International Journal of Engineering, Science and InformationTechnology
Volume 4, No. 2 (2024) pp. 52-58
ISSN 2775-2674 (online)
Website: http://ijesty.org/index.php/ijesty
DOI: https://doi.org/10.52088/ijesty.v4i1.506
Research Paper, Short Communication, Review, Technical Paper

Web-Based Math Braille Translator Using Indonesian Braille Symbols

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The manuscript was received on 1 January 2024, revised on 30 March 2024, and accepted on 19 June 2024, date of publication 16 July 2024

Abstract

According to estimates from the Indonesian Ministry of Health in 2017, at least 3,750,000 people in Indonesia have visual impairments. This significant number highlights the need for special attention to their educational needs, especially in mathematics. Educational media is essential to facilitate learning for visually impaired students and educators, as they often struggle with understanding math due to limited access to visual content. One solution is to use Mathematical Braille symbols, yet the technology that translates these symbols into mathematical text is still limited. To address this, the author has developed a web-based Math Braille Translator application aimed at assisting visually impaired individuals and educators. This website translates mathematical Braille into notation by inputting Braille using the keys s, d, f, j, k, and l on the keyboard. The application is developed using the waterfall methodology and is based on the Indonesian Mathematical Braille Symbol Reference Number 056/U/2000.

***Keywords**: Visually Impaired, Braille Mathematics, Math Braille Translator, Website.*

1. Introduction

In the digital era, websites have become an important medium in human life, fulfilling needs for information, shopping, interaction, and learning. The development of websites has been accelerated by the latest technologies such as HTML5, CSS3, and JavaScript, enabling the creation of more interactive and responsive sites [1]. Despite significant advancements in web development, there are still several issues that need to be addressed [2]. Websites designed for sighted individuals often overlook accessibility for the visually impaired. The visual limitations faced by the blind make it difficult for them to access information and participate in online activities through visual media like computer screens and smartphones, which are commonly used by others. Accessing information and learning facilities, which affects their educational participation. The Chairperson of the Indonesian Blind Union (PERTUNI), Aria Indrawati, stated that only about 20% of blind children attend school, due to low family awareness, a shortage of teachers in inclusive schools, and a lack of facilities for using Braille [3].

According to Law No. 20 of 2003 on the National Education System, citizens with special needs are entitled to receive education that meets their needs. The Ministry of Health of Indonesia estimates that the number of visually impaired individuals in the country is about 1.5% of the total population, approximately 4 million people [4]. For blind students, visual learning materials are inaccessible, whether they are completely blind or have low vision. They often use Braille, a system that enables reading and writing with small dots arranged in six positions to represent letters and numbers [5].

This research was conducted at Yayasan Mitra Netra, a nonprofit organization that enhances the quality of life for visually impaired individuals in education and employment [6]. Interviews with Mitra Netra representatives highlighted the need for a website program that translates Braille into mathematical notation, to assist visually impaired students and educators in learning mathematics. Visually impaired students often struggle to understand dictated mathematical equations, making this software essential for bridging the gap between teachers and visually impaired learners [7] [8].

The Math Braille Translator website was developed to enhance mathematical accessibility for visually impaired individuals. This application translates Braille into mathematical text, making it easier for visually impaired students to learn. The Math Braille Translator can handle various types of mathematical texts, including arithmetic and algebra. The Braille symbols used adhere to the guidelines 056/U/2000. Additionally, this website implements a six-finger typing method, allowing visually impaired users to type combinations of keys that represent Braille dots on a keyboard. For

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example, if a user wants to type the letter "a" in Braille, they can press the "s" key (representing dot 1 in Braille), the "d" key (representing dot 2 in Braille), and the "f" key (representing dot 3 in Braille) simultaneously [5].

2. Literature Review

2.1. Website

A website is a tool on the internet that is used to disseminate information. Apart from functioning as a platform for disseminating information, websites can also act as a platform for running an online business. Websites are located within domains or subdomains on the World Wide Web (WWW) and each page is created using HTML (Hyper Text Markup Language) format. These pages are usually accessible via the HTTP protocol, which sends information from the website server to the user via a web browser. A web browser is software used to access and browse web pages, such as Internet Explorer, Mozilla Firefox, Opera, Safari, Google Chrome, and other similar applications. The publications on this website can form a broad information network on the internet [9] [10].

2.2. Braille Symbols

Braille is a writing system that uses a matrix of two columns and three rows, forming certain patterns in the Braille language. There are 64 possible pattern combinations (2 to the power of 6 = 64) to depict Braille letters. This system was created to make it easier for the blind to read because it uses the sense of touch by touching the prominent points of the Braille letters. Louis Braille was the person who discovered the Braille letter system in 1827 [4] [11].

2.3. Indonesian Mathematics Braille Symbols

Braille continues to experience improvements, especially in Indonesian Mathematics braille symbols. Refining the guidelines based on the main ideas which include, among others: readability, consistency, and orientation towards the highest frequency of word use and following EYD rules. Until now, the valid Indonesian mathematical braille symbols are guided by the Mathematical Braille Symbol Number 056/U/2000, the attachment of which is in the Attachment to the Decree of the Minister of National Education Number 056/U/2000 dated 13 April 2000 on the Indonesian Braille System in the Field of Mathematics [12] [13].

Operation	Symbol	Poin Code
+	⠢	2-6
−	⠔	3-5
:	⠌⠌	1-3, 1-3
×	⠢	2-6
=	⠒⠒	2-5, 2-5
Number Sign	⠼	3-4-5-6
1	⠂	2

Figure 1. Example of Indonesian Mathematics Braille Symbol Reference Number 056/U/2000

2.4. Software Development Life Cycle (SDLC)

Software Development Life Cycle (SDLC) is a system design cycle and methodology for developing software to produce a high-quality system and meet user expectations [14]. SDLC implementation aims to minimize the possibility of a system crisis by providing detailed stages. SDLC implementation produces two main products: Software Requirements Specification (Software Requirements Specification) and applications or systems that suit the specified needs [15] [16]. The SDLC that is used is Waterfall. Below is an illustration of the phases contained in the waterfall method:

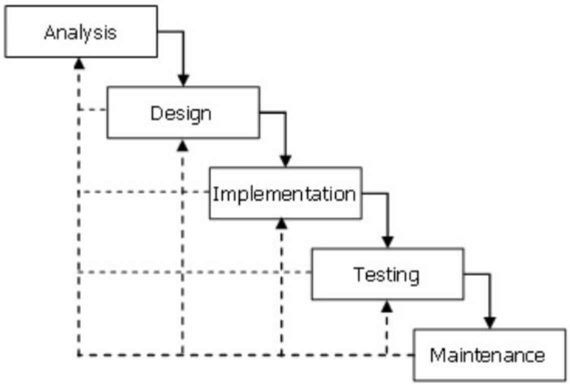

Figure 2. Stages in the waterfall methodology

2.5. Unified Modelling Language (UML)

Unified Modeling Language (UML) is a standard language for visualizing, specifying, constructing, and documenting artifacts of complex software systems. UML can be used to model all processes in the software development life cycle, using specific notation for each stage. In addition, UML functions as a communication tool for the development team and stakeholders. In industry, UML is used to interpret requirements, design and analyze systems, and describe architecture in the context of object-oriented programming [17] [18] [19].

3. Methods

The Math Braille Translator web-based application uses the System Development Life Cycle (SDLC) as its development framework with the Waterfall method, as the software requirements are clearly defined [20]. The Waterfall method is applied up to the testing phase, encompassing four stages: Analysis, Design, Implementation, and Testing. Below is the figure for these stages:

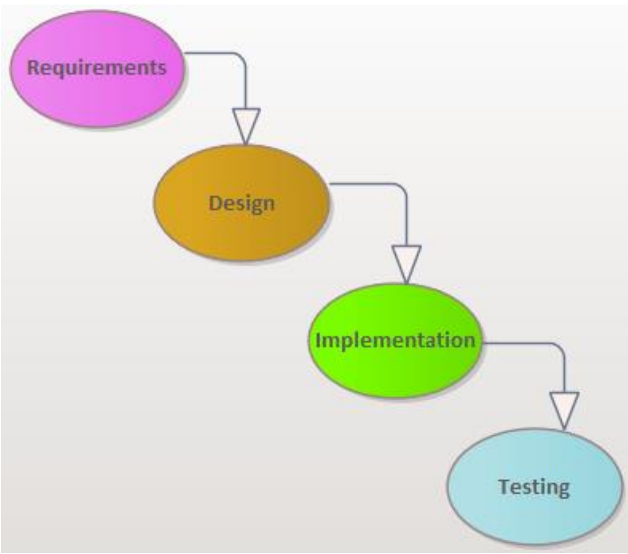

Figure 3. Research stages

3.1. Math Braille Translator Development Method

Requirements Stage is the stage where the author conducted interviews with the Head of Research and Development at Yayasan Mitra Netra regarding the behavior of the software to be developed. This stage produced a use case and activity diagram to define the functional requirements. Additionally, non-functional requirements were generated, such as criteria for designing the website and operating the software.

The design Stage is the stage where the author addressed problems and planned solutions for the software. The output of this stage consists of graphics for the user interface design of the Math Braille Translator website.

The implementation Stage is the stage where the author will realize the needs identified in the analysis and design specification phases by coding the website. In other words, this stage involves transforming all requirements and blueprints into the production phase.

The testing Stage as phase known for validating and verifying, this stage includes processes to check whether the needs and specifications requested by the foundation in previous stages have been met with the developed software solution. Testing at this stage is conducted using User Acceptance Testing (UAT).

3.2 Model of Math Braille Translator Web-Based

The author models the system using a use case diagram, illustrating the interactions between specific actors and the system, as well as showcasing the functions or features present within it. In the Math Braille Translator, there are two main actors: the companion for the visually impaired and the visually impaired individuals (categorized as totally blind and low vision).
The interface design refers to the visual appearance and interaction within an application intended for users. The goal of this interface design is to create an intuitive, efficient, simple, and satisfying user experience when interacting with the system. When the Math Braille Translator website is first accessed, the initial display looks like Figure 3. The vibrant colors are chosen because the website is not only used by individuals who are blind but also by those with low vision, for whom contrast and bright colors make it easier to navigate the system. In this initial display, users can immediately utilize the feature to translate mathematical Braille into visual mathematical notation using Six Keys and download the translated mathematical notation in visual format as an image.

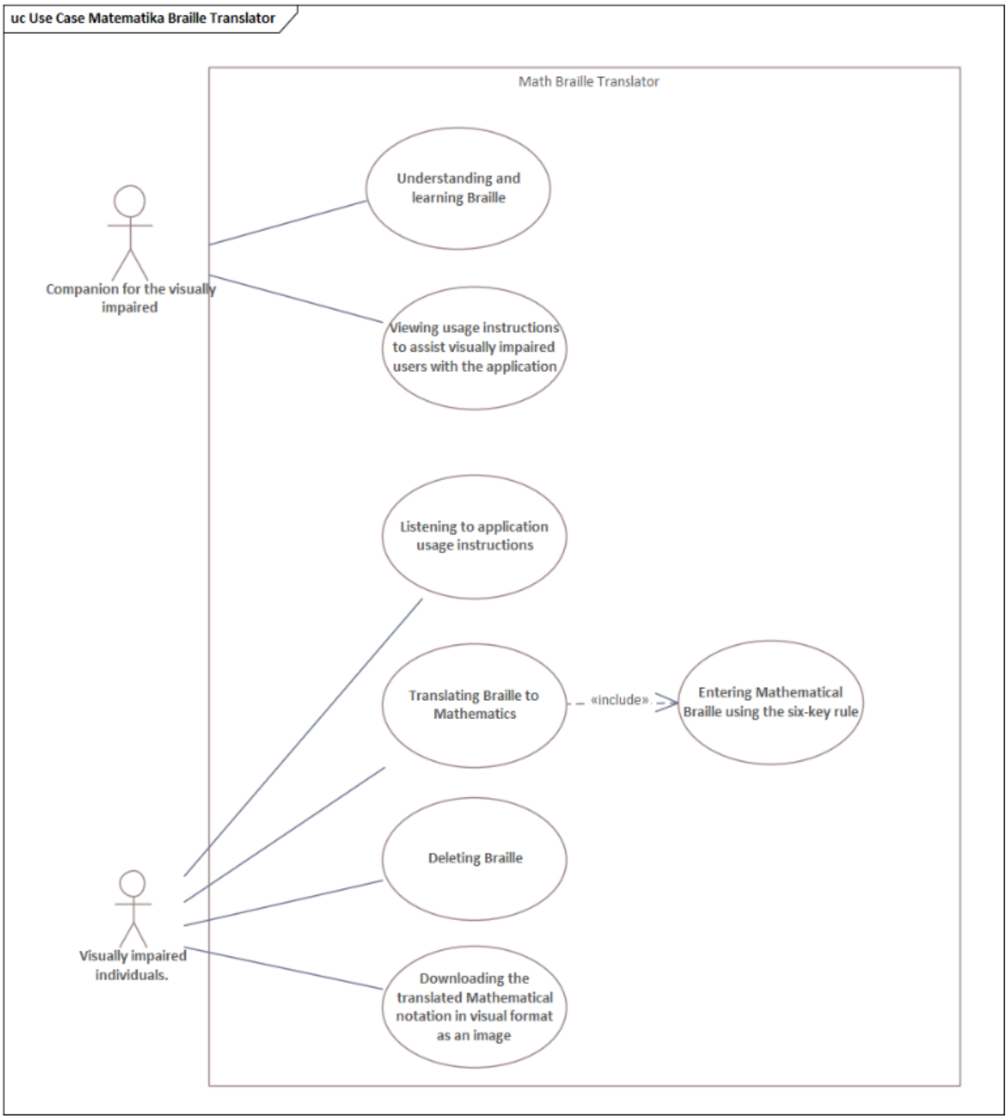

Figure 4. Use case diagram math braille translator.

3.3. Design of Math Braille Translator Web-Based

The interface design refers to the visual appearance and interaction within an application intended for users. The goal of this interface design is to create an intuitive, efficient, simple, and satisfying user experience when interacting with the system. When the Math Braille Translator website is first accessed, the initial display looks like Figure 3. The vibrant colors are chosen because the website is not only used by individuals who are blind but also by those with low vision, for whom contrast and bright colors make it easier to navigate the system. In this initial display, the user can immediately utilize the feature to translate mathematical braille into visual mathematical notation using six keys and download the translated mathematical notation in visual format as an image.

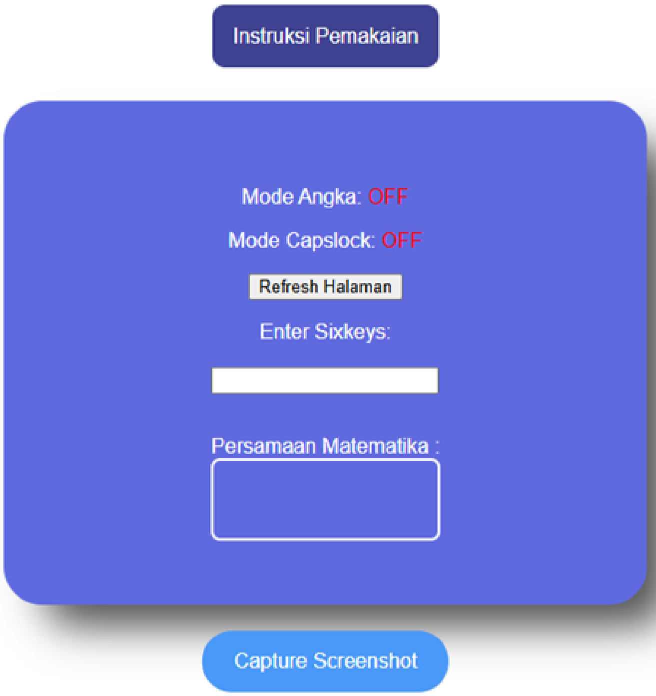

Figure 5. The user interface design of the math braille translator web-based application (Indonesian)

Figure 5 shows the interface design that appears when users access the User Guidelines. In this interface design, the steps are clearly and simply depicted to ensure that the Math Braille Translator website can be used effectively by visually impaired users, with assistance from a guide for the visually impaired.

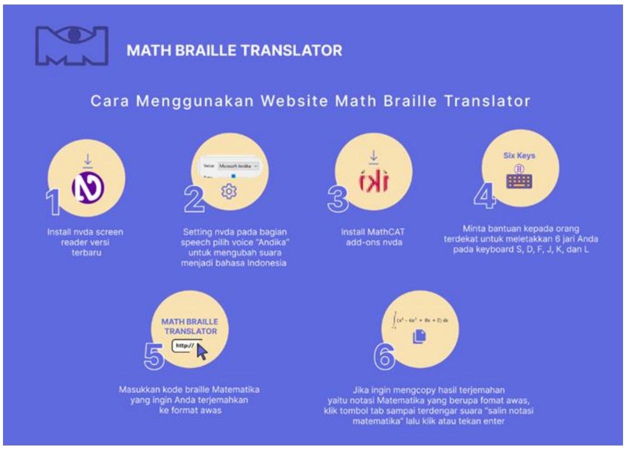

Figure 6. User Interface Design of User Guidelines (Indonesian)

This research was conducted from January 2023 to November 2023. The location for this research was at the Mitra Netra Foundation in Lebak Bulus, South Jakarta, Special Capital Region of Jakarta, Indonesia. A non-profit foundation focused on improving the quality of life and involvement of visually impaired individuals in education and the workforce.

4. Result and Discussion

Here are the implementation results of the system model and design. This website does not require a database because the author uses Unicode contained within an object to display Braille. Before being displayed as mathematical notation, the translated value from Braille is formatted into LaTeX, which is then converted into standard mathematical equations using the MathJax in JavaScript engine. Indonesian Braille has many rules in its writing, especially for mathematical notation. For example, the Braille symbol for the letter "a" is the same as the symbol for the number 1, which is the "f" key on the keyboard. According to certain rules, to differentiate numbers from letters, a number sign (keys "s", "j", "k", and "l") must be added so the letter changes to a number.

Additionally, this website is developed using the HTML attribute "Alt," which serves to describe the appearance and function of images or pages, making it accessible to visually impaired users. A crucial aspect of this system's implementation is its compatibility with screen readers commonly used by the visually impaired. Screen readers like NVDA and its add-on MathCAT are used to correctly vocalize mathematical notation. The author built the system using MathJax to display mathematical notation that can be translated into speech by MathCAT.

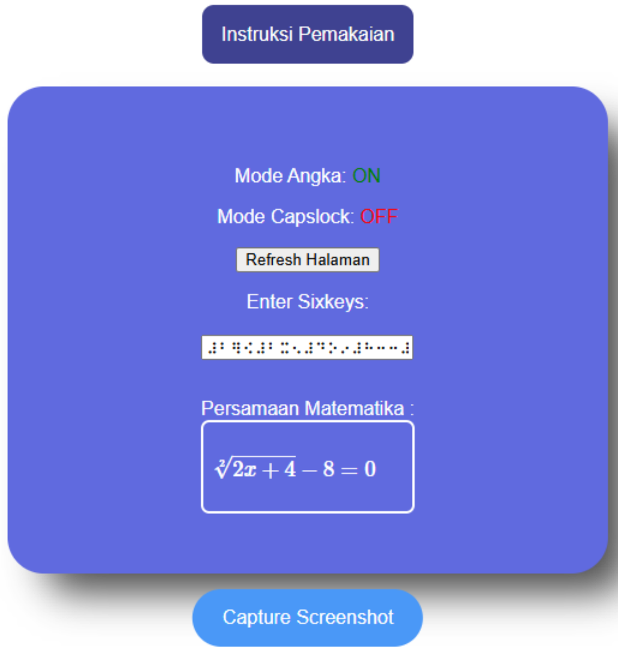

Figure 7. The user interface design of combination keys from s, d, f, j, k, l. (Indonesian)

Table 1. User acceptance test results by students with visual impairments

No.	Assessment Criteria	Score					Total in Likert Scale	Percentage
		1	2	3	4	5		
1.	The Braille writing rules on this website align with what I have learned, referring to the Indonesian Braille System for Mathematics Number 056//U/2000.	0	0	1	2	1	16	80%
2.	This website does not encounter errors in the translation process.	0	0	1	3	0	15	75%
3.	The keys feature works well.	0	0	0	2	2	18	90%
4.	User Guideline's feature works well.	0	0	1	1	2	17	85%
5.	The use of NVDA on the Math Braille Translator website works well.	0	0	0	2	2	18	90%
6.	This website is useful in helping me convert mathematical material from Braille text to accessible text.	0	0	0	2	2	18	90%

The table above presents some statements from the fifteen questionnaire items provided to four visually impaired respondents. The preliminary conclusion based on the data presented in Table 1 indicates that the total percentage of UAT results by students with visual impairments is 85.33%. When interpreted according to the criteria in the Likert Scale [10], this figure defines the rating as "very good," meaning that the Math Braille Translator website is an excellent solution that meets the needs of the system users (students with visual impairments).

5. Conclusion

Based on interviews with the Mira Netra Foundation, a website program is needed to translate Braille into mathematical notation to facilitate blind students and educators in learning mathematics. Many blind students find it difficult to understand mathematical equations dictated by teachers, thus this software is necessary to bridge that gap. The website has been successfully developed to meet user needs, including the implementation of Six Keys features, translation results, compatibility with the NVDA screen reader, accurate reading of mathematical notation, and the use of alt attributes on every component to enhance accessibility. UAT results for blind users showed a percentage of 85.33% with a "very good" criterion [10], indicating that Math Braille Translator meets user needs, is comfortable to use, and provides an effective solution for them.

References

[1] Y. Afrillia, L. Rosnita, and D. Siska, “Analisis Sentimen Ciutan Twitter Terkait Penerapan Permendikbudristek Nomor 30 Tahun 2021 Menggunakan TextBlob dan Support Vector Machine,” *G-Tech J. Teknol. Terap.*, vol. 6, no. 2, pp. 387–394, 2022, doi: 10.33379/gtech.v6i2.1778.
[2] Y. W. Setiya Putra and M. F. Adhim, “Sistem Informasi Presensi Online Menggunakan Teknologi Face Recognition dan GPS,” *J. Tekno Kompak*, vol. 16, no. 1, p. 149, 2022, doi: 10.33365/jtk.v16i1.1470.
[3] N. Martiniello and W. Wittich, “Exploring the influence of reading medium on braille learning outcomes: A case series of six working-age and older adults,” *Br. J. Vis. Impair.*, vol. 40, no. 2, 2022, doi: 10.1177/0264619621990702.
[4] A. AlSalman, A. Gumaei, A. AlSalman, and S. Al-Hadhrami, “A Deep Learning-Based Recognition Approach for the Conversion of Multilingual Braille Images,” *Comput. Mater. Contin.*, vol. 67, no. 3, 2021, doi: 10.32604/cmc.2021.015614.
[5] H. T. Bintaleb and D. Al Saaed, “Extending tangible interactive interfaces for education: A system for learning arabic braille using an interactive braille keypad,” *Int. J. Adv. Comput. Sci. Appl.*, no. 2, 2020, doi: 10.14569/ijacsa.2020.0110247.
[6] E. R. Hoskin, M. K. Coyne, M. J. White, S. C. D. Dobri, T. C. Davies, and S. D. Pinder, “Effectiveness of technology for braille literacy education for children: a systematic review,” *Disability and Rehabilitation: Assistive Technology*, vol. 19, no. 1. 2024, doi: 10.1080/17483107.2022.2070676.
[7] S. S. Anggarawati, E. Kuswarno, and S. Mulyana, “KOMUNIKASI INSTRUKSIONAL SEBAGAI SARANA PENGEMBANGAN AKTUALISASI DIRI PENYANDANG TUNANETRA,” *J. Manaj. Komun.*, vol. 3, no. 2, 2019, doi: 10.24198/jmk.v3i2.20640.
[8] A. Istiarni, “IMPLEMENTASI PERPUSTAKAAN DIGITAL RAMAH DIFABEL (SEBUAH PENGAMATAN PADA PUSTAKA DIGITAL MITRA NETRA),” *VISI PUSTAKA Bul. Jar. Inf. Antar Perpust.*, vol. 20, no. 1, 2019.
[9] R. Alfatiyah, “Analisis Manajemen Risiko Keselamatan dan Kesehatan Kerja dengan Menggunakan Metode HIRARC pada Pekerja Seksi Casting,” *J. Mesin Teknol. (SINTEK Jurnal)*, 2017.
[10] S. Sukmono and W. Yadiati, “Effect of board of Commissionersand Audit Committee on the Firm Value with Mediating Effect Financial Reporting Quality,” 2016.
[11] A. M. Abualkishik, K. Omar, and G. A. Odiebat, “QEFSM model and Markov Algorithm for translating Quran reciting rules into Braille code,” *J. King Saud Univ. - Comput. Inf. Sci.*, vol. 27, no. 3, 2015, doi: 10.1016/j.jksuci.2015.01.001.
[12] A. Al-Salman and A. AlSalman, “Fly-LeNet: A deep learning-based framework for converting multilingual braille images,” *Heliyon*, vol. 10, no. 4, 2024, doi: 10.1016/j.heliyon.2024.e26155.
[13] S. E. Newman, M. B. Kindsvater, and A. D. Hall, “Braille learning: Effects of symbol size,” *Bull. Psychon. Soc.*, vol. 23, no. 3, 1985, doi: 10.3758/BF03329822.
[14] S. Young, I. Nuryasin, and W. Suharso, “Penerapan Metode SDLC RUP (Rational Unified Proses) Dalam Pembuatan Sistem Informasi E-kos Berbasis Web,” *J. Repos.*, vol. 2, no. 3, p. 363, 2020, doi: 10.22219/repositor.v2i3.404.
[15] A. A. Wahid, “Analisis Metode Waterfall Untuk Pengembangan Sistem Informasi,” *J. Ilmu-ilmu Inform. dan Manaj. STMIK*, no. November, pp. 1–5, 2020.
[16] R. Darwin and R. Rahmadian Yuliendi, “Aplikasi Klenteng Kota Pekanbaru Berbasis Webgis,” *J. Tek. Inform. Kaputama*, vol. 5, no. 1, 2021.
[17] L. Safitri and Yuddi, “Sistem Informasi Geografis (Sig) Pariwisata Kabupaten Bintan Berbasis Web,” *J. Bangkit Indones.*, vol. 8, no. 2, 2019, doi: 10.52771/bangkitindonesia.v8i2.107.
[18] D. Maisa Putra and A. Alfauzain, “Design Of Tracer Using Microsoft Access Unit In Medical Record Primary Health In Padang,” *Int. J. Eng. Sci. Inf. Technol.*, vol. 1, no. 3, 2021, doi: 10.52088/ijesty.v1i3.90.
[19] J. S Pasaribu, “Development of a Web Based Inventory Information System,” *Int. J. Eng. Sci. Inf. Technol.*, vol. 1, no. 2, 2021, doi: 10.52088/ijesty.v1i2.51.
[20] A. Hamizan, M. Mayasari, R. Saputri, and R. N. Pohan, “Sistem Informasi Penggajian di PT. Perkebunan Nusantara IV,” *J. Manaj. Inform.*, vol. 10, no. 1, 2020, doi: 10.34010/jamika.v10i1.2656.