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Internet of Hospital Things (IoHT): Designing a Monitor System of Healthcare for Neonates

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Abstract. A newborn's requirements are extremely intense since an infant needs to take time to acclimate to the outer environment. Newborns should be kept in the incubator within a certain amount of time after being introduced to the proper incubator protocols. This is based on the infant's health status. Baby incubators are generally rejected because of their improper designs. This study is an initiative to make use of engineering technology to provide preterm babies a stable environment in order to limit the numbers of early deaths. Therefore, a health system has been designed to take care of this category, for hospitals in Iraq are still lacking it. This paper also aims at developing a platform to provide a means of binary human communication between a doctor and a patient when dealing with each other.

Keywords: Internet of Hospital Things, intelligent sensors, smart neonatal health monitoring system, wireless sensor technologies.

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1. Introduction

A typical duration of pregnancy is around 40 weeks and full-term babies are to be delivered between 37 and 42 weeks of pregnancy whereas premature babies are born before 37 completed weeks of pregnancy [1]. Premature birth forms but a significant public health issue. According to a study conducted on premature infants, it has been found out that these creatures are usually in danger of having adult diabetes, high blood pressure and certain heart and respiratory issues to the extent that they die shortly after birth. Later, premature infants may otherwise turn into children with cognitive impairments, cerebral palsy, and long-term issues such as blindness and loss of hearing [2]. All this suffering can be traced back to premature birth. This means that premature infants need to be treated by implementing highly advanced and costly technological devices. The main reason for the present-day underutilization is the intricacy of design of incubators that has made them too difficult for a good deal of users to maintain if accessible. This is on the one hand.

On the other hand, a significant percentage of the very light-weight babies that die during transit to hospitals cannot be transported in a temperature-controlled setting. That is, these infants are but extremely vulnerable. For the budget-conscious hospitals, the market is comprised of tiny players that may satisfy the need to cater to them. These players, however, have proved to be very costly, with many of the designs being ergonomically subpar. To reduce the large number of preterm babies' deaths, one must plan to create a less expensive - but more reliable -incubator to meet the needs of low-budget institutions. One million newborns in the poor world die each year due to the consequences of heat and loss of weight and dehydration that may be avoided by using incubators that are commonly called critical care units.

In the Iraqi hospitals there are no electronic systems that help the staff to monitor the little babies. Therefore; the design proposed here aims to provide a device that is worn by moms to encourage Kangaroo Mother Care (KMC) [3]. At the same time, this KMC can also operate on its own as an incubator. It is hoped that this is going to be a tremendous help in neonatal critical care, and it will be of some help of the families of newborns by making their house more comfortable. Kangaroo Mother Care is difficult to give in certain circumstances. Anyhow what will exist is the market for a device that encourages KMC, and helps incubate moms in cases when Kangaroo Mother Care cannot be applied. In short, it of help to women in lower-resource settings. By so doing, one can get an embrace incubator that works as a sleeping bag for the baby: a solo newborn incubator [4].

The Internet of Things (IoT) links both the real world and virtual world via the use of sophisticated communication and data collection technologies. The existence of this cause results in IoT being a critical area of study in the twenty-first century. Other IP-based wireless technologies such as Wi-Fi have led to the development of a broad range of WSN applications including environmental monitoring, forest fire warning, and home automation. This work has been conducted in order to design a remote-control system that helps users monitor the temperature and oxygen levels of premature infants.

This research work has utilized a design IoHT real-time healthcare system to solve a problem of relying mainly on the manual and inaccurate method in hospitals all over Iraq. It is by introducing the cost-effective and remotely proposed system; namely, the Arduino Uno and ESP8266 Wi-Fi module, one can safely monitor the child's temperature, oxygen rate and heartbeat and save the lives of as many newborns as possible.

All that follows the introduction section, or better to say section one, is organized as follows. Section two reviews the fundamental concepts and principles that the design relies on. Section three describes all the tools and material used in the system implementation including data acquisition and processing, and data visualization parts. Section four discusses the practical phase of the system and it constitutes the real work that has been carried out in order to fulfill the objectives the study. Section five presents the conclusions and recommendations for further studies.

2. Related works

The first account of an infant warming tank was published in 1857 by a French pediatrician, Deuce [5]. Anyhow, the first published account of an open, double-walled warming tank for infants

can be dated back to the days prior to World War II. It was attempted in a hospital in Moscow; where the tank was operating in the Imperial Foundling Hospital. More precisely, the Moscow hospital began using the double-walled warming tank invented by Carl Crude by 1874 [6].

The past 150 years have produced dramatic changes in neonatal and infant mortality and morbidity (Figures 1); the second half of the twentieth century in particular witnessed an explosion of new concepts and technology in perinatology and neonatology [7-8].

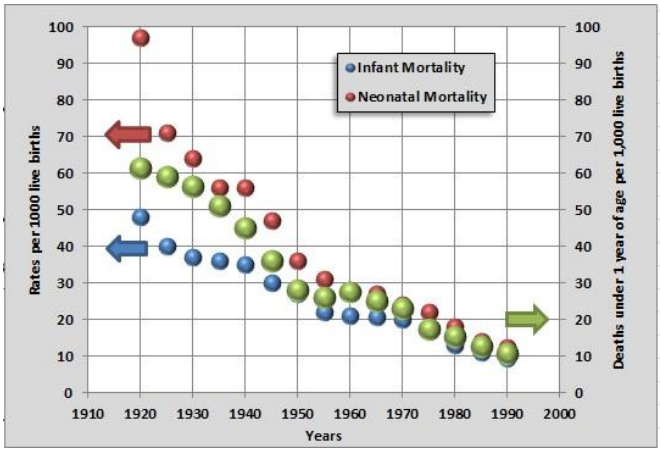

Fig.1. Infant and neonatal mortality rates for the United States, 1916–1990.

Review of literature on chronic illnesses shows that IoT-based healthcare solutions have been implemented in the health sector [9]. Asthma is a major concern in many countries, and clinical recommendations have emphasized the need of at-home monitoring in the development and maintenance of asthma control, which is defined as the degree to which therapy reduces the symptoms of asthma 2007 [10]. In the subject of IoT healthcare for smart data monitoring, there is a lot of state-funded research going on. It can not only help research workers keep track of data, but it can also help them give each patient the care he or she needs to recover.

In order to improve the performance of healthcare services offered, healthcare applications and systems have adopted a variety of innovation technologies/devices. The majority of these systems and apps contribute to the usage of IoT or smart technology devices to improve healthcare services. IoHT refers to these IoT applications and healthcare devices. The healthcare gadget uses a dedicated sensor and has a high level of data collection precision. The following characteristics are present in this sort of device: data interim storage method, long working time, wearability in conjunction with constancy.

As more advance in technology has been made, manual control has been replaced by automated control. The infant incubator is not an exception in this constantly evolving process. Hence, progress in this field will continue to advance as far as the world is ready for it.

Joshi et al in [11] created a wireless monitoring system for Neonatal Intensive Care Units (NICU), which are rooms specifically established for preterm and weak newborns. The system mimics the warmth and care provided by its mother's womb. Many issues are still unnecessarily raised by those who do not pay enough attention to thermo regulations.

The design and implementation of a digital and programmable temperature system for the Oxygen ire Servo Baby Incubator was referred in [12]. Besides, Amer et al [13] have developed their Artificial Neural Network (ANN) simulation of preterm baby incubator control system by utilizing the back propagation approach. Temperature, humidity, and oxygen concentration sensors are utilized to indicate the interior incubator environment. Prior training using sensors results in a report going to the ANN, which identifies the relevant situation and decides the appropriate response for that case based on training.

Kumar et al in [14] also developed a baby incubator with better usability as part of the objective of their research work which provided guidance for fulfilling the requirements of customers. Then this very achievement came to be used as a foundation for creating a technology-enabled QFD, which in turn led to the production of the final design specification (PDS).

The work presented in [15], have designed an infant incubator to help others find what they need and convert those ideas into the development of technically skilled voice for a successful product design specification (PDS), which finally evolved into the finished design specification (PDS). The proposed work proved that the crying need for a newborn incubator that maintains constant temperatures and humidity levels can be satisfied [16].

3. Materials and methods

In this work a system consisting of a set of hardware and software components that are interact together. The overall system is divided into the following four units:

- The data collecting unit.
- Arduino Uno microcontroller.
- ESP Wi-Fi module.
- PC IoHT application.

The system proposed in this paper performs the reading data, processing data, sending data, and displaying data according to the following flowchart shown in Figure 2.

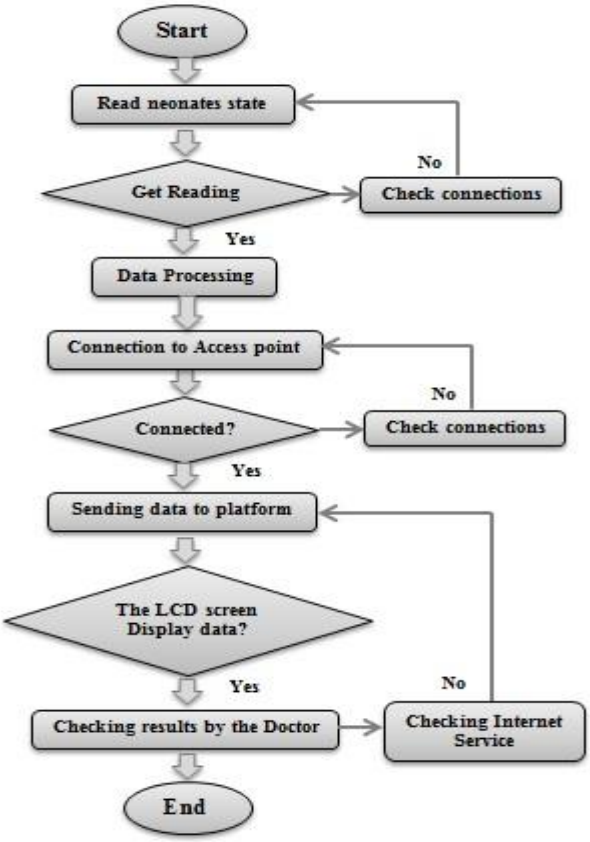

Fig. 2. Flowchart of the Architecture of Healthcare for neonates System.

Figure 3 shows how the internet is used to provide the doctor with the data collected from the patient. Communication over the internet is a significant element of this proposed system.

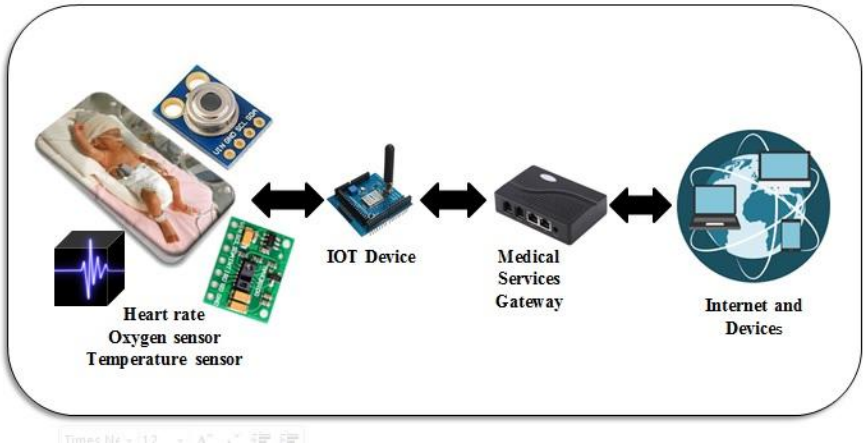

Fig.3. IOT Healthcare System: A Vision

4. A Proposed Hardware Model

The proposed hardware model has been made by connecting a number of different modules and sub-modules together and then connecting the circuit to a power supply. Arduino Uno is an open-source microcontroller board that uses a Microchip. ATmega328P microprocessor is used to process the data from sensors. This work also utilizes The MAX30100 as a pulse oximetry and heart rate monitor sensor system with integrated oxygen sensors and a digital temperature sensor. The MLX90614 is capable of measuring temperatures ranging from -70 °C to 382.2 °C. The sensor utilizes infrared rays to determine the temperature of the item without the object being in touch, and it informs the microcontroller about the measurements via the I2C protocol [17-18].

Furthermore, oximetry, pulse rate and measuring temperatures data are processed by the Arduino and sent to the continuous monitoring devices. After complete connection, the hardware model looks like what is shown in figure 4.

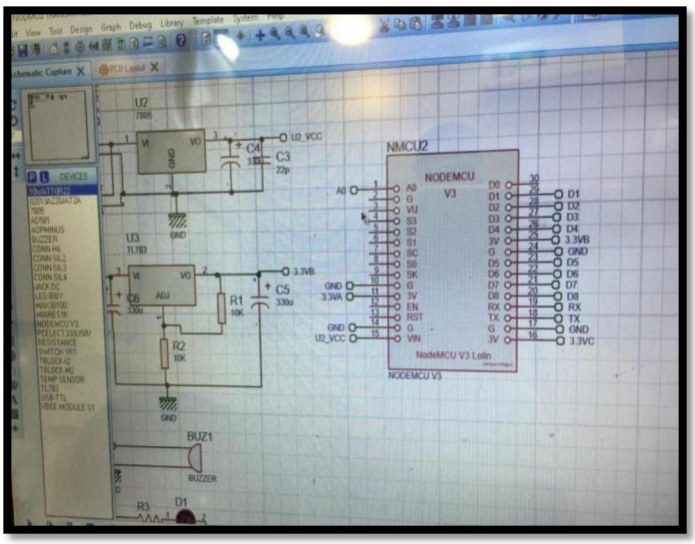

Fig.4. Schematic diagram of the proposed IoHT healthcare system designed in Fritzing

5. The Results

The proposed IoHT healthcare system consists of a monitoring system which utilizes oximetry sensor and temperature sensor to measure oxygen, heart rate and the temperature for newborns respectively. Thus, the experimental methods focus on these three parameters to show the usefulness of the sensors as shown in Figure 5.

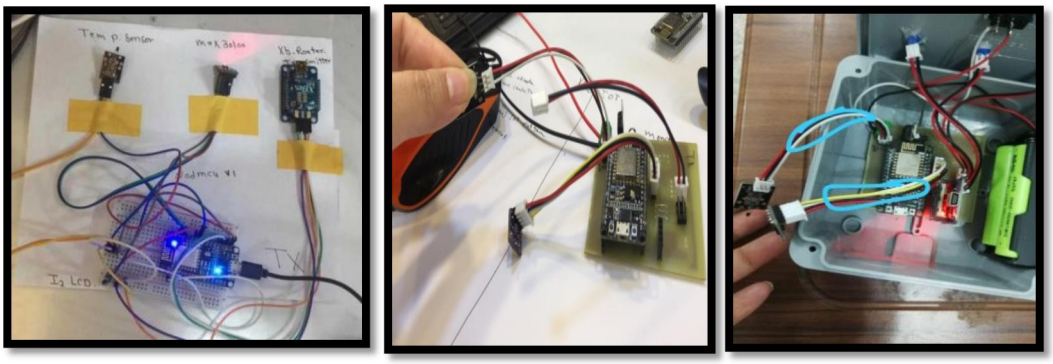

Fig.5. The setup of the Circuit for the IoHT hardware monitoring prototype.

The pulse sensor chosen for the design has to be accurate enough to efficiently catch any changes that may endanger the neonate's health. First of all, it is necessary to estimate the intervals at which heart rate turns to be crucial in order to determine the requisite accuracy. When awake, a neonate's heart rate must be between 100 and 165 beats per minute, and when sleeping, it should be between 90 and 160 beats per minute.

Because the pulse rate ranges are so wide, the pulse sensor's accuracy and precision can be slightly more flexible than the temperature sensor's. As a result, the pulse sensor's accuracy might be as high as +/- 5 beats per minute, with a resolution of 5 beats per minute, and significant alterations may still be predicted and avoided.

The collected data have been divided into three sections as shown in Figure 6. By working with the health system for premature infants, the system can be made to work continuously for children whose conditions need close monitoring. This results in the reduction of the number of medical staff. The sensors being brought together in one system reduce the number of devices dispersed in public hospitals. This facilitates the work of the system and reduces monitoring. All contributors that have been mentioned above will reduce the number of premature infant deaths. The normal pulse rate for infants and newborn babies (0 ~ 3 months), and infants (3 ~ 6 months), Infants (6 ~ 12 months) are Pulse Rate Range (BPM) (100 ~ 150), (90 ~ 120) and (80 ~ 120), respectively. The health care provided is proven in table (1), which shows the result of infant's oxygen, heart rate and the temperature.

Table 1. IoHT Healthcare system results for small babies.

Infants	Oxygen	Temperature	Heart rate	Time of reading
Infants 1	96%	36	100	1 minute
Infants 1	98%	36	102	2 minute
Infants 1	97%	36	95	3 minute
Infants 1	97%	36	102	10 minute
Infants 1	97%	36	101	30 minute
Infants 1	97%	36	100	45 minute
Infants 1	96%	36	103	1 hour
Infants 2	97%	36	108	1 minute
Infants 2	97%	36	102	2 minute
Infants 2	96%	36	105	3 minute
Infants 2	97%	36	108	10 minute
Infants 2	97%	36	106	30 minute
Infants 2	98%	36	108	45 minute
Infants 2	98%	36	108	1 hour

As denoted in the table above, the sensor shows results within the range of the benchmark results with real time data measurement as shown in Figure 6. These results show the usefulness of the chosen pulse rate sensor for the proposed infant monitoring system.

Fig.6. Real time data measurement (Users testing on a neonate).

Figure 7 shows an infant's pulse rate in real time as created with processing software. The physician can then go to the website, view the ECG graph, and take the required steps to enhance the patient's health.

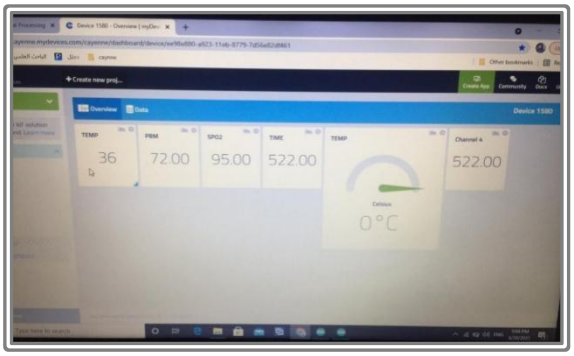

Fig.7. Screenshot of a typical webpage via implementation of IoHT system

6. Conclusions

This work aims at designing an IoHT system for monitoring the newborns. This system is an IoHT application that helps physicians to monitor the oximetry, temperature, and heart state of their patients. Among the main strength points the proposed system has are its being easy to connect and use by doctors and nurses. Besides, this device is easy to carry and control remotely. It is also cost-effective and easily equipped. Furthermore, this system can provide fast response in urgent cases. Hence, it is hoped that this system is of some help to provide the healthcare lots of premature infants receive in hospitals. Hence, this system can beyond doubt save lives.

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Hamid A. Al-Asadi *was born in Iraq. He received the B.Sc and M.S. degrees in electrical engineering and communication engineering from Basra University, Basra, Iraq, in 1987 and 1994, respectively, and the Ph.D. degree from the University Putra Malaysia in Communication Network Engineering in 2011. From 1995-2018, he was a faculty member in the Department of Computer science, Basra University. In 2014, he joined the Basra University as a Full Professor. Since November 2018 he has been head of the Department of communication engineering in the Iraq University College, Iraq. His research interests include optical communications, optical fiber, information theory, Wireless Network, Sensor Network, Fuzzy Logic and Neural Networks, Swarm Intelligence, computer engineering, and Artificial intelligence. He is member of scientific and reviewing committees of many journals and international conferences in the domains of Computer and communications engineering.*

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مجلة كلية العراق الجامعة للهندسة والعلوم التطبيقية

انترنت اشياء المستشفى (IOHT): تصميم نظام مراقبة للرعاية الصحية لحديثي الولادة

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الملخص . تعتبر متطلبات حديثي الولادة مهمة جدا لأن الطفل يحتاج إلى وقت للتأقلم مع البيئة الخارجية. يجب إبقاء الأطفال حديثي الولادة في الحاضنة خلال فترة زمنية معينة بعد تعريفهم ببروتوكولات الحاضنة المناسبة وهذا يعتمد على الحالة الصحية للرضيع. ان رفض حاضنات الأطفال الحالية بشكل عام بسبب تصميماتها غير الصحيحة. هذه الدراسة هي مبادرة للاستفادة من التكنولوجيا الحديثة لتوفير بيئة مستقرة للأطفال الخدج من أجل الحد من أعداد الوفيات المبكرة. لذلك ، تم تصميم نظام صحي للعناية بهذه الفئة ، للمستشفيات العراقية حيث ما زالت تفتقر إليها. كما تهدف هذه الدراسة أيضًا إلى تطوير منصة الكترونية لتوفير وسيلة للتواصل البشري بين الطبيب والمريض عند التعامل مع بعضهما البعض عن بعد.