Jurnal Teknik Informatika C.I.T Medicom 13 (2) (2021) 82-93

Published by: Institute of Computer Science (IOCS)

Jurnal Teknik Informatika C.I.T Medicom

Journal homepage: www. medikom.iocspublisher.org

Application of the Knuth-Morris-Pratt Algorithm on Android-based Money Recognition Applications for the Blind

Yoga Prasetia[1,*], Ghulam Asrofi Buntoro[1], Dwiyono Ariyadi[1]

[3]Prodi Teknik Informatika, Fakultas Teknik, Universitas Muhammadiyah Ponorogo, Jl. Budi Utomo, No.10, Ponorogo 63471, Jawa Timur, Indonesia

Email: [1]yogaprasettia@gmail.com; [2] ghulam@umpo.ac.id*; [3] dwiyono_ariyadi@umpo.ac.id
* corresponding author

ARTICLE INFO

Article history:

Received: August 25, 2021;
Revised: Sept 02, 2021;
Accepted: Sept 21, 2021;
Available online: Sept 30, 2021.

Keywords:

Knuth-Morris-Pratt;
Nominal-Money;
Tunanetra;
Money Recognition.

ABSTRACT

Blind is a term used to define the human condition given a privilege by God in the sense of sight, this condition makes blind people have a little difficulty in carrying out daily activities. Money is a primary human need and is very important for daily buying and selling transactions. Indonesian money, especially paper money, has an embossed line that can help people with visual impairments a little, but there is some money circulating in the market that is damaged or missing lines of appearance which makes it difficult for blind people to recognize the nominal of the money. The research was conducted at the "AISYIYAH" Orphanage for the Blind in Ponorogo by conducting several interviews with blind people, the informants provided information that they could recognize money on a daily basis but only applies to banknotes with good condition and the latest output, for damaged banknotes. or the old output is hard to identify. To help the blind recognize money, an android-based application was designed with the Knuth-Morris-Pratt algorithm which is a type of string matching algorithm. This algorithm is a development algorithm from the previous algorithm, namely the Brute Force algorithm. The final result of this study shows that the android application designed using the Knuth-Morris-Pratt algorithm is able to recognize nominal money with an accuracy rate of 100%.

1. Introduction

Blind is a term used to define the human condition that is given a privilege given by Allah SWT in the sense of sight, this condition makes it difficult for blind people to carry out daily activities. Even though money itself is a primary need for everyone, and is very important for the purposes of buying and selling daily.

Indonesian money[1] especially in paper money[2] generally has an embossed line that can help the visually impaired a little, but there are some money circulating in the market that are damaged or missing the embossed line from the banknotes which makes it difficult for the visually impaired to recognize neutral. The author has conducted research at the "AISYIYAH" Orphanage for the Blind in Ponorogo[3] by conducting several interviews with one of the blind people, in the interview the interviewee provided information that in everyday life it is possible to recognize money, namely by recognizing the lines that appear on the inside. Banknotes, but this only applies to banknotes with good condition and the latest issue, for banknotes that are damaged or old, according to him, are difficult to identify.

To help blind people recognize money, we need a way to detect the character of the money, and it can be converted into sound media [18][19]. In order for the character of nominal money to be converted into sound media, it is necessary to align the results of the detection of the nominal character of the money to the pattern or pattern of nominal money, so that if the pattern is the same as the detection result, then the character will be processed into sound media[20][21][22]. using the Knuth-Morris-Pratt algorithm which is a type of string matching algorithm, in previous studies [4] this algorithm was used for the school library catalog search system, while in this study it was used for nominal detection of money. This algorithm is a development algorithm from the previous algorithm, namely the Brute Force algorithm. In this algorithm, string or character matching is done from right to left, then any information from each string of the pattern will be stored in the Border Function[5].

In this study, the author uses Optical Character Recognition (OCR) as an image processing method[6] that will be used to recognize image characters on Android-based smartphone[7][8] cameras, the image will go through stages in OCR. Furthermore, the results of the image processing will enter the feature extraction and image identification stage, after the character is successfully detected by the OCR system, the character will be matched for similarities with the pattern or nominal pattern of money using the Knuth-Morris-Pratt algorithm[9], if the character is the same as the pattern then character will be forwarded to the sound media conversion stage[10].

2. Research Methods

In this research, there are several things that must be done so that the system designed can be in accordance with what is desired, therefore the following steps are carried [16] out: System Analysis, In this research, steps are taken to describe the design of the system as a whole into a part of the system to achieve certain goals, system analysis aims for strategies in designing or perfecting a particular system, in this study there are two types of system analysis, namely problem analysis and needs analysis. Needs Analysis, In making a system, a needs analysis is needed so that a system that is designed can be useful and easy to use for users. At this stage of needs analysis, it is grouped into two parts, namely functional requirements analysis and non-functional requirements analysis.

General System Flowchart, In a system, a flowchart is needed which is the stages or flow of the system that is arranged systematically. This aims to facilitate the author in designing a system by looking at the rules of the flowchart that has been made so that the work becomes easier and more structured. In Figure 1. Is an overview of the system flowchart designed:

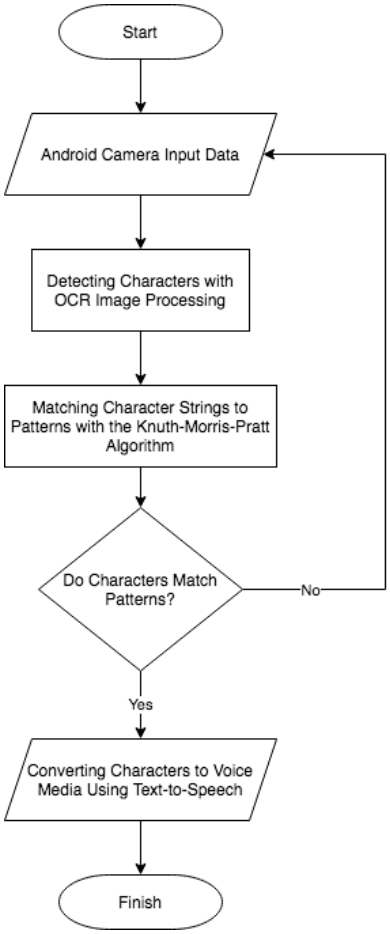

Fig 1. Flowchart of the Knuth-Morris-Pratt Algorithm Application System on Android Applications for Recognition of Nominal Money for the Blind

From Figure 1. which is a system flowchart, it can be seen that this system starts from the user who inputs data in the form of a smartphone camera and then the nominal will be detected using OCR image processing, then the Knuth-Morris-Pratt algorithm will match the character from the nominal to the pattern, if the character matches the pattern then the character will be converted into sound.

Knuth-Morris-Pratt Algorithm [17] Flowchart, The system that will be designed later will use an algorithm called Knuth-Morris-Pratt, this algorithm is one of the string search algorithms[11][12], and this algorithm is a development of the previous algorithm, namely the Brute Force algorithm which starts the character search from the left to the right. The following is a flowchart of the Knuth-Morris-Pratt algorithm and can be seen in Figure 2.

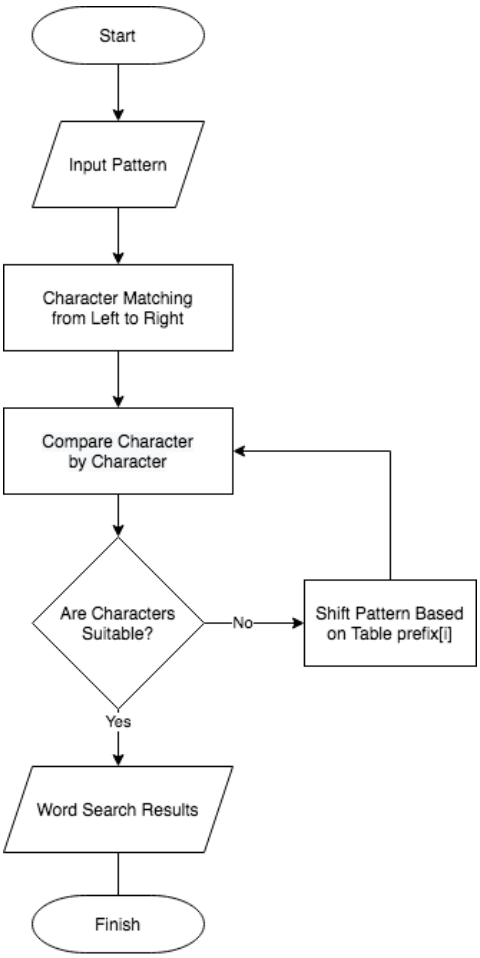

Fig 2. Flowchart of the Knuth-Morris-Pratt Algorithm Application System on Android Applications for Recognition of Nominal Money for the Blind

In the flowchart shown in Figure 2. It shows that the process starts from entering the pattern and then the string matching process will be carried out, then the algorithm will compare character by character, if the characters match, the results of the word search will be processed, but if not, a sliding process will be carried out. pattern based on table prefix[i][13].

Use Case Diagram, Use case diagram is a diagram that describes the interaction process of the system and all its environment, so that it can help simplify the understanding of the system being developed. Use case diagrams play an important role as a medium in the explanation of the system designed and the benefits that will be obtained

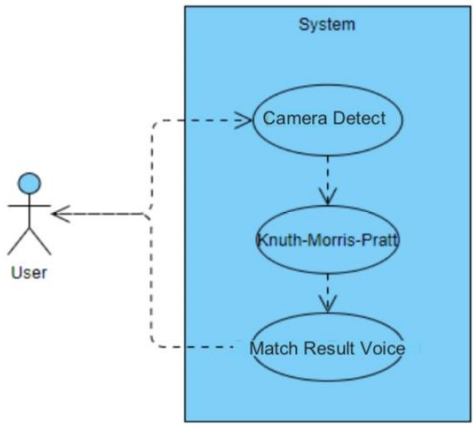

Fig 3. Use Case Diagram of the Knuth-Morris-Pratt Algorithm Application System on Android Applications for Recognition of Nominal Money for the Blind

Activity Diagram, Activity Diagram is a technique in describing a procedural logic, on the work path in the system. This diagram will describe the various workflows in a system that will be in design, in each workflow starting from a decision that might occur, and how an activity or workflow ends. The process of searching with the Knuth-Morris-Pratt Algorithm can be seen in Figure 4. below.

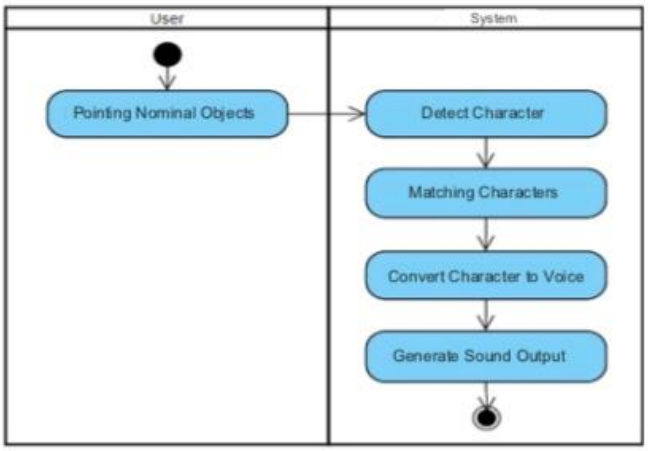

Fig 4. Activity Diagram of the Knuth-Morris-Pratt Algorithm Application System on Android Applications for Recognition of Nominal Money for the Blind

3. Results and Discussion

3.1 Implementation of the Knuth Morris Pratt . Algorithm

In this study the author uses the Knuth-Morris-Pratt Algorithm [17] as the main algorithm for matching characters from nominal money, this algorithm will later be implemented into the system using the Java programming language with several stages including:

The first stage is the initialization of the pattern, the pattern here contains a pattern in the form of variable nominal Indonesian banknotes from a nominal 1000 rupiah to 100,000 rupiah, besides that at this stage also initialization of the camera and also text to speech in android.

```
public class MainActivity extends AppCompatActivity {

    SurfaceView mCameraView;
    TextView mTextView;
    TextToSpeech tts;
    CameraSource mCameraSource;
    Button mBantuan;
    String nominal1 = "100";
    String nominal2 = "200";
    String nominal3 = "500";
    String nominal4 = "1000";
    String nominal5 = "2000";
    String nominal6 = "5000";
    String nominal7 = "10000";
    String nominal8 = "20000";
    String nominal9 = "50000";
    String nominal10 = "75000";
    String nominal11 = "100000";
```

Fig 6. Initialize Pattern of the Knuth-Morris-Pratt Algorithm Application System on Android Applications for Recognition of Nominal Money for the Blind

The second stage, this stage is the pre-KMP stage (pre Knuth-Morris-Pratt) which is the stage of assigning values to shifts in the detected characters. Giving this value is done after the algorithm tries to match the string on the nominal pattern of money, the characters entered will be split into an array of characters. This pre-KMP stage can also prevent unnecessary shifts[14]. The process in the pre-KMP stage in the Java programming language can be seen in Figure 7.

```
private int[] preKMP(char[] pattern) {
    int [] helper = new int[pattern.length];
    int index = 0;
    for (int i=1; i<pattern.length;){
        if (pattern[i] == pattern[index]){
            helper[i] = index+1;
            index++;
            i++;
        } else {
            if (index !=0){
                index = helper[index-1];
            } else {
                helper[i] = 0;
                i++;
            }
        }
    }
    return helper;
}
```

Fig 7. pre-KMP (pre Knuth-Morris-Pratt) of the Knuth-Morris-Pratt Algorithm Application System on Android Applications for Recognition of Nominal Money for the Blind

The third stage is the string matching stage, in this stage the characters that have been broken into an array of characters will carry out the string matching process against the nominal pattern of money, this stage can be seen in Figure 8.

```
public boolean algoKnuthMorrisPratt(char[] str, char[] pattern){
    int helperArray[] = preKMP(pattern);
    int i = 0;
    int j = 0;

    while (i<str.length && j < pattern.length){
        if (str[i] == pattern[j]){
            i++;
            j++;
        } else {
            if (j!=0){
                j = helperArray[j-1];
            } else {
                i++;
            }
        }
    }
    if (j==pattern.length){
        return true;
    }
    return false;
}
```

Fig 8. String Search Stage of the Knuth-Morris-Pratt Algorithm Application System on Android Applications for Recognition of Nominal Money for the Blind

3.2 System Implementation

To prove the overall results of the analysis along with the design of the system that has been built, what is done after is the implementation of the system, in this study it will contain output in the form of an Android-based application with the programming language used is Java, later the result of this implementation is a system file with the extension .apk and source code program with Java programming language. According to the design in the previous chapter, this system will generate as many as one page, which contains the camera interface, and a help button which will later generate the sound media.

In the calculation of this KMP algorithm, the system built is an algorithm for searching for nominal money characters. The main process that will be carried out in the Knuth-Morris-Pratt algorithm is the basis of all characters starting from the leftmost character to the far right until the searched word matches the pattern. In yahoo KMP, the initial process is carried out by calculating the suburban function which is dependent on the character in the pattern[11]. Below will be explained all the steps of the application of the Knuth-Morris-Pratt (KMP) Algorithm in this system.

The first step :

Character	R	U	P	I	A	H	1	0	0	0
Pattern	1	0	0	0						
i	1									

In the first step, it can be seen that there is not a single character whose value is the same as the pattern, so a shift will be made with the value calculated using the formula i-kmpNext[i]=0–(-1)=1. And move on to the next step.

Second Step :

Character	R	U	P	I	A	H	1	0	0	0
Pattern		1	0	0	0					
i		1								

In the second step it is still the same and it can be seen that there is not a single character whose value is the same as the pattern, so a shift will be made with the value calculated using the formula i-kmpNext[i]=0–(-1)=1. And move on to the next step.

Third step :

Character	R	U	P	I	A	H		1	0	0	0
Pattern			1	0	0	0					
i			1								

In the third step it is still the same and it can be seen that there is not a single character whose value is the same as the pattern, so a shift will be made with the value calculated using the formula i-kmpNext[i]=0–(-1)=1. And move on to the next step.

Fourth step :

Character	R	U	P	I	A	H		1	0	0	0
Pattern				1	0	0	0				
i				1							

In the fourth step it is still the same and it can be seen that there is no single character whose value is the same as the pattern, so a shift will be made with the value calculated using the formula i-kmpNext[i]=0–(-1)=1. And move on to the next step.

Fifth step :

Character	R	U	P	I	A	H		1	0	0	0
Pattern					1	0	0	0			
i					1						

In the fifth step it is still the same and it can be seen that there is not a single character whose value is the same as the pattern, so a shift will be made with the value calculated using the formula i-kmpNext[i]=0–(-1)=1. And move on to the next step.

Sixth step :

Character	R	U	P	I	A	H		1	0	0	0
Pattern						1	0	0	0		
i						1					

In the sixth step it is still the same and it can be seen that there is not a single character whose value is the same as the pattern, so a shift will be made with the value calculated using the formula i-kmpNext[i]=0–(-1)=1. And move on to the next step.

Seventh step

Character	R	U	P	I	A	H		1	0	0	0
Pattern							1	0	0	0	
i											

In the seventh step it is still the same and it can be seen that there is no single character whose value is the same as the pattern, so a shift will be made with the value calculated using the formula i-kmpNext[i]=0–(-1)=1. And move on to the next step.

Eighth step

Character	R	U	P	I	A	H		1	0	0	0
Pattern								1	0	0	0
i								1	2	3	4

In the eighth step, the shift is carried out again and it can be seen that there are a number of the same 4 characters, therefore the next shift will be carried out again with the formula i-kmpNext[i]=4–0=4 and this is the last step because the pattern you are looking for is in accordance with character.

3.3 User Interface Results

The following is the final result of the main user interface that the author has designed for this research, which can be seen in Figure 9.

Fig 8. App interface of the Knuth-Morris-Pratt Algorithm Application System on Android Applications for Recognition of Nominal Money for the Blind

3.4 System Test Results

To determine the level of effectiveness of the system, a testing phase is needed. From these tests it can be concluded whether this system is effective enough or not in carrying out its duties, in this study the author conducted a test taking into account the detection distance, time and condition of nominal money, the results of the test can be seen in Table 1:

Tabel 1
Test Result

Nominal Condition	Nominal Amount	Detection Distance	Detection Time	Accuracy
	1000	± 23 cm	1.24ms	100%

Nominal Condition	Nominal Amount	Detection Distance	Detection Time	Accuracy
	2000	± 30 cm	1.61ms	100%
	5000	± 35 cm	1.00ms	100%
	10000	± 44 cm	1.18ms	100%
	20000	± 50 cm	0.95ms	100%
	50000	± 51 cm	2.35ms	100%
	100000	± 55 cm	1.72ms	100%

3.5 SUS Test Results

In this study, the authors conducted a questionnaire to the blind people at the Pondok Pesantren for the Blind 'AISYIAH' Ponorogo to test whether the application that the author designed would provide benefits. The questionnaire was filled out when the respondent had tested the application. This questionnaire uses the System Usability Scale (SUS) method which can be used as a way to measure the usability of a system by prioritizing the user's point of view[15].

Tebel 2
Result Question

No	Question
1.	Is the information provided in the application easy to understand?
2.	Is the use of features in the application easy to use?
3.	Is the app Convenient to Use?
4.	Is the application Easy to operate?
5.	Is the application Helpful for users?
6.	Does the application have the expected capabilities and functions?
7.	Is the application easy to learn?

No	Question
8.	Does the application meet the needs?
9.	Is the application satisfactory?
10.	Is the application running properly?

Each question will be given a weight of 1-4, for a score of 1 means strongly disagree, a score of 2 means disagree, a score of 3 means doubtful, a score of 4 means agree, and a score of 5 strongly agree.

Table 3
Test question

Respondent	Score On Each Question										Amount
	1	2	3	4	5	6	7	8	9	10	
1.	5	5	4	3	3	5	3	3	3	2	36
2.	4	5	5	4	4	5	4	2	2	1	36
3.	5	3	3	5	5	5	3	3	3	2	37
4.	5	4	3	3	3	4	2	2	1	2	29
5.	4	3	5	4	3	2	2	4	5	4	27
Average											**33**

After doing the test and the results in table 3 above are obtained, after that, the System Usability Scale (SUS) calculation is carried out using the rules and instruments in the System Usability Scale (SUS) calculation. SUS) after processing data based on instruments and regulations from the System Usability Scale (SUS) itself can be seen in table 4.

Table 3
Sus calculation results

Respondent	Score On Each Question										Amount	Results SUS x 2.5
	1	2	3	4	5	6	7	8	9	10		
1.	4	4	4	2	2	4	2	2	2	2	28	70
2.	4	4	4	4	4	4	4	2	2	0	32	80
3.	4	2	2	4	4	4	2	2	2	2	28	70
4.	4	4	2	4	4	4	2	2	0	2	28	70
5.	4	2	4	4	3	2	2	4	4	4	32	80
Average												**74**

From the results of calculations using the SUS method, it is found that the average level of testing is 74 which this value means that grade B means good.

4. Conclusion

Based on all the research that the author has done, the conclusion of this study is that the Knuth-Morris-Pratt Algorithm can match strings very well in nominal money recognition applications, so this application can help the blind in recognizing nominal money so as to minimize errors and fraud against the blind. The lighting quality also affects the character detection ability, but this system is able to work well even with poor lighting quality. Suggestions for further research, the system can only detect characters or nominal so that in the future it can be developed again so that it can detect money as a whole.

References

[1] "Sejarah Oeang." https://www.kemenkeu.go.id/single-page/sejarah-oeang/ (accessed Aug. 15, 2021).
[2] "PERURI | Uang Kertas & Logam." https://www.peruri.co.id/banknotes-money-coins (accessed Aug. 15, 2021).
[3] "Tentang Kami « Panti Asuhan Tunanetra." https://pantitunanetraaisyiyahpo.wordpress.com/tentang-kami/

(accessed Aug. 15, 2021).
[4] N. Nursobah and P. Pahrudin, "Penerapan Algoritma Pencarian Knuth-Morris-Pratt (Kmp) Dalam Sistem Informasi Perpustakaan Smk Ti Pratama," Sebatik, vol. 23, no. 1, pp. 112–115, 2019, doi: 10.46984/sebatik.v23i1.451.
[5] B. K. If, S. A. Oleh, and R. Munir, "Persoalan pencarian string," pp. 1–18.
[6] K. Apriyanti and T. Wahyu Widodo, "Implementasi Optical Character Recognition Berbasis Backpropagation untuk Text to Speech Perangkat Android," IJEIS (Indonesian J. Electron. Instrum. Syst., vol. 6, no. 1, p. 13, 2016, doi: 10.22146/ijeis.10767.
[7] G. A. Buntoro, Indah Puji Astuti, and Dwiyono Ariyadi, "Rancang Bangun Aplikasi Belajar Membaca dengan Gambar Animasi Berbasis Android," J. Inform. Polinema, vol. 7, no. 3, pp. 29–34, 2021, doi: 10.33795/jip.v7i3.689.
[8] A. Adhi, N. Purnomo, S. Andryana, and A. Iskandar, "Application of Expert System for Diagnosing Gastric Disease Android Based with Certainty Factor Method," J. Tek. Inform. C.I.T, vol. 12, no. 1, pp. 7–15, 2020, [Online]. Available: www.medikom.iocspublisher.org/index.php/JTI.
[9] A. Saputra and A. Khumaidi, "Development of The Application for Car Audio Parts Detection Damage Using Case Based Reasoning Method and Nearest Neighbor Algorithm," vol. 13, no. 1, pp. 42–50, 2021.
[10] Y. Perwira, W. Apriani, P. Nusantara, J. Iskandar, M. No, and S. Utara, "Application of Weighted Sum Model (WSM) for Determining Development Priorities in Rural," J. Tek. Inform. C.I.T Medicom J., vol. 12, no. 2, pp. 72–87, 2020.
[11] W. Astuti, "Analisis String Matching Pada Judul Skripsi Dengan Algoritma Knuth-Morris Pratt (Kmp)," Ilk. J. Ilm., vol. 9, no. 2, pp. 167–172, 2017, doi: 10.33096/ilkom.v9i2.136.167-172.
[12] I. Algoritma and B. Moore, "Implementasi algoritma boyer moore untuk pernyaringan email," 2020.
[13] M. Fazira, "Perbandingan Algoritma Knuth-Morris-Pratt Dan Boyer-Moore Dengan Metode Perbandingan Eksponensial Pada Aplikasi Kamus Bahasa Indonesia – Jerman Berbasis Android," Maj. Ilm. INTI, vol. 14 No 1, pp. 202–206, 2019.
[14] H. T. Sadiah, "Implementasi Algoritma Knuth-Morris-Pratt Pada Fungsi Pencarian Judul Tugas Akhir Repository," Komputasi J. Ilm. Ilmu Komput. dan Mat., vol. 14, no. 1, pp. 115–124, 2017.
[15] I. A. G. R. W. Astari and T. A. Putra, "Analysis of Information System Kemdikbud in Sdn 2 Dawan Klod With the System Usability Scale," vol. 4, no. 1, pp. 23–30, 2021, doi: 10.33387/jiko.
[16] Suud, F. M., & Madjid, A. (2019). The Study Of Educational Honesty Stages Implementation In an Indonesian School. *Humanities & Social Sciences Reviews*, *7*(4), 502-510.
[17] Abikoye, O. C., Abubakar, A., Dokoro, A. H., Akande, O. N., & Kayode, A. A. (2020). A novel technique to prevent SQL injection and cross-site scripting attacks using Knuth-Morris-Pratt string match algorithm. *EURASIP Journal on Information Security*, *2020*(1), 1-14.
[18] Alon, A. S., Dellosa, R. M., Pilueta, N. U., Grimaldo, H. D., & Manansala, E. T. (2020, August). EyeBill-PH: A Machine Vision of Assistive Philippine Bill Recognition Device for Visually Impaired. In *2020 11th IEEE Control and System Graduate Research Colloquium (ICSGRC)* (pp. 312-317). IEEE.
[19] Tapu, R., Mocanu, B., & Zaharia, T. (2020). Wearable assistive devices for visually impaired: A state of the art survey. *Pattern Recognition Letters*, *137*, 37-52.
[20] Gehringer, A., & König, J. (2021). Recent Patterns of Economic Alignment in the European (Monetary) Union. *Journal of Risk and Financial Management*, *14*(8), 362.
[21] Forbes, C. (2020). Nominal types in Gitksan split-absolutive agreement. *Natural Language & Linguistic Theory*, 1-42.
[22] Karaman, K. K., Pamuk, Ş., & Yıldırım-Karaman, S. (2020). Money and monetary stability in Europe, 1300–1914. *Journal of Monetary Economics*, *115*, 279-300.