Research Statement

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My research lies at the intersection of machine learning and health enhancement engineering, employing a variety of datasets, (video recordings, CT scan images, MRI images, DICOM images, histopathological images, electronic health records, and human biomedical and survey data). My work seeks to develop models aimed at understanding human behavior, explaining model behavior, supporting physicians in clinical decision-making, and ultimately enhancing health and social outcomes.

During my early Ph.D. years, I worked with videos coming from Federally Qualified Health Centers (FQHCs), which serve minority populations, checking how physicians and patients in primary care interact when a computer is in the room in naturalistic settings. I wanted to understand how technology affected their relationship and, ultimately, health results. I was keen on figuring out if having a computer around changed how physicians and patients communicated. By studying their eye gaze closely, I aimed to see if there were subtle shifts in how they interacted and if it affected how well patients did afterward. The big goal was to support the building and designing of health information technologies, which will facilitate the improvement of patient outcomes.

In the initial phase of my research, I acquired a raw dataset, videos from FQHCs, consisting of patient demographic information alongside recorded videos of medical visits. Consequently, I concentrated on the detailed annotation of nonverbal cues, particularly eye gaze, between physicians and patients within these interactions. The entire visit was coded for eye gaze. A coding included subjects (patient and physician), behavior (gaze), and modifiers (patient, physician, technology, chart, other artifacts, and unknown) for events in each video.

My first study focused on assessing the consistency of eye gaze behavior patterns between physicians and patients [1]. To achieve this, I employed two distinct methodologies rooted in both machine learning and statistical analyses: K-means and dynamic time warping (DTW). Remarkably, this study marked the first use of DTW for evaluating eye gaze patterns within medical settings.

In my second study using the same dataset, I conducted a systematic analysis to evaluate the dynamics of eye gaze during patient-physician-computer interactions in order to understand communication patterns across different patient backgrounds [2]. The evaluation involved lag sequential analysis, along with various statistical tests, to identify significant behavior patterns during the encounters. Additionally, the study shed light on distinctions in behavior patterns between minority and non-minority clinics.

Subsequently, my research expanded to investigate machine learning behaviors concerning human-provided data across different datasets. I have dived into the profound implications of artificial intelligence in medical imaging, specifically aiming to enhance computer-aided diagnosis systems (CAD). My investigations have explored computer vision and machine learning methodologies for identifying health-related issues. A significant portion of my research has been dedicated to understanding the impact of human label ambiguity on machine-learning models.

The investigation began with the utilization of medical data, specifically the Lung Image Database Consortium (LIDC), where up to four experienced radiologists assigned ratings to identify nine semantic features of nodule malignancy characteristics. Therefore, obtaining accurate labels is notably costly and often leads to inter-observer variability. Machine and deep learning methods present a promising avenue for obtaining optimal estimations of ground truth labels. However, these estimated labels inherently carry a degree of uncertainty. Consequently, a significant portion of my research has been dedicated to exploring the correlation between human-provided labels, coming from non-consensus panels, and the learning limitations of machine and deep learning methods across various label types based on human agreement. In my work, I have investigated different uncertainty measures to quantify the correlation between human uncertainty and model uncertainty. One of the uncertainty measures used was the Monte Carlo Dropout method.

My dissertation work focuses on exploring how uncertain labels from non-consensus panels affect machine learning in addition to investigating the limits to learning images and labels in the non-consensus panel. I have sought to assess the level of uncertainty inherent in the model by taking into consideration how predictions of the model change as human disagreement changes when we go from full, high, low, and no agreement using MC dropout. The aim was to measure the variabilities within every CT scan (nodule), within each radiologist, and between each radiologist. After getting promising results highlighting the relationship between human uncertainty and machine uncertainty, I decided to generalize the results by investigating the effect of uncertain labels on machine learning using other datasets.

In the future, I aim to broaden the scope of my research by exploring real-world challenges in machine learning and computer vision. This expansion will involve a comprehensive exploration of practical problems including but not limited to, healthcare, machine learning, and human-computer interactions to enhance model and pipeline-level classification accuracy, specifically for image data. By aligning my research with tangible, everyday concerns, my goal is to provide clear insights and advancements that directly enhance the outcomes of models. Emphasizing the practical benefits resulting from this research, I aim to contribute to meaningful developments that have a positive impact.

Published Papers:

1. Almansour AN, Furst J, Raicu D, Montague E, editors. Approaches to Evaluating Eye Gaze Patterns between Physician-Patient Interaction in Primary Care Clinic. 2021 IEEE International Conference on Bioinformatics and Biomedicine (BIBM); 2021: IEEE.
2. Almansour A, Montague E, Furst J, Raicu D. Evaluation of Eye Gaze Dynamics During Physician-Patient-Computer Interaction in Federally Qualified Health Centers: Systematic Analysis. JMIR Human Factors. 2023;10(1):e46120.

Paper under Review:

1. Almansour A, Furst J, Raicu D, Tchoua R. Exploring the Relationship between Uncertainty of Labels from Non-consensus Panels and Machine Learning Uncertainty. International Conference on Machine Learning (ICML); 2024 (Submitted for review)