Thesis Portfolio

Simulating Nutrient Preferences to Inform Co-culture Design for Probiotic Manufacturing

(Technical Report)

A Policy Analysis of Regulations on Artificial Intelligence for the Diagnosis of Disease

(STS Research Paper)

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Sociotechnical Synthesis

In recent years, there has been an increased focus on technical advancements made through computational systems. These advancements will improve technologies in a variety of sectors, especially healthcare. Computational systems are already in use in this sector from the discovery of new pharmaceutical drugs to the maintenance of health system data. These advances when implemented successfully have improved the efficiency of many processes, allowing for more rapid improvements to healthcare and treatments. Both my technical work and my STS research examine the impact of computational approaches to health problems. My STS research looks at artificial intelligence in its application for the diagnosis of disease, whereas my technical work focuses on improving the ability to develop treatments for malnutrition. Taken together, these projects look at improving both ends of patient experience in the health system.

Malnutrition is considered a pressing global health concern because of its role as a contributing factor for almost half of all childhood deaths (Walson & Berkley, 2018) and as an agent in developmental impediments. Gut dysfunction and altered gut microbiota have been linked to clinical outcomes of infantile malnutrition (Subramanian et al., 2014). Thus, nutritional rehabilitation therapies have been developed to help restore a healthy gut microbiome. However, current therapies have proved to be ineffective for sustainable growth. A promising new strategy is the transfer of live gut microbes to restore the gut microbiome. To become feasible for large-scale administration, new strategies must be employed to increase manufacturing yield of these human gut bacteria (O'Toole, Marchesi, & Hill, 2017). This project aims to use optimization techniques such as flux variability analysis (FVA) and parsimonious flux balance analysis (pFBA) to simulate nutrient preferences using genome scale metabolic network models from gut microbes. We developed a computational pipeline involving an iterative process of pFBA that can be applied to various probiotic strains to develop genome scale metabolic network models (GENREs) and nutrient preferences. These nutrient preferences were validated by experimental Biolog data by determining the correlation between the nutrient ranks from the pFBA analysis and experimental results. Nutrient preferences were simulated for a multispecies probiotic to look at the results in context.

Most Americans will receive a medical misdiagnosis at least once in their lifetime (Rue, 2019). Medical misdiagnoses occur in 5% of outpatient office visits, 10% of hospital inpatient deaths, and 12% of hospital adverse events, and contribute to 74,000 deaths per year (Papier, 2015). Artificial intelligence (AI) will be utilized to help with diagnosis of diseases by revealing previously hidden trends in data, and thus will have substantial impact both at the individual patient and system level (Panch et al., 2018). However, these systems prompt concerns related to the privacy of patient data, the quality and safety of these algorithms, and their impacts on the role of physicians and the healthcare system at large. This thesis seeks to answer where is the need for future policies surrounding artificial intelligence for diagnosis to protect patient privacy while providing the best possible care. Due to the risks associated with this technology, AI for the diagnosis of diseases must be considered an inherently political technology. This classification is in part due to how its development may conflict with current regulations and the need for government and healthcare systems to protect the safety and privacy of patients. This paper presents an analysis of the potential impacts of the use of artificial intelligence for the diagnosis of disease and the effects of current policies and regulations on its development and implementation. Additional policies are proposed for the use of this technology while focusing on the protection of the patients.

Working on these two projects in conjunction allowed me to gain different perspectives on each project that were prompted by the other. By studying both national and global regulations for patient data and artificial intelligence systems, I better understood what restraints were on the data I was using for my technical work and what processes would later be needed in order to get regulatory approval if this project continued beyond our end point. Additionally, the process of developing the computational pipeline put me in similar shoes as to the researchers working on artificial intelligence systems for the diagnosis of disease in the way I was using data to inform the development. This gave me further context to understand the policies and regulations I was reading and what they would mean practically. These projects taken as one examine different stages of the research and development process for computational systems to improve diagnosis and treatments.