4 Design

4.1 Design Content

- **Intelligent Diagnostic AI:** In this project we will be creating an AI system that has advanced diagnostic abilities. The AI system should be able to analyze a patient's medical history, symptoms, and possibly their allergy test results to accurately identify and diagnose allergies.
- **Product Recommendations**: After the AI system has diagnosed a specific allergy, it will also recommend treatment and medication options. This feature will help patients and doctors make informed choices about which medications and treatments are safe for the patient.
- **Predict Allergy Reactions:** They AI system will have the capability to predict potential reactions the patient will experience when they come in contact with an allergen based on their allergies and medical history.
- **Collaboration:** This project will provide a system that will enhance collaboration between different medical professions and hospitals to help them diagnose and treat allergens on a grand scale.
- **Data Integration:** The AI system will require a great amount of data including medical records and medication/treatment product details. Creating a secure and efficient data integration system is greatly needed for this project.
- **Ethical and Legal:** Since this project involves handling medical data and providing diagnoses, there will be ethical and legal considerations. The project should incorporate privacy and security measures, follow healthcare regulations, and provide patient confidentiality.
- **User Interface:** Creating a user-friendly and intuitive interface is greatly needed since this system will be used by medical professionals. The design needs to encompass UX and UI considerations.
- **Training and Maintenance:** The AI system needs to be trained so it can diagnose and recommend more accurately. The design should also include plans for training the AI as well as a plan for maintenance of the system over time.

4.2 Design Complexity

Neural networks implement backward propagation, which uses advanced calculus. Backward propagation is the process of the model starting from the output layer towards the input layer, adjusting the weights of the neurons to reduce the MSEs. To calculate the adjustments needed to be made on each layer it uses the cost function which is the sum of the MSEs for the entire data set. It then takes the derivatives in terms of the cost function with the weights. This requires three derivatives. The first is the cost function in terms of the prediction result, then the predictions result to each neurons output, then finally each neurons output to their weight. It uses this gradient to determine the direction and rate of change needed to decrease the cost function. It repeats this process until the cost function reaches a satisfactory accuracy.

The problem scope contains multiple challenging requirements, including accuracy, ease of use and returning quick results that the current procedures of skin and blood test. Either of the current procedures exceeds ease of use or quick results. Both procedures require aa medical procedure, which can be invasive as they require needles to complete and take time to return results/observe reactions. As for accuracy skin tests a positive reaction only suggests that there could be an allergy, and a negative result does not

completely rule out the possibility of an allergy. Blood tests are rarely used as they suffer from inaccuracy from a lack of research and are only really used when doctors fear a severe reaction to skin tests.

4.3 Modern Engineering Tools

Cloud Services – Convient access for data storage and processing/analytics. This allows us to offload server applications for data storage, developing environment, and applications to AWS to handle connectivity and other responsibilities.

Neural Network ML Model: This is the machine learning we will use to perform our predictions.

GitHub – Allows for collaborative coding development

4.4 Design Context

Area	**Description**	**Examples**
Public health, safety, and welfare	People with allergies benefit from improved diagnosis and personalized recommendations.	Example: A doctor who specializes in allergies can use the AI system to speed up their diagnosis and provide even more personalized treatment plans. The doctor would then be able

	Medical professionals can diagnose more efficiently, which can also reduce medical costs. Chemical manufacturing companies can use our system to analyze new products and lead to better product safety. Inaccurate diagnosis could lead to safety concerns. A medication or protocol that is incorrectly prescribed could lead to adverse drug reactions.	to treat patients more efficiently and patients would have faster results and shorter waiting times.
Global, cultural, and social	People are more prone to certain allergies based on their location and culture. Our system should support multiple languages, since allergies affect everyone regardless of language.	Diet preferences and substance restrictions in cultures would affect diagnosis and recommendations. Example: a patient is diagnosed with a gluten allergy, but due to cultural, religious, or social reasons, wants to continue to eat gluten. The system should provide multiple solutions and alternatives.
Environmental	N/A	N/A
Economic	More efficient allergy diagnosis could reduce healthcare costs and medical expenses for patients with allergies.	A patient with a very rare allergy went to many doctors' visits but every time has not been diagnosed correctly because the doctors have never seen the rare condition. However, the AI system will be able to correctly diagnose the rare condition, leading to reduced visits to the doctor and therefore reduced medical costs.

4.5 Prior Work/Solutions

AI Allergy (created by: Ryan Park) -> https://devpost.com/software/ai-allergy

AI Allergy uses a food image database and a SQL recipe database to help users find and explore a variety of foods while avoiding either current or possible allergens. Users can take pictures of food and recipes and determine if there are any harmful allergies or possible allergies. AI Allergy uses a custom dataset that has

been added to an additional dataset and, to quote, “is currently the largest public food image dataset.” The dataset was trained using AWS and finetuned using a powerful NVIDIA GPU.

UCLA’s Label-Free Bioaerosol Sensing Using Mobile Microscopy and Deep Learning -> https://pubs.acs.org/doi/10.1021/acsphotonics.8b01109

Although not a publicly released product, University of California, Los Angeles has conducted research into AI and machine learning in detecting five common allergens. The UCLA biproduct has yielded a 94 percent accuracy with the model and with the result of the training. The product is more of a microscopic device that looks at and reconstructs the amplitude and phase images of captured bioaerosol, something originally done by hand and performed by humans.

Pros	Cons
- Our product is easier to use and is targeted more towards a quick and fast result of detecting health care patients	- We do not use imaging on food for allergy detection
- Use medical history and ancestor history to determine possible allergies users may be at risk too	- We do not analyze, train, and find results on a microscopic level
- Aimed towards the medicinal field	- More of a focus on more niche aspects of allergens

4.6 Design Decisions

Key Design Decisions :

Small :

1. MySql server to maintain all the patient data

2. VisualStudio and Github to write and maintain codebase

Large :

1. Specific ML neural network to begin modifying and training

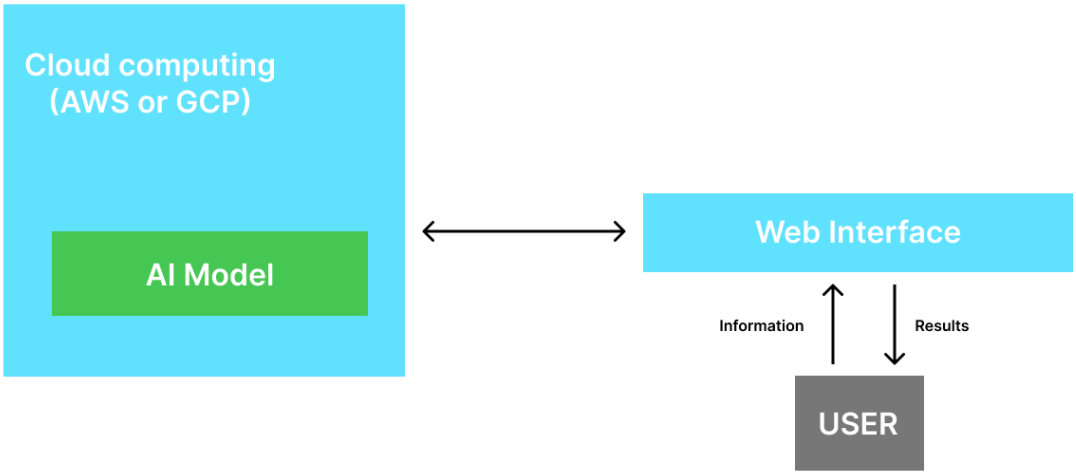
2. Formatting and outputs from UI (Future Decision)

3. Efficiency vs correctness variance and prioritization

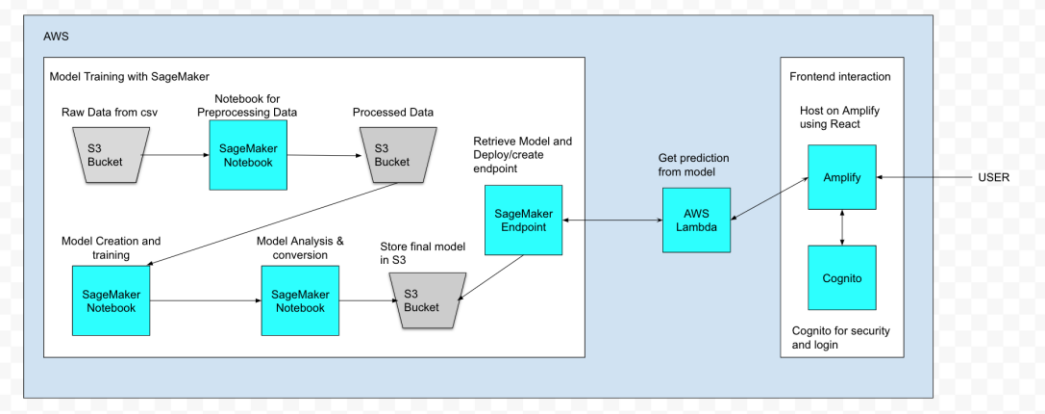
4.7 Proposed Design

4.7.1 Design 0 (Initial Design)

Design Visual and Description



In the future we will create a block diagram for our web application and the AI model that will give more detail.



Our Diagram will be using AWS services as we haven't been able to get access to GCP yet. The AWS services we will be using is S3 buckets as it allows for easy storage and retrieval of data. SageMaker as it has a Notebook functionality for code development which is very similar to jupytier notebooks which team members have familiarity with. Finally, we will be using Amplify for hosting our web app along with Cognito for credential creation and verification to support logins on our web app along with Lambda to support the interaction between our ML model and our web application. We chose lambda as we believe that our application will not require as much resource management as using an EC instance would require and will simplify our project.

The first step of our application will be to upload the dataset to a S3 bucket for storage and retrieval in AWS. Net we will create a SageMaker notebook instance to edit the given dataset and do a general analysis in of the data to notice any trends or irregularities. We will then store the edited dataset into a new S3 bucket. We will then create a new SageMaker notebook for model creation and development. To assist in this, we will import the TensorFlow Keras library. This is a requirement as our client wants us to use the Keras library for model creation, but this will overall be very helpful as the library has functionality devoted to Neural networks development with this type of model stored in the library. Once our model reaches a accuracy and time that is satisfactory we will create a new notebook to load our model convert it to a TensorFlowProtoBuf format and then upload it to S3 for ease of use. Finally we will create an endpoint for our model to facilitate interactions with it. For this we will use another notebook, but it could also be done using console commands.

Finally, we will start on the frontend. For this we will use Amplify to host our web application which we will create using Reactive. We haven't gone to far into what the frontend will require as this isn't a direct requirement from the client and is more so something to work on if we complete our goal and have extra time. But the base functionality will be using Cognito for credentials creation for signups and logins and will be our security and finally we will be using lambda to interact with our model and get the predictions back.

Functionality

Our AI System is to be used by medical professionals mainly. It is to be used by them to diagnose patients with possible allergens. It also recommends to the medical professionals possible mediations or treatment plans to be prescribed to the patient. It also has the possibility to be used by chemical manufacturing company officials to see if products coming out of the company are causing any allergens that medical professionals are diagnosing in patients.

The system we are creating has the main objective of helping medical professionals diagnose and treat allergies in patients more efficiently. We believe since there is a recent uptick in humans having allergens toward more manmade chemicals made today, allowing a collaborative aspect for chemical manufacturing could better help community health, not just a single patient. It will also hold companies more responsible for whatever chemicals/products they put out into the world.

The current design we have now is for a medical professional to be able to input symptoms that a patient is experiencing and the system will output possible allergens. The medical professional will then complete a set of tests to decide which of the system suggested allergens is affecting the patient. Once the allergen is found, the medical professional will input into the system which allergen the patient has, and with the symptom data it previously received, the system will recommend medications and treatments to the medical professional that they then can prescribe the patient with.

For right now, our current design meets the non-functional requirements. It also meets a majority of our functional requirements, but technology and programs will have their issues, as well as human error that will occur while creating this AI system. We believe we have met all the functional requirements with our current design, and we are also prepared with solutions to issues that could occur while creating the system.

4.7.2 Design 1 (Design Iteration)

Include Include another most matured design iteration details. Describe what led to this iteration and what are the major changes that were needed in Design 0.

Design Visual and Description

Include a visual depiction of this design as well highlighting changes from Design 0. Describe these changes in detail. Justify them with respect to requirements.

NOTE: The following sections will be included in your final design document but do not need to be completed for the current assignment. They are included for your reference. If you have ideas for these sections, they can also be discussed with your TA and/or faculty adviser.

4.8 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

4.9 Design Analysis

- Did your proposed design from 4.7 work? Why or why not?
- What are your observations, thoughts, and ideas to modify or iterate further over the design?