Automatic Keyboard Layout Design for Low-Resource Latin-Script Languages

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Abstract
We present our approach to automatically designing and implementing keyboard layouts on mobile devices for typing low-resource languages written in the Latin script. For many speakers, one of the barriers in accessing and creating text content on the web is the absence of input tools for their language. Ease in typing in these languages would lower technological barriers to online communication and collaboration, likely leading to the creation of more web content. Unfortunately, it can be time-consuming to develop layouts manually even for language communities that use a keyboard layout very similar to English; starting from scratch requires many configuration files to describe multiple possible behaviors for each key. With our approach, we only need a small amount of data in each language to generate keyboard layouts with very little human effort. This process can help serve speakers of low-resource languages in a scalable way, allowing us to develop input tools for more languages. Having input tools that reflect the linguistic diversity of the world will let as many people as possible use technology to learn, communicate, and express themselves in their own native languages.

Keywords: keyboard layouts, low-resource languages, mobile input, automation, scale

1. Introduction
As more of the world comes online, many new users may face a language barrier. While the percentage of internet sites written in English has been dropping, the vast majority of the content on the web remains written in only a few languages (Prado, 2012). The interaction between language and technology is especially important in endangered language communities as having technology available can be a significant factor in keeping young people active users of the language (Holton, 2011). If unable to interact with native-language content and tools online or on their devices, they would be compelled to use the majority language exclusively in those contexts and often in their daily interactions, a vicious cycle that further endangers the minority language (Pavlov, 2015).

Enabling interaction with content in these languages requires many complex components in computing, including Unicode encoding, fonts, and rendering. Another blocker is that many speakers of less-resourced languages may be unable to generate text content on the web very easily from their devices, even when encodings, fonts, and rendering are taken care of. For example, difficulty finding a desired character or having words autocorrected to the wrong language can discourage users from typing in the unsupported language. Paterson (2015) provides an example of a speaker of Me’phaa, a language indigenous to Mexico, who is using a standard Spanish or QWERTY keyboard and needs to spend extra effort to type the letter ‘á’, which appears in Me’phaa about 17 times more frequently than in Spanish: this user is likely to stick to typing in Spanish. An important step to increasing the amount of content available in a low-resource language is to give users access to specific keyboards for their own language.

Most keyboard layouts for smartphones and tablets are hand-designed. The creator must decide where each character should go and then produce configuration files implementing that design. This can be a time-consuming process. However, there are many low-resource languages that can be written in the Latin script. Out of the 2,500 languages listed with some amount of data in the Crubadán project, about 1,800 contain data in the Latin script (Scafell, 2007). These are spread all over the world geographically, and are certainly not just limited to Europe. In fact, over 150 are languages spoken in East and Southeast Asia (Table 1), which may not typically be thought of as a stronghold for the Latin script. As long as there is some textual data, creating keyboard layouts for these Latin-script languages can be automated. While we recognize that not all languages use the Latin script, automation for it is easier due to the proportionally high number of languages written in it and the existence of relatively established default keyboard layouts. We can thus save valuable linguistic time for languages and scripts requiring more work.

This paper presents the steps we used to automatically design over 50 Latin-script keyboard layouts for low-resource languages from all over the world in 2017. We hope to use this process for even more languages going forward, and can extend our method to other widely used scripts such as Cyrillic, Arabic, and Devanagari.

2. Intentions
Paterson’s (2015) writings on keyboard layouts for endangered languages make some salient points about the care that must be taken to design the best and most efficient keyboards for a particular language so that the speech community will actually adopt it: “Just because something is usable and useful does not mean that it is desirable.” We certainly agree that for the best results, careful thought should...
Figure 1: An example CSV format describing key positions in a layout. Here, "[punc]" is used in place of whichever punctuation characters you may want to store.

3. Designing Layouts

3.1. Storing the Layout Design

The set-up step in automating the process is to establish a data structure for describing the visible keys and long-presses for each key in a layout. We designed a simple comma-separated value (CSV) format where each row on the keyboard is described by two rows in the CSV: one storing the visible character on each key, and the other storing the characters that should appear when the user long-presses the key, space-separated if there is more than one character appears in the data set, case-insensitive. Punctuation characters are separated by Unicode category and stored for later. We then sort the remaining characters by frequency in their language we hope to be able to get feedback on a language and their ability to use modern information technology; they would appreciate any input tools to type in their own language. In 2017 alone around 180 million new people gained access to the internet and the growth rate is highest in the developing world (Biggs, 2017).

Second, Paterson mentions that while a few years ago, speakers of endangered languages might not have had any previous exposure to computer keyboards, this is no longer the case. If users have already learned letter placement on a QWERTY or another standard keyboard, we believe it is reasonable to keep the same basic layout, simply adding long-presses in logical locations to suit the language.

Third, while we want to develop these layouts quickly and automatically, the ultimate goal is to get them into the hands of users so that they can begin interacting with each other in their own languages and generating more content. Once they are accustomed to using technology more frequently in their language we hope to be able to get feedback on a better, more tailored design, while the users are at least able to continue using the first version in the meantime.

3.2. Gathering Data in the Language

There must be some data labeled in the target language in order to automatically determine which characters to factor into the layout design. Our method does not require a clean, curated corpus to produce effective keyboard layouts, although of course the quality of the layout is tied to the quality of the data. Suitable data can be mined and processed automatically from several resources found online (Prasad et al., 2018). The biggest demand from the data set is the character coverage, so the data set should be large enough that it is likely that all characters used in the language appear in the set. In this work, we used data mined from Wikipedia and from the Crübadán project (Scannell, 2007), as well as the Universal Declaration of Human Rights translations available through Unicode (Unicode Consortium, 2017).

3.3. Determining the Character Set

For each language, we count the number of times each character appears in the data set, case-insensitive. Punctuation characters are separated by Unicode category and stored for later. We then sort the remaining characters by frequency and note the writing script for each character. Any non-Latin characters are removed from the set. Depending on the size of the data set, it may also be helpful to remove any characters that only appear once or twice, although our approach is to leave those characters in the character set.

3.4. Choosing a Base Layout

Many Latin-script languages can likely be represented as QWERTY layouts with various long-press characters. However, there may be slightly more efficient base layouts for certain languages. In our case, linguists choose the base layout before auto-generating the layout, based on considerations such as familiarity with pre-existing layouts in the language community. A fully automated method is simple, however, by choosing QWERTY with ‘ñ’ if that character appears frequently, or AZERTY if the language is French-influenced, or other approximations as desired (Figure 2).

3.5. Gathering Characters for Long-Press

Once the base layout is selected, we determine which characters from the set are not already visible in the base layout.
and should appear as long-presses. We order these characters by frequency so that we will add the most popular characters to the easiest to reach positions in the pop-up (Figure 3).

3.6. Placing Long-Press Characters on Keys

We go through the long-press characters and decide which visible key should contain this character as a long-press. The character can for instance be converted into a Canonical Decomposition using the International Components for Unicode library, which will separate the character into its base character and its diacritic, if possible (Vajda, 2001). For example, ‘ô’ can become the two codepoints ‘o’ and a combining acute accent. Out of the roughly 400 characters in the Latin-1 Supplement, Latin Extended-A, and Latin Extended-B blocks of Unicode, about 250 can be decomposed in this way to determine the base character. 150 of them cannot, including characters such as ‘æ’ and ‘ß’. These are hardcoded into a dictionary so we can return the base character of the key where the given long-press character should be added (in these cases, we chose ‘a’ and ‘s’). Using this system, we update the layout data structure adding in the long presses to their correct keys.

3.7. Updating Other Features

We also automatically add in any codepoints we saw from the Unicode punctuation category (‘‘, ‘‘, and ‘‘, for example) as long-presses to the existing period key. We manually update the primary currency symbol displayed to fit the country primarily associated with the language, although it would be straightforward to automate this as well.

4. Instantiating Layouts

Once the layouts are automatically designed and stored into the CSV format, they need to be implemented. We have structured our keyboard layout implementation for the Android version of Gboard, the Google Keyboard, to be as simple for scaling as possible. The implementation stores the layout data in a hierarchy of XML files, which includes a list of supported languages tagged with BCP 47 language codes as well as sublists of variant keyboards, such as for alternative input modes like transliteration and handwriting. Each keyboard entry references an IME file (Figure 4) which lists supported layout variants and specifies overall properties of the keyboard such as whether auto-capitalization is enabled.

For Latin-script languages, this file generally lists a language-specific layout (such as the QWERTY-based layout with ‘ñ’) if there is one, along with variants for QWERTY, QWERTZ, AZERTY, Dvorak, and Colemak. Each entry references a general keyboard file which may be shared across languages and possibly an additional keyboard fragment file which includes references to language-specific key data (Figure 5).

Keyboard files consist of three elements: a layout grid (Figure 6), which is a hierarchy of Android LinearLayout elements containing Gboard SoftKeyView objects representing each key position; a keymapping (Figure 7), which associates key positions in the layout grid with SoftKey objects containing language-specific key data; and a softkey definition (Figure 8), which specifies each key’s properties.
Figure 6: Excerpt of an example layout grid file.

```xml
<framework>
  <key_mapping>
    <mapping view_id="@id/key_pos_0_0" key_id="@id/latin_q"/> ...
    <mapping view_id="@id/key_pos_0_10" key_id="@id/latin_a_ring_above"/> ...
  </key_mapping>
  <key_mapping state="SHIFT">
    <mapping view_id="@id/key_pos_0_0" key_id="@id/latin_n_tilde"/> ...
  </key_mapping>
  <key_mapping state="SHIFT">
    <mapping view_id="@id/key_pos_0_0" key_id="@id/latin_Q"/> ...
  </key_mapping>
</framework>
```

Figure 7: Excerpt of an example keymapping file for the Chamorro-language keyboard.

The softkey definition defines the main data for a key, which is generally the text entered by tapping the key, the long-press data, and additional information such as hint labels, accessibility content descriptions, and variable properties specifying the behavior of key-presses, most of which is saved in macro templates so that generally only the key position ID and primary and long-press input text need to be specified in the main softkey definition, allowing the file to be more compact.

Our layout generation pipeline automates the creation of new language-specific IME, keyboard, keymapping, and softkeys files as well as the addition of entries into other files such as the overall list of supported IME files and lists of softkey and keyboard IDs. This minimizes the amount of human effort needed to edit these files, leaving only a few tasks which can be manually tweaked if necessary, such as specifying currency symbols and hint labels. In the future, we could automate these elements as well, which would allow keyboard layouts to be fully specified in the Android XML structure given input data for a language.

Figure 8: Excerpt of an example softkey definition file for the Wolof-language keyboard.

```xml
<framework>
  <softkeys>
    <softkey id="@id/latin_q" press="q"/> ...
    <softkey id="@id/latin_e" press="e" long_press="é,è,ê,ë,ê"/> ...
    <softkey id="@id/latin_eng" press="é,è,ê,ë,ê"/> ...
  </softkeys>
</framework>
```

5. Conclusion

Creating mobile keyboards for low-resource languages can empower users to generate more web content in these languages. As Paterson (2015) rightly cautions, “technology in and of itself is not the saviour of an endangered language.” However, we have shown that it is relatively simple to scale this technology to many languages, and we hope that users can benefit from these keyboards. They serve practically as tools, but also as an invitation for groups who were previously excluded to participate in new technology that has been accessible to speakers of more widely spoken languages. As more content is created and the ecosystem grows, it will presumably attract more users, generating yet more content to serve these users, and enabling the development of further tools that depend on larger corpora to support these languages. We hope this paper inspires others to scale their tools automatically to more languages. More vibrant ecosystems and better tools in turn would hopefully enable and encourage more speakers to interact with each other, and the web at large, in their preferred languages.

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