Implementation of voice recognize technique to simulate mouse clicks with a low cost joystick device for severely disabled people

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M.Sc. Practicum Report

Department of Computer Science

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Implementation of voice recognize technique to simulate mouse clicks with a low cost joystick device for severely disabled people

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An M.Sc. practicum report submitted in partial fulfillment

of the requirements for the degree of

Master of Science

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Acceptance of M.Sc. Practicum Report

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Department of Computer Science

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We hereby recommend that the M.Sc. Practicum Report submitted by CHEUNG Saiho entitled "Implementation of voice recognize technique to simulate mouse clicks with a low cost joystick device for severely disabled people" be accepted in partial fulfillment of the requirements for the degree of Master of Science in Advanced Information Systems.

_____   _____

Dr. Byron Choi   Dr.
Supervisor   Observer

Date: _____   Date: _____

Declaration

I hereby declare that this M.Sc. Practicum Report represents my own work which has been done after registration for the degree of M.Sc. at the Hong Kong Baptist University, and has not been previosuly included in a project report, thesis or dissertation submitted to this or other institution for a degree, diploma or other qualification.

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CHEUNG Saiho

Date: _____

Category

Title of Project

Implementation of voice recognize technique to simulate mouse clicks with a low cost joystick device for severely disabled people

Background

In the beginning of 21th century, assistive technology is very popular in western countries. Many IT companies have developed different kinds of computer software and input devices for people with disabilities, with the purpose to ensure that they can access to information technology and get connected to the world for communications, learning, work and social participation (Buyer et al, 2015)(Hirsh et al, 2010)(Cantin, N., 2012)(Myrden et al, 2014)

Although these kinds of software and input devices can be purchased and searched the details of information on the Internet very easily. It is only suitable for generic cases, instead of individual cases. However, people with disabilities have their individual and unique which is according to the symptom(s) of disability for each case. It is impossible to fulfill special needs in the single solution. Unfortunately, most of assistive software is packaged software, all system functions should be fixed by the software company (Hollander 2000). As this kind of software does not separate to the part of system function in the market selling, it does not completely meet the disability needs for each case. Therefore, the packaged software is not suitable in this situation. On the other hand, there is a lack of open source software and other software developers who are especially developed projects to address issues and difficulties related to computer access for people with disabilities, e.g. in Hong Kong IT industry. There have no the local developers or research teams who have interested in developing the assistive software and cooperated with other experts overseas to publish their work on the Internet for a long term (Anon n.d.). Therefore, it is also very difficult to modify the existing functions in the software what they are found appropriate to meet some of the special needs of certain disability condition. On the other hand, the input devices have the system capability problems much more than software, such as operating system support, hardware driver capability and limitation supplier to sell in Hong Kong. In addition, some of the input devices designed to meet the physical needs for people with disability in computer access are either costly as they are imported from overseas or no longer available in the local market because manufacturers cease to produce such product.

Occupational therapists play a significant role to identify challenges and problems people with disability may encounter in use of computer, and to help enhance a barrier-free access by addressing individual needs through professional assessments and application of assistive technology, with an ultimate goal to propose a practical and applicable solution to the improvement of computer input method for people with disability, in particular peoples with special learning needs. In Hong Kong, assistive technology for disability is not mainstream IT development direction and such commercial market is comparatively small that there

is a lack of business interest and research funding to support these projects.

The aim of project

This project builds a software for Cerebral palsy people, which serve as a concrete example of severely disabled people. Most of the Cerebral Palsy peoples have very poor hand function and speech disorder, they can only use the computer to keep contact with other people or their family via social network platform (Pousada et al, 2014). In Hong Kong, the newspapers have reported some real stories about CP patients when they have shared about their studies experience and face up the huge challenges of physical disability in their daily life [1][2][3]. According to these cases, these patients usually have difficulty in hitting the keys of keyboard accurately and controlling the mouse precisely to move the cursors. Although a variety of assistive devices have provided in the commercial market, it can be easy to find and purchase by the people with disability when they are not yet suitable to use in the normal input devices. These assistive devices have focused on increasing the input efficiency for them which is including the alternated mouse and keyboarding devices, such as trackball, special joystick, scanning devices and motion detectors (Pallejà, T. et al., 2013)(Narvekar, S., 2013)(Molina, A., 2016).

According to the symptom of Cerebral Palsy peoples, their hand poor control ability and movement cannot use these existing devices directly. Therefore, therapists need to evaluate these devices which one is the most suitable or need to modify them for every people appropriately. For example, the eye-gaze input device cannot suitable in this case, because their head movement is very unstable and the eye-balls cannot focus on webcam for a long time (Trewin &Pain 1999). Some joystick button size is too small, it should be enlarged the button size for the people pressing it more easily (Shibata et al, 2015)(Gushiken et al, 2014). As a result, the Occupational Therapy Department of The Hong Kong Red-cross John F. Kennedy Centre (JFK) and the School of Medical and Health Sciences of Tung Wah College (TWC) have been collaborating to design a new joystick mouse for improvement of cursor movement control for peoples with Cerebral Palsy.

For these reasons, this project is proposing a computer system using voice recognize technique to simulate mouse clicking behavior for these peoples, the system has collected their pronunciations of English character at most the five characters which are recognized by the speech engine system via the server. The system has rearranged these characters of permutations which is according to the percentage of recognition success from the highest to lowest, then the patients can use the function of system command mapping which is matching the command to voice characters. Thus, they can only say the specific character to execute the system command on this system. Such information can be stored in the database system, including the voice symbols, commands and the speed value of cursor movement of joystick mouse device. Thus, the peoples can avoid to do the repeating task frequently and speed up their efficiency for using the computer (Rao, et al, 2000)(Oskoui, M. et al, 2013).

The description of project

In this project, it is especially targeted for Cerebral Palsy peoples, because the normal mouse and keyboard input method are not suitable for them when they cannot control their limbs very well due to brain damage during born or childhood (Copley et al, 2010).

In this case, the therapists establish a research team and investigate disabled master people, who have the computer science background, in the postgraduate school. Thus, the team can know more about the experience of disabled peoples' needs and face what problems in their school lives. This information is crucial in the project development. The author is suffering from Athetoid Cerebral Palsy and study the master degree in computer science. The author has done some IT projects in related to the topic of assistive technology for the past few years and fully understand peoples with Cerebral Palsy and what problems they face in their lives. Encountering these problems, the author has proposed a new idea of IT system for improvement of their using computer efficiency (Casas, R. et al, 2013)(Henzen, A., 2016).

Design and functions

For the part of new joystick mouse design, it has only used a single button, instead of left click and right click buttons (Fig.1). As the CP patients find it very difficult to control joystick cursor and press a button simultaneously (Man et al 2007). The author has proposed a new way to tackle this problem. People can set a timer in the user interface when the software has executed their chosen/predefined tasks or input alphabet character automatically during the timer time up. This can possibly reduce the effort CP peoples spend on their tasks with their computers.

Fig. 1

Generic USB Joystick with Single button device, made by JFK Workshop

For the part of IT system design, the author has come back to JFK observing this group of peoples' special needs. The observation is that the input method is not very efficient and do the same procedure much more time for each task. Thus, the proposed system has four main functions, listed below:

- To change their traditional input method, such as an on - screen keyboard with rolling character.
- To set time to execute a specific program or web browser, and mouse left, right click, drag and drop functions.
- To voice recognize technique to simulate mouse clicking behavior and fast forward to rolling character.
- To set the cursor movement speed for joystick mouse device.

Then, the CP peoples only needed to practice how to use this joystick mouse fluently from the occupational therapists.

Operating environment and software

The system can be installed in laptops and desktop computers running Microsoft Windows operating systems, because the CP patients can use this system everywhere, which is equipped with WiFi networks.

As this system mainly focuses on this kind of peoples' needs, it must be fulfilled for their learning and communication with other people during the daily life. According to this requirement, the author has proposed some sophisticated solutions to simplify mouse clicking behavior, software facilitating on their computer and enhancement of typing the character accuracy without keyboard support.

For the part of simplifying mouse click behavior, the author has used a voice command to simulate the varying behavior of mouse click, including the left/right click, double left click, drag and drop function. The patients do not need to press the physical mouse buttons by their hand. Therefore, this system needs to install the voice input device for the patient's computer, such as Microsoft Kinect devices or internal microphone system which can capture the voice data from patients. This data should store in the central database and analyze in the speech engine system via data center, so the server systems are needed to implement Microsoft Windows Server Systems, SQL Servers, Speech Server and Microsoft Kinect SDK version 1.8 or higher. In the client side, the voice recognition program is implemented in a C# programming language and multiple Microsoft APIs support, such as Microsoft.Kinect, System.Speech, System.Speech.hypothesizer etc.

For the part of software facilitating, the author has considered for enhancement of this system startup on patient's computer without taking the extra effort from them or helpers. This system has no need any procedure of software installation step and running it for using on their computer directly. After that, the system execution path will be stored in Microsoft Windows Registry system automatically, so the system can run it for itself during the computer boot. On the other hand, the joystick program can adopt any version of Microsoft Windows system without any extra driver support, but this program is exclusively
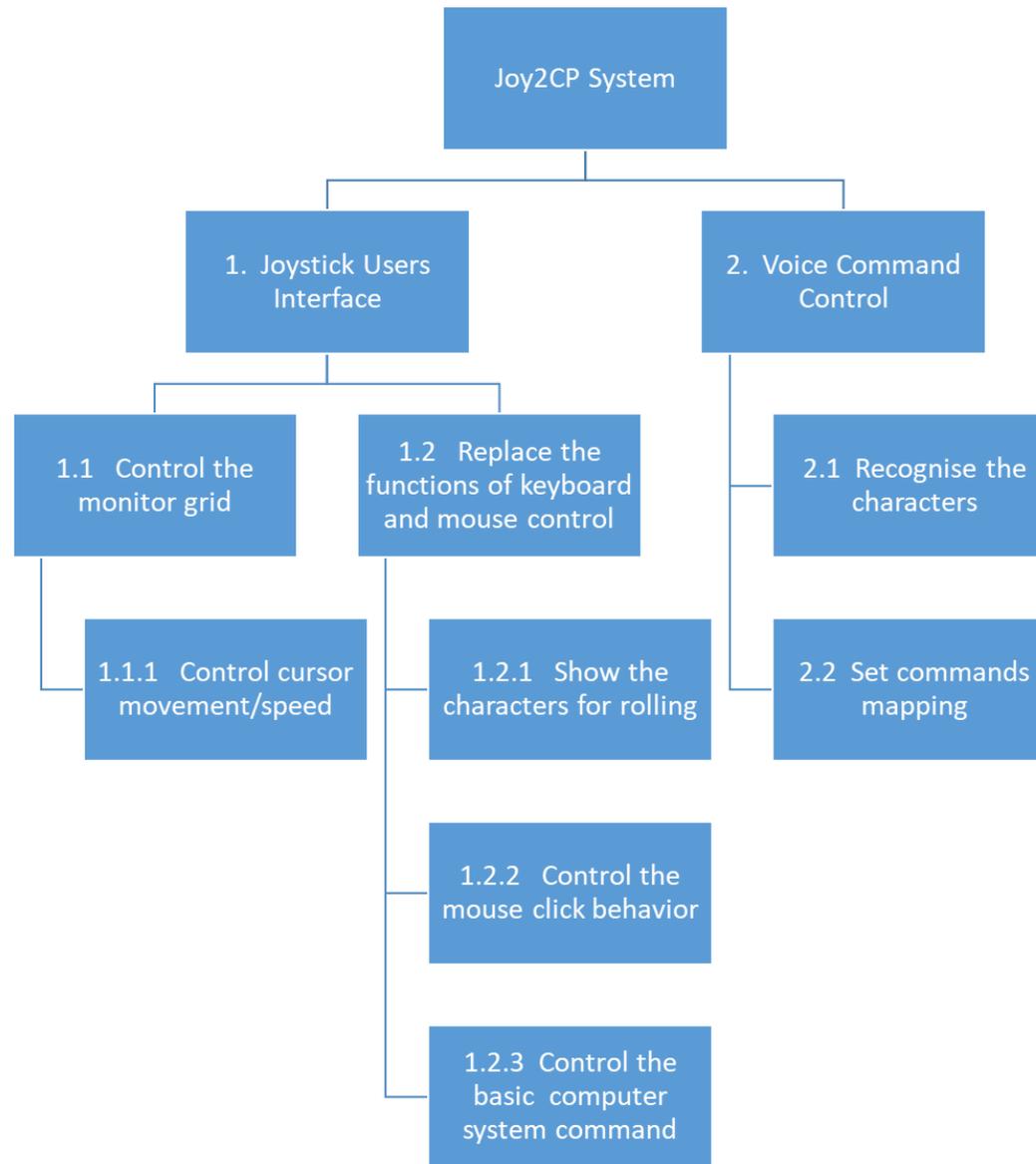
supported Windows XP or below OS versions when these kinds of windows systems have already outdated in the mainstream IT market. The benefit is no needed to purchase the specific joystick and hardware driver support from vendors, this program can adopt any generic USB Joystick device which is compatible with the PC. Thus, it is an innovation idea around the world. The joystick program is implemented in C programming for the cursor movement speed control of joystick device and GUI program in C# programming language with Microsoft APIs support, such as System.Runtime.InteropServices, System.IO etc.

For the part of typing character, the author has proposed a new idea for enhancement of typing speed and accuracy without an input keyboard by the patient's finger directly. As the system interface is separated into three types of character for rolling around when they choose, such as English character, digits and special symbols. In addition, the patients can change the rolling speed faster or slower if they need. In this typing system, it is implemented in VB.NET programming language with multiple Microsoft APIs support, such as System.Threading, System.Timer etc. It involves the system timer function, using multithreading technology to control the interval of rolling character and voice command for fast forward to roll five English characters and type the character on screen which is confirmed by patient's voice command or mouse over the button of pick character on the system interface.

Besides, the system developer is needed to use the Microsoft Visual Studio with MSDN package, because it includes a variety of development tools to support for the whole development cycle and system testing, such as integrated development environment software, windows driver API library and a variety of Windows operating systems and database management system.

In conclusion, this new system aims to improve the Cerebral Palsy peoples to interact with computers more easily and efficiently.

Functional decomposition diagram

Basic state diagram
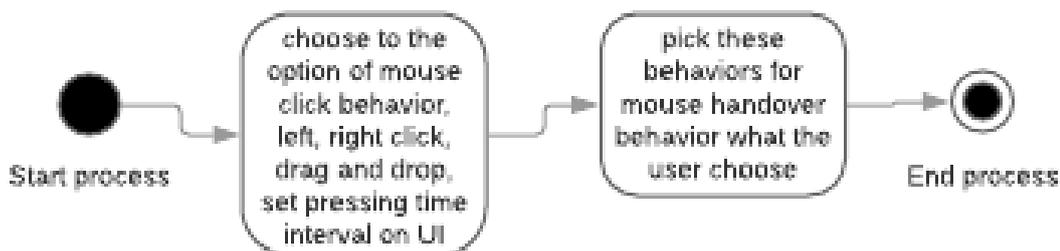
1.1   Replace joystick to the pointer device

Start process → plug in a USB Joystick device to hijack the cursor movement control → fine tune the value of cursor movement speed which is according to monitor dimension —passing the UserID and cursor movement speed value→ store in a database → assign the recordID → **End process**	

1.1.1   Control the position of Monitor Grid

Start process → press the joystick button to fast forward nine positions in monitor grid for clockwise direction —passing the cursor position currently→ control the joystick movement and speed value in four direction, up, down, left and right. → **End process**

1.2.1   Show Character for Rolling three different types of character when the user chooses, such as English character, numeric and special symbols.

Start process → choose to the option of typing English character, numeric or special symbol, set rolling time interval on UI —rolling the specific set of character→ pick the character for mouse handover behavior what the user choose → **End process**

1.2.2   Replace mouse pressing behavior

Start process → choose to the option of mouse click behavior, left, right click, drag and drop, set pressing time interval on UI → pick these behaviors for mouse handover behavior what the user choose → **End process**

1.2.3 Control the basic computer system command, for example, open notepad, Microsoft Word, File Manager, web browser, task manager and system logout, restart or shutdown
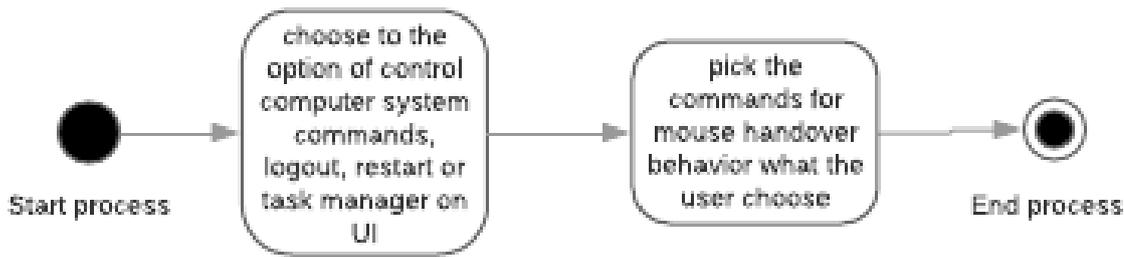
2.1 Recognize the character for voice input device

2.2 Set a few commands from the voice recognized characters

Entity Relationship Diagram

In this diagram, it has contained the five database tables in the backend system which stores some kinds of information from the joystick and a voice recognition system, such as patient information, system login information, voice command information, joystick movement speed information and patient's voice symbols information. As these systems are mainly served to the group of Cerebral Palsy patients in Hong Kong or mainland China, this information can reduce the time of doing the same task in system configuration everyday by the patients, it is only needed to do the procedure of system configuration during the first time of running on their computer. After that, this information can save in this database system and load the system configuration setting information on their computer automatically.

For the database table of 'patient', it is storing the patient's personal information, such as patient name, gender and symptom etc.

For the database table of 'patlogin', it is stored the patient's system login account information, such as username and password.

For the database table of 'joyspeed', it is storing the information of cursor movement speed value which is control of the patient's joystick device. [Refer to the section of Basic state diagram: 1.1 process]

For the database table of 'voicesymbol', it is storing the information of voice characters what the voice input device has recognized the English letter by the patients. [Refer to the section of Basic state diagram: 2.1 process]

For the database table of 'voicecomnand', it is storing the information on voice commands what the patients are matched the mouse click behavior and voice symbols in the system interface. [Refer to the section of Basic state diagram: 2.2 process]
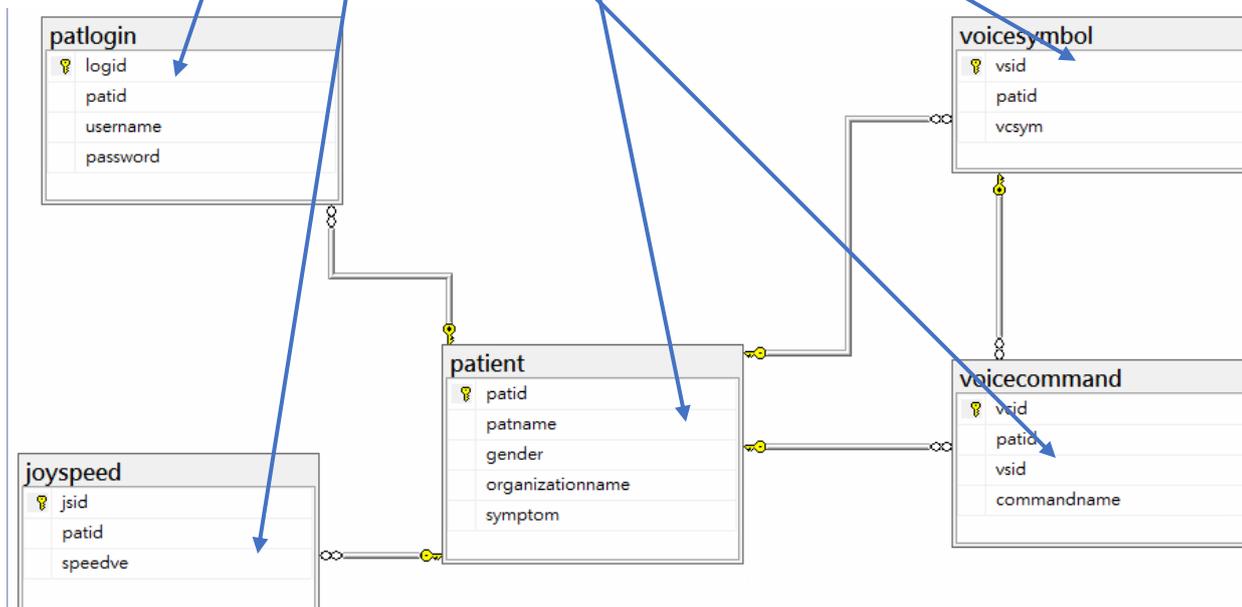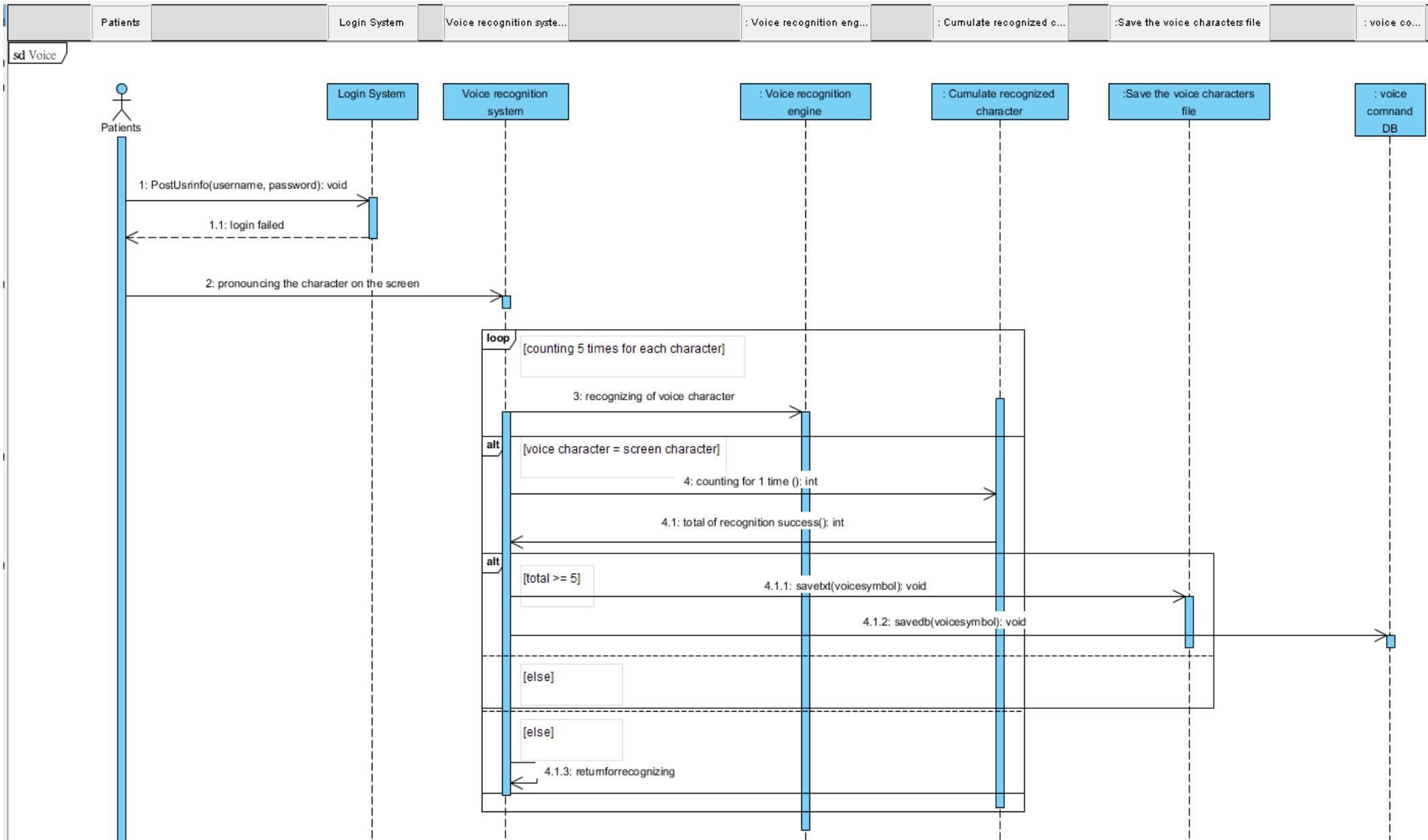
Sequence Diagram

In this diagram, it has described the program workflow in the voice recognition system. Although, some CP patients have a speech disorder problem, they cannot speak the words or complete sentences very clearly. Most of voice recognition platforms cannot understand what they said and execute the command correctly, such as google translate API and Microsoft voice input system. According to this problem, the author has proposed a new method to simplify and increase the accuracy of the voice recognition process in this system. The patients need to pronounce the twenty-six English letters when they login to the system successfully, the voice recognition system has stored the characters in the database system which is recognized successful within five times for each character. It is at most contained the five characters to represent the five different system commands in the system interface. [Refer to the section of Basic state diagram: 2.2 process]

For the first iteration, the recognition system has needed to recognize the twenty-six English letters via the voice input devices which is connected with Microsoft Speech Server, e.g. Microsoft Kinect or speaker. The patients can skip this iteration when the system is recognized at least one English letter.

For the second iteration, the recognition system is only needed to recognize the few characters which are according to those selected characters for the pervious iteration. In this case, the system can speed up the accuracy of the voice recognition rate and reduce the server processing power. After that, the system has automatically generated the priority of character in order to the percentage of recognition from highest to lowest.

For the final iteration, the patients can match the several commands and voice symbols in the system interface, these commands have included mouse left click, mouse right click, mouse double left click, mouse drag and drop function and rolling character, total five commands. As these commands is the most common using in the computer operation for daily, it can be avoided to pay extra effort when the patients press the physical button on mouse or joystick. There can save the movement time by their hand. As a result, the recognition system has collected the information of system setting and stored in the central database system, so the patients do not need to repeat doing the same setting every time.

Patients | Login System | Voice recognition syste... | : Voice recognition eng... | : Cumulate recognized c... | :Save the voice characters file | : voice co...

sd Voice

Patients | **Login System** | **Voice recognition system** | **: Voice recognition engine** | **: Cumulate recognized character** | **:Save the voice characters file** | **: voice comnand DB**

1: PostUsrinfo(username, password): void

1.1: login failed

2: pronouncing the character on the screen

loop [counting 5 times for each character]

3: recognizing of voice character

alt [voice character = screen character]

4: counting for 1 time (): int

4.1: total of recognition success(): int

alt [total >= 5]

4.1.1: savetxt(voicesymbol): void

4.1.2: savedb(voicesymbol): void

[else]

[else]

4.1.3: returnforrecognizing

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UI Design

- The part of voice recognition training and simulation the mouse clicking behavior [Refer to the section of Basic state diagram: 2.1 process and 2.2 process]

Screen capture and workflow	
	1. The patient needs to pronounce the character for 5 times on the screen 2. If the system can recognize the character what the patient said, the system will count one time in the successes field; otherwise, it will count one time in the failed field
	3. If the system has recognized the character for 5 times successful, the character should put in the candidate symbol box, it is contained almost the five symbols. 4. Patient can skip this process which is moved the cursor on the 'abort' button and the system will click to jump the next page automatically
	5. The system has generated the priority of character in order to the percentage of recognition from the highest to lowest 6. The system will jump the next page at the end of process

	7. The patient can set the five commands to match the candidate symbols which is including the mouse clicking behavior, such as mouse left click, mouse right click, double-click , drag and drop and rolling character
	8. The system will save the setting in the database automatically what the patient input, avoid do the same setting for the next time 9. The system can be minimized in the system taskbar

- The part of joystick user interface [Refer to the section of Basic state diagram: 1.1 process]

Screen capture and description of joystick mouse function
1. Change the cursor movement speed 2. The system can be minimized in the system taskbar 3. Change the function of monitor grid or rolling character 4. Press the joystick single button to jump the nine different position which is according to 'z' shape

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- The part of rolling character [Refer to the section of Basic state diagram: 1.2.1 process]

Screen capture and workflow	
	1. Open notepad in the cursor over the button 2. Open Microsoft Word application in the cursor over the button 3. Open File Manager in the cursor over the button 4. Open web browser in the cursor over the button 5. Open mouse click page in the cursor over the button, it can use mouse clicking behavior without the voice recognition function 6. Open voice recognition system in the cursor over the button 7. Open typing word page in the cursor over the button
	1. trigger space bar key in the cursor over the button 2. trigger enter key in the cursor over the button 3. trigger backspace key in the cursor over the button 4. go back to MainGUI page in the cursor over the button 5. pick the character for rolling character duration 5 seconds in default setting 6. change the rolling character for digital 7. change the rolling character for special symbols 8. change uppercase for rolling English character 9. change lowercase for rolling English character 10. change the half/full mode for rolling special symbols when type the Chinese word

1. complex key of 'ctrl-tab' switching different application
2. change the rolling character speed

JoyToTyping

press space	press enter	press backspace	回主版面

5, 4, 3   **0**   半型

pick char

digital	character	special symbol

up case	low case	滑鼠 Click

switch apps   tab次數 1

Speed up	Speed down

Speed: 5

- rolling character for digital

	- rolling character for special symbols

- The part of computer system command control for using timer [Refer to the section of Basic state diagram: 1.2.2 process and 1.2.3 process]

Screen capture and workflow	
	1. go to the MainGUI page in the cursor over the button 2. go to the task manager application 3. go to the computer system command control page in the cursor over the button

Mouse Click Control ✕ Stop 滑鼠左鍵 Mouse Double-click Mouse Right Click Typing word 界面縮少 Idle time: 0 5	4. set the timer interval for the command executing 5. execute the mouse left click which is according the cycle of timer setting 6. execute the mouse double left click during the timer setting 7. execute the mouse right click during the timer setting 8. go to the typing word page 9. go to the MainPanel page 10. stop the command executing when the user selected
MainPanel ✕ program executed during bootPC. Stop 重新開機 關閉電腦 登出系統 滑鼠左鍵 滑鼠左鍵連按兩下 滑鼠右鍵 滑鼠拖曳動作 界面縮少 ☑ Start on boot 20 Counter: 20 Mouse Draging Counter: 20 Developed by CHEUNG Sai Ho	11. execute the restart computer during the timer setting 12. execute the shutdown computer during the timer setting 13. execute the logout computer system during the timer setting 14. control the mouse drag and drop function during the timer setting 15. the system can startup on boot computer automatically

Further development

for the part of further development, the patients always need to open the applications and typing characters more faster and efficiency what they want. according to this purpose, the author has proposed three solutions to fulfill it.

firstly, the part of rolling character should be added the auto-complete function to reduce the typing time when the patients do not need to type for the whole words or complete sentences every time. this function has so many existing free program API and software plug-in to support in Microsoft Windows Systems, so it is the easiest to implement the new feature on the rolling character part.

secondly, some patient's eye vision ability is not so good, they may not able to see the small buttons and word description in the system interface, so it is more difficult for using this system smoothly for them. according to this problem, the author will need to do some graphic design in the system interface, e.g. enlarge the buttons sizes for different kinds of interface layout, use more graphic icon to replace the button of word description. besides, there should be provided some teaching movie clips in the website or social media platforms, the patients can watch easier for self-learning at home or school.

thirdly, most of cerebral palsy (CP) people have used the on-screen keyboard, mouse function software and communication board system which are increasing the communication ability and typing speed for them. Due to their speech disorder and poor hand movement, the IT Companies and universities have developed some assistive technology software, such as text-to-voice, brain computer interface system, adaptive virtual keyboard and mouse program and multiple sensor detective system for the Microsoft Kinect device. These kinds of systems have mainly focused on solving the problem of input method for the computer, but it is not collected their using computer pattern and speed up their choosing application what they want.
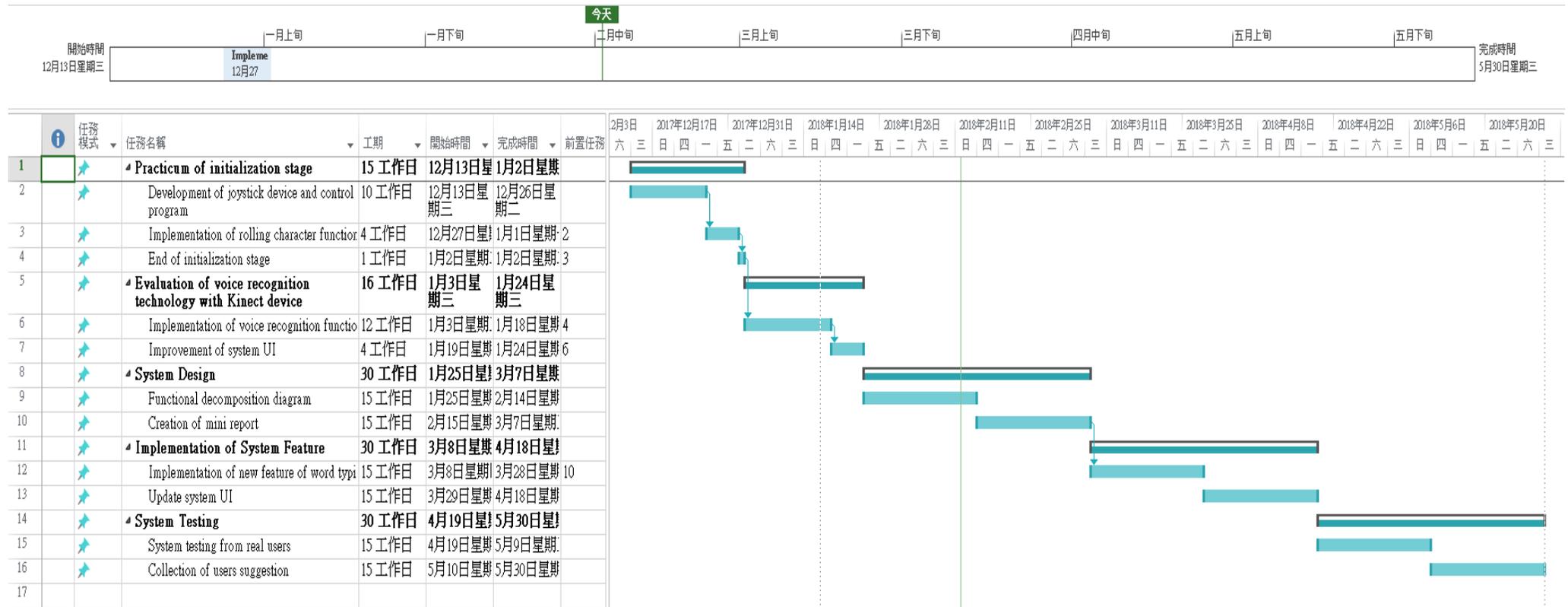
In this case, the author has proposed a solution to collect the information of user using computer behavior, it is separated in the two different methods. The first method has collected this information by the time schedule, the users can define what the application or file is executed in the specific time by themselves. The system interface has provided the time table for users when they can choose these items in the program list and assign in the time table. This information is stored in the central database system, the command system can execute the specificity of an application or file which is according to the schedule automatically. The second method has collected this information by the users the frequency of joystick mouse triggered in which is the application or file on the system interface. As the users maybe choose the wrong choices with the uncertainty movement of their hand function, the system has collected their mouse movement location what they always (or most frequently) execute programs for a specified time. Such information can be stored in the database system for a schedule of time and the system can predict what the user intends to command certain functions to increase the efficiency, it can automate running the same task in their computer which is according for the schedule. Thus, the peoples can avoid to do the repeat task frequently and speed up their efficiency for using computer. there maybe required to use some

machine learning or artificial intelligent technique for training the data model of information collected, it is very challenges part for development in this function.

Conclusion

The main purpose of this practical project is to find a sophistical way of input characters and control the cursor movement for the CP patients, it can reduce the error of typing on the keyboard, enhance the efficiency of mouse click behavior control for themselves. The benefit is reduced the pressure on caregivers and improve the quality of life in this group of people. Besides, the new system has solved the problem of joystick driver compatibility with variety version of Microsoft Windows systems, there has no needed any procedures of installation step during executing in the computer, the patients can get easy to use this system without any helper support, so that the community can easier to understand multiple people with physical disabilities what they need, so this practical project is worth doing and meaningful.

Gantt chart

	任務模式	任務名稱	工期	開始時間	完成時間	前置任務
1	📌	◢ Practicum of initialization stage	15 工作日	12月13日星	1月2日星期	
2	📌	Development of joystick device and control program	10 工作日	12月13日星期三	12月26日星期二	
3	📌	Implementation of rolling character function	4 工作日	12月27日星期	1月1日星期	2
4	📌	End of initialization stage	1 工作日	1月2日星期	1月2日星期	3
5	📌	◢ Evaluation of voice recognition technology with Kinect device	16 工作日	1月3日星期三	1月24日星期三	
6	📌	Implementation of voice recognition function	12 工作日	1月3日星期	1月18日星期	4
7	📌	Improvement of system UI	4 工作日	1月19日星期	1月24日星期	6
8	📌	◢ System Design	30 工作日	1月25日星期	3月7日星期	
9	📌	Functional decomposition diagram	15 工作日	1月25日星期	2月14日星期	
10	📌	Creation of mini report	15 工作日	2月15日星期	3月7日星期	
11	📌	◢ Implementation of System Feature	30 工作日	3月8日星期	4月18日星期	
12	📌	Implementation of new feature of word typing	15 工作日	3月8日星期	3月28日星期	10
13	📌	Update system UI	15 工作日	3月29日星期	4月18日星期	
14	📌	◢ System Testing	30 工作日	4月19日星期	5月30日星期	
15	📌	System testing from real users	15 工作日	4月19日星期	5月9日星期	
16	📌	Collection of users suggestion	15 工作日	5月10日星期	5月30日星期	
17						

開始時間 12月13日星期三

完成時間 5月30日星期三

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