

# A Method for the Affixed Word Transliteration to the Balinese Script on the Learning Web Application

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**Abstract:** This research proposed a method for the affixed word transliteration to the Balinese Script since there has not been studied yet and it is important since the affixed word needs to be transliterated, inevitably. This research is one of the efforts to preserve digitally the endangered Balinese local language knowledge in Indonesia through the multi-discipline collaboration between Computer Science and Language discipline. The proposed method was taken care of two related aspects, i.e.; (1) A Latin root word has its related Balinese Script root word by using default or special transliteration rule; and (2) A Latin root word with a special transliteration rule for its Balinese Script root word, also need a special transliteration rule for its affixed word. This study was conducted on the pioneering web-based transliteration learning application, BaliScript, that receives the Latin text input and outputs the Balinese Script by using the Noto Serif Balinese font with its dedicated Balinese Unicode. Through the experiment, the proposed method gave the expected transliteration results, added a certain perspective, and strengthened the transliteration knowledge. Future work is to enhance and reuse this method on the mobile computing device, as a part of the Balinese Language ubiquitous learning that supports Balinese Language education, which is a mandatory local subject from the elementary school to the high school in Bali Province.

**Keywords:** affixed word, Balinese Script, transliteration, learning web

## 1. Introduction

The Balinese Script as an endangered local language (G. Indrawan, Paramarta, Agustini, & Sariyasa, 2018) in Indonesia affects its Latin-to-Balinese Script transliteration knowledge, as part of the transliteration research in general (Karimi, Scholer, & Turpin, 2011; Kaur & Singh, 2014). The preservation effort by the Bali Government has already been conducted through the Bali Governor Circular Letter (Bali Government, 2018) that follows up the Bali Governor Regulation (Bali Government, 2019). Also, from the previous preservation regulation, the Balinese Language (including all aspects of the Balinese Script) was considered and running as a mandatory local subject from elementary school to senior high school in Bali Province.

As the preservation effort of the language can be done by that governmental/political approach, multiple approaches should strengthen it and should have a greater impact. This research joined the effort through the technological approach, through the multi-discipline collaboration between Computer Science and Language discipline, by proposing a method for the affixed word transliteration to the Balinese Script since there has not been studied yet and it is important since the affixed word needs to be transliterated, inevitably. Moreover, this study was conducted on the pioneering web-based transliteration learning application, BaliScript, as part of the planned Balinese Language ubiquitous learning that supports Balinese Language education. The proposed method can be reused in the future for the mobile application as part of ubiquitous learning to give the transliteration knowledge for the next generations to come. As known, ubiquitous learning improves learning by providing learners with content and interaction anytime and anywhere (Hwang, Tsai, & Yang, 2008) by mobile and embedded computers and wireless networks in everyday life (Ogata, Matsuka, Bishouty, & Yano, 2009).

This research proposes an unexposed method for the affixed word transliteration to the Balinese Script based on the supporting computer font Noto Serif Balinese (NSB). Also, this work advances the previous authors' work on the transliteration process by: (1) accommodating the rule from the Balinese Language, Script, and Literature Advisory Agency (Anom et al., 2009). This Bali Province government agency (Bali Government, 1992) carries out guidance and formulates programs for the maintenance, study, development, and preservation of the Balinese Language, Script, and Literature; (2) accommodating seventeen types of special words (G. Indrawan, Paramarta, & Agustini, 2019; G. Indrawan, Paramarta, et al., 2018) by using a particular table structure in the database which is avoiding hard-coded special word repositories in the learning application; (3) utilizing the Noto Serif Balinese font (Google, 2020b; The Unicode Consortium, 2020b, 2020a) with more developed and less bug than the Noto Sans Balinese font (Google, 2020a). Also, it uses dedicated Balinese

Unicode as a standard Balinese Script font on the computer system including mobile devices (so the method can be reused on the mobile application); and (4) maximizing the learning application, that used this method, for the delivery of the knowledge in the area of transliteration and also translation, at the same time, specifically for the Balinese Script, Indonesian, and English (see the next Figure 2). Overall, all of those advances were considered as the contribution of this work.

This paper is organized into several sections, i.e.: Section 1 (Introduction) states the problem background related to the Balinese Script in general, and the Latin-to-Balinese Script transliteration in specific; Section 2 (Related Work) describes the related works in the area of the Latin-to-Balinese Script transliteration; Section 3 (Research Method) exposes the supporting transliteration computer font (which is the NSB font) with its dedicated Balinese Unicode, and the supporting rule-based algorithm for the affixed word transliteration to the Balinese Script; Section 4 (Result and Discussion) covers the analysis of the testing result; and finally, Section 5 (Conclusion and Future Work) consists of some important conclusion and future work points.

## 2. Related Work

As the Balinese Script adheres with its scriptio-continua writing style like its relatively close (geographically and culturally) Javanese Script (Widiarti & Pulungan, 2020), several related works on Latin-to-Balinese Script transliteration were conducted on the previous author's works (Crisnapati et al., 2019; G. Indrawan, Dantes, Aryanto, & Paramarta, 2020; G. Indrawan, Gunadi, Gitakarma, & Paramarta, 2021; G. Indrawan, Paramarta, et al., 2019; G. Indrawan, Puspita, Paramarta, & Sariyasa, 2018; G. Indrawan, Sariyasa, & Paramarta, 2019; G. Indrawan, Setemen, Sutaya, & Paramarta, 2020; G. Indrawan, Swastika, Sariyasa, & Paramarta, 2020; Loekito, Indrawan, Sariyasa, & Paramarta, 2020). Various non-dedicated Balinese Unicode fonts (i.e. Bali Simbar (Suatjana, 1999) and Bali Simbar Dwijendra (Suatjana, 2009)) and dedicated Balinese Unicode font (The Unicode Consortium, 2020b, 2020a) (i.e. Noto Sans Balinese (Google, 2020a)) were used for displaying Balinese Script output on those previous research. A more developed dedicated Balinese Unicode font was found on Noto Serif Balinese font (Google, 2020b) rather than Noto Sans Balinese font. Bali Simbar font was used in (G. Indrawan, Sariyasa, et al., 2019) with a relatively good accuracy result on testing cases from The Balinese Alphabet document (Sudewa, 2003). It was also used on the developed robotic system that writing Balinese Script from Latin text input (Crisnapati et al., 2019), and on the transliteration line-breaking handling exploration (G. Indrawan, Setemen, et al., 2020). Bali Simbar Dwijendra (BSD) font, as the improvement of Bali Simbar (BS) font, was used in (G. Indrawan, Swastika, et al., 2020) with additional testing cases from the Balinese Script dictionary (Anom et al., 2009), in addition to the same testing cases on (G. Indrawan, Sariyasa, et al., 2019). It was also used on the transliteration exploration of the mathematical expression (G. Indrawan, Dantes, et al., 2020). Ten transliteration lessons were also learned by using this font on the extended testing data (G. Indrawan et al., 2021) other than the initial established testing data (G. Indrawan, Paramarta, et al., 2019; G. Indrawan, Sariyasa, et al., 2019). Noto Sans Balinese font was used in (G. Indrawan, Paramarta, et al., 2019) with the same testing cases in (G. Indrawan, Sariyasa, et al., 2019) and gave a relatively good accuracy result. It was also used on the developed robotic system that writing Balinese Script from Latin text input (G. Indrawan, Puspita, et al., 2018). Extensive accuracy analysis on the developed algorithm (G. Indrawan, Paramarta, et al., 2019) was conducted in (Loekito et al., 2020) for improvement in the future.

For Balinese Script preservation effort and learning, both sides of transliteration knowledge need to be explored from a technological point of view for digitalization. Ref. (G. Indrawan, Ariawan, Agustini, & Paramarta, 2020) was related to the Balinese Script-to-Latin transliteration along with the other authors' work (Gede Indrawan, Gunadi, & Paramarta, 2020) that utilizing GNU Optical Character Recognition (OCR), i.e. Ocrad (Antonio Diaz, 2003). Ref. (Gede Indrawan et al., 2020) is still limited only to basic syllable (Sudewa, 2003) recognition from the Balinese Script image that was based on Bali Simbar glyph shape. For advancing functionality and mobile adoption for ubiquitous learning, utilization of Tesseract<sup>1</sup> OCR was conducted by (G. Indrawan, Ariawan, et al., 2020).

## 3. Research Method

The proposed method for the affixed word transliteration to the Balinese Script was relied on two related aspects, i.e.; (1) A Latin root word has its related Balinese Script root word by using default or special transliteration rule; and (2) A Latin root word with a special transliteration rule for its Balinese Script root word, also need a special transliteration rule for its affixed word.

This section describes: (1) the supporting transliteration computer font (which is the NSB font) with its dedicated Balinese Unicode, as a standard Balinese Script font on the computer system including mobile devices; and (2) the supporting rule-based algorithm for the affixed word transliteration to the Balinese Script.

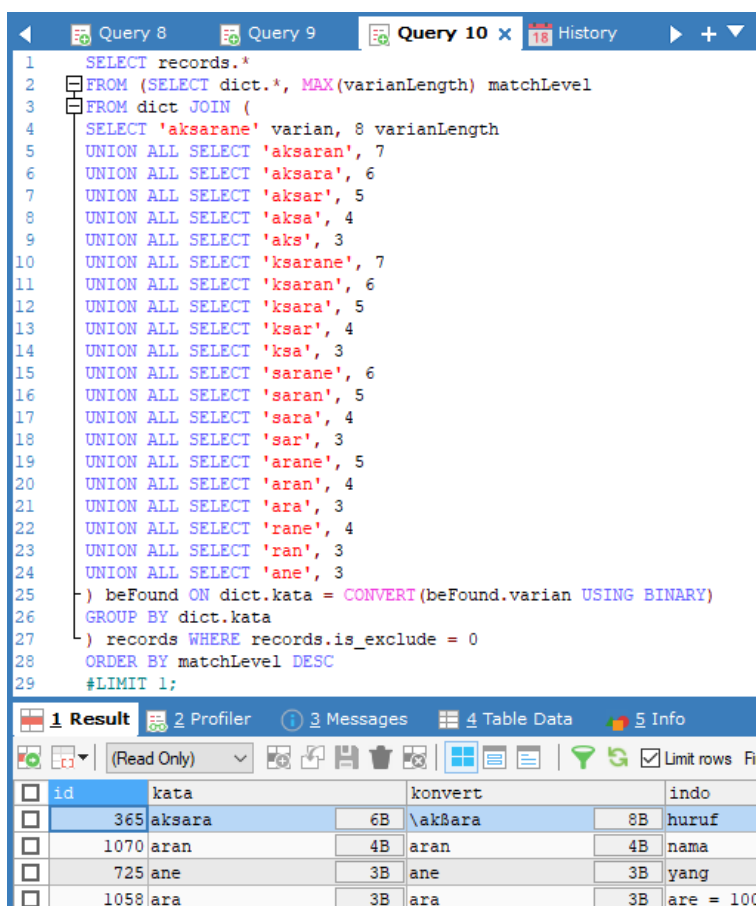
<sup>1</sup> <https://github.com/tesseract-ocr/> (Retrieved April 25, 2021)



clarity, the other records result was shown by commented line “LIMIT 1” of the constructed SQL instruction.

**Algorithm 1.** The affixed word transliteration to the Balinese Script

- 01 **insert** `word_string` and its `word_string_length` to SQL SELECT instruction
- 02 **set** `word_min` = 3
- 03 **set** `word_substring` = `word_string`
- 04 **for** `word_substring` and `word_substring` ≥ `word_min`, do
- 05 **set** `word_substring2` = `word_substring`
- 06 **update** `word_substring2` by removing its most left character
- 07 **for** `word_substring2` and `word_substring2` ≥ `word_min`, do
- 08 **insert** `word_substring2` and its `word_substring2_length` to SQL UNION ALL SELECT instruction
- 09 **update** `word_substring2` by removing its most right character
- 10 **end**
- 11 **update** `word_substring` by removing its most left character
- 12 **end**
- 13 **retrieve** `kata` and its related `konvert` from the database by using constructed SQL instruction with “records.is\_exclude = 0” and “LIMIT 1”
- 14 **update** `word_string` by replacing its same string part (refer to `kata`) with its related `konvert` of `kata`
- 15 **go to** the next transliteration process to get the Balinese Script output from the `word_string`



**Figure 1.** The example result from the fully constructed SQL instruction that was generated by the algorithm

Finally, line 15 gave `word_string` = “\akBarane” from column value “konvert” for the next transliteration process to give the right result “ꦲꦏꦧꦫꦺꦤꦺ”. As a note, the SQL instruction search in the database for all related words which have flag status `is_excluded` = 0. Also “konvert” was referred to as Balinese code in the next

result and analysis section.

### 3.3. The Testing

The testing of the proposed method was conducted on the web application that was run on Intel(R) Core(TM) i7-4600U CPU @ 2.09GHz platform with 8 GB RAM and Windows 8 64-bit Operating System. That web application was constructed by the web server of Apache 2.4.46 (Win64), the database server MySQL 10.4.18-MariaDB, and programming language PHP 7.4.16 combined with JavaScript. Also as one of the contributions of this work, this web learning application, that used this method, maximizing the learning experience through the delivery of the knowledge in the area of transliteration and also translation at the same time, specifically for the Balinese Script, Indonesian, and English (Figure 2). The translation information comes from the columns from the database. For example, Indonesian translation for certain transliterated word can be seen in the column “indo” (Figure 1)

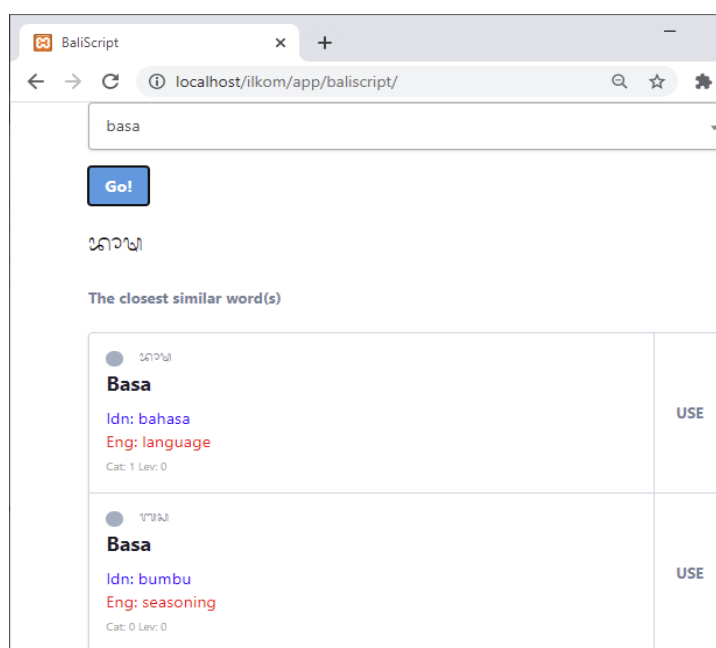
Table 2 shows the testing transliteration cases on several affixed words that exist from the testing data set of the previous authors’ work (G. Indrawan, Paramarta, et al., 2019). Those cases were also accompanied by their counterpart testing cases that comply with the rule from the Balinese Language, Script, and Literature Advisory Agency (Anom et al., 2009). All of those testing cases, along with the root words to be transliterated, consists of various affixed words (the bold words) that using a prefix and/or suffix.

**Table 2.** Testing transliteration cases

| Case <sup>1</sup>  | Case <sup>2</sup>  | Remarks   |
|--|--|---|
| 1 Bank <b>Pembangunan</b> Daerah Bali<br>Be Pe De Bali<br>Ba Pe Da Bali<br>Ba Pa Da Bali   | Bank <b>Pembangunan</b> Daerah Bali<br>Bē, Pē, Dē, Bali<br>Ba, Pe, Da, Bali<br>Ba, Pa, Da, Bali  | Abbreviations section in (Sudewa, 2003). Its English: <b>Regional Development Bank</b><br>Bali Be Pe De<br>Bali Ba Pe Da Bali<br>Ba Pa Da Bali  |
| 2 Akeh <b>akṣarane</b> , 47, luiꦩ ipun: akṣara suara, 14, akṣara wianjana, 33, akṣara suara <b>punika</b> talēr dados <b>pangangge</b> suara, tur <b>madrēwe</b> suara <b>kakalih</b> , <b>kawāšťanin</b> : suara hrēswa miwah dīrgha. | Akeh <b>akṣaranē</b> , 47, luiꦩ ipun: akṣara suara, 14, akṣara wianjana, 33, akṣara suara <b>punika</b> talēr dados <b>pangangge</b> suara, tur <b>madrēwe</b> suara <b>kakalih</b> , <b>kawāšťanin</b> : suara hrēswa miwah dīrgha. | Line Break section in (Sudewa, 2003). Its English: Many of <b>those letters</b> , 47, as follows vowels, 14, consonants, 33, <b>those</b> vowels also become vowel <b>signs</b> , and <b>have two</b> sounds, that <b>was called</b> : sound hrēswa and dīrgha. |

<sup>1</sup>The original testing cases from the previous authors’ work testing data set (G. Indrawan, Paramarta, et al., 2019)

<sup>2</sup>The updated testing cases that comply with the rule (Anom et al., 2009)

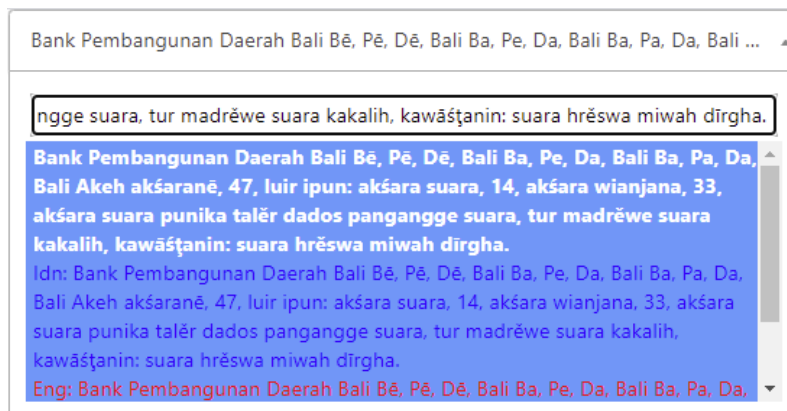


**Figure 2.** The BaliScript transliteration learning web application with translation feature for the Balinese Script, Indonesian, and English

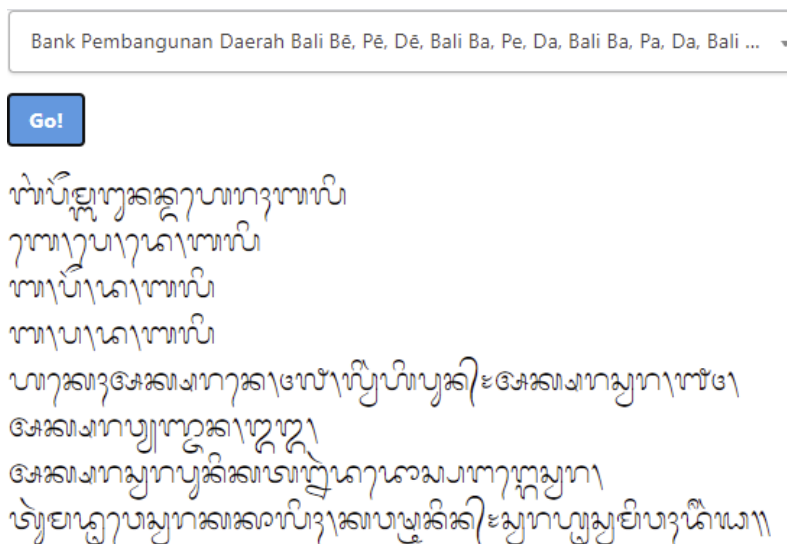
### 4. Result and Analysis

Figure 3 shows the testing result of the proposed method for the affixed word transliteration on the transliteration learning web application BaliScript. The testing on the BaliScript was based on testing cases in Table 2. Figure 3(a) shows the input with various affixed words through the select input box<sup>2</sup>, while Figure 3(b) shows the transliteration output with a line break for each testing case (Table 2). Several aspects were analyzed related to the transliteration process that was successfully displayed by the Noto Serif Balinese (NSB) font with its dedicated Balinese Unicode.

Balinese Script writing uses the non-scriptio-continua style (Widiarti & Pulungan, 2020) which means the output should fully occupy all of the writing space without paragraph and line break. For ease of learning and also for the ease of visual analysis, this aspect could be accommodated in the future by a feature to switch between the scriptio-continua style (the traditional look) and the non-scriptio-continua style (the modern look). The non-scriptio continua style using Cascading Style Sheets (CSS) property white-space<sup>3</sup> with value *pre-line*.



(a)



(b)

**Figure 3.** Transliteration result of various affixed words on the BaliScript learning web application: (a) the input through the select box; (b) the output with a non-scriptio-continua style.

The first affixed word, i.e. an Indonesian word “Pembangunan” (development) was constructed by a prefix “pem”, a root word “bangun” (develop), and a suffix “an”. The writing of “e” and its sound [ə] (Esling, 1999) complies with the rule from the Balinese Language, Script, and Literature Advisory Agency (Anom et al., 2009).

<sup>2</sup> <https://select2.org> (Retrieved April 25, 2021)

<sup>3</sup> [https://www.w3schools.com/cssref/pr\\_text\\_white-space.asp](https://www.w3schools.com/cssref/pr_text_white-space.asp) (Retrieved April 25, 2021)

The affixed word “Pembangunan” was successfully transliterated by the proposed method to the Balinese Script “ꦥꦺꦩꦧꦁꦸꦤꦁ” by using its Balinese code (see column “konvert” at the previous algorithm section) related to the existing root word “bangun” (“ꦧꦁꦸꦤꦁ”) in the database. As a note, consonant “n” (“ꦤ”) of word “Pembangunan” was transformed to “nda” (“ꦤꦢ”) since it was followed by a syllable “da” from word “Daerah”. The appended form of “da” was positioned under the regular form of “na” (“ꦤ”).

The second affixed word, i.e. a Balinese word “akṣarane” (that alphabets) was constructed by a root word “akṣara” (alphabets) and a suffix “ne”. The root word “akṣara” (Sudewa, 2003), as a variant word of “aksara” (Anom et al., 2009) with the same transliteration, is accommodated by the proposed method. Since its intended sound is [e] (Esling, 1999), to comply with the rule from the Balinese Language, Script, and Literature Advisory Agency (Anom et al., 2009), the writing of suffix “ne” should be changed to “nē”. Based on that change, the affixed word “akṣaranē” was successfully transliterated by the proposed method to the Balinese Script “ꦲꦏꦱꦫꦤꦺ” by using its Balinese code related to the existing root word “akṣara” (“ꦲꦏꦱꦫ”) in the database.

The third affixed word, i.e. a Balinese word “punika” (that) was constructed by a prefix “pu”, and a root word “nika” (that). The affixed word “punika” was successfully transliterated by the proposed method to the Balinese Script “ꦥꦸꦤꦶꦏꦏ” by using its Balinese code related to the existing root word “nika” (“ꦤꦶꦏꦏ”) in the database.

The fourth affixed word, i.e. a Balinese word “pangange” (sign) was constructed by a prefix “pang”, and a root word “ange” (use). The root word “ange” (Sudewa, 2003), as a variant word of “anggē” (Anom et al., 2009) with the same transliteration, is accommodated by the BaliScript. Rather than using its Balinese code related to the existing root word “ange” (“ꦥꦁꦁꦺ”) in the database, the affixed word “pangange” was successfully transliterated by the proposed method to the Balinese Script “ꦥꦁꦁꦁꦺ” by using its Balinese code related to the existing root word “ngange” (“ꦤꦁꦁꦺ”) in the database (see Algorithm 1). As a note, syllable “pa” (“ꦥ”) of word “pangange” was transformed to “spa” (“ꦱꦥ”) since it followed a consonant “s” (“ꦱ”) from word “dados”. The appended form of “pa” was positioned after the regular form of “sa” (“ꦱ”).

The fifth affixed word, i.e. a Balinese word “madrēwe” (have/has) was constructed by a prefix “ma” and a root word “drēwe” (belonging). The root word “drēwe” (Sudewa, 2003), as a variant word of “drewe” (Anom et al., 2009) with the same transliteration, is accommodated by the BaliScript. The affixed word “madrēwe” was successfully transliterated by the proposed method to the Balinese Script “ꦩꦢꦫꦺꦮꦺ” by using its Balinese code related to the existing root word “drēwe” (“ꦢꦫꦺꦮꦺ”) in the database.

The sixth affixed word, i.e. a Balinese word “kakalih” (both) was constructed by a prefix “ka” and a root word “kalih” (two). Rather than using its Balinese code related to the existing root word “kalih” in the database, the affixed word “kakalih” was successfully transliterated by the proposed method to the Balinese Script “ꦏꦏꦭꦶꦁ” by setting the flag status “is\_excluded” = 1 of the existing root word “kalih” (“ꦏꦭꦶꦁ”) in the database (see Algorithm 1). As a note, rather than using the Balinese Script “ꦏꦏꦭꦶꦁ” (Sudewa, 2003) as the ground truth for the transliteration result of the affixed word “kakalih”, the proposed method used “ꦏꦏꦭꦶꦁ” (with “ꦏ” as the Balinese Vowel Sign Tedung, U+1B35) since it complies with the rule from the Balinese Language, Script, and Literature Advisory Agency (Anom et al., 2009).

The seventh affixed word, i.e. a Balinese word “kawāṣṭanin” (be named) was constructed by a prefix “ka”, a root word “wāṣṭa” (name), and a suffix “nin”. The root word “wāṣṭa” (Sudewa, 2003), as a variant word of “wasta” (Anom et al., 2009) with the same transliteration, is accommodated by the BaliScript. The affixed word “kawāṣṭanin” was successfully transliterated by the proposed method to the Balinese Script “ꦏꦮꦱꦠꦤꦶꦤꦶ” by using its Balinese code related to the existing root word “wāṣṭa” (“ꦮꦱꦠ”) in the database. As a note, rather than using the Balinese Script “ꦏꦮꦱꦠꦤꦶꦤꦶ” (Sudewa, 2003) as the ground truth for the transliteration result of the affixed word “kakalih”, the proposed method used “ꦏꦮꦱꦠꦤꦶꦤꦶ” (without “ꦏ” as the Balinese Vowel

Sign Tedung, U+1B35) since it complies with the rule from the Balinese Language, Script, and Literature Advisory Agency (Anom et al., 2009).

### Conclusion and Future Work

A method for the affixed word transliteration to the Balinese Script was proposed with the implementation on the web learning application by using Noto Serif Balinese font with its dedicated Balinese Unicode. All various cases were handled successfully by the proposed method. This research added a certain perspective and strengthened the transliteration knowledge, which is part of the Balinese culture preservation effort.

Future work to enrich and strengthen this transliteration knowledge is to enhance and reuse this method on mobile computing through the implementation on the mobile device, as a part of the planned Balinese Language ubiquitous learning that supports Balinese Language education.

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