A qualitative review for wireless health monitoring system

Atika Arshad¹, Ahmad Fadzil Ismail, Sheroz Khan, AHM Zahirul Alam, Rumana Tasnim, Syed Samnan Haider, Mohammed M. Shobaki and Zeeshan Shahid
Department of Electrical and Computer Engineering
International Islamic University
53100 Kuala Lumpur, Malaysia
E-mail: atikaarshad@hotmail.com

Abstract. A proliferating interest has been being observed over the past years in accurate wireless system development in order to monitor incessant human activities in health care centres. Furthermore because of the swelling number of elderly population and the inadequate number of competent staffs for nursing homes there is a big market petition for health care monitoring system. In order to detect human researchers developed different methods namely which include Field Identification technique, Visual Sensor Network, radar detection, e-mobile techniques and so on. An all-encompassing overview of the non-wired human detection application advancement is presented in this paper. Inductive links are used for human detection application while wiring an electronic system has become impractical in recent times. Keeping in mind the shortcomings, an Inductive Intelligent Sensor (IIS) has been proposed as a novel human monitoring system for future implementation. The proposed sensor works towards exploring the signature signals of human body movement and size. This proposed sensor is fundamentally based on inductive loop that senses the presence and a passing human resulting an inductive change.

1. Introduction
Generally the phrase wireless health monitoring system is used for describing a type of patient care system which involves monitoring of a patient's condition via wireless technology located at a healthcare facility which is remote with respect to the location of the patient, allowing overcoming inconveniences of services or devices. An advantage of having wireless monitoring systems is that they are inexpensive to install because extensive wiring is no longer required between sensors and the data acquisition system. Wireless communication can precisely unknotted a patient from a monitoring entity, which is particularly valuable to supervise for long time. Researchers have been incessantly exploring that wireless sensors, as an exciting technology are able to process the human response and monitor data for signs of irregularly human actions. Moreover, wireless sensors have limitations that require novel system architectures and modes of operation. This paper is intended to serve as an overview of the several approaches available to be used in health monitoring systems.

¹ Atika Arshad, Email: atikaarshad@hotmail.com
Department of Electrical and Computer Engineering International Islamic University
2. State of the current art
Recent surveys reveal that elderly individuals or aged people have the strongest impact on long-term healthcare public investments [1-4]. Therefore, current health care system developed should be able to provide efficient, high quality and inexpensive health care services to elderly people by reducing mobility, primarily enabling the elderly to live independently like entering/leaving a room, or taking medication on time, utilization of cooking, washing, and toilet facilities thus allowing elderly people to remain engaged in their normal activities of daily life.
Nowadays, there are several sensors widely used for automated human activity monitoring and detection such as Global Positioning System (GPS), cellular modem, infrared (IR) sensors and image processing, etc.

Previously GPS and cameras were one of the most general way of tracking human activities. Satellite is being used in GPS to give information required to monitor the patient, for instance longitude/latitude coordinates, speed, time and direction. Nevertheless this way of tracking human activities is considered quite undependable as GPS are generally inadequate by dreadful weather, landscapes, and buildings (e.g., indoor) [5].

Cellular modem or the mobile monitoring system allows cellular phone to access the network. The phones will be able to transmit data where the mobile base station is located however the mobile phones cannot communicate when they are unable to connect to the base station [6].

The Smart Medical Home technology makes use of infrared sensors and video cameras, this technology provides medical assistance to patient and health care expert, however IR is sensitive to bad weather conditions and ambient light hence conflicts in identifying and monitor the subjects outside of the home [6]. Image processing usually necessitates extorting required information from data offered by an imaging sensor which gets its information from TV camera or an infrared camera. However, the inadequacy of these cameras is that they require overcoming detection artifacts caused by shadows, and reflections [7-8].

Another method for human detection was published in [9]. The approach used was based on Near Field Imaging (NFI). This technology is able to detect falls i.e. a person lying on the floor, electrodes made of thin films are positioned under the floor surface and these electrodes will produce electric field thus detecting objects near the floor, such as human body. A paper on remote monitoring pacemaker system has been presented [10] employing a near-field coupling technique. A recent work in [11] presents the findings that demonstrate the use and application of magnetic sensors in automobiles where a deployed sensor can detect seat occupancy of a travelling passenger. The detection of vacant or occupied status of seats in vehicles can improve an important stimulus for the timely operation of car airbag safety system. Effective and timely measures can certainly prevent passengers from receiving fatal injuries during accidents.

Another similar concept has been reported in [12], where the authors have applied an inductive transducer method. The distinctive impedance peaks were characterized by passive component in high frequency range under known DC biasing condition. The impedance behaviour of 30Ω and 220Ω resistor and 250μH and 47μH (chosen as the components under test) were detected for a wide range of frequency under different biasing conditions. The circuit element inductance has been proved in showing variations as a function of frequency. The main reason for characterization of resistive elements was to enable the designer to select proper component and deviation or drift in functional specifications and also to achieve optimal circuit performance.

In the most recent reported works [13-14], the authors presented the design idea of a road condition monitoring system (vehicle detection) using inductive sensor loop-based intrusive transducer buried under the surface of roads. The experimental results showed that classifying the sizes of heterogeneous...
traffic was possible besides merely counting the passing by vehicles. The basic principle used here is that a vehicle passing over the sensor brings about a change in the inductance of the transducer loop buried under the road.

Moreover by using the concept of the works reported by [11-14] the proposed work aims at deriving signature signals using multiple inductive loop shaped coils used as inductive sensory transducers for the purpose of detection and identifying wave shapes with features representative of different human body sizes and passing gait. Most of the existing sensing technologies provide measurement with its own shortcomings, affecting the results of the measurement process. Among all the sensing techniques, inductive loop sensors had demonstrated a better reliability.

A general review of existing, relevant technology and products was then undertaken to determine the extent to which these criteria were already being met and to identify the sorts of issues and technologies that might require special consideration in order to develop a proof-of-concept system that would fully satisfy the criteria.

The review indicated that the identified criteria were not being met with existing products and highlighted the techniques of sensing and transmission of information as major areas requiring attention in the development of a system.

3. Proposed architecture of health care system

Researchers have been exploring various novel forms of detectors and health care systems in order to provide more precise and detailed information. In this paper, a novel method of monitoring health care system is proposed. The proposed sensing technique produces changes in the electromagnetic field which is due to the presence of the conductive material. Here, a monitoring system will make use of inductive loops that can collect unique signature waves from inductive loop shaped coils (as in inductive transducers). The produced wave shapes include features representing target body’s conditions. Different size of humans or different human postures can be associated with distinctive signature waveforms.

Fig.1 presents a proposed human monitoring sensor model which is typically a passive sensor assembly modeled as an LC circuit [15] where the sensor acts as a changing capacitive, inductive or resistive element. The inductively coupled transceiver and passive sensor system can be modeled as the primary and secondary sides of an air-core transformer respectively. An inductive link is formed by a loosely coupled transformer consisting of two inductor coils $L_1$ and $L_2$ placed relatively close to one another with currents $I_1$ and $I_2$ and having primary and secondary side with their effective series resistance $R_1$ and $R_2$.

![Fig.1 A schematic illustrating human monitoring wireless sensory system](image-url)
The external or the primary coil is driven by an alternating current to create an electromagnetic field with its magnitude dependent on the dimensions of the coil, the drive current and the frequency of operation. The magnetic flux generated by the primary coil will be linked to the internal or the secondary coil thus inducing a current through this secondary coil which is proportional to the rate of change of the flux and the number of turns in the secondary coil (Faraday’s law of electromagnetic induction). The proportion of energy captured by the secondary coil can be represented by the coupling factor, \( k \). This value (dimensionless and always between 0 and 1) is an important factor in the operation of any inductively coupled system. The inductance impedance of the transformer model is

\[
V_1 = j\omega L_1 I_1 + j\omega MI_2
\]

\[
0 = j\omega L_2 I_2 + j\omega MI_1
\]

(1)

where the mutual inductance, \( M \) is between loop  and loop  is given by . The transfer function of the proposed monitoring system is derived in Equation (2).

\[
H(s) = \frac{V_o}{V_{in}} = R_1 + j2\pi fL_1 + \frac{(2\pi f)^2 M^2}{R_2 + j(2\pi fL_2 - \frac{1}{2\pi jC_2})}
\]

(2)

The detection is carried out as a function of frequency, the signal detected at the secondary coil is simply a function of the electromagnetic coupling and the impedance of the primary coil. Here the LC circuit identifies the resonant frequency of the inhabitant humans, hence the resonant frequency of the LC circuit changes when a change is brought in either inductance or capacitance. Hence in the proposed work the detection principle is the change introduced in the inductance of the sensor which will shift the resonant frequency. The shift in frequency can be given by the formula in Equation (3).

\[
f = \frac{1}{2\pi\sqrt{LC}}
\]

(3)

The inductance and the capacitance values are chosen to resonate by detection, that is a change in human movement will bring about the change in it’s inductance.

4. Results

The sensor portion of the system consists of an LC circuit. The LC circuit has an inductor with a fixed value of capacitor. The detection principle in this work is the shift brought about in the resonant frequency when there are changes in inductance of the employed sensor. The change in resonant are assumed to be under the following scenarios:

- Case 1: assume that there is no object present in the surrounding area; mathematically this is represented by an inductance of 100\( \eta \)H.
- Case 2: assume that there is a metallic object present in the surrounding area, shown by an inductance of 100\( \mu \)H.
- Case 3: assume a human subject present in the area be represented by inductance value of 100mH. The power transfer reaches a maximum value at a certain frequency which can be
referred to as a resonant frequency for that system and it should be tuned to that frequency to get the maximum output.

Fig.2 Magnitude and phase response for the resonance frequency plots of three different assumed scenarios

Using the scenario stated earlier, the values for the sensor’s inductance are \( L = 100\text{nH} \), \( L = 100\mu\text{H} \) and \( 100\text{mH} \) with a capacitor having a value of \( 15\text{pF} \). The calculated resonant frequency of the LC circuit is 41.09 kHz, 1.30 kHz and 129.95 kHz respectively. This is within the low frequency range for biomedical implanted devices. From the assumed results, it is obvious that the distinctive impedance waveforms can be represented as the change in human movement for real time biomedical application.

5. Conclusion
The presented health care monitoring technologies have carried out the detection via wireless means. The modeling and design of few schemes have been discussed in these works. In accordance with the reviewed works, it is apparent that the IIS monitoring system will be able to provide a better solution in term of reliability that ensures interoperability with external health information systems. The system will be able to obtain feedback reports which can be used to inform patients about their daily monitored activities.

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