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Development of an Optimized Keyboard for the Tamazight Language: Integration of the Letter Frequency Model for Improved Ergonomics and Efficiency

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Abstract

The need for an ergonomic keyboard layout to minimize strain on wrists and fingers during prolonged use has become increasingly important with the proliferation of digital devices. For languages without a standardized keyboard layout, such as Tamazight, makeshift solutions have been used, leading to discomfort and strain on the user's hands and wrists, occasionally resulting in conditions such as repetitive strain injury (RSI) and tendonitis in the wrists. This study presents a novel approach to developing an optimized keyboard layout for Tamazight that focuses on user comfort and minimizes strain on the wrists and fingers. A keyboard stress model was developed in which the keys are classified according to their degree of difficulty and stress, taking into account the position of the keys and the strength and length of the fingers. A textual analysis of novels and songs with over 17,000 words in Tamazight was conducted to determine for the first time the frequency-letter model for the Tamazight language, mainly Kabyle. The frequency of use of each letter was used to distribute them based on the estimated stress level for each finger on the keyboard. The resulting layout minimizes the need for frequent finger switching and includes all the necessary additional keys for Tamazight language use, which is a significant improvement and a major step forward for the standardization of the Tamazight keyboard. The finished layout was implemented with the Microsoft Keyboard Layout Creator (MSKLC).

Keywords: Tamazight; Optimized Keyboard; Layout; Letter Frequency; Ergonomic.

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1. Introduction

In the field of linguistic innovation and digital ergonomics, this article aims to shed light on the development of an optimized keyboard specifically designed for the Tamazight language. In order to provide a comprehensive understanding, we will first look at the intricacies of the Tamazight language, its historical context and the various writing systems associated with it.

Tamazight, a Berber language spoken in North Africa, has a rich heritage and has been documented with two primary scripts: Tifinagh, a symbol-based system with deep historical roots, and the Latin alphabet developed by renowned writer and anthropologist Mouloud Mameri. While the Tifinagh has great cultural significance, the Latin script has become the predominant choice for the modern Tamazight script.

Figure 1 summarizes the 33 letters of the Tamazight language in both Latin and Tifinagh, together with the corresponding UNICODE [1]; 29 consonants and 04 vowels, namely “A”, “E”, “I” and “U”; where the “E” is a central silent vowel corresponding to the sound produced when all phonation organs are in a neutral position. A unique aspect of its grammar is the use of the hyphen to connect nouns, verbs or prepositions with their mobile affixes. Moving on to the current state of the Tamazight keyboard, it is important to note that the existing keyboards are merely adaptations of the Azerty layout, which has been expanded to accommodate Tamazight characters.

THE 33 LETTERS OF THE TAMAZIGHT ALPHABET					
UPPER CASE	UNICODE	LOWER CASE	UNICODE	TIFINAGH	UNCODE
A	0041	a	0061	ⴰ	2D30
B	0042	b	0062	ⵀ or ⴱ	2D31 or 2D60
C	0043	c	0063	ⵛ	2D5B
Č	010C	č	010D	ⵞ	2D5E
D	0044	d	0064	ⴷ or ⵔ	2D37 or 2D38
Ḍ	1E0C	ḍ	1E0D	ⴹ	2D39
E	0045	e	0065	ⴻ	2D3B
Ɛ	0190	ɛ	025B	ⵄ	2D44
F	0046	f	0066	ⴼ	2D3C
G	0047	g	0067	ⴳ	2D33
Ǧ	01E6	ǧ	01E7	ⵊ	2D35
Ɣ	0194	ɣ	0263	ⵖ	2D56
H	0048	h	0068	ⵀ	2D40
Ḥ	1E24	ḥ	1E25	ⵃ	2D43
I	0049	i	0069	ⵉ	2D49
J	004A	j	006A	ⵊ	2D4A
K	004B	k	006B	ⴽ	2D48
L	004C	l	006C	ⵍ	2D4D
M	004D	m	006D	ⵎ	2D4E
N	004E	n	006E	ⵏ	2D4F
Q	0051	q	0071	ⵇ	2D48
R	0052	r	0072	ⵔ	2D54
R	1E5A	ṛ	1E5B	ⵕ	2D55
S	0053	s	0073	ⵙ	2D59
Ṣ	1E62	ṣ	1E63	ⵚ	2D5A
T	0054	t	0074	ⵜ	2D5C
Ṭ	1E6C	ṭ	1E6D	ⵟ	2D5F
U	0055	u	0075	ⵓ	2D53
W	0057	w	0077	ⵡ	2D61
X	0058	x	0078	ⵅ	2D45
Y	0059	y	0079	ⵢ	2D62
Z	005A	z	007A	ⵣ	2D63
Ẓ	1E92	ẓ	1E93	ⵥ	2D65

Figure 1: Tamazight Alphabets: Latin and Tifinagh and Corresponding UNICODE

In the digital era, an ergonomic keyboard layout is crucial, as it helps to minimize strain on wrists and fingers. In light of this need, this article presents an innovative approach to optimizing keyboards. As part of a comprehensive study, a stress model was developed that classifies keys based on their difficulty and stress levels, taking into account the position of the keys and the biomechanics of the fingers. In addition, a text analysis of Tamazight novels and songs was conducted to determine the frequency of letter usage. This resulted in the distribution of characters on the keyboard based on the estimated stress levels for each finger.

By the end of this article, readers will gain valuable insight into the development of an optimized Tamazight keyboard designed to improve the user experience and promote healthier interaction with digital devices.

2. Keyboard Stress Model

In the realm of human hand ergonomics and efficient typing experiences, understanding the unique characteristics of each finger is crucial. The index finger, known for its strength and short length, is well-suited for pressing frequently used keys. Conversely, the pinky finger's weakness and short stature may limit its capacity for heavy workloads.

The middle finger, despite being long, offers a balance of strength and length, making it adaptable to various tasks. While the ring finger may be weaker, its length allows it to reach keys that other fingers might find challenging.

When designing interfaces or devices, it is essential to consider the conditions that minimize wrist strain and discomfort. By reducing side-to-side movements and prioritizing up-and-down motions, we can create a more comfortable and efficient typing experience for users.

Moreover, vertical movements between columns are natural for fingers, as they are designed to stretch and fold in these directions. This inherent flexibility contributes to a more comfortable and efficient typing experience.

To optimize finger placements, it is crucial to prioritize reaching for longer fingers and folding for shorter fingers when necessary. This approach takes into account each finger's unique range of motion, ensuring a more ergonomic and efficient layout.

Lastly, placing more frequent keys under stronger fingers can significantly enhance typing efficiency and minimize strain on weaker fingers. This balanced workload distribution reduces fatigue and improves overall performance.

In attempt to quantify the stress levels associated with each keyboard key [2], a rating scale was developed. This scale takes into account the previously described factors that influence the ease or difficulty of keystrokes and the staggered arrangement of the keys. By grading the keys from 1 to 5, representing the degree of difficulty and strain in reaching or pressing the keys with 1 being too easy and 5 being the most strenuous. This scale provides a valuable tool for understanding and potentially optimizing keyboard ergonomics. Figure 2 shows the resulting keyboard stress layout for an ISO 60%.

Figure 2: Standard Keyboard Estimated Strain Distribution

3. Tamazight Letter Frequency

A powerful instrument in the understanding of the verbal processing has been the statistical analysis of the language [3]. Letter frequency refers to the quantitative assessment of the frequency of occurrence in average for each letter within a particular alphabet belonging to a particular linguistic domain. This metric is important in various disciplines such as cryptography, linguistics and data compression. By examining letter frequencies, valuable insights can be gained into the structural intricacies of language, recurring patterns and even the compositional habits of its users. This data is often used to create probabilistic models, improve text prediction in digital devices or optimize the efficiency of encoding and decoding communications.

In the scientific community, there has been no comprehensive letter frequency model developed specifically for the Tamazight language. In order to fill this scientific gap, the present study serves as the first attempt to accurately determine the frequency of individual letters in the Tamazight language domain. This groundbreaking achievement is achieved through a thorough analysis of a variety of texts and poetic songs that are revered in the Tamazight language for their rich literary tradition, ensuring a thorough and comprehensive representation of the language's letter distribution patterns. This groundbreaking model provides a solid foundation for future research and applications, contributing significantly to scientific understanding and progress in the field of Tamazight linguistics.

The first step was to create the Visual Basic program shown in Figure 3 to develop a letter frequency model in the Tamazight language. The program was developed specifically for the analysis of Tamazight texts and focused on enumerating the occurrence of each of the 33 letters by examining 23 texts by different authors [4] and 48 song poems by different Kabyle singers [5], comprising over 17,000 words.

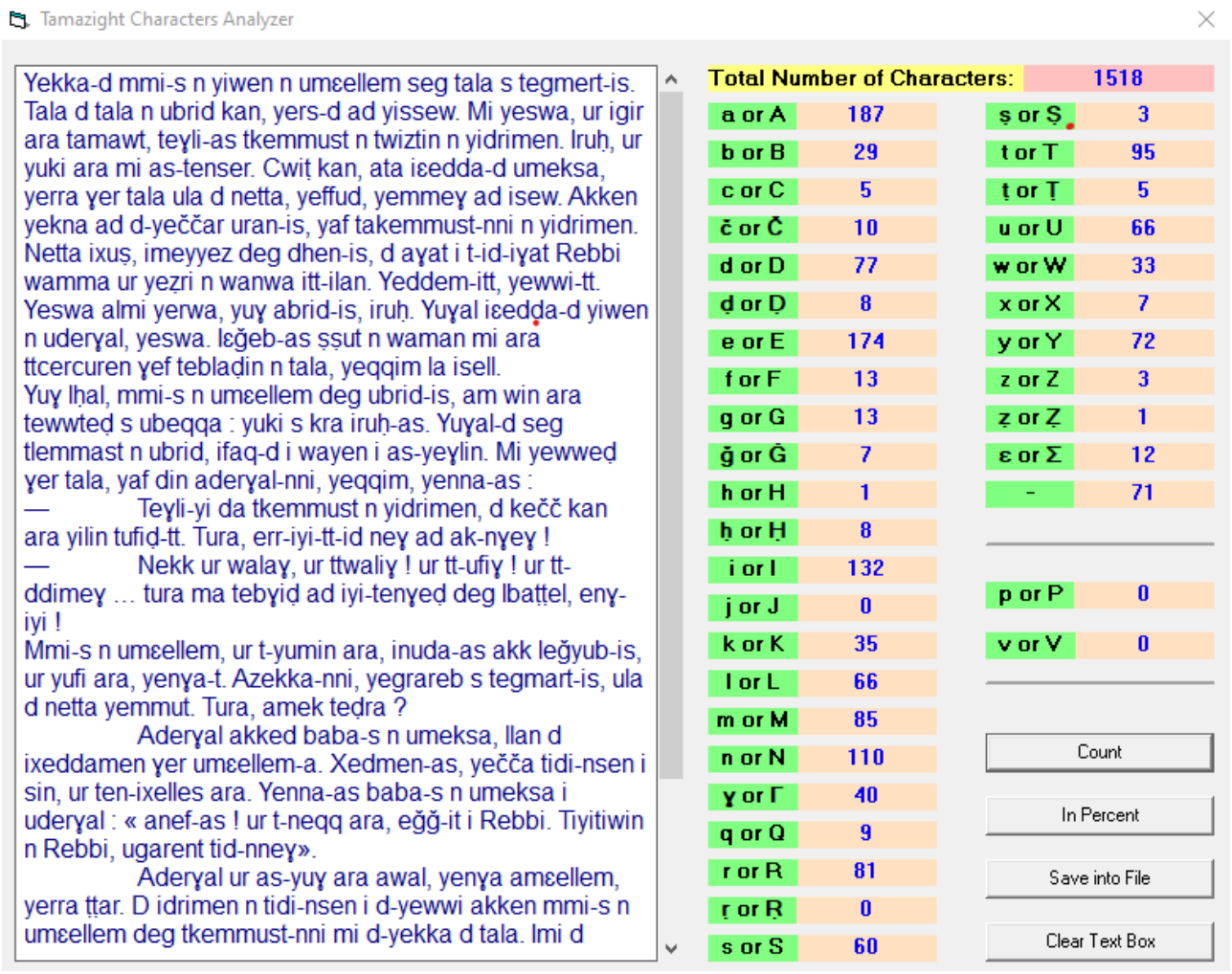

Figure 3: Tamazight Alphabet Letters Counting Program Developed in Visual Basic

Figure 4 illustrates the determined letter frequency model for the Tamazight language. Figure 5 shows the letter frequency for the Tamazight language in decreasing order. The following direct conclusions can be drawn from this model:

- The most dominant letters are "A", "E" and "I", indicating that these letters are frequently used in Tamazight.
- The vowels "A", "E", "I" and "U" together make up around 38.09% of the total letter frequency, with "A" being the most dominant vowel. This shows that vowel sounds are of great importance in the Tamazight language.
- "E" is listed as a silent vowel, which means that it is not pronounced in certain contexts, but still influences the word structure and pronunciation.
- Consonants make up the remaining 61.91% of the total frequency and show a varied distribution across the entire spectrum. It is particularly noticeable that "N", "T" and "D" are the dominant consonants, accompanied by "L", "M", "R" and "S", which are relatively frequent. These seven consonants account for a total of 37.38%. This prominence underlines their central role in shaping the vocabulary and

syntax of the language.

- Consonants "Y", "W", "K", "Γ", "G", "F", "B", "Z", "Ḥ", "Ḍ" and "Q" have relatively low frequencies but still cover 19.81%, indicating their importance in supporting the linguistic structure of the Tamazight language.
- The least frequent letters are "C", "X", "Ṛ", "H", "B", "Σ", "Ṭ", "Č", "Ẓ", "Ǧ", "Ṣ" and "J" have low frequencies, indicating that are used in a in certain linguistic contexts. While less frequent, these letters contribute to the diversity of the Tamazight language, representing specific phonetic nuances and semantic elements.

Letter	Letter Frequency
a or A	12.96%
b or B	1.67%
c or C	0.75%
č or Č	0.35%
d or D	5.93%
ḍ or Ḍ	0.99%
e or E	11.92%
ɛ or Σ	0.49%
f or F	1.67%
g or G	1.76%
ǧ or Ǧ	0.23%
ɣ or Γ	2.31%
h or H	0.52%
ḥ or Ḥ	1.00%
i or I	9.23%
j or J	0.21%
k or K	2.35%
l or L	4.81%
m or M	4.47%
n or N	7.12%
q or Q	0.97%
r or R	4.37%
ṛ or Ṛ	0.57%
s or S	4.28%
ṣ or Ṣ	0.23%
t or T	6.39%
ṭ or Ṭ	0.45%
u or U	3.98%
w or W	2.62%
x or X	0.59%
y or Y	3.28%
z or Z	1.20%
ẓ or Ẓ	0.35%

Figure 4: Tamazight Language Estimated Letter Frequency Model

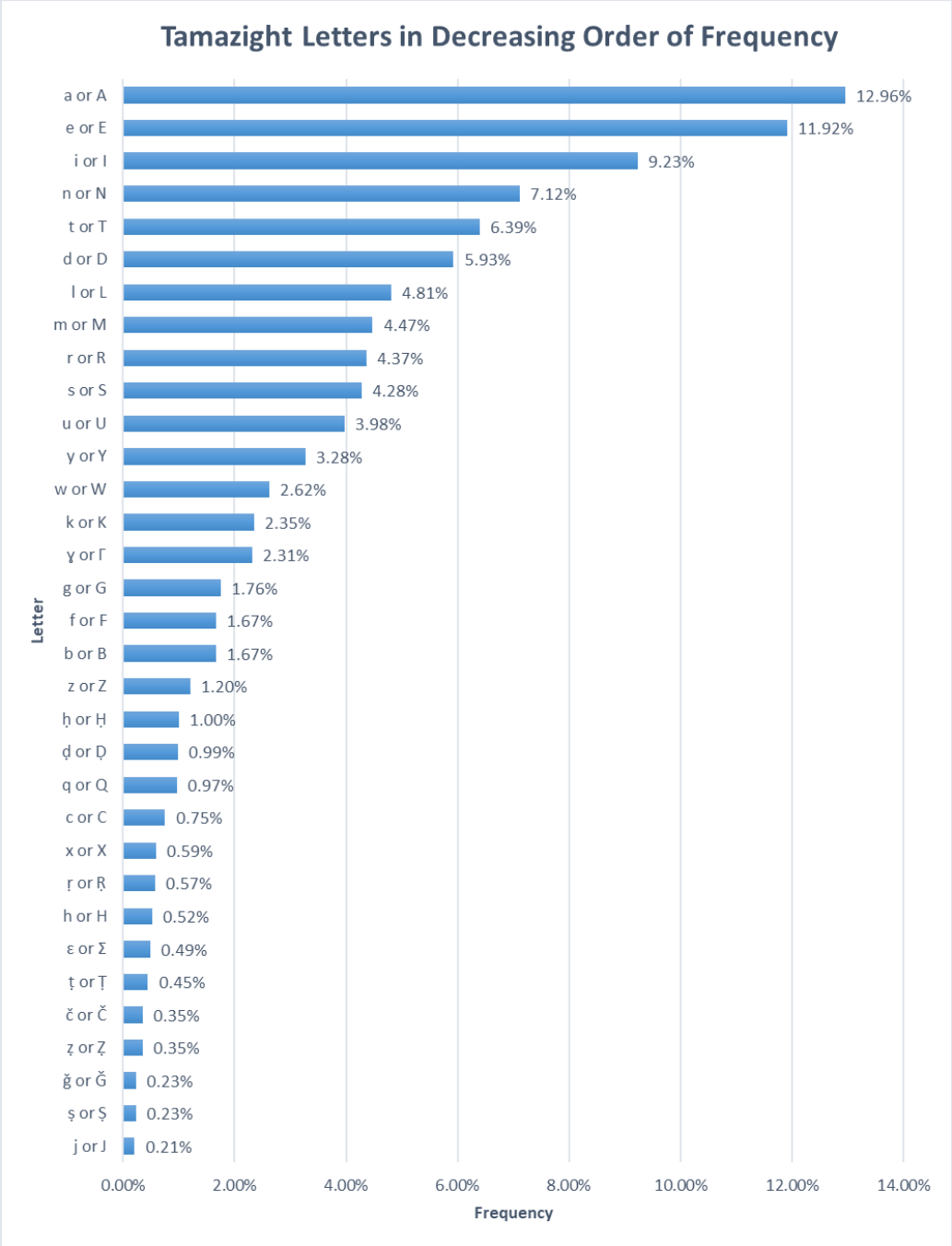

Figure 5: Tamazight Letters Frequency in Decreasing Order

To summarize, the ordered letter frequency model provides valuable insights into the structure, usage and features of the Tamazight language. It provides a basis for further linguistic analysis and practical applications and has significant potential for applications such as language modeling, text classification and speech recognition.

4. Optimized Tamazight Keyboard Layout

In this section, we will discuss the integration of the Keyboard Stress Model and the Tamazight Letter

Frequency Model to develop an optimized keyboard layout. By combining these two essential factors, we aim to create a layout that minimizes stress on the user's hands and fingers when typing in Tamazight. Table 1 shows the explanations for the optimized assignment of the Tamazight letters to the keyboard keys, as shown in Figure 2.

Table 1: Optimized Mapping of Tamazight Letters to Keyboard Keys

Letter	Frequency	Finger	Finger Strain	Explanation
a or A	12.96%	Left Middle	1	The left middle finger is dealing only with four dedicated keys, allowing it to execute repetitive movements without strain. The letter "A" is assigned to the lowest strain level. It is not allocated to the index finger keypads, as these fingers are responsible for managing multiple keys.
e or E	11.92%	Right Middle	1	Similarly to the left middle finger, the right middle finger is also having only 04 dedicated keys; this finger in this position could perform also repetitive moves without being strenuous. The letter "E" is assigned to the lowest strain level. It is not allocated to the index finger sections, as these fingers are responsible for managing multiple keys.
i or I	9.23%	Left Index	1	In the Home Row, two least strain positions are reserved for the left index finger, specifically designated for "I" and "N". To maintain spacing between "A" and "I", the letter "N" is positioned in between. The human brain has a natural inclination to distinguish dissimilar elements.
n or N	7.12%	Left Index	1	Please note the detailed explanation of the letter "I".
t or T	6.39%	Left Ring	1	One least strain position is available for the left ring finger, it is assigned to the letter "T".
d or D	5.93%	Left Pinky	1	One least strain position is available for the left pinky finger, it is assigned to the letter "D".
l or L	4.81%	Right Ring	1.5	One position with low strain is available for the right ring finger, assigned to the letter

				"L".
m or M	4.47%	Left Pinky	1.5	One position with low strain is available for the left pinky finger, assigned to the letter "M".
r or R	4.37%	Right Middle	2	The right and left middle fingers have two second-rank stain positions in the Top Row that will be assigned to letters "R" and "S" respectively.
s or S	4.28%	Left Middle	2	Please note the detailed explanation of the letter "R".
u or U	3.98%	Right Ring	2	Two second-rank stain positions are available for the right and left ring fingers in the Top Row, with one assigned to the letter "U" and the other to "Y" (No second-rank strain positions are available on the index fingers section).
y or Y	3.28%	Left Ring	2	Please note the detailed explanation of the letter "U".
w or W	2.62%	Left Pinky	2	The second-rank strain position for the left pinky is designated for the letter "W".
k or K	2.35%	Left Middle	2	This letter is allotted to the second-rank strain position on the left middle finger, located on the Bottom Row.
ɣ or Γ	2.31%	Right Index	2	The last second-rank strain position remaining on the keyboard is situated in the Bottom Row, allocated for the right index finger, it is assigned to the letter "Γ".
g or G	1.76%	Right Index	3	Two third-rank strain keys remain on the Home Row, both designated for the right index finger, and are respectively assigned to the letters "G" and "F".
f or F	1.67%	Right Index	3	Please note the detailed explanation of the letter "G".
b or B	1.67%	Left Index	3	Two third-rank strain keys are located on the Top Row of the index fingers sections. The one designated to the left index finger is assigned to the letter "B," while the one designated to the right index finger is assigned to the letter "Z."
z or Z	1.20%	Right Index	3	Please note the detailed explanation of the

				letter "B".
ḥ or Ḥ	1.00%	Left Ring	3	There are three third-rank strain keys remaining on the keyboard, located in the Bottom Row: one for the left ring finger and two for the left and right index fingers. Since the ring finger has a lighter workload compared to the index fingers, its position is allocated to the letter "Ḥ".
ḍ or Ḍ	0.99%	Left Index	3	As explained in the Letter "Ḥ" section; the two remaining third-rank strain keys on the Bottom Rows for the left and right index fingers are assigned to the letters "Ḍ" and "Q" respectively.
q or Q	0.97%	Right Index	3	Please note the detailed explanation of the letters "Ḥ" and "Ḍ".
c or C	0.75%	Left Index	4	Take note that only the Top and Bottom Rows contain fourth-rank strain keys. The left index finger section features only one fourth-rank strain key located in the top keypad; it is assigned to the letter "C".
x or X	0.59%	Left Pinky	4	Considering the priority given to the left side due to the keyboard's asymmetry, the second fourth-rank strain key in the Top Row, situated in the left pinky finger section is allocated to the letter "X" in this position.
ṛ or Ṛ	0.57%	Right Pinky	4	The last two fourth-rank strain key positions on the Top Row are situated in the right pinky finger section, designated for the letters "Ṛ" and "H".
h or H	0.52%	Right Pinky	4	Please note the detailed explanation of the letter "Ṛ".
ε or Σ	0.49%	Left Middle	4	Advantaged with strength, the fourth-rank strain position of the left middle finger in the Bottom Row is associated with the letter "Σ".
ṭ or Ṭ	0.45%	Right Ring	4	Due to the limited number of keys operated by the right ring finger, the fourth-rank strain position associated with it in the Bottom Row is assigned to the letter "Ṭ.
č or Č	0.35%	Left Pinky	4	There are two fourth-rank strain positions remaining on the Bottom Row, both linked

				to the left pinky finger. One of these positions is allocated for the letter "Č."
ẓ or Ẓ	0.35%	Left Index	5	Given that there is only one fifth-rank strain key designated for the right index finger in the Top Row, associating this position with the letter "Ẓ" would place it close to its counterpart "Z". Therefore, it was decided to assign it the sole available fifth-rank strain key designated for the left index finger in the Bottom Row.
ğ or Ğ	0.23%	Right Index	5	Building upon the explanation provided for the letter "Ẓ", the letter "Ğ" is positioned in the sole available fifth-rank strain key allocated for the right index finger in the Top Row.
ṣ or Ṣ	0.23%	Right Pinky	5	Two fifth-rank strain keys are associated with the right pinky finger: one in the Top Row assigned to the letter "Ṣ", and the other in the Bottom Row assigned to the letter "J".
j or J	0.21%	Right Pinky	5	Please note the detailed explanation of the letter "Ṣ".

In addition to the alphabetic keypad, the layout of the keyboard's remaining keys has been carefully designed based on the proximity of symbols to ensure optimal accessibility and efficiency for users performing various tasks. The keyboard is designed for a variety of functions, including word processing, web browsing, email, multimedia tasks, spreadsheets, presentations, programming, gaming, file organization and communication, thus meeting the diverse needs of users. In particular, the symbols for mathematical operations, text punctuation, curly brackets and navigation are strategically grouped for intuitive access. In addition, the letters O, V and P have been included in the layout to make it easier to write foreign names such as Olivier, Paris (Pari) or Polish (Apuluni) in appropriate contexts. Figure 6 shows the final layout, which represents the culmination of the work done thus far.

Figure 6: Streamlined Tamazight Keyboard Layout

The Microsoft Keyboard Layout Creator (MSKLC) was crucial in the implementation of the optimized keyboard for the Tamazight language. MSKLC is a user-friendly software from Microsoft for customizing keyboard layouts under Windows. Users can modify existing layouts or create new layouts to suit their language or specific needs and easily assign characters, symbols and functions to keys. As can be seen in Figures 7, 8 and 9 with MSKLC, the customized layout for Tamazight has been carefully designed to ensure optimal accessibility and efficiency for users of the Tamazight language.

Figure 7: Tamazight Keyboard Layout - Primary Layer

Figure 8: Tamazight Keyboard Layout – Secondary (Shift) Layer

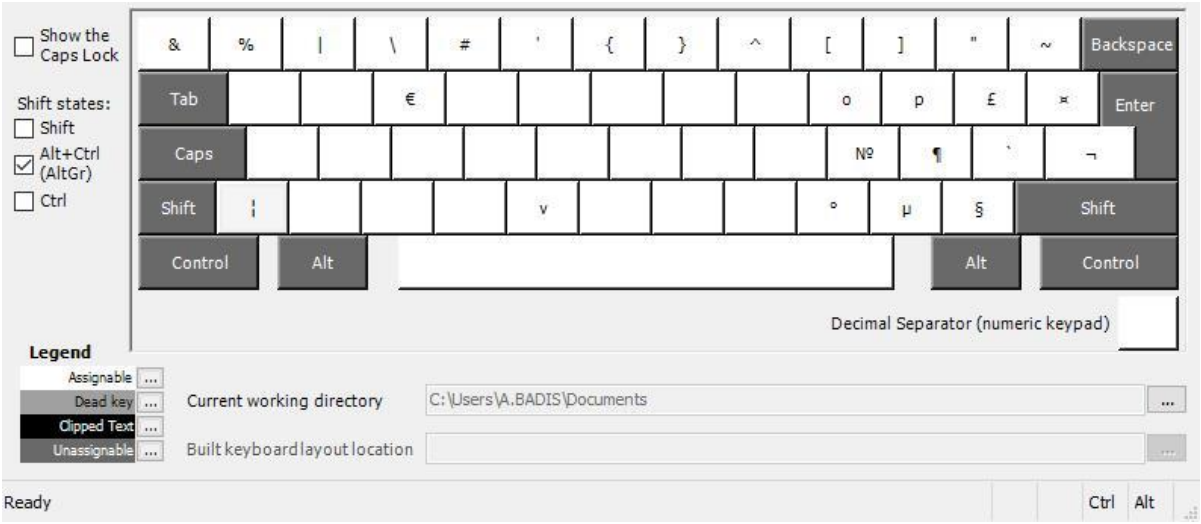

Figure 9: Tamazight Keyboard Layout – Tertiary (AltGr) Layer

Mouloud Mammeri, already mentioned in this article, was a well-known Algerian writer, anthropologist and linguist. He is known for his contributions to Tamazight culture and literature, especially for his efforts to preserve and promote the Kabyle language and culture. It was decided to name this optimized layout Tamazight Mammeri Layout. This name is to honor his legacy and pay tribute to his efforts in promoting the Tamazight language and culture.

5. Conclusion

This work addressed the urgent need for an ergonomic keyboard layout tailored to the Tamazight language, with a focus on minimizing discomfort and strain during prolonged typing sessions. By integrating a keyboard stress model and pioneering the development of a frequency-letter model specifically for Tamazight, an optimized layout has been developed that prioritizes user comfort and typing efficiency. The strategic distribution of letters

based on finger strength and novel frequency analysis is designed to reduce the risk of repetitive strain injuries and improve the overall typing experience for Tamazight users. The implementation of the final layout using the Microsoft Keyboard Layout Creator (MSKLC) represents a significant step towards the standardization of the Tamazight keyboard and provides a practical solution to improve user comfort and productivity in the modern computer age. Future work could explore further refinements to the layout based on user feedback and usability studies, as well as possible enhancements to accommodate additional language features or dialect variations within the Tamazight community.

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- Slimane AZEM: Zzux Zzux d Lmecmel, L ɛeqqal.
- Cherif KHEDDAM: Anef ad Dreɣ Deg Menni, Bgayet Telha.
- Lounes MATOUB: Abrid i Reglen, Tisirt n-Nddama, A Yemma Yemma, Aẓṛu Leɣṛib, Kenza, Ay Adrar n At Yiraten.
- Ali AMRAN: Ma d Awal, Ssfina, Tazla n Wussan, D Yir Ddunit, Ffudeɣ a Win Iswan.
- Smail KESSAY : Ddiban, Laxyalat.
- Lounis AIT MENGUELLET: Tafat, Abrid n Temẓi, Acḥal i Hedreɣ Fell-am, Ay Abrid.
- SI MOH: Mači Wi Ibedden, Ur Neslib Ara, Tasusmi.
- AIT MESLAYEN: A Yemma a Baba, Ṛṛuḥ Ay Aɛṛab ar Tafsut.
- Brahim TAYEB : Ussan-Nni, Lemḥiba-m, Di Laman, Inet-as, Ḥemmleɣ-Kem.
- AFOUS: Ugadeɣ.
- Rabeh LANI: A Tin Ґef ig ul Yeḥreq, Ḥemmleɣ-kem, Walaɣ Lexyal.
- Brahim IZRI: Mennaɣ.
- LES ABRANIS : Adfel, Ameksa d y-Izem.
- Mhenni AMROUN : Tettcekiṛeḍ-iyi-d Jedd-ik.
- MENNAD : Aḥeddad Lqalus, Ḥmed Umerri, Ttuha.