Combination of Hill Cipher Algorithm and Caesar Cipher Algorithm for Exam Data Security

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Abstract—The progress of communication technology has had a positive impact on human life, including in the field of education. The education office is currently implementing computer-based exams starting from the State Higher Education Entrance Joint Selection (SBMPTN) exam to the School Final Examination. But with the implementation of computer-based exams this is of course the less secure the level, therefore the authors make this research with the aim of securing the exam data that will be tested with Hill cipher cryptography and Caesar cipher. Cryptography is a technique of hiding data that is done to secure data, in this case cryptography aims to secure data on exam questions.

Keywords : Kriptografi, Hill Cipher, Caesar Cipher

I. INTRODUCTION

Currently technology has developed very rapidly, including in the field of education, an example of application technological development that is on the exam. The education office is currently implementing a computer-based exam starting from the Joint Higher Education Entrance Examination (SBMPTN) exams to the Final School Exams. But with the implementation of computer-based exams, of course the less the level of security, then of The authors make this research with the aim of securing the data on the exam questions to be tested with Hill cipher and Caesar cipher cryptography [1].

II. METHOD

The method used in this study is the Caesar Cipher and Hill Cipher method for the process cryptography on data security exam questions, to combine the two methods there are several process that must be done. Figure 2 shows the process carried out.

III. RESULTS AND DISCUSSION

The cryptographic process using the Hill Cipher and Caesar Cipher method is done by entering an example Exam
Questions to be encrypted and make a key. First the message will be encrypted with using the Caesar Cipher method, then the results are converted to decimal and re-encrypted with the method Hill Cipher with a single process and a key [5].

Examples of exam questions to be encrypted are English exam questions "I am so. I want to eat" with key (key) = 5. The first stage that will be done is encryption with the Caesar Cipher method. As for the process it is as follows:

Plaintext: I am so. I want to eat
Key: 5
Then change the plaintext and key to binary data, can be seen in Table 1.

| TABLE I | Conversion from Plaintext to Binary |
|----------|------------------------------------|
| **Plain Text** | **Biner** |
| I        | 01001001 |
| a        | 01100001 |
| m        | 01101101 |
| s        | 01110101 |
| o        | 00101110 |
| .        | 00101101 |
| I        | 01001001 |
| w        | 01110111 |
| a        | 01100001 |
| n        | 01101110 |
| t        | 01110100 |
| t        | 01110100 |
| o        | 01101111 |
| e        | 01100101 |
| a        | 01100001 |
| t        | 01110100 |

Then do the encryption process by shifting the binary number 5 steps to the right, can be seen in Table 2.

| TABLE II | Encryption Process with Caesar Cipher |
|----------|---------------------------------------|
| **Biner** | **Cipher Text** |
| 01001001 | 01001010 |
| 01100001 | 00001011 |
| 01101101 | 01101011 |
| 01110101 | 10011011 |
| 01110001 | 01111011 |
| 01110001 | 01110001 |
| 01110100 | 01110100 |
| 01110111 | 01110111 |
| 01110111 | 01110111 |

In Table 2 the encryption results obtained by the Caesar Cipher method are still in the form of binary numbers. Then do the conversion to decimal to facilitate the next encryption process.

| TABLE III | Binary to Decimal Conversion Process |
|-----------|-------------------------------------|
| **Cipher Text** | **Decimal** |
| 01001010 | 74 |
| 00001011 | 11 |
| 01101011 | 107 |
| 10011011 | 155 |
| 01110111 | 123 |
| 01100011 | 113 |
| 01001010 | 74 |
| 10111011 | 187 |
| 00001011 | 11 |
| 01110011 | 115 |
| 10100011 | 163 |
| 10100011 | 163 |
| 01110111 | 123 |
| 00101011 | 43 |
| 00001011 | 11 |
| 10100011 | 163 |

In Table 3 can be seen from the results of the conversion to decimal where the results will be directly encrypted with Hill Cipher method. In the Hill Cipher method, the key used is a matrix in which the matrix is used is 2x2 by using the same key in the encryption process with the method before that is 5 [6] [7].
So that the existing key can be used for the encryption process using the Hill Cipher method, the key will be formed 2x2 matrix by performing a simple calculation process [8].

Key = 5 key k = \[
\begin{bmatrix}
key & key - 1 \\
key + 1 & key + 2
\end{bmatrix}
\]

k = \[
\begin{bmatrix}
5 & 5 - 1 \\
5 + 1 & 5 + 2
\end{bmatrix}
\]

So from the above calculation results obtained 2x2 matrix key with numbers k = \[
\begin{bmatrix}
5 & 4 \\
6 & 7
\end{bmatrix}
\]

Next divide the row of decimal numbers in ciphertext2 into a matrix with the number of key matrix columns (key = 2x2).

Then do the key matrix multiplication with the matrix that has been made.

\[
\begin{bmatrix}
5 & 4 \\
6 & 7
\end{bmatrix}
\begin{bmatrix}
74 \\
11
\end{bmatrix}
= \begin{bmatrix}
414 \\
521
\end{bmatrix}
Mod 255
\begin{bmatrix}
159 \\
11
\end{bmatrix}
\]

\[
\begin{bmatrix}
5 & 4 \\
6 & 7
\end{bmatrix}
\begin{bmatrix}
107 \\
115
\end{bmatrix}
= \begin{bmatrix}
1155 \\
1727
\end{bmatrix}
Mod 255
\begin{bmatrix}
135 \\
197
\end{bmatrix}
\]

\[
\begin{bmatrix}
5 & 4 \\
6 & 7
\end{bmatrix}
\begin{bmatrix}
123 \\
113
\end{bmatrix}
= \begin{bmatrix}
1067 \\
1529
\end{bmatrix}
Mod 255
\begin{bmatrix}
47 \\
254
\end{bmatrix}
\]

\[
\begin{bmatrix}
5 & 4 \\
6 & 7
\end{bmatrix}
\begin{bmatrix}
74 \\
187
\end{bmatrix}
= \begin{bmatrix}
1118 \\
1753
\end{bmatrix}
Mod 255
\begin{bmatrix}
98 \\
223
\end{bmatrix}
\]
The determinant inverse modulo is used to find the matrix inverse.

\[
K = \begin{bmatrix} 5 & 4 \\ 6 & 7 \end{bmatrix}
\]

then

\[
K^{-1} = \begin{bmatrix} d & -c \\ -b & a \end{bmatrix}
\]

So that

\[
K^{-1} = \begin{bmatrix} 7 & -4 \\ -6 & 5 \end{bmatrix} = \begin{bmatrix} 812 & -464 \\ -696 & 580 \end{bmatrix} \pmod{255}
\]

Continue multiplying the matrix with ciphertext.

\[
\begin{bmatrix} 47 & 46 \\ 69 & 70 \end{bmatrix} = \begin{bmatrix} 159 & 119 \\ 79 & 117 \end{bmatrix} = \begin{bmatrix} 797 & 11741 \\ 12305 & 101 \end{bmatrix}
\]

After getting the results ,, then do the conversion to binary to proceed to the next process.

| Decimal | Biner |
|---------|-------|
| 74      | 01001010 |
| 11      | 00001011 |
| 107     | 01101011 |
| 155     | 10011011 |
| 123     | 01111011 |
| 113     | 01110001 |
| 74      | 01001010 |
| 187     | 10111011 |
| 11      | 00001011 |
| 115     | 01110011 |
| 163     | 10100011 |
| 163     | 10100011 |
| 123     | 01111011 |
| 43      | 00101011 |
| 11      | 00001011 |
| 163     | 10100011 |

These binary numbers are then re-encrypted for the last time using the Caesar cipher method by shifting 5 times to the left, with the results that can be seen in Table 6.

| Decimal | Biner |
|---------|-------|
| 87      | 00001011 |
| 94      | 00101011 |
| 143     | 01111011 |
| 228     | 10100011 |
| 107     | 01101011 |

In Table 4 we can see the final ciphertext results from the Caesar Cipher and Hill Cipher method, the ciphertext in the form of ASCII numbers. So, the ciphertext from the example exam questions I am so. I want to eat is Ŷ VT ǂ Å / Ÿ b Ÿ ENQ J Å O SYN DC3 Å ». 

Furthermore, a description process is carried out to find out whether this method is successful for securing data on the sample exam questions. The first thing that will be done for the description process is the Hill Cipher method by multiplying the inverse key matrix with the ciphertext block matrix.

\[
K = \begin{bmatrix} 5 & 4 \\ 6 & 7 \end{bmatrix} \quad \text{det} K = (5 \times 7) - (4 \times 6) = 11
\]

invers modulo:

- 11-1 mod 255
- 11x = 1 mod 255
- 11x = 1+255k
- x = (1+255k)/11

Search for k = n with the result that x is an integer.

K = 5; x = (1 + 255 * 5) / 11 = 116 (whole number)

The inverse of 11 mod 255 is equivalent to 116 mod 255 which is 116.

The determinant inverse modulo is used to find the martiks inverse.

**TABLE IV The Process of Converting Decimal to Character**

| Decimal | Character |
|---------|-----------|
| 159     | Ŷ         |
| 11      | VT        |
| 135     | Ÿ         |
| 197     | Å         |
| 47      | /         |
| 254     | P         |
| 98      | B         |
| 223     | ß         |
| 5       | ENQ       |
| 106     | J         |
| 192     | Å         |
| 79      | O         |
| 22      | SYN       |
| 19      | DC3       |
| 197     | Å         |
| 187     | »         |

In the last process of encryption change the results of this multiplication into the characters that can be seen in Table 4.

**TABLE V**

**TABLE VI The process of converting Decimal to Binary**
In table 5 it can be seen that the results of the description that have been done produce a Plaintext "Iamso.Iwanttoeat" in accordance with the example of the exam questions used for this study, with this the merging of the Hill Cipher and Caesar Cipher methods has been completed.

IV. CONCLUSION

From the results of the research that has been carried out it can be concluded that the Hill Cipher and Caesar Cipher methods can be combined for the process of securing data with a good level of security, this method is also easily understood and for the encryption and description process using only one key so that it is easy to remember.

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