AN IOT-BASED BABY MONITORING SYSTEM

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AN IOT BASED BABY MONITORING SYSTEM

SAIDATUL NUR IZZATI SHAHUL HAMID

Thesis submitted in fulfilment of the requirements
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and, in our opinion, this thesis is adequate in terms of scope and quality for the award of degree of Bachelor of Engineering Technology in Manufacturing.

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ABSTRACT

The number of working mothers has greatly increased compared to the past few decades. Subsequently, baby care during daily life has become a challenge to many families. Thus, most of parents used to send their babies to grandparents' house or baby care-house to take care of their babies. However, the parents cannot continuously monitor their babies' conditions either in normal or abnormal situations. Therefore, this project proposes an efficient and low-cost Internet of Things (IoT) based system for baby monitoring in real time which can play a key role in providing better baby care while parents are away from their babies. NX Siemens software is used for designing the baby cradle. Red meranti wood is used as the main material for the baby cradle. For the making of baby cradle, woods are carefully cut and handled using the tools and machines available in UMP to ensure safety. In system design, NodeMCU Wi-Fi Controller Board is exploited as the main microcontroller to gather the data read by sensors and upload to the AdaFruit MQTT server. The system architecture consists of a baby cradle that will automatically swing using a motor when the baby cries. Parents can also monitor their babies' condition through an external web camera and switch on the lullaby toy located on the baby cradle remotely via the MQTT server to entertain the baby. The proposed system prototype is being fabricated and tested to prove its effectiveness in terms of cost, simplicity, and ensure safety operation to enable the baby-parenting anywhere and anytime through the network. Finally, the baby monitoring system is proven working for monitoring the baby condition and surrounding temperature on the built prototype.

ABSTRAK

Jumlah ibu bekerja telah bertambah dengan banyaknya berbanding dengan beberapa dekad yang lalu. Kemudiannya, asuhan untuk bayi semasa kehidupan harian telah menjadi satu cabaran kepada banyak keluarga. Maka, kebanyakan daripada ibu bapa digunakan untuk hantar bayi mereka untuk rumah datuk nenek atau rumah asuhan bayi menguruskan bayi mereka. Bagaimanapun, ibu bapa tidak boleh memantau secara berterusan keadaan bayi mereka sama ada dalam situasi-situasi normal atau luar biasa. Lantarannya, projek ini mencadangkan satu Internet cekap dan kos rendah berpangkalan sistem untuk pengawasan bayi dalam masa nyata yang boleh memainkan peranan penting dalam menyediakan asuhan bayi lebih baik sementara ibu bapa jauh dari bayi mereka. Perisian NX Siemens digunakan untuk mereka buaian bayi. Kayu meranti merah digunakan sebagai bahan utama untuk buaian bayi. Untuk pembuatan buaian bayi, kayu dipotong dengan berhati-hati dan menangani menggunakan alat dan mesin didapati di UMP bagi memastikan keselamatan. Dalam rekabentuk sistem, NodeMCU Wi-Fi Controller dieksploitasikan sebagai mikropengawal utama menghimpunkan data dibaca oleh pengesan dan muat naik kepada pelayan AdaFruit MQTT. Seni bina sistem terdiri daripada seorang bayi mendukung yang akan secara automatik menghayunkan menggunakan sebuah jentera apabila bayi itu menangis. Ibu bapa boleh juga memantau keadaan bayi mereka melalui kamera web luar dan hidupkan alat permainan dodoi terletak di bayi mendukung jauh melalui pelayan MQTT menghiburkan bayi. Cadangan prototaip sistem sedang dibuat dan diuji untuk membuktikan keberkesanannya dalam soal menelan belanja, kesederhanaan dan memastikan operasi keselamatan membolehkan keibubapaan bayi di mana saja dan bila-bila masa melalui rangkaian. Akhirnya, sistem pengawasan bayi terbukti kerja untuk memantau keadaan bayi dan sekeliling suhu di prototaip dibina.

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LIST OF ABBREVIATIONS

MQTT	Message Queuing Telemetry Transport
SIDS	Sudden Infant Death Syndrome
NICHD	National Institute of Child Health and Human Development
IoT	Internet of Things
NODEMCU	Node-Microcontroller Unit
IDE	Integrated Development Environment
CoSHE	Cloud-based Smart House Environment
M2M	Machine-to-machine
GSM	Global System for Mobile communications
IBM	International Business Machines
LCD	Liquid-crystal display

CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, female participation in the work force in the industrialized nations has greatly increased in present society. This will bring disadvantage to infant care to many families in their daily life. Parents will worry about the health of their baby. For low cost of living, both of parents need to word and look for their babies, therefore it will be more workload and stress to that families especially to their mother. With a baby monitoring system that consists of video camera and microphone with no limitations of coverage that can send the data can make an urgent situation can be quickly be noticed and handled within less time. Usually, when babies cried, the cause can be either they are hungry, tired, not feeling well or need their diaper changed.

Sudden Infant Death Syndrome, abbreviated as SIDS also known as crib death, people call SIDS as crib death because many babies who die of SIDS are found in their cribs. It occurs to infant younger than 12 months of age. Most SIDS death occur in infants younger than 6 months (Willinger, James, Catz, & Participants, 1991). SIDS is a rare case in Malaysia. Even though the professionals did not know what causes SIDS but they do know how to reduce the risk with is place the baby to sleep on a firm surface (crib mattress). One of it is never put the baby sleep on pillow or another soft surface. Researches do not know why sleeping on such surfaces would increase the risk of SIDS but they warn that could be dangerous(Academy et al., 2005). For instance, in 2003, a NICHD- supported study showed that placing an infant to sleep on soft bedding

as opposed to confirm bedding appeared to pose five times the risk of SIDS (Infant &Syndrome, 2000). Secondly, avoid overheating during sleep. Babies should be kept warm during sleep, but not too warm. In winter or cold weather, the risk for babies get SIDS increase because the parents will overdress or place under heavier blanket, which can give them overheat(Malloy & Freeman, 2004). So, in general if the room temperature is comfortable for an adult, then it is appropriate for a baby.

Therefore, we developed a prototype which can monitor the activities of the babies along with finding one of the above causes and give this information to their parents in this project. This should give parents a better sleep at night because it able to keep track of baby' conditions in easy way and every parents and guardian could use it

The Internet of Things, abbreviated as IoT, simply refers to a network of objects that are connected to the internet. It provides devices with the ability to transfer sensor data on the Internet without requiring intervention. Since the Internet of Things is such a broad category, it encompasses many devices and is growing at a rapid rate. In 2015 there were approximately 15.4 billion IoT devices. IHS Markit, a financial resource company, expects there to be 30.7 billion IoT devices by 2020 while Intel, a technology company, expects there to be 200 billion by 2020 (Kelvin Claveria, 2017). Currently of the 15.4 billion devices, about 28.3 million are wearable, but that number is expected to increase to around 80 million by 2020. The total global spending on the IoT in 2016 was 737 billion dollars and was projected to reach 1.29 trillion dollars in 2020 as shown in Figure 1.1. As one can see based on the numbers alone, the IoT is a prominent field that will only getting bigger. The figure below show IoT is growing exponentially. The function of IoT is to control, real-time monitoring, autonomy or autonomous function and optimize. Perhaps one of the main reasons why the IoT is so large is that it aims to make life more convenient, and people are more likely to invest in things that make their lives easier. The IoT is integrated into our baby monitoring system for a quick response time and to provide a greater sense of security for parents during the daily life.

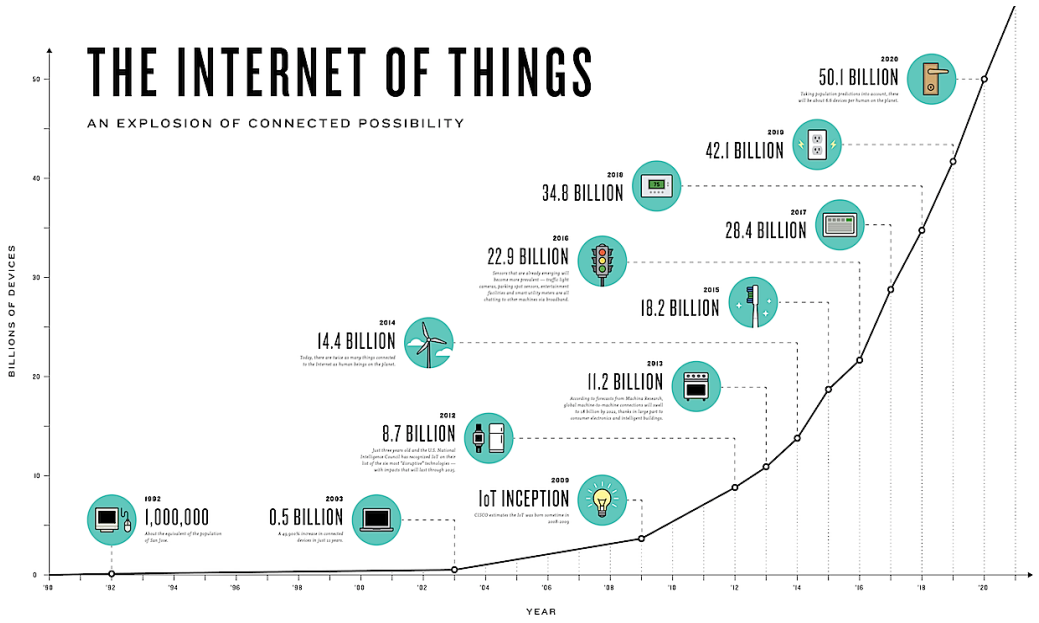


Figure 1.1 Increment of devices connected to internet
Source: https://chrissbell.wordpress.com/

NodeMCU Wi-Fi Controller Board is an open source IoT platform and is used as the main micro-controller in this project. It is basically used to gather data read by the sensors and upload the data to the MQTT server. Besides, it also receives commands given by the user to do specific tasks via the MQTT server. NodeMCU consists of physical programmable circuit board like any other development boards do, such as Arduino board and Raspberry Pi. The programming of the NodeMCU can be done by using Arduino software which is an Integrated Development Environment (IDE) to a write the code of instructions and upload to the micro-controller.

1.2 Problem Statement

In today's fast paced life, everyone is busy in their professional life including parents. They might leave the home early in the morning and come back right before dinner time. That shows how busy someone can be. Nowadays, even the mothers are working, it become a problem when they don't get sufficient time to take care their babies. Not all parents could afford a nanny to help them with their children. After long working hours, the moms have to manage the house and also have to take care of their babies simultaneously.

Parents might not have time to swings their baby to sleep or rocking their baby back to sleep in the middle of the night. Studies have been carried on the effect of rocking on a baby and concluded that baby sleeps better while being rocked or swung lightly (Pederson, 1969; Bayer et al., 2011). This is because the rhythmic movement mimics the gentle rocking they felt while in the mother's womb (Barnard, 1972). Most of the available automated cradles were designed to rock non-stop but this can cause the baby became nauseous and uncomfortable. Thus, not having enough time to swing baby to sleep is one of the problems.

Next, not all the babies were placed in the same room as the parent sleep. This can cause the parents did not hear well if their baby was crying. Or parents were too busy doing house chores around the house until cannot hear if their baby needs their attention. Moreover, sometimes baby just need a little distraction until they can completely get in deep sleep. There are several types of baby cradle that available in stores but the costs for most of them were quite high and not everyone can afford it. Thus, parents are unaware enough or give full attention to their babies while doing house chores.

1.3 Research Objective

The main aim of this project is to develop an efficient and cost effective IoT-Based baby monitoring system. To accomplish this, the following objectives must be achieved:

- To design and fabricate a simple baby cradle that can swing automatically based on baby conditions and provided with web camera and musical toys.
- To implement an IoT-based monitoring system by utilizing sensors and NodeMCU Wi-Fi Controller Board and enabling data transmitting to AdaFruit MQTT server.
- To examine and evaluate the performance of the developed prototype and validate its effectiveness.

1.4 Scope Research

The scopes that are related to this project are:

1) This study focuses on designing a baby monitoring system that can real time monitoring the babies at the ages of one month to one-year-old and protects the safety of the babies with designed cradle.

2) Establishing a control system through the internet to remote the switches built in the system and read recorded data in the MQTT server.

3) Establishing programming codes for NODEMCU microcontroller to interact with the MQTT server by publishing and subscribing feeds.

4) Utilizing a suitable app that can supports both android and iOS version by linking the app to the MQTT server to enable the reality of real-time monitoring anywhere and anytime.

CHAPTER 2

LITERATURE REVIEW

In this chapter, we discuss about the Internet of Things (IoT) concepts, the history of baby cradle, market available products and some related works. Some examples of the hardware and software that are used in this project will also been mentioned in this chapter.

2.1 Internet of Thing Concept

The term “Internet of Things” is first coined by Kevin Ashton executive director of the Auto-ID Centre in 1999 (Ashton, 2009). In 1999, Ashton proposed a concept that could improve the business of Proctor & Gamble(P&G) by linking Radio Frequency Identification (RFID) information to the internet (Lopez Research, 2013). RFID and sensor technology allow the computer to record the track of the products and identify the quantity of products without spending too much money on hiring workers to those tasks.

Internet of Things (IoT) is the idea of data and information exchanges by connecting any devices to the internet and to other devices, which is known as machine-to-machine (M2M). IoT is a massive network that connects things and people together by collecting data on the sensors embedded in a device or people themselves share the data to the internet via various communication protocols (Jen Clark, 2016). The things

can be various sizes and shapes from a mini-size sensor to an advance automation car, which has up to hundreds or thousands of detective sensors.

With the aided of Internet of Things cloud-computing servers, all data uploaded to the servers will be aggregated and analyzed to become valuable information or data to address specific needs. The information can be used to display reading patterns in term of graph, and then detect possible occurring problems before things go bad and give recommendation or alert the user.

Figure 1.1 Wearable health tracker
Source: **https://gearpatrol.com/2014/09/17/mobile-app-alternatives-to-wearables/**

Many of us have a Smartphone, a device that can connect to other device through various protocols, it is also considered as an IoT device. Figure 2.1 showed a Smartphone is connected to a wearable health tracker to view the data read by the sensors in the health tracker. With the emerging of technologies, more and more smart devices that can connect to the internet have been produced such as wearable health tracker, smart home devices, smart cars, city road systems and more. The market research companies had made an estimation that devices connected to the internet will have a huge increase from 16Billions in 2014 to 50Billions by 2020, which means this situation will create a global market for IoT products and services in coming future (Weinberg, Milne, Andonova, &Hajjat, 2015).

IoT is widely used in modern smart home application recently as the technologies are getting more advance. Before the era of IoT started, a smart home application was involving simple application control with Bluetooth connection. However, the advancing technology is enabling the control of the home from anywhere

to be possible via the internet. G. Demiris and B. K. Hensel have explained that a smart home is an advance technology that can monitor the activities in the home to maintain and even enhance functional health, security, safety and life quality of the residents (Demiris & Hensel, 2008).

Healthcare is another field that are starting to use the IoT. Not just in hospital area, remote health monitoring can be used at home to monitor non-critical patients to reduce unnecessary waste of resources like doctors and beds. The measured data can be viewed by the doctors in hospital through the internet to analyses and predict the health condition of the patient. (Baker, Xiang, & Atkinson, 2017) mentioned that the IoT based systems for remote health monitoring will become crucial to healthcare in the future. It will provide an easy access to patients who are living in rural areas or elderly patients to live independently at home. (Pham, Mengistu, Do, & Sheng, 2018) presented a Cloud-based Smart House Environment (CoSHE) that enable accurate home healthcare monitoring that allow the patients to stay at their comfort homes. However, a full medical check-up is advised to be done yearly to have a better understanding on the health condition.

2.2 Baby Cradle History

Figure 2.2 Boxes Mounted Cradle
Source: https://tr.pinterest.com/pin/262475484513688063/?lp=true

A baby cradle is a small cradle that is designed for baby to sleep in. Before babies had cradles like nowadays, parents used to be sleeping with their babies. The earliest type of cradle was known as a rocker and was made from a hollowed-out log. Simple boxes mounted on curved pieces soon had replaced the rocker. Early American colonials used cradles that had sloping sides and a hooded end, as shown in Figure 2.2.

Source: http://www.kidspacestuff.com/blog/2012/08/suspended-baby-cradles-popularity/

Figure 2.3 Hanging Cradle

The design for a baby cradle is changing across time. In 1800's, the cradle hangs on a wooden pole at the ceiling and the cradle itself is made from natural breathable cotton, as shown in Figure 2.3. A futon mattress is put in the cradle so that baby is completely comfortable while resting on it. A cradle has become compulsory for new parents to keep their baby to have a comfortable sleeping place as well as a safety place to prevent fall from bed.

Source: http://outdoorbabyswingwithstand.blogspot.my/

Figure 2.4 Modern Hanging Cradle

Then, the cradle in Figure 2.4 is designed to hang under springs held by metal frame to enable the cradle to be moved around, unlike the cradle in Figure 2.3 which is fixed at a certain place. Modern cradles vary in size and shape and some are even available with motors to rock the cradle automatically, for example the MamaRoo shown in Figure 2.6 and the SNOO smart sleeper in Figure 2.7.

A baby cradle can be one of the safest places for a baby to sleep other than parents' cuddles. A baby cradle might look like an adult bed in first view, but baby cradle has been designed specifically for the needs of infants and little children. It is a place for baby to get some rest as well as fall asleep to the morning. Using a baby cradle can also make it a lot easier to get the babies off to sleep, if you employ a gentle rocking motion along with the security, the rocking feels will work together to get your baby to drift off to sleep. Compare this to having your baby sleep on a straight mattress, whether it is a bed or a crib. It is clear to see the advantages of using a cradle.

Figure 2.5 Baby Prone Sleeping Posture

A benefit of baby cradle is to reduce the risk of Sudden Infant Death Syndrome (SIDS) and it's the leading cause of death for babies within one-year-old life (Cornwell, Ph, & Einstein, n.d.). SIDS is more likely happen among babies placed on their stomachs to sleep as shown in Figure 2.5 than among those sleeping on their backs. Incidences of SIDS have been proven to be higher in babies that sleep on their stomach. For your information, SIDS is not any one illness or disease. Rather, it is the diagnosis given when a child under a year- old sudden death without able to detect the real cause

after a death scene investigation, an autopsy, and a review of the child's medical history. That it can happen without warning makes SIDS particularly devastating for families.

2.3 Product That Available in Market

As the advance in technologies in the 20th century, there are various type of baby cradles on the market with not just safety protection function, but also with some smart features that can reduce parents' burden and increase both babies' and parents' sleeping time. The following description show some elaborations on the currently available baby cradle products that can help the parents to take care of their loved-one.

2.3.1 MamaRoo by 4moms

Figure 2.6 MamaRoo

MamaRoo is a product available in the market that has the function of bouncing up and down and swaying side to side, just like parents do while holding the baby. According to the product's advertisement, the company claimed that they set up sensor vests on parents to understand those motions and then replicated the bouncing and swaying in the MamaRoo to soothe and entertain better than traditional infant seats. Alan Lantzy, MD, a neonatologist and pediatrician, said that "The MamaRoo is calming because it provides an environment that is similar to

still being in utero, babies feel contained, they're moving, there's a bit of sound and we find that very soothing for our babies. ("4moms: Meet the 4moms® mamaRoo® infant seat," n.d.)

It comes with 5 different unique motions, which are car-ride motion, kangaroo motion, tree-swing motion, rock-a-bye motion and wave motion. These motions can be selected according to the baby's favourite and the speed is adjustable. Besides, it is MP3 compatible with Bluetooth enabled cradle where the parents can control the motion and sound from their smart devices. The product comes with an adjustable seat recline and interactive toy balls for the comforts of the baby.

This product is mainly focus for baby from birth to child that reaches a maximum weight limit of 25pounds (11kg). The materials used are classic and plush fabrics which are washable and easy to take off.

2.3.2 Snoo Smart Sleeper

Figure 2.7 SNOO Smart Sleeper

SNOO is a product of *Happiest Baby*, a smart-tech and parenting Solutions Company. It supports 2.4 GHz wireless, 802.11 b /g /n with separate Wi-Fi control switch for the parents to control via Wi-Fi. It can boost baby's sleep with soothing white noise and motion. From their product advertisement, it is known as the safest baby bed in the market ("SNOO – Happiest Baby," n.d.). It has a responsive surrounding light sensor for detecting the surrounding light intensity to adjust the built-in LED intensity.

It has a gently rock function to assist the baby to be a good sleeper during naps or nights with no noisy sound from gears or springs. It has several microphones with leading audio processing to detect sound accurately. Once the sound is detected, it has embedded system that will play three distinct white-noise sounds to calm the baby as well as to enhance sleep. The system will choose soft rain sound for sleeping purpose or womb sound if baby is crying. For the motion, the system will choose the motion that suits the baby either slow swing for sleep or faster jiggles to comfort upset baby.

SNOO comes with a protective swaddle wings that will keep the baby safely. Baby is wrapped in a SNOO Sack and the SNOO Sack's wings have to be slide on the safety clips to the baby sleeps on his back. SNOO will only start to swing when the baby has been wrapped with SNOO Sack and clipped to the safety pin. SNOO comes with organic fitted sheet and 3 SNOO Sacks with organic cotton, which are user-friendly to prevent allergies on baby.

2.3.3 Raybaby

Figure 2.8 Raybaby Smart Monitor

Raybaby was invented by RIoT (Ray IoT) Solutions, a startup founded in 2015. Raybaby is a baby monitor product that can tracks respiration, movements and sleep patterns using a technology that works on the principle of ultra-sound ("Raybaby - World's First Non-Contact Vital Monitor," n.d.). It alerts parents when the baby experiences variations in respiratory or breathing rate. Such variations have been associated with fever and other conditions like asthma or bronchitis. It alerts the parents also when the baby rolls-over

or does any sudden movements.

In addition, Raybaby comes equipped with an integrated infrared video camera that enables live video streaming even in pitch darkness, built in speakers, and audio monitoring that uses a highly sensitive microphone. Many vital and movement trackers have wearable for the baby, some even containing lithium-ion batteries. Lithium-ion batteries are considered a safety risk to infants, and other wearable require upgrades depending on your baby's growth. Raybaby on the other hand is completely non-contact.

It constantly monitors the baby from a distance, analyses and relays any change in their sleep, roll-over movement and breathing pattern along with a host of additional baby health information. Whenever the baby is not in line of Raybaby, it will notify the parents through the internet. Raybaby has revolutionized existing cumbersome and invasive techniques to accurately collect health data of babies that include sleep, movement and breathing data.

Other than that, parents can access the monitoring of the baby condition with smart devices via internet. It can receive audio and video where parents can view them on the internet and talk to the baby through Raybaby whenever they are outside the house. Parents can create custom playlist in Raybaby and playback the music or sounds whenever the playlist is finished played.

2.4 Related Works

A baby monitoring system is proposed by suggesting an enhanced noise cancelling system which has the function of monitoring the baby and reducing sound pollution. The main function of the system is to reduce the noise that might disturb the baby by playing relaxing songs. This system can also adjust the room's light intensity with the aids of light sensor. (Brangui, El Kihal, &Salih-Alj, 2015) However, this system could have some advance improvements such as the implementation of the web camera and transfer data via network to the user.

Misha Goyal introduced her low-cost E-baby cradle that can swing automatically when it detects baby crying voice and stop swinging when the baby stops crying (Goyal, 2013). The speed for the swinging cradle can be controlled based on the user's

need. It has an alarm embedded in the system, which will notify the user when 2 conditions occurred. First, the alarm will alert when the mattress is wet, it indicates that it is time to change the mattress to keep the baby hygiene. Second, whenever the baby does not stop crying for a certain time, the alarm will ring to alert the parents to spend their times on the baby, whether the baby need to change diaper, or the baby is hungry. However, it is only applicable when parents are available near the cradle since it uses only the buzzer as an alarm to alert the parents, the buzzer alarm itself might frighten the baby as well. Parents cannot monitor their baby when they are not available at house compound, for example during work time or travelling on other places.

A new approach of automatic baby monitoring system has been proposed. (Palaskar, Pandey, Telang, Wagh, &Kagalkar, 2015) They have proposed a low-budget system which will swings the cradle when baby crying sound is detected and the cradle will stop when the baby stop crying. The inbuilt alarm will alert if either one of the following conditions (the mattress is found wet or baby did not stop crying after a certain period) is hit. A video camera is placed above the cradle to monitor the baby. Even so, the parents can only receive the notification via SMS which could be improved to a better level, such as via internet. In other words, the parents can access an account via cloud platform to monitor the baby condition anywhere and anytime they want if there is any further improvement by connecting to the internet.

An Arduino-based resonant cradle design with infant cries recognition was proposed by (Chao, Wang, Chiou, & Wang, 2015). First, a ball bearing design is adopted to reduce system damping and let the cradle swing freely, even without electricity. Subsequently, an appropriate sensor is designed to detect the swinging status or angle. Finally, the force is put under the cradle to increase torque, but it engages only during a critical time. In other words, a small motor rotation angle is enough to make the cradle swing. The proposed design is an improvement on previous intelligent cradles as it naturally achieves the energy saving target in accordance with resonance theory. In addition, it has a much lower operating noise which will be welcomed by parents. The infant cries recognition is designed to increase the functionality of the proposed resonant cradle. Infant cries recognition provides inexperienced parents or babysitters with a reference for when an infant cry. With this function, the intelligent cradle can start swinging autonomously when the baby cries and stops when the

swinging motion is no longer needed. The proposed design allows parents to record infant cries due to hunger or pain on a SD card stored in SD module.

(Symon, Hassan, Rashid, Ahmed, & Reza, 2017) have presented a paper on designing a baby monitoring system based on Raspberry Pi and Pi camera. The authors have designed a system that will spot the motion and crying condition of the baby. They used condenser MIC to spot the crying condition of the baby. PIR motion sensor is used to spot the movement of the baby meanwhile Pi camera is used to spot the motion of the baby. The camera will be turned on only when the condenser MIC sensed any sound, which will send a signal to Raspberry Pi. However, the output of this system is only available on monitor display; in other words, the parents can only see the data in limited area.

(Kaur, 2017) propose a system that can monitor pulse rate and body temperature of the person with dedicated sensors along with Raspberry Pi and IoT. According to Kaur, the system is wearable to monitor the health condition by storing the data read by the sensors to Bluemix cloud. The data stored will update to doctor for health analysis and abnormality detection of the user. The pulse rate and temperature of the user are measured by using KG011 (heart rate sensor) and DS18B20 (temperature sensor). Then, the readings are shown at IBM Watson IoT Platform in the graphs form. The article proposed a good point about using the sensors to send data to the IoT platform. However, this system is not suitable for infants since their body immune systems are weaker than adults. There is concern that this wearable system might emit some radiation that could harm the infants and cause some side effects.

(Patil&Mhetre, 2014) had presented a monitoring system based on GSM network. They built a prototype that can measure infants' pulse rate, body temperature, movement and moisture condition and send information through GSM network. It consists of sensors, LCD screen, GSM interface and buzzer, which are controlled by PIC 18f4520 8-bit microcontroller. The LCD module will show the result measured by the sensors and the GSM interface will send alert to the user mobile number. Although the system was proposed to monitor the baby condition, proper control actions are required to take accurate readings since baby could has crawled around and the sensors might be detached. The baby might also get injured or electric-shock whenever the

parents are not at house compound and the baby touches the system circuit. The system should be improved in terms of baby safety and user-friendly.

(Saadatian et al., 2011) proposed a mobile-based system that enable parents to get updated to the infants' status. The system measured the temperature, motion and heart rate then sent the data to server to be analyzed. The analyzed data will then be sent to parents and generated alert system if any abnormal is found. Parents will receive advisory first-aid information to immediate action, and nearby clinic will be notified by the system. The system was put on trial on adults during the prototype stage by collecting data and analyze it. They hoped to use GSM technology instead of currently using Bluetooth module in future as the communication component. They will also add other features such as position monitoring and other behavior monitoring analysis like crying analysis into the system for future improvement.

(Mohamad Ishak, Abdul Jamil, & Ambar, 2017)have proposed on designing a monitor system that use an incubator that has pulse sensor attached on infant to measure infant's pulse rate and humidity sensor to measure humidity level. The recorded data will be sent to the computer through Arduino microcontroller, where the data can be referred by the Neonatal Intensive Care Unit(NICU) personnel for diagnostic purposes. An alarm system is designed to send alarm whenever the data readings reach danger level to prevent harmful situation. They had put the system on trial on infants from three level of ages, which are 0-3 months, 3-6 months and 6-12 months. The outcomes of the trial were matched with their project objective in which the pulse rate sensor was able to detect infant's pulse rate in different age range. However, the data recorded can only be transferred direct to computer and that can be improved by adding Wi-Fi module to send data via the internet. By doing so, infants' conditions can be monitored anywhere at any time.

(Chien, 2008) presented an ARM embedded platform project for baby monitoring. He proposed a system consisting of embedded system platform with a Linux kernel 2.4.18 operation system using TCP/IP protocol, CMOS image sensor and control system. The system is used to monitor baby activities and room environment through a web browser. If the system detected baby's cries, it will alarm the parents by transmitting the audio signal to parents' room. He used ARM9 processor as the CPU for the coordination of the system. A bi-directional triode thyristor(TRIAC) is used as

power regulation component in light control unit and the infant's body temperature is measured by a TMP75 temperature sensor together with a wireless module to send temperature readings to the platform. An LCD display module is used to display the measured readings. There is an improvement can be implemented in this project by designing a cradle that is installed with this system to make the cradle swings itself whenever it detected baby cries to entertain the baby so that parents do not need to rush back home to take care their baby when they are outside the house.

2.5 Baby Monitoring System Components

The following section describes the hardware and software that are being used in this project.

Table 2.1 Hardware for baby system monitoring

Hardware	
NodeMCU ESP8266 Wi-Fi Controller Board	Mini fan
9V DC Power source	Geared motor
4 channel 5V Relays module	Wireless Security camera
Sound sensor module	Baby cradle
Temperature & Humidity sensor	

Table 2.2 Software for baby cradle system

Software	
Arduino IDE	MQTT Protocol server
Proteus Stimulation	Fritzing software

2.5.1 NodeMCU ESP8266 Wi-Fi Controller Board V2

Figure 2.9 NODEMCU Wi-Fi Controller Board

NodeMCU (Node Micro-Controller Unit) is an open source software and development board that is embedded with a System-on-chip (SoC) named ESP8266, which was designed and manufactured by Espressif Systems (Michael Yuan, 2017). It is a self-contained Wi-Fi networking solution offering as a bridge from existing microcontroller to Wi-Fi and is also capable of running self-contained applications (NodeMCU, 2017). It has a built-in USB connector to be connected to the computer using a USB cable to upload coding, same as other development boards available in the market such as Arduino and Raspberry Pi.

Table 2.3 Features of NodeMCU Wi-Fi controller board

Build in with	Wireless 802.11 b / g / n standard, TCP / IP protocol stack to support multiple TCP Client connections (5 MAX)
Support	STA / AP / STA + AP three operating modes and UART / GPIO data communication interface
Power input	4.5V ~ 9V (10VMAX), USB-powered
Current	Continuous transmission: 70mA (200mA MAX), Standby: <200uA
Transfer rate	110-460800bps
Working temperature	-40 deg ~ + 125 deg
Drive Type	Dual high-power H-bridge driver

2.5.2 4 Channel DC 5V Relay Module

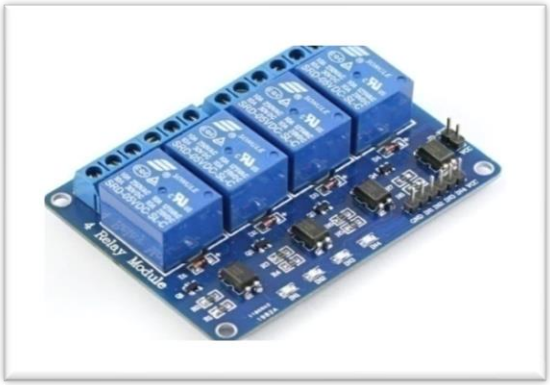


Figure 2.10 4 Channel DC 5V Relay Module

This is a LOW Level 5V 4-channel relay interface board, and each channel needs a 15-20mA driver current. It can be used to control various appliances and equipment with high voltage and current load. It is equipped with high-current relays that work under AC250V 10A or DC30V 10A. It has a standard interface that can be controlled directly by micro-controller ("Arduino IoT 4 Channel Ways Opto Isolator 10A 5V relay module," n.d.).

Table 2.4 4 Channel DC 5V relay module

Relay Maximum output: DC 30V/10A, AC 250V/10A
4 Channel Relay Module with Optocoupler Low Level Triger expansion board, which is compatible with Arduino
Relay of high-quality loose music relays SPDT. A common terminal, a normally open, one normally closed terminal
Standard interface that can be controlled directly by micro-controller (8051, AVR, *PIC, DSP, ARM, ARM, MSP430, TTL logic)
Optocoupler isolation, good anti-jamming

2.5.3 Sound Sensor Module

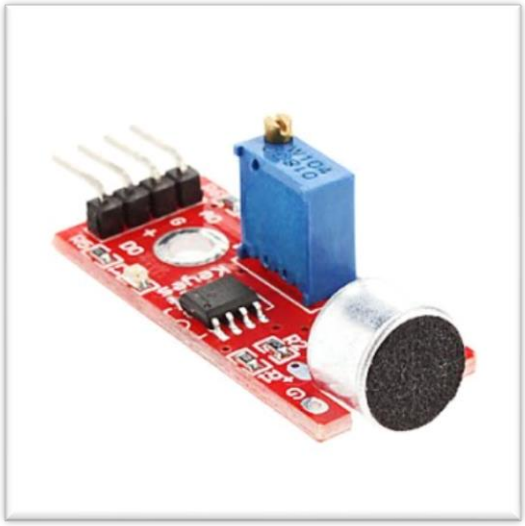


Figure 2.11 Sound Sensor Module

The sound sensor module provides an easy way to detect sound and is generally used for detecting sound intensity. This module can be used for security, switch, and monitoring applications. Its accuracy can be easily adjusted for the convenience of usage. It uses a microphone which supplies the input to an amplifier, peak detector and buffer. When the sensor detects a sound, it processes an output signal voltage which is sent to a microcontroller then performs necessary processing. Its accuracy can be adjusted for the convenience of usage. Sound waves cause the thin film of the electrets to vibrate and then the capacitance changes, thus producing the corresponding changed voltage. Since the voltage change is extremely weak, it needs to be amplified. So it is converted into a voltage ranging from 0 to 5V, which is received by data acquisition unit after A/D adapter conversion and then sent to an MCU.

2.5.4 Temperature and Humidity Sensor

Figure 2.12 Temperature & Humidity Sensor

Temperature and Humidity sensor consists of two parts, a capacitive humidity sensor and a thermostat. The humidity sensor measures and reports the relative humidity in the air. It therefore measures both moisture and air temperature ("what is a humidity, moisture sensors, temperature humidity sensor - Future Electronics," n.d.). There is also a basic chip inside that does some analogue to digital conversion and spits out a digital signal with temperature and humidity values to be read by the micro-controller. Both sensors are often applied in combination to reduce cost. The calculation of the air humidity does not directly influence a wind site assessment, but knowing this parameter helps assessing the potential danger of ice build-up at the measuring location. Temperature sensors should always be mounted at a height of at least 10m to ensure sufficient distance from heat radiating from the earth.

2.5.5 Mini Fan

Figure 2.13 Mini Fan

A mini fan provides strong wind with low power consumption. It comes with unique design, creative style, made of high-quality ABS, has a solid structure and pressure-resistant. With the clipper on the bottom, can be used in anywhere you want. The middle part and the cutting can rotate by 360 degrees without dead ends (“Rechargeable Portable Clip Mini Fan,” n.d.)

2.5.6 Wireless Security Camera

Source: https://www.kkmoon.com/p-s380w-us.html

Figure 2.14 Wireless Security Camera

The camera can send high-quality image and live video with sound through the internet. It can be connected to either wired or wireless network connections. It has a built-in motion detection alarm. When a motion is detected, the camera will send out alarm and record live pictures in TF card and send an alert message to the user phone or email automatically (“KKmoon Wireless Wifi 720P HD Security Camera,” n.d.).

2.5.6 Geared Motor

Figure 2.15 9V DC Geared Motor

The “gear motor” or “geared motor” is a motor having an attached “gear assembly” (or gear train) which enables the gear motor to provide greater torque at a lower rpm than the motor alone. In our experiments however, we didn’t need the gear assembly. We used a 300 rpm, 9V motor to control the speed and direction.

Table 2.5 Features and Application of geared motor

Features	Low cost, high gear ratio and torque output, compact and balanced load distribution.
Application	Automotive applications, robotic applications, used in industry and power winches on trucks

2.5.7 Arduino IDE

Figure 2.16 Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them. Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, boot loaders, and programmer definitions.

2.5.8 MQTT Broker/Server

MQTT stands for Message Queuing Telemetry Transport. It is a publisher/subscribe, extremely simple and lightweight messaging protocol, designed for constrained devices and low-bandwidth, high-latency or unreliable networks. The design principles are to minimize network bandwidth and device resource requirements whilst also attempting to ensure reliability and some degree of assurance of delivery. These principles also turn out to make the protocol ideal of the emerging “machine-to-machine” (M2M) or “Internet of Things” world of connected devices, and for mobile applications where bandwidth and battery power are at a premium.

2.5.9 Proteus Stimulator

Figure 2.17 Proteus Stimulator Software

The Proteus Design Suite is a Windows application for schematic capture, simulation, and PCB layout design. The suite combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete micro-controller base designs. Proteus has also the ability to simulate the interaction between software running on a microcontroller and any analogue or digital electronics connected to it. It simulates Input / Output ports, interrupts, timers, USARTs and all other peripherals present on each supported processor.

2.5.10 Fritzing Software

Figure 2.18 Fritzing Software

Fritzing is an open source software initiative that allows the user to create and plan circuits out before creating them. The program comes with a bunch of pre-loaded circuit boards from different companies such as Arduino and Sparkfun. It is often used to build circuit in the Schematic view or the Printable Circuit Board (PCB) view.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains all the methods and techniques that had been used throughout this process to make a baby cradle to accomplish the objectives that stated in Chapter 1. In addition, this chapter also discusses the process flow of the project which is about the designing the structure and fabrication part of baby cradle. The steps and explanation for the software and hardware development with helps of the electrical circuit diagrams also included in this chapter.

3.2 Planning For Senior Design Project

Each step starting from designing and fabrication this project is carefully planned and approved supervisor so that the criteria needed to build a complete baby monitoring system that implemented on baby cradle can be meet. Figure 3.1 shows the flowchart of the project.

The design part is done during last semester and before the semester end, the materials for the structure are decided before semester ends. Early this semester, the purchasing has been done and the waiting time to receive the material takes about a month. All the expenditures are as shown in appendix A. After that, the construction and chassis development take part. Then, baby monitoring system was mounted to the baby cradle and the electrical part such as controller, power source, geared motor, mini

fan, musical toys and etc was installed. The baby cradle with the baby monitoring system is then tested after all the components are ready. Finally, we proceed with report writing.

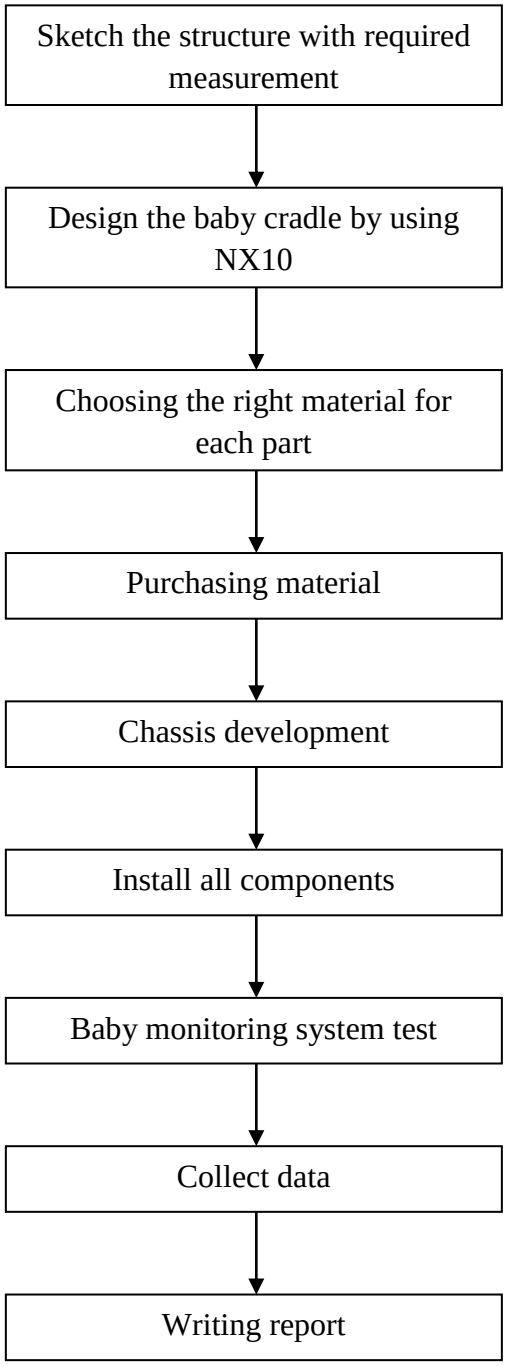


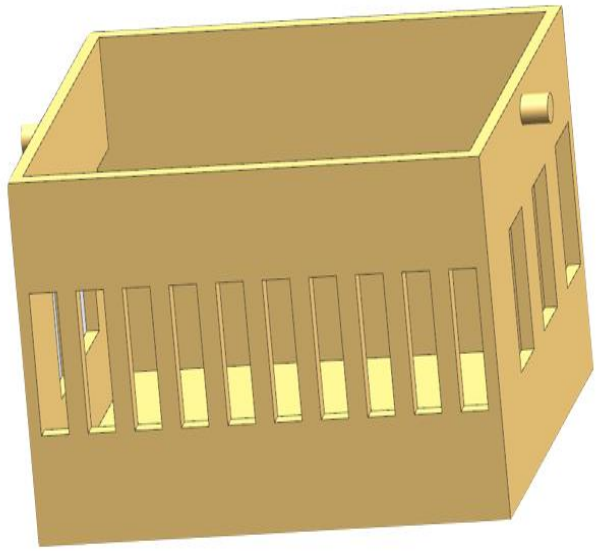
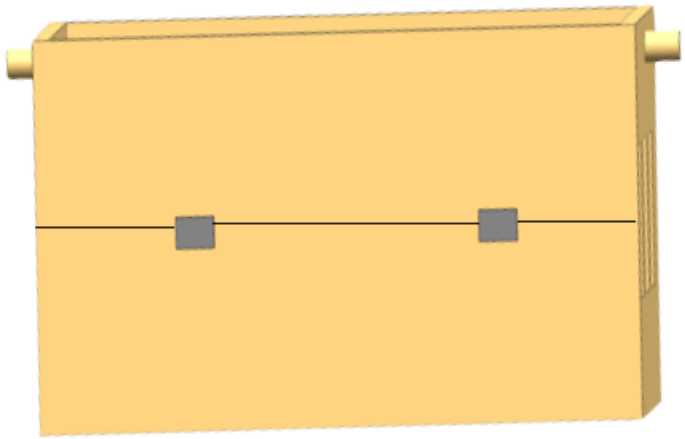
Figure 3.1 Planning for senior design project

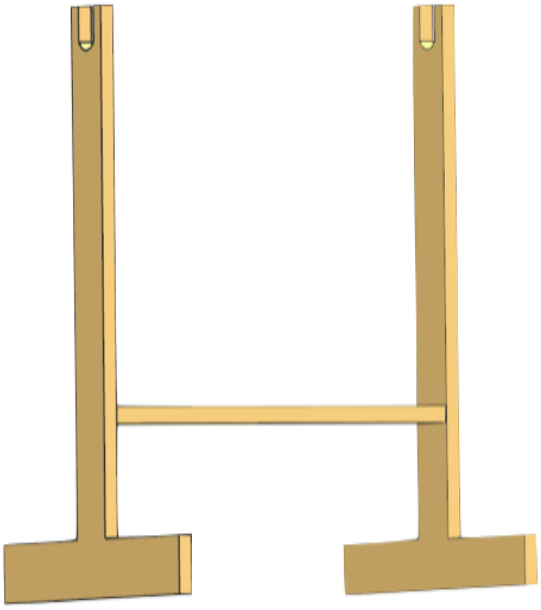
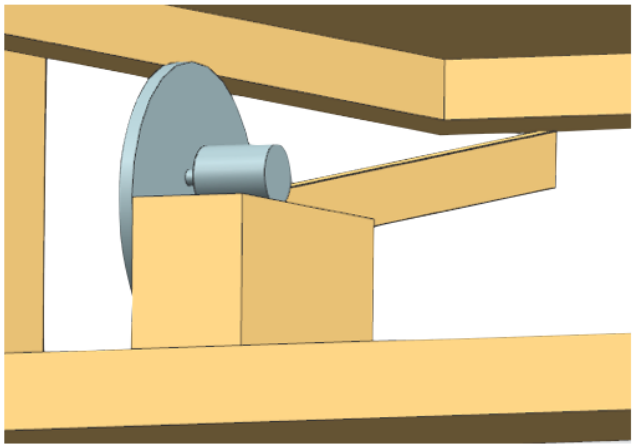
3.3 Designing Structure

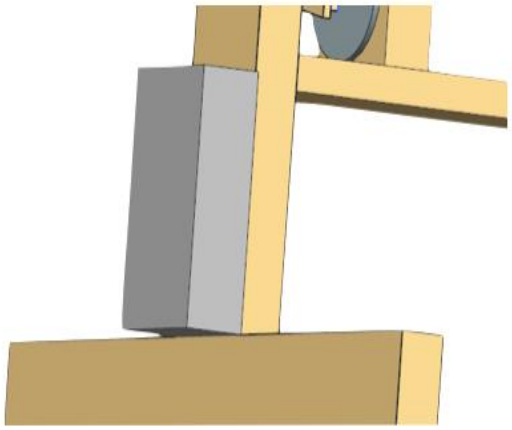
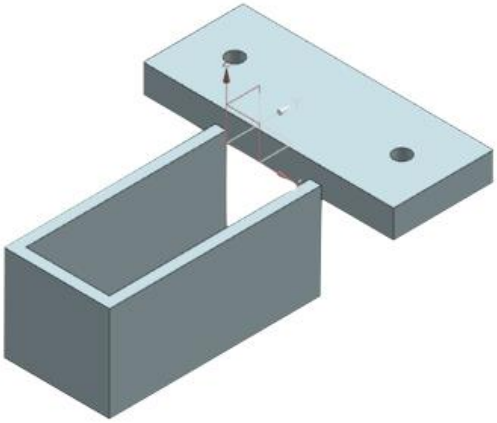
Every product needs to have a complete design with exact measurement before it can be fabricated. The design plays a fundamental role in his project. So, before start design process, a few criteria should be taking note. The information is gathered by doing discussion with the supervisor and also among team members. Firstly, the information regarding the components needed in the baby cradle are decided so that the design can be made to make sure all of the components can be installed without errors. After that, we also survey available baby cradle that included baby monitoring system in the market in order to gain some ideas in the structure of the baby cradle. The process continued by inserting measurement on the sketch.

The engineering design process was a methodical series of step that the engineers use in creating functional product and process. The process is highly iterative; parts of the process often need to be repeated so many times before another can be entered- through the parts that get iterated and the number of such cycles in any given project may vary. The design of part for this project is done by software, which is NX10. Using it, we can visualize our entire sketch into more practical picture. For this baby cradle, we only do for a prototype size since the main part of our project is the system itself which is baby monitoring system.

Table 3.1 Design of baby cradle using NX10 software

COMPONENT	**FEATURES**
	• The main place for the baby. • Size of this part (900x600x500) mm. • The small cylindrical at the side of cradle helps to connect with the legs for supports. • Three side of this baby cradle contain several rectangular holes.
	• Back side of cradle is connected by two hinges. • It can be half open to ease the user. • This cradle can be detached from it legs.

	• Support system for the baby cradle. • Height of these legs is 800mm. • The base size is (900x127x25) mm. • Wood at the centre is to support the legs. • The semi holes at both legs to hang the cylindrical knob. • Four plastic caster wheels are placed on each side at the base.
	• The motor was placed above stack of woods. • Motor and aluminium were connected by using coupler. • Diameter for the round aluminium is 40cm • A single piece of wood is connecter between circle aluminium and the cradle by using hook.

	• Rectangular box for electronic components. • Located far from the baby inside the cradle
	• Sensor's holder which place the sound sensor at the cradle • This sensor will detect baby's crying. • Can avoid sound sensor to be touched by the baby or user.

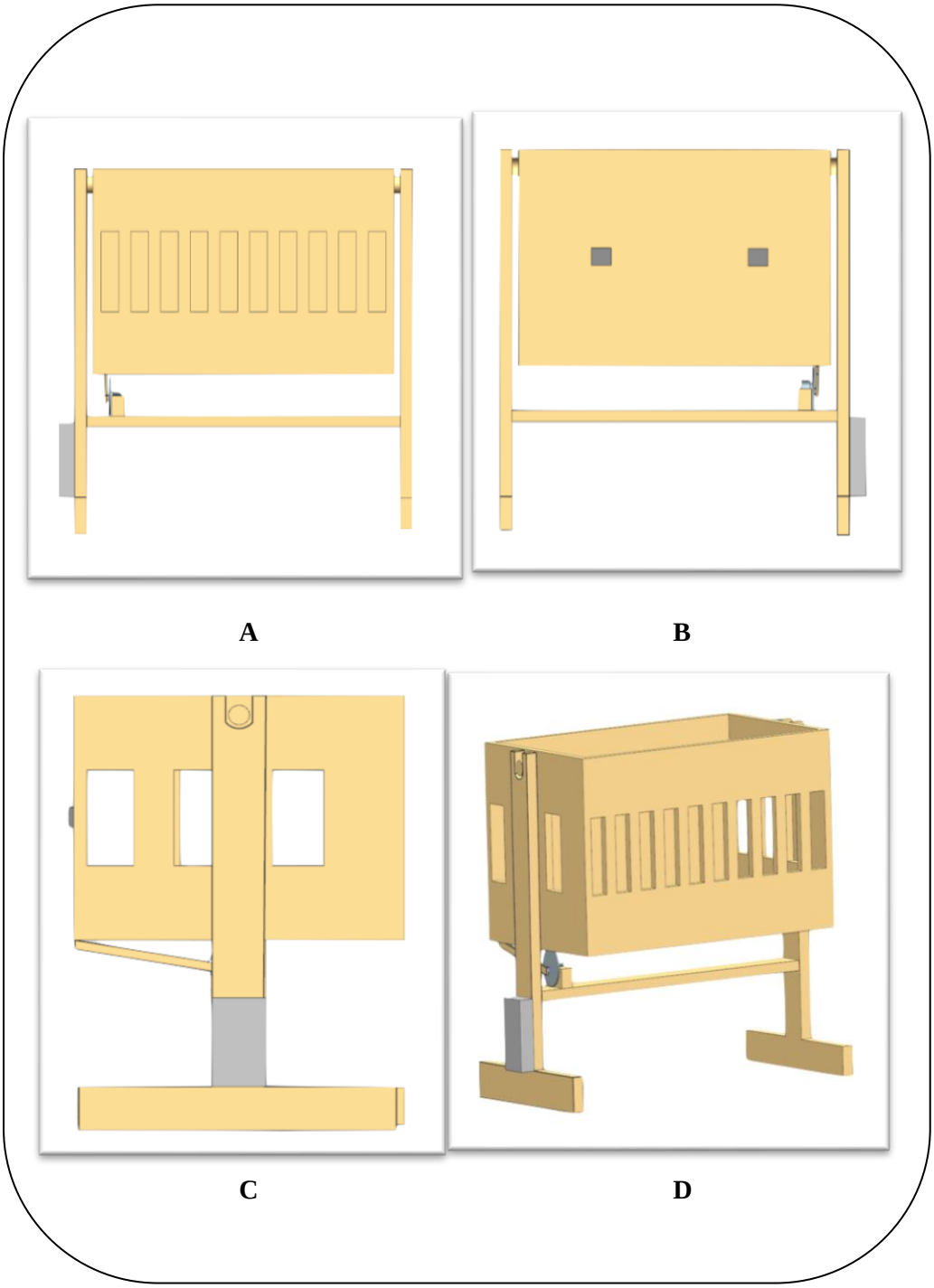


Figure 3.2 Finished design A: Front view, B: Back view, C: Side view, D: Isometric view

3.4 Geometry Parameter

Choosing the right material is one of the keys that lead to success for our project. Material selection is known as a core step in the process of designing any physical object. In the context of designing product, the main goal of material selection is to minimize cost while meeting product performance goals (G.E. Dieter,1997). Systematic selection of the best material for the given application begins with the properties and costs of candidate materials. For our project, we had to choose material that cost within the budget set by the faculty. Our main aim for selecting material was to use woods. This is because we want our product to be eco-friendly. Moreover, there were so many products that available in market were made up form different type of plastic.

After doing some research about wood, there are so may type of woods that suitable for our baby cradle. Our team survey all type of wood that sell in Gambang, Pahang. Mostly, all the carpenter suggested that Red Meranti is the most suitable one as the primary material for the structure. It had met all the criteria needed for this project.

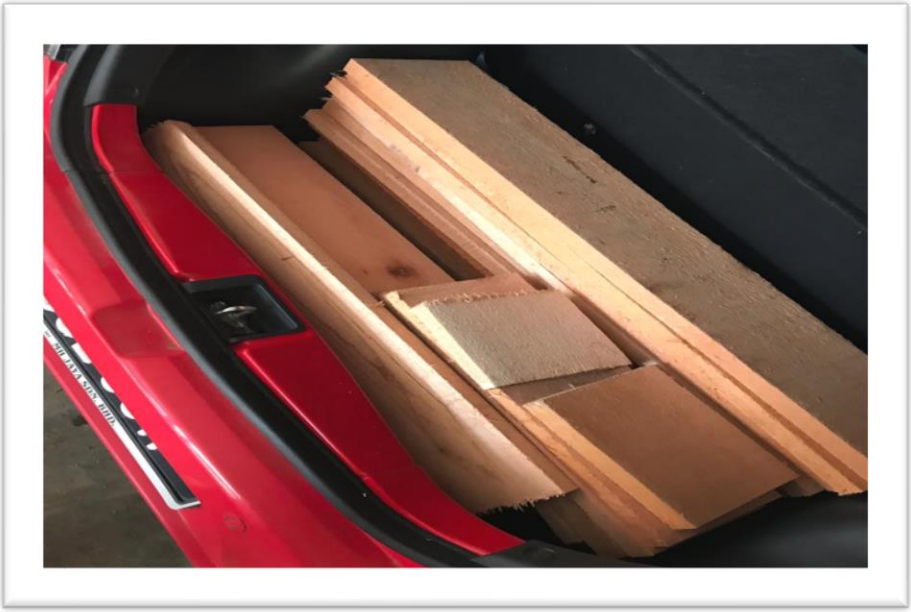


Figure 3.3 Red Meranti Wood

3.4.1 Properties of Meranti

Meranti is a soft to firm hardwood timber commonly used for decorative purposes such as moldings, furniture, paneling, joinery and window frames. It is a very versatile and durable timber for indoor applications, and can be painted and stained to match the colour and designs in a home. Meranti is not subject to warping or twisting and is dent resistant. Because of its stability it can be used for a wide variety of applications. Meranti ranges from pale-red to reddish/brown. Due to the number of variations being marketed under the botanical species name Shorea, yet called Meranti, there will be some colour variation across the timber species. It has a moderately coarse grain but even in texture with an attractive ribbon feature.

Table 3.2 Physical properties of Red Meranti

Properties	Value
Tree size	65-130 ft (20-40 m) tall, 3-6 ft (1-2 m) trunk diameter
Average Dried Weight	30 lbs/ft3 (480 kg/m3)
Specific Gravity (Basic, 12% MC)	0.40, 0.48
Janka Hardness	550 lbf (2,460 N)
Modulus of Rupture	11,210 lbf/in2 (77.3 MPa)
Elastic Modulus	1,652,000 lbf/in2 (11.39 GPa)
Crushing Strength	6,120 lbf/in2 (42.2 MPa)
Shrinkage	Radial: 4.1%, Tangential: 7.8%, Volumetric: 12.6%, T/R Ratio: 1.9

Next, red meranti was chosen because Meranti is widely harvested and available worldwide. It should be moderately priced despite the fact that it is imported. Andalso, it can be easily saw manually. Since the baby cradle is complex and consist of many parts, it is a must to find a material that can be joint easily. Typically, red meranti easy to work, due to its low density. Though some rough or ragged surfaces may be left while sanding, and it may be necessary to sand up to a finer grit to obtain a satisfactory finish. Some species may have a slight blunting effect on tools due to small levels of

silica present in the wood. Moreover, there is no characteristic odour for this type of wood, so it is suitable for baby. It did not bring harm to the baby. Meranti is easy to work with and has good nailing, screwing and gluing properties. Meranti readily accepts varnish, paint or stain. Its open grain structure means surfaces should be sanded before finishing. It is readily used for a wide variety of internal decorative applications and window frames. As Meranti has a fairly high silica content, it is essential to keep all cutting tools very sharp as the silica will dull the edge very quickly.

Meranti is popular for use in a wide variety of internal applications such as joinery applications for moldings, cabinetry, architraves and skirting, newel posts, handrails, furniture and panelling. The colour of Meranti heartwood varies sharply from dark red to light red-brown and from pale pink to pink-red. Given the diversity of tree types and their region of origin, for the Shorea red meranti species there will always be differences in shades and weights in a delivery of timber. The pink grey sapwood is 20-50 mm thick and distinct from the heartwood. Moreover, red meranti is not recommended for external use, so it is suitable for make baby cradle. There are two types of Meranti, Dark Red and Light Red. Meranti consists of 20 different species meaning the span of colours is quite varied so you will see many shades from light-pink to dark-red. Porta manufacturers and moulds Light Red Meranti, which is less dense than Dark Red making it ideally suited to mouldings and internal joinery applications where decorative profiles are needed. This is why light red meranti is the most suitable among other Meranti.

3.4.2 Comparing Light Red Meranti To Other Material

In order to support our decision choosing the light red Meranti as our main material to build the baby cradle, we had done some comparison of materials between the light red meranti, balsa wood and also hard maple. The result is shown in the *Table 9* below:

Table 3.3 Comparison between light Red Meranti, Balsa and Hard Maple

Types of material	Light Red Meranti	Balsa	Hard Maple
Janka Hardness (N)	2460	300	6450
Modulus of Rupture (MPa)	77.3	19.6	109.0
Elastic Modulus (GPa)	11.39	3.71	12.72
Crushing Strength (MPa)	42.2	11.6	54.0

Table 3.4 Advantages and disadvantages of using Light Red Meranti

Advantages	Disadvantages
Low density, easy to work on	Chipping, occasional brittleness, and its open grain defeat attempts if want to create fine detail.
Fire resistance	Open grain of meranti tends to collect finishing material if applied while the wood is spinning. The result is a wrinkled surface.
Last longer than other woods	Easily tear out or splinter in jointing.

After further study, it is believed that the light red meranti is the best material compared to the Hard Maple and also Balsa. Light red meranti is chosen because of their medium Janka hardness. Modulus of rupture, elastic modulus and also crushing strength. Furthermore, it is very cheap and easily to get compared to balsa wood in here. *Table 10* shows the advantages and disadvantages of using light red meranti.

3.5 Fabrication

Manufacturing process in which an item is made (fabricated) from raw or semi-finished materials instead of being assembled from ready-made components or parts. The materials are construct by combining the parts and components to become finish product. The concept of fabrication always involves the process of assembling. The fabrication starts with shop drawings including precise measurements then move to the fabrication stage and finally to the installation of the final project. These value-added processes including cutting, panelling, drilling, sawing, forming, 3D printing and machining are done in workshop.

3.5.1 Planing Process

Before start all cutting process and assembly process, all the wood was going through planing process to avoid the wood chips. The principle is to clean the wood surface of the cutter mark and flatten the wood surface so that the entire surface is equal and make the four sides of the wood 90° angled. Most of the wood thickness are down sized until less than 1 inch. It works to smooth the wood surface after it comes out of the kiln dry.

Figure 3.4 Planing Machine

For finishing, hand planing machine are used for the smaller surface area. This is because the woods that we want modified were already connected with another piece. Thus, it cannot pass through using the automatic machine.

3.5.2 Cutting Process

The red Meranti wood come in 14 pieces of (3x1) feet, 4 pieces of (2x1) feet and also one piece of (2.5x1) feet. The size of wood eases the cutting process for us. Different size of wood is for different part. Mostly 3 feet wood are for main structure which is the rectangular baby cradle. While, 2 feet wood are for fence that protect the baby from falling and also 2.2 feet wood are for both legs that holds the cradle.

The first thing that was going to do is to measure all the material and make sure all the measurement is measured according to the measurement that we have made on NX10 software. This step is using measuring tapes and mark only using pencil and L shape ruler to make sure the line is 90^{o}and not tilted when cut. The measurement is double checked to avoid any mistakes.

Figure 3.5 Measuring tape

Figure 3.6 L Shape Ruler

The material has to be cut into desired size. This is done by various of tools. For our project, we had two type of table saw machine. For example, one of it the saw is attached into the table and we can only turn it up to use it. Another saw table that we use is the one can laser so ensure the cutting is straight. It also has another speciality which it can cuts the wood based on how much degrees we want. Only a little force is needed to cut the wood into pieces.

Figure 3.7 Table Saw Machine (Attachable Saw)

Figure 3.8 Table Saw Machine (Detachable Saw)

There is certain part of the pieces are going through sculpt process to make a place for hinges so that they are not on the top surface. This is because to make a flat surface at the back of baby cradle for a better-looking product. We were using the smallest sculpture for a precise size.

Figure 3.9 Various size of sculpture

3.5.3 3D Printing

3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object. 3D printing is the opposite of subtractive manufacturing which is cutting out / hollowing out a piece of metal or plastic with for instance a milling machine. 3D printing enables to produce complex (functional) shapes using less material than traditional manufacturing methods.

The casing of the sensor was made by 3D printing. The dimension of the casing is about (1.5x3) cm. There are two holes was made for the screw and also the there is a open side so that sound sensor can detect sound effectively.

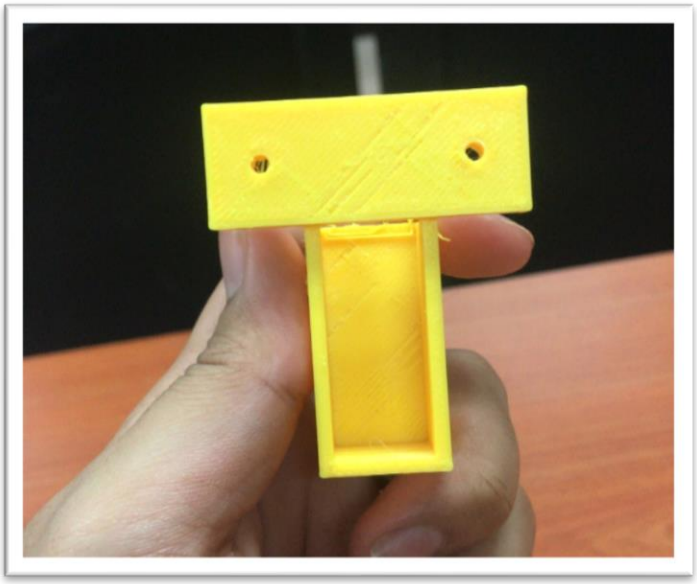


Figure 3.10 Sound sensor casing

3.5.4 Assemble Process

After cutting and 3D process are done completely, we need to join all the pieces based on the design that have been made using NX10 software. The assembling process is done by using glue, screw and also nut which will hold the all parts of baby cradle include their legs and electrical parts. Every part has to secure by glue to make sure the join between pieces are strong enough to hold up.

First part that we join up together is the front part of baby cradle. To make sure the fence is glued together completely, we using the wood joinery setter principle. A 3cm round wood be a filler on the holes that have been drilled using hand driller. the place where should the hole are be made are marked using pencil and ruler to make sure the holes are parallel with another side and also to ease the drilling process.

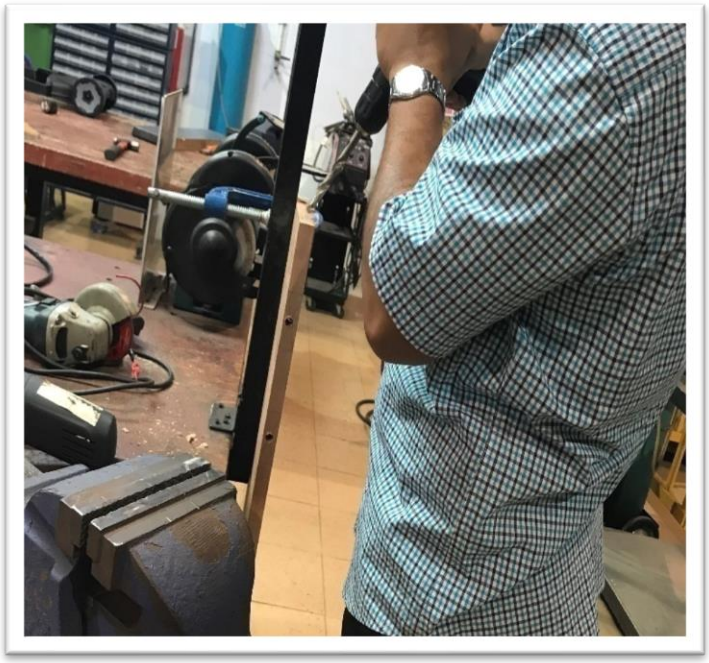


Figure 3.11 Drilling Process

Right after all pieces are done drilled, the wood filler is placed in the holes and glue plays a big rule to hold up the pieces together stronger. Wood glue are applied all over the surface that need to be stick together.

Figure 3.12 Joining process

Figure 3.13 Front part that fully joined

Since the side also have a same design, it also goes through the same process as front side. For the back side of baby cradle, is was connected by only using two hinges that have been screwed onto the pieces. In order to make sure all the pieces glued perfectly, they were clamped for at least one day by using various size of G-clamp that available in the workshop.

Figure 3.14 G-Clamp

While waiting for all the part are dried completely, we are moving on to next step which is combining the legs part. A rectangular hole was made at the base. Figure 3.16 shows the legs of baby cradle that have been screwed together.

Figure 3.15 Leg of baby cradle

Once all parts are completely dried, by using hand driller, all the segments are screwed together became a rectangular shape as shown in Figure 3.17. The works are done carefully so that the cradle was not slanted or the woods are not chipped off during the process.

Figure 3.16 Completed cradle

Next, at both side holes was made by using a different type of head that can make hole with 3cm diameter of more. Exactly 3cm diameter of cylindrical wood was inserted into the holes to be a holder.

Figure 3.17 Holder

After that, we proceed to make half circle holes at the legs of the cradle. By using mini saw and files wood craft, the shaped that can hold the holder was made. Also, the centre wood was act as support.

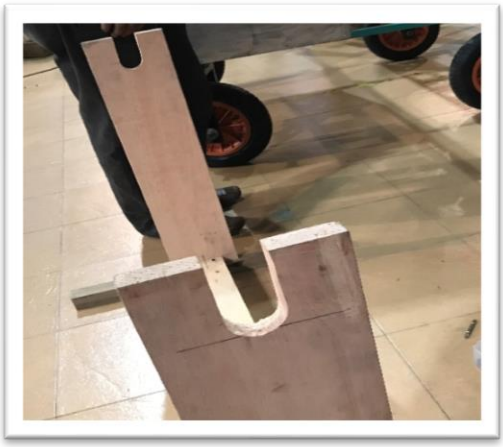


Figure 3.18 Making holes at the legs

Lastly, all the completed part was assembled together to become a baby cradle.

Figure 3.19 Front view

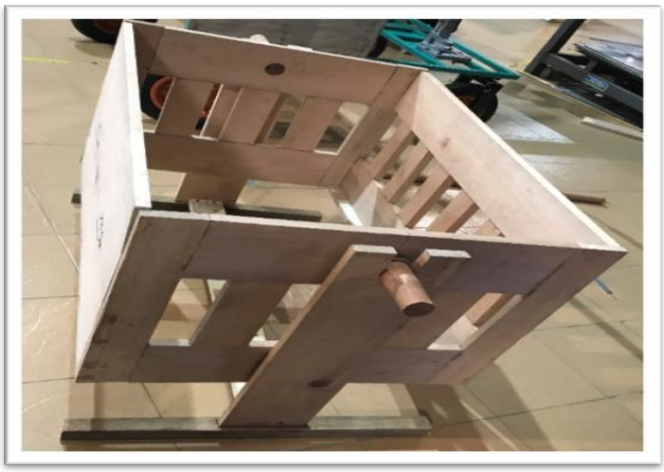


Figure 3.20 Side view

3.5.5 Decoration Process

The whole baby cradle was shellac brush colour pine wood. But unfortunately, the colour a little bit off then we change it. We paint the baby cradle using brush in white and decorate it with maroon ribbon and put baby bed in it. We layered the paint four times to make sure all parts of the wood are totally covered.

Figure 3.21 Painted cradle

3.6 Summary

In conclusion for chapter 3, all the process had been done in workshop in UMP with helps of the machine and the training engineer. The duration for this process is almost a month and half. Since all the part had been assembled, they are ready to be tested with the baby monitoring system.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Project Outcome

At the end of this project, testing had been held to ensure it is functioning as stated in the objectives. After the first trial, the baby cradle did not swing perfectly because of the connecter between the motor and the cradle This is due to the unexpected diameter of the aluminium. The aluminium is slightly bigger that the designed that had been made. So, a few ideas are generated and it is decided to change the diameter and lengthen the length of the wood that connect into the cradle by 2cm so that it when the motor rotates, it can make the swings more smoothly and achieved the angle that we want. Apart from that, the position of the sensor initially was a bit too far from the baby. So, the sensor cannot detect the sound of baby crying. In order to overcome this problem, we shorten the length between the baby and the sound sensor so that it will sense accurately. After the adjustment is done, the baby cradle is able to operate correctly according to the program. The baby cradle able to detect sound of baby's crying accurately and the swings of the cradle is very smooth.

4.2 Prototype Validation

Prototype was tested with helps of 10kg ballast that act as baby. Most of babies in Malaysia average weight are 10kg. After that, we started to test the system whether it can accommodate to run smoothly as we planned. With the aids of mobile phone by

opening baby crying sound from the internet. A mobile phone was placed near the sound sensor as the stimulation of real baby crying situation. Due to the loop process in the programming codes, the sound detection was having some time delay. The cradle would start the swinging action whenever the value of the detected sound. Notification on the mobile phone will pop out as soon as the signal is received at the MQTT server.

4.3 Discussion

4.3.1 Baby Cradle Design

The initial design was made at NX10 software as Figure 4.4 below. We improvise the design because as we make more research about designs that available at the market, mostly there is so much similarities in it. We decided to design a baby cradle that can act more than one task. So, we make a new design that the cradle itself can detachable from the legs. By doing one side that can half open, the baby cradle can act as changing table also.

Figure 4.1 Initial baby cradle design

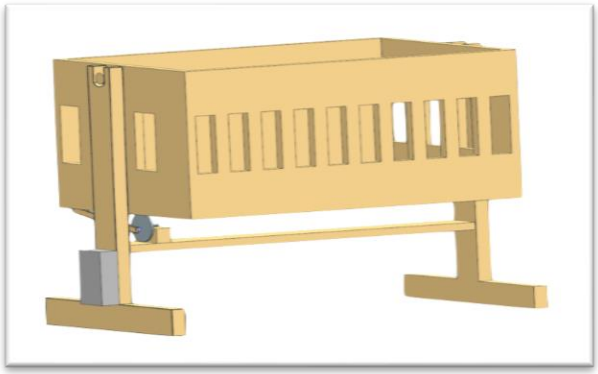


Figure 4.2 Latest baby cradle design

Four rotating wheels with locks on each wheel as shown below were used in the baby cradle prototype. It eases the user to be able to move around the house without to disassembly the prototype. It was installed at the corner of base of the prototype. The wheels could be locked or unlocked based on the user's preference. To prevent movement of baby cradle while the baby is in it, the user can lock the wheel so that the baby cradle can stay still.

Figure 4.1 Plastic rotatable caster wheel

Rotating mechanism that included the round aluminium that connected with a piece of wood and also it was tighten up by the coupler. Basically, all the motor needed a coupler to be a connecter. The coupler screwed on the round aluminium that will trigger it to rotate 360^{o} degree and it would cause the cradle to swing by elevate around 20^{o}degree on one side.

Figure 4.2 Rotating mechanism of baby cradle

One of the specialities of this baby cradle is it can act changing table also. The back side of the baby cradle can open half ease the user to change the baby cloth as well as transferring baby in or out the cradle. It completes with two latch that will hold the door. If the user wants to open the cradle, just open the latch and attached it back to avoid the baby sneak out.

Figure 4.3 Back side

Figure 4.6 and 4.7 below show both before and after final touch to the baby cradle. The concept of this baby cradle has been changed due to several reason such as the colour did not so suitable for the baby. Moreover, nowadays mostly parents are more interested onto bright colour such as white colour. Several decorations were made on the final prototype as shown in Figure 46 included the musical toys that can control by mobile phone. All others pictures during the process are shown in appendix B.

Figure 4.4 Unfinished prototype

Figure 4.5 Final prototype

4.3.2 Baby Monitoring System

The result of the data measured from the sound sensor and temperature & humidity sensor can be obtained in both Adafruit MQTT server and MQTT Dash mobile application. From Figures 5 and 6, both MQTT server and MQTT Dash apps are synchronized and displayed same reading uploaded by the NODEMCU microcontroller in the baby monitoring system.

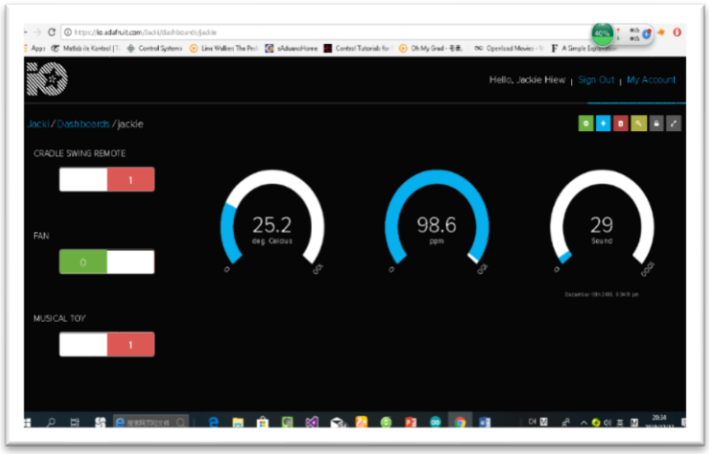


Figure 4.6 User interface on AdaFruit.io

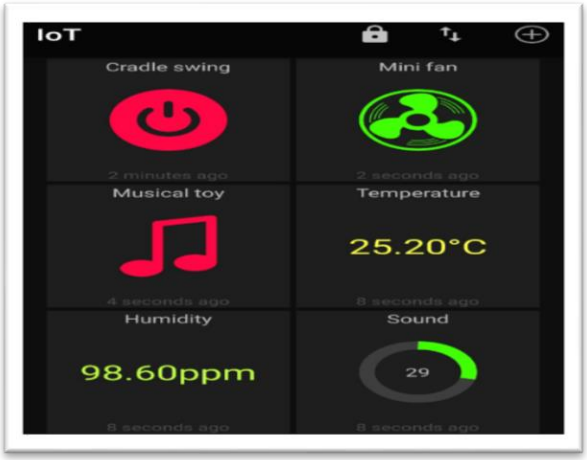


Figure 4.7 MQTT Dash mobile application interface

The final prototype can be swing automatically whenever sound is detected by the sound sensor. A notification, shown in Figure 51, will be sent to the user through IFTTT mobile application to notify the user that crying is detected on the baby monitoring system. The user can also remote the cradle to swing manually by toggles the switch in the MQTT server or mobile apps. User can also remote the mini fan through both MQTT server and mobile application. A musical toy, which can be remoted by the user, is installed to entertain the baby.

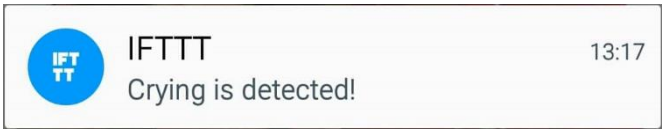


Figure 4.8 Notification through IFTTT application

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Red Meranti is the main material to build the baby cradle because it is generally used in woodworks due to its durability and workability. To achieved the objectives of the project, a lot of improvements were made during the enhancement phases to make sure a better outcome. The finishing prototype is tested by using a mobile phone with a baby crying ringtone which put in the cradle. The cradle would start swinging assuming the baby is crying because of the detected sound. A notification would be sent to the mobile phone of the user, notifying the user that the baby is crying.

Real-time monitoring is achieved by the aids of the wireless camera. Through the camera mobile application and talk to the baby through the built-in microphone on the wireless camera the user can monitor their baby. Temperature and humidity of surrounding would be taken and turned on the mini fan is the measured temperature is above 28^{o}C. With the aid of NodeMCU, parents can also remote the baby cradle and the mini fan with the tip of their fingers using mobile apps or the computer connected to the network.

A low-cost baby monitoring system prototype was managed to build by the team that can measure the baby's vital parameters such as the baby crying condition and surrounding temperature. NodeMCU is used as the main controller board in the project's circuit design because it had a built-in Wi-Fi module which enables the implementation of IoT concept in the project. The demand of IoT can be achieved by using the NodeMCU due to its simplicity and available examples from the network open-sources.

5.2 Recommendation

For this project, it is recommended to test it in the real environment such as put the real baby aged 2years and below so that we can know the condition for the baby cradle when it hears the baby is crying. It is important to know the sensitivity of the sound sensor and how fast it sends a signal to the server. For a better result, the sound system can change into the better sound sensor that can picks up of the sound of baby crying as soon as it hears. It also recommended to test with varieties weight from 0 until 12 kg whether it can accommodate and swings smoothly. Next, it is better to add some safety precaution for the cradle such as all the edges was covered so that baby hands are safe from the chipped woods. A lighter and safer material, such as soft plastic, can be used to replaced wood material so that the safety of the baby can be ensure. Then, the rotation mechanism may change into other mechanisms that more compatible for user. In future, there is a lot of changes and improvement that can be made to make a better baby cradle with IoT – based baby monitoring system.

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APPENDIX A

Total budget and cost analysis for equipment of an IoT based Baby Monitoring

NAME OF EQUIPMENT	UNIT PRICE (INCLUDE GST)	UNIT	TOTAL PRICE (INCLUDE GST)
NodeMCU ESP8266 Wi-Fi controller Board	21.90	1	21.90
4 Channel Ways Opto Isolator 10A 5V Relay Module	15.90	1	15.90
40p Jumper Male to Male(MM) 20cm	3.90	1	3.90
Analog & Digital Mic Microphone Sound Detection sensor (4 pin)	5.90	1	5.90
Solderless Breadboard 830 Hole	5.90	1	5.90
Mini clip fan	30.00	1	30.00
Lullaby toy	30.00	1	30.00
KKMoon Wireless security camera	100.00	1	100.00
Red Meranti Wood (1'' x 6'')	2.50	60	150.00
12V DC Geared motor	55.00	2	110.00
AC to DC 12V power supply	48.00	1	48.00
Electrical Box	11.00	1	11.00
Buzzer	3.00	1	3.00
DHT22 Temperature & humidity sensor	22.00	1	22.00
DC motor coupler	21.00	1	21.00
MD10-POT 10Amp DC Motor Driver	20.00	1	20.00
USB Data cable	10.00	1	10.00
TOTAL COST			**RM608.50**

GHANTT CHART

WEEK / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SDP2 Briefing															
Preparation, procurement list and place order															
Material arrival															
Fabrication of Baby cradle															
Assemble of project															
Thesis writing															
Testing and improving of BMS															
Preparation of group report, poster and presentation slide															
Poster printing															
Presentation of project															
Submission of log book and group report															
Submission of final individual thesis report															

APPENDIX B

Sanding the woods using stearates papers to get a smooth surface

Sculpt process for hinges.

Shellac process before painting in white

Drilling process using hand driller.