Prospectus

A Machine Learning Approach to Brain Metastases Treatment and Identification

(Technical Report)

The Impact of Cultural and Political Context on Maker Culture

(STS Research Paper)

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Introduction:

The news cycles of the 21st century have been dominated by talk of the political, economic, and cultural differences between the United States and China. One of the issues at the heart of this discourse is the technical competition between the two nations. This competition is centered around the development and use of the next generation technology: 5G, artificial intelligence (AI), and the Internet of Things (IoT). One major field of study being pursued by both these countries is the use of artificial intelligence and machine learning in medical research. In this report, I present a research proposal for the development of machine learning algorithms to better treat and identify brain metastases. This research will involve extensive review of existing machine learning algorithms and adjusting them to process image data obtained during doctor's visits. Developing AI, along with other next generation technologies, indigenously has been a major priority for China and the United States, resulting in STEM funding and education overhauls. In this environment, makerspaces are a tool gaining increased popularity and government recognition in the US and China for their ability to curate innovation and creativity. I propose research into the influence of the cultural and political environments of the United States and China on the current and future state of makerspaces.

A Machine Learning Approach to Brain Metastases Treatment and Identification

Brain metastasis is a significant consideration and complication in developing cancer treatment plans. Estimates for the percentage of cancer patients who develop brain metastasis has been reported as ranging from 20-40% depending on the type of data reviewed (Nussbaum, Djalilian, Cho, and Hall, 1996). This range, however, likely understates the actual incidence rate. The majority of these estimates are based on sets of historical data in which metastasis may not have been accurately documented, especially in the case of discovery in terminally ill patients and asymptomatic metastasis (Gavrilovic & Posner, 2005). Additionally, as identification and treatment of primary cancers continue to increase patient survival time, the incidence rates for brain metastasis also increase (Fox, Cheung, Patel, Suki, and Rao, 2011). One of the main factors for brain metastasis incidence is the histology of the primary cancer. Lung cancer is the most common primary cancer to develop brain metastasis with incidences up to 65%. Other high incidence cancers include breast cancer and melanoma (Nayak, Lee, and Wen, 2012). Brain metastases contribute unique neurological clinical manifestations that can further decrease the quality of life of cancer patients. The most common presenting symptom for brain metastases is headaches (50%), followed by focal weakness (27%) and change in mental status (31%). Seizures are a less common presenting symptom (10%) but occur in a significant amount (40%) of patients over the course of the illness (Klos & O'Neill, 2004). For some patients, neurological symptoms are so debilitating, that the brain metastases are identified by MRI before a primary cancer is discovered (Pol, Aalst, Wilmink, and Twijnstra, 1996). The prognosis for brain metastases is not favorable with a median survival of 3.4 months, with a 2-year survival percentage of only 4% (Lagerwaard et al., 1999). Lagerwaard et al. (1999) do show that patient prognosis has a significant dependence on treatment method.

Gamma knife radiosurgery (GKS) is an effective tool for the treatment of brain metastasis (Petrovich, Yu, Giannotta, O'Day, and Apuzzo, 2002; Muacevic et al., 1999). GKS is a procedure that allows for precise targeting of radiation treatment at the convergence of 192 individually focused gamma radiation sources (Lunsford, Flickinger, Lindner, Maitz, 1989). The ability to target specific points in the brain without releasing high levels of radiation to surrounding tissue makes GKS a popular choice for treatment of brain metastasis, especially in the case of multiple recurring tumors. Currently, GKS treatment plans are developed by physicians based on an array of T2, diffusion, and perfusion MRIs. These plans are limited by an incomplete knowledge of how individual tumors will react to certain doses and the inability to predict where new tumors will arise. To this end, we propose to develop a **machine learning application that will predict tumor response to a given GKS dosage** (Aim 1). Additionally, we will go a step further to develop a **machine learning application that will predict the location of new brain metastases** during initial screening (Aim 2).

Aim 1: Predict tumor response to gamma knife radiation treatment from MRI data:

A. Use existing programs to automate the capture of tumor volume from MRI data. B. Determine a predictive model of correlation between treatment and change in volumetric data using existing machine learning algorithms.

C. Analyze the accuracy of the model in predicting the manner in which tumors will respond to treatment based on volumetric data.

Aim 2: Predict future tumor occurrence based on prior MRI data:

A. Utilize MRI data of patients with recurrent tumor formation to capture volumes that will become cancerous in the future.

B. Analyze MRI data of pre-cancerous volumes in comparison to that of healthy tissue using existing neural networks.

C. Determine if this model can accurately predict tumor occurrence based on MRI data taken prior to its visible diagnosis.

Completion of these aims provides a tool for medical professionals to predict and better understand the behavior of brain cancer metastasis in both pre and post radiation therapy. Ultimately, advancement of this work could lead to more efficient radiation treatment (a1) and the development of targeted preventive therapies (a2).

The Impact of Cultural and Political Context on Maker Culture

Introduction

The maker movement represents a large and growing community in both the United States and China. In the US alone there are over 500 active or planned makerspaces (Hackerspace, 2019), while China has gone from one active makerspace in 2010 to over 100 in 2015 (Saunders & Kinsley, 2016). At their core, the driving force behind makerspaces is innovation and creativity, but the values behind that drive vary largely, both between and within the two countries. Prominent values among makerspaces include economic mobility, 21st century education, civic innovation, community building, and for-profit technical advancement. These values, while curated by the spaces' founders and nurtured by the community that utilizes the space, are influenced by the broader cultural and political contexts that surround the space. A prominent example of this is Huaqianghei in Shenzhen, China. Huaqianghei is a shopping district dominated by electronic components, logos for the hottest international tech brands, and makers of all genders and ages. The markets and shops in Huaqianghei are made home by the individual makers and their families, but have direct roots to China's domestic economic policy and Eastern community centric psychology. This is one example of how interconnected groups of people, political and social forces, and existing material conditions influence the past and future development of maker spaces. I propose a structured investigation into how the cultural and political tradition of China versus that of the United States has influenced the current state and future potential of their respective maker movements.

The implication of this investigation is an added depth to the understanding of the larger global tension and cooperation between China and the United States. This includes issues such as intellectual property law, development of next generation technology, and international trade agreements.

Literature Review

The majority of existing literature in both China and the United States is presented as analysis of specific makerspace case studies. In 'Made in China: Makerspaces and the search for mass innovation,' a report by the innovation charity Nesta for the British Council, looks at several distinct makerspaces throughout China and general trends of the Chinese maker movement (Saunders & Kinsley, 2016). Some of the major trends identified by Saunders and Kinsley are the Chinese government's interest in innovation-led development, the desire for education system reform, and the importance of Shanzhai. The Chinese government has taken a vested interest in makerspaces and see them as a key instrument to their national agenda. In 2015, the Chinese government introduced 众创空间 ('mass makerspace'), a policy designed to spread the maker and entrepreneurial attitude more evenly in the hopes of optimizing China's extensive human capital (Lindtner, 2016). This same desire has been a motivating factor for educational reform. Of the 93 makerspaces surveyed by Saunders and Kinsley (2016) around 20% reported that a majority of its users are school-aged children. Additionally, over 75% of Chinese makerspaces have a relationship with a University that provides education, events, or advanced equipment. Apart from a desire to cultivate entrepreneurial attitudes at a younger age, makerspaces outside of the major cities of China's east coast, such as Zibo makerspace in Zibo, Shandong, see makerspaces in schools as an opportunity to keep their students technologically competitive (Saunders and Kinsley, 2016). While the maker movement is relatively new to China, its predecessor, Shanzhai, has been an impactful part of the Chinese and world economy since the early 2000's. Shanzhai, literally meaning remote fenced mountain village, has taken on a new meaning as the manufacturing, designing, and selling of imitation or counterfeit electronics (Lindtner, Greenspan, and Li, 2015). Similarly, an analysis of United States' makerspaces in 'Makerspace: Towards a New Civic Infrastructure' reveals trends through multiple case studies (Holman, 2015). One of the major trends discussed by Holman (2015) is the tension between for-profit makerspaces and not-for-profit spaces. This tension is a factor of high start-up costs and low new membership rates. To counter this, some federal funding through grants have been given to makerspace companies to expand to new locations.

In addition to literature review, I have completed some preliminary interviews with a university student in Shenzhen, China. The purpose of these interviews is to provide basic insight into Chinese technical and university culture. An example insight that has already been helpful in framing my research approach, is the suggestion that the introduction of makerspaces in primary and secondary schools in China may receive pushback in rural areas where students already feel a disadvantage in gaining acceptance into top tier technical universities. This idea has influenced me to make sure I take into account how maker culture is potentially different in rural China compared to major cities such as Beijing or Shenzhen.

STS Framework & Method

In order to analyze this complex sociotechnical system, I will utilize the social construction of technology (SCOT) framework. SCOT (figure 1) is a framework that maps the relationship between three fundamental nodes: stakeholders, conflicts or problems, and existing artifacts (Bijker, Hughes, and Pinch, 1984). The stakeholder nodes represent the individuals, demographics, and communities that have influence on or are influenced by the system. Examples of stakeholders that will be key to the analysis of maker spaces are makers, the STEM workforce, the non-STEM workforce, and the local and national governments. In most cases, the general stakeholders in China and the US will be similar, but how they interact and connect will vary. Problem nodes refer to anything that exist as a conflict or constraint in the system. In the makerspace system this could include legislation, budgets, geography, and existing global standards of learning. The final node type, artifacts, represent the existing solutions and realities in the system. For the Chinese system this would include the Huaqianghei market and Shanzhai

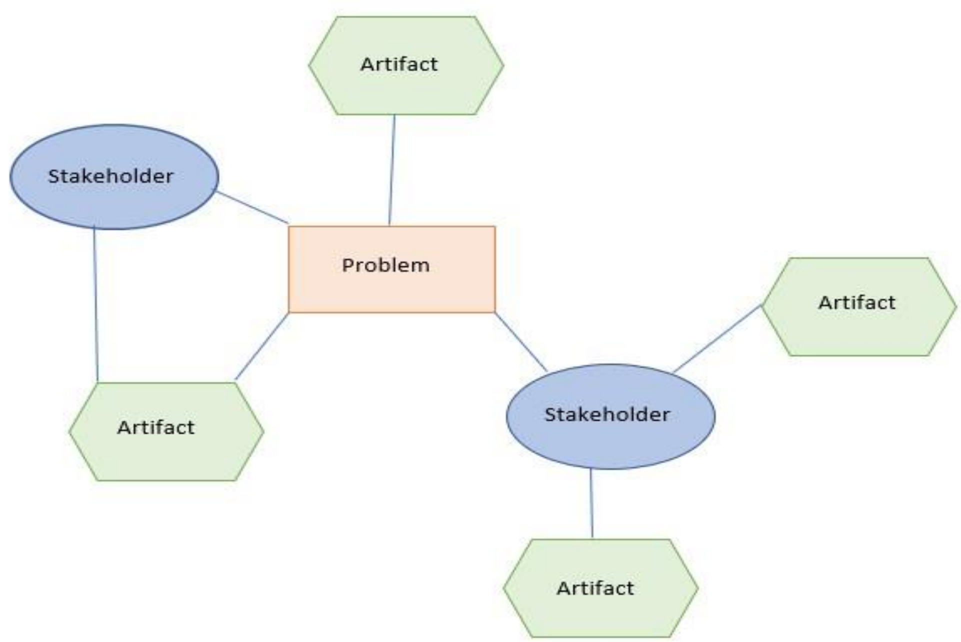

Figure 1: An example of the SCOT framework.

tradition. SCOT will be especially useful in the description of the makerspace system because it will allow connections to be drawn both within and between the stakeholders, historical and cultural artifacts, and problems of both China and the United States, simultaneously. I will then use the resulting connections, or lack thereof, to investigate how different approaches taken by the US and China in cultivating and regulating makers/makerspaces will impact the evolving culture of makers in the future.

My primary goal moving forward is to expand my SCOT framework diagram of the maker movement. My method for building out this framework and identifying relevant nodes will be through interviews with stakeholders. My interview pool will consist of Chinese and US nationals attending university in the United States. Within these groups, as a result of preliminary interview data, I am looking for individuals who grew up in both rural and urban settings. My goal for these interviews is to build out my network around the major stakeholder nodes: Chinese citizens and US citizens. Unfortunately, university aged Chinese and US students are not truly representative of their respective country. However, in China, 54% of people that use makerspaces are university students (Saunders and Kingsley, 2016). So, while my interviewee pool is restricted, it is more representative of the makerspace movement and will hopefully provide me a more accurate insight into makerspaces, and their users perception, compared to an interviewee pool that is demographically representative of the nations at large. My goal is to use a mixture of a questionnaire and an in-person interview with five Chinese nationals and five US nationals. Additionally, it is important that my interview pool be diverse in regards to gender, ethnicity, and region (urban versus rural). I will utilize personal connections and contacts at the University of Virginia to gather my interview pool. I will also conduct continued literature review for both countries to add in relevant cultural, political, and historical artifacts and conflicts. After developing a comprehensive framework for the current state of makerspaces and makers in China and the United States I will use insights from my framework to propose potential trends or problems that may develop within maker culture in the future.

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