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A Sign Language Learning Application for Children with Hearing Difficulties

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ABSTRACT [1]

The purpose of this paper is to develop a mobile application to support both sign language and literacy skills among children with hearing difficulties as part of rehabilitation engineering and to implement its basic functionality. This study will make it possible to support children with hearing difficulties in learning written language in combination with sign language, thereby emphasizing the importance of the latter, and in learning and communicating with their parents who use spoken language. This application has the following functions: (1) to register sign language clips acquired from a mobile device's camera by attaching tags to them, (2) to save multiple sign language clips using sets and tags, and (3) to reproduce and play back sequences of the saved sign language clips. Because of a preliminary evaluation experiment, the application was highly evaluated by the collaborators, and most of the negative comments were attributed to the small amount of registered data and its inability to support use in complex situations. Based on this, we consider that the basic concept of this application has been successfully realized.

Keywords: Sign Language Learning, Speech Recognition and Mobile Applications.

1. INTRODUCTION

Hearing impairment is commonly referred to as a "communication disability." There is no doubt that hearing impairments such as deafness and hearing difficulties present a distinct disadvantage for accessing and transmitting information. In particular, for deaf and hearing-impaired children who will acquire language skills in the future, provision of continuous intervention support right from the early stages and over a long period of time is essential.

Language skills can only be supported through such intervention techniques. For this reason, the medical and rehabilitation fields have been aiming to develop technologies to support language acquisition. This paper aims to utilize technology from such a standpoint.

As background in Japanese society, the "Act on Promotion, Acquisition, Use, and Communication of Information by Persons with Disabilities" (Act on Promotion of In-formation Accessibility and Communication Policies for Persons with Disabilities) is to be enacted this year (that is, 2022). The supplementary resolution states, "In the light of the fact that all 47 prefectures and all 141 municipalities have submitted written opinions to the government requesting the enactment of the Act, further consideration should be given to the further enhancement of measures related to sign language, including legislation of a Sign Language Act" [1]. Thus, in recent years, the need to support the existence of sign language as a language and the communication conducted through it has become increasingly important.

The "Japanese Sign Language Bill" drafted by the Japanese Federation of the Deaf emphasizes the importance of education through sign language [2]. However, even to-day, there are still many cases of deaf people and some hearing-impaired people not receiving sufficient support for learning sign language or facing difficulties in learning it.

The current authors' research aims to support children's learning of written characters and communication and learning with parents that use spoken language—especially, for children with hearing difficulties—as well as the importance of sign language education in combination with it. In particular, this paper proposes and tries to develop a mobile application to support the sign language and literacy skills learning of children with hearing difficulties. The authors have previously developed mobile applications for assisting children with hearing difficulties and developmental disabilities in communicating and planning for the future [3][4]. By extending these applications, this paper aims to devise a mobile application for supporting the sign language and literacy skills learning of children with hearing difficulties and to implement its basic functionality.

2. RELATED RESEARCH

One of the earliest attempts to digitize the learning of Japanese Sign Language was the sign language learning system "Mascot" [5]. Since then, several further attempts have been made, including the development of "Mimehand II" (Mimehand Two), which is an animated version of sign language.

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To cite an overseas example, El-Seoud et al. proposed a system to support communication and sign language learning for the hearing impaired [6]. This is a server-client type system with mobile devices as the client, in which users can browse words, phonemes, and numerals using photos and video. Joshi et al. developed an application to help deaf people learn the basic signs used in Indian Sign Language and communicate with hearing people [7]. The application's learning function includes signs for the alphabet, numbers, and greetings. The communication feature displays a sign language video corresponding to the text entered by the listener. These efforts certainly focused on sign language and were aimed at constructing a support system for it, and while the inclusion of video was a feature, it did not go so far as to enable it to compose sentences and support communication.

Al Ameiri et al. have developed an application for teaching and communicating in Arabic Sign Language [8]. By selecting a word from a list, users of this application can view a sign language video corresponding to that word. The application also allows users to communicate by converting text into Arabic Sign Language, chat using Arabic Sign Language, and capture their own sign language and send it to others. Emad E. Abdallah et al. have developed applications for learning sign language and communicating with deaf people [9]. Although these were developed from the perspective of emphasizing communication, the sign language display is limited to images and is not fully capable of displaying video. Considering that sign language is a spatial language that involves movement, it is difficult to evaluate whether these applications make full use of this feature.

In terms of sign language learning in Japan, Ishihara et al. proposed a "sign language word retrieval system" for sign language learning [10]. Although there have been some scattered attempts at establishing databases storing sign language words and expressions such as these, there have not been enough attempts to support communication or to express sentences and meaning through them.

3. A SIGN LANGUAGE LEARNING APPLICATION

3.1. Proposal

Sign language is composed of hand actions and non-hand actions (non-manual markers) such as facial expressions and head movements [11]. There are two main types of signs in Japan: Japanese Sign Language and Japanese Correspondence Sign Language, and a mixed type of both, which is called Hybrid Sign Language [12][13]. Japanese Sign Language is a language with its own system that differs from that of Japanese, and Japanese Correspondence Sign Language arranges signed words in Japanese word order.

In the case of sign languages that involve hand actions and facial expressions, it is considered easier to learn by viewing videos rather than reading illustrations, photographs, or written explanations. Furthermore, since there are three types of sign languages, in-stead of the application provider specifying the type, the learners themselves should decide what they want to learn. Therefore, it is necessary to allow the learners and their parents to register sign language clips in the application.

Currently, various books are available as learning materials for sign language (e.g., [11][12][14]). In many of these books, illustrations or pictures showing the words or phrases in sign language are accompanied by the corresponding words or phrases in the spoken language—in the case of Japanese Sign Language, the Japanese words or phrases. Furthermore, sign language learning contents on DVDs and video sharing sites often display words and phrases corresponding to the signs like subtitles in TV programs. Therefore, in this application, the words and phrases in the spoken language corresponding to the words and phrases in the sign language will also be indicated together. However, in order to support both sign language and literacy, the learners themselves can register the sign language clips and the words and phrases corresponding to the signs and search for them.

We have developed a mobile application to support communication primarily for children with hearing difficulties [3][4]. This application is characterized by the following features: (1) short words and phrases (we called them tags) are connected to illustrations and photos in the tablet device and stored and (2) depending on the communication setting, illustrations and photos are retrieved through speech recognition and displayed along with the tags as if they were sentences, thereby supporting communication for children with hearing difficulties. These features are considered effective for the requirements of a sign language learning-support mobile application that supports both sign language and literacy, as described above. Therefore, in this paper, we propose and implement an application that follows these features and has the following functions.

1. Function to associate tags with sign language clips acquired from mobile device cameras and register them;
2. Function to save multiple sign language clips in a row with tags and sets;
3. Function to reproduce and play back sequences of saved sign language clips

1. Function to associate tags with sign language clips acquired from mobile device cameras and register them

Sign language clips that have been captured in advance or captured by starting the device camera from this application are displayed on the device screen, and the phrases and words corresponding to the signs are assigned as tags and registered in the database of the application.

2. Function to save multiple sign language clips in a row with tags and sets

Sign language clips are retrieved through speech recognition or keyword search and displayed side by side with their tags. Then, their sequence is added to the database. If none of the sign language clips are found, the system searches for any illustrations or photographs to which the tag is attached. In this study, sign language clips and so on along with the sequence of their tags are referred to as a sequence.

3. Function to reproduce and play back saved sign language clips and tag sequences

The sequence of sign language clips and tags added to the database—that is, sequence—is reproduced, and each sign language clip is played back. When playing back the sign language clips, two methods can be used: one allows the user to specify the clip he/she wishes to play back, and the other allows the user to play back the sign language clips in synchronization with the sequence of the sign language clips—that is, each clip is played back in order.

3.2. Implementation

Sign language is composed of hand actions and non-hand actions (non-manual markers) such as facial expressions and head movements [11]. There are two main types of signs in Japan: Japanese Sign Language and Japanese Correspondence Sign Language.

3.2.1. Tagging sign language clips

To register a new sign language clip, first, either record a new sign language clip or select a clip that has already been recorded. To record a new sign language clip, start the camera application installed on the tablet device and take a video of the sign language using the application. When the user is recording a new sign language clip or selecting an existing one, the sign language clip is displayed on the screen, and the user can enter a word or short phrase that indicates the sign language content while viewing the clip (Figure 1). When those clips and tags are saved, information about the sign language clip, which is described in the next section, is added to the database, completing the registration of the sign language clip.

Figure 1. Tagging and registration of sign language clips (in Japanese)

3.2.2. Searching for sign language clips and saving and playing back sequences

This application searches for sign language clips by using speech recognition or keywords, and displays the sign language clips together with their tags (Figure 2). The application manages the sequence of sign language clips and tags by maintaining a list of sign language clip file names, types, tags, and other information about individual sign language clips (sign language clip information). The sign language clip type indicates the type of clip that is preinstalled in the application or the type of clip that was captured by the mobile device's camera application, and this application switches the method of displaying the clip in the video view according to its value. Therefore, in the future, by increasing the number of types, it will be possible to use videos from websites.

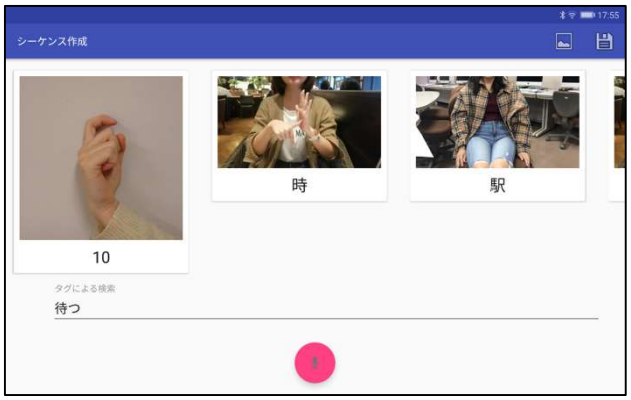

Figure 2. Achieving Sentence representation by searching and sequencing sign language clips (in Japanese)

If none of the sign language clips are found through the search, the application will search for any illustrations or photographs to which the tag is assigned. Furthermore, if there are multiple clips or illustrations/photos with the same tag, the user can select which one to add to the sequence.

When playing back a saved sequence, a list of sequences is first displayed (Figure 3), and by selecting one of them, the sequence is reproduced, and the respective sign language clip is played back as shown in Figure 4. When playing back a saved sequence, the sequence is also managed through the list detailing the sign language clip information.

There are two ways to play back a sequence of sign language clips: by tapping each sign language clip individually, or by having each sign language clip play automatically in the order of the sequence after the first sign language clip in the sequence is played.

Figure 3. List of sequences (in Japanese)

Figure 3. List of sequences (in Japanese)

Figure 4. Reproducing and playing back sequences (in Japanese)

4. PRELIMINARY EVALUATION EXPERIMENT

4.1. Experiment Overview

Using the application described in the previous chapter, an experiment was con-ducted for future development.

The experiment was conducted by lending a tablet containing this application to users for two weeks. The participants were students, who were briefed on the application in advance and confirmed with the experimenter that there were no problems with the tablet or the application. The participants conducted a "quest," in which they communicated in a specified situation by using the app in pairs and wrote the results on a specified sheet. The application was preloaded with 260 sign language clips.
Experiment participants: 13 groups of students attending the 2019 Tsuda College course "Introduction to Media Practice"
Period: November 6-20, 2019.

Quest 1: Compose and save a sequence for "What I did in school yesterday (or the day before)" by using sign language clips, fingerspelling, and clip registration. The experimenter refers to this as the "classroom display."
Quest 2: Compose and save a sequence for "What I did outside of school yesterday" by using sign language clips, fingerspelling, and clip registration. The experimenter refers to this as the "social display."
Quest 3: Register sign language clips and combine them to create a free sequence (three per person). The experimenter refers to this as "free display."

The answer sheet asked the following questions for each quest: 1. The sequence created, 2. Whether the content was considered sufficient, 3. Good and bad points, 4. Words that could not be displayed well and words or functions they wanted to include and 5. Words that were newly recorded and registered in the video. The participants were asked to rate their understanding of Item 1 on a 5-point scale: 5. Well done, 4. Mostly well done, 3. Undecided, 2. Not well done, 1. Not at all well done.

They were also asked to use a 100-point scale to rate what was good and bad about the operability, sign language comprehension promotion, usefulness of video communication, and expectations. They were also asked to report any bugs they found.

4.2. Experiment Results

4.2.1. Results of each quest

All participants in the experiment completed all quests and submitted completed evaluation sheets. The comments below summarize the main points (omitting trivial differences in textual expression and so on).

The results of Quest 1, "Classroom Display," were as follows. The sentences created in response to the quest were short sentences such as "I read a book in school yesterday." The contents were actions such as eating, studying, and dropping a smartphone.

The average rating on the 5-point scale was 3.2 for whether the contents were adequately displayed. The good points included comments such as "Almost everything was displayed," "I think that I could understand it," "The speech recognition performance was better than I expected," "When there is no corresponding word, I can quickly add it by taking a video," and "The use of video registration makes it concrete and easy to understand." As for the bad points, there were comments such as "After making a sentence, it is not possible to add it in the middle," "There is no past tense" "Speech recognition does not work well, and it is slow," and "Japanese has many verb patterns, and more data is needed."

The results of Quest 2, "Social Display," were as follows. The content included actions such as shopping, talking on the phone with a friend, and taking a picture with a camera. The sentences created in response to the quest were short sentences such as "I played volleyball yesterday."

Regarding whether the content was adequately displayed, the average rating on the 5-point scale was 3.1. As for the good points, there were similar comments to those of Quest 1 as well as "I was impressed when I found the corresponding words." The bad points included comments such as "It is difficult to use (or select) the registered words because there are so many," "I wish it would recognize verb conjugations," "Conjunctions do not work," "Words I want to use are not registered," and "I cannot distinguish which 'take' is 'take'" (meaning that it could not distinguish between homonyms).

The results of Quest 3, "Free Display," were as follows.
The sentences produced in response to the quests were short sentences that contained more complex elements than Quests 1 and 2 (for example, "I have a cat" and "I went to Korea with my friends").

Regarding whether the contents were adequately displayed, the average 5-point rating was 3.0. Good points included comments such as "It has the ability to search by text if it does not appear in the audio" and "The sequence list page is easy to read." As for the bad points, there were comments such as "I did not know how to express auxiliary verbs," "The part that can be displayed on an actual smartphone (when showing a smartphone)," "I do not know how to express the verb 'to do,'" and "There is not enough data (to express what I want to say)."

The results of the operability evaluation throughout the quest were as follows.

4.2.2. Evaluation through all quests

The evaluation of operability throughout the entire quest was as follows.

The average rating on the 100-point scale was 53.5, with a minimum score of 30 and a maximum score of 80. For the good points, most of the comments were about voice recognition and its ease of use and comprehensibility in operation, such as "Voice search is possible and easy to understand," "What is not recognized as a sentence is recognized as a word," "The design is simple," and "There are almost no complicated operations, and it is easy to create sequences and take videos." Most of the comments were about the "simplicity of the design" and "the fact that there are almost no complicated operations and it is easy to create sequences and take videos. As for the bad points, they concerned issues with input such as "I was surprised when the video played by itself," "I had to speak slowly to be heard," "It is slow," "Sometimes, it is difficult to recognize the speech, and the videos are not played clearly," "(Certain words) were not recognized no matter how many times I tried," and "Words are recognized, but sentences are not recognized through speech recognition or the keyboard (no input functionality)." Words are recognized, but sentences do not work (cannot be input) either by voice recognition or by keyboard. There were two user comments that stated, "I want to edit part of a sequence, but I have to re-enter the whole text." One person commented on the operability issues with the video, saying, "There were many sign language videos that stated, 'This video cannot be played.'"

The evaluation of the promotion of sign language understanding throughout the entire quest was as follows.

The average rating on the 100-point scale was 62.3, with a minimum score of 30 and a maximum score of 90. The most

common positive points concerned the basic concept of this application and its potential; see, for example, “Interpretation with people who use sign language is possible” (4 persons), “Any conversation is possible,” “There are interesting points and possibilities even if I do not use sign language” (2 persons), and “I can talk regardless of age and nationality.” One common bad point was expressed in “I do not need to use it to talk” (2). The most common negative points included functional problems such as “Sign language corresponding to trivial changes such as adverbs and past tenses does not appear” (2 persons) and photography issues such as “The sign language database makes it difficult to see unless the angle of the view is adjusted” (2 persons). Furthermore, there were also comments that may be of concern to those who do not use sign language such as “It is difficult to tell whether the sign language is a mirror image or not,” “It is difficult to tell whether the sign language displayed is really appropriate for the content,” and “Unnecessary movements may make it difficult to convey the message” (1 person).

The evaluation of video communication throughout the entire quest was as follows.

The average rating out of 100 was 66.9, with a minimum score of 30 and a maximum score of 100. Good points included evaluations of specific functions such as “The ability to save videos that I entered myself” (3 persons), “The sense of accomplishment in being able to do it makes it fun,” and “Being able to use videos is interesting, and I never get bored” (2 persons).

The most common comments on the bad points were about portrait issues such as “It is hard to concentrate when the faces of various people who created the signs are shown” (2 persons), “I am worried about misuse because my face is shown,” and “It is not exactly fun to see the faces of people I do not know.” There were three comments about the registered vocabulary: “If there are not enough words, I end up typing in letters (more data would be good)” and “I cannot express what I want to express adequately.” Other comments included “It is difficult to use” (2 persons), “It may be confusing if gestures using sign language are mixed in,” “Displaying the number of times the video has been played is unnecessary,” “I want to give titles to sequences,” and “I might get bored if I cannot share the videos I have created with others.”

The average expectation score was 73, with a minimum score of 50 and a maximum score of 100. Although they overlapped with the previous items, many comments were concerned with the basic concept of this application. These were comments such as “It can be used to communicate with people who use sign language” and “It can be used for learning sign language.” There were also comments on specific operations and requests for improvement. Furthermore, many other possibilities for use beyond hearing-impaired children were indicated, such as communication with people who speak different languages, use as an illustrated book application, and use with young children.

4.3. Discussion of Survey Results

Overall, the experiment collaborators rated the application highly, and most of the negative comments were attributed to the small amount of registered data and the inability of the application to withstand use in complex situations. Based on this, we believe that the basic concept of this application has been achieved.

The score-based evaluations varied depending on the quests at the time of the experiment; the more limited the situation, the higher the evaluation. When the situation was more flexible, there were more negative comments about the small number of registered vocabulary words, lack of abundance of expressions (e.g., past tense), and increased slowness during operation. This indicates that it is necessary to first limit the situations in which this application is used to some extent, augment the registered data related to those situations, and create a manual that includes the purpose and situations in which the application is to be used. Furthermore, although the application was evaluated as being easy to operate in this experiment with students, it is necessary to continue verifying whether there are any problems for actual users, including children.

The application showed a high level of expectation and many potential applications. It can be said that there is room to develop various versions of this application as a prototype.

5. CONCLUSION

Regarding language acquisition technology, this paper aimed to develop an application that can support language acquisition by utilizing sign language videos.

In particular, this paper provides a concrete implementation and preliminary verification of the basic functions of the application including sign language clip registration and retrieval. This paper also confirms that these functions work properly and are useful. However, we are also aware that several features are still insufficient for users who want to actually learn a sign language or for assisting users who want to use it in communication. First, the standard vocabulary that can be stored does not allow for sufficient organization of its variations.

Sign language consists of sentences made up of a series of movements, and many of these movements are difficult to isolate as words. The same word can have a variety of “conjugations” where the meaning is emphasized or reduced depending on the movement, but it is This difficult to store these in this application. A typical challenge will concern how to resolve such changes and variations in sign words. Another challenge, again, concerns the use of a large-scale use experiment to test how far it can respond in practice.

Although a certain degree of effectiveness can be expected at this stage, the true value of the system will not be known until it is actually used in a variety of communication situations. We believe that the next task is to conduct use experiments with the cooperation of actual deaf and hearing-impaired people.

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