Thesis Project Portfolio

AI-Powered Prediction of Off-Target Effects in Genetic Engineering: A Bioinformatics and Machine Learning Approach

(Technical Report)

Navigating Ethical and Regulatory Frameworks in Genetic Engineering

(STS Research Paper)

An Undergraduate Thesis

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Natalie Nieves

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Department of Computer Science

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Executive Summary

In both my Technical Report and STS research paper, I examine different dimensions of genetic engineering, each offering distinct viewpoints. While the Technical Report focuses on the development of an AI-powered algorithm to predict off-target effects in genetic modifications, the STS research paper examines the broader ethical and regulatory frameworks governing genetic engineering practices. Despite their different approaches, both projects intersect on a central theme: the need to navigate the ethical and regulatory landscape of genetic engineering responsibly. By developing tools to enhance the safety and predictability of genetic modifications in one hand and analyzing the historical evolution and contemporary implications of regulatory frameworks in the other, both projects contribute to the ongoing discourse surrounding the ethical and societal implications of genetic engineering.

In my Technical Report, I propose a solution that would tackle the problem of the need for better tools to predict unintended outcomes in genetic engineering, specifically focusing on off-target effects. The project aimed to create a solution to reduce the risks associated with unintended genetic changes. To achieve this, I proposed an AI-powered algorithm that combines different types of data: synthetic data, which imitates genetic sequences and potential off-target effects, and real genetic data for validation. Through testing, the algorithm showed promising results in identifying possible off-target effects, suggesting its potential usefulness for genetic engineers. However, it still needs further testing and refining to ensure it works well across different genetic situations. The findings highlight the importance of using AI and machine learning to address the complex challenges in genetic engineering. By offering a tool to flag potential off-target sites, the algorithm could assist genetic engineers in making safer decisions during the modification process. Developing an AI-driven algorithm presents an opportunity to

improve the safety and predictability of genetic engineering. With ongoing development and collaboration, this tool could significantly impact the field by helping ensure more predictable and controlled outcomes in genetic modifications.

In my STS research paper, I explored the connection between ethics and regulations in human genetic engineering. Beginning with an overview of the historical evolution of human genetic engineering starting from early ethical dilemmas to groundbreaking achievements, in the paper I highlighted the role of regulatory frameworks in shaping the course of the field. It discusses the diverse perspectives surrounding genetic engineering governance, examining the transition from voluntary guidelines, such as those established at the Asilomar Conference, to contemporary regulations tailored to address the complexities introduced by advanced technologies like CRISPR/Cas9. Through a systematic review of existing regulatory mechanisms in the United States, the paper discusses the essential contributions of organizations like the FDA, NIH, and IRB in ensuring the safety, efficacy, and ethical integrity of genetic engineering practices. Furthermore, I researched the ongoing discourse between those who advocate for strict rules compared to who advocate for more flexible approaches, emphasizing the need for a balanced regulatory environment that encourages innovation while upholding ethical standards. The paper highlights how vital it is to navigate both ethical and regulatory aspects to guide genetic engineering responsibly. This ensures that advancements benefit society while also protecting human welfare and dignity.

In reflecting on my research this year, I'm pleased with the progress made in both the technical and socio-ethical dimensions of genetic engineering. The development of an AI-powered algorithm to predict off-target effects represents a significant breakthrough, offering a potential solution to a pressing challenge in the field. While further refinement and testing are

necessary, I'm confident that this tool holds promise for genetic engineers aiming to enhance the safety and predictability of their modifications. Similarly, my exploration of ethical and regulatory frameworks has shed light on the complexities surrounding genetic engineering practices. As engineers pick up where I left off, I recommend continued collaboration with geneticists and ethicists to refine the algorithm and navigate the evolving landscape of regulations. By remaining attentive to ethical considerations and fostering interdisciplinary dialogue, future researchers can build upon this foundation to ensure responsible and impactful advancements in genetic engineering.