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Arabic and English Texts Encryption Using Proposed Method Based on Coordinates System

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Abstract

Arabic and English texts are encrypted using an innovation cryptology method. An innovated cipher method deals with two languages, Arabic and English, and belongs to substitution cipher family. The core idea of the innovated method is to use coordinates system on x-axis and y-axis completely. The method supports mono- alphabetic substitution cipher and Polygram substitution cipher. In the mono- alphabetic substitution cipher, the encryption process consists of two steps, the first step is text encryption via x- axis and second step is text encryption via y- axis. This means multiple level of ciphering. The obtained cipher text is decrypted by two methods; the first decryption method is the reverse order of the encryption process (decryption via y- axis then decryption via x- axis). The second decryption method is decryption via origin point. In the decryption process, the second decryption is faster than first decryption method. In the Polygram substitution cipher, the plaintext is encrypted as blocks, each block contains three letters, and each letter in the block is encrypted by different way according to scheduling reflection types stored in vector that shifted at each time. The practical experiments show that the innovated cryptology method is faster than all substitution cipher methods for encryption and decryption processes. The innovated cryptology method is more effective than all substitution cipher methods since it's mathematical model depends on coordinates system instead of algebraic operations.

Keywords*: Cryptology, coordinate system and substitution, Cryptosystems, Security.*

1 Introduction

The classical or traditional ciphers and updated ciphers are considered cryptosystems [1]. Substitution and transposition techniques belong to classical or traditional ciphers. The updated or modern ciphers include a symmetric and an asymmetric method [2]. There are two types of ciphers: substitution and transposition ciphers [3]. By using a specific key, the letters via transposition of plain text are re-arranged or scrambled for determining locations of letters [4]. The columnar method is an example of the transposition. in the any organization, information is the most important part and must be secured via protection techniques[5]. There are many technologies used by people or parties for accessing information [6, 7]. cryptography is considered the strongest technique used for message or information protection and developed to reach optimal security level [8].

2. Substitution Cipher Technique

The replacing process of plain-text letter by different letter in cipher text is called substitution technique [9]. There are two types of replacement process, the first type is single alphabet replacement that is called mono-alphabetic substitution technique, while the second type is

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multiple alphabet replacements that is called poly-alphabetic substitution technique [10]. The substitution technique for ciphering message or information is declared for comminuted party's sender and receiver. [11]. for obtaining cipher text from original text using traditional cryptography, there are two basic techniques: substitution and transposition Ciphers [12]. The Product Cipher is obtained from mixing substitution and transposition Ciphers to work together [13]. In encrypting process, each letter of the original data is replaced with specific manner. in deciphering process, each letter of the encrypted information is obtained by using the reverse manner [14]. An authentication, integrity, confidentiality and non-repudiation are considered the main objectives of cryptography [15].

3. Related Work

There are many types of mathematics models used by cipher techniques[16]. Basically, the power of cipher techniques depends on mathematics model used in the encryption and the decryption processes[17]. This paper deals with different manner for cryptology. Using coordinates system as mathematics model for ciphering and deciphering processes is proposed in this paper. In [18], the main idea is based on a modular 37, since using Arabic letters, the integer values are being assigned to Arabic letters considering numbers from 0 to 9. The procedure of encryption and decryption is simple and effective. The integer values are selected randomly, then calculating an inverse of the selected integer considering modular 37. In [19], the KAJ is proposed that uses spiral method to support Play fair cipher for different languages. The size of each block is more than two letters at a time. The letters are distributed via a spiral shape on x-axis and y-axis based on circles manner [20].

4. The General Structure of Proposed Method

The proposed method is implemented by two different ways: the mono-alphabetic substitution and the Polygram substitution. The general structure of proposed method is shown in figure 1 below.

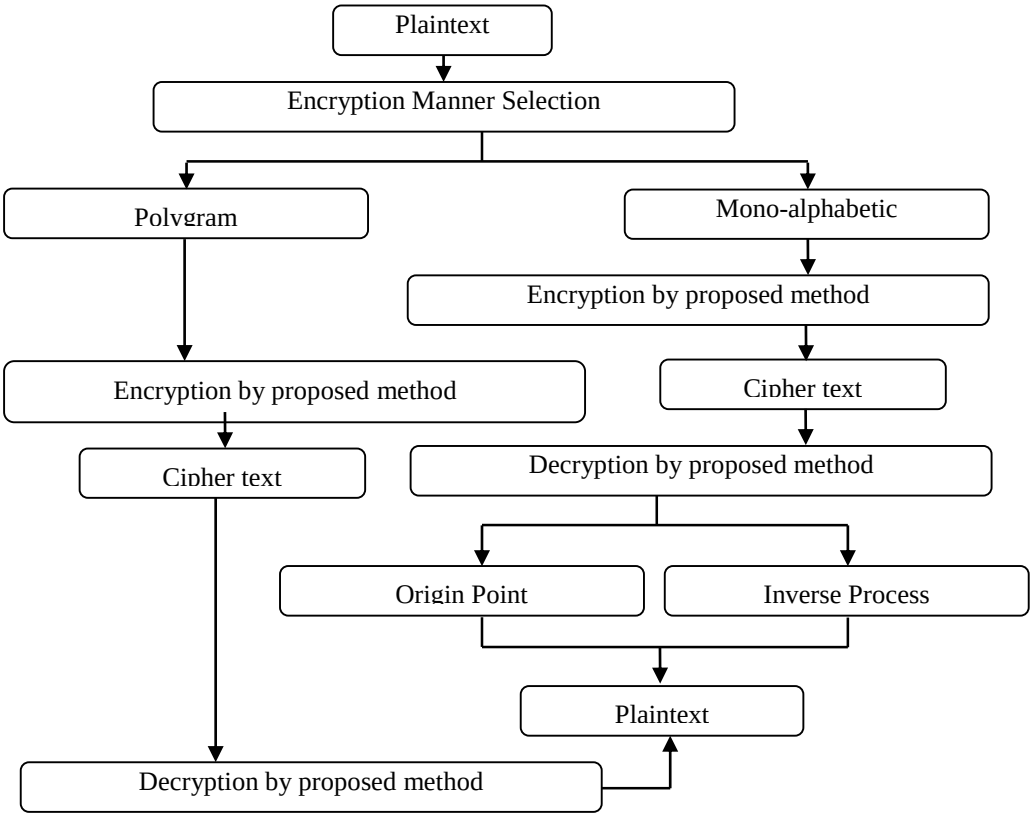

Figure 1: General Structure of Proposed Method

5. Structure of Mono-alphabetic by proposed Method

The method supports mono-alphabetic substitution cipher. With this type of implementation, each letter of the selected language will be encrypted by double replacements. The proposed method with mono-alphabetic substitution cipher consists of many stages that will be explained in this section. the stages of mono- alphabetic substitution cipher of proposed method are the preparing stage, the drawing stage, the distribution stage, the indexing stage, the encryption stage, and the decryption stage. The proposed method is depending on the coordinates system and x and y axes for ciphering and deciphering processes. The basic structure of mono- alphabetic substitution cipher of Proposed method is shown in figure 2 below.

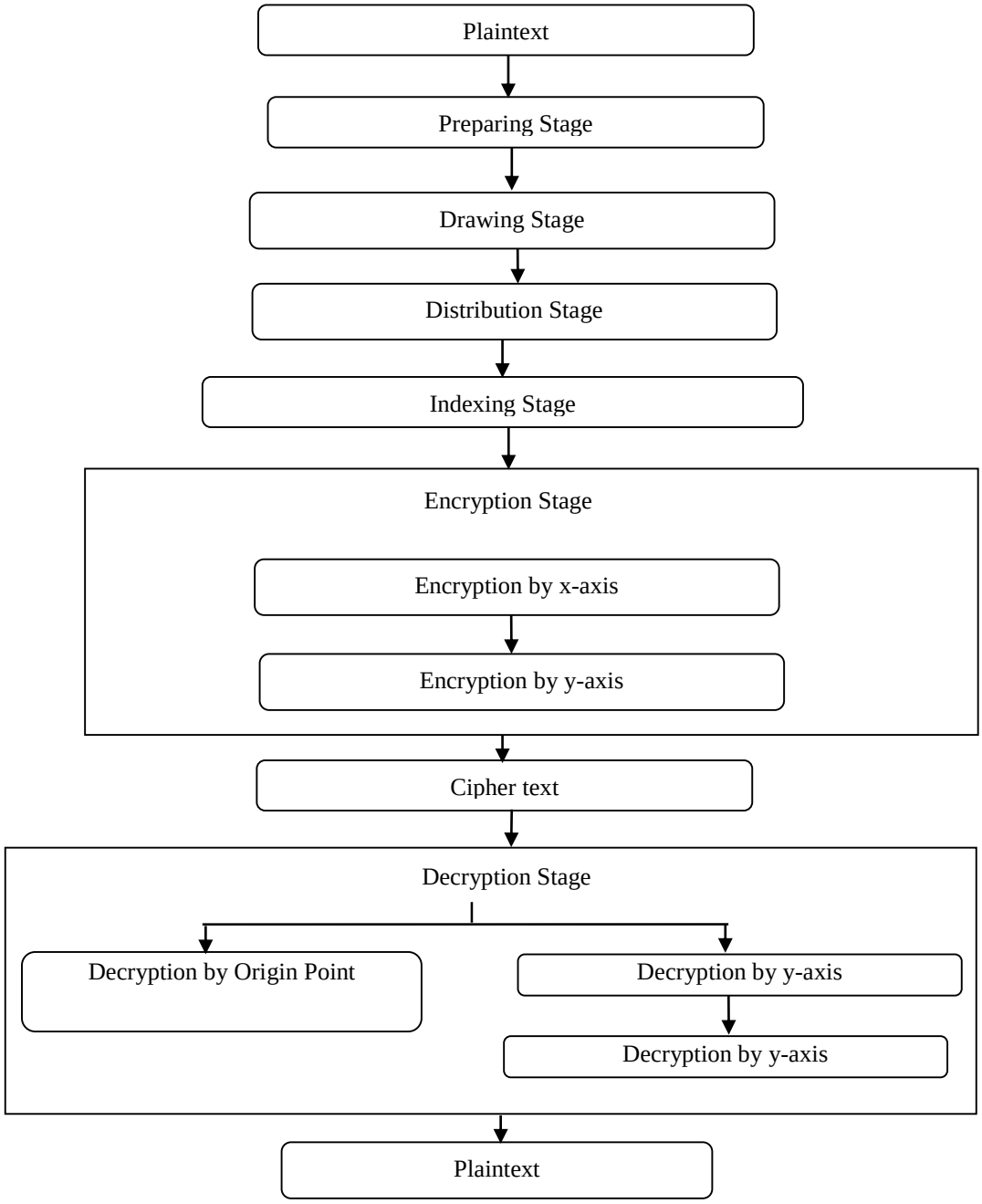

Figure 2: The Mono-alphabetic Structure of Method

5.1. The Preparing Stage

There are several steps through in this stage, the first step is loading and reading a massage or clear information. the second step is specifying used language of a message (Arabic or English). the third step is deleting special symbols, characters, and separators from a message

since the proposed method cipher does not support encryption of special symbols, characters and separators. The last step of this stage is dividing a message into blocks, and each block contains three letters only if Polygram substitution cipher is used by proposed method. When the mono-alphabetic substitution cipher is used by the proposed method, the last step is not required. This stage is shared between mono-alphabetic substitution cipher and the Polygram substitution cipher via the proposed method. The letters of Arabic or English languages that will used by method are shown in tables 1 and 2.

Table 1: The Letters of Arabic Language

ح	ج	ث	ت	ب	ا
س	ز	ر	ذ	د	خ
ع	ظ	ط	ض	ص	ش
م	ل	ك	ق	ف	غ
ء	ئ	ي	و	ه	ن
آ	ى	إ	أ	ؤ	ة

Table 2: The Letters of English Language

A	B	C	D	E
F	G	H	I/J	K
L	M	N	O	P
Q	R	S	T	U
V	W	X	Y	Z

5.2. The Drawing Stage

The basic mathematical principle of the proposed method is the coordinates system. The requirements of coordinates system are two steps generally: the first step is drawing x-axis with limit according to language of message or plaintext used. If the language of English is used, then the limit of x-axis to 5 in different directions, while if the language of message is Arabic, then limit of x-axis to 9 in different directions. The second step is drawing y-axis with limit according to language of message or plaintext used. The limit of y-axis is same to what happens to x-axis. This stage is shared between mono-alphabetic substitution cipher and Polygram substitution cipher via proposed method. The drawing of x-axis and y-axis is shown in figure 3.

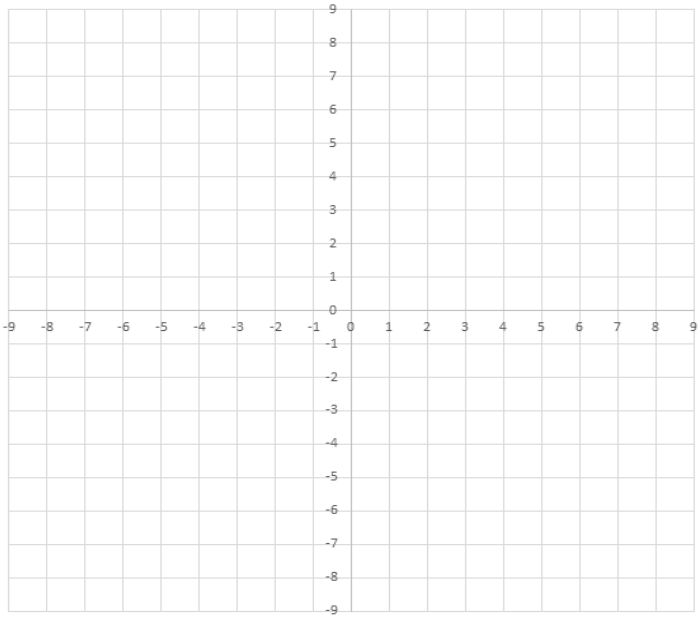

figure 3: The Drawing Process of Axes.

5.3. Distribution Stage

The letters of Arabic or English languages are distributed on all quadrants equally. If Arabic letters are used, then each quadrant contains the same number of letters. This means 9 letters in each quadrant. If English letters are used, then 5 letters will be in each quadrant. The x value and y value are equal for all letters in Arabic or English, but the sign of x value and y value is different according to the quadrant that is found in it, or may be equal in quadrant1 and quadrant 3 especially. This stage plays the main role in ciphering process since distribution manner used. The distribution of letters depends on wrapping task around origin point totally. For example, the first wrapping around origin point is clockwise while the next wrapping is inverse clockwise and so on. The distribution process of Arabic and English letters are shown in figures 4 and 5.

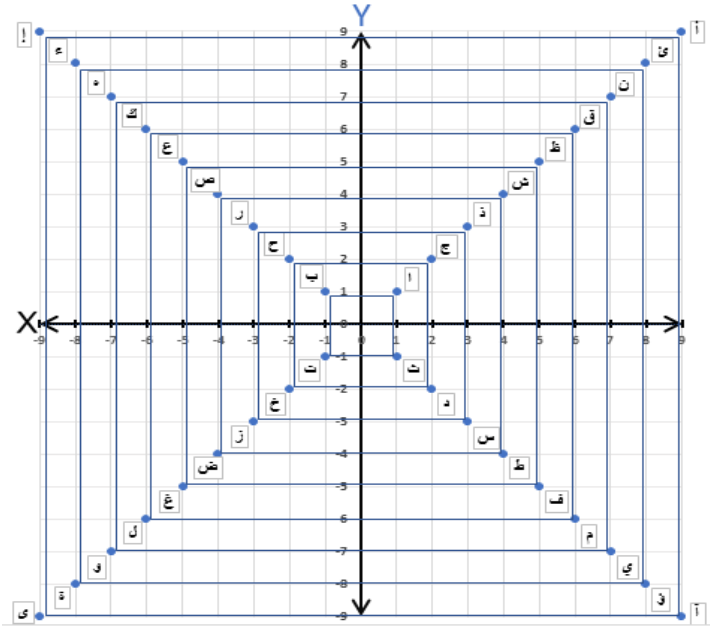

Figure 4: The Distribution Process of Arabic Letters

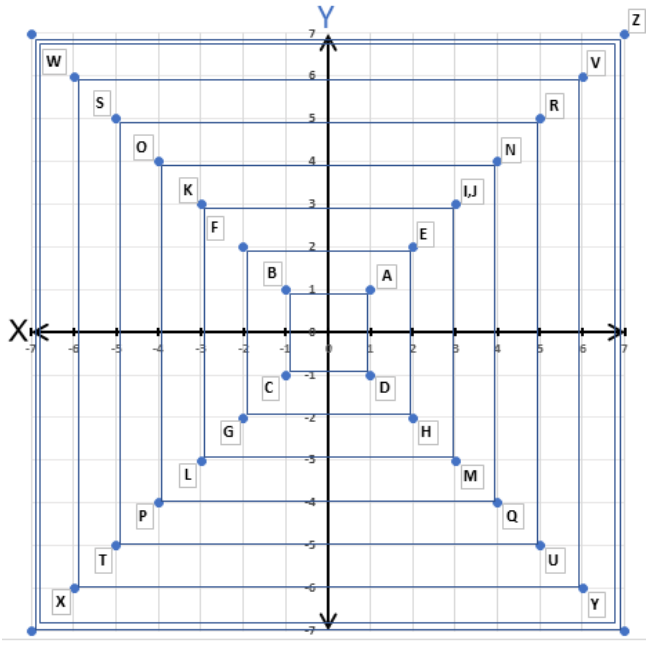

Figure 5: The Distribution Process of English Letters

5.4 . Indexing Stage

For all letters of Arabic and English, the access index for each one of them is by coordinates pairs that pointed by x-axis and y-axis. Using coordinates pairs allows letters encryption around three directions that are x-axis, y-axis, and the origin point. The coordinates pairs of Arabic letters are shown in table 3 while the coordinates pairs of English letters are shown in table 4 below.

Table 3: The Coordinates Pairs of Arabic Letters

ح (-2,2)	ج (2,2)	ث (1,-1)	ت (-1,-1)	ب (-1,1)	ا (1,1)
س (3,-3)	ز (-3,-3)	ر (-3,3)	ذ (3,3)	د (2,-2)	خ (-2,-2)
ع (-5,5)	ظ (5,5)	ط (4,-4)	ض (-4,-4)	ص (-4,4)	ش (4,4)
م (6,-6)	ل (-6,-6)	ك (-6,6)	ق (6,6)	ف (5,-5)	غ (-5,-5)
ء (-8,8)	ئ (8,8)	ي (7,-7)	و (-7,-7)	ه (-7,7)	ن (7,7)
آ (9,-9)	ى (-9,-9)	إ (-9,9)	أ (9,9)	ؤ (8,-8)	ة (-8,-8)

Table 4: The Coordinates Pairs of English Letters

E (2,2)	D (1,-1)	C (-1,-1)	B (-1,1)	A (1,1)
K (-3, 3)	I/J (3,3)	H (2,-2)	G (-2,-2)	F (-2, 2)
P (-4,- 4)	O (-4, 4)	N (4, 4)	M (3,-3)	L (-3,-3)
U (5, -5)	T (-5, -5)	S (-5, 5)	R (5, 5)	Q (4, -4)
Z (7,7)	Y (6,-6)	X (-6,-6)	W (-6,6)	V (6,6)

5.5 The Encryption Stage

In the mono-alphabetic cipher of the proposed method, each letter of Arabic or English is encrypted by double replacement. The first replacement is around x-axis, and the second replacement is around y-axis. This process does not require a key. Any letter in the 1st quadrant that is indexed by $P_i=(X_i , Y_i)$ is encrypted based on the reflection around x-axis to result in the coordinate pair $C_i=(X_i , -Y_i)$ that refers to cipher letter, the letters in 2nd quadrant that are indexed by coordinate pair $P_i=(-X_i , Y_i)$ are encrypted based on the reflection around x-axis to result in the coordinate pair $C_i=(-X_i , -Y_i)$, the letters in 3rd quadrant that are indexed by coordinate pair $P_i=(-X_i , -Y_i)$ are encrypted based on the reflection around x-axis to result in the coordinate pair $C_i=(-X_i , Y_i)$, and the letters in 4th quadrant that are indexed by coordinate pair $P_i=(X_i , -Y_i)$ are encrypted based on the reflection around x-axis to result coordinate in the pair $C_i=(X_i , Y_i)$. The reflection around the x-axis is the first replacement, while the second replacement is performed by the reflection around the y-axis for each letter such as the letter in the 1st quadrant that is indexed by coordinate pair $C_i=(X_i , Y_i)$ is encrypted based on reflection around y-axis to result coordinate pair $CC_i=(-X_i , Y_i)$, the letters in 2nd quadrant that are indexed by the coordinate pair $C_i=(-X_i , Y_i)$ are encrypted based on reflection around y-axis to result in the coordinate pair $CC_i=(X_i,Y_i)$, the letters in 3rd quadrant that are indexed by coordinate the pair $C_i=(-X_i,-Y_i)$ are encrypted based on the reflection around the y-axis to result in the coordinate pair $CC_i=(X_i,-Y_i)$, and the letters in 4th quadrant that are indexed by the coordinate pair $C_i=(X_i , -Y_i)$ are encrypted based on the reflection around y-axis to result in the coordinate pair $CC_i=(-X_i , -Y_i)$. The encryption procedure is illustrated in algorithm 1.

Algorithm 1: Letters Encryption With Mono-alphabetic Manner
Input: $P_i=(X_i , Y_i)$ as letter from plaintext.
Output: $C_i=(X_i , Y_i)$ as encrypted letter.
Begin
Preparing plaintext.
Load and read the prepared plaintext as file f.
While f file is not empty
read plaintext letter as the coordinate pair $P_i=(X_i , Y_i)$.
If $P_i=(X_i , Y_i)$ does not equal space or special character then:
If encryption manner is Mono-alphabetic Manner then
Apply reflection of coordinate pair $P_i=(X_i , Y_i)$
around x-axis to obtain$C_i=(X_i , Y_i)$
considering quadrant of loaded letter.

Apply reflection of coordinate pair that obtained C_i=(X_i , Y_i)
around y-axis to obtainCC_i=(X_i , Y_i) and
considering quadrant of C_i=(X_i , Y_i).
Save the result CC_i in new file;
end if
end if
END While
END

5.6. The Decryption Stage

The output of the encryption stage is cipher text; the cipher text is an input for this stage. In this method with mono-alphabetic manner, the cipher text is decrypted by two methods. The first method is an inverse process and the second method is the origin point process. When applying the inverse process on cipher text, the reflection around the y-axis then the reflection around the x-axis are done to obtain plain text according to coordinates pairs table that were explained above, which depends on the x-axis and the y-axis. Therefore, Any letter in the 1st quadrant that is indexed by the coordinate pair CC_i=(X_i , Y_i) is decrypted based on the reflection around the y-axis to result in coordinate pair C_i=($-X_i$, Y_i) that reflected around x-axis to obtain plain text that indexed by coordinate pair P_i=($-X_i$, $-Y_i$), the letter in the 2nd quadrant that is indexed by the coordinate pair CC_i=($-X_i$, Y_i) is decrypted based on the reflection around the y-axis to result in coordinate pair C_i=(X_i , Y_i) that is reflected around the x-axis to obtain plain text that is indexed by coordinate pair P_i=(X_i , $-Y_i$), the letter in 3rd quadrant that is indexed by the coordinate pair CC_i=($-X_i$, $-Y_i$) is decrypted based on the reflection around the y-axis to result in coordinate pair C_i=(X_i , $-Y_i$) that is reflected around x-axis to obtain plain text that indexed by coordinate pair P_i=(X_i , Y_i) and the letter in 4th quadrant that is indexed by coordinate pair CC_i=(X_i , $-Y_i$) is decrypted based on the reflection around the y-axis to result in coordinate pair C_i=($-X_i$, $-Y_i$) that is reflected around the x-axis to obtain plain text that is indexed by coordinate pair P_i=($-X_i$, Y_i). The coordinates pairs of decryption process are shown in figure 6, and the decryption procedures are illustrated in algorithm 2.

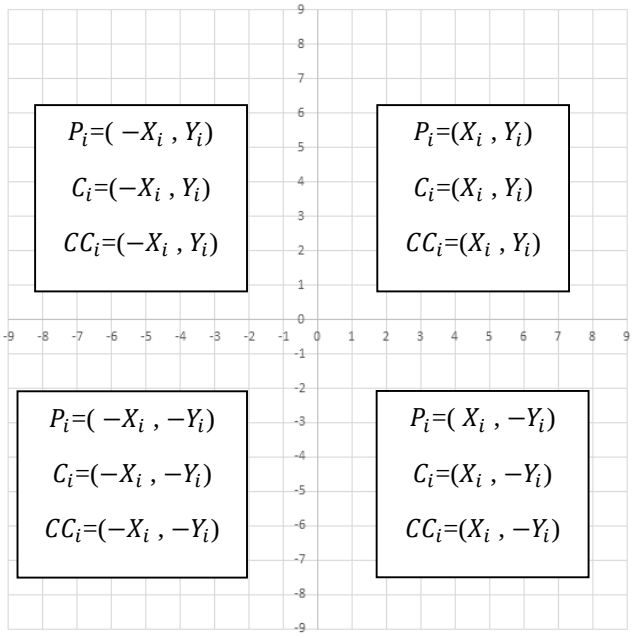

Figure 6: Coordinates Pairs of Cryptology Process

The second method for decryption in this method with mono-alphabetic manner is the origin point process. This method performs decryption by applying reflection around the origin point.

For any distribution manner of letters used, this method is applied correctly and efficiently. The main advantage of this method is that is it faster than first method to decrypt cipher text.

Algorithm 2: Letters Decryption with Mono-alphabetic Manner
Input: $CC_i=(X_i , Y_i)$ as letter from cipher text.
Output: $P_i=(X_i , Y_i)$ as letter from plain text.
Begin
Preparing cipher text.
Load and read prepared cipher text as file f.
While f file is not empty
read cipher text letter as coordinate pair $CC_i=(X_i , Y_i)$.
If $CC_i=(X_i , Y_i)$ is not equal space or special character then:
If encryption manner is Mono-alphabetic Manner, then
If inverse process method is used, then
Apply reflection of coordinate pair $CC_i=(X_i , Y_i)$
around y-axis to obtain$C_i=(X_i , Y_i)$
considering quadrant of loaded letter.
Apply reflection of coordinate pair $C_i=(X_i , Y_i)$
around x-axis to obtain plain text $P_i=(X_i , Y_i)$ and
considering quadrant of $C_i=(X_i , Y_i)$ according to coordinates pairs tables.
Save result P_i in new file;
Else
Apply reflection of coordinate pair $CC_i=(X_i , Y_i)$
around origin point to obtain plain text $P_i=(X_i , Y_i)$
Save result P_i in new file;
endif
endif.
Endif
Endwhile
END.

5.7. Applied Examples

In the method with mono-alphabetic manner, for encrypting and decrypting the plaintext "جامعة بغداد" by using coordinates pairs according to its table above that is based on x-axis and y-axis as shown following:

Plaintext=جامعة بغداد
Prepared Plaintext= ج ا م ع ة ب غ د ا د
Cipher text= خ ت ك ف ئ ث ظ ح ت ح
Decrypted text= ج ا م ع ة ب غ د ا د
Plaintext= Baghdad university
Prepared Plaintext= b a g h d a d u n i v e r s i t y
Cipher text= d c e f b c b s p l x g t u l r w
Decrypted text= b a g h d a d u n i v e r s i t y

6. Structure of Polygram by proposed Method

The WISAM method supports Polygram substitution cipher. With this type of implementation, the plaintext is divided into blocks, each block has three letters only. Each block of selected language such as Arabic or English will be encrypted by using the reflection around three axes that are x- axis, y-axis and the origin point. These directions allow to encrypt each letter in the block with a direction that differs from other letters of the block. Since the block has three letters, the 1st letter is encrypted by the reflection around the x- axis, the 2nd letter is encrypted by the reflection around the y- axis and the 3rd letter is encrypted by the reflection around the origin point. This method requires using vector with size of three nodes to save x- axis, y-axis and origin point in it as indexes for each block in encryption and decryption processes. The Proposed method with Polygram substitution cipher consists of many stages that are similar stages of mono-alphabetic except for one stage that is the rules applying stage. All other stages are not explained since we explained them in section 5 above. But the rules applying stage includes four steps. The first step is dividing the plaintext into blocks and each block consists of three letters only. The second

step is processing repeating letters and set separators between them. The third step is creating vector to store x- axis, y-axis and origin point as index for ciphering and deciphering of each block, and the last step is processing of blocks that contains less than three letters via adding extra letter or letters to complete three letters in each block. The general structure of method with Polygram substitution is shown in figure 7.

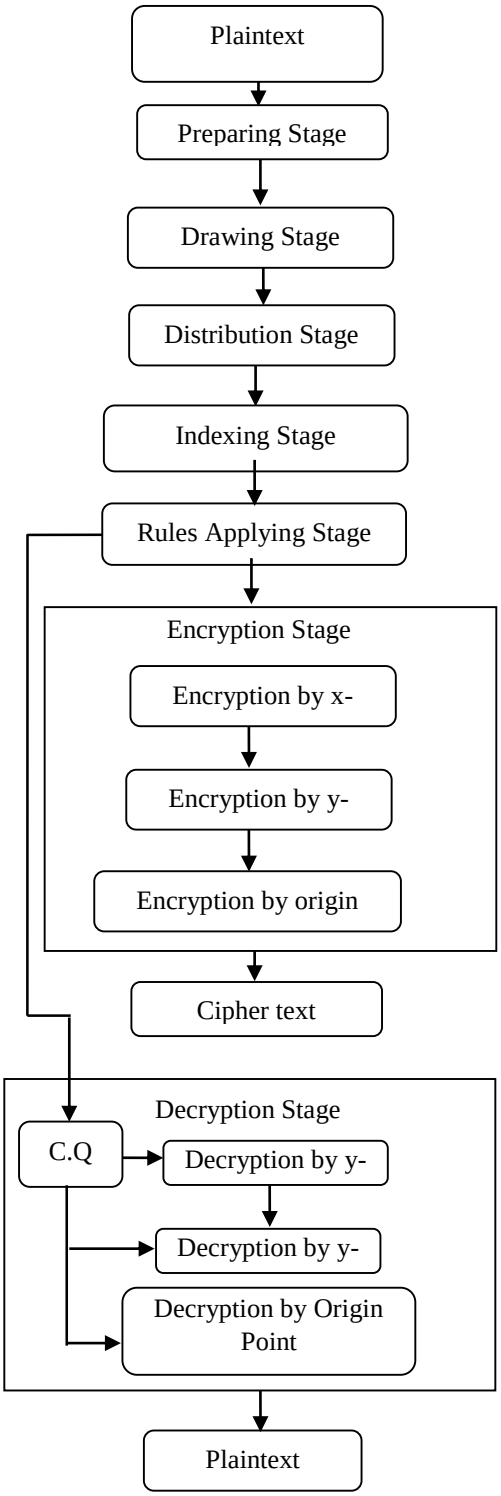

Figure 7: General Structure of Polygram in proposed method

Applying encryption algorithm requires reading vector that represents scheduling of reflection types. According to scheduling of reflection types, the encryption and decryption processes are applied. Using scheduling of reflection types strengthen procedures of encryption. Algorithm 3 shows process of encryption and Algorithm 4 shows process of decryption.

Algorithm 3: Process of Encryption with Polygram.

```
Input: Bi, Pi where B and P are block and plaintext respectively.
Output: BBi, Ci
Begin
Load and read plaintext from file F ;
Preparing loaded plaintext;
Dividing plain text into blocks Bi and each block contains 3 letters;
    If encryption manner is Polygram Manner, then
   While F file is not empty
      Read Pi  from Bi;
      If  Pi is not equal special character then
          Load and read scheduling of reflection types from vector;
          Apply encryption process on Pi by selected reflection type from vector;
          Save result Ci in new BBi block;
          Save result BBi in new FF file;
     Endif
End while
   Else
       Apply mono-alphabetic substitution cipher in proposed method
END.
```

Algorithm 4: Process of Decryption with Polygram.

```
  Input: BBi, Ci
  Output: Bi, Pi where B and P are block and plaintext respectively.
  Begin
        Load and read cipher text from file FF;
        Preparing loaded cipher text;
        Dividing cipher text into blocks Bi and each block contains 3 letters of cipher text;
       If encryption manner is Polygram Manner, then
         While FF file is not empty
            Read Ci from BBi;
            If Ci is not equal special character, then
              Load and read scheduling of reflection types from vector;
              Apply decryption process on Ci by selected reflection type from vector;
             Save result Pi in new Bi block;
             Save result Bi in new F file;
           Endif
        Endwhile
    Else
    Apply mono-alphabetic substitution decipher in proposed method
  END.
```

6.1.Applied Examples

In the proposed method with Polygram substitution cipher manner, to encrypt and decrypt the plaintext " جامعة بغداد" by using coordinates pairs according to its table above, that is based on scheduling of reflection types from vector, as shown in the following examples for Arabic and English when the scheduling of reflection types from circular queue is indexed according to : the reflection around x-axis =1, the reflection around y-axis =2 and the reflection around the origin point =3. Since the vector is used to save it, then shifting to right is done each time. This means that the first letter of the block will be encrypted by reflecting around the x-axis, the second letter of block will be encrypted by reflecting around y-axis, and the third letter of block will be encrypted by reflecting around the origin point. This process is repeated but with shifting vector to right each time until all blocks are finished.

Example 1: encrypt the plaintext=جامعة بغداد by Polygram substitution cipher in method. The encryption process is shown in table 5 below.

Table 5: The Encryption Process by Polygram

Plaintext			جامعة بغداد						
Prepared Plaintext				**Vector**			**Cipher-text**		
Block1	م	ا	ج	3	2	1	ك	ب	د
Block2	ب	ة	ع	1	3	2	ت	ئ	ظ
Block3	ا	د	غ	2	1	3	ب	ج	ظ
Block4	ؤ	ؤ	د	3	2	1	ء	ة	ج

The obtained cipher text is د ب ك ظ ئ ت ظ ج ب ج ة ء and decryption process for above cipher text is in table 6 below.

Table 6: The Decryption Process by Polygram

Cipher text			د ب ك ظ ئ ت ظ ج ب ج ة ء						
Prepared Cipher text				**Vector**			**Plaintext**		
Block1	ك	ب	د	3	2	1	م	ا	ج
Block2	ت	ئ	ظ	1	3	2	ب	ة	ع
Block3	ب	ج	ظ	2	1	3	ا	د	غ
Block4	ء	ة	ج	3	2	1	ؤ	ؤ	د

Example 2: encrypt the plaintext= Baghdad university by Polygram substitution cipher in WISAM method. The encryption process is shown in table 7 below.

Table7: The Encryption Process by Polygram

Plaintext			Baghdad university						
Prepared Plaintext				**Vector**			**Cipher-text**		
Block1	b	a	g	3	2	1	c	B	e
Block2	h	d	a	1	3	2	g	B	d
Block3	d	u	n	2	1	3	b	R	o
Block4	i	v	e	3	2	1	m	W	g
Block5	r	s	i	1	3	2	s	U	m
Block6	t	y	j	2	1	3	r	V	k

The obtained cipher text is (cbegbdbromwgsumrvk) and decryption process for above cipher text is in table 8 below.

Table 8: The Decryption Process by Polygram

Cipher text			Cbegbdbromwgsumrvk						
Prepared Cipher text				**Vector**			**Plaintext**		
Block1	c	b	e	3	2	1	b	A	G
Block2	g	b	d	1	3	2	h	D	A
Block3	b	r	O	2	1	3	d	u	n
Block4	m	w	G	3	2	1	i	v	e
Block5	s	u	M	1	3	2	r	s	i
Block6	r	v	K	2	1	3	t	y	j

7. Conclusions

When the proposed method is applied, there are several conclusions drawn from the implementation of the mono- alphabetic substitution cipher and the Polygram substitution cipher. These are as the following.

The method supports any language generally, but Arabic and English languages are supported especially. The method supports two types of substitution cipher that are mono- alphabetic and Polygram ciphers. In the method, the mono- alphabetic cipher is faster than the Polygram cipher. Also, the Polygram cipher is more secure than the mono- alphabetic cipher. The proposed method is performed with any type of distribution manner efficiently. The decryption process by reflecting around the origin point is not affected when any type of distribution manner is used. The encryption process must not start from the origin point then x-axis and y-axis since it returns to same letter. In the proposed method, using the vector in the Polygram cipher is a power point since each letter will be encrypted differently.

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