Thesis Project Portfolio

Using Computer Vision and Vision Artificial Intelligence to Improve the Fan Experience at Sports Stadiums

(Technical Report)

The Socio-Technical Implications of Artificial Intelligence in Medical Image Analysis

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Kaihil Patel

Spring, 2024

Department of Computer Science

Table of Contents

Executive Summary

In the modern world of incorporating technology into everyday lives to increase efficiency and enhance user experiences, the use of Artificial Intelligence and Computer Vision has led the way. These technologies are increasingly being used in a plethora of industries, including sports and healthcare. Both my internship-focused technical project and Science, Technology, and Society research involve the inclusion of computer vision technology, however, they span two different sectors. My internship was focused on increasing operations efficiency in a stadium setting. Modern sports stadium venues accommodate large crowds of people who are constantly moving around and have different desires as the event progresses. However, increasing line lengths and inefficient operations are causing decreasing attendee experiences. Using computer vision to identify inefficiencies is a cost-friendly, adaptive method for correcting them and providing a personalized and immersive experience for attendees, making every visit memorable and smooth. On the other hand, my research paper focused on the integration of computer vision identification in medical imaging centers. In the medical field, the stakes are higher, as the primary concern is the health and well-being of patients. Computer vision brings the ability to boost the precision and speed of diagnostic procedures by automating the analysis of complex images. However, the potential for bias and misinterpretation poses challenges, prompting further research into the development and use of these technologies to ensure accuracy and fairness in patient care. Transitioning from theory to practice, my project exemplifies the practical application of computer vision across diverse sectors, from enhancing stadium experiences to understanding bias in medical imaging algorithms, showcasing the technology's broad impact.

Stadiums and venues worldwide experience operating inefficiency issues at each event they hold, causing revenue loss and unfavorable attendee experiences. The use of Artificial Intelligence in the computer vision field is a modern and effective solution to these issues. I built a prototype using the new, state-of-the-art computer vision model developed by Ultralytics, YOLOV8. By integrating YOLOV8 with Roboflow's Supervision in Python, I designed a model to track guests' movements across a venue using live data. Various information including walking paths, population density, and flow rates were tracked without storing any personal information. Prototypes were built and tested in experimental spaces and at actual stadium events. Although major findings are still being discovered from the model, I expect to identify the primary movement patterns of people along with corresponding peak times and events that could influence both. Recognizing the demand and flow of people is critical in providing the optimal resource supply and solutions to increase revenue and improve the attendee experience. Advanced models are needed to target specific issues within the venue. In addition, collecting more data enables the models to learn and generalize from a wider range of visual patterns and variations, leading to improved accuracy and performance overall.

Artificial Intelligence also has a stronger presence in the healthcare industry, particularly in automated medical imaging analysis. However, rapid advancements in breakthrough technology are not without their drawbacks. The Machine Learning models behind automated imaging technology depend on the data that they are trained and tested with. This training data must be comprehensive and representative of a diverse range of patient demographics, medical conditions, and imaging modalities to ensure accuracy and reliability in diagnosis and analysis. Nevertheless, there remains inherent bias in the predictions of these models, prompting research into the extent of implicit bias and the impact of computer vision by healthcare imaging centers

in the United States. Bruno Latour's Actor Network Theory framework is used for a deeper investigation of this issue. Relationships and networks, rather than individual entities, are crucial in understanding social processes. Regarding computer vision in the healthcare industry, there are key actor relationships between the technology and the users that can be studied to better comprehend the technology's processes. Anticipated are findings of misunderstanding the models and their true applications by the users. A disconnect or gap in knowledge communication may be at the root of misuse of the technology, while ample and diverse data could cause overfitting or underrepresentation of certain groups, leading to biased outcomes and further complicating the proper application and trust in these models. Identifying the roots of bias will enhance diagnostic accuracy, ensure equitable treatment across diverse patient populations, and ultimately elevate the overall quality of healthcare services.

Working on these projects provided me with a holistic understanding of the machine learning process, including how the technology is built and how it can be used in the future. My summer internship allowed me to explore different computer vision software and use them in a practical setting. Undergoing the traditional software development cycle was useful in gaining a deeper awareness of specific algorithms and their potential. This knowledge also extends to what situations and circumstances – such as lighting, movement, and recognition – work best for computer vision technology. On the other hand, researching where bias can arise in the and how it can affect the final product gave me a unique perspective on the software development process. As a computer scientist, learning how to use software and adapt to its flaws was a critical skill. However, that skill improved once I understood why certain flaws are present and the potential they have in deployment. Furthermore, assessing these inefficiencies in the healthcare field provided me with a grounded appreciation for the ethical implications and the need for precision

in developing technologies that directly impact human lives. Understanding the nuances of computer vision technology, including its optimal conditions and potential biases, has underscored the importance of ethical and precise technological development, honing my skills in creating impactful, responsible innovations that address key societal challenges.