Healthcare-Oriented Computerised Chinese Speech and Language Assessment Tools

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Chapter 1

Introduction

Healthcare-Oriented Computerised Chinese Speech and Language Assessment Tools is a group research project of module: Software Engineering Group Project. This project seeks to produce computerised Chinese language assessment software for child healthcare. Also, the software can provide assistance for children language evaluation processes and linguistic research. In order to achieve this, the team has gone through several full cycles of software engineering processes, including background research, requirements engineering, software design, implementation and testing. As a result, three software prototypes have been developed.

1.1 Motivation

Assessment methodologies in child language in China are rather mechanical and labor-intensive. Also, most of the tools/inventories that have been used can be influenced by subjective perceptions, while the field of computerised, objective and systematic assessment tools for Chinese language is still blank. Futhermore, in China, there are few widely recognized metrics for computerised Chinese speech and language assessments. This situation results in incompatible test outcomes of the assessments developed by different researchers.

1.2 Aims and Objectives

The project aims to help ease the mechanical and labor-intensive situations of conducting Chinese speech and language assessments. In other words, the finally developed software will be able to provide interfaces to conduct assessment and analyze child responses in a computerised way. The results will be stored digitally for researchers' further research. At the request of the project stakeholders, this project has the following main objectives:

a. Provide the platform/tools to conduct Chinese language assessments.

b. Analyze child response automatically by the computer.

c. Store and display the assessment results digitally.

1.3 Team Members

This team consists of six team members from Computer Science and Computer Science with Artificial Intelligence year 3 undergraduate students in UNNC.

Dr Dave Towey: Supervisor

Jiaye Zhu: Leader, Script Leader, Editor

Jing Lu: Coordinator, Meeting Recorder

Tianyi Yu: Test Leader, Script Assistant

Kangming Feng: Maintenance Leader

Huili Geng: UI Designer

Yu Wang: Script Assistant

Chapter 2

Background and Related Work

In this chapter, the background information about the language assessment and related work regarding this field will be discussed. We will also illustrate several key concepts and design that used in this project.

2.1 Background

2.1.1 Current Situation

It is estimated that about 5%-10% of the population may suffer from language disorders [16]. Given by the Second National Sample Survey of the Handicapped in 2006 [24], children with language disorder took up about 77% of all handicapped children in school age. Language disorders of children can be caused by various reasons. According to Jin [17], expression and reception abilities are the two quantifiable criteria for children's language assessment. Jin also indicates that the diagnosis excludes hearing or other sensory impairments, motor disfunction or other mental disorders. Hence, the diagnosis is focusing on Specific Language Impairments. Specific Language Impairments (SLI) are failures in developing certain language abilities compared to people at similar age [33]. In this project, the research scope is in SLI assessments.

With a large Mandarin-speaking population around the world, language assessment tools are urgently needed in Mandarin-speaking communities. Unlike the assessment procedures in western countries, there are gaps in such services of speech and language therapy in China. For example, in the field of phonology assessment, research and therapies of Chinese language have fallen behind compared to other languages such as English [38]. The majority of assessment and analysis methods in China are still clinical and based on subjective perceptions. Jin et al. [16] states that there is difficulty in developing an appropriate assessment tool for Chinese language. Although the studies related to different aspects of this field are increasing, there are few published, widely-agreed assessment systems, especially for Chinese grammatical terms and syntactic structures.

2.1.2 Computational Analysis Methods

Dependency grammar

One of the most popular methods in computational grammar analysis is the dependency grammar (DG). Ahmad & Rahoman [1] illustrate that each word in a sentence has dependency relations to other words, and these dependencies can be classified into syntatic and semantic dependencies. The dependency grammar describes the syntactic dependencies between words in a sentence. Shown by Niu & Osborne [28], the dependency grammar within a sentence can be visualized in a tree structure:

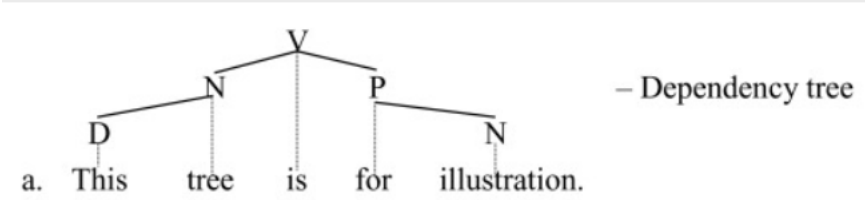

Figure 2.1: Dependency Tree [28]

Figure 2.1 shows the DG tree of the sentence 'This tree is for illustration.'. In the DG, there is one and only one root word, equivalent to the root of the tree. Every word in the DG tree has zero or more child words. The child word denotes its parent as 'head', i.e.

the word depends on its head.

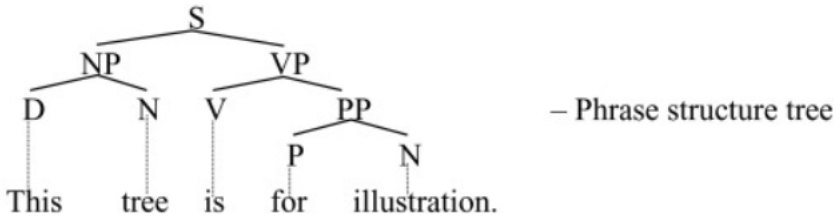

Figure 2.2: Phrase Structure Tree [28]

Niu & Osborne also indicates that the dependency tree can be converted into the phrase structure tree, as in Figure 2.2. This phrase structure tree respresents the Phrase Structure Grammar (PSG), which regards phrases as the basic sentence structures. Specifically, there are certain types of PSGs like Generalized Phrase Structure Grammar (GSPG) [31] and Head-driven Phrase Structure Grammar (HPSG) [6]. In this project scope, we only consider the tree that representing the sentence's PSG, and extract information from it. By analyzing both the dependency tree and phrase structure tree, the program can identify different levels of grammatical structures in the sentence.

Word2vec and semantic distance

Word2vec (word to vector) is a widely used natural language processing tool based on deep learning, developed by Mikolov et al. [27] in 2013. It can map the word to a specific vector in a multi-dimensional vector space. The similarity of two words can be measured by two vectors using word2vec model. In order to obtain the semantic distance between two words, we need to calculate the cosine distance between the vectors of these words in the word2vec model [13]. If denotes the vector of word A as $\vec{x}$ and vector of word B as $\vec{y}$, then the similarity of these two words can be given by:

$$Sim(A, B) = \frac{\vec{x} \cdot \vec{y}}{\|x\| \cdot \|y\|}$$

The result value of this formula ranges from 0 to 1. This is similar for two sentences. The value closed to 1 means that the semantics of the two sentences are similar. On the

contrary, the value near 0 shows the non-similarity in the meanings of two sentences.

2.2 Related Work

2.2.1 Relevant Assessment Tools

Language assessment tools can be classified into standardized and non-standardized tools [24]. Standardized tools follow the designed procedures and use quantified metrics. These tools have detailed marking regulations, which can represent children's language development using criteria or norms. Non-standardized assessments can be classified into self-design/modification tests and language sample analysis. Self-design/modification tests are often designed to evaluate the specific aspect of child language, such as the Narrative Assessment Protocol [22]. The language sample analysis often takes language elicitation as the main approach. That is, the researchers gather child languages through interactions for futher study. Long & Li [24] also points out that assessments in China mainly use traditional ways, rather than modern, computerised approaches.

There are a lot of traditional approaches used in Chinese language assessment. For example, one of the most widely applied assessment tools in hospitals is the S-S (sign-significant relations) inventory [36]. This inventory includes child's cognitive, expressive, operative abilities and attention during communication. Other tests like Chinese Communicative Development Inventory [21] also assess children's language ability from various of aspects. In Taiwan and Hong Kong, there are tools designed for different cultural backgrounds such as Cantonese and traditional Chinese, like Mandarin Token Test and Peabody Picture Vocabulary Test (revised) [23].

The problem of these inventories is that the assessment itself is subjective. The results can be influenced greatly by the perception of the tester, especially in narrative assessments [22]. Also, current standardized tests require a large amount of tester's work on questioning, judging and analyzing. This could result in lack of accuracy and labor-intensive

work.

2.2.2 Current Computerised Tools

There is research related to computerised tools for Chinese language assessment. With the development of computer technology, approaches like multimedia, fuzzy mathematics and speech recognition are coming into use for language assessment [19]. Zhang [38] presents a computerised tool for language disorder assessment, using vocabulary and grammar as metrics. In phonology assessment, Zhang [37] designed a functional articulation disorder evaluation tool based on speech recognition. Unfortunately, the data used to build the computerise tools mentioned above only includes children from some of the areas in China. In other words, it might be difficult to represent child language from across China using current computerised tools. Dream-C developed by Bethel [4] claims to be the first standardized, norm-referenced assessment tool for Mandarin. This tool assesses child language ability from four aspects: receptive, expressive, semantics and syntax. The tester can assess language ability through the child's interactions with games based on portable electronic devices.

In conclusion, the demand for systematic computerised tools for Mandarin assessment is increasing nowadays, but few of these tools can suffice this urgent need. On the one hand, Dream-C is more focusing on the child's reception ability. On the other hand, the expression ability also plays an essential role in child's language development. Therefore, in order to target the expression ability, especially the grammatical structure that the child could use, our project implements the C-LARSP chart (see Appendix A) in grammar assessment. C-LARSP, which is designed by Jin et al. [16], is a criteria-based grammar assessment tool. This chart inspects child's expression ability via grammatical structures. In terms of phonology assessment, this project implements the Phonology Assessment of Chinese (Mandarin) [39]. By combining these two methods, the software can assist research in the area of specific language impairments. Both the C-LARSP and the Phonology Assessment of Chinese (Mandarin) will be illustrated in the next chapter.

Chapter 3

Design

In this chapter, we will introduce the participants of this project and the approaches of software implementation. We will also discuss in detail how the assessments in this project are going to be conducted as the stakeholders required. Finally, the user interfaces of the software prototype will be shown to demonstrate the design.

3.1 Participants

The team interviewed three stakeholders of this project to better understand related background and gather information for software design. They have provided valuable information for the team to design software accordingly.

Participant 1: Chair Prof. Lixian Jin

Lixian Jin is the Chair Professor of Applied Linguistics of University of Nottingham Ningbo China [14]. She has profound experience in fields such as linguistics, English teaching, intercultural communication and qualitative research methods. Her research interests includes various aspects of linguistic study. In the interview with Jin, the team consulted her about grammar asssessment for Chinese language. Jin also provided the

sample C-LARSP chart and guidance for software design.

Participant 2: Prof. Hua Zhu

Hua Zhu is Professor of Applied Linguistics and Communication of Birkbeck, University of London [40]. She has research interests like intercultural communication, child languages, Chinese pragmatics and speech acts. The team obtained useful information and materials on phonology assessment through Zhu.

Participant 3: Jiajie Chen

Jiajie Chen is an assistant research fellow of Prof. Lixian Jin. He has provided information on background of Chinese language assessment and some advice on designing computerised assessment tools.

The team has met with the stakeholders both physically and online several times. Through these interviews and meetings, the opinions and demands on the project are obtained from the stakeholders. These information are documented in the software requirement specification and used as the guidance for prototype implementation. The latest version of the requirement specification can be found in Appendix B.

3.2 Approaches to Software Implementation

The team implemented the Chinese speech and language assessments by two main tests: grammatical and phonology assessments, as requested by the stakeholders. After interviewing the participants and looking into several current computerised Chinese language assessment techniques, the team decided to implement the C-LARSP chart and Phonology Assessment of Chinese (Mandarin) for the grammatical and phonology assessments. In this chapter, the details of these two tests as well as the user interfaces of the software

are discussed.

3.3 Grammar Test Design

3.3.1 About the C-LARSP

The grammar test is implemented based on C-LARSP assessment. C-LARSP (Chinese Language Assessment, Remediation and Screening Procedure) is an assessment tool developed from LARSP [16], serving the rising needs of Chinese language assessment (see Appendix A for full chart). The C-LARSP chart groups grammatical structures by age periods. Each age period refers to several corresponding grammatical structures of three different levels: clause, phrase and word (prefix and suffix of word). The age period can be also called as 'stage'. There are seven stages in the C-LARSP chart, representing child age from 1-year, 0-month to 4-year, 6-month old.

Figure 3.1: Stage II in C-LARSP

For example, Figure 3.1 shows Stage II of the C-LARSP chart. This stage represents the grammatical structures that the child aged 1-year, 6-month to 1-year, 11-month can achieve. The column 'Clause' contains the clause types like SV and VCv. Similarly, in column 'Phrase' and 'Word' there are structures representing some certain types of phrases or words.

3.3.2 Test Questions

The test question in the grammar test contains question image, target structures and sample answers.

Figure 3.2: Sample Question Image in the Grammar Test

Figure 3.2 shows the image used as one of the test questions in the grammar test.

Targeted structure elicitation and **possible** errors which may be identified in any answers below					
Stages	Clause	Phrase	Word	Expansion	Possible Errors
II III	SV;	DN aux°	-3s; -ing; 'aux°; pron^{p}	X+S:NP; X+V:VP	∅-3s; ∅D; ∅S; ∅V; ∅aux° ∅-ing

Figure 3.3: Sample Question (English version)

Figure 3.3 shows the target structures of the question. The column 'Stages' means the stages that the target structures in this question belong to. The column 'Expansion' contains some structure combinations. The column 'Possible Errors' listed the structures that the child might miss in the response.

Figure 3.4 shows the possible response that the child might give and the analysis to this utterance. In this project, the scores of the grammatical structures are marked based on the analysis like in Figure 3.4.

1.	The teddy	is walking
C	S	V
P1	NP	VP
P2	D N	aux° V
W		-3s -ing
EXP	X+S:NP; X+V:VP	
Err		

Figure 3.4: Sample Answer (English version)

3.3.3 Scoring

The scoring standard in the grammar test is Meaningfulness and Correctness of Utterance Structure (MCUS) scoring (see Appendix C). This scoring standard considers the use of correct structures and the appropriate meaning in the response. A rating of six levels is given as follows:

5 = correct meaning and correct structure

4 = correct meaning and incorrect structure

3 = incorrect meaning and correct structure

2 = partial or full repetition (e.g. repetition of what the tester said)

1 = Incorrect meaning and incorrect structure

0 = silence or 'I don't know'

3.3.4 Test Procedure

The user first selects the stages that he/she wishes to test. After selection, the software will load the questions with the selected stages. In each question, the user describes the image, asks a question and elicits the child's response. To input the response, the user can choose either recording or selecting sample answers.

a) If the voice is recorded, that voice will be converted into text by the speech-to-text API. Next, the text is analyzed by natural language processing tools. The software then identifies the grammatical structures in the analysis result and give scores.

b) If a sample answer is selected, the software will take the selected answer as child's response. Then, the scores stored in this answer are given to this question.

When all questions are answered, the test stops. The software calculates the average score and saves the result to the child's profile.

3.4 Phonology Test Design

3.4.1 Phonology Assessment of Chinese (Mandarin)

The phonology test is implemented based on Phonology Assessment of Chinese (Mandarin) by Zhu [39]. This test consists of 44 test questions. Each question targets a single word in Chinese language. By eliciting the target word from the child and comparing it with the autual target word in pronunciation, the present/absent consonants and error patterns can be found in the child's pronunciation.

3.4.2 Test Questions

Figure 3.5 shows an image of ear as a question image in the phonology test. In this example, the question targets the pinyin 'erduo'. The child's response will be compared to this pinyin in analysis.

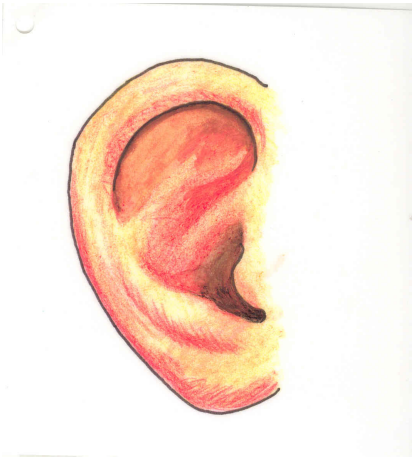

Figure 3.5: Sample Question Image in the Phonology Test

3.4.3 Test Results

Percent consonant correct

Percent consonant correct (PCC) describes the percentage of correct consonants in all the child's responses in one test. If denotes the total number of consonants attempted in the sample as N, and the number of consonants produced correctly as m. Then the PCC is given by:

$$PCC = \frac{m}{N} \times 100\% \text{ [39]}$$

Present and absent consonants

The table of present and absent consonants is an illustration of the differences on the consonants that the child can pronuounce, compared to the other children in the same age period. There are two versions of this table, one is comparing to 75% of the other children in the similar ages. The other one is comparing to 90% of the children. Each table has six age periods, ranging from 1-year, 6-month old to 4-year, 6-month old. In this table, three conditions are recorded:

a) The child can/cannot produce the consonant, as the other children in the same age

period (age-appropriate).

b) The child can produce the consonant, while the other children in the same age period cannot (unusual).

c) The child cannot produce the consonant, while the other children in the same age period can (delayed).

Error patterns

The error patterns are the patterns of the child's incorrect pronunciation. For example, pattern 'Fronting' means the child gives pinyin /s/ when pronuoncing /sh/ [39]. Simliar to the present/absent consonants table, the error patterns table also has six age periods with the same range.

3.4.4 Test Procedure

The software loads all the questions when the phonology test starts. Like in the grammar test, the user elicits the child's response and records the voice. After a sound is recorded, the software automatically calls the speech-to-text API and text-to-pinyin methods, and shows the transcribed pinyin to the user. If the user is not satisfied with the accuracy of the speech-to-pinyin process, he/she can manually alter the transcribed pinyin. Then, this pinyin is compared with the target pinyin and the correct consonants and error patterns are identified. If all the questions are answered, the software will compare the result to the inventories and give the present/absent consonant table and the error patterns table.

3.5 User Interfaces

In this section, the user interfaces of the software prototype will be briefly demonstrated. A user manual of this software is also included. See Appendix D for the user manual.

3.5.1 General

Figure 3.6: Main Menu

Figure 3.6 shows the UI of main menu. The main menu contains three entries: 'start assessment', 'view profiles' and 'exit'. If the user clicks 'start assessment', the software will show the agreement dialogue box. If the user clicks 'view profiles', the software will go to profile selection page. If the user clicks 'exit', the software will exit.

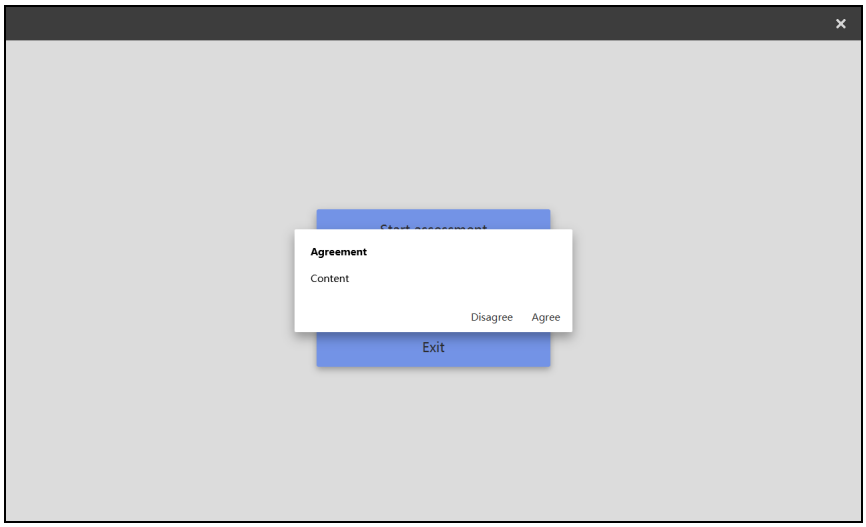

Figure 3.7: Agreement

Figure 3.7 shows the dialogue box for client's consent. The agreement dialogue box will be shown after the user selects to start the assessment. The user can only be allowed to continue if the child's guardian clicks 'agree'. If agreed, the software moves to profile selection page. Otherwise, the software returns to the main menu.

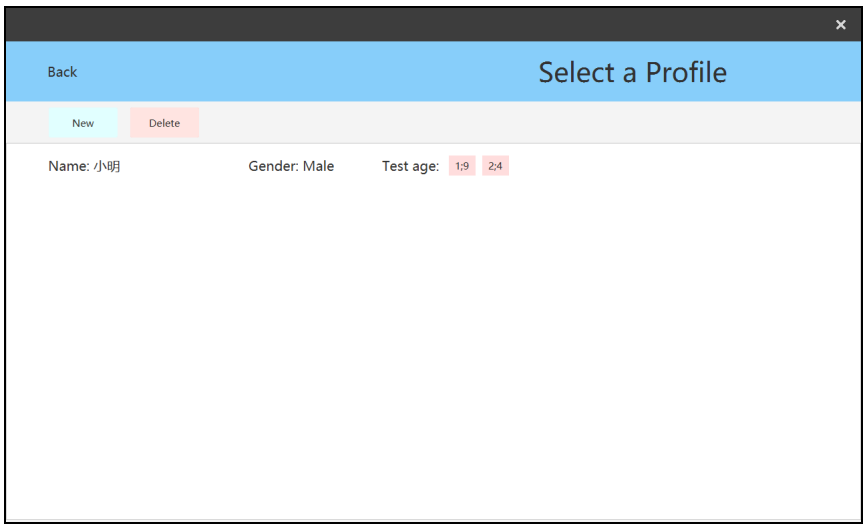

Figure 3.8: Profile Selection

Figure 3.8 shows the UI of selecting a profile. In this page, the user can select a profile from the list by double-click it. If the user clicks 'new', the software will go to the page where the user can setup a new profile. If the user clicks 'delete', this interface will enter the delete mode. If the user clicks 'back', the software will return to the previous page.

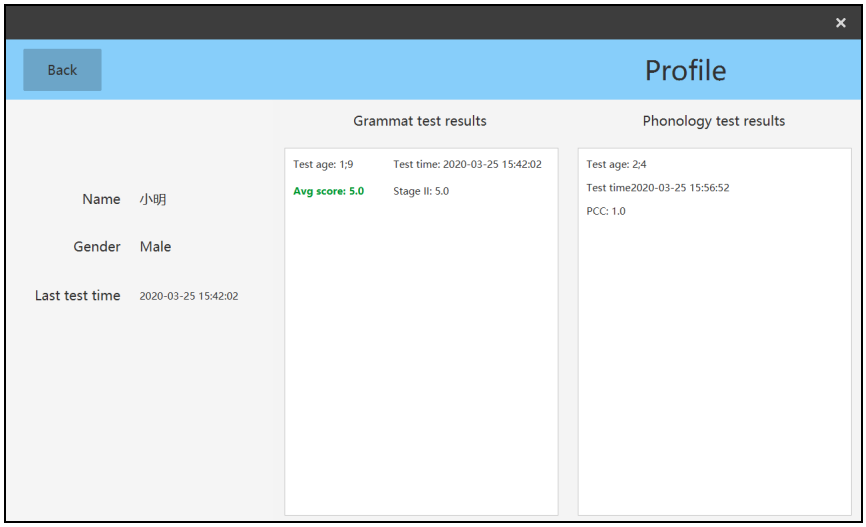

Figure 3.9: View Profile

Figure 3.9 shows the UI of inspecting a profile. If the user selects a profile through 'view profiles' entry in the main menu, the software will display the profile as in this page. The name, gender and the last test time are shown on the left. All the grammar test results and phonology test results stored in this profile are listed seperately and briefly in two list views: 'grammar test results' and 'phonology test results'. The user can view the detail

of a specific result by double-clicking it in the list. If the user clicks 'back', the software will move to the previous page.

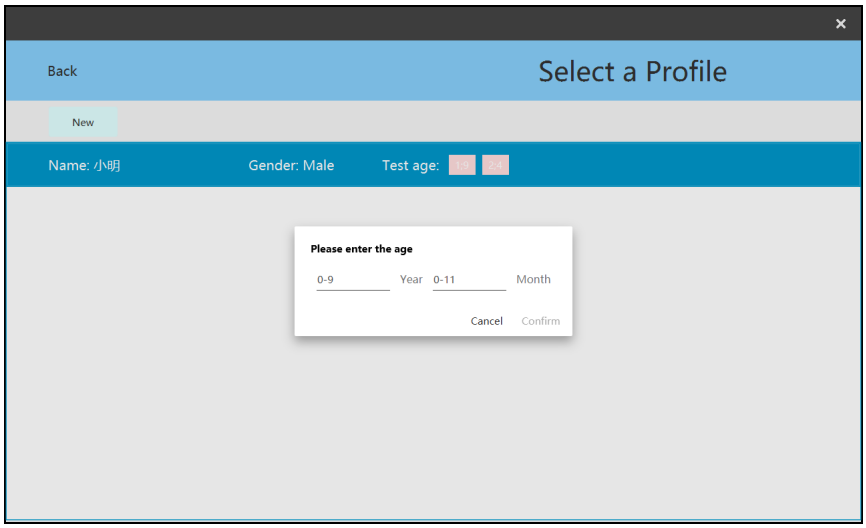

Figure 3.10: Input Test Age

Figure 3.10 shows the dialogue box for the input of test age. If a profile has been selected for the assessments, this box will prompt the user to enter the test age of child. After the user enters the year and month of the child's age, he/she can click 'confirm' to continue.

Figure 3.11: New Profile

Figure 3.11 shows the UI of setup a new profile. The software provides entries for the user to enter the name and gender of the child. If the user fills in the name and gender and clicks 'save', the software will prompt the user that the profile has been setup and move

to the previous page. If the user clicks 'back', the software will return to the previous page directly.

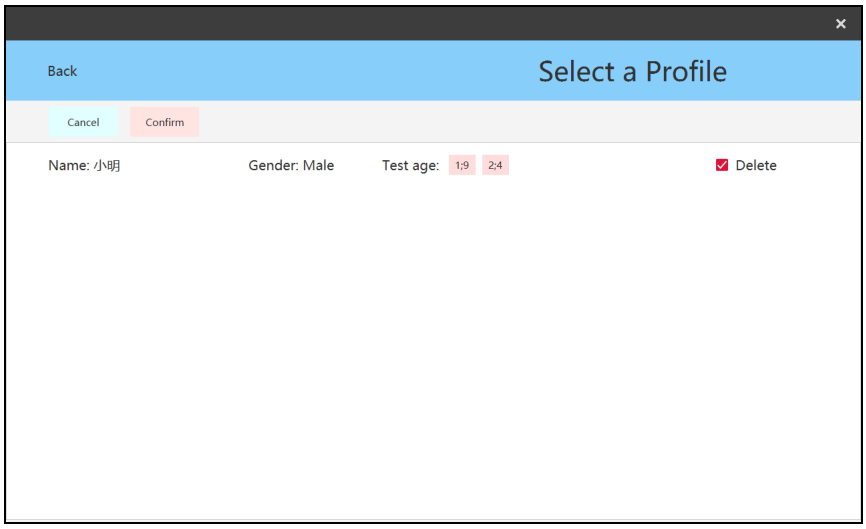

Figure 3.12: Delete Profile

Figure 3.12 shows the interface when the user wants to delete one or more profiles. The user can select the profile to be deleted by the 'delete' checkbox. After selection, the user can click 'confirm' to delete or 'cancel'.

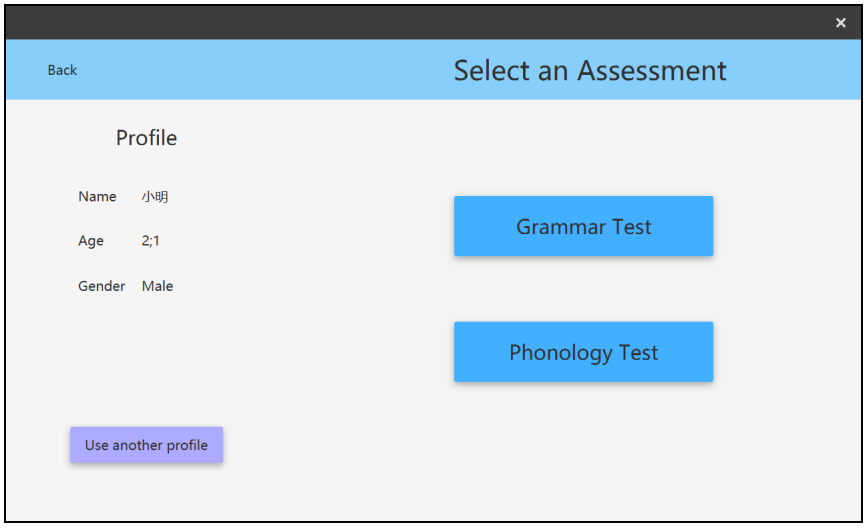

Figure 3.13: Test Menu

Figure 3.13 shows the UI of test menu. After the profile has been selected and the age has been entered, the software moves to this page. In this page, the user can select to conduct grammar test by clicking 'grammar test', or phonology test by clicking 'phonology test'. If the user wishes to change the selected profile, he/she can use the 'use another profile'

button to return to the profile selection page. If the user clicks 'back', the software will return to the main menu.

3.5.2 Grammar Test and Result

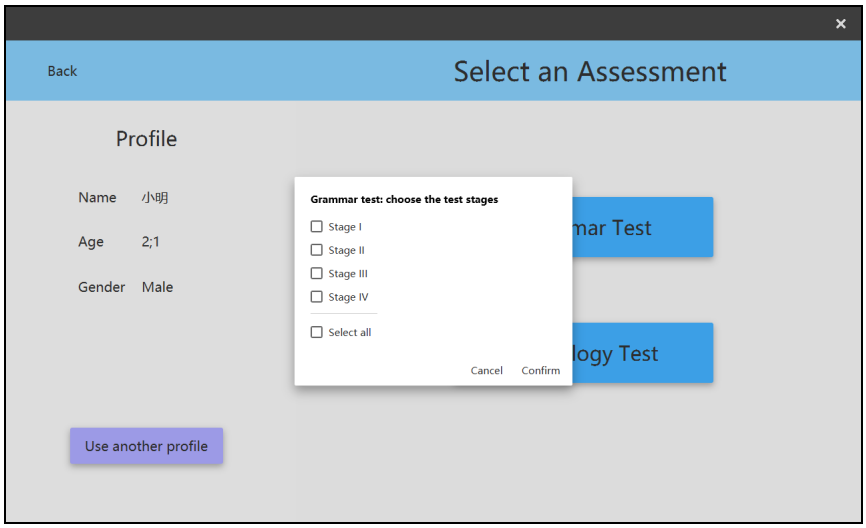

Figure 3.14: Test Stage Selection

Figure 3.14 shows the dialogue box for selecting desired test stages for the grammar test. Before the start of the grammar test, the user must choose the question sets to be tested. The user can select one or more stages from this box, or choose 'select all' to select all stages. After the user clicks 'confirm', the software will load the corresponding questions and start the assessment.

Figure 3.15 shows the UI of the grammar test. The question image is displayed on the left, and the panel for input and output is on the right. The user can click 'record' to record the child's voice. After the recording, the software will automatically display the text transcribed from the voice just recorded. The user can click 'analyze' to view the auto-analysis result, or click 'next' to move to the next question directly. If the user is not satisfied with the auto-analysis result, he/she can choose one of the sample answers in 'quick select' and then move to the next question. When all the selected questions are tested, the software will display the result summary.

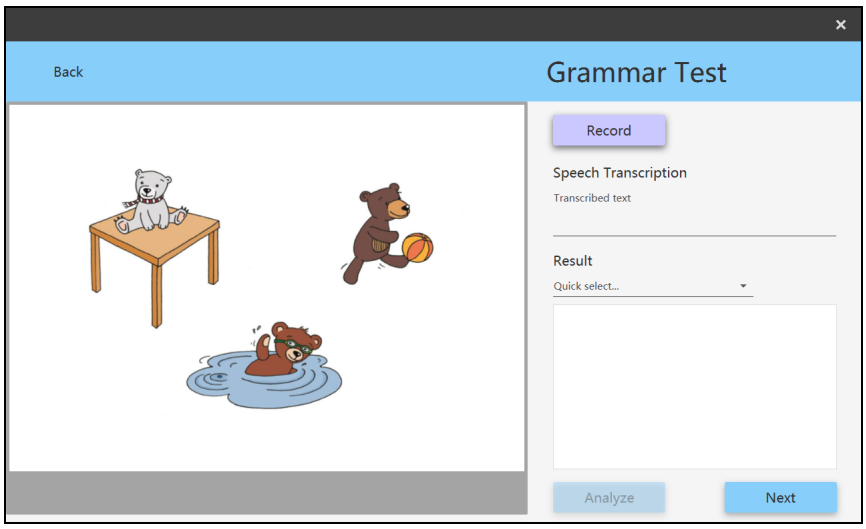

Figure 3.15: Grammar Test

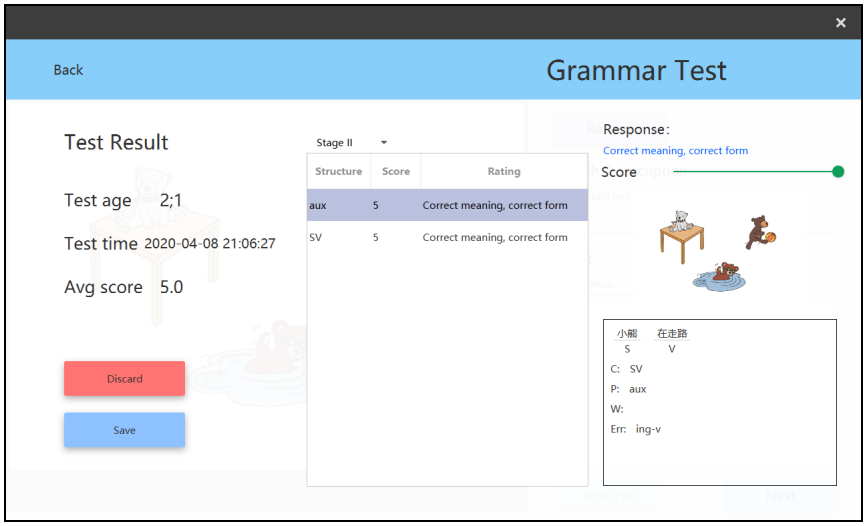

Figure 3.16: Grammar Result Summary

Figure 3.16 shows the UI of phonology result summary. In the grammar result summary shows the detail of a grammar test result. The test age, test time and average score are shown on the left, the table that displaying all the questions and grammatical structures are shown in the middle and the question image, analysis of response and the slide bar for scoring are shown on the right. If the user selects a specific question/structure in the table, then the components on the right will display the corresponding information. To discard the result in this page, the user can click 'discard'. If the user wants to save the result after the test or made some modifications to the scores, he/she can click 'save'.

3.5.3 Phonology Test and Result

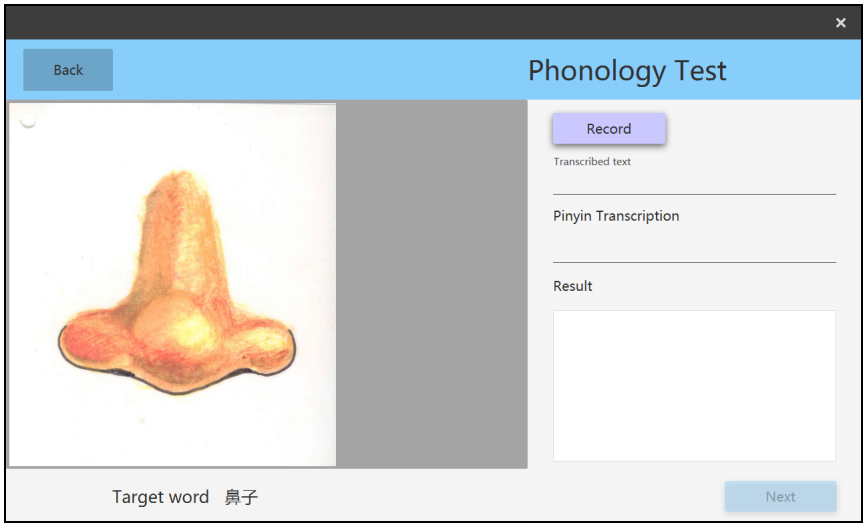

Figure 3.17: Phonology Test

Figure 3.17 shows the UI of the phonology test.

The question image is displayed on the left, and the panel for input and output is on the right. The user can click 'record' to record the child's voice. After the recording, the software will automatically display the pinyin transcribed from the voice just recorded and the analysis result from that pinyin. If the user is not satisfied with the speech-to-pinyin result, he/she can directly modify the transcribed pinyin in the textfield. When all the questions are tested, the software will display the result summary.

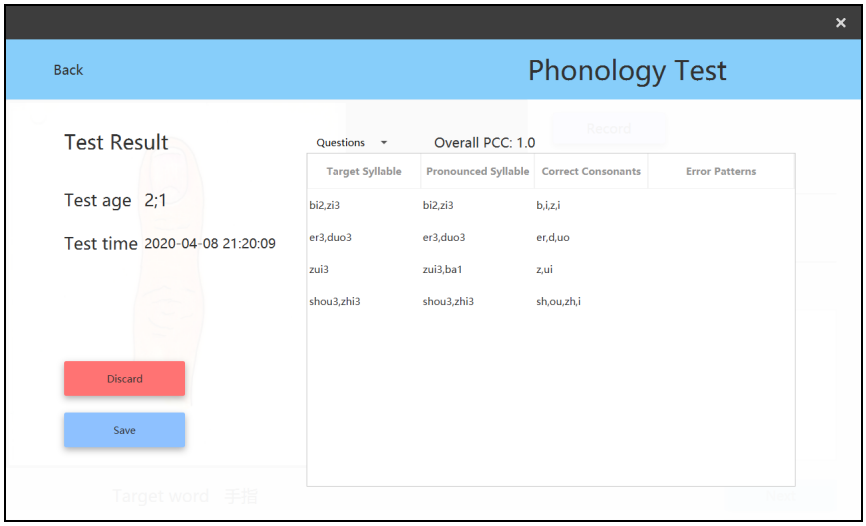

Figure 3.18: Phonology Result Summary: Test Questions

Figure 3.18 shows the UI of phonology result summary when displaying the test questions and their corresponding responses. In the phonology result summary shows the detail of a phonology test result. The test age and test time are shown on the left and the table that displaying all the questions are shown on the right. The table listed the questions and their responses, along with the error patterns discovered in the response (if there is any). To discard the result in this page, the user can click 'discard'. If the user wants to save the result after the test, he/she can click 'save'.

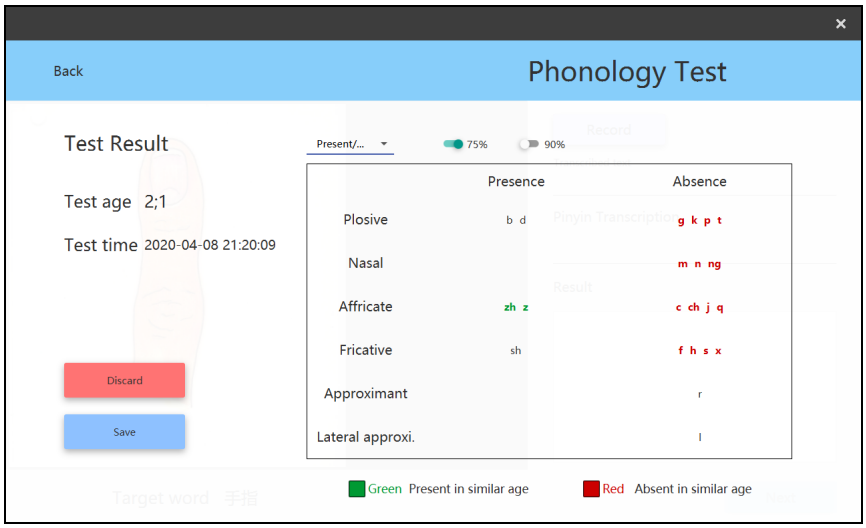

Figure 3.19: Phonology Result Summary: Present/Absent Consonants

Figure 3.19 shows the UI of phonology result summary when displaying the present and absent consonants from the result. If the user selects 'present/absent consonants' in the combo box lies on the top of the table, the table will display the present and absent consonants of this child. The consonants are classified into six categories according to Zhu's inventory [39]. Each consonant is put into column 'presence' or 'absence' after the comparison with Zhu's inventory. In this table, the color of black, green and red represents age-appropriate, unusual and delayed as this chapter mentioned above. There are two inventories for comparison, one is comparing with 75% of the children and the other one is with 90% of the children. The user can use the toggle button above the table to view the different comparing results.

Figure 3.20 shows the UI of phonology result summary when displaying the error patterns list from the result. If the user selects 'error patterns' in the combo box lies on the top of

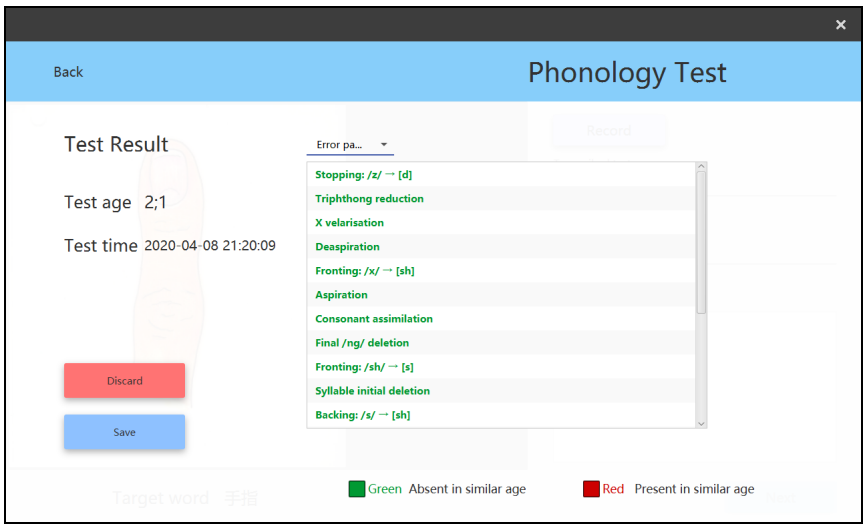

Figure 3.20: Phonology Result Summary: Error Patterns

the table, the table will display the error patterns of this child. A list of all error patterns, discovered or not, are displayed in this list with black, green and red colors. The error patterns are also compared with Zhu's error pattern inventory [39] and colored using the same rule as the present and absent consonants.

Chapter 4

Implementation

In this chapter, we will discuss the prototyping procedure, platforms/softwares used in prototyping and major system components. Also, the code hierarchy and the project timetable will be shown.

4.1 Prototyping Procedure

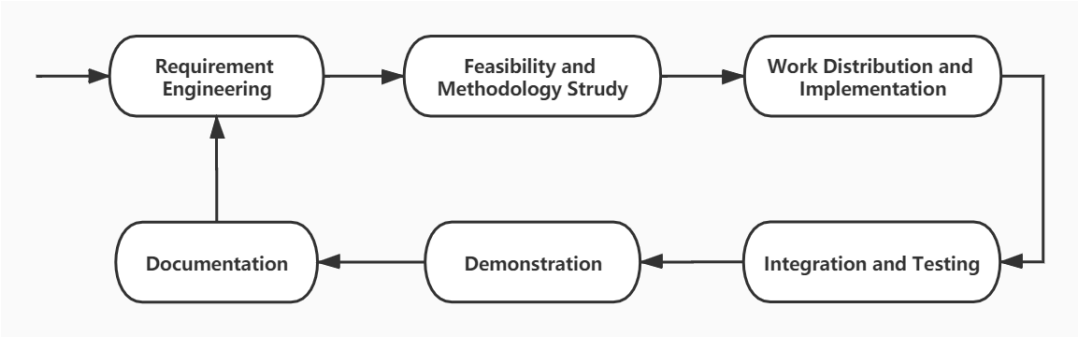

Figure 4.1: Prototyping Procedure Chart

Figure 4.1 shows the procedure of one prototyping iteration. Every iteration lasts for two or three weeks. In each week, the team has a formal meeting physically or online. The meeting minutes of all formal meetings can be found in Appendix G.

Requirement engineering: Identify the jobs (e.g. add/modify the functionalities in the software) from the initial requirements given by the stakeholders.

Feasibility and methodology study: Research in the jobs and find the optional approaches to accomplish the desire goals. In detail, use what algorithms and tools.

Work distribution and implementation: Allocate the jobs to the different team members by the team leader. Then, the members finish their jobs. If some works are found to be too difficult, more people will be assigned to these jobs after easier works has been completed.

Integration and testing: All finished jobs go back to the team leader and be integrated into the software. Conduct testing on the newly developed prototype.

Demonstration: Record videos and demonstrate them to the stakeholders through WeChat [34] or Zoom [41].

Documentation: Receive and document the feedbacks from the stakeholders through WeChat for developing the next prototype.

4.2 Production Softwares and Tools

Programming language: Java SE 8u231 [29].

Operating systems: Windows 10 and Mac OS.

Integrated development environment: JetBrains IntalliJ IDEA [11].

Communiation: WeChat [34] and Zoom [41].

Dissertation writing: Visual Studio Code [26] and LaTeX [18].

Repository: Github [5].

Diagrams: ProcessOn [30].

4.3 Data

Dictionary and dependency parsing model: Data for HanLP v1.7 [7].

Word2vec model: Pre-trained Chinese word vectors. Corpus: People's Daily News [20].

Sample question image and answers: Provided by Prof. Jin and Prof. Zhu.

4.4 Testing

The software prototype has already been through three iterations since the beginning of the project. Apart from the tests that are conducted along with coding, the major, documented tests are applied after each iteration of prototyping. The testing consists of two parts: functionality verification and requirement validation.

4.4.1 Verification

The functionality verification focuses on the functionalities that the software provides. To inspect whether the components in the program work correctly, a checklist of software functions is designed. This checklist classifies the actions (e.g. clicking a button) by interfaces (e.g. the main menu) and marks true or false by whether or not the result of these actions is correct. The content of the checklist changes as the functions are added or removed from the prototype. Another part of the verification is input checking. For example, to check the input of test ages, both the legal and illegal inputs should be examined. The team has also designed a series of tables (referred to as the test inventory) to verify the system handling user inputs.

The test inventory (Appendix E) consists of two main parts: the functional test tables and input test tables. Each prototype has several functional test tables and one input test tables. In the functional test tables, all the interactive UI components are listed.

There are tables for the following pages: Main Menu, Profile Selection, Profile Set Up, Profile Viewing, Test Menu, Grammar Test, Phonology Test, Grammar Result Summary and Phonology Result Summary page.

The other part is input test tables. According to the software design, there are four text areas (five before the 1st prototype) that the user can input freely. The input test tables examines the correctness of the program's response to user inputs. The text areas are: name input in the Profile Set Up page, age input in the Profile Selection page, response input in the Grammar Test and Phonology Test page. Each text area was tested with various inputs. To see the detail information of the test inventory, check Appendix E.

4.4.2 Validation

The requirement validation focuses on whether the functionalities of the software suits the stakeholders' needs. In order to check this, each prototype is demonstrated through a video recording. The video is sent to the stakeholders using WeChat. Then, the stakeholders will give their feedbacks on the prototype. The team can also talk to the stakeholders directly via an audio meeting on Zoom about the specific requirements.

The feedbacks from the stakeholders are documented for the next iteration of prototyping. See Appendix F for the feedbacks of the first and second prototypes and changes in the second and third prototypes.

4.5 Major System Components

4.5.1 Third Party Components

Dom4j

Dom4j [3] is a Java library that provides methods to read/write XML files. Compared to the XML read/write methods provided in Java, dom4j can achieve the same functionalities much simpler. It can also make the code easier to maintain. This library is used in read/write profiles, inventories and sample answers to the questions in XML files.

HanLP: Han Language Processing

The HanLP [10] is a natural language processing tool kit based on Java. It can provide various NLP functionalities such as segmentation, dependency parsing and semantic distance calculation. The team has also investigated in another similar tool called Stanford CoreNLP [25] and found out that the HanLP can also achieve CoreNLP's functions, while have two mean advantages compared to CoreNLP:

a) The HanLP is lighter in code and required less memory. Thus, the time required to initialize HanLP is lesser than CoreNLP.

b) The HanLP gives better results when parsing some sentences. The HanLP is designed speficically for Chinese language environment.

As a result, the team chooses to implement the grammar test using HanLP instead of Stanford CoreNLP. In this project, the dependency parsing and semantic distance calculation will help in the grammar test implementation. How does these two functions are going to work in the software will be discussed later.

JPinyin

JPinyin [32] is a Java library that prodives methods to convert the Chinese characters into pinyin.

JFoenix

JFoenix [12] is JavaFX GUI library which allows the team to build good and clean user interfaces. It contains a large number of UI components that the team can use directly. UI built using JFoenix has a better appearance compared to original JavaFX library.

Recorder

The source code of the recorder used in both assessments is modified from Internet source [2]. The recorder uses the microphone of the computer and outputs .wav files.

Xunfei voice dictation

Xunfei voice dictation [35] is an application programming interface provided by Xunfei Open Platform. In the software implementation, the input voice is required to be transcribed into text in both grammar and phonology tests. This API takes an audio fragment with length less than 60 seconds as input, and outputs Chinese character text.

4.5.2 Developed Components

Assessments and data storage

The grammar test and phonology test are the two assessments in the software. Both of the tests have the similar subroutines:

```xml
<?xml version="1.0" encoding="UTF-8"?>

<answer id="1">
  <item>
    <response_clause utterance="Partial or full repetition">
    </response_clause>
    <response_phrase>
    </response_phrase>
    <response_word>
    </response_word>
    <scores>
      <structure score="2" type="clause">SV</structure>
      <structure score="2" type="phrase">pron p</structure>
      <structure score="2" type="phrase">aux</structure>
      <structure score="2" type="word">ing-v</structure>
    </scores>
  </item>
  <item>
    <response_clause utterance="小熊在走路">
      <structure value="S">小熊</structure>
      <structure value="V">在走路</structure>
    </response_clause>
    <response_phrase>
      <structure value="pron p">小熊</structure>
      <structure value="aux">在</structure>
    </response_phrase>
    <response_word>
      <structure value="-ing">在走路</structure>
    </response_word>
    <scores>
      <structure score="5" type="clause">SV</structure>
      <structure score="5" type="phrase">pron p</structure>
      <structure score="5" type="phrase">aux</structure>
```

Figure 4.2: Sample Answer Xml

```xml
<?xml version="1.0" encoding="UTF-8"?>

<inventory name="75_pc">
  <age period="1;6-2;0">
    <plosive name="Plosive">
      <present>b,p,d,t,g</present>
      <absent>k</absent>
    </plosive>
    <nasal name="Nasal">
      <present>m,n,ng</present>
      <absent/>
    </nasal>
    <affricate name="Affricate">
      <present>j,q</present>
      <absent>z,c,zh,ch</absent>
    </affricate>
    <fricative name="Fricative">
      <present>x,h,f,s</present>
      <absent>sh</absent>
    </fricative>
    <approxi name="Approximant">
      <present/>
      <absent>r</absent>
    </approxi>
    <l_approxi name="Lateral approxi.">
      <present/>
      <absent>l</absent>
    </l_approxi>
  </age>
  <age period="2;1-2;6">
    <plosive name="Plosive">
      <present>b,p,d,t,g,k</present>
      <absent/>
```

Figure 4.3: Present/Absent Consonant Table Xml

a) Load the questions at the beginning of the assessment and store them in a queue. Poll one question at a time.

b) Record and receive text from Xunfei voice dictation. Analyze the text using utterance builder and marker (grammar test) or pinyin identifier (phonology test).

c) Store the analysis result in the corresponding test result.

d) Poll the next question. End the test if the question is empty.

One of the main tasks in this project is designing the data storage hierarchy, in order to achieve the read/write result operations and select questions by age. As a result, all the inventories, results and sample answers related to the tests are stored in XML files. Shown in Figure 4.2 and 4.3 are the fragments of XMLs that the team designed to store test information. In these files, every age group contains different information (e.g. targets of question). Therefore, by loading the information in the corresponding age group that the test age belongs to, the test can assess different structures for various ages in one question.

Utterance builder and marker

The utterance builder is the component that identifies the clause, phrase and word level grammatical structures in C-LARSP chart from the parsing result of HanLP. The neural network dependency parser in HanLP [8] parses the input sentence and outputs the dependency grammar tree. From the parsing result, the utterance builder identifies the clause level structures from the dependency tree. It also converts the dependency tree into phrase structure tree and recognizes the grammatical structures of phrase and word levels.

The utterance marker is the component that gives scores to the analyzed utterance. It firstly calls the method for semantic distance calculation with a pre-trained word2vec model in HanLP. This method returns a double-type value ranged from 0 to 1. As requested by the stakeholders, in the scoring standard, if the child has mentioned things that is relative to the question, the meaning of this utterance can be considered as correct. Hence, the correct distance of meanings should not be set very low. A threshold of 0.7 has been set in the marker to identify similar meanings.

The marker can also identify whether or not the child has said a target structure from the result of the utterance builder. An example of the final formatted result of the utterance builder and marker is as follows:

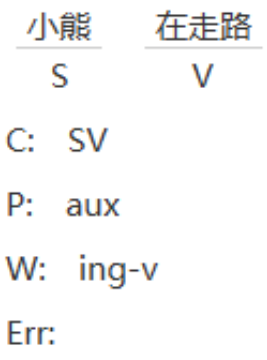

Figure 4.4: Formatted Analysis Output in the Grammar Test

In Figure 4.4, the analyzed utterance is displayed on the top. The characters in the

utterance are grouped according to the clause level strucutures found by the utterance builder. Below the utterance, there are rows named 'C', 'P', 'W' and 'Err'. The 'C', 'P' and 'W' represents the clause, phrase and word level structures marked as correct by the utterance marker respectively. The 'Err' row contains the target structure(s) that the child failed to say.

Pinyin identifier

The pinyin identifier is used in the phonology test to analyze the pinyin from the child's response. It contains two functionalities: percent consonant correct (pcc) calculation and error patterns identification. Every analyzed response has its own pcc and a list of presented error patterns. This is an example of the formatted output from pinyin identifier:

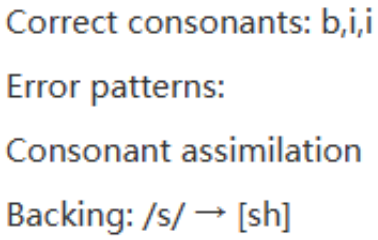

Figure 4.5: Formatted Analysis Output in the Phonology Test

Figure 4.5 shows the output with the target pinyin 'bi,zi' and response pinyin 'bi,zhi'. In this example, the pinyin identifier marked pinyin characters 'b', 'i' (first one) and 'i' (second one) as correct. The correct pinyin characters are displayed in 'correct consonants'. The pinyin identifier also recognized two error patterns and showed them in 'error patterns'.

4.6 Code Hierarchy

In this section, we discuss the code hierarchy of the implemented prototype. The package diagram is demonstrated, followed by the class diagrams of the major packages.

4.6.1 Package Diagram

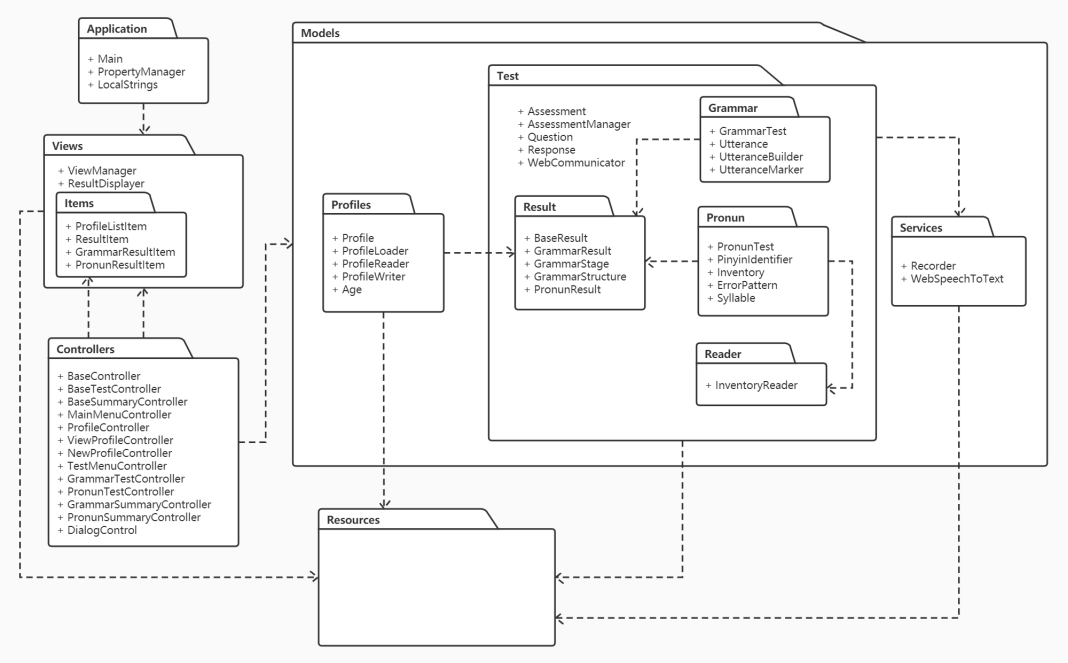

Figure 4.6: Package Diagram

The package diagram in Figure 4.6 shows the relationships between the packages. The major packages are:

Main: The entrance of program.

Controllers: The controllers of JavaFX scenes.

Views: Contains the FXML files and classes for displays.

Resources: Contains all the resources (profile, image, question files).

Models: The source code of the profiles, tests and results.

4.6.2 Class Diagrams

Package: Application

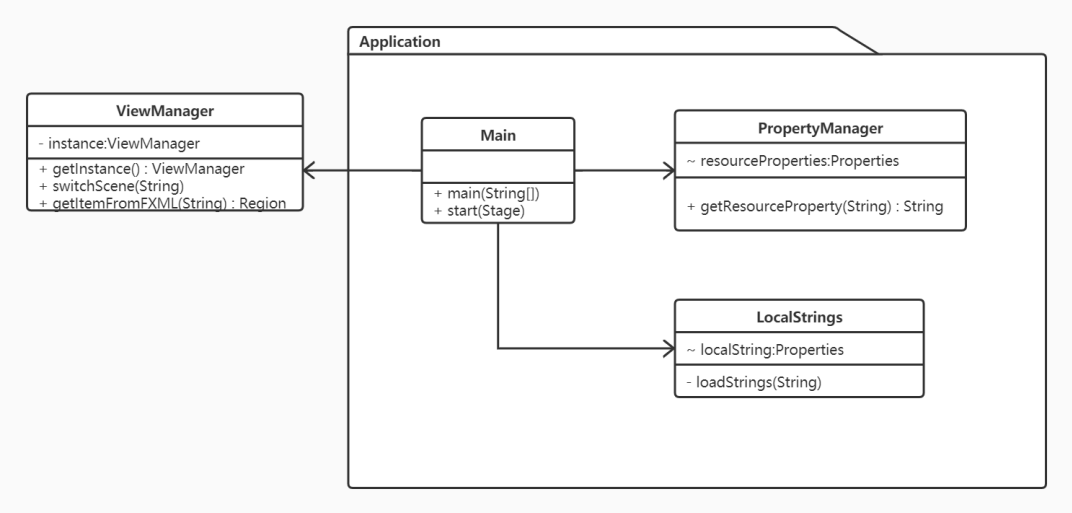

Figure 4.7: Class Diagram: Application

Shown in Figure 4.7, in package 'Application' is the entrance of the program. The Main class uses the PropertyManager and LocalStrings to initialize the properties and texts in the software.

Package: Controllers

The diagram in Figure 4.8 shows the interactions of all the controllers of scenes. The switch between scenes is handled by the ViewManager, but not by the controllers themselves. Hence, there are no direct interactions between the controllers, except for the BaseTestController and BaseSummaryController. In the end of each test, the result is shown by the BaseSummaryController. Also, through the entries on the BaseSummaryController, the program exits the test.

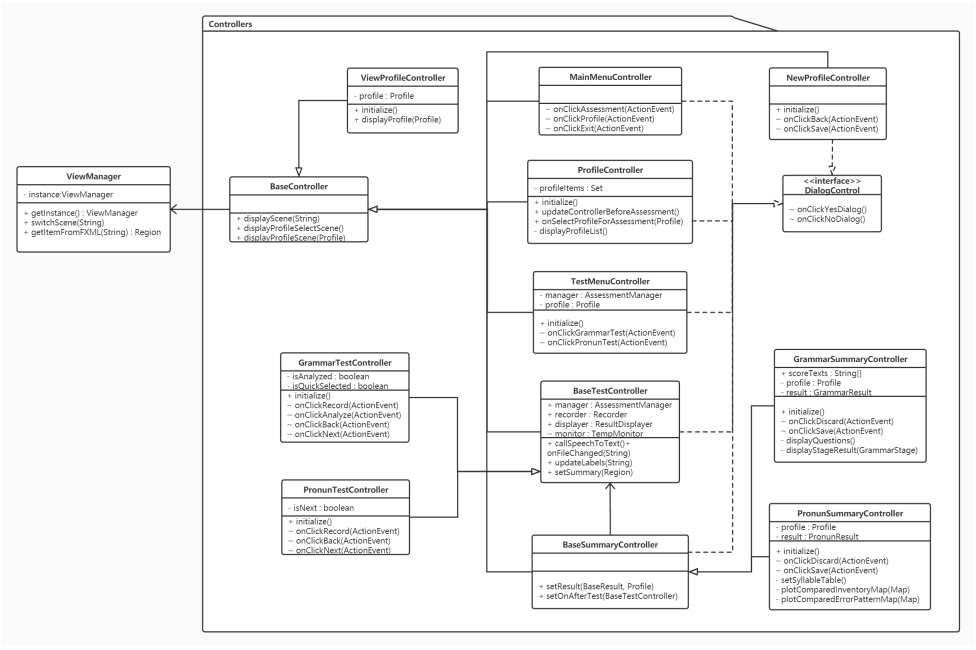

Figure 4.8: Class Diagram: Controllers

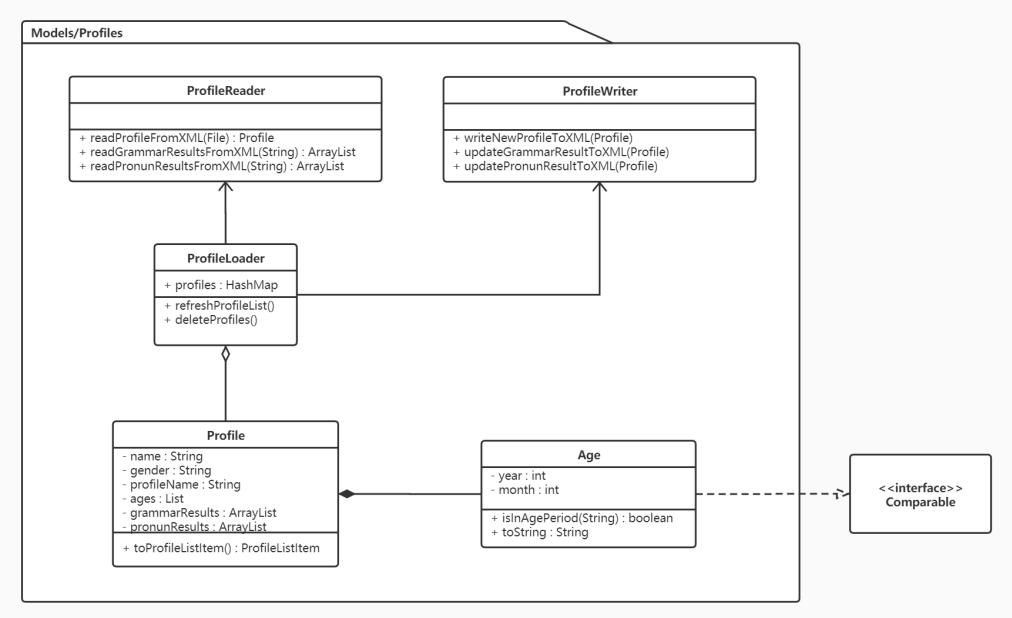

Figure 4.9: Class Diagram: Models/Profiles

Package: Profiles

The hierarchy of the package 'Profiles' is shown in Figure 4.9. In the prototype, the profiles are loaded/saved in the ProfileLoader through the ProfileReader/ProfileWriter.

Package: Grammar

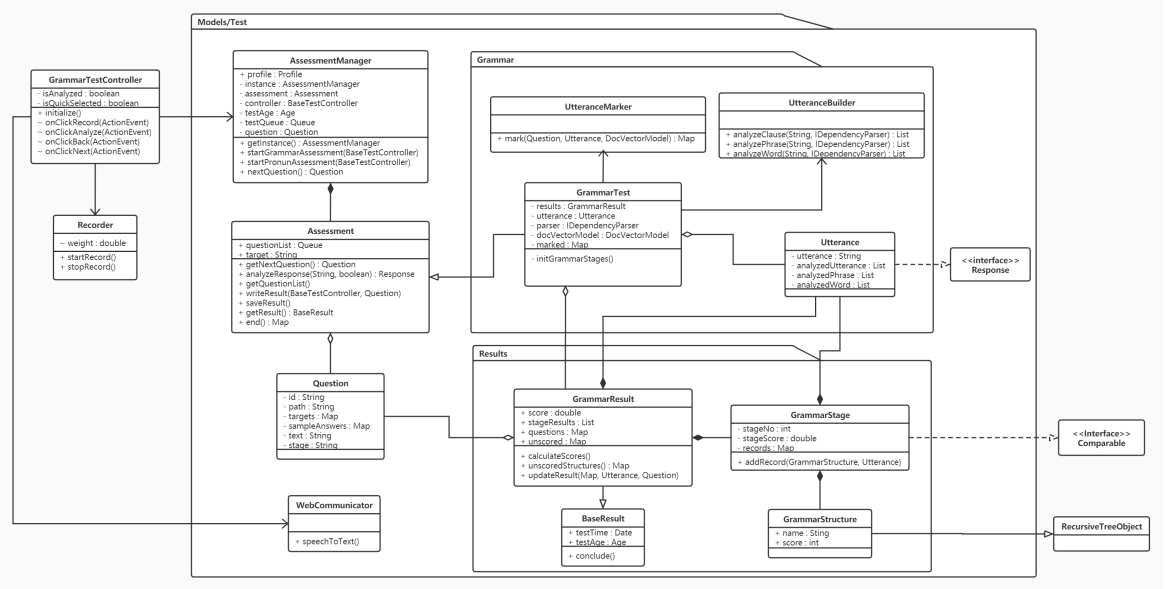

Figure 4.10: Class Diagram: Models/Test (grammar test part)

To demonstrate the hierarchy of the source codes of two tests more clearly, their class diagrams are drawn seperately.

Figure 4.10 shows the relationships between the classes involved in the grammar test. The controller controls the assessment via the AssessmentManager class. The questions used in the assessment are stored in the GrammatTest, extended from the Assessment class, and in the GrammarResult. The final result of the grammar test is the GrammarResult, which is extended from the BaseResult, consists of the Question, Utterance, GrammarStage and GrammarStructure objects.

Package: Pronun

The hierarchy of the phonology test source code shown in Figure 4.11 is similar to the grammar test. The difference is that the result object, PronunResult, is composed of Syllable objects. The PronunResult class also uses the InventoryReader to obtain the compared present/absent consonant table and error pattern table.

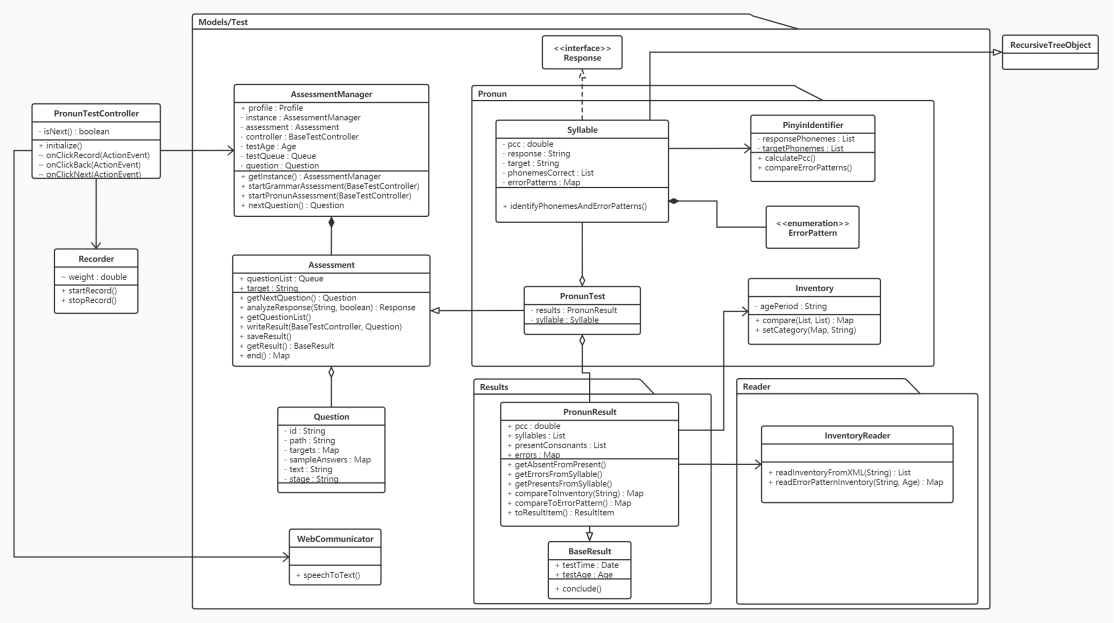

Figure 4.11: Class Diagram: Models/Test (phonology test part)

Package: Views

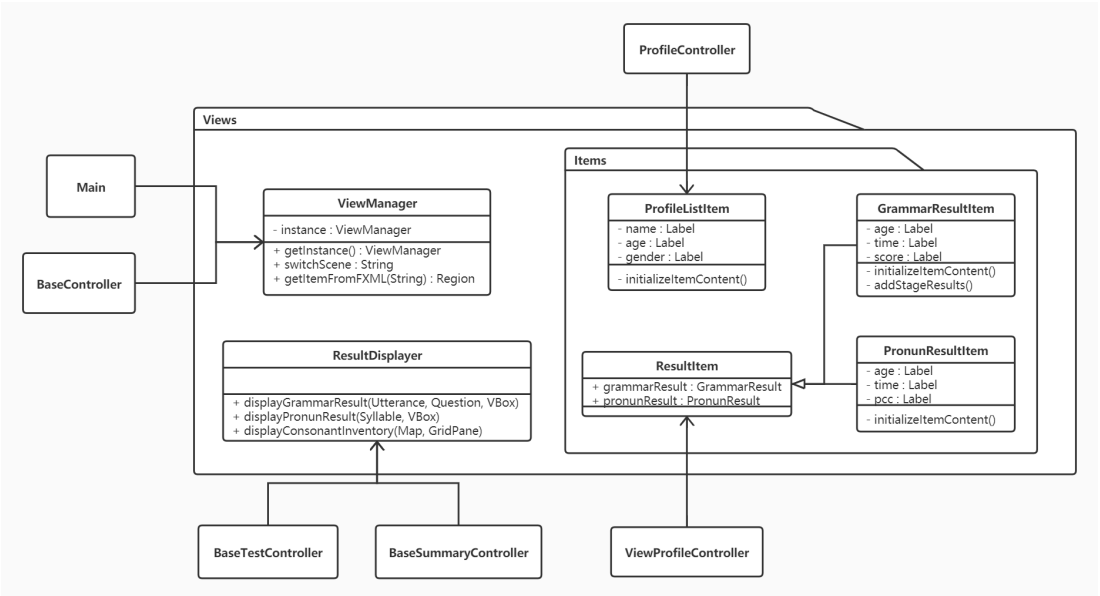

Figure 4.12: Class Diagram: Views

The class diagram in Figure 4.12 shows the hierarchy of the package 'Views'. The classes in this package handles the display of information. For example, the ResultDisplayer can format the grammar and phonology test results and display them on the interface like they are shown in the section 'Major System Components'.

4.7 Timetable

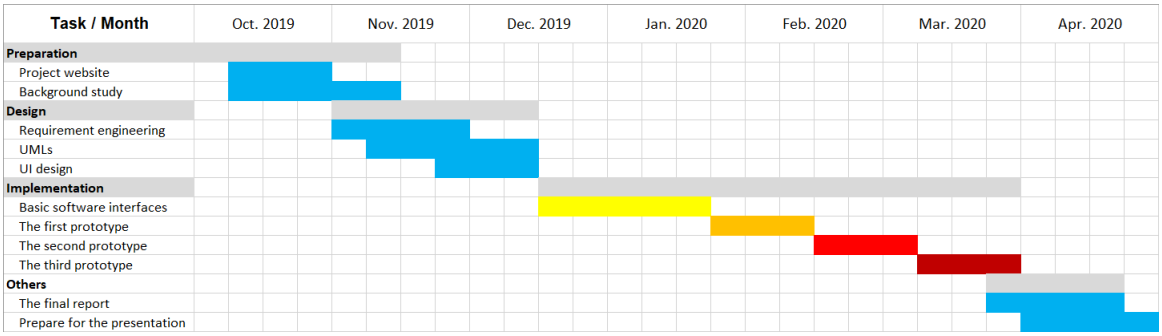

Figure 4.13: Project Time Table

Figure 4.13 shows the project time table of the past months. The project design ended in mid December in 2019 and then the implementation started. The requirement engineering process continued along with implementation. In time of implementation, the prototyping timeline is:

The first prototype: From the late January to mid February.

The second prototype: From the mid February to early March.

The third prototype: From the early March to April.

Due to the deadline of courseworks and exam preparations during mid December to early January, the progress of this project was slow. Therefore, the implementation of basic software interfaces took longer time than originally planned. In April, the team is focusing on demonstrating the project.

In the next chapter, we will evaluate the outcomes of this project and discuss the problems encountered from the technical and management perspective.

Chapter 5

Evaluation

In this chapter, we will firstly summarise the achievements of this project. Then, the technical and management issues as well as their solutions will be illustrated.

5.1 The Current Prototype

The current prototype, finished by March 25, 2020, is the third prototype of this project.

5.1.1 Achieved Requirements

a) Create, delete and view profiles.

b) Conduct the grammar assessment by implementing C-LARSP chart. Provide quick selection of sample answers in the grammar test. Identify and display the grammatical structures in clause, phrase and word level.

c) Conduct the phonology assessment by implementing the Phonology Assessment of Chinese (Mandarin). Record the child's response and convert it into Pinyin. Calculate or identify the percent consonant correct, present/absent consonants and error patterns.

d) Save the results in the profile and the results can be viewed later.

5.1.2 Unsolved Requirements

a) Store the profiles on a server. The profiles are currently stored in local.

b) Identify all the structures in the C-LARSP chart. The system of the third prototype can only identify the correctness of stage I and II structures.

c) Convert the voice into International Phonetic Alphabet (IPA) accurately. There are no existing tools to transcribe voice into IPAs directly. Moreover, the speech-to-text API cannot transcribe the response into the most precise pinyin.

5.2 Problems and Solutions

The team has encountered several issues regarding both implementation and team work during working on this project. For some of the issues, the team has come out the solutions or made compromises. For some other issues, the solutions to them have been brought out but haven't been implemented yet.

5.2.1 Technical Issues

Designing: The references of similar products

The development of computerised language assessment tools for Chinese is still immature. Moreover, the detailed design information of tools like Dream-C cannot be found. All the information that the team has about Dream-C is obtained from their website [4]. The detailed information regarding Dream-C assessment is only available from participating in the Dream-C assessment. Thus, it is difficult for the team to design a software without refering to other related computerised assessment tools. In order to address this problem,

the team relys more on information provided by the stakeholders. This solution reflects on the prototyping procedure in chatper 5: the team collects the feedbacks of the stakeholders on the interfaces as well as the functionalities in each iteration of prototyping.

Designing: International Phonetic Alphabet in the phonology test

As requested by Prof. Zhu, the phonology test should examine the child's pronunciation through International Phonetic Alphabet (IPA). However, there is no tool available now for transcribing speech to IPA directly. Therefore, the team makes a compromise with Prof. Zhu, and uses pinyin for pronunciation accuracy checks. In the software prototype, the speech from the child is transcribed into text in Chinese character first using Xunfei voice dictation [35]. Then, the text is converted into pinyin by JPinyin [32].

Implementation: The accuracy of natural language processing tool

During the implementation of the grammar test, the team discovered some parsing problems occured in HanLP. When inputing some types of utterances, the parser cannot give the correct dependency grammar tree. These errors can influence the final marking results greatly.

After investigation on the HanLP source code, it is found that before a sentence is parsed, the sentence will first be segmented. If the segmentation result is incorrect, then the outcome of parsing will definately wrong. The default segmentation method in HanLP is Hidden Markov Model (HMM). To increase the accuracy of segmentation, the team conducted experiments and choose the Structured Perceptron [9] as the segmentation method.

Implementation: The accuracy of speech-to-pinyin process

As was mentioned above, the speech-to-pinyin process can be divided into speech-to-text and text-to-pinyin. However, after the process of speech-to-text, the output text sometimes is not the exact transcription of the voice. For example, if the child pronounced 'sou3,zi3', the API will likely to give the text with pinyin 'shou3,zhi3'. Because in Mandarin Chinese there is no character pronounced as 'sou3', the API will automatically correct the text in the output. This is a major issue in the phonology test, which can lead to failure in both pcc calculation and error patterns identification.

So far, the team has found no solution to address this problem. This situation is brought to Prof. Zhu and Zhu agrees that user involvement in pinyin transcription is necessary. Therefore, in the prototype, the user can modify the text-to-pinyin result directly during the phonology test.

Testing: Quantify the accuracy of the analysis scripts

One of the most difficult part in the verification is to test the accuracy of analysis scripts in the grammar test. The analysis scripts take the result of NLP parsing as input, and output the structures in C-LARSP chart. The accuracy of this script is hard to quantify because it is hard to find sample utterances that can cover the majority of structures in the C-LARSP chart.

In order to conduct testing to the analysis scripts, the team uses the utterances listed in the guidance of C-LARSP provided by Jin [15]. By comparing the results from the analysis scripts and the sample analysis in the guidance, the team can measure the number of correct analysis. This number is regarded as the analysis scripts' accuracy.

Performance: The initialization time and memory

Before the start of the grammar test, the software needs to initialize the NLP tools such as HanLP and word2vec model. This initialization process will take approximately 30 seconds to one minute depending on the machine. Also, with the NLP models loaded into memory, the software will occupy roughly 2.5 gigabytes of memory. On some machines with poor hardware performances, this might greatly influence the software's performance.

Putting the NLP tools on the server can be a solution to this problem. However, the team has not implement it in the third prototype yet.

5.2.2 Team Management Issues

Late or absent for meetings

Members being late or absent for meetings happens from time to time. This occurs not only in some informal meetings, but also in some formal meetings as well, especially for online formal meetings. The members being late or absent were asked for explanations, and the replies were 'I forgot'.

In order to minimize this issue, a coordinator has been assigned to oversee the attendency of meeting. Also, the coordinator will inform the team members before the meeting starts. The members who missed the meetings without a valid explanation are warned that such behaviour will lead to a reduction of scores in peer assessments.

Refused to work

During extend the winter holiday due to the COVID-19 outbreak, the team members are working at home. Because the team members cannot meet physically, all communication has to be online. One of the problems caused by online communication is that there is member who refused to work.

It has been made clear that refusing to make contribution will receive a low mark in the peer assessment. Also, the coordinator should check each member's progress in a weekly routine.

Communication

Another problem cause by online communicating is that the work assigned to the team members sometimes cannot be explained thoroughly. In other words, sometimes the person may misunderstand the goal of the piece of work assigned. This problem has resulted in extra work when misunderstanding happens. To address this problem, the team leader explains the work in detail and double-checks that the person has understood.

Chapter 6

Summary and Reflections

In this chapter, we will summarize the successfulness of this project. Also, the reflections on how to improve in both technical and management perspectives will be included.

6.1 Summary

Since the beginning of the project in Oct 2019, the team has been working on this project for 6 months. In conclusion, regardless of the issues encountered, the team delivers a prototype capable of suiting the stakeholder's demands. Although the prototype has not yet achieved full functionalities, it can serves as a demonstration of a computerised Chinese speech and language assessment tool.

6.2 Reflections

There are things that can be better conducted in this project, including the works in requirement engineering, prototyping, testing and team managing.

6.2.1 Technical

Background study and interviews

The very first task for the team is to do the background research of this project topic. However, the team did not deliver a thorough research related to the field of language assessment. As a result, the team's background knowledge is lacked and the preparation for the interviews is poor.

It can be improved by practising interviews more, especially the questions of the interview should be clear and be able to extract what the team wants to know easily. The team should learn the background information in more specific detail, like some general knowledge regarding the linguistics. With these knowledge, the team can talk to the stakeholders with lesser gaps. We should have spent more time on preparing the interviews, which could certainly make a difference.

Requirements in detail

When implementing the early prototypes, the requirement specification is not detailed enough. Therefore, the functionalities provided in the prototype are not quite exact to what the stakeholders want. The team could do a better job by checking the requirements with the stakeholders more often. This could be done by having a regular meeting with the stakeholders every one or two weeks and demonstrate the progress. Furthermore, we should ask more questions regarding the tests and clear any misunderstandings. By doing so, the time could be saved because the times making large modifications to the source code could be minimized.

Testing and documentation

The work of documenting the tests/changes/feedbacks is missed during early implementations. Also, some tests and experiments (e.g. the experiment on speech-to-text results) conducted during coding are not documented. This can be imporved by keeping records of all the decisions and feedbacks when implementing the software. Templates for recording tests and communications should be generated. With the templates, the team members can record the information more conveniently.

6.2.2 Team management

Job allocation

The unbalanced job allocation occurred in prototyping. Some team members were assigned the work that is too difficult, while others had little work to do. The improvement has reflected on the prototyping procedure that the jobs are assigned more evenly, and the members with fewer jobs will help the others after he/she finishes the work.

After the work distribution, some members need to study the relevant knowledge before working, which is the main reason of the slow progress. To make a difference, the team leader, or other teammate, should provide more guidance on how to finish the task. More importantly, the team leader should be familiar with all members' skills and assign work base on this.

Cooperation

Some issues on team cooperation has been illustrated in the previous chapter. If some clear rules of teamwork were set up at the beginning of this project, the cooperation among teammates is going to be much closer. It could make a difference by asking the team members to report their progress every half a week, and attend all the meetings on

time. Also, for those who are not willing to follow the rules, certain penalties could be given. For example, a deduction in the peer assessment.

Due to the COVID-19 situation, the team has to cooperate online. One of the things that we could do better is having group meetings more often. In the past months, the frequency of group meeting was reduced. If the team maintains the frequency of one or two meetings per week, the team leader can make the teamwork more efficient.

6.3 Future Work

Our team will learn from the previous experiences and mistakes and improve the prototype. The team can solve the problems encountered so far by implementing the changes discussed above during the future iterations of prototyping. In the future, the work will be focusing on implementing the full C-LARSP grammar test and phonology test, and also improve the accuracy of current analysis result. More specifically, these five tasks will be conducted:

a) Implement the analysis methods for the rest of the stages in the C-LARSP chart.

b) Improve the accuracy of error pattern analysis in the phonology test.

c) Move the data of NLP tools and profiles to a server so that the user is not required to download data files and can share the profiles.

d) Develop a speech-to-IPA model to trancribe the voice into International Phonetic Alphabet directly and improve the overall accuracy of the phonology test.

e) Update the user interfaces to provide better user experiences.

In conclusion, the team has learned valuable skills in software engineering process. There is still a large amount of work ahead in order to deliver a well-functional healthcare-oriented computerised Chinese speech and language assessment tools.

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Appendix A

C-LARSP Chart

姓名: **年龄: (/ /)** **语言测试日期: / /** **类型:**

第一段 (1;0-1;5)	**小型句** response 回答 vocative 呼叫 other 其它 problem 分辨疑惑类						
	完整句	命令句	疑问句	statement 陈述句			
		v 动词	Q 疑问词	v 动词 N(n-dup)名词（复） VO 述宾 aux[m] 情态动词 pron-m 代-量词 AV 状述	Other 其它	Problem 分辨疑惑类	
第二段 (1;6-1;11)	Conn 连句词	Clause 句子			Phrase 词组结构		Word 功能词缀
		VX 述 X SV 主述	WhX 疑问词 X XQ X 疑问词	SV 主述句 VCv 述补句 VO 述宾句 VV 连谓句 SO 主宾句 AV 状述句 NegV 否定述句 Other 其它句型 SA 主状句	Endo(x-dup *de* y-dup) 偏正结构(x-复的 y-复) aux [m] 情态动词 x-dup x-复字 vv 连谓 pron n 代词名词 N (x-*de*) x-的构名词 pron[p] 人称代词 Prep 介词 x-comp x-组合 Adv 副词 Other 其它		Suffix-*zi* (子) 后缀--*子* *de*→n *的*-构名词 *de*→poss *的*-构所有 *de*→emp *的*-构强调 *de*→attri *的*-构形容 *de*→con *的*-构确认 *de*→ly *地*-副词 *de*→Cv *得* 构补语 pl 复数 tm (ed) 过去时 tm (v-ing) 动词-进行时 tm (ing-v) 进行时-动词
第三段 (2;0-2;5)	Conj-comp 连词组合	X+S:NP	X+V:VP	X+Cv: VP	X+O:NP	X+A:NP	
		Gei XY 给 XY SVO 主述宾	WhQX (why, where, who) Wh 疑问词 X WhQXY Wh 疑问词 XY XYQ/WhQ XY 疑问/ Wh 疑问词 XWhQY X Wh 疑问词 Y WhQSVO Wh 疑问词主述宾 SVOQ 主述宾疑问词	S P 主谓句 AVO 状述宾句 SVV 主连谓句 SAV 主状述句 SVCv 主述补句 VVO 连谓宾句 SVO 主述宾句 Passive 被动句 VOsV 兼语句 Neg XY 否 XY 句 SVCvO 主述补宾句 AAXY 状状 XY 句 Other 其它句型	pron-nu-m 代-数-量词组 adv.adj. 副词形容词组 Endo.(x-dup *de* y-comp) 偏正结构(x-复的 y-组合) adv.adj.n 副词形容词名词组 pron m n-comp 代-量-名-词组合 N (xy-*de*) xy-*的*构名词 v neg vc 动否动补 prepQ 介疑问词 aux[m]-comp 情态动词组合 Neg v 否 动词 Cv-comp 补语词组合 I-m-n 总括词-量-名词 Apposit (pron-pron) 同位词(代词-代词) Other 其它		
第四段 (2;6-3;0)		XY+S:NP	XY+V:VP	XY+Cv:VP	XY+O:NP	XY+A:NP	
		VXY+ 动 XY+	SVOsVQ 主兼语疑问词 S SV(X)Q 主谓谓语句疑问词 TagOQ 附加疑问-宾-疑问词 TagOVQ 附加疑问-兼语-疑问词	S SV(X) 主谓谓语句 VOsVCv 兼语补语句 SVVO 主连谓宾句 SVCvO 主述补宾句 SVVOCv 主连谓宾补句 S complexV 主复杂述句 SVOiOd 主述双宾句 S complexVCvO 主复杂述补宾句 SVOsVO 主述兼语宾 Other 其它	Apposit (n-pron) 同位词(名词-代词) v-neg-v 动-否-动词 nu m n-comp 数-量词-名词组合 neg Cv-comp 否-补语组合 NPcNP 名词短语加名词短语 complex NP 复杂名词短语 Other 其它		
第五段 (3;0-3;6)	Conj 连词 Conj-paired 配对连词 Other 其它		Compressed Double 紧缩双疑问句	Compressed clause 紧缩句 Other 其它	Compound clauses 复合句	superlative adv 最高级副词 Other 其它		pre-fix (第) 前缀-第 pre-fix est 前缀-最
第六段 (3;6–4;6)	(+)			(-)			
	Conjunction	NP	Clause	Conn.	Clause	Phrase	Word
	Complex 复杂连词句	Complex 复杂名词组合	Composite sentences 合成句 Comparative 比较句 Narrative event sequence 叙述事件顺序	Conj Conj-paired 配对连词	Element Ø 缺少 ← 错位 →	NP m m Ø n 缺量词-名词 *de*-N *de* Ø *的*名词缺*的* *de*-Cv *de*-ly *得*补语 *地*副词错位 pron-m ⇄ 代词量词错位 VP Aux[m] V neg Ø 缺情态动词， 动词，否定词	N *de*- 构名词*的*错误 V tm 时态错误
	Other 其它						Ambiguous 意思含糊
第七段 (4;6 +)	*Discourse 语篇*		*Narrative structure 叙述结构*	*Syntactic Comprehension 语法与理解程度*		*Style 语言风格*	
	Total No. 句子总数: Sentences		Mean No. 每话段句子平均数: Sentences Per Turn			Mean Sentence 句子长度平均值: Length	

Appendix B

Requirements

The detail of requirements changes as the software develops. They are modified according to stakeholders' feedbacks. This requirements specifications is the third version since the initial version.

User Requirements

1) The user can setup a new profile for the child or load an existing profile.

2) The user can start a language assessment session.

3) The user can show a consent form to the child (or guardian) before testing.

4) The user can test the child's grammatical ability using images as questions.

5) The software shall present questions that corresponding to the child's age first, with ascending difficulty.

6) The software shall automatically analyze and score the child's response in the grammar test.

7) The user can receive the overall average score, age-phased average score (grouped by

age periods) and items correct/incorrect from the grammar test.

8) The user can modify the scores given by the software after grammar test.

9) The user can test the child's pronunciation ability using images as questions.

10) The software shall automatically analyze the child's response in the phonology test.

11) The user can receive results of the phonology test, including percentage of correct consonants, summary of present and absent phonetic consonants, and error patterns.

12) The user can view and store the results in the child's profile.

13) The user can store and load profiles.

14) The software shall be able to display in Chinese or English.

System Requirements

Set up profile

1) The system shall provide an entry to enter the profile setup page.

2) The system shall provide an entry to load an existing profile. The profiles are loaded from XML files.

3) The profile shall contain the name, age and gender of the child and his/her test results if applicable.

4) The system shall provide an interface to enter the name and gender of the child when creating a new profile.

5) The system shall store the profile in a XML file.

Start an assessment session

1) The system shall provide an entry to start an assessment session at the main menu.

2) Before the start of assessment, The system shall provide an interface to display the consent form.

3) The consent form shall contain two selections, agree or disagree.

4) If the child (or guardian) agrees, the test shall proceed. Otherwise, the system shall go back to the main menu.

5) The system shall prompt the user to choose creating a new profile or loading an existing profile in order to continue.

6) The system shall provide an interface for the user to enter the test age of the child when a profile is selected.

7) The system shall provide entries to start the grammar or the phonology test after the profile is created or loaded.

Grammar test

1) The system shall provide an interface to select the stage(s) (question sets) that the user wishes to test.

2) The system shall provide an interface to display the question images.

3) The system shall load the question set(s) which the user selected previously.

4) The system shall display the questions in ascending order of difficulty.

5) The system shall take the input of audio recording from the child or text input from the user.

6) The system shall provide an entry to record the child's voice through a microphone.

6) The system shall provide an entry for the user to enter what the child said as text.

7) If the system takes audio input, it shall transribe the voice into text through speech-to-text API.

8) The system shall identify the parts of speech and dependencies from the text using the HanLP.

9) The system shall score the child's response according to the metrics in MCUS scoring.

10) The system shall provide an entry containing sample answers for the user to choose quickly. If a sample answer is choosed, the system shall regard it as the child's response and make record.

11) The system shall calculate the overall percentage of correct and percentage of correct items in each stage.

12) The system shall save the result to the profile.

Phonology test

1) The system shall provide an interface to display the question images.

2) The system shall provide an entry to record the voice of the child through microphone.

3) The system shall transcribe voice into text using speech-to-text API, then translate the text into pinyin.

4) The system shall provide a textfield for the user to modify the translated pinyin.

5) The system shall be able to identify consonants from the pinyin.

6) The system shall record all the correct and incorrect cases according to target conso-

nants of questions.

7) The system shall calculate overall percentage of correct consonants.

8) The system shall identify and classify the present and absent phonetic consonants using phonetic consonant inventory.

9) The system shall identify the error patterns of the child's articulation.

10) The system shall save the result into the child's profile.

Profile management

1) The system shall provide an entry to view the child's profile in the main menu.

2) The system shall display the list of profiles with the name, gender and test ages of each profile.

3) The system shall provide an entry to delete the profile.

4) The system shall enable the user to view the detail of test results in each profile.

Profile display

1) The system shall display the name, gender and last test time of the chosen profile.

2) The system shall display the lists of the grammar and phonology assessment results of the profile.

Grammar test result display

1) The system shall display the average score of the result.

2) The system shall provide entries for the user to view the results grouped by stages or questions.

3) The system shall display the tested grammartical structures in the tables.

4) The system shall display the tested questions in a table.

5) The system shall display the detail of the corresponding response if the user selects a grammartical structure/question in the table.

6) The system shall enable the user to modify the score of a specific grammartical structure through a slide bar.

7) The system shall refresh the values in tables after the user made any modification to the scores.

8) The system shall provide an entry to save user modifications.

Phonology test result display

1) The system shall display the percentage consonants correct (pcc) of the result.

2) The system shall provide entries to view responses by question, the table of present and absent consonants and the list of error patterns.

3) The system shall display the response of each question in a table, along with the correct consonants and error patterns corresponding to this response.

4) The system shall display the present/absent consonants in a table, using red and green colors to denote the differences compared to children with similar age.

5) The system shall display the error patterns in a list, using red and green colors to denote the differences compared to children with similar age.

Non-functional Requirements

Performance

1) The software shall be able to make a relatively fast response during the assessment.

2) The software shall load the profiles in an acceptable time when selecting profiles, 2 seconds for the files in local and 5 seconds for the files on server.

3) The server shall be able to store at least 500 profiles.

Reliability

1) The software shall minimize the occurrences of crashing and not responding.

2) The server shall provide a fast access in both China and abroad.

Compatibility

1) The software shall be able to run on both Windows 10 and Mac OS.

Usability

1) The user interface of the software should be clear and simple while achieving the main functions.

Maintainability

1) The software shall enable the developers to modify the criteria of both assessments in a convenient way.

2) The software shall enable the developers to add/remove test questions conveniently.

Safety

1) The profiles on the server shall only be pulled and uploaded from this software.

Appendix C

MCUS Scoring

Guidance and Example of MCUS Scoring

Lixian Jin

MCUS stands for **M**eaningfulness and **C**orrectness of **U**tterance **S**tructure, i.e. the child's utterances are counted for the use of correct structure and appropriateness in meaning in the context.

A scoring system was used to see the meaningfulness and correctness of utterance form.

- Ratings (5 – 0)

5 = correct meaning, correct form.
4 = correct meaning, incorrect form.
3 = incorrect meaning, correct form.
2 = partial or full repetition (e.g. repetition of last word in stimulus)
1 = Incorrect meaning, incorrect form
0 = silence or '*Don't know*'

The first number is for the age group; the second number is the child code number;
b = boys g = girls

Child code (1;0-1;2)	Type of data & utterance numbers		MCUS numbers and percentages											
			5		4		3		2		1		0	
			NO	%	NO	%	NO	%	NO	%	NO	%	NO	%
1;0-1-b	Free	50	1		0		1		0		0		48	
1;1-1-b	Free	50	5		0		0		1		0		44	
1;2-1-b	Free	50	1		2		0		0		0		47	
1;0-2-b	Free	50	0		0		0		2		0		48	
1;2-2-b	Free	50	3		0		0		1		0		46	
1;0-1-g	Free	50	2		0		0		2		0		46	
1;0-2-g	Free	50	5		0		0		2		0		43	
1;1-1-g	Free	50	0		0		0		4		0		46	
1;0-4-g	Free	50	0		0		0		2		0		48	
1;0-3-g	Free	50	5		0		0		2		0		43	

Appendix D

User Manual

This user manual will guide you to use this software to conduct the Chinese speech and language assessments.

Set Up/Delete a Profile

Set Up a Profile

You can use either of these two entries shown in figure D.1 to set up a new profile or delete profiles. These two buttons will take you to the profile selection page. You can click the 'New' button shown in figure D.2 to go to the set up page.

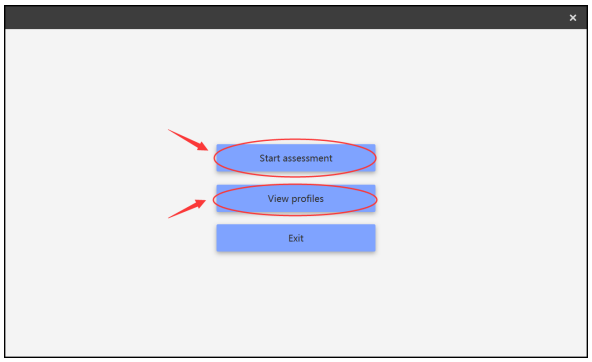

Figure D.1

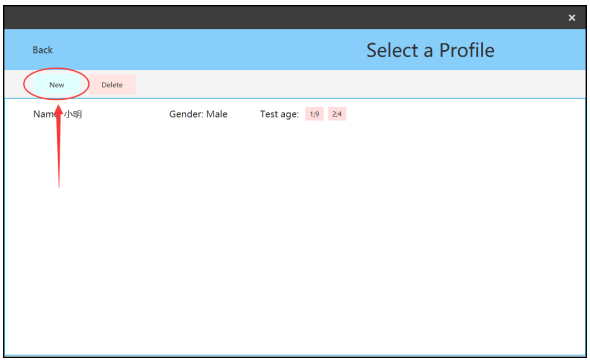

Figure D.2

Figure D.3

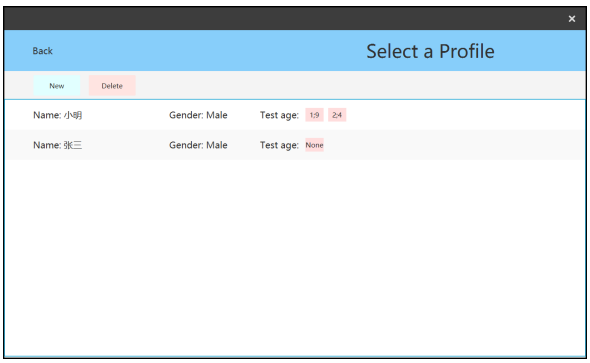

Figure D.4

In this page (figure D.3), you need to enter the name in Chinese characters, and select the gender. After you have inputted these information, you can click 'Save' to finish setting up the profile. You can also click 'Back' to return to the previous page directly without saving. After saving the profile, you can see the new profile in this page as shown in figure D.4.

Delete Profiles

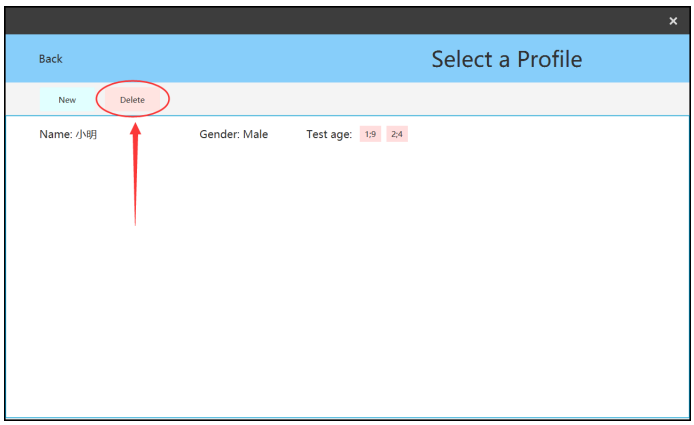

Figure D.5

If you want to delete profiles, you can use the button 'Delete' to enter delete mode in the profile selection page (figure D.5).

After switching to delete mode, you can select the profile to be deleted through the checkboxes as shown in figure D.6. Then, click 'Confirm' to delete. Figure D.7 shows

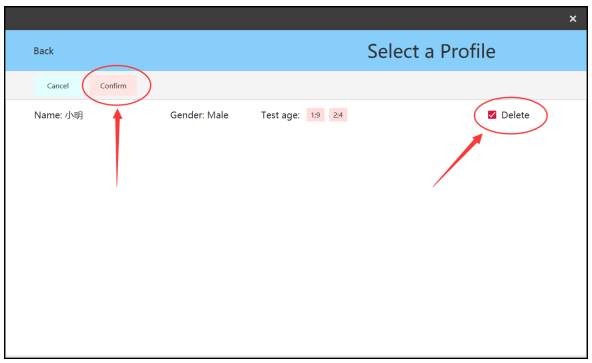

Figure D.6

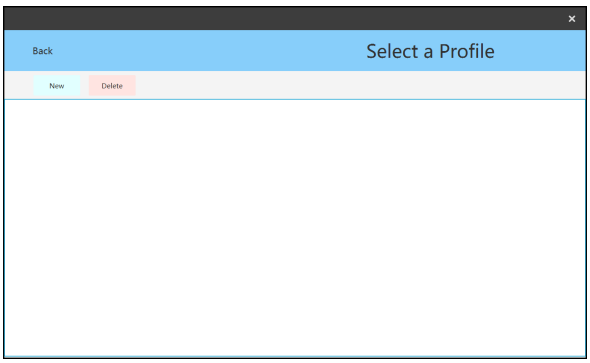

Figure D.7

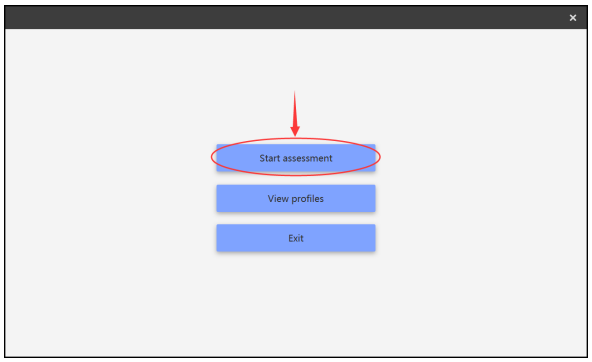

Figure D.8

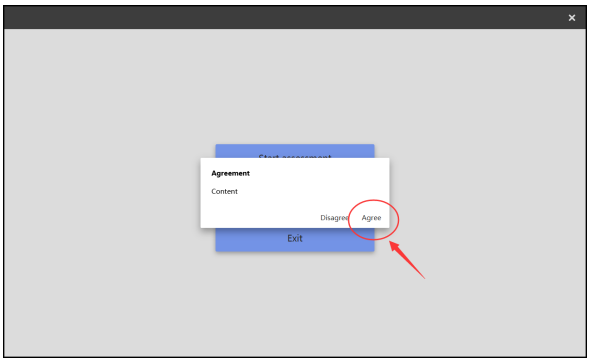

Figure D.9

after the deletion.

Start a Assessment

Use the button highlighted in figure D.8 to start an assessment. A dialog of agreement will pop up like it is shown in figure D.9. You must get the client's consent and click 'Agree' in order to continue.

You need to select a profile in this page shown in figure D.10 before going to the assessment. Double-click the profile to continue.

After you have selected a profile, you need to enter the age of client. In the dialog shown in figure D.11, the year and month are required as Arabic numerals. Then, click 'Confirm'.

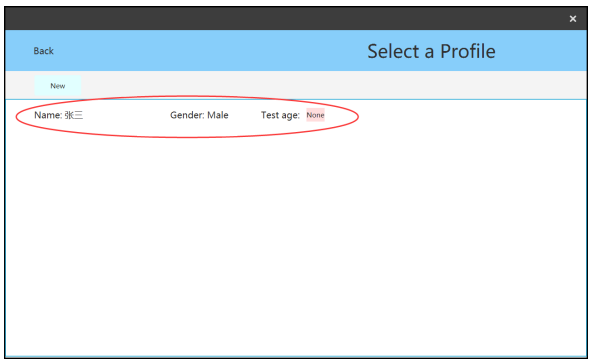

Figure D.10

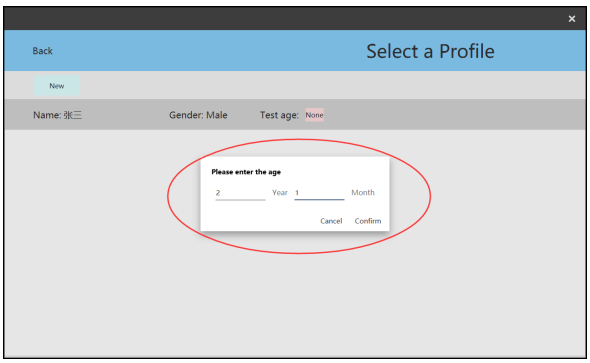

Figure D.11

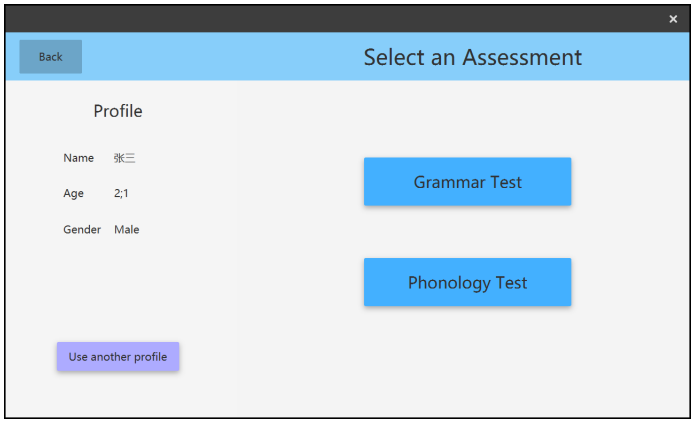

Figure D.12

You will come to the test menu (figure D.12). In this page, you can select the assessment that you wish to conduct. Also, you can switch another profile or return to the main menu.

Conduct a Grammar Test

To start a grammar test, you can click the 'Grammar Test' button in the test menu page (D.13). Then, in the dialog shown in figure D.14, you need to select the stages for the test and click 'Confirm'.

At the beginning of the grammar test, the software will load the required resources. Figure D.15 shows the software is initializing. Please wait the initialization to be completed, the time may vary in different machines. After initialization, you will see the page like D.16.

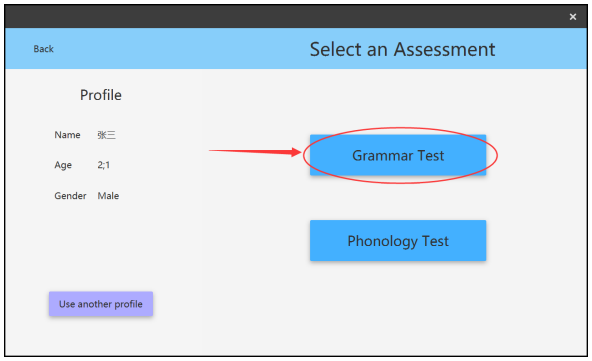

Figure D.13

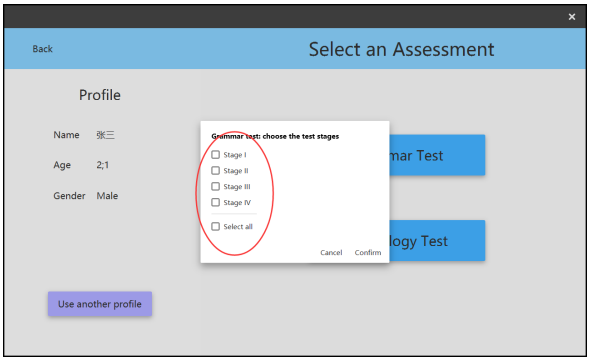

Figure D.14

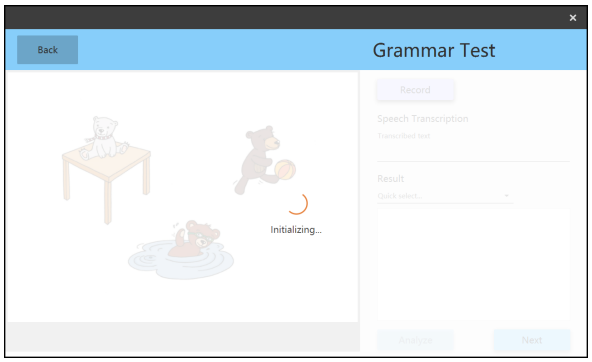

Figure D.15

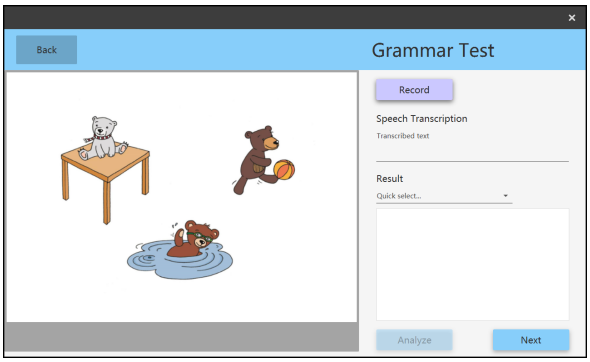

Figure D.16

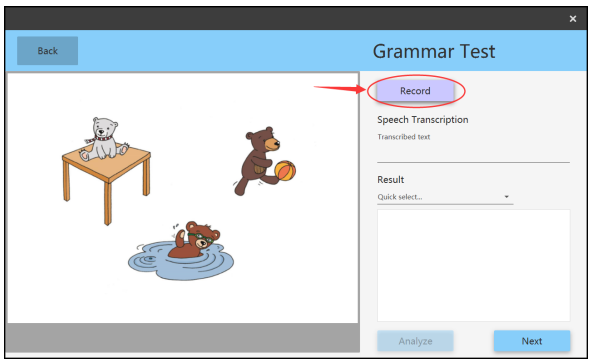

Figure D.17

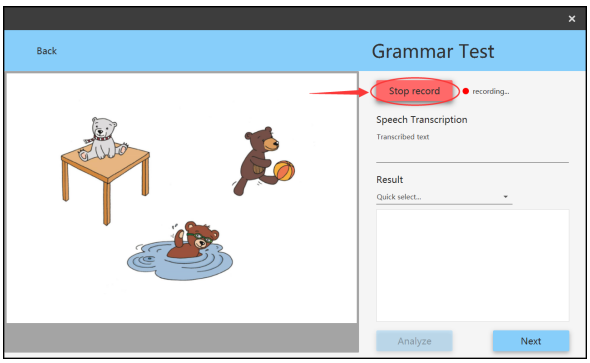

Figure D.18

To conduct the grammat test, you can follow these four steps.

Step 1: Input

After you have elicited the child's response, you need to input this response into the software. There are two ways you can do this: recording or selecting sample answers.

Input by recording

To record the sound, you can use the button circled in D.17. In figure D.18, after clicking 'Record' and the red dot appears, the recording is start. You can click the 'Stop record' button to finish recording.

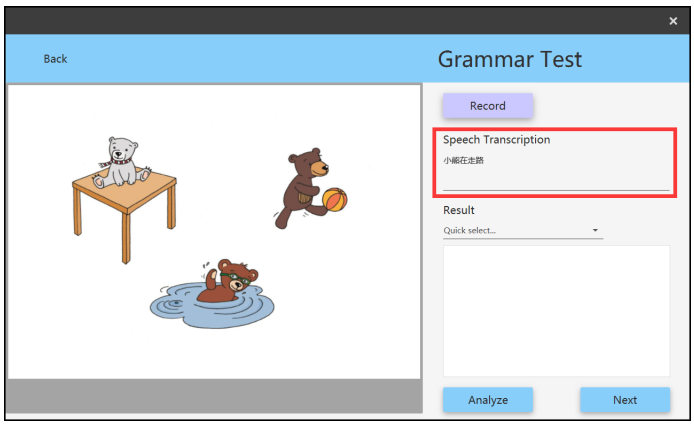

Figure D.19

Once you have finished the recording, you will see the transcribed test in the textfield

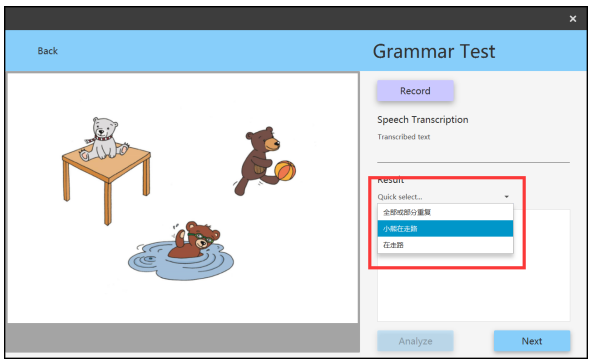

Figure D.20

Figure D.21

shown in D.19. If you are not satisfied with the text, you can record again or modify the text directly in this textfield.

Input by selecting sample answers

You can also select the response from the sample answers directly. In the combo box shown in D.20, there are several possible answers. You can choose one that is the closest to the child's actual response. The analysis of the chosen answer will be displayed (D.21).

Step 2: Analyze (optional)

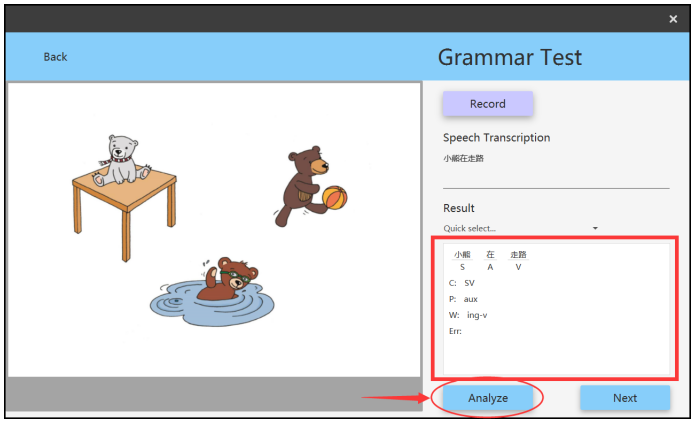

Figure D.22

This step is optional and is only usable when you inputted the response through recording. If you don't want to see the result of analysis, please move to step 3.

Shown in D.22, you can click the 'Analyze' button. Then, the analysis result will be display in the highlighted box.

Step 3: Next

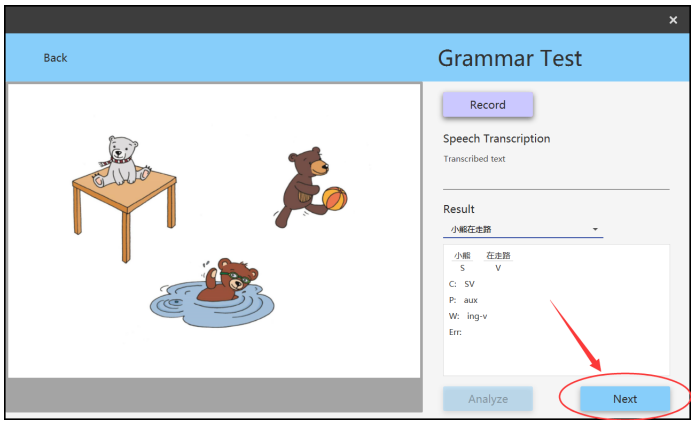

Figure D.23

After you have recorded a response or chosen a sample answer, you need to click the 'Next' button to continue (D.23). Then the software will display the next question.

Step 4: Save

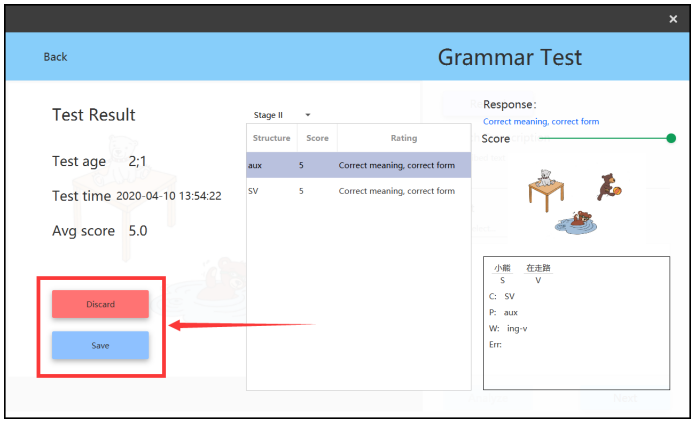

Figure D.24

When all the questions you've selected are tested, this summary in figure D.24 will be shown to you. You can view the test results from here and use the 'Save' button to store the result into the profile.

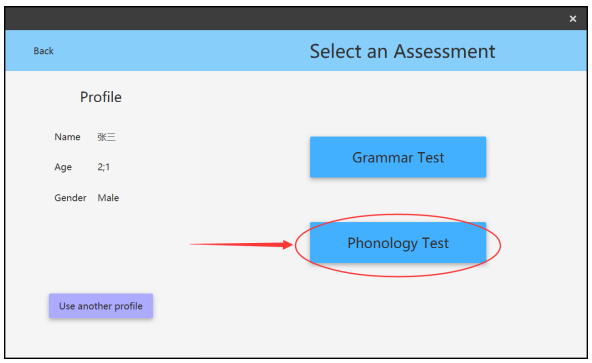

Figure D.25

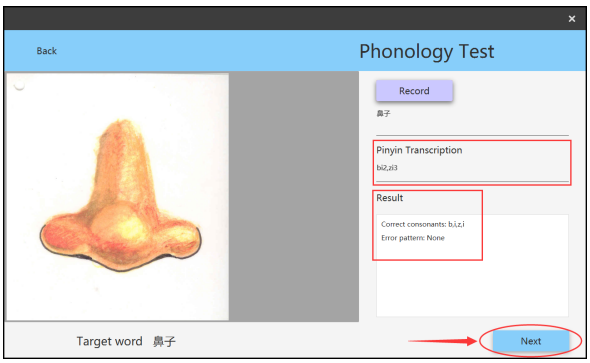

Figure D.26

Conduct a Phonology Test

To start a phonology test, you can click the 'Phonology Test' button in the test menu page (D.25).

It is simple to conduct the test. The recording function is the same as in the grammar test. After recording, the transcribed text and pinyin will be shown in the textfields (D.26). The analysis result is also displayed automatically. If you are not satisfied with the speech-to-pinyin result, you can change the pinyin directly.

You can then click the 'Next' button to continue.

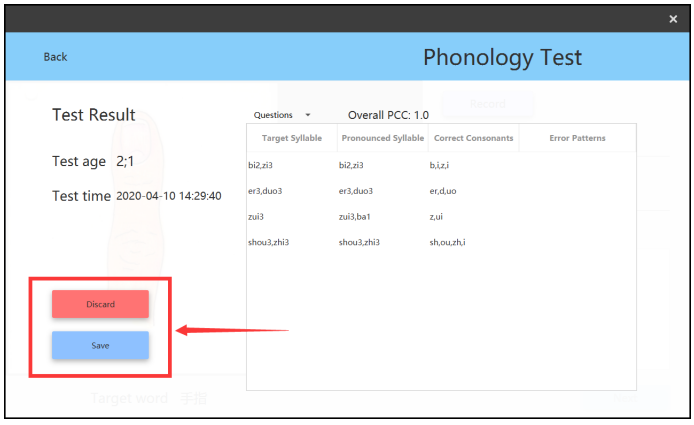

Figure D.27

When all the questions are tested, this summary in figure D.27 will be shown to you. You can view the test results from here and use the 'Save' button to store the result into the profile.

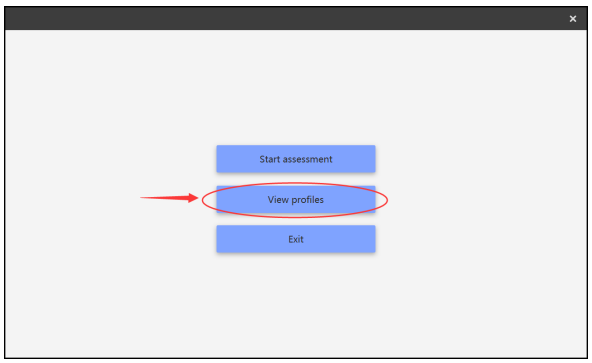

Figure D.28

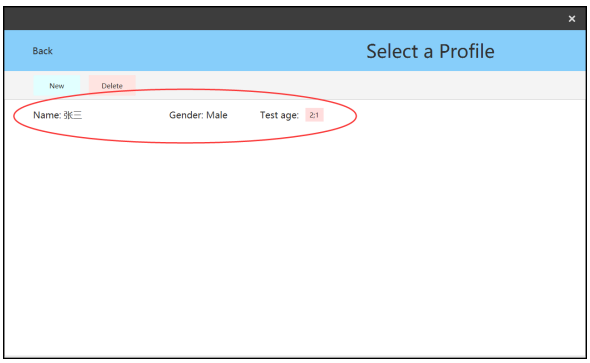

Figure D.29

View the Test Results

To view the result stored in a profile, you need to firstly click 'View Profiles' in the main menu (D.28). Then, from the page listing all profiles (D.29), select the profile that you want to see by double-clicking it.

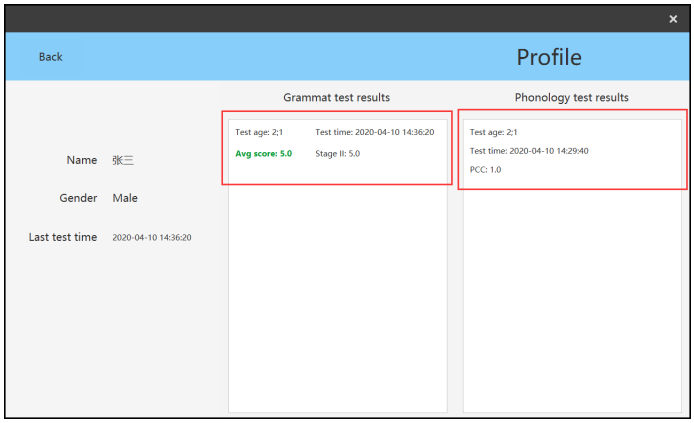

Figure D.30

After selecting a profile, the information stored in this profile, along with a brief summary of each past test will be shown in this page (D.30). If you want to see the detail of a test result, you can simply double-click it.

Appendix E

Tests

1. Test for HOCCSLATs Software

1.1 Purpose：

The system test report is focused on the group software project (HOCCSLATs: Healthcare-oriented computerized Chinese speech and language assessment tools) .The purpose is to develop and implement the system results test and analysis, find the problems in the system, describe whether the system meets the requirements of the project from both function and performance aspects of view.

1.2 Info

Project name: HOCCSLATs: Healthcare-oriented computerised Chinese speech and language assessment tools
System Developer: GRP team 03
System testing: testing of the overall functionality of the system according to the requirements specifications.
Functional test: test whether each functional module of the software is correct, and whether the logic is correct.

1.3 Functional test results and analysis

First prototype:
System test time: 2020/2/22

Part1： main menu:

Clicking start testing button, whether it will jump to agreement dialog or not.	True
In the agreement dialog, click yes button , check whether it will jump to profile selection interface or not. Click no button and check whether it will jump back to main menu or not.	True
Clicking view profile button, whether it will jump to profile viewing interface or not.	True
Clicking exit button, whether the program will exit or not	True

Part2： profile selection:

Read profiles from XML files and display name, gender and age on the interface.	True
Select button appears when select one specific profile	True

Clicking select profile button, whether it will pop out dialog about entering age or not. Entering a string and accept it as age.	True
Click back button, the program will return to main menu	True
Click the create button to enter the new interface to allow the user to input string	True
Clicking select profile button, program will enter result view interface.	True
Click the delete button, program will enter to delete mode and users can delete the selected profiles.	False

Part3: new profile:

In creating new profile interface, whether the generated profile is correct or not when clicking the save button.	True
Use the radio button to select the gender	True
Use text field to input the name of children	True
Click save button to save profiles into the xml files	True
After clicking the save button, whether it will jump back to profile selection interface	False

Part4: test menu:

Display the selected profiles correctly	True
Click change profile button ， program will return to the selection interface, users can reselect profiles.	True
Click on the syntax test button, program will pop out a dialog box for selecting different stages.	True
Can choose the stage, click ok button, enter the grammar test interface.	True
Click pronunciation test button, program will enter the pronunciation test interface.	True

Click back button, the program will return to main menu	True

Part5: grammar test

Whether clicking analysis button to invoke the natural language processing tool is correct or not.	True
Whether tools that give the dependency analysis of a sentence is correct or not.	True
Whether the generated grammatical structure on the program software for the user to see is correct or not.	True
Whether questions scored on a sliding scale (manually) are correct or not.	True
Click the next item button to save the current result, then clear the interface. Whether reading the new question and displaying new picture are correct or not.	True
If the list of questions is already empty, then it will jump to the summary interface. Whether recording the test time of the system is correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether records of each structure can be displayed correctly or not.	True
Whether responding to a review of the project title according to the mouse click is correct or not.	True
When clicking discard button, whether the records are actually discarded or not.	True
Whether saving results and generating XML files are correct or not.	True
Whether reading questions from folders and generating questions and pictures on the screen are correct or not.	True

Part6: pronunciation test

Whether the translation pinyin is correct or not and whether it will be automatically displayed.	True
Click the analysis button, whether calling the method to calculate the correct rate and returning the correct sound are correct or not.	True
Whether the method to determine the error mode and returning to the error mode are correct or not.	True
Whether click the next item button to save the current results is correct or not.	True
Clear the interface. Whether reading new questions and displaying pictures of new questions are correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether the records that the table shows are correct or not. Three tables include syllables and consonant inventory.	True
Whether the consonant inventory for the age group read from the XML files is correct or not.	True
Whether the sounds recorded in the results compared with the consonant inventory are correct or not.	True
Different types of sounds are classified into six categories, and then marked with presence and absence. Whether the procedure is correct or not.	True
When clicking discard button, whether the records are discarded or not.	True
When clicking save button, the dialog box will pop up to confirm the save operation and generating XML files are correct.	True
Whether reading questions from folders and generating questions and pictures on the screen are correct.	True

Part7: test menu:

Whether the translation pinyin is correct or not and whether it will be automatically displayed.	True
Click the analysis button, whether calling the method to calculate the correct rate and returning the correct sound are correct or not.	True
Whether the method to determine the error mode and returning to the error mode are correct or not.	True
Whether click the next item button to save the current results is correct or not.	True
Clear the interface. Whether reading new questions and displaying pictures of new questions are correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether the records that the table shows are correct or not. Three tables include syllables and consonant inventory.	True
Whether the consonant inventory for the age group read from the XML files is correct or not.	True
Whether the sounds recorded in the results compared with the consonant inventory are correct or not.	True
Different types of sounds are classified into six categories, and then marked with presence and absence. Whether the procedure is correct or not.	True
When clicking discard button, whether the records are discarded or not.	True
When clicking save button, the dialog box will pop up to confirm the save operation and generating XML files are correct.	True
Whether reading questions from folders and generating questions and pictures on the screen are correct or not.	True

Part8: speech to text

Click the recording button to start record, and the recording prompt will come out.	True
Click the stop recording button and check generated sound file is correct or not	True
Whether automatically calling the speech-to-text API is correct or not.	True
Whether typing the outcoming texts into the text box is correct or not.	True

Second protoype:

System test time: 2020/3/2

Part1： main menu:

Clicking start testing button, whether it will jump to agreement dialog or not.	True
In the agreement dialog，click yes button , check whether it will jump to profile selection interface or not. Click no button and check whether it will jump back to main menu or not.	True
Clicking view profile button, whether it will jump to profile viewing interface or not.	True
Clicking exit button, whether the program will exit or not	True

Part2： profile selection:

Read profiles from XML files and display name, gender and age on the interface.	True
Select button appears when select one specific profile	True
Clicking select profile button, whether it will pop out dialog about entering age and month or not. Entering two numbers and accepted as age and month respectively.	True

Click back button, the program will return to main menu	True
Click the create button to enter the new interface to allow the user to enter two numbers as age and number.	True
Clicking select profile button, program will enter result view interface.	True
Click the delete button, program will enter to delete mode and users can delete the selected profiles.	False

Part3: new profile:

In creating new profile interface, whether the generated profile is correct or not when clicking the save button.	True
Use the radio button to select the gender	True
Use text field to input the name of children	True
Click save button to save profiles into the xml files	True
After clicking the save button, whether it will jump back to profile selection interface	False

Part4: test menu:

Display the selected profiles correctly	True
Click change profile button ， program will return to the selection interface, users can reselect profiles.	True
Click on the syntax test button, program will pop out a dialog box for selecting different stages.	True
Can choose the stage, click ok button, enter the grammar test interface.	True
Click pronunciation test button, program will enter the pronunciation test interface.	True
Click back button, the program will return to main menu	True

Part5: grammar test

Whether the two toggle buttons related to the lexical level and the clause level can be switched or not.	True
Whether the generated grammatical structure in the lexical level for the user to see is correct or not.	True
Whether the generated grammatical structure in the clause level for the user to see is correct or not.	True
Whether clicking analysis button to invoke the natural language processing tool is correct or not.	True
Click the next item button to save the current result, then clear the interface. Whether reading the new question and displaying new picture are correct or not.	True
If the list of questions is already empty, then it will jump to the summary interface. Whether recording the test time of the system is correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether records of each structure can be displayed correctly or not.	True
Whether responding to a review of the project title according to the mouse click is correct or not.	True
When clicking discard button, whether the records are discarded or not.	True
When clicking save button, the dialog box will pop up to confirm the save operation and generating XML files are correct.	True
Whether reading questions from folders and generating questions and pictures on the screen are correct or not.	True

Part6: pronunciation test

Whether the translation pinyin is correct or not and whether it will be automatically displayed.	True
Whether the analysis result is correct or not and whether it will be automatically displayed.	True
Whether the method to determine the error mode and returning to the error mode are correct or not.	True
Whether click the next item button to save the current results is correct or not.	True
Clear the interface. Whether reading new questions and displaying pictures of new questions are correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether the consonant inventory for the age group read from the XML files is correct or not.	True
Whether the sounds recorded in the results compared with the consonant inventory are correct or not.	True
Different types of sounds are classified into six categories, and then marked with presence and absence. Whether the procedure is correct or not.	True
When clicking discard button, whether the records are discarded or not.	True
When clicking save button, the dialog box will pop up to confirm the save operation and generating XML files are correct.	True
Whether reading questions from folders and generating questions and pictures on the screen are correct or not.	True
Whether the colors display for detected errors and undetected error modes are correct or not.	True

Part7: test menu:

Whether the translation pinyin is correct or not and whether it will be automatically displayed.	True
Click the analysis button, whether calling the method to calculate the correct rate and returning the correct sound are correct or not.	True
Whether the method to determine the error mode and returning to the error mode are correct or not.	True
Whether click the next item button to save the current results is correct or not.	True
Clear the interface. Whether reading new questions and displaying pictures of new questions are correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether the records that the table shows are correct or not.	True
The items in the combo box at the top of the interface are displayed correctly or not	True
Whether the consonant inventory for the age group read from the XML files is correct or not.	True
Whether the sounds recorded in the results compared with the consonant inventory are correct or not.	True
Different types of sounds are classified into six categories, and then marked with presence and absence. Whether the procedure is correct or not.	True
When clicking discard button, whether the records are discarded or not.	True
Whether saving results and generating xml files are correct or not.	True
Whether reading questions from folders and generating questions and pictures on the screen are correct or not.	True

Part8: speech to text

Click the recording button to start record, and the recording prompt will come out.	True
Click the stop recording button and check generated sound file is correct or not	True
Whether automatically calling the speech-to-text API is correct or not.	True
Whether typing the outcoming texts into the text box is correct or not.	True

Third prototype:

System test time: 2020/3/26

Part1： main menu:

Clicking start testing button, whether it will jump to agreement dialog or not.	True
In the agreement dialog, click yes button, check whether it will jump to profile selection interface or not. Click no button and check whether it will jump back to main menu or not.	True
Clicking view profile button, whether it will jump to profile viewing interface or not.	True
Clicking exit button, whether the program will exit or not	True

Part2： profile selection:

Read profiles from XML files and display name, gender and age on the interface.	True
Select button appears when select one specific profile	True
Clicking select profile button, whether it will pop out dialog about entering age and month or not. Entering two numbers and accepted as age and month respectively.	True
Click back button, the program will	True

return to main menu	
Click the create button to enter the new interface to allow the user to enter two numbers as age and number.	True
Clicking select profile button, program will enter result view interface.	True
Click the delete button, program will enter to delete mode and users can delete the selected profiles.	True

Part3: new profile:

In creating new profile interface, whether the generated profile is correct or not when clicking the save button.	True
Use the radio button to select the gender	True
Use text field to input the name of children	True
Click save button to save profiles into the xml files	True
After clicking the save button, whether it will jump back to profile selection interface	True

Part4: test menu:

Display the selected profiles correctly	True
Click change profile button ， program will return to the selection interface, users can reselect profiles.	True
Click on the syntax test button, program will pop out a dialog box for selecting different stages.	True
Can choose the stage, click ok button, enter the grammar test interface.	True
Click pronunciation test button, program will enter the pronunciation test interface.	True
Click back button, the program will return to main menu	True

Part5: grammar test

Whether the correct grammatical structures about clauses, phrases and words are displayed or not.	True
Whether the wrong grammatical structures which the child does not say are displayed or not.	True
Whether the generated grammatical structure in the clause level for the user to see is correct or not.	True
Whether clicking analysis button to invoke the natural language processing tool is correct or not.	True
Click the next item button to save the current result, then clear the interface. Whether reading the new question and displaying new picture are correct or not.	True
If the list of questions is already empty, then it will jump to the summary interface. Whether recording the test time of the system is correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether records of each structure can be displayed correctly or not.	True
Whether responding to a review of the project title according to the mouse click is correct or not.	True
When clicking discard button, whether the records are discarded or not.	True
When clicking save button, the dialog box will pop up to confirm the save operation and generating XML files are correct.	True
Whether reading questions from folders and generating questions and pictures on the screen are correct or not.	True
The software determines which structures to test based on the child's age.	True
User can choose the item in the combo	True

box related to the quick selection.	
Users can view the test questions and responses from the corresponding children	True

Part6: pronunciation test

Whether the translation pinyin is correct or not and whether it will be automatically displayed.	True
Whether the analysis result is correct or not and whether it will be automatically displayed.	True
Whether the method to determine the error mode and returning to the error mode are correct or not.	True
Whether click the next item button to save the current results is correct or not.	True
Clear the interface. Whether reading new questions and displaying pictures of new questions are correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether the consonant inventory for the age group read from the XML files is correct or not.	True
Whether the sounds recorded in the results compared with the consonant inventory are correct or not.	True
Different types of sounds are classified into six categories, and then marked with presence and absence. Whether the procedure is correct or not.	True
When clicking discard button, whether the records are discarded or not.	True
When clicking save button, the dialog box will pop up to confirm the save operation and generating XML files are correct.	True
Whether reading questions from folders and generating questions and pictures on the screen are correct or	True

not.	
Whether the colors display for detected errors and undetected error modes are correct or not.	True

Part7: test menu:

Whether the translation pinyin is correct or not and whether it will be automatically displayed.	True
Click the analysis button, whether calling the method to calculate the correct rate and returning the correct sound are correct or not.	True
Whether the method to determine the error mode and returning to the error mode are correct or not.	True
Whether click the next item button to save the current results is correct or not.	True
Clear the interface. Whether reading new questions and displaying pictures of new questions are correct or not.	True
In the summary interface, whether testing for age, time and calculating the average score are correct or not.	True
Whether the records that the table shows are correct or not.	True
The items in the combo box at the top of the interface are displayed correctly or not	True
Whether the consonant inventory for the age group read from the XML files is correct or not.	True
Whether the sounds recorded in the results compared with the consonant inventory are correct or not.	True
Different types of sounds are classified into six categories, and then marked with presence and absence. Whether the procedure is correct or not.	True
When clicking discard button, whether the records are discarded or not.	True
Whether saving results and generating	True

xml files are correct or not.	
Whether reading questions from folders and generating questions and pictures on the screen are correct or not.	True

Part8: speech to text

Click the recording button to start record, and the recording prompt will come out.	True
Click the stop recording button and check generated sound file is correct or not	True
Whether automatically calling the speech-to-text API is correct or not.	True
Whether typing the outcoming texts into the text box is correct or not.	True

1.4 Input test

First prototype:

1.Age input

Input	Program response	Whether the response is expected or not
0;0	Accept	Yes
9;11	Accept	Yes
11	Error	No
1234;10	Accept	No
我；我	Error	No
12；弥	Error	No
	Error	No

2.Name input

Input	Program response	Whether the response is expected or not
猫猫	Accept	Yes
猫猫猫猫猫猫猫猫猫猫	Accept	No
1234	Accept	No
王猫猫	Accept	Yes
欧阳猫猫	Accept	Yes
猫　猫	Accept	No
@@@@@	Accept	No

Abcd	Accept	No

3. Transcribe and parse the text input in the phonology test and grammar test.

Input	Program response	Whether the response is expected or not
猫猫	Accept	Yes
1234567	Error	No
@@@@	Error	No
猫猫!!猫	Error	No
我在　　山坡	Accept	Yes
	Error	No

Second prototype:

1.Age input

Input 1	Input 2	Program response	Whether the response is expected or not
0	0	Accept	Yes
9	11	Accept	Yes
11	12	Error	Yes
1234	1234	Error	Yes
我	我	Error	Yes
1	我	Error	Yes

2.Name input

Input	Program response	Whether the response is expected or not
猫猫	Accept	Yes
猫猫猫猫猫猫猫猫猫猫	Accept	No
1234	Accept	No
王猫猫	Accept	Yes
欧阳猫猫	Accept	Yes
猫　猫	Accept	No
@@@@@	Accept	No
王_猫	Accept	No
Abcd	Accept	No

3. Transcribe and parse the text input in the phonology test and grammar test.

My input	Program response	Whether the response is expected or not
猫猫	Accept	Yes

1234567	Error	No
@@@@	Error	No
猫猫!!猫	Error	No
我在　　山坡	Accept	Yes
	Error	No

Third prototype:

1. Age input

Input 1	Input 2	Program response	Whether the response is expected or not
0	0	Accept	Yes
9	11	Accept	Yes
11	12	Error	Yes
1234	1234	Error	Yes
我	我	Error	Yes
1	我	Error	Yes

2. Name input

My input	Program response	Whether the response is expected or not
猫猫	Accept	Yes
猫猫猫猫猫猫猫猫猫猫	Accept	No
1234	Error	Yes
王猫猫	Accept	Yes
欧阳猫猫	Accept	Yes
猫　猫	Error	Yes
@@@@@	Error	Yes
王_猫	Error	Yes
Abcd	Error	Yes

3. Transcribe and parse the text input in the phonology test and grammar test.

My input	Program response	Whether the response is expected or not
猫猫	Accept	Yes
1234567	Error	No
@@@@	Error	No
猫猫!!猫	Error	No
我在　　山坡	Accept	Yes
	Accept	Yes

Appendix F

Feedbacks and Changes

Feedbacks on the First Prototype

a. The software should give the score automatically in the grammar test.

b. The 'Analyze' button should be an optional operation. The user can click 'Next' directly if he/she don't want to view the analysis result.

c. If the accuracy of speech-to-pinyin cannot be assured, then the user should be trained to recognize the child's response.

Changes on the Second Prototype

a. Changed the way of inputting the age. Instead of entering the age in the form of a single string 'X;Y' (where X and Y are the year and month respectively, seperated by a semi-colon), the user can only type two integers representing the year and month in the second prototype. If the user enters any invalid character, the software will prompt the user that the age is invalid.

b. Clicking 'Analyze' button is no longer a required step in the grammar test. Now, the

user can click ‘Next’ and move to the next question directly without clicking ‘Analyze’. In this case, the software will analyze the response automatically when ‘Next’.

c. Removed the ‘Analyze’ button in the phonology test. The software will analyze the response automatically when there is a change in the inputted response.

d. Added the phrase level grammatical structure analysis for the grammar test. Added the phrase level result display in the grammar test and grammar result summary. The user can use a toggle button to switch the display of clause and phrase level results.

e. Added the question image display and slider for marking in the grammar result summary. The user is able to modify the score of each tested grammatical structure in the summary.

f. Fixed the bug that the profile cannot be set up properly in the new profile page.

Feedbacks on the Second Prototype

a. A question in the grammar test should target multiple structures. It should be designed as the sample question given by Jin.

b. Target structures in each question should fit the child’s age. For example, in Figure 1, for a child aged younger than 2, the software should examine the grammatical structures that belongs to stageII only (‘SV’, ‘aux’ and ‘pronp’ in this case). For a child older than 2, all grammatical structures should be examined.

c. In the case of the NLP tool cannot parse the utterance correctly, the user can instead choose an utterance that is the most similar to what the child said from a combobox containing some possible answers.

Changes on the Third Prototype

a. Changed the segmentation model for the dependency grammar analysis and semantic distance calculation. The system is using Structured Perceptron (SP) model instead of Hidden Markov Model (HMM) now. By using the SP model, the system can achieve higher grammatical analysis accuracy compared to HMM.

b. Modified the structure of grammar test questions. The test question can include multiple target structures now. The target structures in each question changes according to the test age.

c. Added the word level analysis and result display for the grammar test.

d. Removed the toggle button for switching different levels of grammar analysis displays. All analysis results from one response are displayed together as the sample answer given by the stakeholders.

e. Added a quick select combo box in the grammar test. The sample answer that the user selects is regarded as the child's response and saved.

f. Added result display grouped by test questions in the grammar result summary. Re-aligned the position of UI components in the summary page.

g. Fixed the bug that the profiles cannot be deleted properly.

h. Fixed the bug that in the grammar result summary, if the user first selects a marked structure, then selects a unmarked structure, the unmarked structure will be marked automatically.

i. Fixed the bug that the empty string cannot be analyzed properly in the grammar test.

Appendix G

Meeting Minutes

Meeting Record

Fletcher

Tuesday, 2019-10-15

Abstract

This meeting covered subjects on weekly report, meeting time, team management tools and next week's work.

Attendance

Present: Yu Tianyi, Zhu Jiaye, Feng Kangming, Geng Huili, Wang Yu, Dave Towey
Absent: Lu Jing

Minutes

1. Weekly report

A report of past week's work should be submmited to Dave via Moodle forum every **Monday 4pm**. A weekly report should contain:

> Work report of this week.
> Issue(s) encountered in whis week.
> Work plan of the next week.
> Evaluation of work in this week.

2. Weekly Meetings

Tuesday, 18:10-18:40, PMB419
If neccesary: Wednesday, 8:10-8:40, PMB419

3. Team Management

The team needs a team management tool for easier work allocation, resourse sharing, schedule upkeep, etc.

4. Next Week's Work

4.1 Requirement engineering revision
4.2 Learn interviewing
4.3 Project background: 100 words background information on current situation in China about this project, included in next week's report.

Meeting Record

Fletcher

Tuesday, 2019-10-22

Abstract

This meeting covered subjects on interviews, references and work related topics.

Attendance

Present: Yu Tianyi, Lu Jing, Zhu Jiaye, Feng Kangming, Geng Huili, Wang Yu, Dave Towey
Late: Yu Tianyi

Minutes

1 Interviews

1.1 Preparation

Prove the team is ready to do interview tomorrow (Wednesday, 10-23) 6pm. Otherwise it will be put in next week.

1.2 Questions

Find out what information we want from the stakeholder. Use the skill of elicitation: It's sometimes hard to get an answer directly, interviewer can ask something around the topic. The questions should be divided into different levels, starting with easy questions, then move on into topics.

1.3 Interview process

Before the interview, the team needs to obtain ethics permission. The interviewers should introduce themselves and the project, inform participant of why/where the information will be used. The team also needs to get approval from participant on note taking/using information from the interview, and acquire his/her signature on consent form.
During questioning, if the participant is uncomfortable with any part of interview, the interview should end immediately and have all records deleted.

Meeting Record

Francis

Tuesday, 2019-10-29

Abstract

This meeting referred to what we have done last week and talked about some problems that we are going to do.

Attendance

Present: Yu Tianyi, Lu Jing, Zhu Jiaye, Feng Kangming, Geng Huili, Wang Yu, Dave Towey

Minutes

1 Summamarize for last week

1. Summarize summary.
2. Ethnic list.
3. Update the website.

2 Dave's instructions

2.1 Stakeholder

Dave will introduce a stakeholder this week and go interview next week. We need to do the relevant preparations.

2.2 Work time

20 hours a week, 9 is the minimum, do more job at this time.

2.3 Stakeholder information

This stakeholder is nonlogical, not a decision maker, not so powerful but helpful.

2.4 Software requirement

Write reference in LaTeX and record the content of meeting using LaTex.

Meeting Record

Francis

Tuesday, 2019-11-05

Abstract

This meeting mainly talked about the content of interview we did last week and relevant indtructions Dave gaved for us.

Attendance

Present: Yu Tianyi, Lu Jing, Zhu Jiaye, Feng Kangming, Geng Huili, Wang Yu, Dave Towey

Minutes

1 Summamarize for last week

1. article summary.
2. the result of interview.
3. SS form, DREAM-C and prototype.

2 Dave's instructions

2.1 Software Plan and UML

Plan the software and start to write the UML.

2.2 Meeting Time

Will make a meeting in the restaurant.

2.3 Project Resource

Keep reading more papers related to our project.

2.4 Template

Generate a template by summarizing relevant reports.

Meeting Record

Francis

Tuesday, 2019-11-12

Abstract

This meeting mainly talked about the interview.

Attendance

Present: Yu Tianyi, Lu Jing, Zhu Jiaye, Feng Kangming, Geng Huili, Wang Yu, Dave Towey

Minutes

In a summary, this meeting mainly referred to the interview and talk about something related with our lives.

Meeting Record

Francis

Tuesday, 2019-11-20

Abstract

This meeting mainly talked about the interview and interim report.

Attendance

Present: Yu Tianyi, Lu Jing, Zhu Jiaye, Feng Kangming, Geng Huili, Wang Yu, Dave Towey
Late: Wang Yu

Minutes

1 Summarize for last week

Interview and the part of interim report.

2 Dave's instructions

2.1 Meeting Time

Maybe only 2 meeting2 left on November 26th and December 26th. The meeting on December 17th is uncertain. Then the next meeting will be in January,2020.

2.2 Report word count

Appendix not in the word count.

2.3 Prototype

Make a lo-fi prototype before Feb.

2.4 Report and feedback

Before next week's meeting, see report draft and give the feedback.

Meeting Record

Francis

Tuesday, 2019-11-26

Abstract

This meeting mainly talked about interim report.

Attendance

Present: Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Geng Huili, Wang Yu, Dave Towey

Minutes

1 Summarize for last week

Write the interim report.

2 Dave's instructions

2.1 Meeting Time

Next meeting time: next Monday 3pm. Maybe have a meeting on the 17th December, it's up to the group.

2.2 UML diagram

Revise usecase diagram and activity diagram.

2.3 Application design

1.The database.
2.The network problem about how to connect the WIFI.
3.The profile of the user.

2.4 Application platform

Need to clarify whether this application is a desktop application or a mobile application and where it is used in (Windows/Macos/ios/Android).

Meeting Record

Francis

Tuesday, 2019-12-02

Abstract

This meeting mainly talked about coding plan and some tools our team maybe use.

Attendance

Present: Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Geng Huili, Wang Yu, Dave Towey

Minutes

1 Summarize for last week

1. Write the interim report.
2. Revise UI design.

2 Dave's Instructions

2.1 Coding Plan

Assign tasks which contains writing codes and test codes to every teammate.

2.2 Stanford CoreNLP

Go to study Stanford CoreNLP this week.

2.3 Web Reference

Modify the web references.

2.4 Interim Report

For the report, if we update it before Wednesday, Dave will check it, or Dave will give feedback to the current version.

Meeting Record

Francis

Tuesday, 2020-3-10

Abstract

This meeting mainly talked about the software and the problems encountered in designing software.

Attendance

Present: Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Wang Yu, Dave Towey
Absent: Geng Huili

Minutes

1 Summarize for last week

1. Get feedbacks on the first prototype.
2. Make changes on the second prototype based on the stakeholder's idea.

2 MEETING CONTENT

2.1 Age Input

1.The user only need input his/her name and age including year and month. It don't require ID card.

2.2 Scoring Set

1."Analyze" button is now an optional operation.
2.Removed the entry for the user to score the response in the grammar test.
3.Software can give marks automatically after user completes the test.

2.3 Issues

1.Speech recognition API might correct it to the string with correct pinyin when the software records a piece of voice with wrong pronunciation.
2.How to improve software performance.

Meeting Record

Francis

Tuesday, 2020-3-17

Abstract

This meeting mainly talked about some small problems.

Attendance

Present: Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Dave Towey
Absent: Geng Huili, Wang Yu

Minutes

1 Summarize for last week

1. Get feedbacks on the second prototype.
2. Third prototype development.

2 MEETING CONTENT

2.1 Explanation for Special Identifier

1. SV
2. aux
3. pron(pronoun).

2.2 Speech API

1. Try to use other language API to translate the speech.

2.3 Time plan

1. 3.23 - 3.30: Finish the third prototype (the last prototype before the final report) by the end of March and show it to the stakeholders.
2. 3.16 - 4.7: Final report.
3. 3.30 - 4.22: Developing the fouth prototype according to the feedback of the third prototype.

Meeting Record

Francis

Tuesday, 2020-3-24

Abstract

This meeting mainly talked about some small problems about the teammate and progress.

Attendance

Present: Dave Towey, Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Geng Huili
Absent: Wang Yu

Minutes

1 Summarize for last week

1. The main modifications of the third prototype are almost complete.
2. Modify pronunciation and grammar test based on the suggestions of Prof. Jin.

2 MEETING CONTENT

2.1 Team Cooperation Issues

1. Ask the reason why Geng Huili did not complete his task last week.
2. Please take part in meeting on time.

2.2 Speech API

1. The result using other language API to translate the speech did not turn out very well.

2.3 Time plan Next Week

1. Finish the third prototype.
2. Write the final report.

Meeting Record

Francis

Tuesday, 2020-3-31

Abstract

This meeting mainly talked about final report and website.

Attendance

Present: Dave Towey, Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Geng Huili, Wang Yu

Minutes

1 Summarize for last week

1. Finished the final report draft.
2. Demonstrated the third prototype to the stakeholder and waited for the reply.

2 MEETING CONTENT

2.1 Website Issues

1. After getting the website to the server, it didn't work. Kangming is solving it.

2.2 Project Timeline

1. Final Group Report & Software: Thursday, April 23
2. Presentation Day: Wednesday, April 29. (10 minute presentation recording)
3. Open Day is cancelled.
4. Final individual Report: Monday, May 11

2.3 Presentation Video

1. Whether you need show your faces depends on you.
2. Choose a better way to record video. For example, show your faces at some point, but the most important point.

Meeting Record

Francis

Tuesday, 2020-4-7

Abstract

This meeting mainly talked about the presentation and other small problems.

Attendance

Present: Dave Towey, Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Geng Huili, Wang Yu

Minutes

1 Summarize for last week

1. Make presentation plan.
2. Work on the website and reports.

2 MEETING CONTENT

2.1 Presentation

2.1.1 Overview

a. Introduction(2-3 min): The project title, background, technology used.
b. Design and Implementation (5-6 min).
c. Conclusion(2-min): Evaluation of the project in the technical perspective.

2.1.2 Requirements/ Advice

a. Must be constrained to 10 minutes.
b. Can do some edits to the presentation video. For example, you can make an animated movie and use some artistic styles. As well, you need cover all the important things and show your faces at some points in the video.
c. At the beginning of the video, give some introductions. For example, for the team

Meeting Record

Francis

Tuesday, 2020-4-14

Abstract

This meeting mainly talked about the submission of software.

Attendance

Present: Dave Towey, Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Geng Huili
Absent: Wang Yu

Minutes

1 Summarize for last week

1. Wrote some of the appendixes for the final report.
2. Fixed several bugs in the software.

2 MEETING CONTENT

2.1 Presentation

1. Prepare the ppt for presentation.

2.2 Website

1. Keep on working.

2.3 Final Report

1. It is already completed.

Meeting Record

Francis

Tuesday, 2020-4-21

Abstract

This meeting mainly talked about the presentation video and final report.

Attendance

Present: Dave Towey, Yu Tianyi, Zhu Jiaye, Lu Jing, Feng Kangming, Geng Huili, Wang Yu

Minutes

1 Summarize for Last Week

1. Finished the final report.
2. Commented the code and wrote readme for submission.

2 MEETING CONTENT

2.1 Presentation Script

1. Team members are writing it.
2. Expected to be completed in the last two days.

2.2 Final Report

1. Reference: The capital letters and lowercase letters are incorrect.
2. The meaning of mandarin at the end is ambiguous in the reference 38.
3. For the unpublished paper, need to ask the author's idea.
4. For the reference which has more than three authors, it should use "et al".