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Implementation of the Autokey Algorithm ASCII Text Cryptography Using JavaFX GUI

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ABSTRACT

The advance of information and communication technology has transformed the world in ways we could never have imagined. From the analog era to the digital age, technology has paved the way for new innovations and discoveries, changing the way we interact, communicate, work, and even play. Data breaches are one of the threats that frequently arise in this era of digital information since the data has great value in enhancing the security of the data we transmit, one of which is using code. There are numerous ways to encode data in cryptography, but one popular technique is Autokey Cipher cryptography. Autokey cipher is a development of vigenere cipher which is a solution to overcome the repetition of certain characters in keys. Autokey operations are performed based on the key length and calculated using the tabula recta of the vigenere cipher, the key from autokey is a combination of plaintext to produce a new key along the plaintext. In this research we built the implementation using Java library JavaFX. The GUI also shows how the autokey cipher works, which will give us an understanding about the encryption and decryption process that is built with ASCII text. And the other additions are the GUI that shows the calculations such as Avalanche Effect (AE), Bit Error Rate (BER), Character Error Rate (CER), and Entropy.

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1. INTRODUCTION

Java is a programming language that is widely used for coding web applications. Java also supports a graphical user interface or GUI which is one of Java's main features. The main GUI we use is the Java library also known as JavaFX. GUI is a system of interactive visual components used in software, smartphones, and various other electronic devices [1], [2]. GUI are represented using several images which are referred to as GUI elements. With elements such as windows, icons and menus, computers can carry out commands such as opening, deleting, and moving files. One of the libraries provided by Java for building GUIs is JavaFX. JavaFX is a software platform for building Rich Internet Applications also known as RIA applications that can run on various devices. Such as desktop computers, web browsers on Windows, Linux and MacOS. Below is an overview of both processes in cryptography.

Cryptography is a process for disguising information so that it cannot be understood by other people, Cryptosystem is a method designed to carry out a cryptographic process while cryptanalysis is a process for re-disguising the results of a cryptosystem into understandable information [3], [4], [5], [6]. Plaintext can be said to be the original message/information that can still be understood or understood by humans, while ciphertext is a message that has been disguised so that it cannot be understood by humans [7],

[8]. What about Encryption and Decryption? Encryption is the process of changing from plaintext to ciphertext while decryption is the process of changing ciphertext back to plaintext as shown in Figure 1.

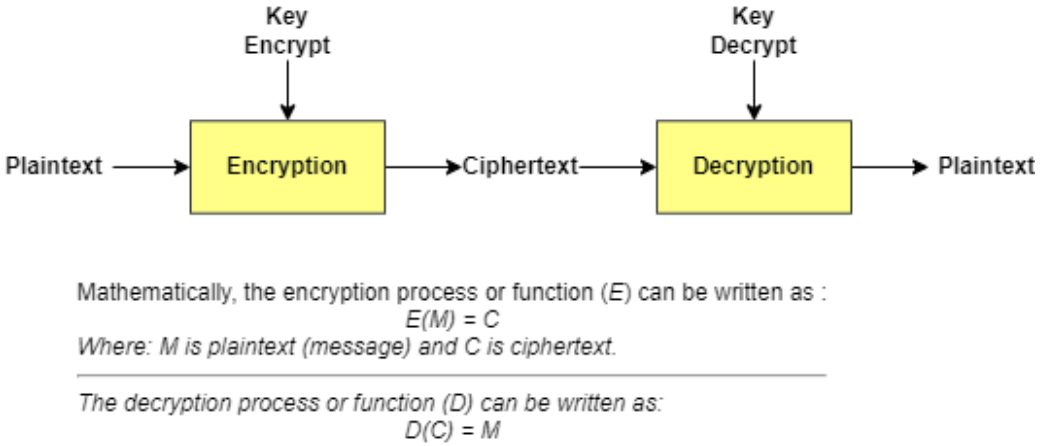


Figure 1. Common Cryptography Scheme [9]

The main problem from this research that we made is to implement a graphical user interface that integrated with Autokey Algorithm to make it easy to use and understand for users [10], [11], [12], [13]. The GUI should support many text types and formats, and that why we used ASCII text to make it easier, and it will assist users that use our program to understand how an algorithm keyboard should operate automatically throughout a process. In addition, efficiency, and speed of the encrypt and decrypt processes are quite important for long and complex texts that are encoded with ASCII. In addition, the primary concern in this study is the security and privacy of user data during the encrypting and decrypting processes. The validation and verification process to ensure that the encrypt and decrypt functions are appropriate and crucial in this course are highly important [14], [15], [16]. In addition, the GUI needs to be simple to learn or modify to support other encrypt and decrypt algorithms in the future.

Here, we want to introduce to people about how the autokey cipher algorithm is implemented or works in a GUI using the Java programming language. In this journal we also explain the calculations, namely Avalanche Effect, Bit Error Rate, Character Error Rate and Entropy, so that people can better understand the performance of the autokey algorithm and examples of its use that we describe in the GUI implementation.

2. METHOD

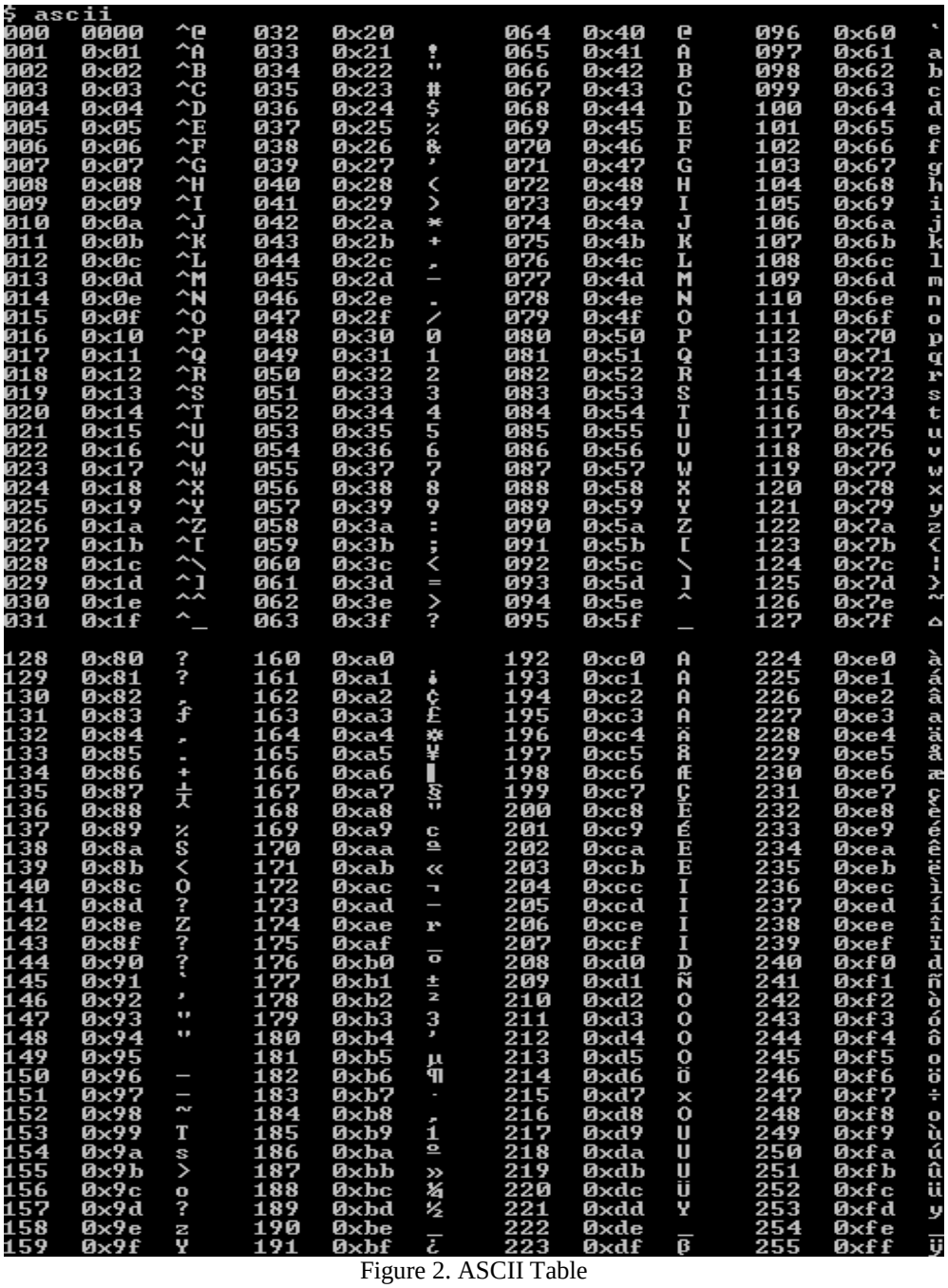
For this Research Method we started by searching for information about the AutoKey Cipher Algorithm and several tutorials for implementing it in a GUI using JavaFX. From these two things, we knew of the basic concepts of how AutoKey cryptography can be implemented in GUI-based applications. In this way we can carry out encryption and decryption as well as other calculations. After doing this, we also don't forget to carry out testing or tests regarding our application so that it is suitable and works correctly as we want.

2.1. Cryptography

Cryptography is an important component for maintaining data confidentiality. Cryptography plays an important role in the security and protection of network data because it allows the storage and transmission of sensitive data over unsecured networks, such as the Internet, so that it cannot be read by anyone except the person intended to receive it [3], [17], [18], [19], [20]. Cryptography Symmetric is a type of cryptography, where there is only one key to encrypt and decrypt from the information. Meanwhile, cryptography asymmetric is a type of cryptography that uses two keys: public key that can be shared to public and a private key that is only known by the data owner [21], [22], [23]. Further information about the public key is that it can be shared with anyone, but for the private key it must be kept confidential. If someone has your public key and they can encrypt your messages but only you with the private key can decrypt them.

2.2. ASCII

ASCII is based on the simple idea of using numbers to represent text, for example numbers that represent letters "A", "q", or "!", collectively letters, numbers and symbols are called characters [24]. By signing a number to each of characters in a block of text, the block of text can be represented entirely by numbers and that easily stored in the computer memories, for example letter "A" is always assigned the number '065' conversely '065' always reverse for letter "A". ASCII is an english language subsets of Unicode meaning that all of ascii exists within the Unicode. ASCII is also commonly used in computer science particularly in programming language, text files and data conversions as displayed in Figure 2.



$ ascii

000	0000	^@	032	0x20		064	0x40	@	096	0x60	`
001	0x01	^A	033	0x21	!	065	0x41	A	097	0x61	a
002	0x02	^B	034	0x22	"	066	0x42	B	098	0x62	b
003	0x03	^C	035	0x23	#	067	0x43	C	099	0x63	c
004	0x04	^D	036	0x24	$	068	0x44	D	100	0x64	d
005	0x05	^E	037	0x25	%	069	0x45	E	101	0x65	e
006	0x06	^F	038	0x26	&	070	0x46	F	102	0x66	f
007	0x07	^G	039	0x27	'	071	0x47	G	103	0x67	g
008	0x08	^H	040	0x28	(	072	0x48	H	104	0x68	h
009	0x09	^I	041	0x29	)	073	0x49	I	105	0x69	i
010	0x0a	^J	042	0x2a	*	074	0x4a	J	106	0x6a	j
011	0x0b	^K	043	0x2b	+	075	0x4b	K	107	0x6b	k
012	0x0c	^L	044	0x2c	,	076	0x4c	L	108	0x6c	l
013	0x0d	^M	045	0x2d	-	077	0x4d	M	109	0x6d	m
014	0x0e	^N	046	0x2e	.	078	0x4e	N	110	0x6e	n
015	0x0f	^O	047	0x2f	/	079	0x4f	O	111	0x6f	o
016	0x10	^P	048	0x30	0	080	0x50	P	112	0x70	p
017	0x11	^Q	049	0x31	1	081	0x51	Q	113	0x71	q
018	0x12	^R	050	0x32	2	082	0x52	R	114	0x72	r
019	0x13	^S	051	0x33	3	083	0x53	S	115	0x73	s
020	0x14	^T	052	0x34	4	084	0x54	T	116	0x74	t
021	0x15	^U	053	0x35	5	085	0x55	U	117	0x75	u
022	0x16	^V	054	0x36	6	086	0x56	V	118	0x76	v
023	0x17	^W	055	0x37	7	087	0x57	W	119	0x77	w
024	0x18	^X	056	0x38	8	088	0x58	X	120	0x78	x
025	0x19	^Y	057	0x39	9	089	0x59	Y	121	0x79	y
026	0x1a	^Z	058	0x3a	:	090	0x5a	Z	122	0x7a	z
027	0x1b	^[	059	0x3b	;	091	0x5b	[	123	0x7b	{
028	0x1c	^\	060	0x3c	<	092	0x5c	\	124	0x7c	|
029	0x1d	^]	061	0x3d	=	093	0x5d	]	125	0x7d	}
030	0x1e	^^	062	0x3e	>	094	0x5e	^	126	0x7e	~
031	0x1f	^_	063	0x3f	?	095	0x5f	_	127	0x7f	⌂
128	0x80	?	160	0xa0		192	0xc0	À	224	0xe0	à
129	0x81	?	161	0xa1	¡	193	0xc1	Á	225	0xe1	á
130	0x82	‚	162	0xa2	¢	194	0xc2	Â	226	0xe2	â
131	0x83	ƒ	163	0xa3	£	195	0xc3	Ã	227	0xe3	ã
132	0x84	„	164	0xa4	¤	196	0xc4	Ä	228	0xe4	ä
133	0x85	…	165	0xa5	¥	197	0xc5	Å	229	0xe5	å
134	0x86	†	166	0xa6	¦	198	0xc6	Æ	230	0xe6	æ
135	0x87	‡	167	0xa7	§	199	0xc7	Ç	231	0xe7	ç
136	0x88	ˆ	168	0xa8	¨	200	0xc8	È	232	0xe8	è
137	0x89	‰	169	0xa9	©	201	0xc9	É	233	0xe9	é
138	0x8a	Š	170	0xaa	ª	202	0xca	Ê	234	0xea	ê
139	0x8b	‹	171	0xab	«	203	0xcb	Ë	235	0xeb	ë
140	0x8c	Œ	172	0xac	¬	204	0xcc	Ì	236	0xec	ì
141	0x8d	?	173	0xad		205	0xcd	Í	237	0xed	í
142	0x8e	Ž	174	0xae	®	206	0xce	Î	238	0xee	î
143	0x8f	?	175	0xaf	¯	207	0xcf	Ï	239	0xef	ï
144	0x90	?	176	0xb0	°	208	0xd0	Ð	240	0xf0	ð
145	0x91	‘	177	0xb1	±	209	0xd1	Ñ	241	0xf1	ñ
146	0x92	’	178	0xb2	²	210	0xd2	Ò	242	0xf2	ò
147	0x93	"	179	0xb3	³	211	0xd3	Ó	243	0xf3	ó
148	0x94	"	180	0xb4	´	212	0xd4	Ô	244	0xf4	ô
149	0x95	•	181	0xb5	µ	213	0xd5	Õ	245	0xf5	õ
150	0x96	–	182	0xb6	¶	214	0xd6	Ö	246	0xf6	ö
151	0x97	—	183	0xb7	·	215	0xd7	×	247	0xf7	÷
152	0x98	˜	184	0xb8	¸	216	0xd8	Ø	248	0xf8	ø
153	0x99	T	185	0xb9	¹	217	0xd9	Ù	249	0xf9	ù
154	0x9a	š	186	0xba	º	218	0xda	Ú	250	0xfa	ú
155	0x9b	›	187	0xbb	»	219	0xdb	Û	251	0xfb	û
156	0x9c	o	188	0xbc	¼	220	0xdc	Ü	252	0xfc	ü
157	0x9d	?	189	0xbd	½	221	0xdd	Ý	253	0xfd	y
158	0x9e	ž	190	0xbe	¾	222	0xde	Þ	254	0xfe	þ
159	0x9f	Ÿ	191	0xbf	¿	223	0xdf	ß	255	0xff	ÿ

Figure 2. ASCII Table

2.3. Autokey Cipher

Autokey in cryptography refers to a method of encryption where the key used in the encryption process is based on the original text. In the autokey method, the original text serves as the key, and this key is

automatically or cyclically applied to the text to produce the encrypted text. This method falls under the category of symmetric-key algorithms as shown in equation (1) and (2).

$$Ci = (Pi + Ki)\ mod\ 26 \quad (1)$$

Where :
C is Result of encrypted text (Ciphertext) from i
P is Plainteks from i
K is Key from i
The encryption process involves converting the text's original length (Pi) to the text's original length (Ki), and the result is expressed in modulo (M).

$$Pi = (Ci + Ki)\ mod\ 26 \quad (2)$$

Where :
P is Plaintext from i
C is Result of encrypted text (Ciphertext) from i
K is Key from i
The Decryption process involves reversing by subtracting the value of the encrypted text (C_i) from the value of the key (Ki), and the result expressed in modulo (M).

2.4. Avalanche Effect (AE)

The Avalanche Effect is very important because it ensures that even small changes in the autokey algorithm will produce the same output, this ensures that attackers cannot easily predict the original text through statistical analysis. This happens because in an auto-key algorithm, a small change in the original text or key must result in a significant change in the encrypted text.

$$AE = \frac{Total\ different\ bits\ from\ plaintext\ and\ ciphertext}{total\ characters} x\ 100\% \quad (3)$$

This equation above calculates the proportion of the encrypted text that changes when the original text or key is slightly changed.

2.5. Bit Error Rate (BER)

Bit Error Rate (BER) is a measure of telecommunication signal integrity based on the quantity or percentage of transmitted bits that are received incorrectly. Essentially, the more incorrect bits, the greater the impact on signal quality. Bit error rate is an effective indicator of full end-to-end performance because it encompasses the receiver and transmitter as well as the media between them.

$$BER = \frac{Total\ different\ bits}{total\ bits} x\ 100\% \quad (4)$$

The equation above shows us how to calculate BER by the percentage difference in bits between the encrypted text and the plaintext.

2.6. Character Error Rate (CER)

Character Error Rate is to calculate percentage levels the accuracy of an encryption results by matching and comparing characters (letters, numbers, symbols). plaintext has compared to plaintext that is added or changed with a lower presentation.

$$CER = \frac{Total\ different\ bits\ from\ plaintext\ and\ ciphertext}{total\ characters} x\ 100\% \quad (5)$$

The equation above shows us how to calculate CER by the percentage of character differences between the generated encrypted text and the expected text.

2.7. Entropy

Entropy is a measure of the amount of information in a message or text and is expressed in units of bits. Entropy is used to estimate the average number of bits to encode each element of the message. The higher the number of bits of entropy, the greater the complexity and the level of security in a cryptographic system. In general, entropy can be calculated using equation (6).

$$H(X) = -\sum_{i=i}^{n} a_i{}^2 log(p(S_i)) \quad (6)$$

Where :
X is message
Si is the ith symbol in the message p(S) = the chance of occurrence of S i
a is number of occurrences of S i

2.8. Proposed Method

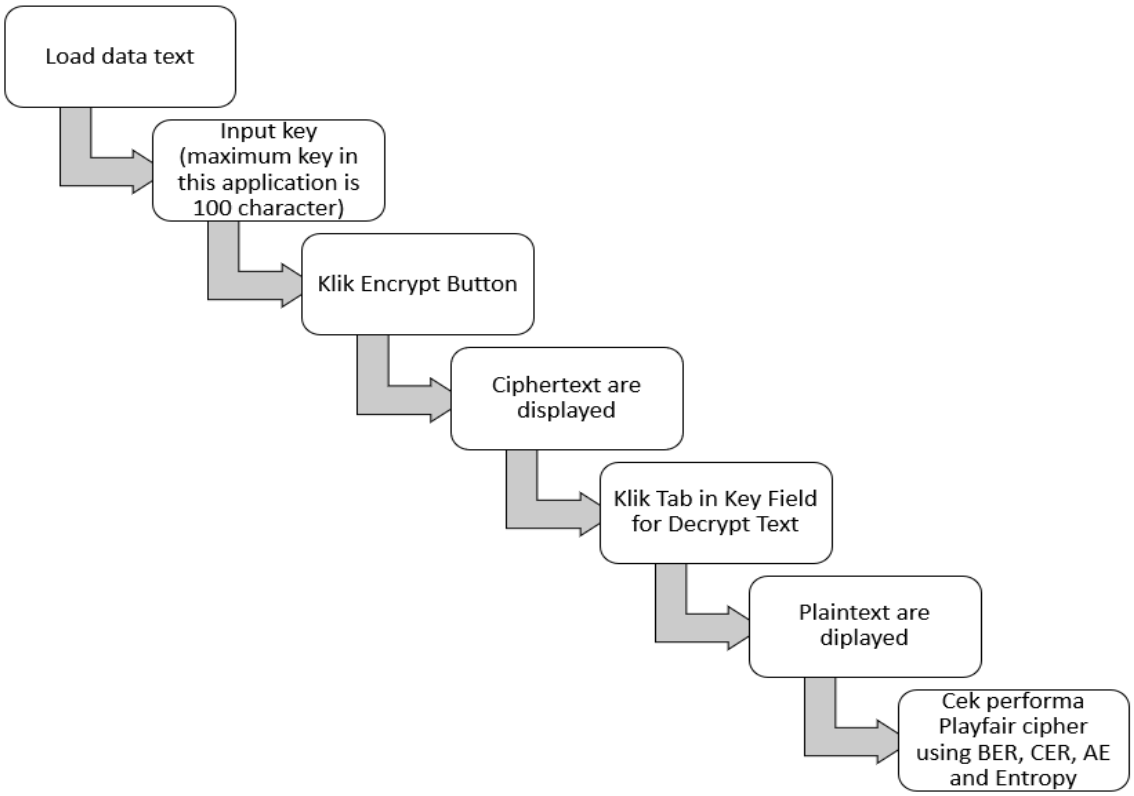


Figure 3. Proposed method based on Playfair Cipher

3. RESULTS AND DISCUSSION

This research is implemented using the Java programming language with JavaFX as its user interface, and it is executed using the IntelliJ IDEA software. The following is the GUI display when it is run, as shown in Figure 4.

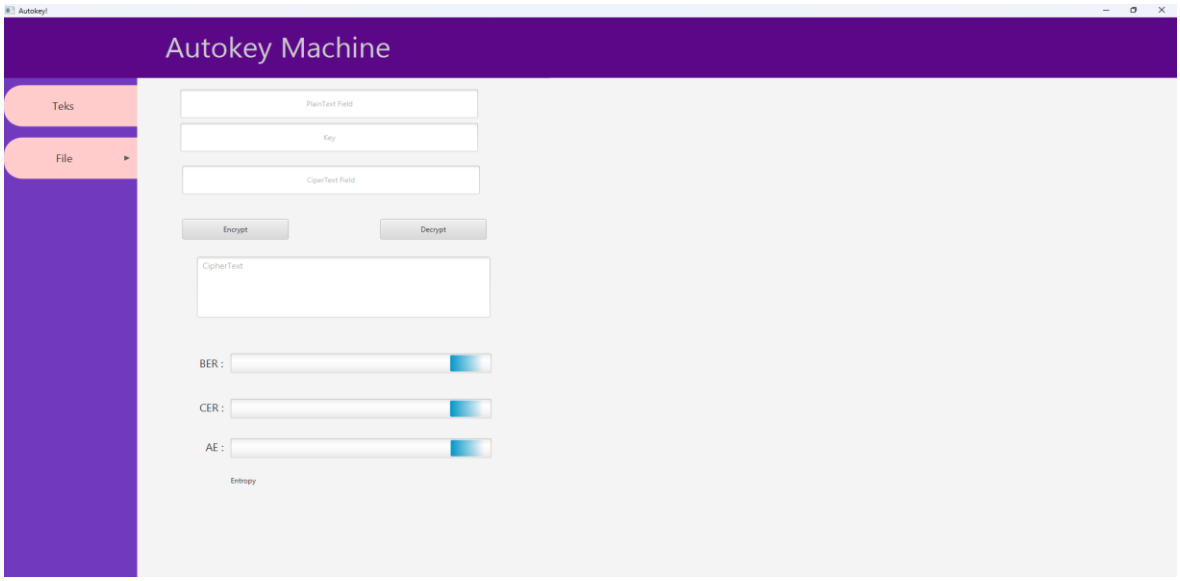


Figure 4. Display result

Figure 4 shows the initial view before inputting the plaintext and key; the Avalanche Effect, Character Error Rate, Bit Error Rate and Entropy item is not yet given results because the empty fields in the plaintext, key, and ciphertext and need to be filled in and entered first. After entering the plaintext and key/ciphertext in the provided columns, as shown in the display in Figure 4, and pressing the encrypt/decrypt button, the display will be complete. Once data security has been implemented by entering the plaintext and key/ciphertext, it is ensured that when executed by pressing the encryption/decryption button, the output results will be displayed as shown in Figure 5.

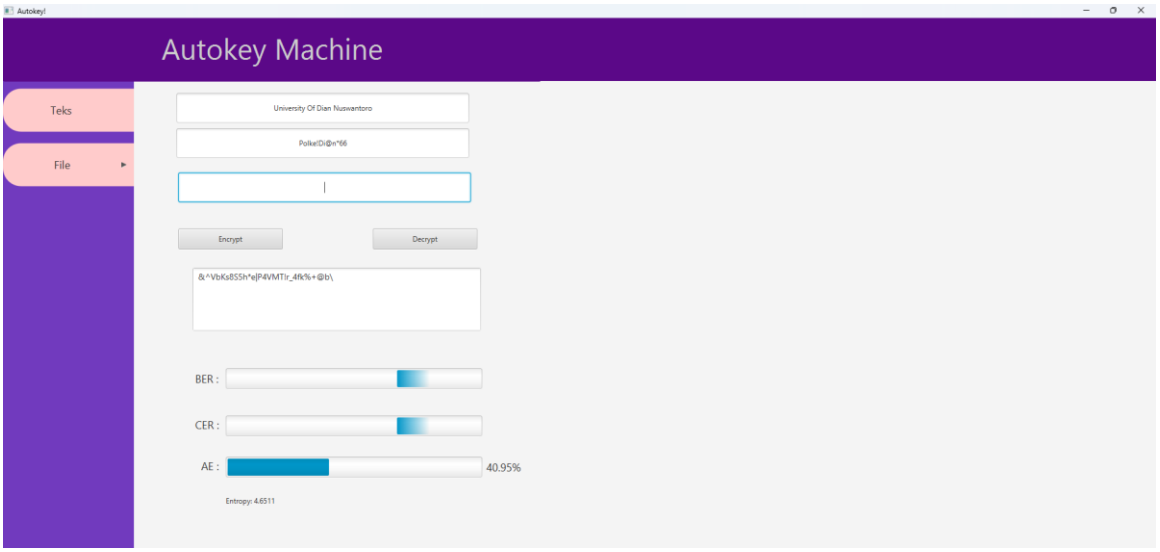


Figure 5. Encrypt Output Result

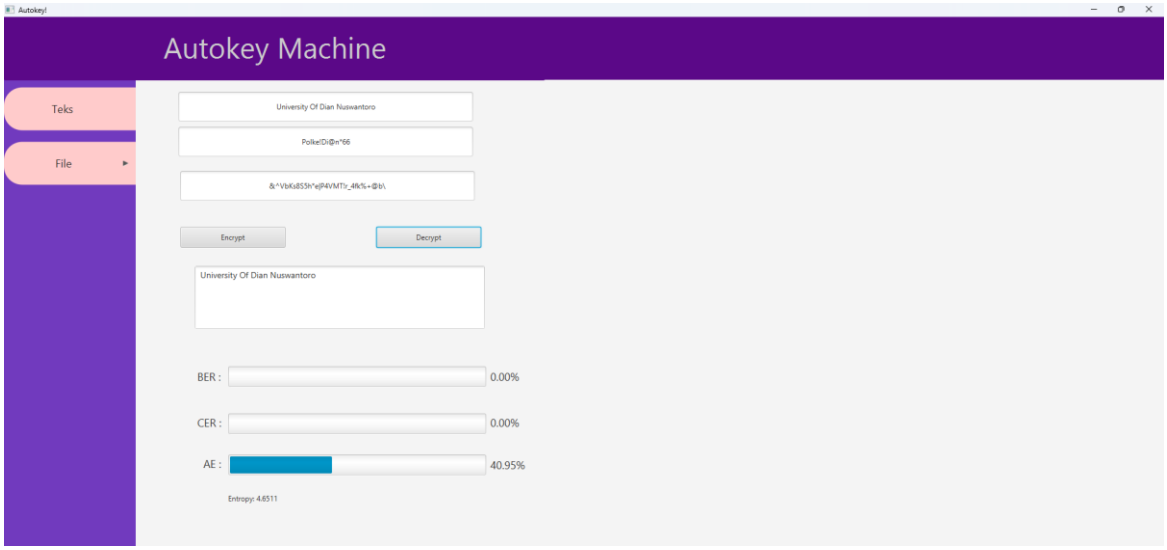


Figure 6. Decrypt Output Result

Figure 5 shows the encrypt output results when entering the plaintext and key. Meanwhile Figure 6, the decryption output displays the results when entering the same key and alo the results of the ciphertext from Figure 5, including the original text, encrypted text, decrypted text, Bit Error Rate (BER), Character Error Rate (CER), Avalanche Effect (AE), and Entropy.

Table 1. Test Results with Autokey Method

Plaintext	Key	Ciphertext
Universitas Dian Nuswantoro	Polke!Di@n*66	&^VbKs8S5P}6Z:Q[k4v8a"]~&)@
Testing number 45 with Autokey Method	Polke!Di@n*66	%U``Oo,i/dwx{Co!!ex.^)nK,+@[ReeN*^)^n
RickyDirgantara@mhs	Polke!Di@n*66	#YPW_E.\(Px+wCQ-YNt
HansVal3r1An_Lenice	Polke!Di@n*66	xQ[_<b1|3 K%u|U[UIf
Autokey_Ricky_hans@mhs.dinus!ac	Polke!Di@n*66	qea[Qf>IrXm"00XNZYA2R4|n %FcmMI
<?R1ckY_W1th_H4nS??	Polke!Di@n*66	l/?|Il}Iw ~~ux$[?%@

Based on Table 1, it had been seen that the autokey method can be applied to ASCII text with a combination of letters, numbers, and symbols, resulting in encrypted text or ciphertext in the form of symbols based on the ASCII table. Next, tests were conducted for Avalanche Effect, BER, CER, and Entropy with results as shown in Table 2, Table 3, and Figure 7.

Table 2. Avalanche Test Results

Plaintext	Key	Avalanche Effect %
Universitas Dian Nuswantoro	Polke!Di@n*66	43%
Testing number 45 with Autokey Method	Polke!Di@n*66	39%
RickyDirgantara@mhs	Polke!Di@n*66	42%
HansVal3r1An_Lenice	Polke!Di@n*66	37%
Autokey_Ricky_hans@mhs.dinus!ac	Polke!Di@n*66	38%
<?R1ckY_W1th_H4nS??	Polke!Di@n*66	36%

Based on Table 2 above, the average Avalanche Effect value from the 6 conducted tests is 39%. This means that the Avalanche Effect generated using the Autokey method is considered quite good. The use of ASCII text with a range of letters, numbers, and symbols enhances the level of information security derived from the use of the Autokey method. However, the Avalanche Effect value is considered quite good depending on the context and desired security requirements. In cryptography, the higher the avalanche effect is the better it gets. That means a small change in the original text or key should result in a significant change in the encrypted text.

Table 3 Bit Error Rate (BER) and Character Error Rate (CER) Test Result

Plaintext	Key	Bit Error Rate %	Character Error Rate %
Universitas Dian Nuswantoro	Polke!Di@n*66	0%	0%
Testing number 45 with Autokey Method	Polke!Di@n*66	0%	0%
RickyDirgantara@mhs	Polke!Di@n*66	0%	0%
HansVal3r1An_Lenice	Polke!Di@n*66	0%	0%
Autokey_Ricky_hans@mhs.dinus!ac	Polke!Di@n*66	0%	0%
<?R1ckY_W1th_H4nS??	Polke!Di@n*66	0%	0%

Table 3 shows us the Bit Error Rate and Character Error Rate values. The BER and CER values for each test are 0, which indicates that the encryption test has a high level of accuracy. Tests with high BER and CER values have lower CER values which indicates that the resulting ciphertext is better along with lower bit and character error rates. When evaluating algorithms for encryption or decryption, it is very important to pay attention and understand about the Character Error Rate and Bit Error Rate values. These values will show us how well the algorithm can produce precise and accurate encrypted text.

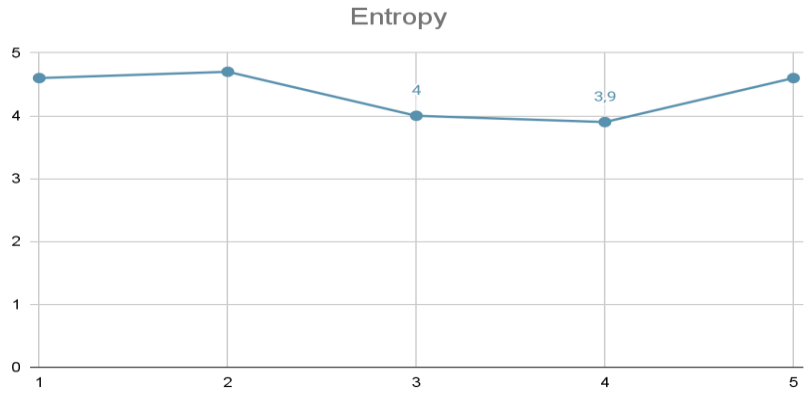


Figure 7. Entropy Test Result

Figure 7 shown that the average of the entropy test result obtained is 4 and if we look at the entropy value, it may be reasonable for randomness, but keep in mind that this value still depends on you or the final assessment set in the system. We now can understand if the high entropy results can be obtained if the text has a lot of long texts, numbers and symbols or complex randomness, and for low entropy results are text that has few short letters, numbers, and symbols.

4. CONCLUSION

This research was created using the Autokey Algorithm and the programming language used was Java and the library used from Java was JavaFX. The GUI that we created in this research has several features that have been created such as input plaintext fields, key fields, and ciphertext fields, other features are the results of input created such as ciphertext (results from plaintext encryption) and calculations that include things like Avalanche Effect, Character Error rate, Bit Error Rate, and Entropy Calculation. Apart from that, the IDE used to help run the GUI is Intellij IDE from Jetbrains. The purpose of this research is that the cryptography implementation created can be easily understood by users who use it. We hope that by making this research we can understand that cryptography is no longer used only for writing or completing code, but has developed into various functions such as encryption or decryption for data security, identity and message authentication, digital signatures and certificates, key exchange protocols, digital money, and so on.

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