SPOT: An AI - Assisted Medical Diary

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Capstone Project

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1. Introduction

We decided to build this AI software for a number of important reasons. One of the primary reasons is to improve people's health and well-being. Skin diseases can be painful, uncomfortable, and even life-threatening if left untreated. By detecting and treating skin diseases early, we can help people to avoid unnecessary suffering and improve their overall quality of life.

According to the World Health Organization (WHO), skin diseases are among the most common types of illnesses worldwide. In fact, up to one-third of the world's population may be affected by skin diseases at any given time (WHO, 2022). Skin cancer, in particular, is a major health concern. It is one of the most common types of cancer worldwide, with an estimated 3 million cases diagnosed each year (American Cancer Society, 2022).

Early detection and prevention are crucial in the treatment of skin diseases. Skin cancer, for example, is highly treatable if detected early. However, if left untreated, it can spread to other parts of the body and become much more difficult to treat. That's why it's important to catch skin diseases as early as possible, before they have a chance to develop into more serious conditions.

Unfortunately, not everyone has access to regular skin checks or can afford to get them. In the United States, for example, the cost of a skin disease check-up can range from $100 to $200 (Healthcare Bluebook, 2022). For many people, this is a significant expense that may be difficult to justify, especially if they are already struggling to make ends meet. By providing accessible and affordable skin disease detection services, we are empowering people to take control of their health. Regular skin checks can help people to identify any potential skin diseases early on, allowing them to take action before the problem becomes more serious. This can not only improve their health outcomes but also reduce the overall cost of treatment.

In addition to improving people's health outcomes, our AI-powered skin disease detection system also has the potential to help healthcare providers to diagnose skin diseases more accurately and efficiently. As mentioned earlier, skin diseases are among the most common types of illnesses worldwide. However, accurately diagnosing skin diseases can be challenging, even for experienced healthcare professionals.By using advanced machine learning algorithms, our software can help to improve the accuracy of skin disease diagnoses. This is because machine learning algorithms can analyze large amounts of data much more quickly and accurately than humans can. This can help healthcare providers to make more informed decisions about treatment options and improve patient outcomes.

Furthermore, our software has the potential to help healthcare providers to better manage their resources. By accurately diagnosing skin diseases early on, healthcare providers can prevent unnecessary testing and reduce the overall cost of care. This can help to alleviate some of the strain on healthcare systems, especially in countries where resources are limited.

Finally, we decided to build this AI software as a way to contribute to the global effort to achieve the United Nations' Sustainable Development Goals. One of these goals is to promote good health and well-being for all (United Nations, 2022). By providing accessible and affordable skin disease detection services, we are helping to promote this goal and make a positive impact on people's lives.

2. Analysis

2.1 Planning

In order to provide a solution to the observed problem, we decided to build a web application assisted by an AI model for image classification as skin disease classification is in essence an image classification problem. For developing our app, we had to choose between using Flutter or to use Angular, an open-source, JavaScript framework written in TypeScript. After meeting, our plan to develop our application's front-end and back-end is as follows:

1. **Flutter**: this coding framework allows us to code our front end once and potentially deploy on multiple kind of devices
2. **Apache Server**: this server acts as a mailbox, receiving requests from users to pass to our main WSGI server and pass all responses back to the user
3. **WSGI/ Flask Server**: this our main workhorse server, coded in python and using a package called Flask, this server is responsible for tasks such as user sign up, log in, and using our AI model to create predictions from user pictures as well as interaction with user data
4. **MariaDB**: our database that stores a majority of user data for our users to later recall

Skin disease detection is in essence an image recognition problem. Some popular algorithms used in this area are SIFT (Scale-invariant Feature Transform), SURF (Speeded Up Robust Features), PCA (Principal Component Analysis), and CNNs (Convolutional Neural Networks). Melanoma detection is a life-critical problem. We decided to use convolutional neural networks because this is by far the most accurate algorithm in image recognition. Also, Dr. Yow has suggested that there are many existing tools that we can use such as ResNet50.

Eventually, our final plan for the AI building involves the following steps:

1. **Data preprocessing**: We will collect and preprocess a dataset of skin images, specifically melanoma images, using standard image processing techniques such as normalization, resizing, and augmentation.
2. **Splitting the dataset**: We will split the dataset into training, validation, and test sets using a stratified sampling technique to ensure a balanced distribution of melanoma and non-melanoma images in each set.
3. **Model evaluation**: We will evaluate the performance of the trained model on our validation set using standard metrics such as accuracy, sensitivity, specificity, precision, and recall. We will also perform cross-validation and external validation to ensure the generalizability of the model.
4. **Model deployment**: We will deploy the trained model as a part of the Flutter application that can take input images of skin lesions and output a prediction of whether the lesion is a part of a skin disease/condition or not.

We chose to focus first on developing a benign/malignant melanoma detector in the first semester , which would serve as a proof-of-concept for the feasibility of our solution and the successful interfacing of the front-end and back-end of the system. Additionally, the data required for this specific application was readily available, which helped streamline the development process. Once this initial task was completed, we moved on to develop a generalized detector as we realized that we assumed that our users already knew they have Melanoma which is not always true.

This table below has indicated our original plan for AI development.

	SPOT AI Lite	**SPOT AI 1.0**	**SPOT AI 2.0**
Datasets	3000+	15000+	80,000+
Datasets	Kaggle	Kaggle & ISIC	Kaggle & ISIC & Manual Gathering
Model	ResNet50	ResNet50	ResNet50 FastAI MobileNet
Features	Melanoma oriented: will categorized images into two groups: “Benign” and “Malignant”	Will be able to detect 7 main types of skin conditions: Bowen's disease, Melanoma, Melanocytic nevi, Vascular lesions etc.	Higher Accuracy; More Diversity
Pros	Fast to develop	Wider application	Higher accuracy rate
Cons	Narrow Application	Time consuming	Time consuming

On the User Interface development we had two goals, one was to make sure our system was usable to our users without foreknowledge about the full extent of the functionalities of our system. To do this we employed a lot of useful design strategies such as using symbolism in conjunction with text to try to illustrate the functionalities of these buttons, this can be seen in the bar at the bottom of the home screen where we have our home button, new scan button, and history button. Secondly, we tried to give examples in taking scans, to give users an example of how to take pictures of their own spots in such a way to provide the best quality. The second objective to design for was security, to make sure that user data was protected. To accomplish this we utilized normalized industry techniques such as salting and hashing user passwords, as well as sanitizing variables before performing SQL queries to avoid SQL injection. But we have also implemented some security features that are not standard in industry such as the function of our API sending back the Bytes of an image

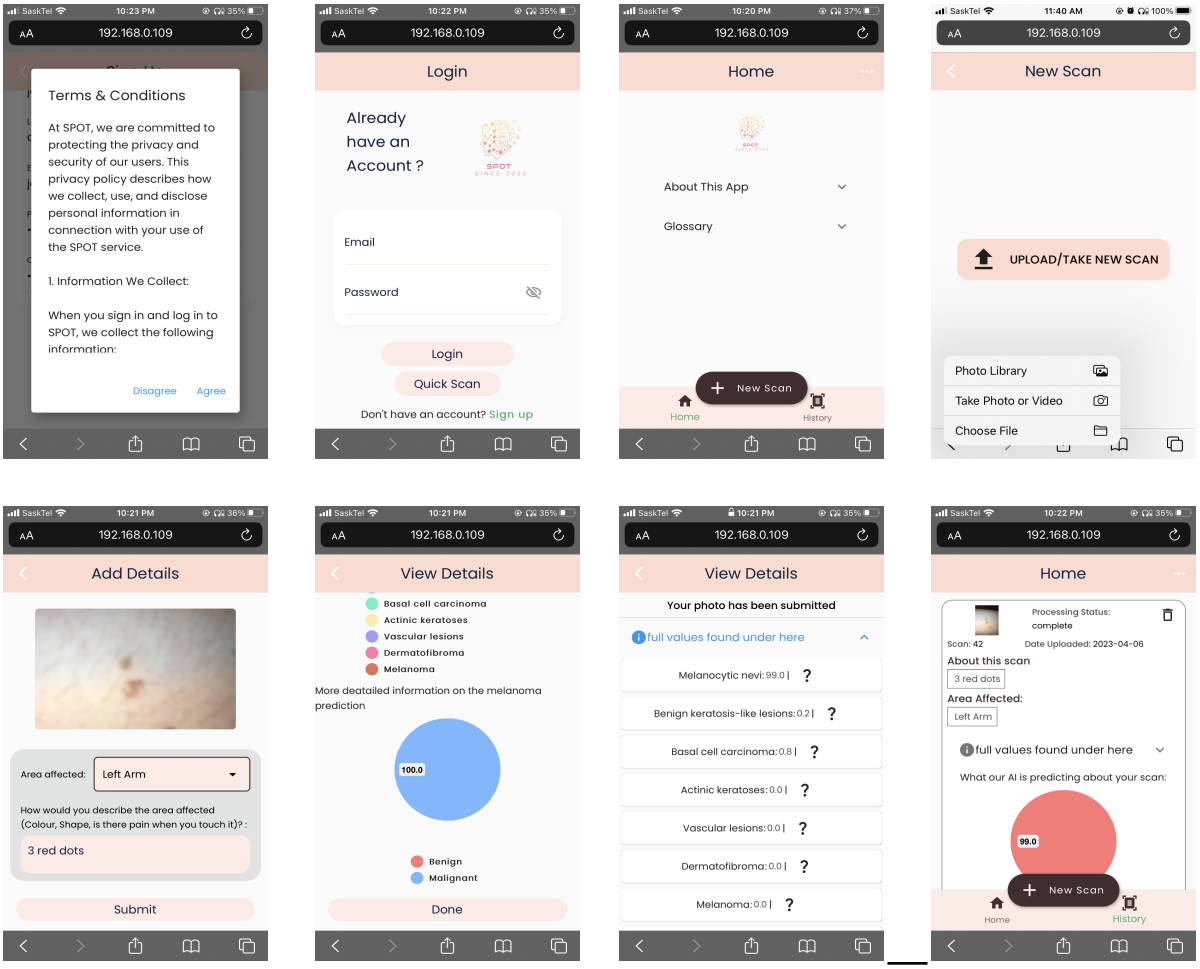
back to a user's device instead of providing a link to where the user's image is stored on the file system of the server, this was seen as safer as it in theory will prevent access to users images through a URL in which case we would have had to implement authorization measures to access certain images, in which case the aim would be to lower the possibility of someone accessing images that they are not authorized to see. We believe that our way cuts out this possibility entirely.

2.2 Solution and Results

Once we had successfully developed and validated the melanoma detector, we moved on to develop a generalized detector. This was a natural progression of the project, as it allowed us to expand the scope of the system to include other skin diseases beyond melanoma. However, developing a generalized detector presented its own unique set of challenges.

At the end of the project, we found our AI lies between 1.0 and 2.0. Although we had used some data entries gathered outside of Kaggle and ISIC, the magnitude of these two datasets was far greater, making them the primary sources of our data. While the additional data entries had little impact on the overall result, they did contribute to a more diverse and well-rounded dataset. Throughout the development process, we also experimented with other AI models, including FastAI and MobileNet. However, we found that they did not perform as well when it came to interfacing with the rest of the software.

The following are some of the screenshots highlighting the key features of our application:



2.3 Experiences

Developing an AI-powered skin disease detection AI system was an ambitious project that required a great deal of attention to detail, including the creation of terms and conditions and a privacy policy. As the developers on this project, we consulted with our law professor, Dr. McDonald, to ensure that these critical documents were created in accordance with all legal requirements.

The creation of the terms and conditions document involved a careful review of all legal and regulatory requirements. We needed to ensure that the document clearly outlined the terms and conditions of using the system, including any limitations or restrictions on its use. We also needed to ensure that the privacy policy was in line with all applicable laws and regulations. This document needed to clearly outline how user data would be collected,

stored, and used, as well as any measures that would be taken to ensure the security of this data. For example, if the users choose to use the “quick scan” function in our application, no data will be stored into our database at all.

Working with Dr. McDonald was a valuable experience, as he was able to provide valuable insights into the legal and regulatory aspects of this project. He was able to help us navigate complex legal issues, and ensure that all necessary legal documents were created in a timely and accurate manner.

As a developer, it was important to be mindful of the legal implications of this project, particularly given its life-critical nature. We needed to ensure that all necessary legal documents were in place to protect both users of the system and the developers themselves.

Using Flutter was an interesting experience for everyone. Even Though we have used Flutter for a short time in some of the courses that we have taken, it was a good challenge to actually work with to develop our front-end as it is still new and there is not much documentation that we can look at.

One unique experience that was had by the team was during the trade show and presentations on the Project Day April 1, 2023. Unlike most presentations we have done, we were presenting our ideas to people who are close to the same level of knowledge that we ourselves have. This meant we could have discussed our findings at a higher level of understanding. But in this case we were presenting to the public, meaning we had to develop our presentation for the public, composed of people from all walks of life. Not only did this give us an opportunity to pitch our ideas to the public, but it gave us a chance to pitch ourselves to the public as well to expound our knowledge and experience and so far this has paid off so well including an interview with JCME that is to be conducted on April 11, 2023, due to an interaction that our team had with a reporter during the trade show.

2.4 What went well and What did not went well

At the beginning of the capstone project, we had issues with our communication which led us to work on our project with the doubt of this project not working out as well as losing quite a lot of precious time for work progress. But we are glad that we managed to pull ourselves together and communicate more with each other by setting up more meeting times and keeping in touch with everyone and updating their work progress.

One thing that really went well for us was the communications between our AI side and our UI side. Since we have this good communication, we were able to catch a bug that was not allowing us to use our general AI model. We worked together and diagnosed it to make the model work and be ready before the project deadline.

Getting medical experts involved in our project did not go so well for us as we transitioned from Melanoma alone to Melanoma and 6 other skin diseases which means we had to do outreach to different medical experts to get the needed information that is useful for the scope of our project.

During the AI development process, we encountered a significant challenge that arose due to our inexperience. Initially, we were utilizing eight professional high-RAM graphic GPUs that we had access to through a Google Colab Pro subscription. However, we quickly discovered that we had underestimated the learning curve associated with AI development, as well as the amount of time that would be required to complete this process.

2.5 Lessons learned

As a group of undergraduate students, we had the opportunity to work on a life-critical system that had the potential to make a significant impact in the field of healthcare. Throughout the project, we learned a great deal about not only the technologies

involved but also about the importance of effective collaboration, problem-solving, and self-development.

Here are some key points about our experience working on this project:

1. **Collaboration & Communication**: The most important lesson that we have learned is that communication is vital and really important when working with other people. Without it, progress would be out of reach. Working with each other also has taught us the importance of effective collaboration in achieving project goals. We learned to communicate more effectively, listen to others' perspectives, and work towards a common goal.
2. **Problem-solving**: Developing an AI-powered skin disease detection system presented a number of complex problems that required creative solutions. We learned to approach problems systematically, breaking them down into smaller parts and tackling them one at a time. There was also problem solving in the front end development side, one strong anecdote of problem solving was the creation of the getPieChart function on line 557 of ./code/FrontEnd_V1/lib/Controllers/home_controller.dart, where a problem occurred with the chart itself would not load all pie widgets. Due to the lack of documentation surrounding the pre-created pie chart widget that was used , the writer of function had to rely on their learned knowledge involved in such matters such page design using CSS, to know that the problem must have laid with trying to put too many pie pieces in such a small space was breaking entire pie chart, the solution to this problem was to decrease the decimal point accuracy so that we were spacing out the pieces of the pie chart , we even set pieces of the pie chart that were less than one percent to zero percent. This was the solution that was developed to this issue

3. **Self-development**: As developers, we constantly sought opportunities to improve our skills and knowledge. We watched tutorials, read articles and reached out for help to stay up-to-date with the latest developments in AI and machine learning as well as front-end technologies.
4. **Time management**: Developing a system like this requires careful planning and effective time management. We learned to prioritize tasks, set realistic deadlines, and manage our time effectively to ensure that the project was completed on time.
5. **Legal considerations**: Developing a life-critical system also requires an understanding of the legal and regulatory frameworks that govern its use. We learned to work closely with our law professor to develop the necessary legal documents, ensuring that they were in compliance with all applicable laws and regulations.
6. **Continuous improvement**: Finally, We learned that the development of a system like this is an ongoing process. Even after the project was completed, there were still opportunities to improve and refine the system. We learned to take feedback from users, analyze data, and make iterative improvements to the system.

2.6 Changes we would do

As with any project, there is always room for improvement. Here are some potential changes that could be made to make this skin disease detection project more successful:

1. **Increase dataset size**: While the SPOT AI dataset is already quite large, there is always the potential to add more data to improve the accuracy of the model. Additional data could be sourced from other sources such as hospitals or clinics.
2. **Improve image quality**: High-quality images are essential for accurate diagnosis, and sometimes the images in the dataset may not be of sufficient quality. As such, it may

be beneficial to develop a tool that can help improve image quality by enhancing low-resolution images or removing artifacts.

3. **Integrate with electronic health records (EHR)**: Integrating the skin disease detection system with electronic health records can make the system more efficient and effective. By analyzing a patient's EHR, the system can take into account the patient's medical history, medications, and other factors that may impact the diagnosis.
4. **Increase the number of skin diseases**: While the current system is capable of detecting several skin diseases, there are many other skin diseases that could be added to the system. By increasing the number of skin diseases, the system would become more versatile and could be used to diagnose a wider range of skin conditions.
5. **Implement a feedback loop**: Implementing a feedback loop would allow the system to learn from its mistakes and improve over time. By collecting feedback from patients and doctors, the system could be improved through continuous learning.
6. **Using markdown files**: Using markdown files for most of our documentations would be one of the things we would do as it is accessible to review and edit using different code editors instead of using pdfs as it is not viewable for vscode.
7. **Consider different types of neural networks**: While convolutional neural networks are currently the most accurate for image recognition, other types of neural networks could potentially be used to improve the accuracy of the system. For example, recurrent neural networks could be used to analyze temporal data, such as changes in skin lesions over time.
8. **Consider regulatory compliance**: As a life-critical system, it is important to ensure that the skin disease detection system is in compliance with all applicable laws and

regulations. This may involve working closely with regulatory bodies to ensure that the system meets all necessary requirements.

2.7 Incorporating lessons learned going forward

1. **Perform Compatibility analysis of Packages and version types before integration into the system:** One major issue we encountered on the courses of our project was that of package comparably issues. In particular the creation of our second general AI model (modelGen.h5) , in which one needed package called " tensorflow" split into two different versions, one version exclusively utilized GPU's in training and using any model produced in this version, meanwhile the version we were using in our system utilized a computer's CPU. when it came time to integrate the created model into our system. The model would not even load into our backend. This result came as a shock to us, as we had a false sense of security that the model would be easy to integrate into our system as it was easy to do so for the melanoma specific model (modelMel.h5). Once we found out the issue, we had to rebuild our general AI model using the specific versions that were utilized in our system. This is a pain that could have best been avoided if we had performed compatibility testing to nail down which specific version of packages and software components we could and could not use.
2. With all the lessons that we have learned in this project, we would be able to apply these lessons outside the real world. These would help us build our character and give us an idea of what future works can be as an Engineer.

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