Personal Education Machine for Children
Group Number: 18

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I have read this report and approve its content.

Abstract

Future is in our children's hand. It depends on how they grow and prosper. Child development is one of the major issues in the world citizenship. However, as a society develops, parents which have to take part in the society through their work often do not have enough time to spend with their children. They need helping hands that could alleviate the load they are facing. The common solution is probably to hire a babysitter. So in this scenario, the babysitter will be responsible for the children development. However, parents usually want to have some level of monitoring and control over the situation. Having a technology that could facilitate such a situation is necessary. This is why our project rise.

Our project, Personal Education Machine for Children (PEM) addresses the issue raised above. PEM is an interactive doll for child development. It is able to respond and interact with children through visual and vocal interactions. This creates a conversational and interactive activities between children and PEM which facilitates learning. Children can ask questions to 'PEM' and it will answer based on predefined set of questions stored in its database. It can also move and the statistics of the conversation will also be recorded, and the parent can access it every time they want so they can adjust their method of teaching to their children's behavior. Other than the mechanical function of 'PEM', it is a doll which is light, adorable, and fluffy.

The project's results from observation and experiment show both errors and potential sights. Using provided speech recognition APIs with kids' voice doesn't work effectively as we plan and causes the interaction between doll the kid to fail desperately. This is occurred because of the high tone of the kids' voice and unclear pronounce. On the other hand, remote control function on mobile application is extremely satisfied by parents. Having the doll to act as other friend to talk with their children while parents can observe is really beneficial. This allows parents to see their children in other perspective that they cannot when they're with their children alone.

While the project has a lot of flaw, but with an improvement, the project definitely has a lot of room to grow and potential to become a commercial product. This project directly answers to parents who don't have enough time to play with their children and want a toy or tool to help them.

Acknowledgement

Table of Contents

List of Figures

List of Tables

CHAPTER 1
Introduction

1.1 Problem Statement, Motivation, and Potential Benefits

Playing is a very important step in children's development. Parents often find themselves in a situation that there are many things to do but they have to take care of children at the same time. A child caretaker may be a solution but it is still hard to trust a stranger to take care of children. However, with this project, the problem can be manageable. This project proposes a development of an educational toy that can help improving children's learning ability by teaching various kind of subject, telling stories, asking questions and providing answers. These feature will be implemented in an interactive doll. The doll can also monitor children's behavior and provide these data to parents. With this, parent will have a helping hand in taking care of their children and providing them an edutainment toy that will help in children's development.

1.2 Objective

1. To help children learn by interacting with the doll such as talking, and gesturing.
2. To help parents observe children learning using mobile application.
3. To create a friend which parents can control and play with their children.

1.3 Scope

1. Target children who are around 3 to 5 years old.
2. Design to be fluffy and cute for children's favor.
3. Using Raspberry Pi as a main component in doll.
4. Using a server as a main computing component.
5. Mainly communicating using Thai language and gestures.
6. Required Wi-Fi internet to function properly.
7. Using rechargeable battery which provides at least 3 hours usage.
8. The doll can answer simple question such as date and time, calculation, etc.
9. The doll can do activities such as telling a story, playing simple game, etc.
10. Parent can use mobile application to view the data about their children online such as conversation history, which topic children talk the most, etc.

1.4 Task and Schedule
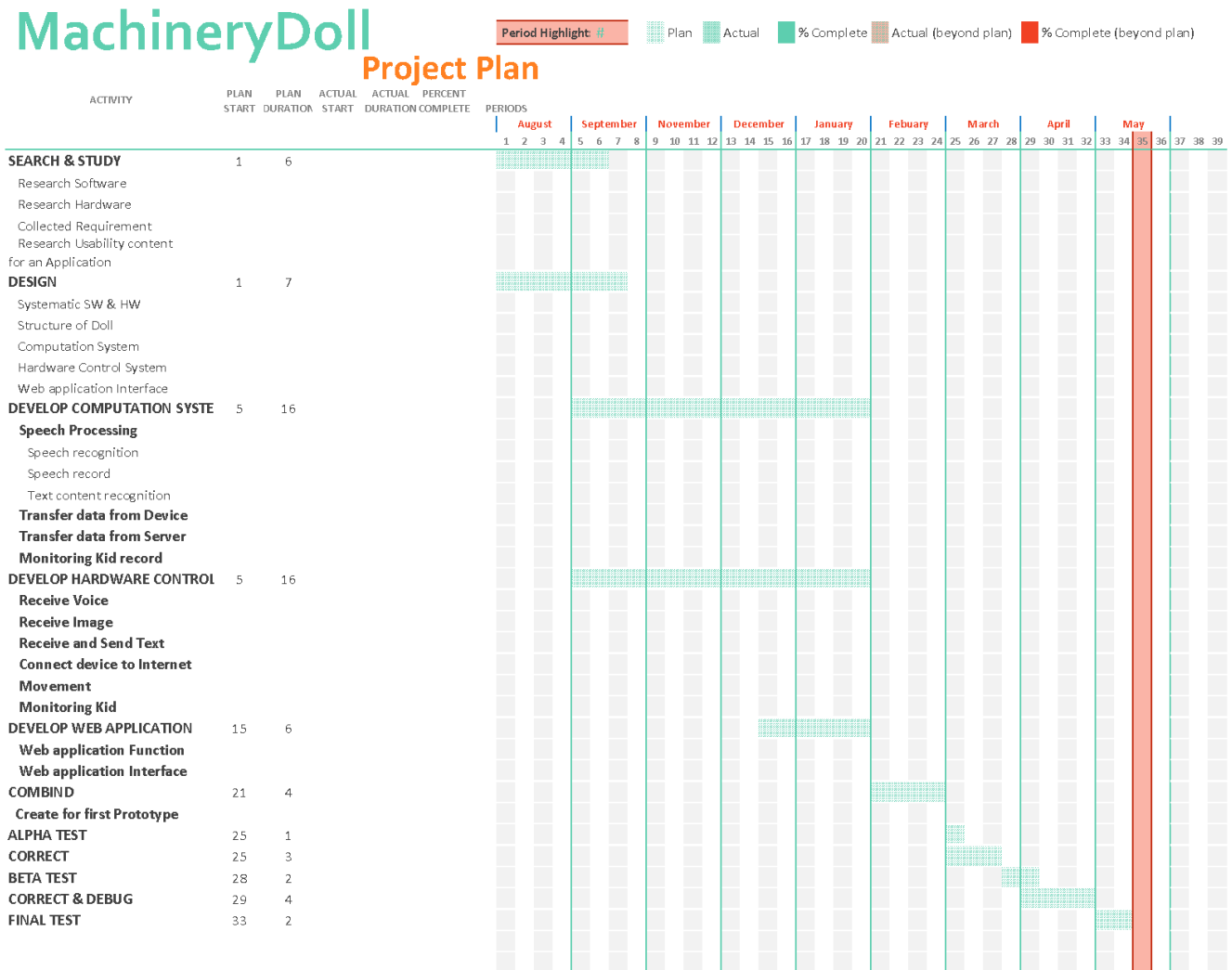
Figure 1.1 Task and Schedule Plan

CHAPTER 2
Background, Theory and Related Research

2.1 Background

Figure 2.1 NAO Robot

Figure 2.2 Huggable Project

Interactive doll is not a new innovation. There is a lot of interactive doll in recent year. Some is created for a development purpose such NAO robot, Bioloid robot, etc. While some is created for medical purpose such as Huggable project, etc. The different purpose will affect the functionality and appearance of the doll. The development purpose doll, like NAO robot, will focus mainly on the movement of the body, while the medical purpose doll, like Huggable project, will focus mainly on interactive conversation, and cute appearance.

The main comparison of this project will fall into commercial purpose doll. In this category, we select other three recently invented product based on the commercial purpose to compare with our project. The products are Ubooly, Zoomer Dino, and Furby.
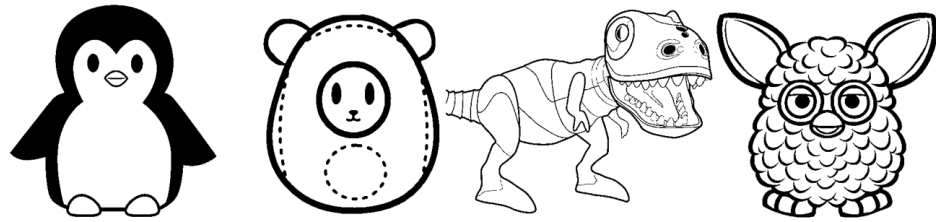
Functions	PEM	Ubooly	Zoomer Dino	Furby
1. Talking	✔	✔	✘	✘
2. Movement	✔	✘	✔	✔
3. Locomotion	✘	✘	✔	✘
4. Sensor	microphone	✘	Infrared	✘
5. Control	voice , app	voice	voice , remote	app
6. Interactive	voice , gyro	voice	voice , infrared , holding	gyro
7. Spoken Language	Thai	Eng, Fr, Jp, Ge, It, Sp	-	Furbish
8. Internet connection	✔	not require but recommended	✘	✘
9. Target (years old)	3 - 5	4 - 8	7 - 16	all age
10. Cuteness	✔	✔	✔	✔

Table 2.1 Comparison of Commercial Dolls

Ubooly is an empty shell doll. This means the doll will only act as a shell. The main component of this doll will be mobile application. Inside the doll, there will be a space for a mobile to fit in and run a Ubooly application. Ubooly is not a thinkable doll. It only catches the keyword in the conversation and process a suitable answer.

Zoomer Dino is an unspeakable doll. The main purpose of this doll is to act like a pet. It can walk using two wheels and follow us using infrared sensor.

Furby is one of the oldest interactive doll invented. It designs to be cute and simple like having a pet. Recently, developers create an application to extend the function of Furby.

Comparison, every product has a similar function one or two, it can talk, it can move, or it can be played with application. The real difference that separate our project from theirs is language. Thai language is not a simple language to develop with due to the nature of it. It is also not a widely used language in the world. Because of these reasons, it is normal that Thai language isn't one of the feature of these doll. However, our project isn't, our project uses Thai language as a main language in the doll.

2.2 Theoretical Support

2.2.1 Technical Concept

Speech Processing

Speech processing is study of speech signal and the processing method of this signal. The main concept we use is speech recognition. Speech Recognition is the process of analysis the speech and convert it to text. The mainly use of this is to translate speech input to text in order to analyze the context of the text.

NoSQL

NoSQL is the database using key and value format and is schema less. These characteristics make the data become more flexible and support the large scale of data which also help the data management to become easier. The tools that support NoSQL is MongoDB, CounchDB, etc.

Word Segmentation

Word segmentation is the concept of acquire the words from the sentence. In most language, this can be simply done by using space to separate each word. But for Thai language, this can't be done because Thai language has no space between words so the concept of "Longest Matching" is used. "Longest Matching" will analyze each character in the sentence and use dictionary to acquire the word that has meaning. The longest word that has meaning will be selected and cut out of the sentence then the process continues until the end of the sentence.

RESTful Service

RESTful service (Representational State Transfer) is the concept of construct the model that has scalability and modifiability. In this project, we are using this concept to a HTTP model to use this model as a communicator between three platforms which is doll, server, and mobile application. The methods involving around this project are GET, POST, PUT, and DELETE.

2.2.2 Protocol Theory

Bluetooth

Bluetooth is a wireless technology that is well-known as wireless for exchanging data between devices in short distance. This can build mobile personal area network (PAN). There is many Bluetooth application and device, for example transfer file between mobile phone, headset, headphone, speaker, mouse, and keyboard. Bluetooth is easy to configure and connect with headless, so it is selected as a connection between doll and mobile application in order to set the doll settings such as wireless, speaker volume.

I²C

I^2C is a serial connecting invented by Philips Semiconductor. It uses only two bidirectional open-drain lines, Serial Data Line (SDA), and Serial Clock Line (SCL). I^2C is used to communicate between Raspberry pi and other component (Arduino and accelerometer).

2.2.3 Program language & Important Libraries (For each part)

Python

Python is high-level programming language that is widely used in nowadays because of low level requirement of understanding and very clear statement. Python can be used to implement complex function with a simple statement. There are many libraries implemented by python. Python is used in this project in hardware interface and server.

Node.js

Node.js is the language for creating backend for web service. This project use Node.js to create API as a connection between three platforms which is doll, server, and mobile application. The API will be built based on the concept of RESTful service which allows system to be scalable and modifiable. The advantages of using Node.js over regular web language such as PHP are scalability, and asynchronous system.

2.2.4 Software & Tool for implement

Google Speech

Google Speech is a API service which provide speech application. The main services that this project use is "Speech Recognition". The service is using http command line interface to send a request to Google Speech server and receive a response by the same way. Google Speech is free for the developers and require no registration to use.

MongoDB

MongoDB is a tool for developing NoSQL database. In the project, MongoDB will be accessed through Node.js API and "mongoose" library. MongoDB can also be accessed through other language such as python, java, c, etc.

LexTo

LexTo (Thai Lexeme Tokenizer) is a tool for word segmentation. LexTo's outputs after separate the word from the sentence, will be Thai word, English word, unknown word, number, and special characters.

Apache Cordova

Apache Cordova is an open source framework for quickly building cross-platform mobile application. The framework uses HTML5, CSS, and JavaScript on the backend then the tool will adapt the code to suit the operation system of each platform some people know in another project which is for commercial called Phone Gap. The advantage of using Apache Cordova is that it allows the developers to be able to create cross-platform mobile application without learning each platform coding.

jQuery Mobile

jQuery Mobile is a tool for building mobile website along side with Apache Cordova. The tool is used to implement PHP and MySQL inside the mobile application.

Ionic framework

Ionic framework is a framework which using to develop cross-platform mobile applications look and feel like native application. For develop application from this framework, it uses HTML5, CSS3 and JavaScript language to done the project.

Sublime 3

Sublime version 3 is a text editor program which using for editing software source code.

2.2.5 Hardware Components

Raspberry Pi

Raspberry Pi is a low cost computer in credit card size. It can plug to monitor, keyboard and mouse to use like normal computer. Most of people widely use it in embedded module because of low cost with good performance. Because of this, Raspberry Pi has very big community. Raspberry Pi supports Python officially, therefore Raspberry Pi has many Python libraries. Raspberry Pi is used as main processor in doll.

Arduino

Arduino is one of microcontroller developed by Arduino.cc. it is designed for using easily with C language. Arduino provides many official libraries therefore Arduino can connect with many components such as LED, motor, SD card reader, microphone, etc. Arduino is used for controlling motors of the doll by command sent from Raspberry Pi.

Servo motor

Servo is the one type of motor that allow precise control of angular, linear position, velocity, and acceleration. It can be positioned to specific position by sending signal to servo. Servo is widely used in robotics because of small size and is lightly. The servo used in this project is micro servo 9g because of light and inexpensive. This allows the doll to be able to move.

Accelerometer

Accelerometer is a device used to measure the acceleration force such as gravity. It can detect how much the doll is tilted. The model we use is MPU-6050 communicated by I^2C.

Webcam

Webcam is a camera which functions are to take the photo, and record the video. Webcam can be plugged as USB device. The doll uses the webcam to upload the video to server's database.

2.3 Related Research

Children's Developments

Children's development is the processes for increasing performances in each parts of learning abilities. Children will have capacity to do harder and more complex activities. The processes will create the developments in controllable way according to proper periods and times.

Dr.Nattawan Jraruworraponkun, the children's development specialist and pediatrician in Prayathai 3 hospital said "Children's development is the important foundation to grow up to be a great adult. These great mans will be the powerhouse of the national and the world in future. The continuous developing along all the processes have to take lots of care from people surround the child to do it together."

Playing

From a lot of researches about children's skill development, the well-known divisions are divided into 4 parts. There is physical development, mental development, emotional development, and social development. The mental part is the most important part which most of parents are concern about. The mental part is about the brain. Children's brain development has started since the mom is pregnant. The brain will develop faster when children were born until the age of 6. When people thought about intelligence development in brain, the learning to speak is the obliviously part of it.

According to the children specialist from KMUTT's children learning center, she said that "Playing and Kid belong to each other". Playing is the best way to develop children learning, Children play all the time even if they have people to play with or not. There is a lot of ways children can play. Then 'what to play' must be match to 'when to play' in each period of age.

There are some results from the researches confirm that "playing" is the important part for developing the brain's structure. Playing will stimulate association neurons between brain's neurons, especially in the first 3 years old child's brain to grow up in lively and creative. The increase of brain's neurons stimulating or the increase of electricity in a brain will create the development of a child's brain especially in the smartness in mental development part.

Toy

3 to 4 years old child will start to imagine and imitate an adult. The child should be able to use his body, arms and legs fluently. The proper toys for this age is a doll, a musical, or things that can call child's attention, a role plays toy, an animal doll, a board game, or a brain toys.

An animal doll is a useful toy to help children's development. Beyond the cuteness and fluffy, an animal doll can create many benefits for example; learning from touching sense, learning to take care and be kind for an animal and creating the basic of merciful mindset, learning language and speaking skill, and learning to create imaginations. An animal is an unlimited role play toy and unlimited the way to play. Children can create and imagine the doll to be anything depended on their imaginations. It can also help to develop emotional development by practicing the children to be careful when they playing, pitching, hugging, hitting, or kissing.

Speaking and Speaking and Language Milestones

Between ages 3 to 4, a child should be able to say his or her name and age, speak 250 to 500 words, and answer simple questions something likes Yes – No questions. A child in this age range can make up a new word from 2 – 3 words or a conversation from 5 – 6 words. He or she can understand words, speak clearly, and speak a complete sentence by age 4. He or she can tell stories or explain some simple answer.

The easy questions and simple conversations which we use in a prototypes (in control of children's development specialist) are :

Greeting Questions	Yes-No Questions	Simple Explanations
สวัสดี	จำเราได้ไหม	เคยเห็น...ไหม มันร้องยังไง
สบายดีไหม	หิวข้าวหรือยัง	... บวก ... เท่ากับเท่าไหร่
ชื่ออะไร	มีอะไรอยากเล่าให้เราฟังอีกไหม	โตขึ้นอยากเป็นอะไร
ทำอะไรอยู่	ออกกำลังกายกันไหม	ชอบกินอะไร
กินข้าวหรือยัง	ยกแขนขึ้น / เอาแขนลง	ชอบสีอะไร
ลาก่อน	อันนี้แขนอะไร	ไปโรงเรียนสนุกไหม
ราตรีสวัสดิ์	หนาวไหม	วันนี้ทำอะไรมาบ้าง
	ร้อนไหม	
	เล่นเกมส์กันไหม	
	เต้นกันไหม	
	ร้องเพลงกันไหม	
	อร่อยไหม	

Table 2.2 Easy questions and Simple conversations

CHAPTER 3
Design and Methodology

3.1 Feature list

Figure 3.1 A doll's Features

Server

- ♦ Analyze the main idea of speech and process the suitable answers.

- ♦ Save the uploaded speech in a text format and display when it is requested.

- ♦ Gather the collected data to display as statistic.

Doll

- ♦ Interactively talk with child using server for computation.

- ♦ Can move some part of the body such as rowing the wing, etc.

- ♦ Record and upload to server's database which can be viewed later.

Application

- ♦ Show the saved data in server's database such as setting, child development, etc.

- ♦ Remote to control basic action of the doll such as speaking, moving, etc.

- ♦ Edit the user data such as default setting, saved data, etc.

- ♦ Download data from database such as history, statistic, etc.

<u>List of action</u>

The doll can be interacted with the pre-programed word.

♦ Greeting - the doll will greet back based on the given inputs.

- สวัสดี
- ลาก่อน
- ฝันดี
- ชื่ออะไร

♦ Calculating - the doll will calculate the result based on the given inputs.

- หนึ่งบวกหนึ่งเท่ากับเท่าไร
- สี่ลบสองเท่ากับเท่าไร

♦ Action Command - the doll will interact with action based on the given commands.

- ยกมือซ้าย
- ยกมือขวา
- ชูมือ
- โบกมือซ้าย
- โบกมือขวา
- ออกกำลังกาย
- บิน

♦ Date and Time - the doll will answer based on the given inputs.

- ตอนนี้กี่โมงแล้ว
- วันนี้เป็นวันอะไร
- พรุ่งนี้เป็นวันอะไร
- เมื่อวานเป็นวันอะไร
- เดือนนี้เป็นเดือนอะไร
- เดือนหน้าเป็นเดือนอะไร
- เดือนที่แล้วเป็นเดือนอะไร

3.2 Overview Architect

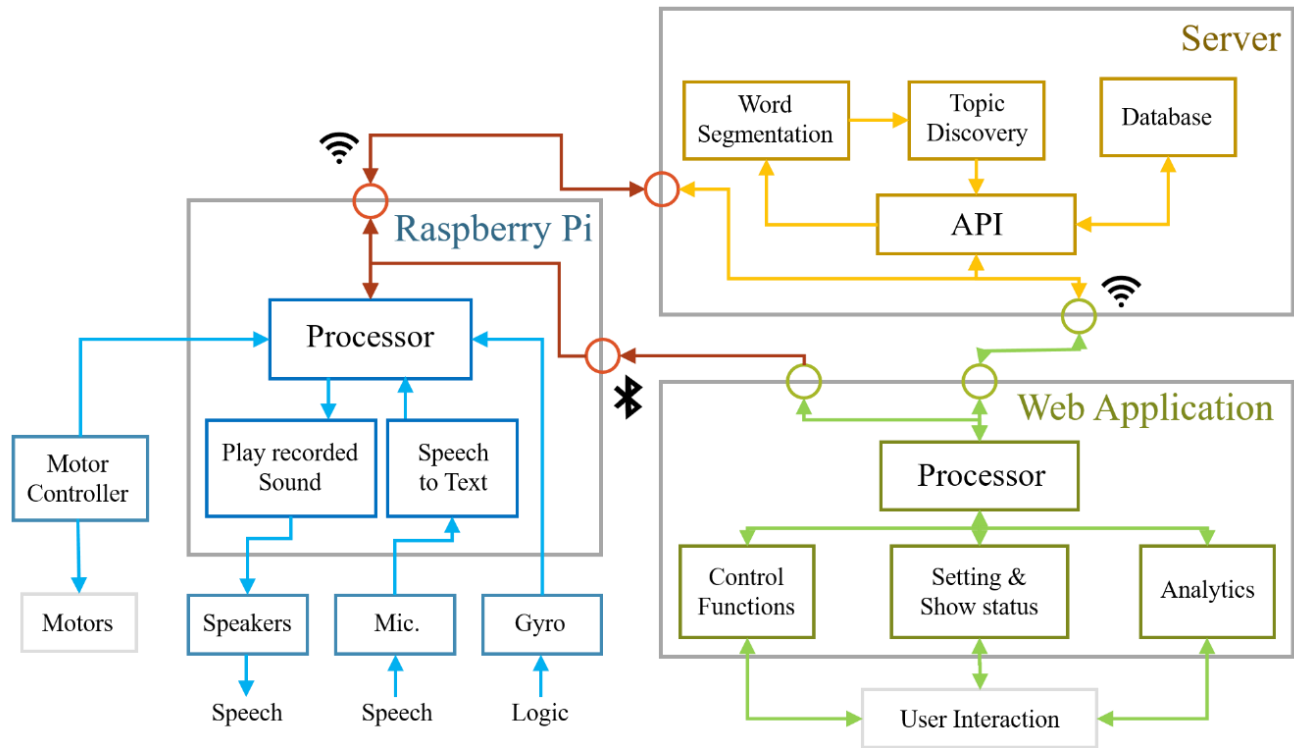Figure 3.2 Overview Architect

The architect mainly cover three parts which are Raspberry Pi, Server, and Application. The outer modules represent the hardware parts which are connected to Raspberry Pi. While the inter modules represent the functional programming part. The connection point between three parts (Raspberry Pi, Server, Web Application) is a API which will act as a RESTful gateway.
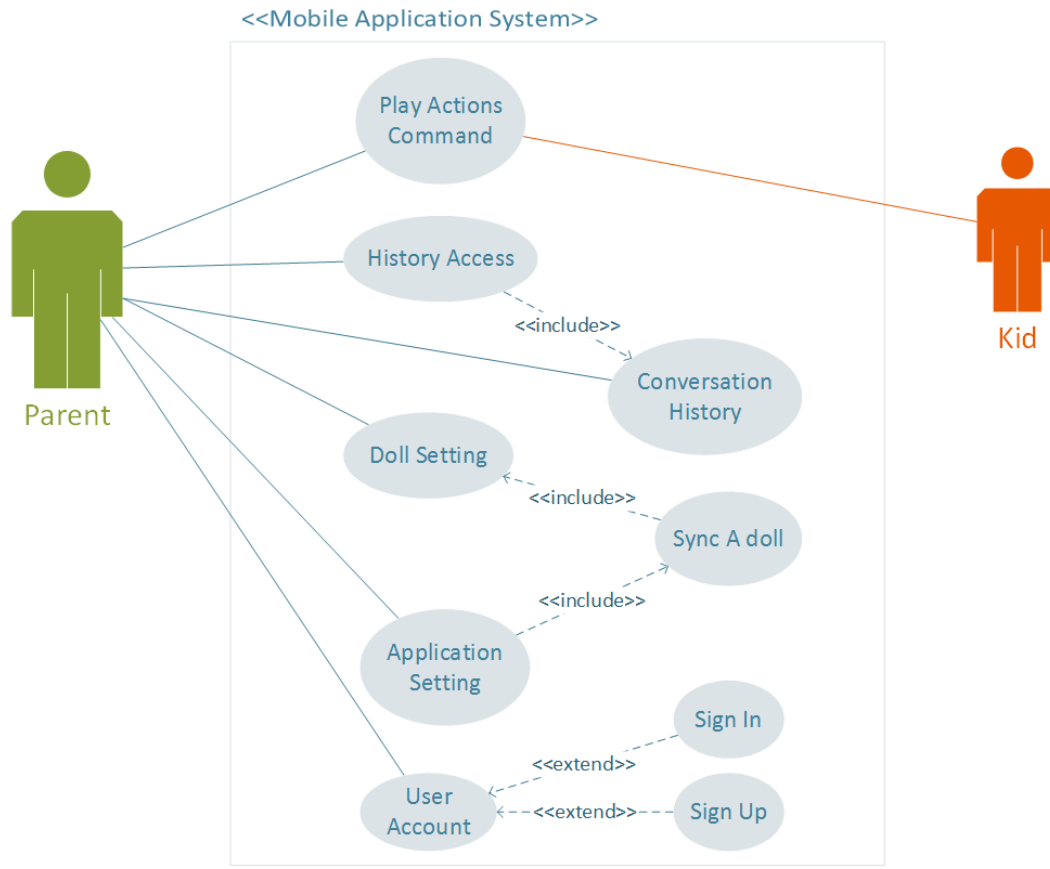
3.3 Use case Diagram

Figure 3.3 Use Case Diagram

The two actors in the diagram are parent, and kid. The module represents the action they can take. Mainly and only action kid can take is play and command the doll. While the parent can use mobile application to access a lot of function such as sign in, sign out, viewing history, etc.

3.4 Functionality Diagram (Swim lane and Sequential)

Turn on

This diagram describes the activity when the doll is turned on.

Figure 3.4 Functionality Diagram – Turn on

The diagram explain the sequence activities that the doll will automatically act when turn on. It will simply find the connection to server and then wait for the request command from the users.

♦ Doll Activity

This diagram describes the activity to receive sound and response.
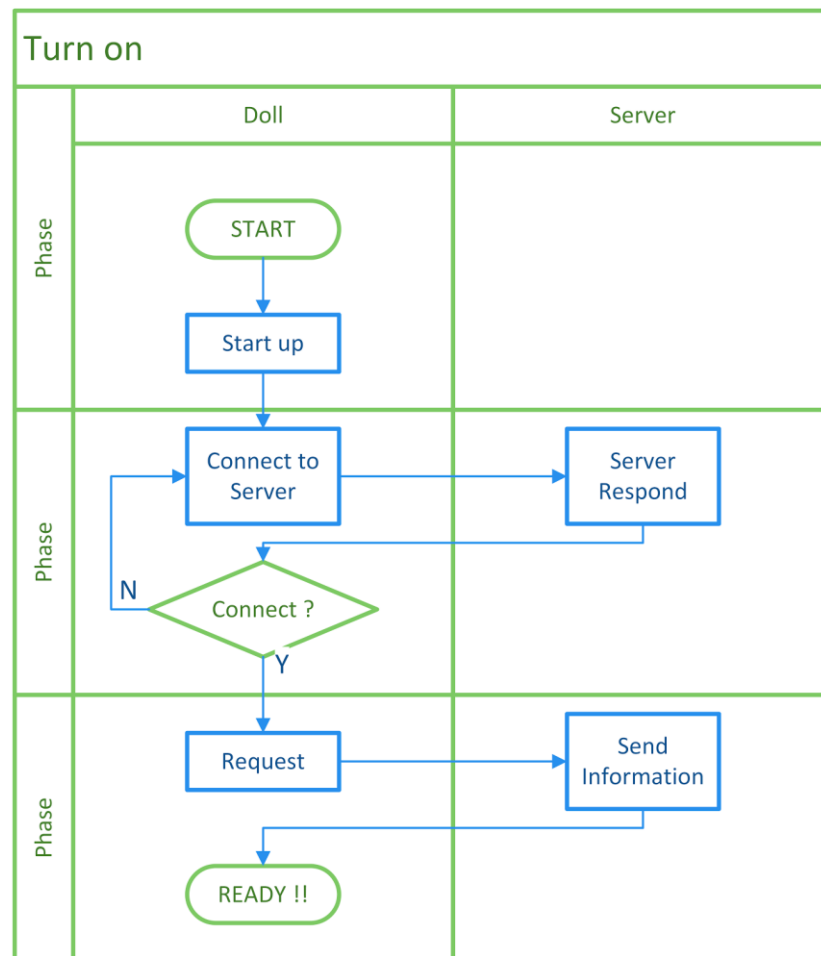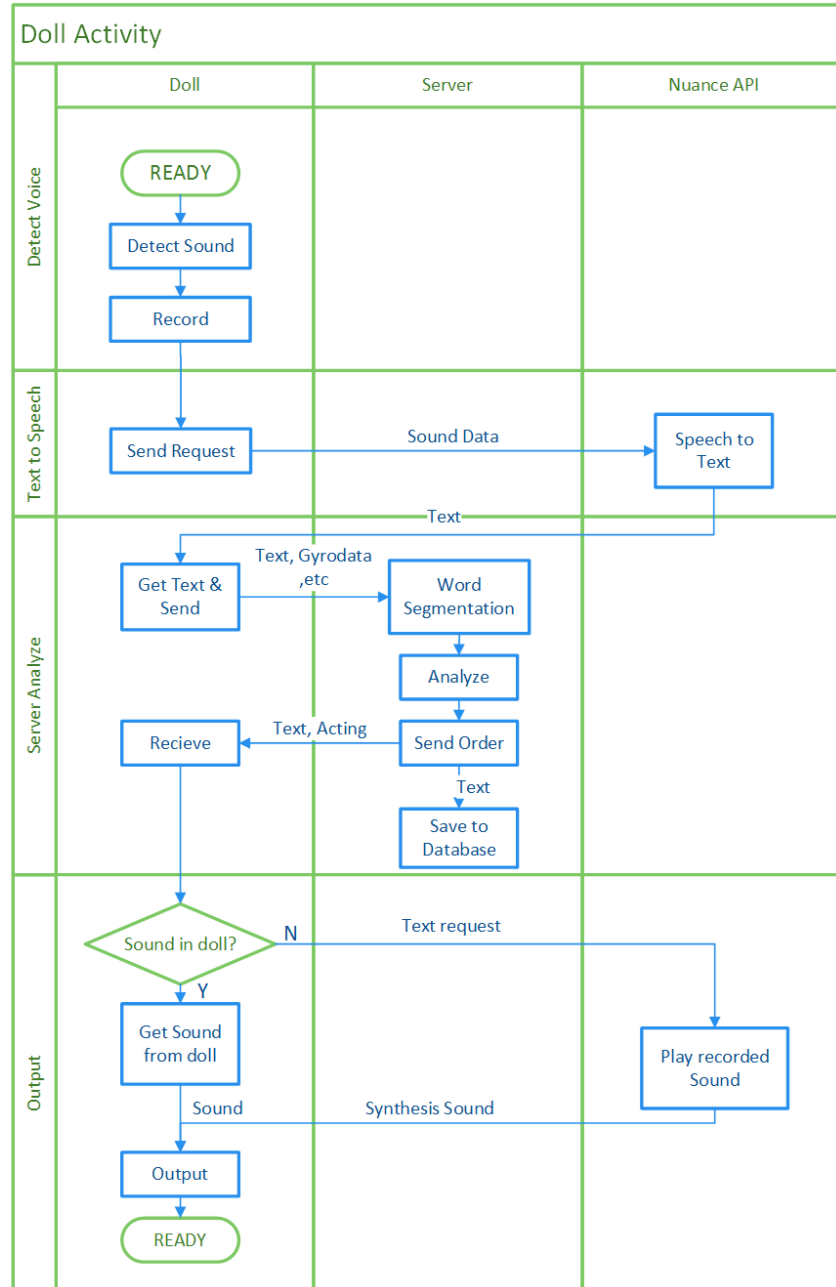

Figure 3.5 Functionality Diagram – Doll Activity

The diagram explain the sequence activities that the doll will automatically act when it receives the command from users.

When the sound is detected, the sound will be converted to text. Then it will be sent to server and receive the answer back.

The last action is to play the given output sound. Then the process repeats again.

3.5 Application Activity
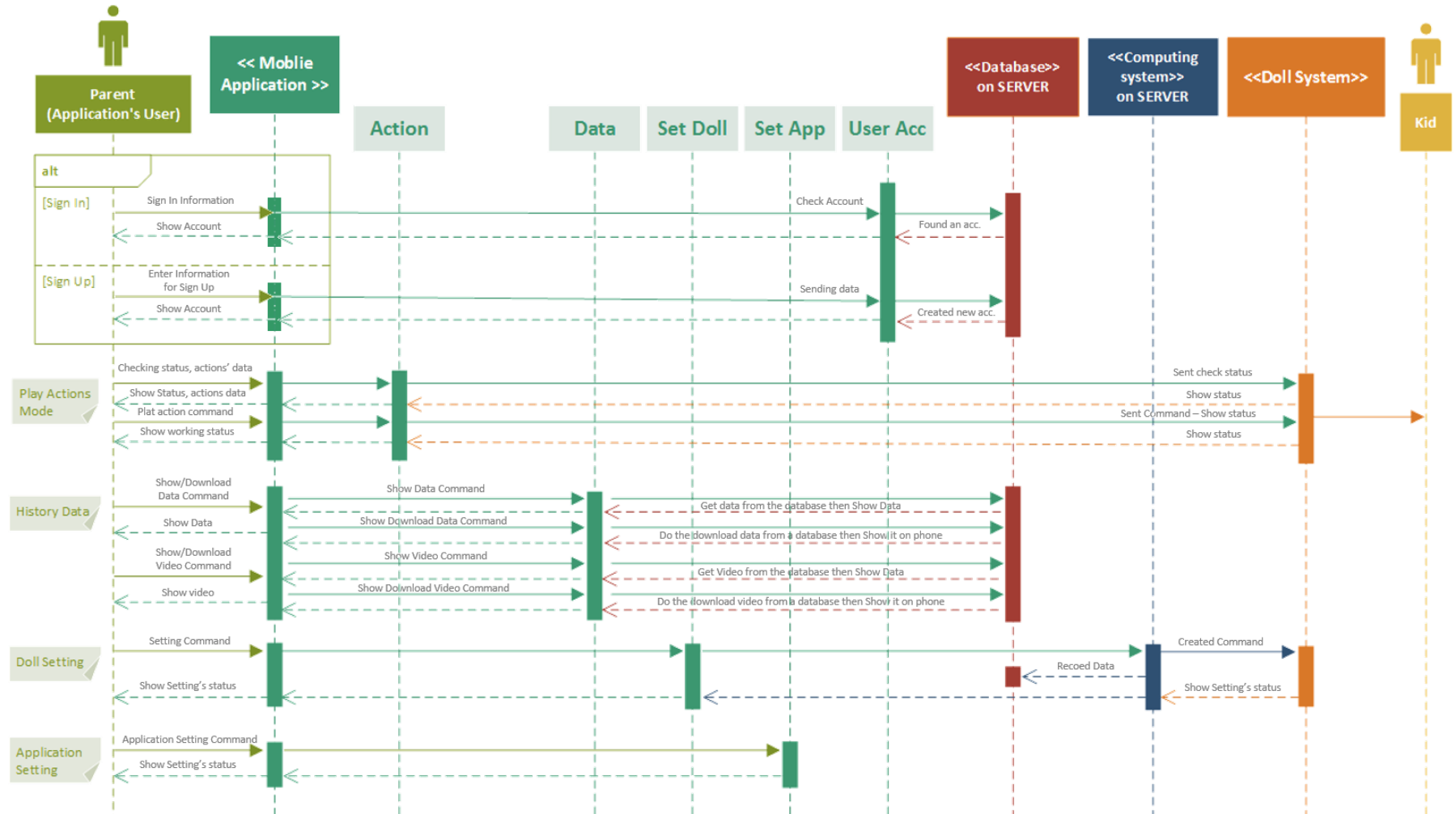
Diagram show how to interact by application.

Figure 3.6 Application Activities

The diagram explain the sequence activities that the application will interact to the server and doll. The main activities are play mode, viewing data, setting doll, and application setting.

3.6 Hardware's Structure Design
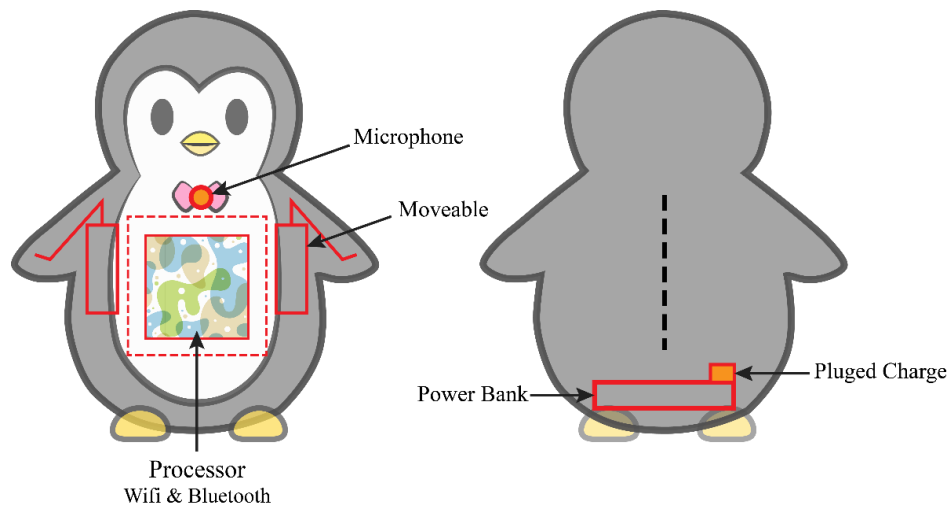
Figure 3.7 A doll's structure design

The figure shows the initial design of the doll and the hardware placement. The main component, processor, will be placed at the center of the doll to balance the weight of hardware. The microphone will be placed at the neck for it to receive the voice as best as possible. The power bank which is the heaviest part will be placed at the bottom of the doll so that the doll can stand.

3.7 User Interface

Mobile application is the parent's tool to control all feature in doll's system. There are several features which parents can access such as remote control, view statistic, etc.
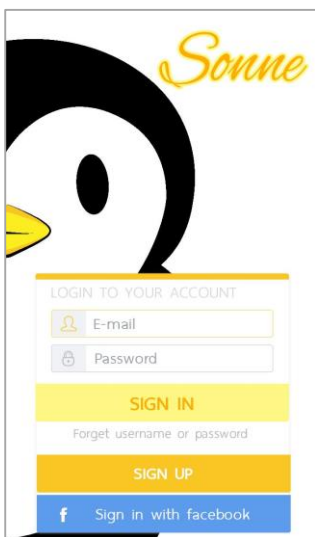
3.7.1 First Time Login page is a requirement sign in after application installation. The page allows parents to access to their account, setting data, etc.

Figure 3.8 First time Login Page

Figure 3.9 Signup

3.7.2   Signup page is used for creating a new account. Username, email, and password are required in
registration. Username and password will be required in next login.

Figure 3.10 Main menu page

3.7.3 Main menu page is used for showing all features in the application.

If users have more than one dolls, they will be able to select one they want to use. There are four
major features in here, "action", "note", "history", and "doll setting". Application setting is also attached
to "doll setting".
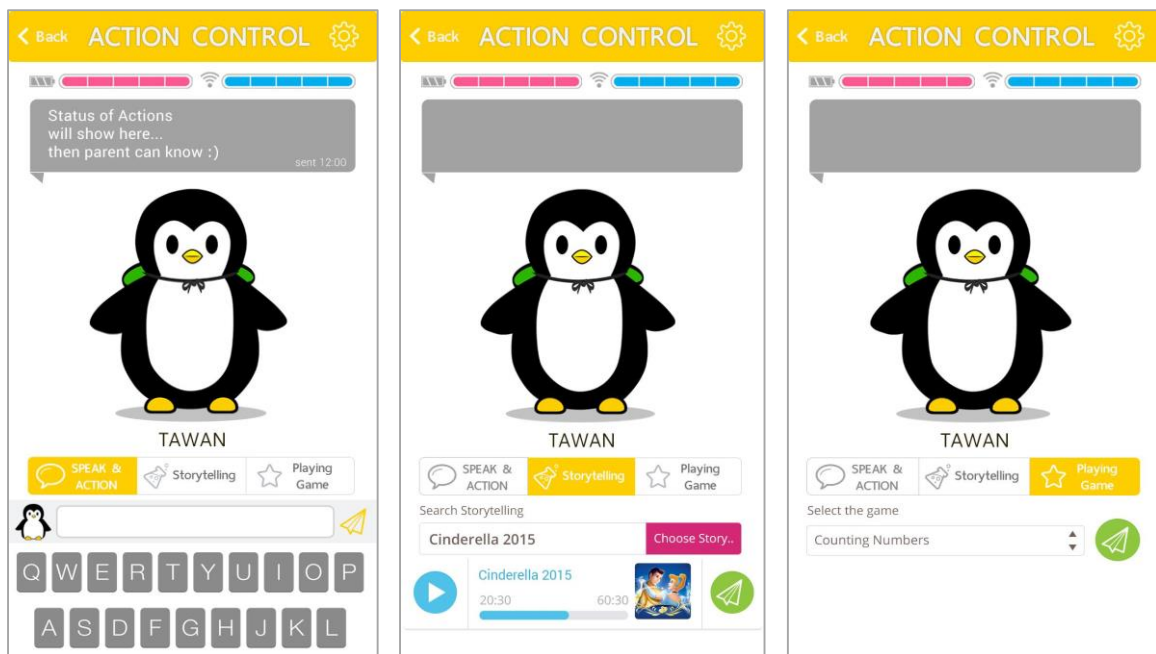
Figure 3.11 Action control module and Show status mode

3.7.4   Action control module and Show status mode

Action control module contains 3 command functions. There are Speaking or Acting command, storytelling command, and playing game with a child command. This mode will allow parent to participate with children through doll.

Status is showed on a top part in page that will show 2 statuses, Battery status, and Online (Wifi) status of a doll.
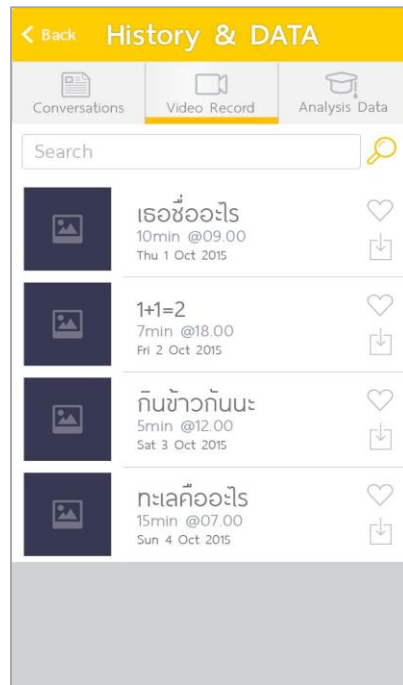
Figure 3.12 Histories and analytics mode

3.7.5   Histories and analytics mode

Usage History: Conversation records

This page will show the history of conversation records; what a child said, asked, or commanded a doll to do. These data will be queried from the server's database with the parent's account and a doll's ID.

Statistic record

This page will show the statistical data from the conversation records. Parent can use this information to make decision about the children's development.

Figure 3.13 A doll's setting
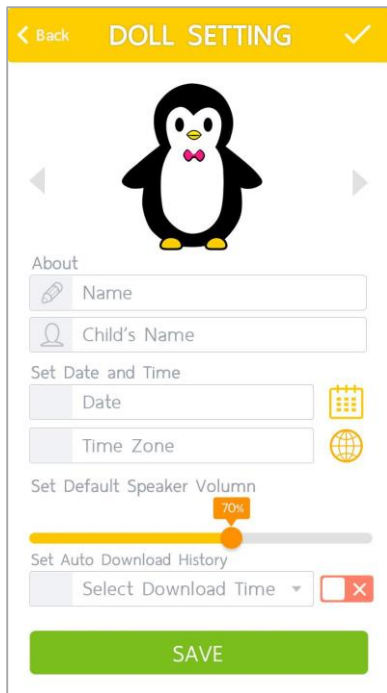
3.7.6 A doll's setting mode

This page is used for showing and editing all of a doll's functions setting. Parents can set up the setting for a child as their wishes.

Figure 3.14 Add and Sync a doll

3.7.7 Add and Sync a doll module

This module is used to add a new doll's account into a parent's account; by adding a doll's ID, a doll's name, and basic setting. It is connected via Bluetooth. After the connection is completed, parents can use the application's feature freely within the range of the connection.

Figure 3.15 Application Setting

3.7.8   Application Setting

Application Setting is used for setting all application's functions setting. For example, application language, time zone, personal data, and auto login or pin login setting.

3.8 Database Design

Data in this project store in the NoSQL format database. There are two collections in this project. First collection is the user data. It stores all uses' information and the registered code of the doll. Second collection is conversation history between kids and the doll. The history collection also contains the date key to allow the date query.

User: {

       username: String <Unique>,

       password: String,

       doll code: String

}

History: {

       sentence: String,

       actor: String <Kid, Doll>,

       doll code: String,

       date: Date

}

3.9 Protocol Usage

- ♦ Server and Doll - HTTP

- ♦ Application and Server - HTTP

- ♦ Doll and Application – Bluetooth

3.10 Node.js Design

In this project, we create API using node.js as a backend engine. This backend will be running on a server allowing the data to be computed using this backend everywhere. There are five routes for the backend; "/signup", "/signin", "/project", "/getdata", "/querydata", and "/updatedata".

"/signup" is a POST method to register the user to the system. The system will return true or false value and the message that will display if there is an error.

Input: {username: String, password: String, doll code: String}

Output: {success: Boolean, message: String}

"/signin" is a POST method to log in to the system. The system will return true or false value and the message that will display if there is an error.

Input: {username: String, password: String, doll code: String}

Output: {success: Boolean, message: String}

"/project" is a POST method to analyze the content of the sentence and return the predefined output.

Input: {sentence: String, doll code: String}

Output: {sentence: String}

"/getdata" is a POST method to get conversation history from the database. The returned data can also be queried using different date range and actor.

Input: {doll code: String, actor: String <both, kid, doll> date: String <all, month, week, day>}

Output: {sentence: String, actor: String <kid, doll>, date: Date}

"/querydata" is a POST method to get statistic data from the database. The returned data can also be queried using different date range.

Input: {doll code: String, date: String <all, month, week, day>}

Output: {sentence: String, count: Numberic}

"/updatedata" is a UPDATE method to change the user information. The system will return true or false value and the message that will display if there is an error.

Input: {username: String, password: String}

Output: {success: Boolean, message: String}

3.11 Python Design

In this project, we use python to recognize the content of the receiving text from the doll. At first, the sentence will be segmented into multiple words by Lexto, Thai sentence segmentation from NECTEC. Next, the words will pass through python files to do keyword matching, this will determine the content of the sentences what does it mean. Then we will be able to answer corresponding to the given sentence and send the output back to the doll.
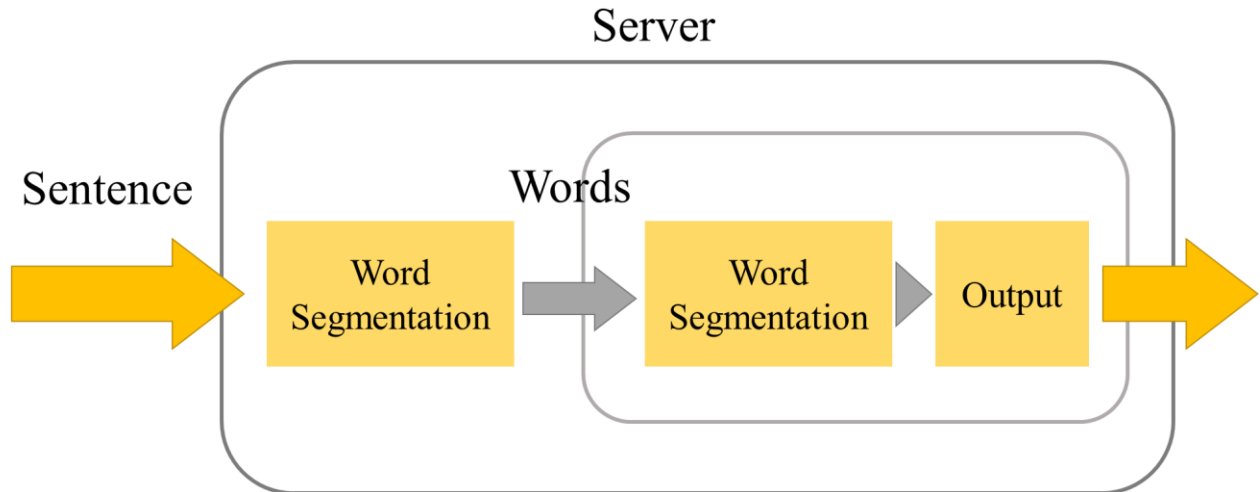
Figure 3.16 Module inside server

LEXTO

Lexto is the official word segmentation from NECTEC using Longest Matching concept. The program itself does everything about Thai word segmentation, we only need to change the input and output path to match with our own program. After segmenting, one sentence will be transform into multiple words and proceed to the python file to recognize the content.

Keyword Matching

To recognize the content is tricky because content free grammar of Thai language is larger than English. In Thai language, sometime you don't even need a verb and the sentence is perfectly understandable. Because of this, we use only some of the word to analyze the content, it's called keyword matching. The table below lists all the of content available and the keyword we use to recognize it.

Input	Keywords			
สวัสดี	สวัสดี	ฮัลโหล	หวัดดี	
ลาก่อน	ลาก่อน	บ๊ายบาย		
ฝันดี	ฝันดี			
ชื่ออะไร	ชื่อ, อะไร	แนะนำตัว		
หนึ่งบวกหนึ่งเท่ากับเท่าไร	เท่ากับ, เท่าไร			
ยกมือซ้าย	ยก, มือซ้าย	ยก, แขนซ้าย	ยก, ข้างซ้าย	
ยกมือขวา	ยก, มือขวา	ยก, แขนขวา	ยก, ข้างขวา	
ชูมือ	ชู, มือ	ยก, มือ	ยก, แขน	
โบกมือซ้าย	โบก, มือซ้าย	ขยับ, มือซ้าย	โบก, แขนซ้าย	ขยับ, แขนซ้าย
โบกมือขวา	โบก, มือขวา	ขยับ, มือขวา	โบก, แขนขวา	ขยับ, แขนขวา
ออกกำลังกาย	ออกกำลังกาย			
บิน	บิน	กระพือ, ปีก		
ตอนนี้กี่โมงแล้ว	กี่โมง			
วันนี้เป็นวันอะไร	วันนี้, อะไร			
พรุ่งนี้เป็นวันอะไร	พรุ่งนี้, อะไร			
เมื่อวานเป็นวันอะไร	เมื่อวาน, อะไร			
เดือนนี้เป็นเดือนอะไร	เดือนนี้, อะไร			
เดือนหน้าเป็นเดือนอะไร	เดือนหน้า, อะไร			
เดือนที่แล้วเป็นเดือนอะไร	เดือนที่แล้ว, อะไร			

Table 3.1 Keyword Matching

Output

After content recognition is done, we will process the output based on the given content. Most of the output is fixed on the content, but some is required a little processing such as computing, time question. The output will be sent as a text to the doll using a response in RESTful API.

CHAPTER 4
Results and Discussion

From the design in chapter 3, we create the prototype, experiment and improve it. This is the result of the work.

4.1 Hardware

Shell

To creating a doll, we need a shell. We find a normal doll on the market then simply remove all the cotton wool inside the doll and sew the zip line at the back. This will create a perfect shell for the main component to sit inside. For the cotton wool, we pick up some and put it in multiple bags. When the component inside is placed, the cotton wool bag will be covered the component to make the doll stuffy as much as possible.

Figure 4.1 The front and the side of the doll with all the component inside except stuffing.

Figure 4.2 The back of the doll before zipping and after zipping.

Component

There is a lot of component to put in the doll so the organization is a must. We also need to consider the amount of heat is generated when the crucial components such as raspberry pi and power bank are working. Some component also need an extra protection from the bag of cotton wool such as Arduino Nano is set inside the box.

Prototype #1

First prototype is completely an experiment for the future work. The design is optimized for equip and un-equip component inside because of the system inside still has a lot of unorganized error. Two arms are connected to the main box inside which isn't good idea for durability, except for the experiment. This prototype is simply a model product.
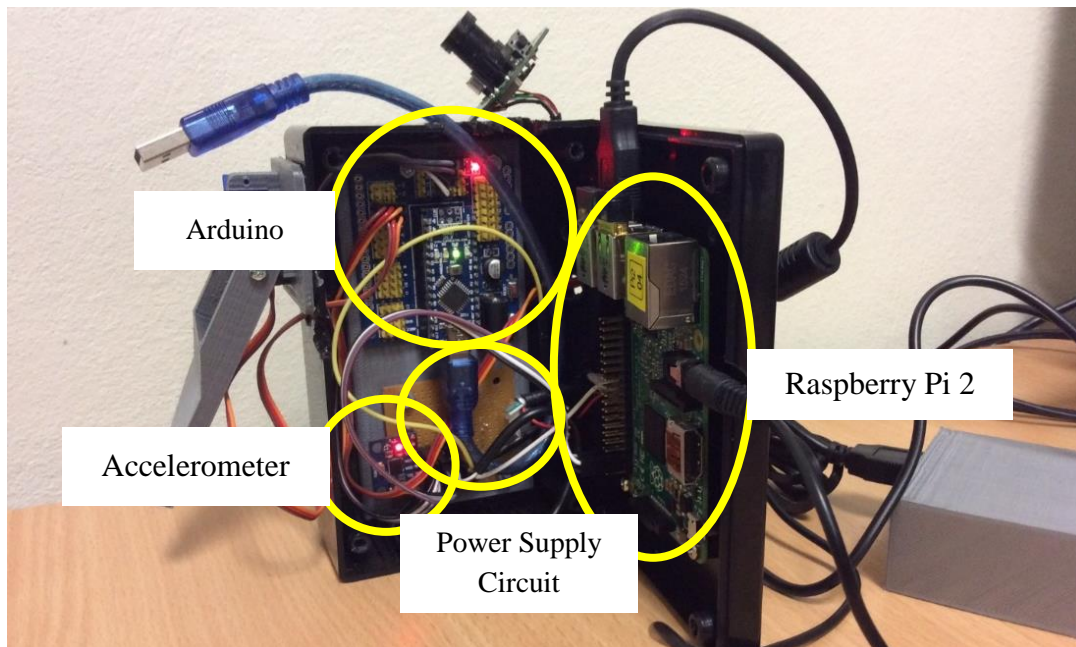
Figure 4.3 A Doll Prototype 1

Prototype #2

Second prototype has a lot of improvement. The design is not only optimized for equip and un-equip but also for wire to be able to connect without removing all of the component. The main improvement from the first prototype is the change of raspberry pi 2 to raspberry pi 3 which improves a lot of performance especially the reaction speed between user and the doll. Accelerometer also be added to the component. Two arms are now independent with the box which allows more freedom for durability. The supply circuit also get completely reorganized. This prototype is a testing product.

Figure 4.4 A Doll Prototype 2

4.2 Nuance Thai Speech API VS Google Thai Speech API

There are currently only two official Thai speech API available for free development which are Nuance and Google. These two hold each own advantage and disadvantage. Nuance API has a wider Thai vocabu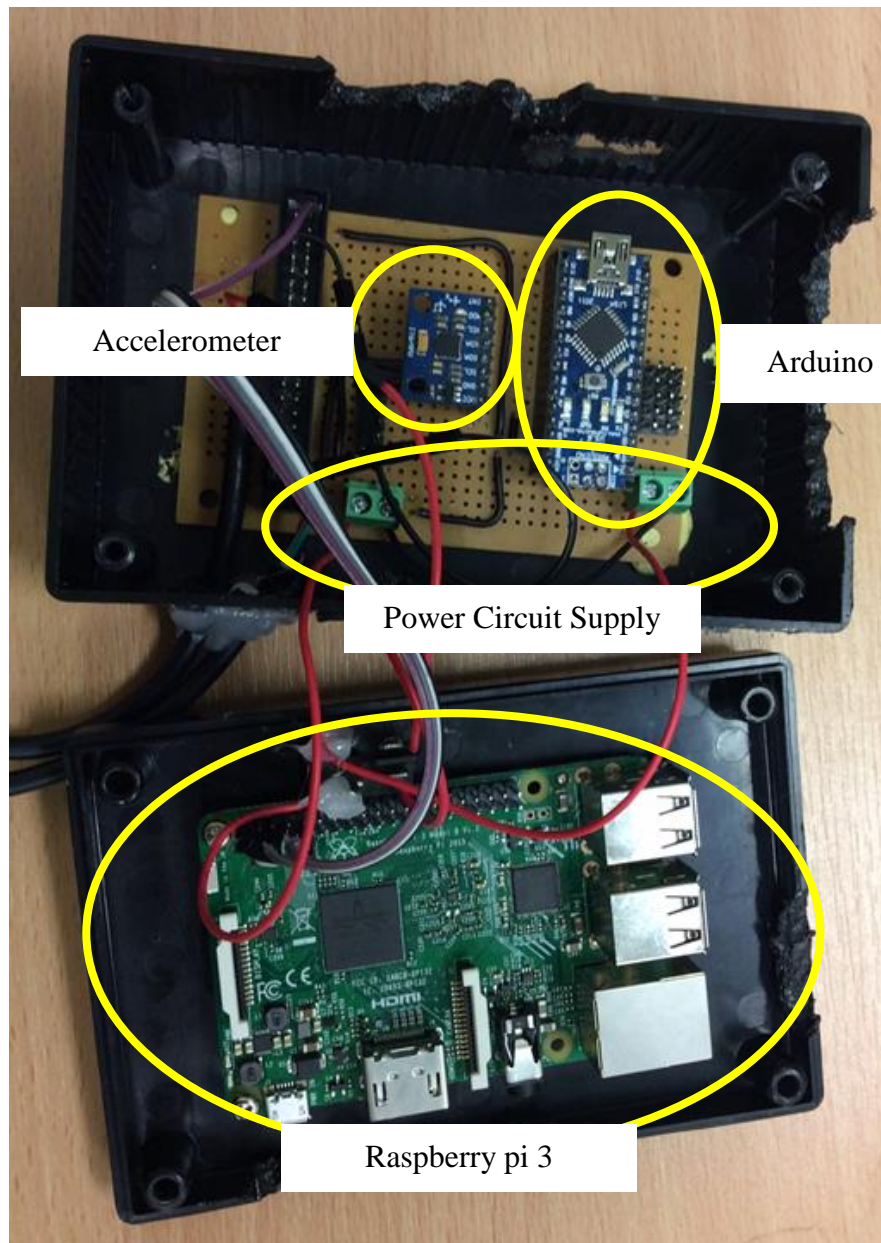lary and more accuracy than Google, but it sacrifices the whole processing speed (uploading speech file, processing speech to test, and downloading the result which makes the interaction between user and doll slower. While Google API has less accuracy than Nuance, but the speed is noticeable improved. It is a tradeoff between the accuracy and speed. Please take note that both of the testing is done on the same parameters which are same internet network, same speech input, and same computer's performance.

In this case, we prefer to sacrifice some accuracy to get a better interaction speed While the accuracy is not as good as Nuance, it still works out quite well and we can lock out context by some case because of the word used by kids is quite simple, this will slightly improve the accuracy.

Word Test สวัสดี (Sawaddee)

	1	2	3	4	5	6	average
Nuance	2.02	2.04	2.02	2.04	2.00	2.01	2.02
Google	0.30	0.32	0.31	0.32	0.33	0.31	0.32

Table 4.1 Nuance Thai Speech API VS Google Thai Speech API comparison

Testing Speech API

Thai language is a very complicated language. While the international language like English has only 5 vowels, Thai language has more than 20. This is one of the facts that make Thai language very hard to learn and also hard to analyze. These are the reason why there is only two official Thai speech API available. The speech API is also working way far from perfect. There is a lot of nondeterministic output and unrecognized voice. It's working fine if the sentence is short and clear, but it still suffers if the voice is out of the tone like too pitch or too deep. When we use kids' voice as an input, the results are quite expected.
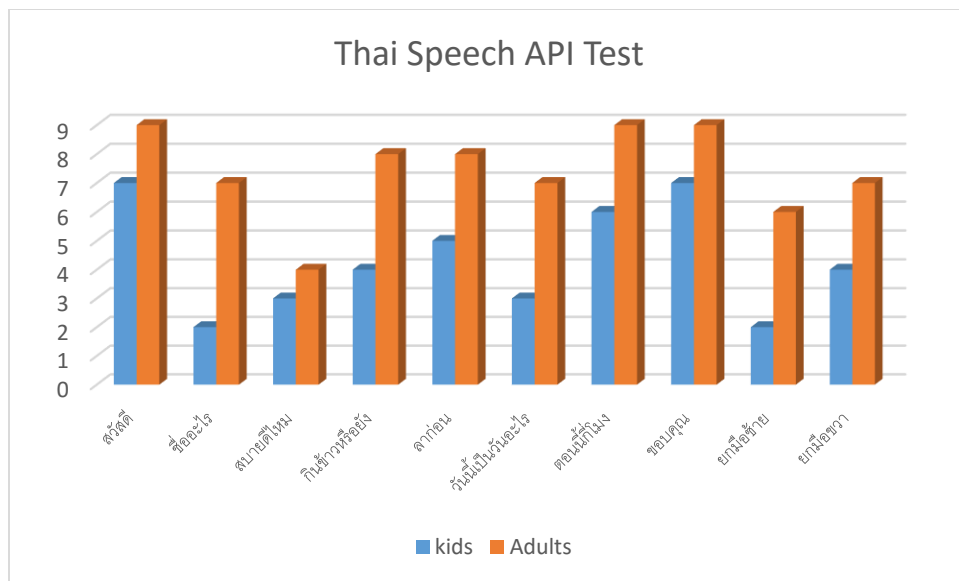
Figure 4.5 Kid (3 – 5 years old) compare to Adult (20 – 22 years old)

To easily understand the problems, we create the table compare 10 adults testing the speech API with 10 kids. The results are so clear. Speech API is able to detect and recognize adults' voice average 7 out of 10, while the average of kids is 4 out of 10. Please take note that it's not like the speech API detect the voice from kid and recognize it wrong, but rather the speech API won't detect kids' voice as an input at all.

From these statistic, we can assume two reasons. First, the kids' voice is out of range of the detecting value which results in the speech API won't detect it as a voice. Solution is to increase the range of the detection. However, the detection process doesn't provide by the API.

Second, the training data of the voice recognition is the adults' voice. Since the adults and kids have a significant different, so the recognized system won't be able to recognize the kids' voice correctly. Solution is to use kids' voice as a training data from the start and since the range of conversation of the kids isn't widely as the adults, we can also limit the outputs to match the kids' ability. However, to train the speech model requires a lot of data collecting and efforts.

Raspberry Pi 2 VS Raspberry Pi 3

Since the world wide release of Raspberry Pi 3 on 29th February, 2016, we decide to test and compare the performance between the old version and the newest version. The new version simply upgrades the CPU performance and add a built in Wi-Fi and Bluetooth which are extremely handy.

The improved version adds a really nice touch to the interaction speed which is noticeable faster. The faster CPU allows overall performance to be better. The built in Wi-Fi and Bluetooth also give the direct access to the processor which results in faster transfer rate between two access points.

Overall, raspberry pi 3 definitely give a better overall performance, allowing the interaction to be faster and cleaner than raspberry pi 2.

	RPi2	RPi3
Processor	900 MHz 32-bit quad-core ARM Cortex-A7	1.2 GHz 64-bit quad-core ARM Cortex-A53
SoC	Broadcom BCM2836	Broadcom BCM2837
RAM	1 GB	1 GB
On-board network	10/100 Mbit/s Ethernet (8P8C) USB adapter on the USB hub	10/100 Mbit/s Ethernet 802.11n wireless Bluetooth 4.1
Power ratings	800 mA (4.0 W)	800 mA (4.0 W)
Size	85.60 mm × 56.5 mm (3.370 in × 2.224 in)	85.60 mm × 56.5 mm (3.370 in × 2.224 in)
Price	US$35	US$35

Table 4.2 Raspberry Pi 2 VS Raspberry Pi 3 comparison

4.3 Application

For the application, we have finished some of the front-end interface and test it. The application can be run perfectly fine as a normal native application.
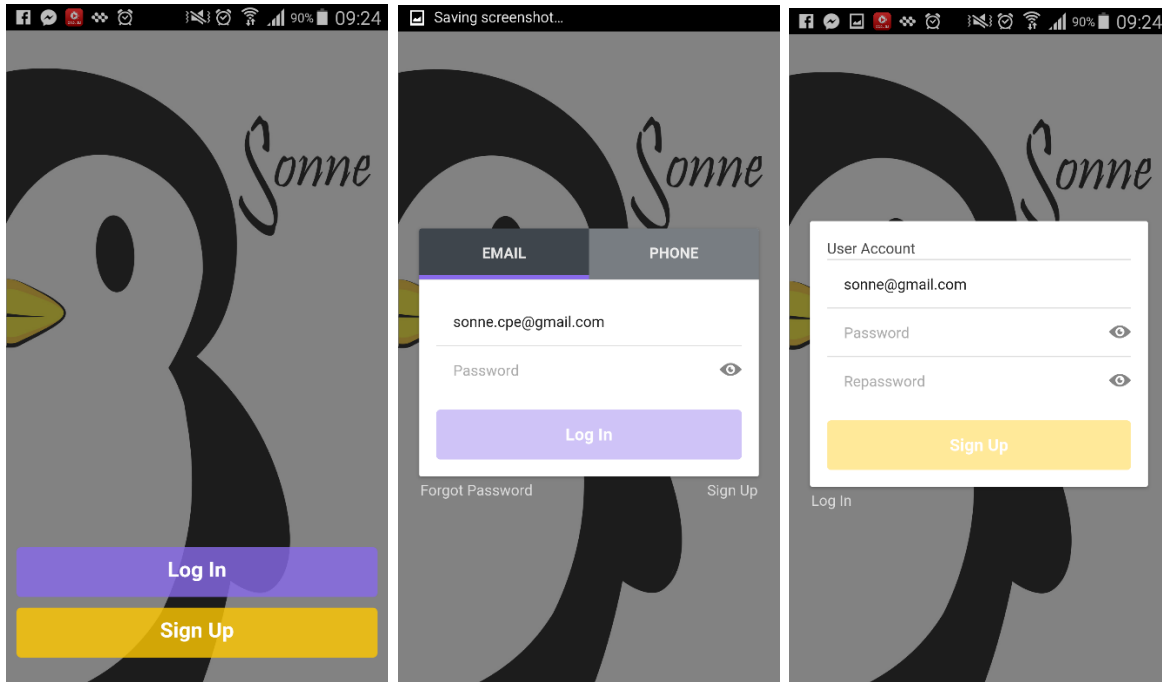

Figure 4.6 Front-end example interface of application – Login and Sign up
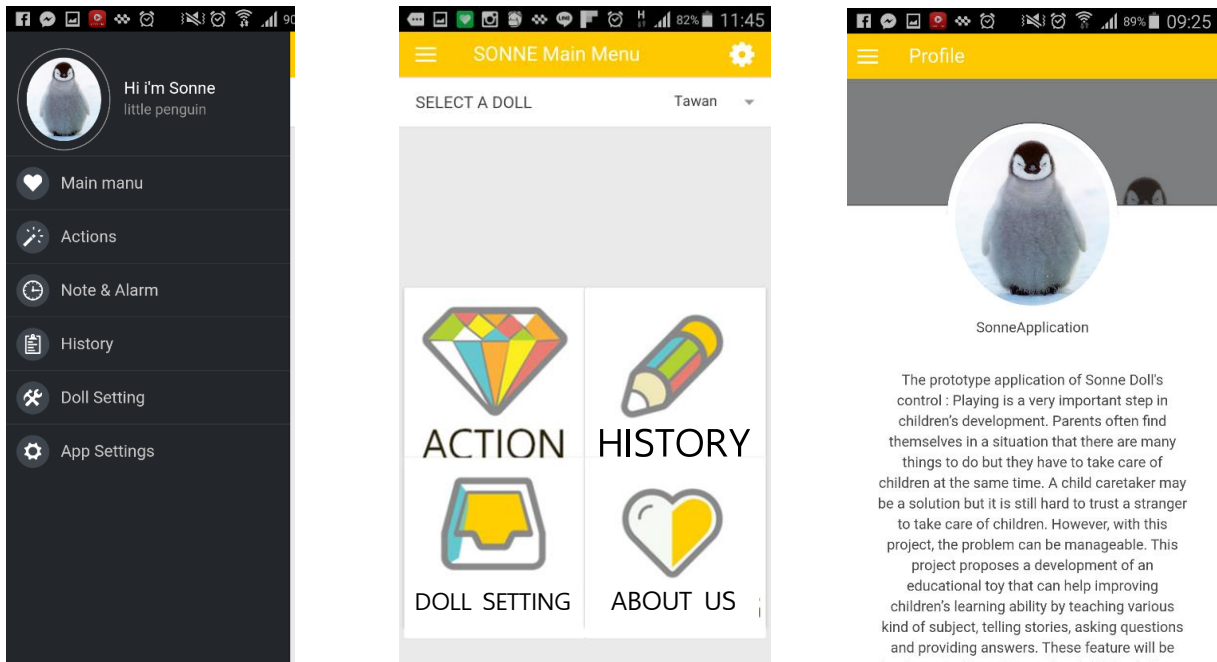
Figure 4.7 Front-end example interface of application – Main Menu
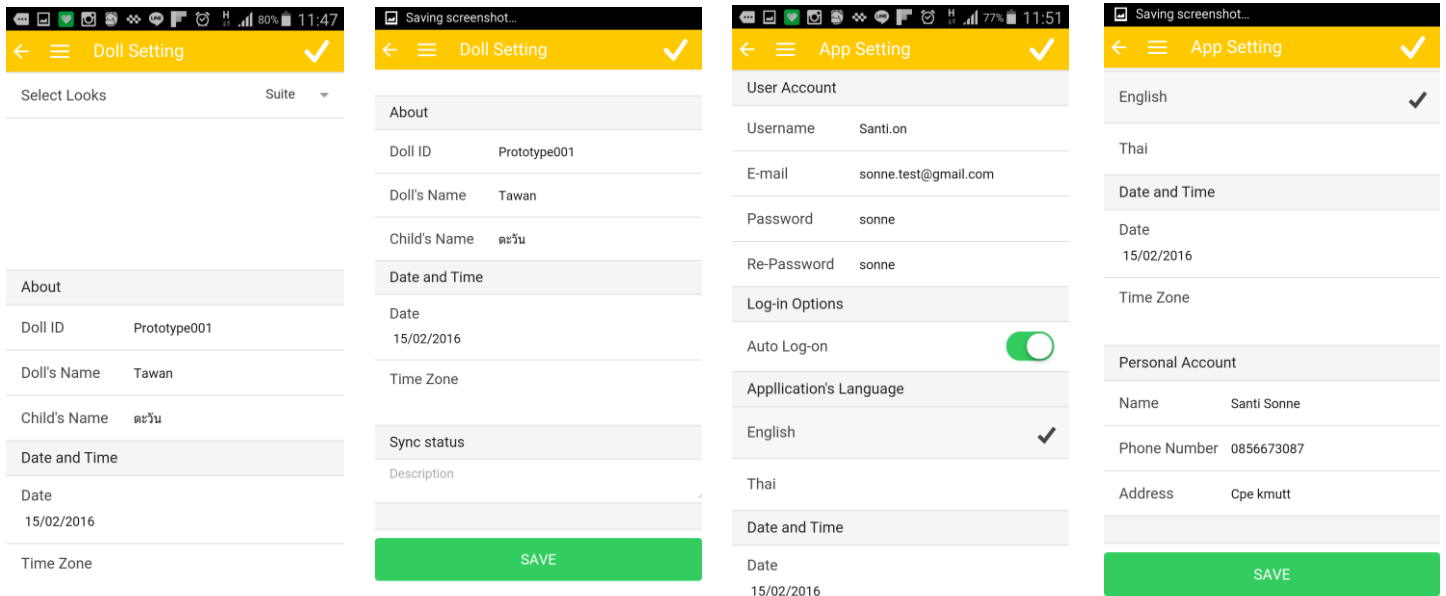
Figure 4.8 Front-end example interface of application – Setting part

When we give front-end interface to the target users which are parent for the basic usability testing, we recognize a lot of misunderstand function such as unclear icons. The test users of this is 5 parents, however this is only a first step of testing.

When front-end interface is completely finished and is able to connect to hardware, and server, the application will be required for the test at least two more times with a larger group of target users.

Chapter 5

Conclusion

Personal Education Machine is project which definitely has a potential to become a commercial product. However, in this project, we are merely testing and experiment the possible ways to approach the final product. In this chapter, we will conclude everything we learn so far, while working on this project, both successful one and failure one. The project itself indeed has a commercial product potential, but it needs to adjust in a lot of ways before it can reach the point which it's on the shelf in some department store.

Using official Thai Speech API is definitely not a way to go, The API is working fine with the adults, but terrible with kids. It is also an overkill to detect the speech because kids around this age will almost speak in pattern all the time. The better way is to train the speech model with the limited outputs. This way the amount of data collecting won't be too much pain and the limited outputs can suit the speaking pattern of kids.

The appearance and durability are also important. The doll must be light enough for the kids to lift and durable enough for the kids to throw and sleep on. The doll must also be cute enough for the kids to gain their first impression positive. Otherwise, the kids won't stay near your product at all. Safety measurement is also another important one. Durability doesn't mean that the product has good safety. Durability will keep the product from getting harm while the safety measurement keeps the user from getting harm from the product. If the safety ability of the product isn't verified, the product itself may not pass especially if the target is the kids. In this project, we only consider appearance and durability factor as a main point. The cute animal appearance helps us approaching the kids a lot and plastic box inside the doll is strong enough to withstand kids' force.

Raspberry Pi is working quite well for the processor component in the project. However, it is a developing board and cost a lot for the work it actually does. To improve this, we can redesign the processor and change it to a specialized board to reduce the cost and optimize the workload.

The interacted question and answer of the project is based on the behavior we observed from the kids. It's important for the doll to be more active than responsive. The reason is kids don't know how approach the things they don't know. Even though the doll is cute and attractive, kids will still keep their distance. And even you will them to talk to the doll, more than half of the kids will stay silent because they don't know what to do. So it's important for the doll to be active and initiate the conversation first.

Mobile application crucial function is the remote control. It allows third person such as parents or teachers to play with kids. As we said before, the doll needs to be the initiator so the kids can follow up. The remote control function works extremely well and children did become a friend with the doll. Another improvement is to allow the remote control connection to be established from afar. Instead of using Bluetooth, we can use Wi-Fi connection and the third person will be able to play with kids from anywhere anytime.

In this project, the doll requires a connection from server all the time to function properly which is good in some sense, but also bad in other. It's good because all the data is required to pass through the server, so the main coding will always stay at the server allowing the developers to change it easily if have to. However, the downside is if the internet connection is weak and slow, the upload and download time will take a long time which isn't good for the interaction. To improve this, we can change the server base system to local base system, which means all the process will be done inside the doll without the access from the server. Then later when the internet connection is strong enough, the doll could connect to the server to update the system, and history conversation. This allows the stable interaction without the sacrifice of the advantage of the server base system.

Figure 5.1 National Software Contest 3rd place award

This project has joined the competition National Software Contest #18 by NECTEC and received the 3rd place award on the educational topic on 18, March 2016. The project also has joined the startup project, Hatch Startup Program 2016 by King Mongkut's University of Technology Thonburi on April 2016 and Startup Thailand 2016 on 29, April 2016 at Queen Sirikit National Convention Center.

As results go, the project can get an improvement and become a commercial product. The project also has joined a lot of events and received good responses.

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