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ORIGINAL ARTICLE

Encryption Algorithms for the Bioinformatics Data

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Abstract

17 The security of the bioinformatics data is one area that is still overlooked by the cybersecurity
18 community. There are several issues that should be catered accordingly, such as data privacy and
19 restricted data access. Encryption algorithm might be the solution to solve this problem because it is
20 the industry standard approach to the cybersecurity issues. That is why in this review we will try to find
21 the most suitable and effective encryption algorithm that can be used to preserve security to biological
22 data by doing some comparison using several parameters and methods accordingly. It is found that
23 the Cryfa tool is one of the most promising applications for securing the bioinformatics data. Beside the
24 tools, in this regard, artificial intelligence-based approach could leverage the security level significantly.

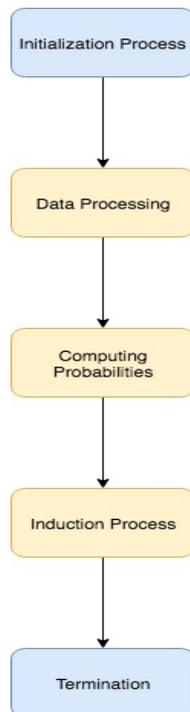
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26 **Keywords:** Data Security; Encryption; Cryfa Tools; Forward Algorithm; Biological Data
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Introduction

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31 Advance Technology in this new-era is rapidly developing especially in big data processing or
32 high-throughput sequencing technologies. This advancement in high-throughput sequencing
33 technologies triggers a revolution in many fields of science especially in life sciences such as
34 medical informatics, personalized medicine, pharmacy, biotechnology and also bioinformatics
35 (Hosseini, Pratas, & Pinho, 2019; Pratas, Hosseini, & Pinho, 2017). Advance Technology in
36 high-throughput sequencing or big data processing maybe gave us many advantages especially
37 for research purposes but don't forget that it also raises an issue especially to big-data security,
38 which is very sensitive and private. The researcher tries to figure an effective way to protect the
39 biological data and also its privacy, one way to preserve security to biological data is to use an
40 algorithm specifically encryption algorithm. Based on current standing of information, currently
41 the healthcare industry needs to improve their cybersecurity measures significantly, especially in
42 regard for protecting their medical information from unauthorized access (Kruse, Frederick,
43 Jacobson, & Monticone, 2017) . This security risk is increasing significantly due to the broader
44 access to the mobile health data with smartphone and portable gadgets (Luxton, Kayl, &
45 Mishkind, 2012).

46 What is the Encryption Algorithm? Is it possible to preserve security to biological data by
47 using the encryption algorithm? In simple understanding, the Encryption Algorithm consists of 2
48 words, which are Encryption and Algorithm. Encryption is the process of converting information
49 or data into a binary form to prevent unauthorized people to access the data and the Algorithm is

1 the method to transform or convert the information or the data into binary form. So, encryption
2 algorithm is a method to help in processing the information or data into unreadable (binary) form
3 to preserve security to the data or information (Kumari, 2017). To help them on their research
4 purpose or studies, the researcher use the existed encryption that had been developed by
5 people in the past like RSA, DES, 3DES, and AES or they develop their own encryption
6 algorithm by “upgrading” the ability of the existed algorithm to suit their research needs.
7 Encryption process consists of 5 major steps, which start with the Inputting the data that we want
8 to encrypt into the initialization process, then we compute the probabilities which then the result
9 will enter the induction process and finally the final output will be produced after the termination
10 process as it will be shown in Figure 1.
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12
13 **Figure 1:** Encryption Process
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15 In this review, we will do a comparison between 4 kinds of algorithm that had been developed
16 before by several researchers. Those algorithms are RSA, which we usually called it as the
17 basic encryption algorithm, AES Algorithm, HMM Forward Algorithm that is using RSA Algorithm
18 as its based algorithm and the last one is the Cryfa Tools that is using the AES Algorithm as its
19 based algorithm. There are several parameters that we will use to find the algorithm that is
20 suitable for preserve security to biological data such as Time complexity, Algorithm Complexity,
21 and also their strength/weaknesses.
22

23 **Materials and Methods**

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25 Seven (7) Journals Articles have been collected from Research Gate and NCBI PubMed. The
26 searching of journals was conducted from 6th June 2019 until 18th June 2019 with “Encryption
27 Algorithm” and “Biological Data” as the keywords search. All journals that have been selected
28 were published in the range of 2011 - 2019. Each of these journals implemented the RSA, AES,
29 and HMM algorithm in Biological data, especially gene sequences. From 7 journals article that
30 has been found, they mostly discussing the implementation of RSA and AES Algorithm in

1 securing data or information. Table 1 shows the review summary of 7 journals and Table 2
 2 shows the strength and the weaknesses of each algorithm.

3
 4 **Results**

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 7 The journals had been reviewed and it shows that each algorithm has its strength either it is
 8 on the algorithm complexity, how fast they process data, security, or their time complexity. From
 9 Table 1 we can see that all of the algorithms were fast when they process the data but it also
 10 depends on the data or sequences that we process, the bigger the size of the data then the
 11 more time was taken by the algorithm to process the data. The most important thing is doing
 12 they preserve security to the data or biological data, in Table 1 it shows that most of the
 13 algorithms did preserve security to the data but we need to find the most secure algorithm that
 14 can give the best data security service. Studies that were done by Lou et.al and Franz et.al
 15 (Franz et al., 2012; Yang Lou, 2017) which is about the forwarding Algorithm shows that it gave
 16 very high security towards the biological data because the data were encrypted 2 times. Also, it
 17 has several other strengths such as user-friendly and it helps to generate alignment of the
 18 sequence that was being encrypted. Everything in this world has its weakness, HMM Forward
 19 Algorithm has a weakness which is it consumed a lot of memory when they store big size data, it
 20 also needs to be trained before we can use it for our research purpose and it needs high
 21 computational power if we want to encrypt a huge size of data such as the Genome sequence,
 22 the strength, and weaknesses of each algorithm can be seen in Table 2 below.

23
 24 **Table 1:** Review summary of the algorithms in the 7 journals that had been collected

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| Author(S) | Topics | Algorithm | Time Complexity | Algorithm Complexity |
|--------------------------------------|--|-------------------|---|--|
| (Zhou & Tang, 2011) | Research and Implementation of RSA Algorithm for the Encryption and Decryption | RSA | Quite fast, it depends on the sequences/data that were inputted | The algorithm is quite long and complex. But it helps in preserving security to the data |
| (Franz et al., 2012; Yang Lou, 2017) | Hidden Markov Models Approaches for Biological Studies | Forward Algorithm | Quite fast, it depends on the sequences/data that were inputted | The algorithm is quite long and complex. But it helps in preserving security to the data |

| | | | | |
|--|---|-------------|---|--|
| (Hosseini et al., 2019; Pratas et al., 2017) | Cryfa Tools : a secure encryption tools for genomic data | Cryfa Tools | Quite fast, it depends on the sequences / data that were inputted | It does the encryption 2 times using the same algorithm which RSA Algorithm that has been updated |
| (Rehman, 2016) | Characterization of Advanced Encryption Standard (AES) for Textual and Image Data | AES | Quite fast, it depends on the sequences / data that were inputted | The algorithm is complex and needs higher computational power to run it if the data that was inputted is big or long |

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Table 2. Strength and Weaknesses of the algorithms in the 7 journals that had been collected

| Algorithm | Strength | Weakness |
|-------------------|--|---|
| RSA | <ul style="list-style-type: none"> - It is safe and secure for its users - It is hard to crack / hack - RSA uses public key to encrypt data | <ul style="list-style-type: none"> - It can be very slow when it encrypts a large amount of data - Requires a third party quality assurance approach to verify the reliability of public keys |
| Forward Algorithm | <ul style="list-style-type: none"> - Provides better compression - Helps to generate alignments - User-Friendly | <ul style="list-style-type: none"> - Memory Consuming - Needs to be train first like machine learning |

| | | |
|-------------|---|--|
| | | <p>methods</p> <ul style="list-style-type: none"> - High Computational Power (Depends on the size of the data) |
| Cryfa Tools | <ul style="list-style-type: none"> - Low memory usage - Work in almost all types of computer | <ul style="list-style-type: none"> - High Cost |
| AES | <ul style="list-style-type: none"> - Mostly it is used for wide various of applications such as e-business, encrypted data storage and financial transactions - Hard to be hacked/cracked | <ul style="list-style-type: none"> - Uses simple algebraic structure - Hard to implement with existing software - Might affect the performance and the security of a data |

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Discussion

A deep concern in bioinformatics security is on the restriction of access to the genomics database. This particular condition should be considered because the currently popular Role-Based Access Control (RBAC) is mainly utilized for the electronic health record (Fernández-Alemán, Señor, Lozoya, & Toval, 2013). National Institute of Health (NIH) already provide genomic data sharing policy for personal genome project but this protocol should be socialized further, especially to the developing countries (Zarate et al., 2016). Moreover, there is a significant potential risk of privacy violation to outsource cloud computing of the Single-Nucleotide Polymorphisms (SNPs) data to the third party vendor (Hasan, Mahdi, Sadat, & Mohammed, 2018). This situation is even more serious in the current standing of the COVID-19 pandemic when big data analytic is necessary to annotate contact tracing information (Chen et al., 2020).

A lot of people had developed a very useful and efficient algorithm nowadays, especially to help in preserving security to biological data. Even though the algorithm is efficient and useable, those algorithms had their drawbacks and weaknesses such as the Cryfa Tools, it might be sophisticated but we found its weaknesses which is if you want to you this tools to encrypts the genomic data, we need to use higher computational power and it means that it cost a lot of money too. So, for further study maybe we can create some encryption tools that use the strength of other algorithms to solve the problem that is available before. For example like we can combine the low-memory usage of Cryfa tools (Zhou & Tang, 2011) with forwarding Algorithm Users-friendly and Security strength. A more plausible implementation of the

1 encryption algorithm is implementing artificial intelligence-based (AI) approach that already
2 commonly utilized in the area of the medical diagnostics (Bernard & Parikesit, 2020). Although it
3 is still in its infancy, AI has started to find potential application in web applications security with
4 the utilization of Knowledge Based Systems, probabilistic reasoning and Bayesian updating
5 (Morel, 2011). In this end, bioinformatics service in the cloud could be more secure than ever.
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8 **Conclusion**

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10 We have reviewed each algorithm and compared them with each other using several
11 parameters like time complexity, algorithm complexity, their strength, and also their weaknesses.
12 We can conclude that each algorithm has its strength and weaknesses, all of the algorithms are
13 easy to use and could be applied in almost all data either basic data or biological data but we
14 found out that there is 1 algorithm that shows a very promising result which is the HMM Forward
15 Algorithm. Why Forward Algorithm? Because it uses the RSA algorithm which cannot be
16 cracked or hacked easily, it is user friendly and the most crucial thing is that it does the
17 encryption 2 times which makes it more secure and hopefully can help in securing the biological
18 data. Even though the HMM Forward Algorithm shows very promising features, it still has its
19 weaknesses that's why for future study hopefully people can develop a user-friendly encryption
20 algorithm, more advance, and also has high security to help in preserving the security of
21 biological data.
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23 **Acknowledgments**

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25 The authors would like to thank the Department of Research and Community Service
26 (LPPM), Department of Bioinformatics (BI) and Center of Student Development (CSD)
27 Department of the Indonesia International Institute for Life Sciences (i3L) for supporting this
28 research.
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