data processing. Collected sensor data are of low level information containing only status of the sensor as active or inactive and identity of the sensor. To sense the activity behavior of elderly in real time, the next level software module will analyze the collected data by following an intelligent mechanism at various level of data abstraction based on time and sequence behavior of sensor usage.**

A wireless network containing small interdependent sensor nodes is called WSN (wireless sensor network). Environmental quantities like Light, Temperature, Pressure, Motion, Humidity, Sound etc. are to be measured and monitored with the help of this system. The data that is measured by these sensor nodes is sent to a base station using RF (radio frequency) communication. The communication between the nodes and the base station can be a single hop communication or it can be a multi hop communication depending on the remoteness of the sensor node. The base station also controls the whole network.

On each sensor node there are various hardware components. Some of those are Microcontroller, Sensor or Transducer, Radio Frequency Transceiver, Battery or some other power source. Several other components are used for signal processing purpose to bring the sensor output signal in proper form and for proper power supply required for main components. The components required for this purpose are voltage regulators, Amplifiers, resistors, capacitors and crystal oscillator of different frequencies.

The developed monitoring system is used to recognize activities of daily living and life style of elderly person living alone. Even though the monitoring system uses a limited number of sensors, it determines the daily behavior of the person. The system was installed in residential environments with ease. Moreover, the proposed sensing system presents an alternative to sensors that are perceived by most people as invasive such as cameras and microphones, making the sensors are almost invisible to the user thereby increasing the acceptance level to use the system in a household environment.

The results obtained from this research demonstrate the feasibility to build a system based on wireless sensors, to identify, and possible to distinguish between normal and abnormal situation of an elderly person living alone in a home.

Keywords: wsn, zigbee, sensor, hearbeat sensor.

I INTRODUCTION

Wireless sensor network for wellness determination of elderly involves functional assessment of daily activities and health monitoring of elderly in this A smart sensor coordinator collects data from the sensing units and forward to the computer system for data processing. Collected sensor data are of low level information containing only status of the sensor as active or inactive and identity of the sensor. To sense the activity behavior of elderly in real time, the next level software module will analyze the collected data by following an intelligent mechanism at various level of data abstraction based on time and sequence behavior of sensor usage.

1.1 EXISTING SYSTEM

- Home Monitoring Activities through camera lacks a huge acceptability among elder persons. Other than camera, infrared small motion detectors, passing sensors, operation detectors and IR motion sensors have been incorporated in the house for monitoring human activity behavior and the interpretation of human activity is limited only to a few human activities
- There are many existing systems on personal wellness monitoring and safety like RFID Communication technology and wearable health devices integrated with sensors to provide continuous monitoring of person's health related issues and activity monitoring
- RFID (Radio Frequency Identification) is the abbreviation for individual identification by radio waves. The system is able to collect positional information when a radio wave transmitted by an RFID reader strikes an RFID tag with embedded information, which is then included in the radio wave reflected to and captured by the reader
- Though these devices are for specific purposes they have severe concerns related to security, privacy and legal aspects. Usually people are reluctant to wear a system continuously on their body. So it may not be viable option for a healthy elderly people. This situation may be acceptable for a patient under rehabilitation
- Wireless sensor networks offer a number of advantages over traditional RFID implementations, First of all, the ability to rapidly deploy a multi-hop network (RFID is single hop only) allows WSNs to be used in a number of ad hoc/temporary.
- WSN is ability to locally store data when the tag/node is 'out of network' and then download that data when the tag or node comes back into a network provides an audit trail with time line, environmental conditions and location
- Using wireless sensor network it is possible to monitor elder person who is alone at home, using Zigbee module.

1.2 PROPOSED SYSTEM

- In the present work, an intelligent home monitoring system based on ZIGBEE wireless sensors networks has been designed and developed to monitor the and evaluate the well being of the elderly living alone in a home environment. Wellness of elderly can be evaluated for forecasting the unsafe situations during monitoring of regular activities

- At the low level module wireless sensor network integrated with ZIGBEE modules of mesh structure exists capturing the sensor data based on the usage of electrical appliances and stores data in the computer system for further data processing
- Collected sensor data are of low level information containing only status of the sensor as active or inactive and identity of the sensor
- The low level module consists of a number of sensors interconnected to detect usage of electrical devices, bed usage and chairs etc. ZIGBEE transceiver which communicates at 2.4 GHz (ISM) through radio frequency protocols and provides sensor information that can be used to monitor the daily activities of an elderly person
- Using wireless sensor network it is possible to monitor elder person who is alone at home, using Zigbee module and GSM module.

A. Temperature sensor:

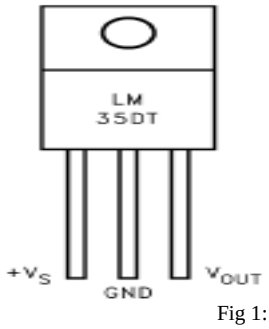

Fig 1: Temperature sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

B. Sensors for tracking and monitoring various appliances in a home

In this section research works on finding the residents behaviour by monitoring the appliance usage is discussed. The sensors installed in a smart home will monitor the usage of the appliances and devices of the person in their daily life. The behavior pattern is identified in correlation with the usage of the appliances. By using sensors to monitor the usage of appliances and devices in a house-hold, an estimate of the resident's life pattern can/may be established.The real-world situations can be sketched by the data collection, the abstraction of the data collected.

This kind of approach keeps residents' privacy without intrusion of the house, in comparison to systems like the audio-video based health care system. Smart homes that have now been developed are able to monitor elderly subjects with motor, visual, auditory or cognitive disabilities. In each case the smart house consisting of varied types of appliances and devices which are commonly used by the resident on daily basis. These appliances and devices have been fitted with sensors, actuators to detect the activities of daily life of the resident(s). It is feasible to detect certain real-world situation through capture sensors data. Some of the sensors which are most predominantly used in building a smart home are discussed below.

C. Pressure Sensor:

In many smart home applications piezoelectric pressure sensors are generally employed. This kind of sensor uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical signal. Kaddoura et al. has described such a system where a pressure sensor is centrally placed underneath each square foot block of the floor and is able to detect a foot step on any part of that block. The Gator Tech Smart House has a residential-grade raised floor consisting of floor tiles measuring one square foot each, a sensor that covers the whole floor area would be able to locate and track the position of multiple users in a smart home. The pressure sensors have a wide range of applications for smart home monitoring. The pressure sensors can be used for bed monitoring. Pressure sensors are placed on a regular grid under each bed sheet. Each sensor indicates a value that corresponds to the amount of pressure being exerted on it.

One such device manufactured by the Tactex Controls Inc, Bed Occupancy Sensor (BOSTM) which can be installed under the bed mattress to monitor the patient's condition at rest. These pressure mats can detect the changes in bed entry and exit patterns, thus identifying the changes in the physiological condition of the occupant on the bed. The

sensor monitors occupants' sleep patterns and keep track of sleepless nights. The pressure sensors can be used on grab bars in the home especially in bathrooms. This grab bars can identify and monitor the entry and exit from the shower and bathtub, as well as transfers on and off the toilet.

D. Motion / Proximity Sensor:

Proximity Infrared (PIR) sensors can be installed strategically in a home environment to detect the movement of the person within the home. This helps to find out the activity of a person. These Sensors track the presence and motion of the resident throughout the living space by infrared motion sensors which are installed in each room. This type of sensor can also be used as a fall detection device .The values can be continuously checked via an analogue to digital converter (ADC); it then packetizes the values and sends for processing. The system with this kind of sensor can detect any abnormality in the living pattern of the resident, if a person extensively stays in one room may indicate a problem with the resident's mobility or if he/she is wandering or sporadic changes in the direction of motion may indicate signs of mental anxiety or confusion. In mentioned the use of IR sensors along with magnetic switches for statistical detection of abnormal inactivity or household appliance use. One of many disadvantages of Motion / Proximity Sensor's is their limited reliability. These sensors can be deceived by warm objects and motionless individuals. Also the acceptance level of smart homes based on this technology is not much.

E. Temperature Sensors:

Temperature sensor can be used in a smart home to monitor house-hold temperature changes. These sensors can provide information regarding stove or oven status, as well as faucet water temperature . When installed on the appliances like fridges the usage of the fridge can be known.

F. RFID Sensors:

Radio Frequency Identification sensors have proved useful for detecting a variety of fine-grained activities. Patterson et al. report accuracies of around 80% for recognition of 12 activities in a kitchen instrumented with 60 RFID tags. A common problem of elderly people and patients with early stages of Alzheimer's or dementia is forgetfulness where they have placed commonly used objects. RFID tags can be placed on commonly misplaced objects to retrieve them at home . Tags do not require a power source of their own, but they get the energy they require from a nearby reader which they then use to transmit their designation to the reader. RFID enabled sensors can be installed at the door entrance/hall way to detect and monitor the person, which room he/she is in. The main objective of this sensor is to detect if a person with early stages of Alzheimer's disease goes out of his/her house. RFID sensing system consist of a series of active/passive scanners that are located in the ceiling of each room, to detect persons tagged with RFID passes through the entrance of a room to determine who it is that is in the area . The main disadvantage of RFID sensors is the number of sensors that are needed to be installed in a home and also there is a need for the inhabitant to carry a RFID reader at all times. This may cause inconvenience to the user and also makes it impractical in 24/7 monitoring.

G. *Switch Sensors*:

Magnetic switches can be used on doors throughout the home, kitchen appliances, such as the oven, refrigerator, or dishwasher, which monitors whether the appliance is 'open' or 'closed'. This is useful in monitoring the entry and exit from the various rooms of the home. The MIT Place Lab is a residential condominium, which has been designed to be an observational facility for the scientific study of people in home environments using over 300 switch sensors which are installed in nearly every part of the home ranging from switch

sensors on lights, cupboards, electrical appliances faucet, and mail boxes. The switches can be placed all around the knobs of different appliances, in order to detect the state of each of them. The data from all of these sensors is sent to a central processing and storage device wirelessly to detect the activities of daily living in the facility and to monitor the activity of the resident.

H. Vibration Sensors:

Accelerometers can be placed in a smart home for detecting vibrations, when a person moves around the house [83]. These can be installed on everyday objects like chairs,sofas, bed etc. to monitor the resident's movements. Impacts with the sitting furniture could represent a lack of muscular strength or control over time. Impacts with the floor, however, could represent the occupant losing their balance and falling, which may require immediate attention. With proper installation the vibration sensors can detect the fall/slips of the elderly person at the smart home in an efficient way.

I. Water flow monitoring Sensors:

Most common consumable that a household uses is water. Monitoring the water flow into the house will give a general overview of when water is being used in the home. Without water people cannot survive. Water is used for drinking and washing. People also use water to have a shower or bath. It is used in a toilet system and also used to clean clothes and dishes. This covers a large variety of systems in a home. The water use in the household can be monitored with the use of water monitoring sensor .

J. Current Sensors:

Detection the usage of electrical devices for general equipment (such as the kettle and toaster) acts as a medium between the power socket and the equipment to be monitored. The level of monitoring can range heavily depending on each case; some people may object to a high level of monitoring and are happy with one or two simple rules such as the kettle. C. Kiluk [85] has reported a method of an alarm system which is intended for monitoring of apartments for elderly and/or handicapped person in his invention. The energy consumption of the apartment is measured and recorded over a period in a computer. The actual energy consumption of the apartment is compared with the expected energy consumption which is recorded in the computer to generate different degree of alarm level.

Housing Learning & Improvement network published [86] a smart home definition offered by Interetec, which states that a smart home is a dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be remotely controlled, monitored or accessed using current sensors.

K. Heart beat sensor:

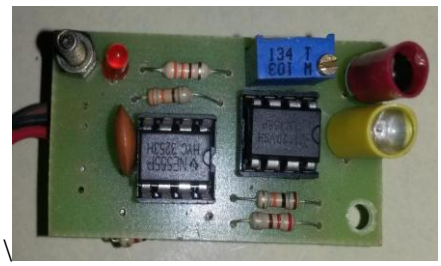

Fig 2: Heart beat sensors

The sensor consists of a light source and photo detector; light is shone through the tissues and variation in blood volume alters the amount of light falling on the detector. The source and detector can be mounted side by side to look at changes in reflected light or on either side of a finger or earlobe to detect changes in transmitted light. The particular arrangement here uses a wooden clothes peg to hold an infra red light emitting diode and a matched phototransistor. The infra red filter of the phototransistor reduces interference from fluorescent lights, which have a large AC component in their output.

The skin may be illuminated with visible (red) or infrared LEDs using transmitted or reflected light for detection. The very small changes in reflectivity or in transmittance caused by the

varying blood content of human tissue are almost invisible. Various noise sources may produce disturbance signals with amplitudes equal or even higher than the amplitude of the pulse signal. Valid pulse measurement therefore requires extensive preprocessing of the raw signal.

The setup described here uses a red LED for transmitted light illumination and a pin Photodiode as detector. With only slight changes in the preamplifier circuit the same hard- and software could be used with other illumination and detection concepts. The detectors photo current (AC Part) is converted to voltage and amplified by an inexpensive operational amplifier (LM358). A PIC16F877 microcontroller converts the analog signal with 10 bits resolution to a digital signal. An average is calculated from 250 readings taken over a 20 milliseconds period (This equals one period of the european power line frequency of 50 Hz).

L. LDR Sensor:

Although the M1 has a Sunrise / Sunset clock built in that will determine when the sunrises and sets, hence if it is Dark or Light outside, often inside light is a totally different subject. The system needs to know what the light level is in a particular room so when automating internal lighting it needs to know if the lights should be activated or not. Otherwise it defeats the purpose of energy saving by Automating the lights for cost savings.

One way of doing this is with a $5.00 item from Ness with our Ness-LDR. This LDR wires directly into a M1 Zone Input (Any Zone). The Zone need to be programmed as a Analog Zone. The more light the LDR sensor has on it the lower the voltage the zone will read and the lower the light level, the higher the zone voltage. The following table will provide a summary of the type of voltages v's light (Lux) you could expect to read.

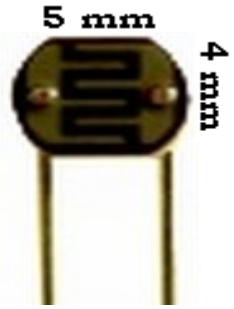

Fig 3:LDR Sensor

As the Ness LDR is very small (approx 5 mm x 4mm x 2 mm) it can be installed anywhere. Although it can be installed on a PIR detector consideration must be given as to the amount of light near the ceiling in a corner compared to lower near the floor. As a suggestion you could mount it on a blank electrical plate attached to the wall near the floor / power point level where the light is more even. This would change from site to site, room by room The LDR Sensor is wired directly to any Zone input. (Even the Keypad Zone input, (where a good location for the LDR could be on the keypad)) It does not need power.

MEMS Sensor:

MEMS accelerometers are one of the simplest but also applicable micro-electromechanical systems. They became indispensable in automobile industry, computer and audio-video technology. This seminar presents MEMS technology as a highly developing industry.

Fig 4: MEMS Sensor

An accelerometer is an electromechanical device that measures acceleration forces. These forces may be static, like the constant force of gravity pulling at our feet, or they could be dynamic - caused by moving or vibrating the accelerometer. There are many types of accelerometers developed and reported in the literature. The vast majority is based on piezoelectric crystals, but they are too big

and to clumsy. People tried to develop something smaller, that could increase applicability and started searching in the field of microelectronics. They developed MEMS accelerometers. The first micro machined accelerometer was designed in 1979 at Stanford University, but it took over 15 years before such devices became accepted mainstream products for large volume application. In the 1990s MEMS accelerometers revolutionised the automotive-airbagsystem industry. Since then they have enabled unique features and applications ranging from hard-disk protection on laptops to game controllers. More recently, the same sensor-core technology has become available in fully integrated, full-featured devices suitable for industrial applications. Micro machined accelerometers are a highly enabling technology with a huge commercial potential. They provide lower power, compact and robust sensing. Multiple sensors are often combined to provide multi-axis sensing and more accurate data.

Zigbee module:

The XBee/XBee-PRO RF Modules are designed to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within the ISM 2.4 GHz frequency band and are compatible with the following:

- XBee RS-232 Adapter
- XBee RS-232 PH (Power Harvester) Adapter
- XBee RS-485 Adapter
- XBee Analog I/O Adapter
- XBee Digital I/O Adapter
- XBee Sensor Adapter
- XBee USB Adapter
- XStick
- Connect Port X Gateways
- XBee Wall Router.

The XBee/XBee-PRO ZB firmware release can be installed on XBee modules. This firmware is compatible with the ZigBee 2007 specification, while the ZNet 2.5 firmware is based on Ember's proprietary "designed for ZigBee" mesh stack (EmberZNet 2.5). ZB and ZNet 2.5 firmware are similar in nature, but not over-the-air compatible. Devices running ZNet 2.5 firmware cannot talk to devices running the ZB firmware.

GSM Modem:

A GSM modem is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves.

A GSM modem can be an external device or a PC Card / PCMCIA Card. Typically, an external GSM modem is connected to a computer through a serial cable or a USB cable. A GSM modem in the form of a PC Card / PCMCIA Card is designed for use with a laptop computer. It should be inserted into one of the PC Card / PCMCIA Card slots of a laptop computer. Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate.

As mentioned in earlier sections of this SMS tutorial, computers use AT commands to control modems. Both GSM modems and dial-up modems support a common set of standard AT commands. You can use a GSM modem just like a dial-up modem.

In addition to the standard AT commands, GSM modems support an extended set of AT commands. These extended AT commands are defined in the GSM standards. With the extended AT commands, you can do things like:

- Reading, writing and deleting SMS messages.
- Sending SMS messages.
- Monitoring the signal strength.
- Monitoring the charging status and charge level of the battery.
- Reading, writing and searching phone book entries.

The number of SMS messages that can be processed by a GSM modem per minute is very low, only about six to ten SMS messages per minute.

II OPERATION AND RESULTS

Wireless sensor network for wellness determination of elderly is working with sensors includes heart beat sensor, temperature sensor, LDR sensor, MEMS sensor, and Driver unit which is connected to two external devices such as fan and light. Sensors sense the respected values and send it to the ARM7 processor, that will be processed and send it to the Zigbee module and GSM module, while coding we will set particular value to the temperature sensor, heart beat sensor, LDR sensor, MEMS sensor, when it exceeds that particular value then we will be getting message to our mobile through GSM module.

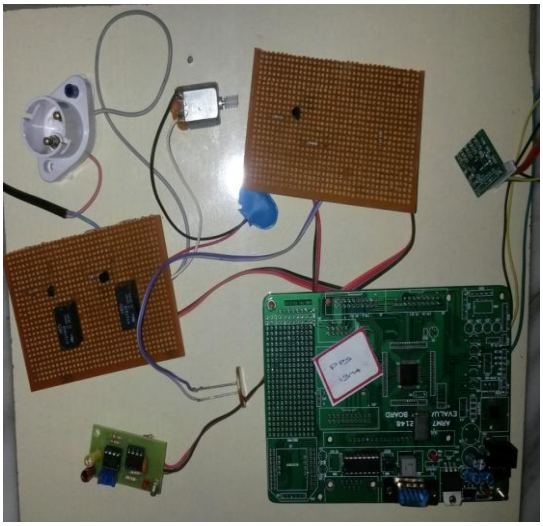

Fig 5: Integration of all sensors with ARM7

The temperature and heart beat rate values are displayed in our personal computer as given below.

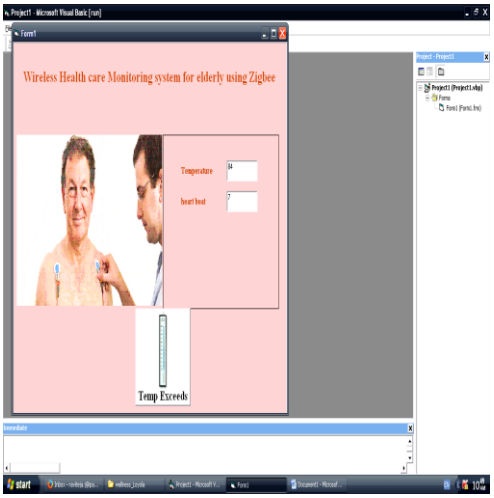

Fig 6: Temperature & Heart beat rate display

III CONCLUSION

In this system, the required number of sensors for monitoring the daily activities of the elderly have been used. A smart sensor coordinator collects data from the sensing units and forward to the computer system for data processing. Collected sensor data are of low level information containing only status of the sensor as active or inactive and identity of the sensor. To sense the activity behavior of elderly in real time, the next level software module will analyze the collected data by following an intelligent mechanism at various level of data abstraction based on time and sequence behavior of sensor usage.

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