Development of Natural Language Processing based Communication and Educational Assisted Systems for the People with Hearing Disability in Myanmar

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ABSTRACT

Information and communication technologies (ICTs) provide people with disabilities to better integrate socially and economically into their communities by supporting access to information and knowledge, learning and teaching situations, personal communication and interaction. Our research purpose is to develop systems that will provide communication and educational assistance to persons with hearing disability using Natural Language Processing (NLP). In this paper, we present corpus building for Myanmar sign language (MSL), Machine Translation (MT) between MSL, Myanmar written text (MWT) and Myanmar SignWriting (MSW) and two Fingerspelling keyboard layouts for Myanmar SignWriting. We believe that the outcome of this research is useful for educational contents and communication between hearing disability and general people.

Index Terms — Myanmar sign language, Natural language processing, Myanmar SignWriting, Machine Translation

1. INTRODUCTION

There are about 4.6% of the population are disable and 1.3% of the population are deaf and hearing impairment in Myanmar [1]. There are four schools for the Deaf children in Myanmar, Mary Chapman School for the Deaf Children in Yangon (est. 1904), School for the Deaf Children in Mandalay (est. 1964), Immanuel School for the Deaf in Kalay (est. 2005) and School for the Deaf Children in Tamwe, Yangon (est. 2014). In Myanmar, based on the information from these four Deaf schools, only 0.006% of the Deaf have a university level education. This percentage is very low compared to all the population in Myanmar. In Myanmar, a developing country, children with hearing loss and deafness rarely receive any schooling. Unemployment rates in the deaf community are high and most live in poverty. The main reasons are communication problems and lack of educational resources for the deaf community. For these reasons, we wish to break down the language and communication barriers between hearing impaired and general people.

Our purposes was not only to break down the communication barriers between Deaf and general people but also to raise awareness, information and respect for understanding Deaf culture and sign language. With these purposes, we developed MSL corpus, MT systems for MSL and two Fingerspelling keyboard layouts for Myanmar SignWriting.

The structure of the paper is as follows. In the next section, we present a sketch of MSL and Myanmar language. Section 3 and 4 introduce the Myanmar fingerspelling and SignWriting. Section 5 presents preparation of the MSL corpus. Then, in Section 6, we describe the methodologies used in the machine translation experiment, statistical information of the corpus and the experimental settings. Results together with some discussions and proposed two fingerspelling keyboard layouts are also presented in section 6. Finally in section 7, we present our conclusions and indicate promising results for future research.

2. MYANMAR SIGN LANGUAGE AND MYANMAR LANGUAGE

MSL like other known Sign Languages (SLs) depends on three basic factors that are used to represent the Manual Features (MFs): hand shape, hand location and orientation. In addition to the MFs, MSL also has Non-Manual Features (NMFs) that are related to head, face, eyes, eyebrows, shoulders and facial expression like puffed checks and mouth pattern movements. Postures or movements of the body, head, eyebrows, eyes, cheeks, and mouth are used in various combinations to show several categories of information, including lexical distinction, grammatical structure, adjectival or adverbial content, and discourse functions [2]. Grammatical structure that is shown through non-manual signs includes questions, negation, relative clauses [3], boundaries between sentences [4], and the argument structure of some verbs [5]. Similar to American Sign Language (ASL) and British Sign Language (BSL), Myanmar Sign Language use non-manual marking for yes/no questions. They are shown through raised eyebrows and a forward head tilt [6] [7] [8]. Figure 1 shows an example of MSL sentence “မွေး ဘယ်မှာ” + “NMFs – chin up and raised eyebrows for wh-question”. The meaning of the MSL sentence is “မင်း ဘယ် ဇာတိ လဲ ။” in Myanmar language and “Where are you born?” in English respectively.

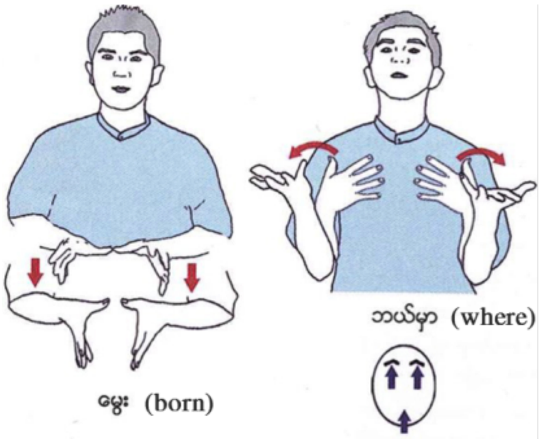
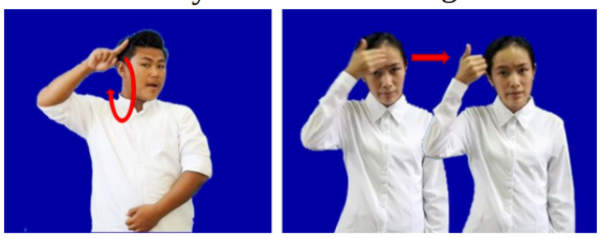


Figure 1. An example of MSL sentence that used non-manual features (from Myanmar Sign Language Basic Conversation Book)

Mandalay Yangon



(a) "အမေ"Mother

Mandalay Yangon

(b) "မနက်"Morning

Figure 2. Examples of different signs used in Mandalay and Yangon which correspond to the same Myanmar word

Sign language used is different in Yangon and Mandalay regions with many dialects. To the best of our knowledge, MSL using in the Mary Chapman School for the Deaf Children, Yangon is mainly different with MSL of Mandalay region. Figure 2 shows two examples of different signs used in Yangon and Mandalay which correspond to the same meaning. Figure 2 (a) is for a Myanmar word "အမေ" (mother in English) and Figure 2 (b) is for a Myanmar word "မနက်" (morning in English). The left sides of the figure are the signs used in Mandalay and the right sides are the signs used in Yangon. Figure 2 (a) in Mandalay three times repeated rotation the sign; the hand shape and movement are different with Yangon. Figure 2 (b) one handed sign is used in Mandalay and two handed sign is used in Yangon. This difference gives the difficulty of communicating and dealing between Deaf or hearing disabilities in different cities. A government project was set up in 2010 to establish a national sign language with the aid of the Japanese Federation of the Deaf.

Naturally, hearing problems can affect the ability to read or write the Myanmar language. This is due to the differences between their native language SL and the spoken Myanmar language. Moreover, Myanmar language is tonal and syllable-based. MSL does not have the same grammar, syntax, and vocabulary as Myanmar. Examples of different grammar, syntax and vocabulary between Myanmar and MSL can be seen in the followings.

English: Which months are the hottest months?
Myanmar: ဘယ် လ တွေ က အပူဆုံး လ တွေ လဲ ။
MSL: ပူ (hot) အရမ်း (very) လ (month) ဘာလဲ (what)

English: It is 10 past 6.
Myanmar: ၆ နာရီ ထိုး ပြီး လို့ ၁၀ မိနစ် ရှိ နေ ပြီ ။
MSL: နာရီ (clock) ၆ (six) ကျော် (pass) မိနစ် (minute) ၁၀ (ten) နဲနဲကျော် (pass a little)

English: Extinguisher
Myanmar: မီးသတ်ဆေးဘူး ။
MSL: အနီ (red) ဘူး (aerosol bottle) ဖြန်း (spray)

English: Please call an ambulance!
Myanmar: ကျေးဇူးပြုပြီး လူနာတင်ကား ခေါ်ပေး လို့ ရ မလား ။
MSL: ကြက်ခြေနီ (red cross) ကား (car) အရေးပေါ် (emergency) ဖုန်းဆက် (phone call) ကျေးဇူးပြု၍ (please)

3. MYANMAR FINGERSPELLING

MSL uses fingerspelling like in other sign languages. Myanmar fingerspelling is the representation of Myanmar characters and numbers with hands. It is used especially for signing names, city names and words, which do not exist in sign language. As we mentioned in Section 2, there are also two different fingerspelling character sets for MSL; one is used in northern Myanmar and the other is used in southern Myanmar [9]. They are similar in consonant but mainly different in vowels, medial and symbol [10]. Only focuses on 33 Myanmar consonant fingerspelling characters, twelve of them are different between Mary Chapman School for the Deaf and Mandalay Deaf School (Ni Htwe Aung et al., 2019) [11].

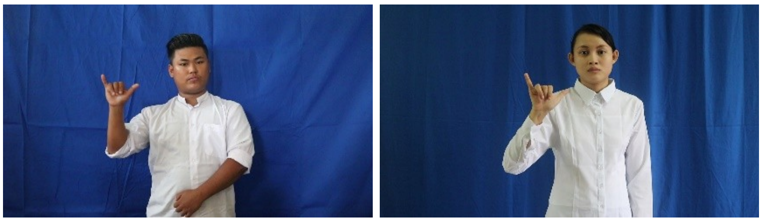
Figure 3 shows an example of Myanmar fingerspelling character differences between Mary Chapman School and Mandalay School. Figure 3 (a) is different sign used for same "ဍ" (dda) consonant and figure 3 (b) is same sign used for different "သ" (sa) and "ရ" (ra) consonants in Mandalay and Yangon respectively. The left sides of the figure 3 are the sign used in Mandalay and the right sides are the signs used in Yangon. Signs used in Mary Chapman were invented by Dr. Maliwan Tammasaeng in collaboration with Myanmar Sign Language teachers and students in 1987 [10].

Mandalay **Yangon**

"ဍ" (dda) sign used in Mandalay and Yangon

(a)

Mandalay **Yangon**



"သ" (sa) sign used in Mandalay

"ရ" (ra) sign used in Yangon

(b)

Figure 3. Examples of different fingerspelling character signs used in Mandalay and Yangon

4. SIGNWRITING

There are many writing systems to represent sign languages in written form in other countries. Among them, SignWriting is becoming widespread because it is language independent, which contains a large number of basic symbols [12]. It is usable by deaf people in their daily life such as education, communication, and reading. It was developed by Valerie Sutton in the 1974s. It is a writing system of sign languages using a combination of iconic symbols and the shapes of characters, that are abstract pictures of the hand, body, face and so on. It includes International SignWriting Alphabet (ISWA) with 30 groups of symbols used to write any Sign Language in the world. It is composed of seven categories of base symbols

[12]: Hand, Movement, Dynamics and Timing, Head and Face, Body, Detailed Location, and Punctuation. The words in SignWriting may be written from the point of view of the signer and assume the right hand is dominant. The orientation of the palm is indicated by filling the glyphs for the hand shape [12]. A white glyph indicates that one is facing the palm of the hand, a black glyph indicates that one is facing the back of the hand and half-shading indicates that one is seeing the hand from the side. SignWriting is the first writing system for sign languages to be included in the Unicode Standard. The Unicode block for Sutton SignWriting is U+1D800-U+1DAAF [13].

SignWriting is widely used as the written form for sign language in over 40 countries. There are many text editor programs to write their sign language with SignWriting such as SignMaker 2015 [14], SignPuddle Online [15], SignWriter studio [16], Rand SignWriting Keyboard [17], DELEGS SignWriting editor [18] and so on. SignWriting is not currently used in Myanmar deaf society, and in deaf education. We defined Myanmar fingerspelling characters with SignWriting symbols as follows:

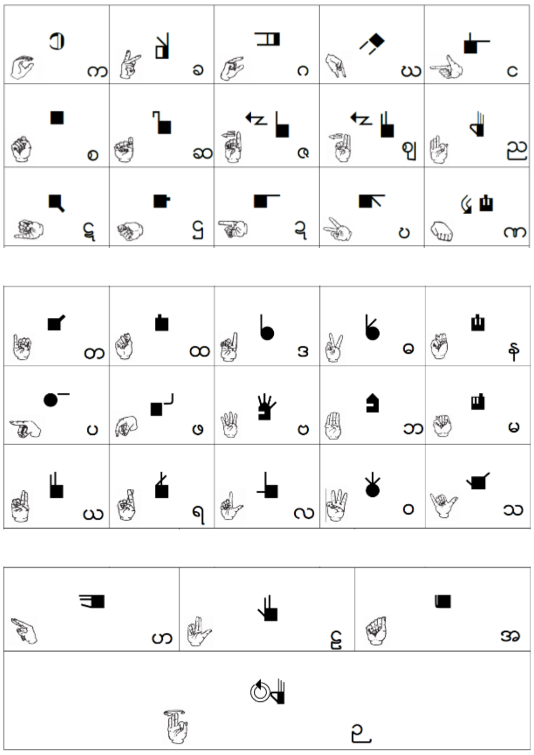
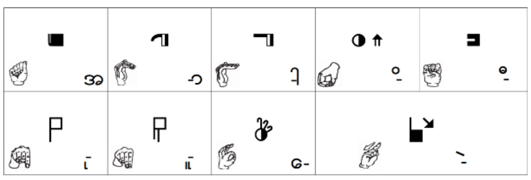


Figure 5. Consonant



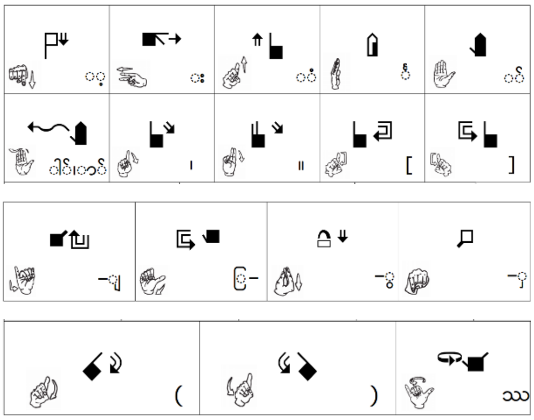


Figure 6. Vowel, consonant sign, various sign and symbol

Figure 7. Independent vowel and symbol

5. CORPUS PREPARATION

Myanmar NLP researchers are facing with many difficulties arising from the lack of resources; in particular parallel corpora are scare [19]. Currently, there is no parallel corpus for MSL. Therefore, as a first step, we began building multimedia parallel MSL corpus in October 2016. This corpus is designed to be able to make end-to-end translation between MSL video and Myanmar written text. The purpose was to increase awareness of sign language as a distinctive language in Myanmar. This corpus is beneficial not only to NLP research but also to hearing-impaired and deaf individuals, as it helps them to recognize and respect their language differences and communication styles. To the best of our knowledge, this is the first MSL corpus developed for both academic and public use. Our MSL corpus building is work in progress and MSL video, translated MSL sentences and transcript Myanmar language sentences for Emergnecy (health, accident, police, fire, earthquake, flood and storm) is publicly available (https://github.com/ye-kyaw-thu/MSL4Emergency).

For this purpose, data collection with 30 SL trainers and Deaf people: males and females, age range from 11 to 48, from School for the Deaf (Mandalay), Mary Chapman School for the Deaf Children (Yangon), School for the Deaf (Tamwe), Myanmar Deaf Society and Literacy and Language Development for the Deaf in Yangon and Mandalay regions has been carried out. We also considered covering different MSL dialects.

The MSL corpus contains MSL video, textual and Myanmar SignWriting annotation of Myanmar sign language and translated Myanmar written text. Here, we have to carefully consider boundaries of MSL video segmentation for transcription with Myanmar text.

Currently, there is no defined Myanmar gloss transcription for MSL and we are developing an unambiguous textual representation that covers start and end points of SL sentences. This textual glossing scheme development is the most challenging part of MSL corpus building. MSL videos were annotated using EUDICO Linguistic Annotator (ELAN). Figure 4 shows an example of MSL video annotation with ELAN. Video segmentation is based on MSL word units.

Figure 4. An example of MSL video annotation with ELAN

5.1. Manual Annotation with SignWriting

After video data collection had been finished, we have to define SignWriting symbols for each sign of MSL. In details, we watched the recorded video several times for defining both manual and non-manual signs. After that, sign symbols are placed on the canvus of SignMaker to form the shape and movement of signs. SignWriting symbols are needed to arrange in unique sequence. Figure 5 shows the sign symbols arrangement in SignMaker. There are two ways to prepare SignWriting data: one is the formal SignWriting-based on 2-dimensional mathematics and written as a string of ASCII characters and another is Unicode representation of SignWriting symbols. In our work, we use Unicode numbers for SignWriting symbols seeing SignWriting symbols arrangement in SignMaker. An example of word "doctor" is as follows and equivalent MSW can be seen in Figure 5.

English: Doctor
Myanmar: ဆရာဝန်
Unicode Block: "\U1D800\U1DAAA\U1D800\U1DA9C\U1D80A\U1DA9B\U1DAA8
\U1D9FF\U1DA30\U1D80A\U1DA9B"

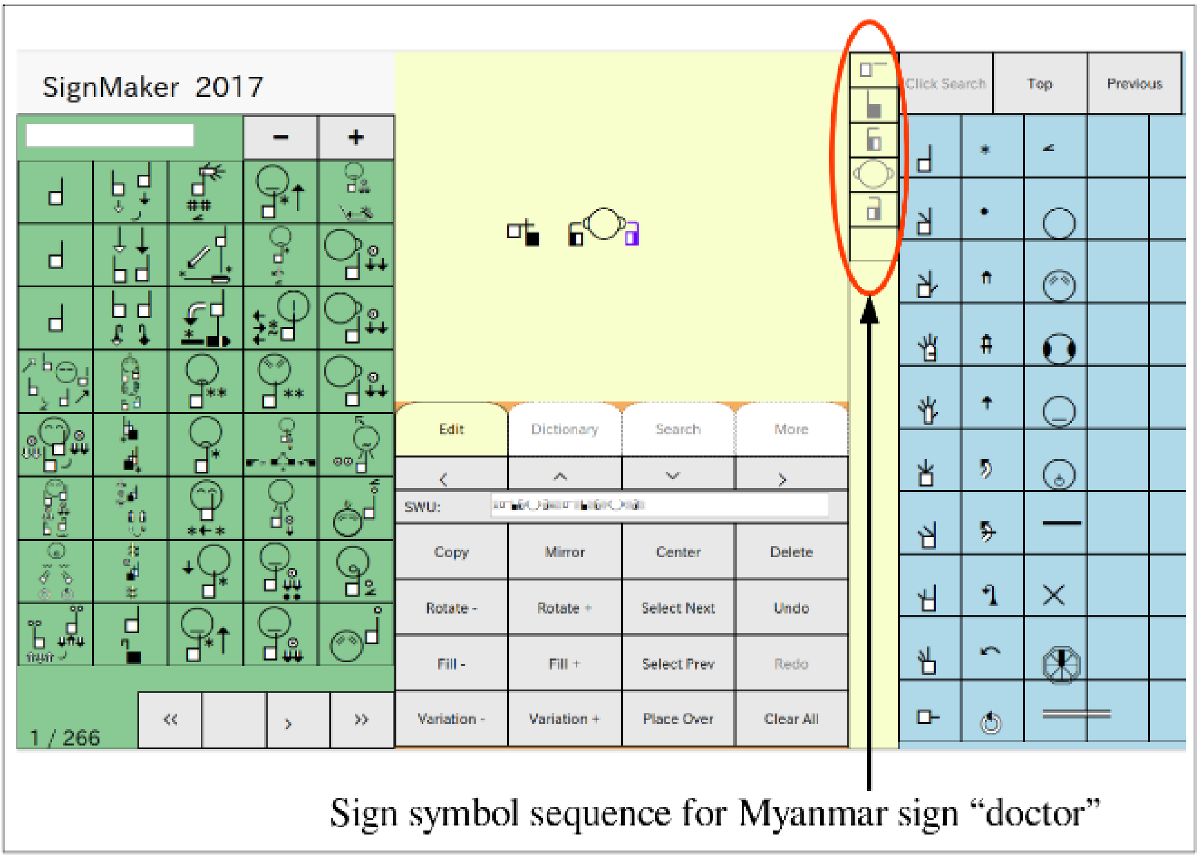


Figure 5. An example of sign symbol sequence arrangement in the SignMaker 2017

5.2. Syllable and Word Segmentation

In MT, word segmentation is a necessary step in order to yield to set of tokens upon which the alignment and indeed the whole machine learning process can operate. We did sign unit based word segmentation for both text representation of MSL and MSW. Sign unit based word segmentation was done manually for the whole parallel corpus. The followings show the different word segmentation between MSL and MWT ("She is engaged with Wunna." in English):

Word segmentation for MWT:
သူ ဝဏ္ဏ နဲ့ စေ့စပ်ကြောင်းလမ်း ထား တယ် ။

Sign Unit based segmentation for MSL:
သူ စေ့စပ် ကောင်လေး နာမည် စလုံးပေါင်း ဝ ဏ ဏ ။

6. TECHNOLOGY ADAPTATION

In this section, we present developing process for Machine Translation (MT) for MSL and two Fingerspelling keyboard layouts for Myanmar SignWriting.

6.1. MT of MWT-MSL and MSL-MSW

Sign language is the primary means of communication for deaf people, although there are not enough specially trained sign language teachers, interpreters and communication systems for the deaf community in Myanmar. Deaf people are suffering substantial exclusion and isolation from social networks for the hearing. The main reasons for this exclusion are communication problems. To help them to integrate the society and to communicate easily with the hearing people, there is a big requirement to develop an automatic machine interpreter that can translate Myanmar spoken or written language and MSL. MT of MSL would be useful in enabling hearing people who do not know MSL to communicate with Deaf individuals.

6.1.1. Experimental Methodology

We describe the three Statistical Machine Translation (SMT) approaches used in the machine translation experiments.

6.1.1.1 Phrase-based Statistical Machine Translation (PBSMT)

A PBSMT translation model is based on phrasal units [20] [21]. Here, a phrase is simply a contiguous sequence of words and generally, not a linguistically motivated phrase. A phrase-based translation model typically gives better translation performance than word-based models. We can describe a simple phrase-based translation model consisting of phrase-pair probabilities extracted from corpus and a basic reordering model, and an algorithm to extract the phrases to build a phrase-table [22].

6.1.1.2 Hierarchical Phrase-based Statistical Machine Translation (HPBSMT)

The hierarchical phrase-based SMT approach is a model [23] based on synchronous context-free grammar. The model is able to be learned from a corpus of unannotated parallel text. The advantage this technique offers over the phrase-based approach is that the hierarchical structure is able to represent the word re-ordering process. The re-ordering is presented explicitly rather than encoded into a lexicalized re-ordering model (commonly used in purely phrase-based approaches). This makes the approach particularly applicable to language pairs that require long-distance re-ordering during the translation process [24].

6.1.1.3. Operation Sequence Model (OSM)

The Operation Sequence Model (OSM) [25], combines the benefits of phrase-based and N-gram-based SMT [26] and remedies their drawbacks. It is based on minimal translation units, capture source and target context across phrasal boundaries and simultaneously generate source and target units. Providing a strong coupling of lexical generation and reordering gives a better reordering mechanism than PBSMT. The list of operations can be divided into two groups and they are five translation operations (Generate (X, Y), Continue Source Cept, Generate Identical, Generate Source Only (X) and Generate Target Only (Y)) and three reordering operations (Insert Gap, Jump Back (N) and JumpForward).

6.1.2. Experiments

6.1.2.1. Corpus statistics

MSL corpus is a collection of everyday basic conversation expressions. It contains six main categories and they are people (greeting, introduction, family, daily activities, education, occupations, and communication), food (food, beverage and restaurant), fun (shopping, hobbies and sports), resource (number, time, weather and accuracy), travel (bus, train and airport) and emergency (health, accident, police, fire, earthquake, flood and storm). In our MSL data, 6% of sentences are containing Myanmar fingerspelling characters.

We used 1,448 MSL and MSW parallel sentences of our MSL corpus for MT between MSL and MSW. In this experiment, 1,000 sentences were used for training, 170 sentences for development and 278 sentences for evaluation.

We used 2,510 MWT and MSL parallel sentences of MSL corpus for MT between MSL and MWT, 2,000 sentences were used for training, 310 sentences for development and 200 sentences for evaluation. We prepared four types of segmentation pairs and they are word-word, syllable-syllable, syllable-word and word-syllable.

6.1.2.2. Moses SMT system

We used the PBSMT, HPBSMT and OSM provided by the Moses toolkit [27] for training the PBSMT, HPBSMT and OSM statistical machine translation systems. The word segmented source language was aligned with the word segmented target languages using GIZA++ [28]. The alignment was symmetrized by grow-diag-final-and heuristic [29]. The lexicalized recording model was trained with the msd-bidirectional-fe option [30]. We used KenLM for training the 5-gram language model with interpolated modified Kneser-Ney discounting [31] [32]. Minimum error rate training (MERT) [33] was used to tune the decoder parameters and the decoding was done using the Moses decoder (version 2.1.1) [27]. We used default settings of Moses for all experiments.

6.1.3. Evaluation

We used two automatic criteria for the evaluation of the machine translation output. One was the de facto standard automatic evaluation metric Bilingual Evaluation Understudy (BLEU) [34] and the other was the Rank-based Intuitive Bilingual Evaluation Measure (RIBES) [35]. The BLEU score measures the adequacy of the translations and RIBES is suitable for distance language pairs such as Myanmar and English. The higher BLEU and RIBES scores are better.

6.1.4. Result and Discussion

The BLEU and RIBES score results for machine translation experiments between MWT and MSL tasks with PBSMT, HPBSMT and OSM for word-word, syllable-syllable, syllable-word and word-syllable segmentation pairs are shown in Table 1, 2, 3 and 4, respectively. The BLEU and RIBES score results for machine translation experiments with PBSMT, HPBSMT and OSM between MSL (word) and MSW (word) are shown in Table 5. The results for MSL (syllable) and MSW (word) pair are shown in Table 6. RIBES scores are shown in brackets. Bold numbers indicate the highest scores among the three Statistical MT approaches.

Looking at the results in Table 1, 2, 3 and 4, it is clear that the syllable-syllable segmentation pair scheme was by far the most effective for both MWT-MSL and MSL-MWT translations. In Table 2, for the MWT-MSL translation the highest BLEU and RIBES scores (35.11 and 0.8402) were achieved by HPBSMT and 0.3 BLEU and 0.0013 RIBES scores higher than that of OSM. The BLEU and RIBES scores of PBSMT and OSM are comparable (34.42, 34.81 and 0.8392, 0.8389) respectively. For the MSL-MWT translation, OSM gave the highest BLEU and RIBES scores; 34.78 and 0.8446 respectively.

Surprisingly, if we only focus on MWT-MSL translation, the HPBSMT gave the highest BLEU and RIBES scores for all segmentation pairs except word-syllable segmentation. On the other hands, for MSL-MWT translation, OSM gave the highest BLEU scores for all segmentation pairs. Obviously, not both BLEU and RIBES scores are the highest performance always together. HPBSMT with word-word and PBSMT with syllable-word segmentation pairs achieved the highest RIBES scores 0.8332 and 0.7416 respectively (see Table 1 and 3). The possible explanation is the RIBES metric is more sensitive to reordering.

Table 1. BLEU and RIBES scores of word-word segmentation pair for PBSMT, HPBSMT and OSM

Src-Trg	**MWT (Word) – MSL (Word)**		
	PBSMT	HPBSMT	OSM
MWT-MSL	25.80 (0.8023)	26.42 (0.8125)	25.38 (0.8004)
MSL-MWT	29.77 (0.8280)	29.70 (0.8332)	30.38 (0.8261)

Table 2. BLEU and RIBES scores of syllable-syllable segmentation pair for PBSMT, HPBSMT and OSM

Src-Trg	**MWT (Syllable) – MSL (Syllable)**		
	PBSMT	HPBSMT	OSM
MWT-MSL	34.42 (0.8392)	**35.11** **(0.8402)**	34.81 (0.8389)
MSL-MWT	33.54 (0.8442)	33.01 (0.8414)	**34.78** **(0.8446)**

Table 3. BLEU and RIBES scores of syllable-word segmentation pair for PBSMT, HPBSMT and OSM

Src-Trg	**MWT (Syllable)- MSL (Word)**		
	PBSMT	HPBSMT	OSM
MWT-MSL	21.02 (0.7847)	**21.96** **(0.7945)**	20.55 (0.7685)
MSL-MWT	20.93 **(0.7416)**	20.18 (0.7389)	**21.21** (0.7370)

Table 4. BLEU and RIBES scores of word-syllable segmentation pair for PBSMT, HPBSMT and OSM

Src-Trg	**MWT (Word)- MSL (Syllable)**		
	PBSMT	HPBSMT	OSM
MWT-MSL	24.17 **(0.6785)**	23.94 **(0.6785)**	**24.38** (0.6757)
MSL-MWT	25.31 (0.7344)	26.03 (0.7382)	**27.23** **(0.7411)**

From the overall results, it can be clearly seen that HPBSMT and OSM approaches are significantly better than PBSMT. Although word-word segmentation results are higher than syllable-word and word-syllable segmentations, it is significantly lower than syllable-syllable segmentation scheme.

Looking at the results in Table 5 and 6, MSL(word)-MSW segmentation scheme of MSL was by far the most effective for both MSL-MSW and MSW-MSL translations. In Table 5, MSL-MSW translation achieved the highest BLEU and RIBES scores (37.54 and 0.8280) using OSM approach and MSW-MSL translation gave the highest BLEU and RIBES scores (52.79 and 0.8756) in HPBSMT. From the overall results (see Table 5 and 6), it can be clearly seen that OSM approach is better for both MSL to MSW and MSW to MSL translations. PBSMT and HPBSMT results are comparable for both word and syllable segmentations. If we only focus on syllable segmentation experiments (see Table 6), all three SMT approaches, PBSMT, HPBSMT and OSM results are comparable.

Table 5. BLEU and RIBES scores of MSL (word) and SignWriting pair for PBSMT, HPBSMT and OSM

Src-Trg	**Word Segmented MSL**		
	PBSMT	HPBSMT	OSM
MSL-MSW	34.44 (0.8014)	34.99 **(0.8049)**	**37.54** (0.8280)
MSW-MSL	52.66 (0.8754)	52.79 (0.8756)	**49.99** **(0.8675)**

Table 6. BLEU and RIBES scores of MSL (word) and SignWriting pair for PBSMT, HPBSMT and OSM

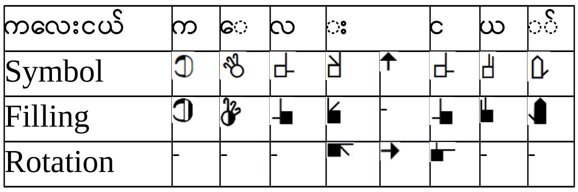
Src-Trg	**Syllable Segmented MSL**		
	PBSMT	HPBSMT	OSM
MSL-MSW	33.99 (0.8206)	34.04 **(0.8260)**	**34.38** (0.8200)
MSW-MSL	49.47 (0.8660)	49.62 (0.8650)	**50.42** **(0.8676)**

6.2. Two Fingerspelling Keyboard Layouts for Myanmar SignWriting

In Myanmar, there are very few MSL users who know about SignWriting and those do not use it. And thus, we studied SignWriting by ourselves to represent Myanmar sign language fingerspelling with SignWriting symbols. There is no Myanmar language specific SignWriting text editor for Myanmar Deaf society yet. Therefore, we started working on finding user-friendly and efficient Myanmar fingerspelling keyboard layout for SignWriting. Moreover, we believe that SignWriting will be very useful for Deaf children education and documentation of sign language literature in Myanmar. We proposed two fingerspelling keyboard layouts, one is based on pronunciation of Myanmar characters and another is based on the shapes of SignWriting symbols. A user study with both hearing-impaired and hearing users was conducted and the comparisons are made between two keyboard layouts in terms of CPM and Likert scale feedbacks.

6.2.1. Prototype Development

In this paper, we also present our proposed two Myanmar fingerspelling keyboard layouts with SignWriting (MSW). Generally, typing SignWriting symbols are very different with typing Myanmar characters. For typing a SignWriting symbol, we need to press at least two keys (i.e. symbol modifier and fill modifier keys). For some SignWriting symbols (see Figure 5), we need a combination of symbol modifier, fill modifier and rotation modifier keys. For example: to type Myanmar character "င" (nga) with SignWriting, (symbol), (filling) and (rotation) keys are needed. For example, typing a Myanmar words ‘ကလေး ငယ်’ (children in English) with SignWriting, we need to type 18 keys (See Figure 6). Here, the typing order is symbol key, filling key and rotation key.



ကလေးငယ်	က	ေ	လ	း		င	ယ	်
Symbol								
Filling								
Rotation								

Figure 6. Example of typing Myanmar word ‘ကလေးငယ်’ (children in English) with SignWriting

6.2.2. Phonetic-based Keyboard Layout for Myanmar SignWriting

The Phonetic based keyboard layout is mapping Myanmar characters on English QWERTY keyboard based on their phonetic similarities with English characters such as Myanmar consonant “က” (Ka) on k key, "ခ" (Kha) on K (Shift + k) key, “ဂ” (Ga) on g key, “စ” (Ca) on s key, “ဆ” (Cha) on S (Shift + s) key and so on. The concept is same with the kKg (ကခဂ) Myanmar keyboard [36]. Although all Myanmar characters are difficult to map based on phonetic similarities with English keys, many Myanmar consonants and vowels are easily mapping on English keyboard layout. The merit point of the kKg keyboard mapping is very easy to type Myanmar characters even for the first-time users who already familiar with English QWERTY keyboard. From this reason, we applied kKg keyboard mapping concept for mapping SignWriting symbols for Myanmar fingerspelling. Generally, Myanmar SignWriting fingerspelling characters’ symbols under the group of unaspirated Myanmar consonants such as “” (Ka), “” (Ca), “”, (Ta) etc. on unshifted keys and Myanmar SignWriting fingerspelling characters under the group of aspirated and voiced Myanmar characters’ symbol such as “” (Cha), “” (Ga), “” (Da), “” (Dha) etc. are mapped on shifted keys. However, most of the SignWriting symbols for fingerspelling characters are same shapes such as “” (Ga) and “ ” (Gha), “” (Ttha) and “ ” (Tha) etc. and thus, we do not need to map every fingerspelling character on the keyboard. As we followed the kKg keyboard mapping concept, for some Myanmar fingerspelling characters are mapped on English keys based on the similar shape of characters, for example: Myanmar consonant "င" (Nga) is mapping to English small c key, Myanmar “့” (sign dot below) and “ံ” (sign anusvara) are mapping on the “.” or full stop key. The phonetic-based keyboard layout for MSW can be seen in Figure 7.

6.2.3. Symbol-based Keyboard Layout for Myanmar SignWriting

The Symbol-based keyboard mapping is based on the shape similarities of SignWriting symbols as shown in Figure 8. Generally, MSW symbols are grouped by the shape of the symbols. For example: symbols with the same shape and are mapped on s key and S (shift + s) key and and symbols are on d key and D (shift + d) key, respectively and so on. Moreover, Thumb group of SignWriting symbols such as “” (Le gaung), “” (Ca), “” (a) are mapped on the bottom row keys (i.e under the home row keys) of QWERTY keyboard layout. The group of filling such as “” (White glyph), “” (Half-shading), “” (Black glyph) etc. and rotation modifiers such as “” (-45 °), “” (-90 °), “”(-135 °) etc. are on the top row keys (i.e. above the home row keys) of the keyboard layout. This keyboard mapping concept might be difficult for the first-time users who are unfamiliar with Myanmar fingerspelling and SignWriting symbols.

6.2.4. Implementation

Both phonetic-based and symbol-based keyboard layouts were implemented for Linux or Unix like operating system computers using X Keyboard Extension (XKB). The XKB is a part of the X Window System (used on most Unix Like systems) that extends the ability to control the keyboard and provides access to internal translation tables of keyboard codes. We prepared two new symbol files (i.e. mapping file between keyboard codes and SignWriting Unicode symbols) for our two Myanmar fingerspelling SignWriting keyboard layouts (See Section 6.2.2 and Section 6.2.3). We can activate Myanmar fingerspelling SignWriting keyboards by copying our two new symbol files to the default path of XKB symbols (e.g. “/usr/share/X11/xkb/symbols/ “for Ubuntu Linux OS) and adding that two new keyboard names into the list of text entry setting of X Window System. We used TrueType font of Sutton SignWriting built with the SignWriting 2010 Tools to display Myanmar fingerspelling characters with SignWriting [37].

Figure 7. Phonetic-based keyboard layout for Myanmar SignWriting

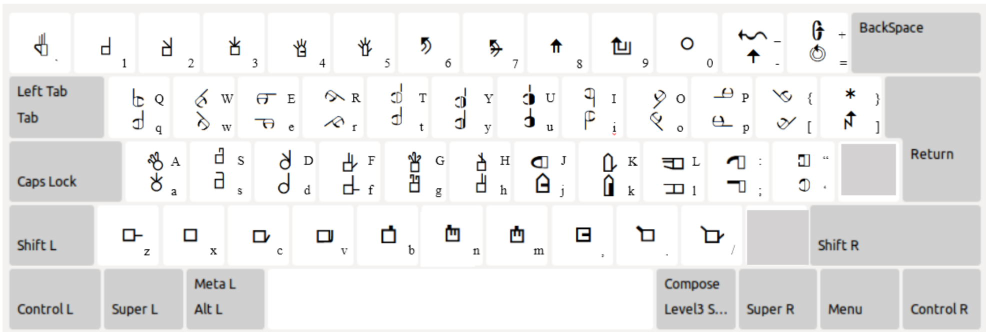


Figure 8. Symbol-based keyboard layout for Myanmar SignWriting

6.2.5. Methodology

6.2.5.1. Participants

The seventeen volunteer participants (9 males, 8 female) were recruited and we considered both hearing-impaired and hearing participants. Eight male hearing-impaired participants are ranging in age from 15 to 22 years. All of them are students of School for the Deaf, Mandalay and most of them are not familiar with personal computer. User study with hearing-impaired users was held at School for the Deaf, Mandalay. Nine hearing participants (8 females, 1 male) are ranging in age from 20 to 30, most of them are students of the Faculty of Information Science, University of Technology (Yatanarpon Cyber City), Pyin Oo Lwin city, Myanmar and all they are familiar with one of the Myanmar Keyboard layouts (Zawgyi or Myanmar3). None of them had prior experience with SignWriting Keyboard for Myanmar fingerspelling characters.

6.2.5.2. Apparatus

Testing was done on five Ubuntu desktop computers running Ubuntu 16.04 LTS Linux OS. The two Myanmar fingerspelling SignWriting keyboards were installed in advanced. Figure 9 shows user study environment with hearing-impaired users at School for the Deaf, Mandalay.

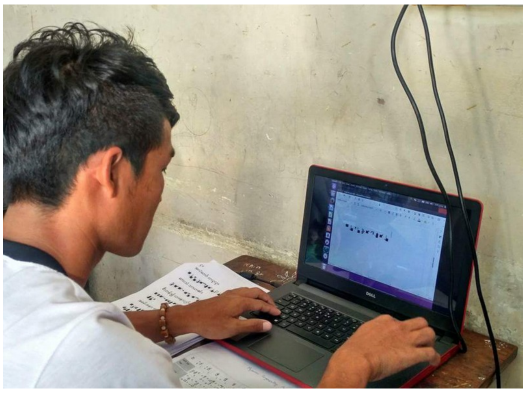


Figure 9. Experimental Environment with hearing-impaired users

6.2.6. Procedure

The experiment was performed in a quiet room of School for the Deaf, Mandalay. Participants sat in front of a desk of a laptop or a desktop computer that were already installed our SignWriting keyboard prototypes. We also provided printouts of the two keyboard layouts and three SignWriting poems (parallel sentences with Myanmar language) for the user study (See Figure 10). At first, introduction to what is SignWriting and two keyboard layout mapping concepts to all participants. The demonstration of how to type Myanmar SignWriting characters for all Myanmar consonants (characters Ka to A) and one poem was given before starting the user study. All participants were allowed to practice typing all Myanmar consonants (characters Ka to A) for two times to get some level of understanding on two keyboard layouts. The typing speed of all participants for each poem for 10 times were recorded. After finishing typing processes, we made discussion with participants and collecting their feedbacks, suggestions and comments.

Poem No.1:

စာရသလား

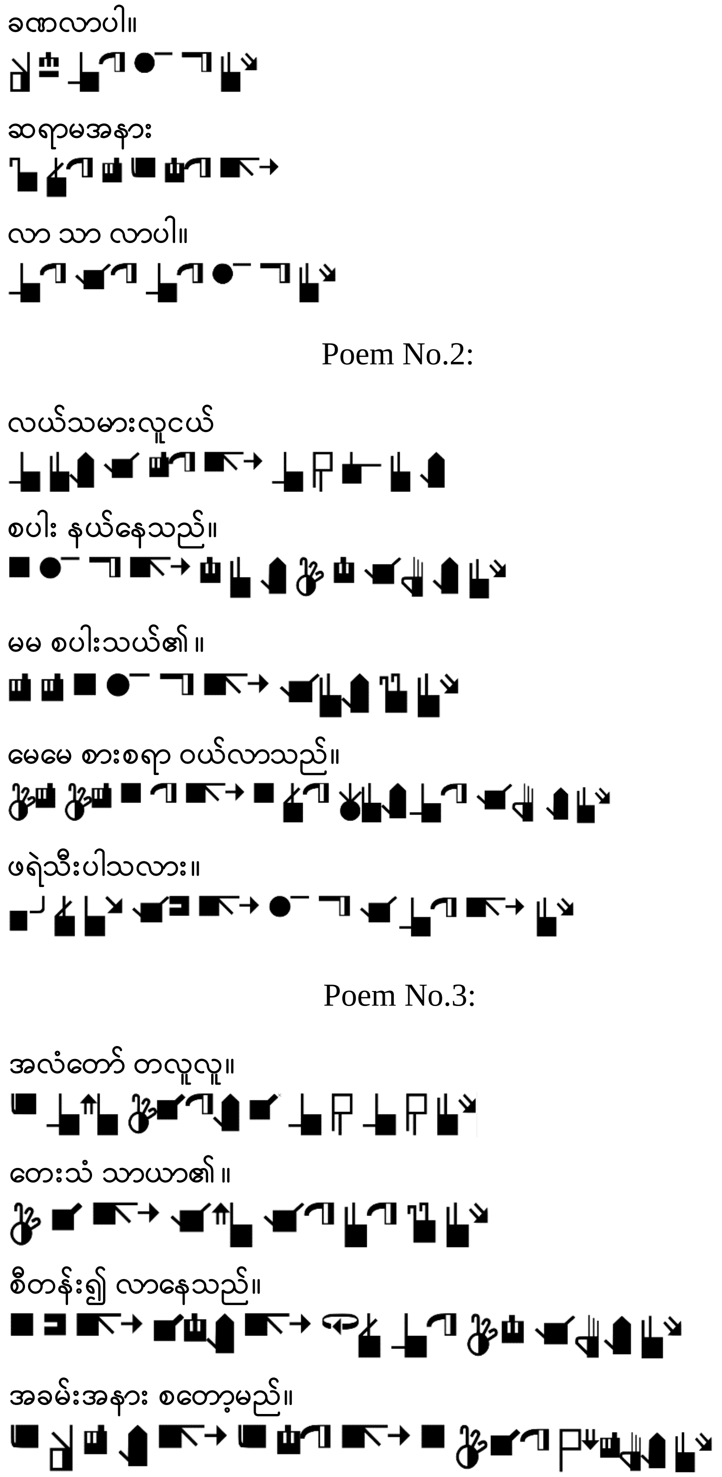


Figure 10. Three fingerspelling poems with SignWriting for user study

6.2.7. Design

We selected three poems from Myanmar language Primary School textbook for user study and they are as shown in figure 10 [38]. All Myanmar participants are already familiar with all these three poems. They cover most combination patterns of vowels and medial with a consonant.

6.2.8. Result and Discussion

6.2.8.1 Typing Speed

We used Character per Minute (CPM) to evaluate typing speed of participants. The formula for computing CPM is as follows:

$$CPM = \frac{|T|-1}{S} \times 60$$

Here, |T| is the length of this string and T may contain SignWriting symbols. S indicated how many seconds are spent from the entry of the first character to the last.

Although some space was put between SignWriting symbols in Figure 10 for easier reading, we don't need to consider a space for calculating CPM. This is because we did not allow users to type a space between symbols.

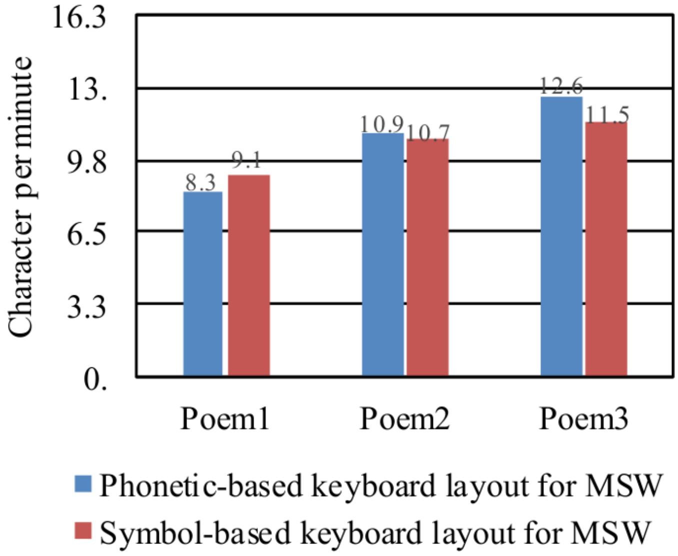


Figure 11. Average CPM of hearing-impaired participants' typing for three poems with both two fingerspelling keyboard layouts for MSW

Figure 11 shows average CPM values of 8 hearing-impaired participants for typing each Myanmar fingerspelling SignWriting poem 10 times. CPM values of typing with phonetic-based keyboard layout are 8.3, 10.9 and 12.6 for poem 1, 2 and 3, respectively. CPM values of typing with symbol-based keyboard layout are 9.1, 10.7 and 11.5 for poem 1, 2 and 3, respectively. CPM of typing with phonetic-based keyboard layout is slighter higher than that of typing with symbol-based keyboard layout for poem no.2 and poem no.3.

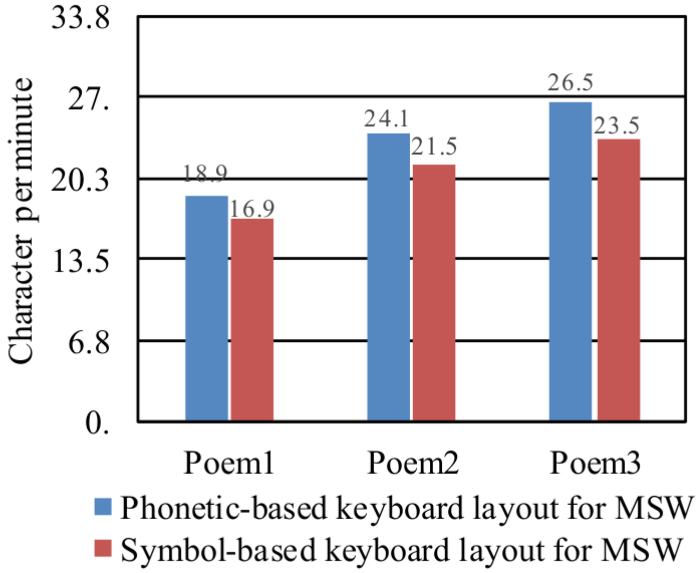


Figure 12. Average CPM of hearing participants' typing for three poems with both two fingerspelling keyboard layouts for MSW

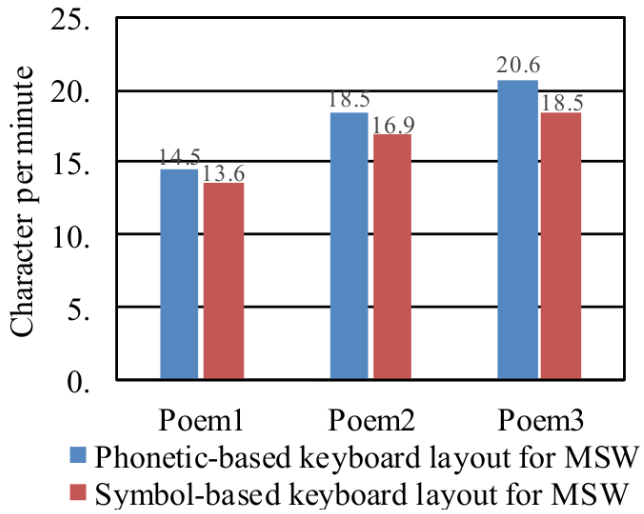


Figure 13. Average CPM typing speed of two types of participants: hearing-impaired and hearing participants for three poems with both two fingerspelling keyboard layouts

Figure 12 shows average CPM of 9 hearing participants for each user study. CPM values of typing with phonetic-based keyboard layout are 18.8, 23.8 and 26.4 and that of typing with symbol-based keyboard layout are 17.1, 20.1 and 21.4 for poem 1, 2 and 3, respectively. From the results, CPM values of typing with phonetic-based keyboard layout achieved higher typing speed for all three poems. According to the average CPM values of both hearing-impaired and hearing participants, typing speed with phonetic-based keyboard layout is obviously faster than symbol-based keyboard layout (see Figure 13).

6.2.8.2. Participant Questionnaire

After the typing experiments with one keyboard layout, questionnaires were taken to the participants immediately in order to get their comments and suggestions on that keyboard layout. Hearing-impaired participants were communicated through sign language teachers' translation as well as writing messages on the paper. The questions are:

1. Do you have any experience of using personal computer?
2. Are you familiar with one of the existing Myanmar PC keyboard layouts?
3. Can be skillfully used QWERTY keyboard layout?
4. Which keyboard layout is the best suitable to use in real time?
5. Do you have any comments or suggestions?

In summary, we received the answer “No”, “Yes” and “Yes” respectively for the question no.1, 2 and 3 from 8 hearing-impaired participants. For the question 4, 63% of hearing-impaired participants chose phonetic-based keyboard layout is the best suitable to use. As for the question 5, we received some comments such as “Phonetic-based keyboard layout's keys mappings are easy to remember”, “Phonetic-based keyboard layout is possible to use” and “Symbol-based keyboard layout is good because of grouping the symbols but it is difficult to memorize”. We also received some suggestions to change some key mappings. For example: in phonetic-based keyboard layout, the group of filling which are frequently used such as “” (White glyph), “” (Half-shading), “” (Black glyph) etc. should not be mapped on comma (,) , full stop (.) and slash (/) keys.

The answers to questions 1, 2, and 3 from 9 hearing participants are “Yes” to all. For the question 4, 78% of hearing participants chose phonetic-based keyboard layout is the best suitable to use. As for the question 5, we received some comments such as “Phonetic-based keyboard layout is easy to remember Myanmar characters with SignWriting symbols”, “Symbol-based keyboard layout is difficult to memorize but it is very fast in typing”. We also received the same suggestions to change some key mappings with hearing-impaired users and to develop platform independent.

Four Likert scales (1 to 5) are set to rate the user-friendliness of two fingerspelling keyboard layouts for Myanmar SignWriting. The scales are (1) difficult-easy (2) slow-fast (3) dislike-like (4) impossible-possible. Likert scales value 1 is the most negative, value 3 is neutral and value 5 is the most positive. The average or arithmetic mean results of Likert scale questions to hearing-impaired users and hearing users can be seen in Table 7 and Table 8.

According to the Likert scale evaluation results, we can generally say that both hearing-impaired and hearing participants are enjoyed of typing SignWriting symbols with phonetic-based keyboard layout of fingerspelling. We calculated the overall average Likert scale value on four categories (Difficult-Easy, Slow-Fast, Dislike-Like, Impossible-Possible) and made a comparison graph for two proposed keyboard layouts (see Figure 14). As the results of this comparison, interestingly, 4.4:4.1 (from hearing-impaired users) and 4.4:4.3 (from hearing users). And thus we can say hearing-impaired participants prefer phonetic-based keyboard layout. On the other hand, hearing participants accepted both of the keyboard layouts clearly.

As mentioned above, we conducted both CPM and Likert scale evaluations on the user study experiment of two Myanmar SignWriting keyboard layouts. Our result show that phonetic-based keyboard layout achieved higher CPM values for all the experiments. The evaluation results on two proposed keyboards in terms of Likert scale show that both of them are comparable.

Table 7. Evaluation by hearing-impaired users

Likert scales	**Phonetic-based keyboard layout for MSW**	**Symbol-based keyboard layout for MSW**
Difficult-Easy	4.3	4.1
Slow-Fast	4.3	3.9
Dislike-Like	4.5	4.3
Impossible-Possible	4.4	4

Table 8. Evaluation by hearing users

Likert scales	**Phonetic-based keyboard layout for MSW**	**Symbol-based keyboard layout for MSW**
Difficult-Easy	4.4	3.9
Slow-Fast	4.1	4.2
Dislike-Like	4.2	4.3
Impossible-Possible	4.8	4.6

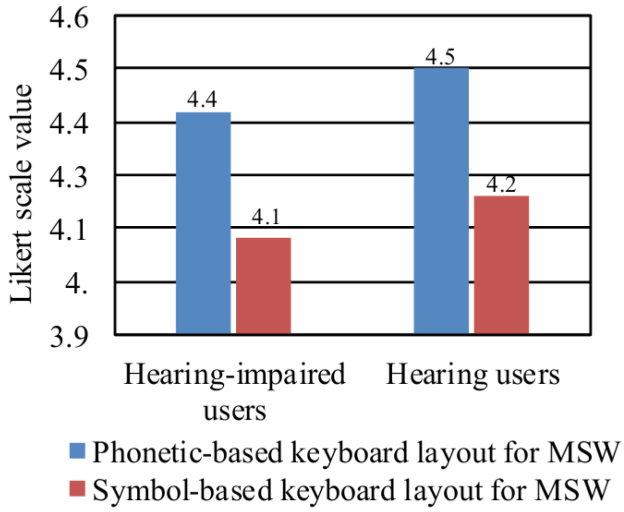


Figure 14. Comparison of Likert scale evaluation results for “Phonetic-based keyboard layout for MSW” and “Symbol-based keyboard layout for MSW”

7. CONCLUSION

This paper has presented the first study of the statistical machine translation between Myanmar sign language, Myanmar language and Myanmar SignWriting. We implemented three SMT systems (PBSMT, HPBSMT and OSM) with our developing MSL-MSW parallel corpus. We also investigated the effectiveness of two word segmentation schemes (word segmentation and syllable segmentation for Myanmar sign language) for SMT. In this paper, we have proposed two fingerspelling keyboard layouts for Myanmar SignWriting: phonetic-based and symbol-based keyboard layouts. An experiment was made to compare two keyboard layouts with 8 hearing-impaired participants and 9 hearing participants.

In the future work, we plan to expand the MSL-MSW parallel data and conduct experiments on SMT with SignWriting character level (i.e combination of basic symbol, filling symbol and spatial rotation symbol as a one SignWriting character) segmentation approach. We also plan to develop GUI Myanmar SignWriting text editor to cover the whole Myanmar Sign Language (MSL).

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