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Enabling Text Translation Using the Suggestion Bar of a Virtual Keyboard

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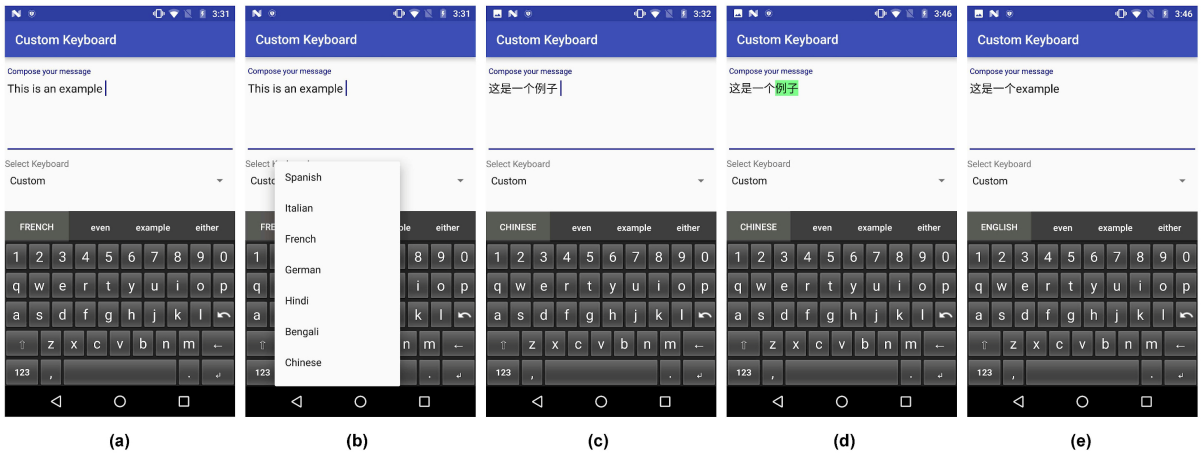

Fig. 1. The proposed real-time translation method: (a) the user types as she usually would. Her default translation language is French, thus tapping on the language button will translate the input to French, (b) but she decides to translate to Chinese. She selects the target language from a list, which appears when she long presses on the language button, (c) she taps on the button to translate the input, (d) she decides to revert a chunk of the text back to English. She highlights that chunk and taps on the language button, (e) this reverts the highlighted text back to English. Pressing the button without highlighting reverts the complete translation to the original language. This method does not replace the default predictive features, instead adds extra features to the suggestion bar.

***Abstract*—This work augments novel text translation features to the suggestion bar of a virtual keyboard to facilitate fast and easy translation on mobile devices. The method was evaluated in two user studies. In the first study, native Hindi and Mandarin speakers exchanged text messages in each other's language using the method. All participants found the method fast and easy, the quality and the flow of the conversation satisfactory, and wanted to use it frequently for multilingual and polyglot texting. In the second study, participants performed various translation tasks using the proposed method and the default Google keyboard's translation feature. Results revealed that the proposed method was significantly faster and required fewer actions for translation tasks. Further, most participants found the method more effective and user-friendly.**

***Index Terms*—Text entry, multilingual, polyglot, texting**

I. Introduction

The world has become more multicultural and multilingual due to global communication and trade. While this opens us up for new opportunities, cultures, and relationships, overcoming the language barrier remains a challenge [1]–[3]. An effective mobile translation method can mitigate this by allowing people speaking different languages to communicate. But the existing translation methods are unintuitive, inconvenient, and require much time and effort to learn and use. The default translation app on Android-based mobile devices, Google Translate, automatically displays a floating button when users copy text that is in a language other than the system default [4]. Users can tap on the floating button to see the copied text translated into the default language and for accessing additional translation features. This app makes the task of translation much easier, but requires users to perform a sequence of cut/copy and paste actions and switching between the current and the translation interface, which take extra time and interrupt the task at hand. Besides, the floating button and the translation overlay occupy valuable screen real-estate, often occluding important details and interactive elements. Recently, the default Google Android keyboard, Gboard, included a new translation feature that user can enable from the suggestion bar [5]. When enabled, it displays an additional input area above the suggestion bar where users can enter text to translate it to a different language (Fig. 2). There are also numerous third-party apps that include a similar feature. However, one problem with this method is that users have to actively enable this feature before each text translation episode. It also takes up extra screen real-estate and do not provide the support for translating a select part of the text or incoming text messages, which makes it difficult to use for polyglot texting.

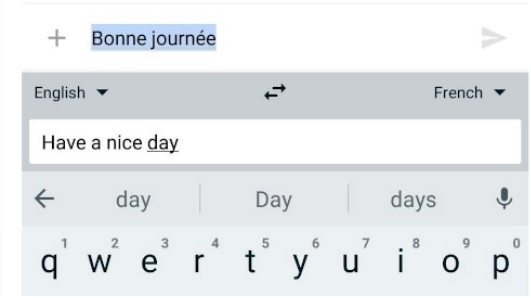

Fig. 2. Gboard's new translation feature displays an extra input area above the suggestion bar to enable real-time text translation.

This paper proposes a real-time text translation system on the suggestion bar of a virtual keyboard that works on both current input, existing text, and incoming text messages. It can translate the complete text or a selected chunk and can easily revert to the original text with a small number of actions (mostly, by a single tap). Fig. 1 presents the main features of the proposed method.

II. Related Work

Nowadays, almost all virtual keyboards include a suggestion bar that suggests words that users are most likely to enter next based on the text that has been entered so far. Users can actively select a word from the suggestion bar to enter it. Most suggestion bars also offer auto-correction and auto-completion for partially entered words. Although suggestion bar plays an important role in mobile text entry, it has not received much attention from the research community. Some have extended the functionality of the suggestion bar by providing the support for phrase prediction [6]–[8]. A recent work also suggests apps and relevant information based on the contextual information of ongoing conversations [9]. Another work further extended the functionality of the suggestion bar by providing the support for predictive number entry and editing [10].

III. Design and Development

We developed a custom suggestion bar with Android Studio 3.1.2 that offers both word suggestion [11] and text translation (Fig. 1). Users can select a translation language by tap-holding the translation button. They can also enable/disable the translation feature by double-tapping on the button. Currently, the system supports seven languages but the support for additional language can be easily added. On each translation request, the system passes the text to the Google Cloud Translation API[1] to receive the translated text. The API first attempts to translate the text using a Neural Machine Translation (NMT) model [12], [13] that uses Recurrent Neural Networks (RNNs) [14] to directly learn the mapping between an input sequence to potential output sequences [15]. This model considers the entire input sentence as a single unit for translation. If the model does not support the requested language translation pair, the system switches to a Phrase-Based Machine Translation (PBMT) model [16], [17] that breaks the input sentence into words to translates each word largely independently. Fig. 3 illustrates the high-level architecture of the translation service. However, the contribution of this work is not the translation service but the novel features (described below) that make text translation on mobile devices faster and easier.

[1]https://cloud.google.com/translate/docs

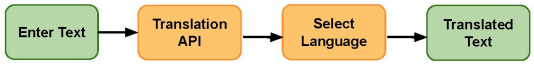

Fig. 3. High-level architecture of the translation service used in the proposed method.

The ***selective translation*** feature enables translating a select part of text. For this, users first select parts of the text that they want to translate, then tap on the translate button. Tapping on the button without selecting anything translates the complete text to the target language. For example, to translate the word *"Hello"* in the phrase *"Hello sunshine!"* to Spanish, users first select the word then tap on the language button to get *"¡Hola sunshine!"*. The ***undo translation*** feature makes it easier to revert to the original text after performing a translation task. For this, users tap on the language button immediately after a translation. For example, if users translate the word *"Hello"* by mistake, they can tap on the language button again to undo the translation. The ***reuse translation*** feature keeps record of all translations performed in a conversation for users to reuse those. It enables users to rotate through all past translations in a conversation by tapping on the "Return" key repeatedly. For example, if users want to reuse the previously translated phrase *"¡Hola sunshine!"*, they can enter it by cycling through all past translations in the conversation. For security reasons, this feature deletes the translation record when users leave the conversation.

IV. Pilot Study

We conducted a pilot study to find out if the topics used in the pilot trigger engaging conversations between participants. Eight volunteers from the university community (22–26 years) participated in the pilot. Two of them were female and six were male. They all knew each other from before. The pilot used Hindi as the target translation language. During the the study, participants were randomly paired up and asked to chat using an app on a randomly selected topic from a list. In each pair, one arbitrarily picked participant used the proposed translation method and the other participant used Gboard's translation feature (Fig. 2).

A. Topic Selection

We selected twelve topics to replicate natural daily conversation. To maintain privacy, we did not include any topic that could compromise the anonymity of the participants or reveal their personal, sensitive details, such as phone number or home address. We also ignored topics that could trigger unpleasant experiences, for example road accidents or financial hardship. Finally, we excluded all topics that require the knowledge of a

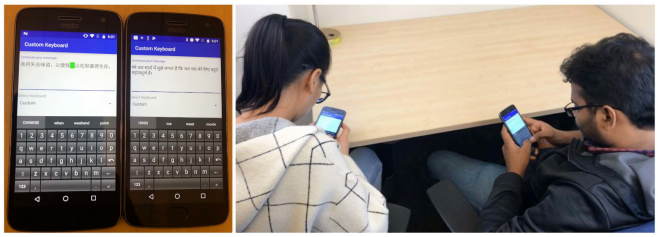

Fig. 4. Left: the device and the custom application used during the final study. Right: a pair of users participating in the final study.

specific domain, for example Newton's laws of motion. Some example topics are: discuss your bucket list, discuss what you would do with $1 million and why, and discuss your plans for the weekend.

B. Results

Participants spent on average 5.9 minutes (SD = 1) per topic. A post-study discussion revealed that most participants did not find the topics assigned to them interesting, which resulted in unnecessary pauses between the messages. However, they liked some of the other topics and felt that they would have been more engaged in the conversation if they could select the topics themselves.

V. User Study 1: Qualitative

We conducted a study to record the perceived performance, preference, usability, and learnability of the proposed method.

A. Participants and Apparatus

Twenty-four participants aged 23–28 years (M = 25.7, SD = 1.6) took part in the study. Four of them were female and twenty were male. Half of them were native Hindi speakers and the other half were native Mandarin speakers. The two groups did not speak each other's language but they all were proficient in English. Seventeen participants responded that they often use their native writing system on mobile devices, the remaining seven did not. They all responded that they feel left out on social networks, message boards, and group chats when someone starts messaging in an unfamiliar language. Sixteen of them had a translation app installed on their devices, six did not, the remaining two did not respond to this question. Yet, they all expressed interest in a translation method that will enable them to translate text on mobile devices easily, which suggest that they were not satisfied with the existing methods. We used two Motorola Moto G5 Plus smartphones (74.5 cm^2, 155 g) at 1080×1920 pixels (Fig. 4). The custom app automatically logged all interactions with timestamps.

B. Design and Procedure

During the study, we paired up one Hindi speaking person with one Mandarin speaking person. We then explained the study procedure to all participants and collected their consents. They completed a demographics and mobile usage questionnaire. We then demonstrated the new translation features and asked them to complete a pre-study questionnaire where they rated their immediate impression of the proposed method on a 7-point Likert scale. Understanding immediate impression of a method is important since users are usually reluctant to learn a new method even when it is more efficient than the existing methods if they are not immediately impressed with it [18]. We enabled participants to practice with the method for about one minute. They could extend the practice period on request. Once they were familiar with it, each pair was asked to pick a topic from the list and start discussing it with each other using the app. They were instructed to enter text in English then translated it to the other person's native language before sending. We did not ask them to enter text in their native language to eliminate a confounding factor. Both Hindi and Mandarin have multiple keyboards and not all participants were familiar with the same keyboard. They were instructed to continue chatting until they felt that they had fully covered the topic. They sat close to each other (Fig. 4), but were instructed not to initiate any verbal communication. Timing started from the entry of the first character and ended with the last. Once finished, they all completed a post-study questionnaire that included the same questions as the pre-study questionnaire. In addition, it included questions about their experience with the method and the quality of translation.

VI. Results

A complete study session took about 30 minutes, including practice, demonstration, and questionnaires. All participants responded that the method was easy to use even before using it (Fig. 5). In the post-study questionnaire, they all responded that the method enabled them to translate text much faster than the existing methods. When asked about the willingness to use, all of them stated that they will frequently use the method on their mobile devices. They also felt that the method enhanced the quality of conversation and was able to translated text with high accuracy, which enabled them to express their thoughts in another language. They all were satisfied with the flow of conversation. Further, they all felt that the new features will enable them to participate in multilingual and polyglot conversations.

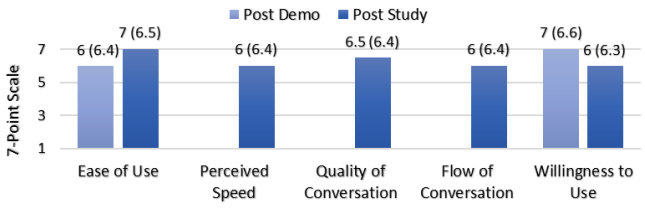

Fig. 5. Median user ratings of the proposed translation method on a 7-point Likert scale, where *1–7* signified *strongly disagree–strongly agree*. The values inside the brackets are the average user ratings.

A. Quality of Translation and Conversation

We conducted a post-hoc analysis of conversation transcripts to investigate the reliability of the method and the quality of

the conversation. For this, we recruited four graduate students, two native Hindi speakers and two native Mandarin speakers, and instructed them to carefully study and rate the following aspects of a conversation on a 5-point Likert scale: ***naturality***: whether the conversation felt natural, ***fluency***: whether the conversation progressed smoothly regardless of the language barrier, ***clarity***: whether the messages were clearly conveyed, and ***understandability***: whether the translated texts were easy to understand. None of them participated in the study. They were all male, aged 23–28 years. The Hindi speakers reviewed and rated the Hindi conversations, while the native Mandarin speakers reviewed and rated the Mandarin conversations. Fig. 6 presents the results, where the understandability, clarity, and naturality of the conversation yielded high ratings and the fluency of the conversation received a neutral rating.

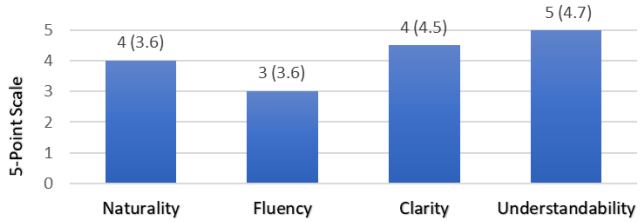

Fig. 6. Median ratings of the translation and the conversation on a 5-point Likert scale, where *1–5* signified *strongly disagree–strongly agree*. The values in the brackets are the average ratings.

B. Discussion

The results are encouraging since all participants found the method fast and easy. One participant (male, 27 years) wrote, *"[it is] super easy to use, extremely simple"*. Another participant (male, 24 years) wrote, *"It is very user-friendly and it can be very useful at times especially if one is travelling to a non-native language speaking country"*. All participants wanted to use the method frequently on their mobile devices. One participant (male, 24 years) wrote, *"If I had the choice to use it in everyday life, it will make my day-to day chores quick to do"*. Further, all participants were satisfied with the quality of the translations and the flow of the conversation. Post-hoc analysis of the conversation transcripts also supports this. External reviewers found the conversations natural, clear, and understandable. Interestingly, some participants felt that the method is more accurate than the Gboard's default translation features (Fig. 2), when in reality both use the same translation service. One participant (male, 25 years) wrote, *"The translation method is very good [...], Google translation is not very accurate"*. We did not find any significant difference between responses in pre- and post-study questionnaires. This suggests that participant had a very good impression of the method even before using it, and their impression did not deviate much after using it, in fact, improved in some cases. In a deeper analysis, we did not identify a significant difference between responses from participants who used a translation app (16 out of 24 participants used a translation app on their devices) and those who did not. This means participants' exposure to an existing translation method did not affect their opinion of the proposed method.

VII. User Study 2: Comparative

This study compared the proposed method with the default Google Android keyboard's translation feature (Fig. 2).

A. Participants and Apparatus

Twelve volunteers, aged 23–28 years (M = 26.5, SD = 1.6), participated in the study. One of them was female and eleven were male. Six of them were native Hindi speakers and six were native Mandarin speakers. All of them were proficient in English. They all used their native writing system on mobile devices. Eight of them had a translation app installed on their devices, two did not, the remaining two did not respond to this question. This study used the same device and app as the first study. The default Google Android keyboard's (Gboard) translation feature was used as the baseline condition.

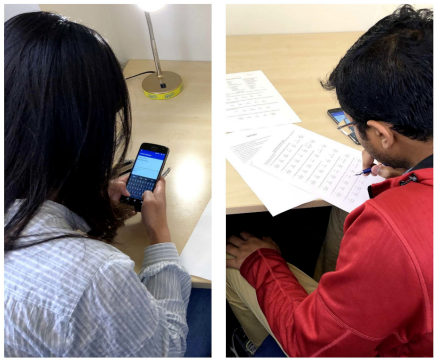

Fig. 7. Two volunteers taking part in the study: performing the tasks using the new method (left) and completing the post-study questionnaire (right).

B. Design

The study used a within-subjects design, where the independent variable was *method* and the dependent variables were the following metrics. ***Task completion time*** (seconds) is the average time users took to complete a task. ***Actions per task*** is the average number of actions (taps and gestures) performed to complete a task. ***Corrective action*** is the average number of actions performed (backspace, deletion, and changes via the suggestion bar) to correct input errors.

Participants performed three different types of translation tasks that were presented in printed task sheet. ***Full:*** participants translated a complete phrase to another language, e.g., they translated the following phrase to Hindi *"How often do you eat Italian food?"*. There were four full translation tasks per condition. ***Partial:*** participants translated a select part of a phrase to a different language, e.g., they translated the underlined part of the following phrase to Mandarin: *"Football is my favorite sport too!"*. There were four partial translation tasks per condition. ***Multiple:*** participants translated two select parts of a phrase to two different languages, e.g., they translated

the underlined part of the following phrase to Mandarin and the bold part to Hindi, *"Thank you! That was really helpful."* There were eight multiple translation tasks per condition. Therefore, the design of the study was: 12 participants × 2 conditions × 3 categories × 16 translations = 1,152 translation tasks.

C. Procedure

During the study, participants were asked to complete three different types of translation tasks using Gboard [5] and the new translation methods in a counterbalanced order. First, we explained the study to all participants and collected their consents. We then asked them to complete a short demographics questionnaire. Then, we randomly assigned each participant to one of two groups: the first started with Gboard and the second started with the proposed translation method. We demonstrated each method before starting the respective condition, even when participants were familiar the method. We allowed them to practice with the methods for about one minute. But they could extend the practice period on request. We started a condition only after participants were comfortable with the respective method. In an attempt to replicate actual mobile translation scenarios, participants were asked to, first, transcribe all phrases in English, then perform the translation tasks. All phrases and tasks were provided in a printed task sheet. Participants were instructed to type and translate as fast and accurate as possible and correct any typing mistake as they notice them. However, the performance metrics ignored all typing errors and correction efforts to isolate the performance of the translation methods. Timing started from the moment participants started translating and ended when they moved to the next task. Upon completion of all tasks, participants completed a questionnaire that asked them to rate the performance of the examined methods.

D. Results

A complete study session took about 60 minutes, including demonstration, practice, and questionnaire. We used a paired sample t-test for all analysis as a Shapiro-Wilk test confirmed that the data did not violate its normality assumption. Table I presents the results of the study.

TABLE I
PERFORMANCE OF GBOARD'S TRANSLATION FEATURES AND THE PROPOSED METHOD. VALUES INSIDE THE BRACKETS ARE STANDARD DEVIATIONS (SD).

Metrics	Google	Custom	Paired Sample T-Test
Task Completion Time	2.6 (0.3)	1.7 (0.2)	t_{23} = 21.3, $p < .0001$
Actions per Task	7.5 (1.1)	2.3 (0.9)	t_{23} = 19.4, $p < .0001$
Corrective Actions	7.8 (2.4)	7.2 (1.5)	t_{23} = 1.2, $p = .24$

E. Post-Study Questionnaire

In the post-study questionnaire participants rated the overall performance, usability, and convenience, as well as the effectiveness of the undo/redo and the selective translation features of the proposed method on a 7-point Likert scale. A Wilcoxon Signed-Rank test identified a significant effect of method on performance (z = 4.50, $p < .0001$), usability (z = 4.44, $p < .0001$), and convenience (z = 3.04, $p < .005$). There was also a significant effect on the undo/redo (z = 4.80, $p < .0001$) and the selective translation feature (z = 4.37, $p < .0001$). Figure 8 presents all user responses.

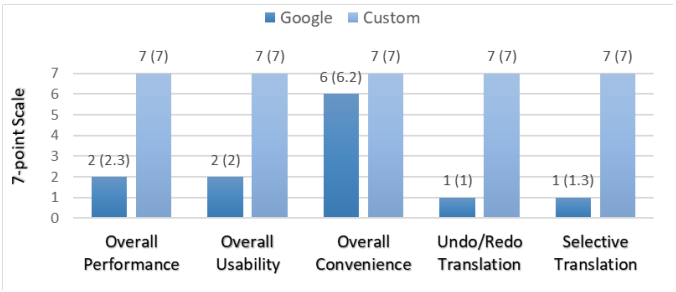

Fig. 8. Median user ratings of the translation method on a 7-point Likert scale, where *1–7* signified *completely dissatisfied–completely satisfied*. The values inside the brackets are the average user ratings.

VIII. DISCUSSION

The proposed translation method yielded a significantly better performance compared to the Gboard's translation features in terms of speed, average number of actions, and error correction effort. Results revealed that performing translation tasks with the proposed method was about 35% faster. It also required about 70% fewer actions to perform translation tasks. Further analysis revealed that only 3.3% of all translation tasks required multiple actions with the proposed method. However, there was no significant effect of method on corrective actions. This is because participants rarely committed errors in performing the translation tasks. Participants did commit errors in transcribing the phrases in English but we ignored these since these were not related to translation tasks. We did not find a significant difference in performance between the Mandarin and the Hindi native speakers.

User feedback was overwhelmingly positive (Fig. 8). Participants found the proposed method significantly more effective and user-friendly than Gboard. It yielded the highest median score of 7 for both performance and usability, when Gboard yielded a much lower median score of 2. Interestingly, participants found both methods equally convenient but rated the proposed method's ability to translate text using the suggestion bar significantly higher. Participants also found the undo/redo translation and the selective translation features of the proposed method significantly more effective. These two features yielded the highest median score of 7, when Gboard yielded 1. Further, participants learned the proposed method quickly during the practice period. They all were confident with their ability to use the method. After the study, almost all of them expressed their excitement and enthusiasm about the proposed method and wanted to install it on their mobile devices.

IX. Conclusion and Future Work

We added new text translation features to the suggestion bar of a virtual keyboard to facilitate fast and easy translation between different languages on mobile devices. We evaluated the proposed method in two empirical studies. In the first study, native Hindi and Mandarin speakers chatted with each other in each other's native language. Results revealed that all participants found the method fast and easy. They were satisfied with the quality and flow of the discussion and wanted to use it on their mobile devices for multilingual and polyglot conversation. In the second study, participants performed a range of translation tasks using Gboard and the proposed translation method. Results showed that the proposed method was significantly faster and required a significantly fewer number of actions per task. Qualitative data revealed that participants found the proposed method significantly more effective and user-friendly. They also found the undo/redo and the selective translation features of the method significantly more efficient.

This work highlights how seemingly minor design changes can make a big impact on the usability and the effectiveness of an existing system. We did not develop a novel translation service or an input method, instead proposed more intuitive interaction approaches with an existing service. The method proposed in this work can make a positive societal impact by enabling two users unfamiliar with each other's languages to engage in seamless, stimulating discussion without the hassle of switching between apps and repeated cut/copy-paste. It can also empower users by enabling them to enter polyglot text, for example mixing English and another language, instead of forcing them to one alphabet. This method can also uphold inclusivity by enabling users to take part in conversation and discussions in a foreign language.

In the future, we will investigate transliteration, where users enter text in one language using the alphabet of another language (for example, write Hindi using the Roman alphabet) for the system to convert the text to the target language's phonetic equivalent.

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