Technological University of the Philippines
Ayala Blvd, Ermita, Manila, 1000 Metro Manila
Applications Development and Emerging Technologies
College of Science

A REVIEW OF CURRENT EMERGING TECHNOLOGIES:

THE POWER OF ALGORITHMS IN BIOTECHNOLOGY

In Partial Fulfillment of the Requirement

in Applications Development and Emerging Technologies

Submitted By:

Tejada, Jerry Boy

Caturla, Simone Arabella

Guevarra, Elizabeth

Nario, Jolo Czar Ken

BSCS-NS-2AB-M | GROUP 10

Submitted to:

Professor Amador, Peragrino, Jr B.

CC223-M Instructor

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TABLE OF CONTENTS

INTRODUCTION

Biotechnology is a rapidly advancing field that applies principles of biology, chemistry, and engineering to develop new products, processes, and technologies for a wide range of applications. It involves the manipulation of living organisms or their components to create useful products or solve complex problems in fields such as medicine, agriculture, and industry. Biotechnology encompasses a broad range of disciplines, including genetic engineering, bioprocessing, bioinformatics, and biopharmaceuticals. With its potential to address some of the most pressing global challenges, such as climate change, food security, and healthcare, biotechnology is playing an increasingly important role in shaping the future of our world.

It has its roots in ancient history, with early civilizations using fermentation to produce alcoholic beverages and bread. Fast forward to the 19th century, when in 1919 Hungarian scientist Karl Ereky coins the term biotechnology. In 1928. Alexander Fleming discovers penicillin, the first true antibiotic. Pressing on in 1943 Oswald Avery proves DNA carries genetic information. After a decade 1953 James Watson and Francis Crick discover the double helix structure of DNA. In the 1980s the first biotech drugs to treat cancer are developed. Then 1997 The first mammal is cloned. Furthermore, in 2013 The first bionic eye is created. Lastly, this timeline in 2020 mRNA vaccine and monoclonal antibody technology is used to treat the SARS-CoV-2 virus. Over subsequent years, biotechnology has revolutionized the healthcare industry, with new drugs and therapies that have transformed the way we treat diseases. It also has applications in the food and agriculture industries, where it is used to develop new crops that are more resistant to pests and disease and to produce food products with improved nutritional value. Sorts of various ideas that are put into action with the help of newly made machinery and technologies created by man. There are various types of biotechnology: Red biotechnology involves medical processes, White or gray refers to industrial processes, Green covers agricultural processes, and Gold, also known as bioinformatics, is a cross between biological processes and informatics. , Blue encompasses processes in marine and aquatic environments, Yellow refers to processes that aid food production, Violet ensures the practice of biotechnology follows laws and ethical standards governing each field, and Dark is the use of biotechnology for weapons or warfare.

In correlation to our subject, Biotechnology, Applications Development, and Emerging Technologies are all interconnected fields that share many similarities and opportunities for collaboration. Biotechnology involves the use of living organisms or their components to develop new products, processes, and technologies for various applications. Applications Development involves the creation of software programs and mobile applications that can solve complex problems and improve people's lives. Emerging technologies, such as artificial intelligence, blockchain, and the Internet of Things (IoT), are constantly evolving and transforming the way we live and work. By combining the strengths of these fields, we can create powerful synergies that can lead to groundbreaking innovations. Overall, the intersection of biotechnology, application development, and emerging technologies is a fertile ground for new ideas and collaborations and has the potential to drive significant progress in various fields.

Pros And Cons of Biotechnology

a. PROS

Improved healthcare. Biotechnology has revolutionized the treatment of diseases.

Increased food production. Genetically modified crops produce higher yields to feed the global population.

Environmental benefits. Biotechnology has the potential to reduce chemical use, emissions, and climate change.

Industrial applications. Biotechnology can reduce reliance on non-renewable resources.

b. CONS

Ethical concerns. Biotechnology can have unintended consequences for biodiversity and ecosystem stability.

Safety risks. Biotechnology can be harmful to human health and the environment.

Economic inequality. Biotechnology can lead to economic inequality by favoring large corporations.

Intellectual property issues. Biotechnology raises issues of intellectual property, limiting access to life-saving technologies.

OBJECTIVES

- Explain why algorithms are widely used in Biotechnology.
- Enumerate and give a basic understanding of some of the popular algorithms that are used in Biotechnology.
- Show how algorithms are crucial a crucial aspect of Biotechnology and how it positively impacts the field.

SCOPE

This paper will focus on the algorithms that are used in biotechnology as well as discuss the benefits that these algorithms bring to the said field.

Presentation of the chosen technology

a). Uses and Functions

1. Sequence alignment algorithms. Sequence alignment algorithms are computational methods used to identify regions of similarity between two or more biological sequences. Vladimir Levenstein performed one of the earliest attempts to align two sequences in 1965, dubbed "edit distance" and now commonly referred to as Levenshtein Distance. In biotechnology, these algorithms are commonly employed for tasks such as detecting homologous genes and predicting protein structure and function.

Example: The BLAST (Basic Local Alignment Search Tool) algorithm is a widely used sequence alignment algorithm that compares a query sequence to a database of known
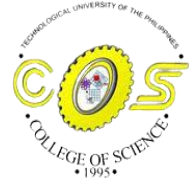
sequences to identify similar sequences. BLAST can be used to identify the function of a protein or to find homologous genes in different organisms.

2. Hidden Markov Model. A Hidden Markov Model (HMM) is a statistical model for representing probabilistic sequences. In biotechnology, HMMs are commonly employed for tasks such as gene prediction and protein sequence analysis. They offer a conceptual framework for creating complicated models simply by drawing an intuitive picture of biological items of interest.

Example: HMMs can be used to predict the secondary structure of a protein. The HMM model is trained on a set of known protein structures to learn the probability distribution of each amino acid and its position in the protein structure. The trained model can then be used to predict the secondary structure of a new protein sequence.

3. Clustering Algorithm. Clustering algorithms are a sort of unsupervised machine learning method that is frequently used to evaluate gene expression data in order to discover clusters of genes that are co-expressed. Clustering algorithms operate by grouping together comparable data points based on a measure of similarity or distance. Clustering algorithms are frequently used in biotechnology to evaluate gene expression data in order to discover groupings of genes that are co-expressed. This can aid researchers in understanding the underlying biological processes and identifying possible drug development targets.

Example: k-means clustering is a widely used clustering algorithm that groups data into k clusters based on their similarity. In gene expression analysis, k-means clustering can be used to group genes with similar expression patterns into clusters. This can help to identify genes that are co-regulated or involved in the same biological pathway.

4. Machine Learning Algorithms. Machine learning algorithms are a subset of artificial intelligence that can use data to create predictions or judgments. To classify biological data, such as gene expression data or medical imaging, machine learning algorithms such as support vector machines, random forests, and neural networks are utilized. These algorithms can be trained to recognize patterns or relationships in data and generate predictions depending on

fresh information. Machine learning algorithms are employed in biotechnology for a variety of tasks, including gene expression analysis, drug development, and personalized medicine.

Example: Support vector machines (SVMs) can be used to classify cancer patients based on gene expression data. The SVM model is trained on a set of known cancer patients and healthy individuals to learn the patterns of gene expression that are associated with cancer. The trained model can then be used to classify new patients as either cancer or healthy based on their gene expression data.

5. Genetic Algorithms. Genetic algorithms are a sort of optimization technique that is inspired by natural selection. Genetic algorithms are employed in biotechnology for a variety of tasks, including protein structure prediction, gene expression analysis, and drug development. Genetic algorithms mimic the process of natural selection. They begin with a population of potential solutions to a problem and then employ selection, crossover, and mutation operators iteratively to evolve the population toward superior solutions. Genetic algorithms are employed in biotechnology for a variety of tasks, including protein structure prediction, gene expression analysis, and drug development. A genetic algorithm, for example, may be used to find the best medicine combination to treat a specific ailment.
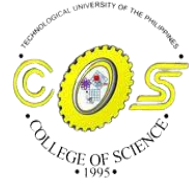
Example: Genetic algorithms can be used to optimize metabolic pathways in microbes to produce biofuels or pharmaceuticals. The genetic algorithm starts with a population of potential pathway designs and evolves them over multiple generations by selecting the best designs and breeding them to create new designs. The goal is to find the optimal pathway design that maximizes the production of the desired product.

6. Beehive algorithm. The Beehive method, sometimes known as the Bees Algorithm, is a population-based search method that replicates honeybee colonies' food-gathering behavior. Pham, Ghanbarzadeh, and colleagues created it in 2005. In its most basic form, the algorithm combines neighborhood search with global search and can be used for both combinatorial and continuous optimization. The algorithm begins with a population of bees spread randomly in the search space. Each bee is next searches its immediate surroundings for a food supply (i.e., a solution to the optimization problem). The best food sources are then chosen, and more bees

are sent to look for them. This method is repeated until either a good solution or a stopping criterion is reached.

Example: The beehive algorithm can be used to optimize the design of protein structures. The algorithm starts with a population of potential protein structures and evolves them over multiple generations by selecting the best structures and exchanging information between bees. The goal is to find the optimal protein structure that maximizes its stability or activity.

b.) Importance and Benefits

The use of algorithms in biotechnology is significant because it can aid in the advancement of research and development in the field. It can aid in the creation of new biotechnology products and processes, as well as the identification of potential therapeutic targets. Algorithms can also be used to investigate and model complicated biological systems, resulting in a greater knowledge of their behavior and application.

Algorithms are significant in biotechnology because they can help scientists discover new drug targets, simulate complicated biological processes, and increase the efficiency and effectiveness of research and development.

LITERATURE REVIEW

Biological systems, animal, and microorganism behaviors have inspired multiple algorithms. For instance, the optimization technique, Particle Swarm Optimization (PSO), has been inspired by behaviors from bird flocks/fish schools, and the probabilistic technique, Ant Colony Optimization (ACO), is based on pheromone-based communication of ants (Marinakis, Marinaki, & Dounias, 2011). Another example of this is neural networks, a class of computational methods influenced by the activity of neurons in the brain (Navlakha & Bar-Joseph, 2011). Lastly, Pigeon-Inspired Optimization (PIO), which has been influenced by the behavior of a swarm of pigeons, has been found to successfully solve combinatorial problems like the Travelling Salesman Problem (Zhong, Wang, Lin, & Zhang, 2019).
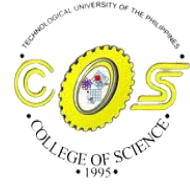
In biological research, computer algorithms are used to collect, process, and organize data. Genetic Algorithms (GA) can be applied to complex data systems and optimize data structures, but when combined with ACO, they can create a more efficient algorithm to analyze larger amounts of bioinformatics data. Sun's (2022) experiment on gene sequence alignment found that combining these algorithms results in faster and more accurate analysis and calculation of biological information.

Algorithms also have several applications in the medical field, including predicting the probability of developing diseases using Machine Learning (Holzinger, Keiblinger, Holub, Zatloukal, & Müller, 2023). Another important application is creating antigens for neurodegenerative disorders such as Parkinson's disease and Alzheimer's disease, which are caused by protein aggregation. By using computational algorithms, aggregation-prone regions (APR) can be identified and studied to create biotherapeutic proteins that can reduce aggregation susceptibility (Santos, Pujols, Pallarès, Iglesias, & Ventura, 2020). Besides the medical field, Machine Learning (ML) algorithms can also benefit the agricultural industry by predicting the environmental changes that can impact crop yield (Holzinger, Keiblinger, Holub, Zatloukal, & Müller, 2023).

Biotechnology also has the potential to reduce Food loss/waste (FLW), a major global problem with an annual global economic cost of $2.6 trillion USD (Fao, 2014). According to Mouat (2022), FLWs can be reduced by either transforming them into something useful or extending their shelf life using genetic modification. However, more research is needed to understand the environmental impact of FLW-prevention biotechnologies to ensure that they are sustainable and do not have unintended negative consequences.

Algorithms have provided new potential solutions to fields of research and applications such as computer science, medicine, agriculture, and more. By integrating biological systems into computational and technological innovations and using biotechnology to create sustainable solutions, many breakthroughs in research can be made.
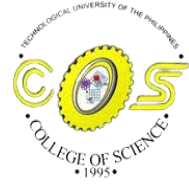
CONCLUSION

In conclusion, biotechnology is a rapidly evolving field that holds great potential for addressing some of the most serious global challenges, from healthcare to food security and the

environment. As biotechnology continues to advance, algorithms have become increasingly crucial in facilitating the processing and analysis of large and complex biological datasets. Algorithms enable researchers to quickly and accurately identify patterns, similarities, and differences in biological sequences, structures, and functions, leading to new insights and discoveries that were once impossible.

The researchers also discussed the commonly used algorithms in biotechnology: Sequence Alignment Algorithms, Hidden Markov Models, Clustering Algorithms, Machine Learning Algorithms, Genitive Algorithms, And Beehive Algorithms. These algorithms play critical roles in tasks such as gene prediction, protein structure and function prediction, and the identification of biomarkers and therapeutic targets. The BLAST algorithm has become a cornerstone of bioinformatics research, allowing researchers to rapidly search massive databases of biological sequences to identify potential homologous genes or proteins.
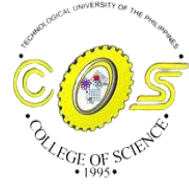
The benefits of algorithms in biotechnology extend beyond facilitating research and discovery. By enabling the rapid identification and analysis of biological data, algorithms have the potential to accelerate the development of new drugs, therapies, and technologies, improving human health and quality of life. Additionally, algorithms can help to optimize processes in industries such as agriculture and environmental management, leading to increased efficiency and reduced environmental impact. Despite the many benefits that algorithms bring to biotechnology, of course, there are also potential risks and challenges. One of the main concerns is the potential for biases and errors in algorithmic analysis, which can have significant consequences for decision-making and the accuracy of research findings. Additionally, there are ethical considerations around the use of algorithms, particularly in the areas of privacy, security, and intellectual property.

Overall, the innovation and combination of biotechnology and algorithms present aspiring innovative fields with a huge potential for progress and advancement. As the field continues to evolve, it is essential that researchers, policymakers, and stakeholders work together to ensure that algorithms are developed and used responsibly and ethically. By doing so, we can have the power of algorithms to drive positive change in biotechnology and create a better future for all.

RECOMMENDATIONS

There are several recommendations to carry on with the development of algorithms in biotechnology:

Invest in research and development of new algorithms. As the field of biotechnology continues to grow and evolve, new challenges will appear that require carefully considered solutions. Investing in research and development of new algorithms can help address these challenges and will aid the innovation in the field.

Prioritize ethical considerations. As with any emerging technology, it is important to consider the ethical implications of using algorithms in biotechnology. It is crucial to prioritize ethical considerations such as data privacy, and intellectual property to ensure that the benefits of these algorithms are shared just and objectively.

Continue to improve accuracy and efficiency. Algorithms are only as good as the data they are trained on, and it is important to continue to improve the accuracy and efficiency of these algorithms. This can be achieved using high-quality data sets, advanced machine-learning techniques, and ongoing optimization.

Invest in education and training. The use of algorithms in biotechnology requires a high level of expertise in both computer science and biology. Investing in education and training in these fields can help ensure that there is a skilled workforce capable of developing and utilizing these algorithms effectively.

Overall, by investing in research and development, prioritizing ethical considerations, improving accuracy and efficiency, and investing in education and training, we can ensure that the benefits of these algorithms are shared equitably.
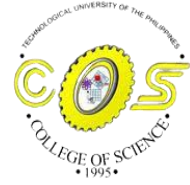
REFERENCES

Barney, N., & Lewis, S. (2022). biotechnology (biotech). *WhatIs.com*.
https://www.techtarget.com/whatis/definition/biotechnology

Hendrix, D. A. (2019, October 3). *Chapter 3: Sequence Alignments*. Pressbooks.
https://open.oregonstate.education/appliedbioinformatics/chapter/chapter-3/

D'haeseleer, P. (2005). How does gene expression clustering work? *Nature Biotechnology*, 23(12), 1499–1501. https://doi.org/10.1038/nbt1205-1499

Eddy, S. R. (2004). What is a hidden Markov model? *Nature Biotechnology*, 22(10), 1315–1316.
https://doi.org/10.1038/nbt1004-1315

Arnedo-Pac, C., Lopez-Bigas, N., & Muiños, F. (2021). Predicting disease variants using biodiversity and machine learning. *Nature Biotechnology*, 40(1), 27–28. https://doi.org/10.1038/s41587-021-01187-w

Wikipedia contributors. (2022). Bees algorithm. *Wikipedia*.
https://en.wikipedia.org/wiki/Bees_algorithm

Cerón-Muñoz, M. F., López, J. A., & Caicedo, E. (2009). An artificial beehive algorithm for continuous optimization. *International Journal of Intelligent Systems*, 24(11), 1080–1093.
https://doi.org/10.1002/int.20376

Fao, F. (2014). Food wastage footprint full-cost accounting. Food Wastage Footprint.

Holzinger, A., Keiblinger, K., Holub, P., Zatloukal, K., & Müller, H. (2023). AI for life: Trends in artificial intelligence for biotechnology. New Biotechnology, 74, 16–24.
https://doi.org/10.1016/j.nbt.2023.02.001

Marinakis, Y., Marinaki, M., & Dounias, G. (2011). Honey bees mating optimization algorithm for the Euclidean traveling salesman problem. Information Sciences, 181(20), 4684–4698.
https://doi.org/10.1016/j.ins.2010.06.032

Mouat, A. R. (2022). Sustainability in food-waste reduction biotechnology: a critical review. Current Opinion in Biotechnology, 77, 102781. https://doi.org/10.1016/j.copbio.2022.102781

Navlakha, S., & Bar-Joseph, Z. (2011). Algorithms in nature: the convergence of systems biology and computational thinking. Molecular Systems Biology, 7(1), 546.
https://doi.org/10.1038/msb.2011.78

Santos, J. B., Pujols, J., Pallarès, I., Iglesias, V., & Ventura, S. (2020). Computational prediction of protein aggregation: Advances in proteomics, conformation-specific algorithms and biotechnological applications. Computational and Structural Biotechnology Journal, 18, 1403–1413. https://doi.org/10.1016/j.csbj.2020.05.026

Sun, H. (2022). Construction of Computer Algorithms in Bioinformatics of the Fusion Genetic Algorithm. Mathematical Problems in Engineering, 2022, 1–8. https://doi.org/10.1155/2022/8632490

Zhong, Y., Wang, L., Lin, M., & Zhang, H. (2019). Discrete pigeon-inspired optimization algorithm with Metropolis acceptance criterion for large-scale traveling salesman problem. Swarm and Evolutionary Computation, 48, 134–144. https://doi.org/10.1016/j.swevo.2019.04.002