Capstone Project Proposal

Sukanya Rammohan

Business Goals

Project Overview and Goal What is the industry problem you are trying to solve? Why use ML/AI in solving this task? Be as specific as you can when describing how ML/AI can provide value. For example, if you're labeling images, how will this help the business?	Diagnosis of diseases in a timely manner is a challenging task everywhere. Especially in the United States, getting appointments from specialists is challenging and it takes a minimum of three months of wait time. In case of speciality care, scheduling happens from primary care physician to the specialist by means of transfer or referral. Sometimes, the intensity of the patient's issue does not get perceived by the primary care physician due to lack of expertise in that specific field. For example, if a person visits a primary care physician, her or she is administered painkillers, then if only the issue persists for a longer period, the patient is prescribed an X-ray, a CT scan and then an MRI. The diagnosis of the actual spine issue takes longer as most of the treatment during the initial period is focused on treating the symptoms. Then the patient is transferred or referred to a spine specialist, who then prescribed physiotherapy, chiropractor, injection or spine surgery based on the frequency of patient's appointments. Usually the spine specialist first recommends a few sessions of physiotherapy, which ranges from 15 days to about 8 months on an average. Only if there is no improvement, the patient is then suggested to opt for chiropractor service or spine injections. If everything else fails, the patient is offered spine surgery. Utilizing Artificial Intelligence to label and classify the MRI helps speed up the process of early diagnosis. Based on the degree to which the spine MRI shows issues, the patient can be quickly suggested the further course of actions without having to wait for other processes. 'SpineAI' is the product recommended to speed up the diagnosis and treatment process

Business Case Why is this an important problem to solve? Make a case for building this product in terms of its impact on recurring revenue, market share, customer happiness and/or other drivers of business success.	American Chiropractic Association(ACA) has stated that "Worldwide, back-pain is the single leading cause of disability, preventing many people from engaging in work as well as everyday activities" (The global burden of low back pain) ACA has also stated that more than 264 million lost work days are reported in one year just because of back pain. It estimates that 80% of the American population experiences back pain at some time in their lives. In the article "What Low Back Pain Is and Why We Need to Pay Attention", it is estimated that disability due to back pain has increased by 54% from 1990 to 2017 (Hartvigsen). With the increasing number of affected cases, with long wait times, it is imperative to expedite the diagnosis and proper treatment process. SpineAI will enable healthcare professionals to take a quick treatment process plan for the patients by diagnosing issues as soon as the MRI is taken. This will greatly reduce the duration of disability in patients and as a result, the product will help hospitals treat more patients reducing multiple re-diagnosis steps.
Application of ML/AI What precise task will you use ML/AI to accomplish? What business outcome or objective will you achieve?	SpineAI integrates classification of spine diseases by means of Medical Imaging Analysis and identifying patterns from a wide source of MRI training dataset. This classification is mapped with the symptoms of the patients collected through a chat application, which can be installed on both Android and IOS devices. The resultant from both the symptoms from the patient and the MRI helps the SpineAI to arrive at a proper diagnostic solution. As a result of utilizing SpineAI, hospitals can serve more patients and the patients with the most critical health issues could be given priority for scheduling appointments. Thus SpineAI makes healthcare more efficient and fast.

Success Metrics

Success Metrics What business metrics will you apply to determine the success of your product? Good metrics are clearly defined and easily measurable. Specify how you will establish a baseline value to provide a point of comparison.	Business Key Metrics: • Reduce the wait time for spine specialist appointments to less than 15 days • Increase the number of patients served by a specific specialist by 40% • Reduce the symptom to cure time to less than 5 months • Reduce the time to diagnosis to less than 2 days While building datasets for this AI product SpineAI, collecting samples from patients metrics such as the appointment scheduling, referral, diagnostic test, treatment plan and further course of action recommended by healthcare professionals, helps to build a standard or baseline to compare with the above mentioned key business metrics. Collecting data from several age groups of spine affected patients will help establish baseline values that can help provide better values to compare with the estimated metrics.

Data

Data Acquisition Where will you source your data from? What is the cost to acquire these data? Are there any personally identifying information (PII) or data sensitivity issues you will need to overcome? Will data become	The data for SpineAI is sourced from primary care hospitals, specialists clinics, Medical Imaging Centers, and symptom data from customers. Since most of the customer data is from surveys, there exists no risk of involving personally identifying information. Data can be collected from a variety of patient surveys, hospital scheduling databases, government agencies, and the National Center for Health Statistics.

available on an ongoing basis, or will you acquire a large batch of data that will need to be refreshed?	Even though there may be some costs associated with data collection, SpineAI can collaborate with hospitals, clinics and Medical imaging centers to have access to project related data on an ongoing basis. The project related data only includes the medical imaging, the scheduling time span for appointments and symptoms. Hence, there exists no necessity to collect any personally identifiable information. The estimated timeline to acquire a large batch of dataset down the lane is about less than 10 months.
Data Source Consider the size and source of your data; what biases are built into the data and how might the data be improved?	As it is known that back pains being a central cause of disability, the probability of acquiring more data is high in a shorter span of time. According to Statista, the average population of the United States for the year beginning 2021 is 320.82 millions. As about 25% of the population of the United States report back-pain, with the assumption of about 20% of the patients getting an appointment once every 3 months, the approximate number of samples that could be collected for the past three months would be 16,041,000 images. But, the issue with the hospital treatment process is that people who belong to the age group of 28-45 do not pay attention to mild symptoms too seriously to take action. As a result, the dataset may be biased with a huge collection of imaging and records of elderly population compared to the middle-age group. Some of the milder symptoms of elderly population could cause more discomfort compared to the age group of 30-40s. As a result, the bias may affect a younger patient, whose mild medical imaging indication could be flagged as an alarming critical health condition. To overcome this bias, the data can be improved by collecting information from diverse age groups of patients. Similarly, ethnicity of the patients are to be noted as some ethic groups are perceived to possess healthier spine compared to the rest. Though there is no established study on this influence of ethnicity in spine related problems, having such information may prove to be worthy in case some study proves the theory in future.

Choice of Data Labels What labels did you decide to add to your data? And why did you decide on these labels versus any other option?	SpineAI utilizes multiclass classification and it is expected to address several forms and types of spine related issues. As a pilot version, the following labels are used: • Normal (No Spine issues) • Degenerative Disc Disease • Facet Joint Syndrome • Herniated Disc • Nerve Compression • Sciatica • Spinal Cord Compression • Spondylolisthesis SpineAI utilizes multiclass classification to address maximum possible variants of spine issues. A binary classification is not really helpful in this scenario of spine issues because a patient visits specialist to not just confirm he or she has a spine issue, but to identify the actual disease and to cure it. As a multi-class model, this product can effectively provide a wide variety of possible diseases that a MRI can capture. Hence, a patient can be prescribed proper treatment plans based on the specific disease of spine identified.

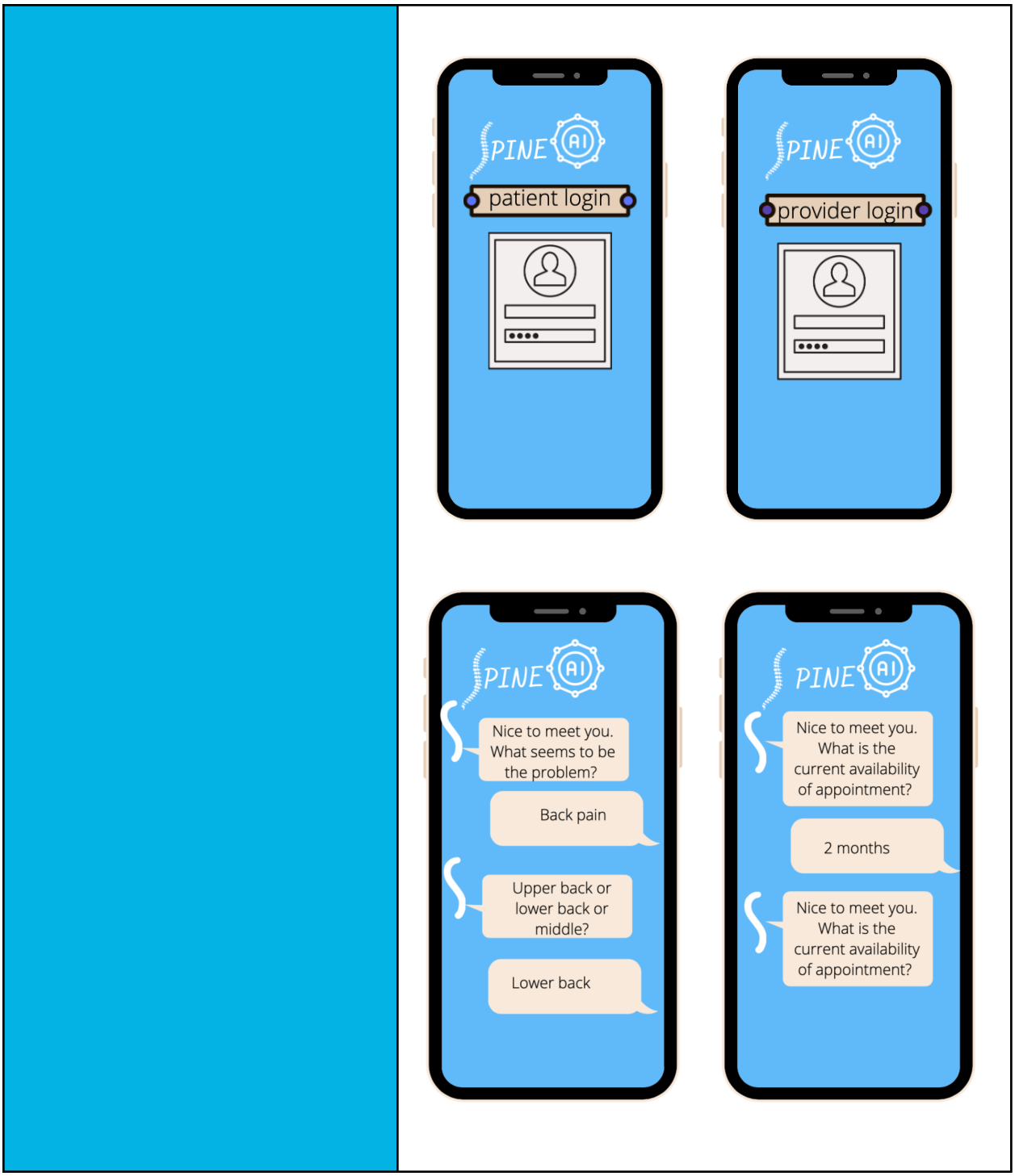
Model

Model Building How will you resource building the model that you need? Will you outsource model training and/or hosting to an external platform, or will you build the model using an in-house team, and why?	According to the Center for Disease Control (CDC) 25% of the US population reported back pain in the last three months. This SpineAI machine learning model can be hosted in the cloud on Medical Imaging data combined with the symptoms data collected from both hospitals and patients from the application. Automated Machine Learning tools such as Google AutoML or Azure Machine Learning Studio. The model is built as an in-house team as a pilot version to have more control over the operations and to ensure the adherence to HIPAA regulations. Having control over the initial build would help customize features and optimize performance based on trial and error in a streamlined manner. Once the product is absolutely successful, it can be outsourced depending on the

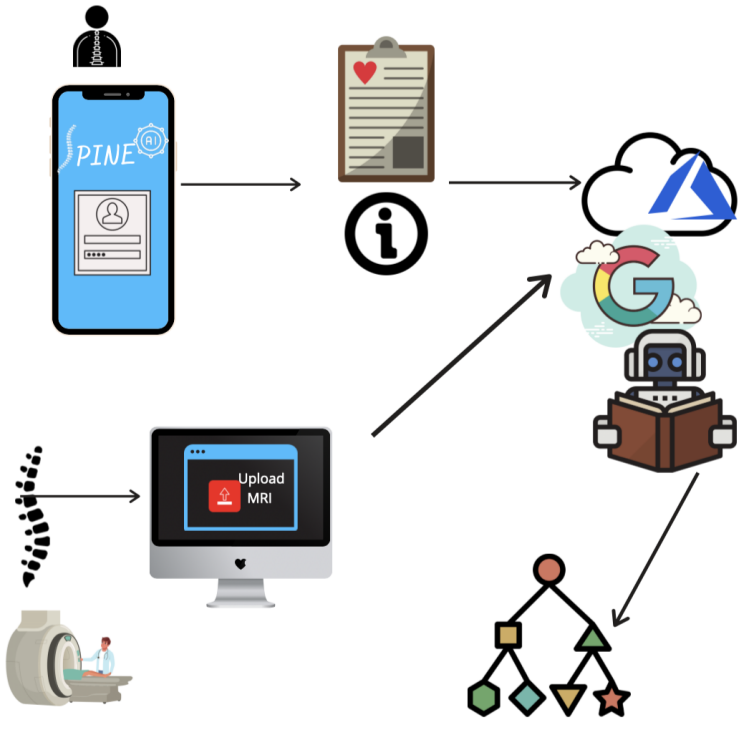
	demand for the product in healthcare.
Evaluating Results Which model performance metrics are appropriate to measure the success of your model? What level of performance is required?	Providing quality prediction is the main goal of SpineAI and that said, more emphasis will be laid on optimizing in such a way that the model predicts relevant information that is true, i.e. is giving more importance to recall. Precision only refers to the results that are relevant, but recall on the other hand refers to correctly classified relevant results, which is more important in spine problems detection. True positive rate to the maximum tells how accurately the model is able to identify spine issues. Hence, this is a better method of analysing the performance.

Minimum Viable Product (MVP)

Design What does your minimum viable product look like? Include sketches of your product.	SpineAI is a web and mobile application that can actively interact with patients and linked to the portals of hospitals to collect information regarding patient appointment schedule, wait times, referrals and transfers processing time and Medical imaging. It will have a seperate login for patients, hospital staff and Medical Imaging center staff


PINE
patient login
PINE
provider login
PINE
Nice to meet you. What seems to be the problem?
Back pain
Upper back or lower back or middle?
Lower back
PINE
Nice to meet you. What is the current availability of appointment?
2 months
Nice to meet you. What is the current availability of appointment?


SPINE AI
Upload
MRI


SPINE AI
Upload
MRI

Use Cases What persona are you designing for? Can you describe the major epic-level use cases your product addresses? How will users access this product?	SpineAI is designed for: ● Aged patients who are facing disability due to spine problems. Patients from this category are allowed to use the interface through primary caregiver. The patients are given an option to login with email id and password. Then with the chatbot, they can interact and specify all their symptoms usually as a one word option or indicate their pain level in likert scale. They are given an option to provide wait times for treatment and diagnosis. ● Young and middle age working professionals who are facing minor symptoms can access the web interface and share their symptoms with the pain scale. They also have an option to indicate their experienced wait times for appointments. ● Health care professionals who seek quicker diagnosis can utilize the hospital portal. They can login with the unique code generated for hospitals and fill in the details of number of patients that visit per day, number of referrals given or received, average time to appointments and tentative treatment plan timeline. They are provided with options to indicate the approximate average age of patients and their distribution. ● Medical imaging can upload the images through their specific link portal. Medical Imaging centers also have unique identification codes for login. They upload labeled as well as non labeled MRI results into the upload link along with the information about symptoms or patient's approximate age to support the data collection process. The data collected is given a specific unique identifier that surpasses the necessity to collect Personal identifier information. The only information with regards to identity is the email id, which is used solely for login purposes. They are given an option to opt out of further communication if they do not want to.

Roll-out How will this be adopted? What does the go-to-market plan look like?	Go-to-market plan: • Online advertising of product with infomercials • Start with internal advertising to physicians and Healthcare network • Non-profit collaborative initiatives with hospitals, clinics, primary health care centers and local pharmacies • Advertise project success by means of success stories published on local magazines and newspapers along with including students from various educational levels and institutions for the awareness programs.

Post-MVP-Deployment

Designing for Longevity How might you improve your product in the long-term? How might real-world data be different from the training data? How will your product learn from new data? How might you employ A/B testing to improve your product?	SpineAI will constantly collaborate with healthcare networks for updates and carrying up-to-date information. Product becomes efficient with continuous feedback on performance on predictions. There will be a significant difference between training data and real world data as training data might be biased with respect to age, ethnicity, amount of information available and image labeling. Since SpineAI is an interactive platform based on continuous feedback, the real life data prediction will get improved with including a huge real-life data set. The product adaptively improves its performance as the count of samples increase. With the increasing population affected by back pain, data collection will be possible so as to gain adequate data for better classification. As this product is also based on a feedback mechanism and interactive learning of symptoms from patients, it becomes easier to arrive at better prediction as the model prediction does not only rely on image classification. Text analysis also plays a major role as patients interact with the SpineAI to discuss information

	on spine related issues. When the age of patients is a key role in diagnosing disease better, there will also be an analysis of age of patients with no spine issue. Similarly, if there is any other data correlating with the prediction efficiency, A/B testing is done with respect to the following: ● Are people with certain deficiency have more spine issues or even a healthy individual is prone to spine related problems ● Are people with spine problems are more from IT background or other working groups ● Are people with sciatica or spinal arthritis report back pain quicker As the product is in the initial build stage, in the near future of implementation, more AB testing will be undertaken before the project is outsourced as per increase in demand.
Monitor Bias How do you plan to monitor or mitigate unwanted bias in your model?	Bias in the SpineAI model will be essentially due to the collection of data from a concentrated pool of specific age range and ethnic groups. Constant feedback loop between SpineAI and the healthcare networks will enable the model to mitigate bias. Moreover, by creating awareness among the middle and young patients with basic symptoms of spinal issues, there will be more chance of collecting data from a wide age group range. As per the research by the National Center for Biotechnology Information, ethnic groups like African-Americans and Hispanics are less represented in research on spine injuries. Hence the data collected from national sources could be biased too. To alleviate the bias by under-represented groups, more data has to be included for patients from these ethnic groups.