Undergraduate Thesis Prospectus

Building a deep-learning model for segmentation and motion estimation of the myocardium

(technical research project in Biomedical Engineering)

AI in Art: What is Art and Who are Artists?

(sociotechnical research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How has artificial intelligence (AI) promoted new sociotechnical capacities?

The cultural history of artificial intelligence (AI) is far older than the technical capacity to develop it. The oldest known story of AI can be traced to Homer's *Iliad*, dating back to the eighth century BCE (Cave et al, 2018). In the *Iliad*, Hephaestus, the god of smithing, made machines, "attendants made of gold, which seemed like living maidens. In their hearts there is intelligence, and they have voice and vigor" (Cave et al, 2018). The greatest density of fictional narratives exploring AI, such as the "heartless" tin man from *The Wizard of Oz* and the humanoid robot Maria in *Metropolis*, is found in the first half of the 20th century, prior to the coinage of the term in 1955 (Cave et al, 2018; Anyoha, 2017).

In "Computing Machinery and Intelligence," Turing (1950) introduced the logical framework for building and testing intelligent machines. In 1956, Allen Newell, Cliff Shaw, and Herbert Simon developed the Logic Theorist, perhaps the first AI program. In the 1980s, John Hopfield and David Rumelhart developed deep learning techniques and Edward Feigenbaum introduced the expert system. Thereafter, computers could learn from experience and mimic the decision-making of human experts (Anyoha, 2017). In 1997, IBM's Deep Blue applied AI to defeat world chess champion and grandmaster Gary Kasparov (Anyoha, 2017).

Today AI has diverse applications, such as high-frequency stock trading, healthcare systems, surveillance systems, and automated vehicles (West & Allen, 2018). PriceWaterhouseCoopers estimates "artificial intelligence technologies could increase global GDP by $15.7 trillion, a full 14%, by 2030" (West & Allen, 2018). Yet experts in technology, business, policy, and research caution that AI systems can degrade human agency, promote data abuse, displace jobs, foster dependence on automated networks, erode socio-political structures, and automate lethal weapons (Anderson & Rainie, 2018). Thus, recognizing and re-evaluating AI technologies within the context of such concerns is necessary for resolving the ethical dilemmas presented by them.

Building a deep-learning model for segmentation and motion estimation of the myocardium

How can ventricular remodeling be assessed using a deep-learning model developed for segmentation and motion estimation of the myocardium?

In the United States, a heart attack occurs every 40 seconds, with about 1.5 million heart attacks and strokes occurring every year (CDC, 2022; CDC, 2021). Accurate cardiac image segmentation is crucial for the diagnosis and treatment of cardiovascular diseases (Ouyang et al, n.d.). Medical image segmentation involves identifying the pixels of organs or lesions from background medical images such as CT or MRI images (Hesamian et al, 2019). Numerous image segmentation methods have been developed in the past, including manual (slice-by-slice) and semi-automatic segmentation (Fasihi & Mikhael, 2016). However, these methods are variable, time-consuming, and susceptible to error (Fasihi & Mikhael, 2016). Automatic segmentation has the potential to extract information from large amounts of medical image data with increased quality, accuracy, and decreased computation time (Ouyang et al, 2020). Recently, automatic segmentation methods using deep-learning models have been developed to classify heart failure based on ejection fraction (Ouyang et al, 2020). However, these models have a significant error rate and only use ejection fraction to quantify heart dysfunction (Ouyang et al, 2020). To this end, we propose to develop **a deep learning model for automated image segmentation of left ventricle heart ultrasound images** (Aim 1)**.** We will then use machine learning techniques to

improve the accuracy of the model and identify heart dysfunction using relevant physiological metrics (Aim 2). The following specific aims include model development, optimization, and application for cardiac image segmentation.

Aim 1: Develop a deep learning model for left heart ventricle image segmentation

a) Extract and prepare frames from mice heart ultrasound video data pre and post-myocardial infarction (MI) to be used as training and testing image sets in the model.

b) Combine existing and novel deep learning algorithms to automate image segmentation and identification of the inner left ventricle heart wall.

Aim 2: Optimize and apply the model to quantify and classify heart dysfunction post-MI in mice

a) Demonstrate the model is more accurate than existing segmentation methods, with reduced computation time and lower error rate.

b) Apply the model to extracted data to measure heart dysfunction in mice using relevant metrics and determine how the model can be translated to identify heart dysfunction in humans.

We collected videos of murine echocardiography prior to and after the administration of iNOS, a medicine that induces a heart attack in mice. Ground truth labeling with the appropriate tools will be performed once the frames have been extracted (Aim 1a). One constraint we anticipate is varied image quality. We hope to enhance image quality by using motion correction methods and noise filters to remove noise and other artifacts. We will be using U-net architecture, a fully convolutional network, to develop the deep learning model since it was created specifically for biomedical image segmentation and has strong performance across a range of segmentation applications (Aim 1b) (Seo et al, 2020; Duan et al, 2022). The Adaptive Moment Estimation (ADAM) and other techniques will be used to optimize the model, and accuracy will be confirmed through comparison with commercially used segmentation methods (Aim 2a) (Kingma & Ba, 2017). Relevant physiological measurements, such as wall thickness, ejection fraction, and cardiac contractility, will be quantified using mathematical methods appropriate in mice models (Aim 2b) (Gao et al, 2011). Since human and mice imaging have a 10-fold ultrasound frequency difference, this model has the potential to be used for human echocardiography (Aim 2b).

We aim to develop an effective image segmentation model with increased accuracy and speed, measured by dice coefficient and computational time respectively, in identifying heart dysfunction post-MI in mice (Ouyang et al, 2020). This model will aid continuing research applications, as mice are commonly used animal models of cardiac failure. Cardiovascular changes in humans and mice are comparable post-MI; thus, this model can be applied to quantify heart dysfunction in humans (Krishnan et al, 2014). This model could allow for reduced time in analyzing imaging data and ultimately improve patient outcomes by contributing to research, diagnosis, and treatment of cardiovascular diseases.

AI in Art: What Is Art and Who Are Artists?

How has the art community responded to the growing capabilities of AI algorithms to generate art?

Innovations in computing power, artificial intelligence (AI), and robotics over the past two decades, and consequent employment displacement, promote automation anxiety (Autor, 2015). In a 2017 Pew Research Center survey, 72 percent of Americans reported feeling worried about automation (Smith & Anderson, 2020). Creative fields have resisted automation (Vinopal, 2018), but recent text-to-image AI tools, such as DALL-E and Midjourney, have breached this barrier and now produce stunning imagery. Some argue that such tools devalue human artists and their hard-earned skills (Klingermann, 2022). Therefore, it is vital to understand the perspectives of those in the art community.

At least three classes of artists are engaged in the debate. Some welcome text-to-image tools as the future of art (Knight, 2022). Others oppose them as antithetical to art (Vincent, 2022). Some are ambivalent, favoring some applications over others (Gurney, 2022). Art venues such as galleries and auction houses are also engaged. Such venues seek income from artistic work, but they also legitimize some artistic media relative to others. For example, when Jason Allen's piece Théâtre D'opéra Spatial won first prize in the digital art category at the Colorado State Fair, and Allen then revealed that he used Midjourney to create it, the judges stood by their judgment (Roose, 2022). Finally, participants include developers of text-to-image AI tools, many of whom have championed their technology as a transformative tool for all (The Alan Turing Institute, n.d.).

Researchers have previously investigated the role of AI technology in art. Reexamining the role of an artist, Elgammal (2019) compares the emergence of AI technology to that of the camera. Elgammal and Ploin et al. (2019) conclude machine learning will become a tool for artists, rather than replace artists. Ghosh and Fossas (2022) consider whether AI tools can exacerbate the exploitation of artists. They conclude responsible inclusion of AI into art may enable it to be a positive, new modality in art that does not harm artists. However, responsible development and use of AI tools currently hinge on user advocacy, not their developers.

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