

Allergy Prediction using Artificial Intelligence

Team 13

Client : Ashraf Gaffar

Initial Component Design : Eric Christensen

Team Organizer : Zoe Davis

Documentation and Frontend Support : Josh Dutchik

Backend Development and Testing : Blake Friemel

Front and Backend Testing : Jack Gray

Client Interaction : Michael Koopmann

Team Email : sdmay24-13@iastate.edu

Team Website : <https://sdmay24-13.sd.ece.iastate.edu/>

Executive Summary

Development Standards & Practices Used

IEEE 829: Software Test Documentation

IEEE 2801-2022: Recommended Practice for the Quality Management of Datasets for Medical Artificial Intelligence

IEEE 2830-2021: IEEE Standard for Technical Framework and Requirements of Trusted Execution Environment based Shared Machine Learning

IEEE 2841-2022: IEEE Recommended Practice for Framework and Process for Deep Learning Evaluation

IEEE 2842-2021: IEEE Recommended Practice for Secure Multi-Party Computation

P3123: Standard for Artificial Intelligence and Machine Learning (AI/ML) Terminology and Data Formats

IEEE 7000-2021: IEEE Standard Model Process for Addressing Ethical Concerns during System Design

P7003: Algorithmic Bias Considerations

P7015: Standard for Data and Artificial Intelligence (AI) Literacy, Skills, and Readiness

Summary of Requirements

- Our AI model must return accurate information
 - Uses an intelligent search to return predicted allergic reactions based on patient information and a selected product
 - Return percent likelihood that a patient will be allergic to a given product.
- We need to build and train multiple AI models to find the best model for our use
 - AI must be trained and tested using the given dataset
 - Must be able to be trained from data on an Excel spreadsheet
 - AI model input must use rules of association to predict potential allergic reactions (patient gender, age, race, location, etc.)
- Have a simple website/web interface
 - Interface has an intuitive search that can be used by medical personnel
 - Interface has a simple login for doctor credentials
- Patient information and products need to be stored in a database
 - New patient information will be stored here
 - Old patient information will be pulled from here
- The AI model must be run on the AWS framework
 - The model must pull data from our web interface or a database

Applicable Courses from Iowa State University Curriculum

- SE 185
- COM S 227
- COM S 228
- CPRE E 281
- SE 319
- SE 309
- COM S 363
- SE 339
- SE 317

New Skills/Knowledge acquired that was not taught in courses

- AI model training
- How to create AI with python
- AI testing and optimization of different models
- Correlations between patient information and allergies
- Using cloud computing platforms (AWS)
- Data security compliance with healthcare regulations
- UI and UX design
- Knowledge of different types of allergies and how they appear

Table of Contents

1	Team Skills and Roles	7
1.1	Team Members	7
1.2	Required Skill Sets for Your Project	7
1.3	Skill Sets covered by the Team	7
1.4	Project Management Style Adopted by the team	8
1.5	Initial Project Management Roles	8
2	Problem Statement, Requirements, and Engineering Standards	9
2.1	Problem Statement	9
2.2	Requirements & Constraints	9
2.3	Engineering Standards	11
2.4	Intended Users and Uses	11
3	Project Plan	12
3.1	Task Decomposition	12
3.2	Project Management/Tracking Procedures	12
3.3	Project Proposed Milestones, Metrics, and Evaluation Criteria	13
3.4	Project Timeline/Schedule	13
3.5	Risks And Risk Management/Mitigation	15
3.6	Personnel Effort Requirements	15
3.7	Other Resource Requirements	16
4	Design	17
4.1	Design Content	17
4.2	Design Complexity	17
4.3	Modern Engineering Tools	18
4.4	Design Context	18
4.5	Prior Work/Solutions	19
4.6	Design Decisions	19
4.7	Proposed Design	20
4.7.1	Design 0 (Initial Design)	20
	Design Visual and Description	20
	Functionality	21
4.7.2	Design 1 (Design Iteration)	22

Design Visual and Description	22
4.8 Technology Considerations	25
4.9 Design Analysis	26
5 Testing	28
5.1 Unit Testing	28
5.2 Interface Testing.....	28
5.3 Integration Testing.....	29
5.4 System Testing.....	30
5.5 Regression Testing	30
5.6 Acceptance Testing	30
5.7 Security Testing (if applicable)	31
5.8 Results	31
6 Implementation.....	33
7 Professionalism.....	34
7.1 Areas of Responsibility	34
7.2 Project Specific Professional Responsibility Areas	35
7.3 Most Applicable Professional Responsibility Area	36
8 Closing Material	37
8.1 Discussion.....	37
8.2 Conclusion	37
8.3 References	38
8.4 Appendices	38
8.4.1 Team Contract	38

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

AWS - Stands for Amazon Web Services. It is a comprehensive and widely used cloud computing platform provided by Amazon. AWS offers a vast array of services, including computing power, storage options, networking, databases, machine learning, analytics, security, Internet of Things (IoT), and more.

AI - Computer systems that can perform tasks that typically require human intelligence, such as learning from experience and making decisions.

Training Data - The information used to teach an AI model. Our dataset will include thousands of vectors as follows: [patient info: allergies]. The patient info will include Name, age, gender, geography, race, etc. The patient history will also include all previous allergies they have had.

UI and UX - The visual part of the software that users interact with. It includes buttons, screens, and other elements.

HIPPA – A law that ensures the security and privacy of healthcare information. Important when dealing with patient data.

1 Team Skills and Roles

1.0 TEAM MEMBERS

ERIC CHRISTENSEN, ZOE DAVIS, JOSH DUTCHIK, BLAKE FRIEMEL, JACK GRAY, MICHAEL KOOPMANN

1.1 REQUIRED SKILL SETS FOR YOUR PROJECT

- Basic software engineering skills
- Basic knowledge in Calc 2 and Statistics
- Experience in Python, JavaScript
- Experience in Machine Learning Models
- Knowledge in Neural Networks (mainly their training and then implementing a trained model)
- Knowledge in implement software testing
- Knowledge in analyzing and optimizing machine learning models
- Knowledge in mapping calls from the frontend to the backend
- Knowledge in cloud servers/computing
- Experience frontside web development including security
- Experience with setting up a database

1.2 SKILL SETS COVERED BY THE TEAM

- Basic software engineering skills: Zoe Davis, Josh Dutchik
- Proficiency in mathematics: Michael Koopmann, Zoe Davis
- Experience in Python: Zoe Davis, Michael Koopmann, Eric Christensen, Blake Friemel, Josh Dutchik
- Experience with Java: Eric Christensen, Josh Dutchik, Zoe Davis
- Experience with SQL: Eric Christensen, Josh Dutchik, Zoe Davis
- Experience Machine Learning Models: Michael Koopmann
- Experience in Embedded Systems: Josh Dutchik, Eric Christensen, Blake Friemel
- Experience with AWS / GCS: Michael Koopmann
- Experience with backend dev: Eric Christensen
- Experience with frontend dev: Josh Dutchik, Zoe Davis
- Experience with testing frameworks: Zoe Davis
- Experience with neural networks: Eric Christensen

1.3 PROJECT MANAGEMENT STYLE ADOPTED BY THE TEAM

AGILE

1.4 INITIAL PROJECT MANAGEMENT ROLES

Zoe Davis: Team organization

Michael Koopmann: Client Interaction

Josh Dutchik: Documentation and Frontend support

Eric Christensen: Initial Component Design and Testing

Jack Grey: Testing

Blake Friemel: Backend work and testing

2 Problem Statement, Requirements, and Engineering Standards

2.1 PROBLEM STATEMENT

This project addresses the challenge of optimizing medical treatments for individuals with allergies. In traditional healthcare, doctors face the complex task of considering a patient's unique medical history when prescribing treatments. Allergic reactions to medications can be unpredictable, posing risks to patient safety. This AI-driven solution aims to streamline this process by leveraging a comprehensive dataset of patient information and allergies. By identifying correlations between individual profiles and the chemical compositions of prescribed products, the system assists doctors in making more informed decisions, ultimately minimizing the potential for allergic reactions and enhancing the overall effectiveness of medical treatments. In essence, it seeks to provide a personalized and data-driven approach to healthcare, promoting patient well-being through a more nuanced understanding of individual health factors.

2.2 REQUIREMENTS & CONSTRAINTS

Requirements:

Functional Requirements:

- Our AI model needs a certain level of accuracy to ensure patients, doctors, and all users receive accurate information about prescriptions and the allergic reaction risk that may come with it. Without quality assurance of accuracy, results may be missed, causing fatal consequences.
- Our AI model will require a well-trained AI (Artificial Intelligence) model which will require using a large/sufficient sized dataset for training.
- **Our application needs to be reliability and have little downtime**, especially in the medical world, it's important that the application provides a consistent and reliable quality service. With healthcare, lives can be lost if our service is unreliable.

Non-Functional Requirements:

- Our application must be easy to use and operate because the user will be a medical person with prior medicinal experience. Our project must be easy to understand and have a simple/easy-to-navigate UI/UX.
- Our project must be accessible and available to only medically licensed individuals. If our services are too complex and doctors cannot use them, we miss our project's main goal of providing an easy-to-use and reliable service.

Constraints:

- **Constant Retraining:** Our project needs the ability to implement new/refined AI models. So that when our AI is retrained it can be implemented.
- **Constant Expandability:** As our project enters its future, we will need the resources, time, and workforce to help expand and grow the future of our project.
- **Worldwide Coverage:** A requirement that will help provide more reliability and accuracy is worldwide coverage. The requirement means to reach users around the globe and to have access to allergies, medical centers, and medicine worldwide to provide a reliable and quality service for all.
- **Surveys for Experience/Service (Wants/Needs):** Understanding what our users need is important to the project's success. We need to find out what the user likes/dislikes or what the user is looking for to get out of our project.
- **Law protection(constraint):** With our product for recognizing allergies, our service may have a few outliers, and people could get hurt. It is important to not only legally protect ourselves and the project but also make people aware and understand that although we can guarantee a reliable service, there is always the possibility of something going wrong that the users must be prepared for.
- **HIPAA (constraint):** For our project, we must ensure we are careful with patient's medical records and history. We must make sure to have a level of anonymity and privacy.
- **Access to Allergens (constraint):** Allergens are unpredictable, and there is a need for a large database to determine trends and characteristics of allergens to allow for better predictions.

2.3 ENGINEERING STANDARDS

IEEE Standard:

Health informatics--Device interoperability Part 40102: Foundational--Cybersecurity--Capabilities for mitigation

<https://standards.ieee.org/ieee/11073-40102/7680/>

This IEEE standard will help mitigate the threat of Information disclosure and elevation of privileges on any point-of-care device and interface since our project will include point-of-care devices to perform DNA or blood tests.

AI IEEE standards:

<https://standards.ieee.org/initiatives/autonomous-intelligence-systems/standards/>

Since we are venturing into unfamiliar territory with AI, following a set of standards regarding how the AI is trained will help reduce the number of variables that could potentially cause incorrect results or indirect problems within our project.

2.4 INTENDED USERS AND USES

Use Case 1 (Doctors/Medical Personnel):

In a modern healthcare setting, the integration of AI technology revolutionizes the way medical professionals can now approach treatment planning. This allergy detection has already had the patient's allergy and medical history input into its data. The doctor can now just input what medicine/treatment they want to prescribe the patient into the AI. The AI will output a percentage that will indicate the patient's risk of having an allergic reaction if the patient uses the medicine/treatment. This percentage is a valuable tool to the doctor's decision-making process, enabling the doctor to tailor the patient's treatment plan with heightened focus on patient safety and efficiency.

Use Case 2 (Average Person):

The patient experiences the benefits of this advanced approach to healthcare. With the patient's allergy and medical history stored in the AI's dataset, each piece of patient data can be meticulously considered by the AI system. The AI generates a personalized percentage reflecting the potential allergic reaction risk. The result is an optimized prescription that not only considers the complexities of the patient's medical history, but also takes into account correlations identified by the AI. As a result, the patient gains confidence in their treatment, benefiting from a healthcare approach that maximized safety and effectiveness through the fusion of medical expertise and cutting-edge AI analysis.

3 Project Plan

3.1 TASK DECOMPOSITION

1. Individual knowledge and understanding of ML models specifically Neural Networks
 - a. Logistic Regressions, Linear algebra, Derivatives, Matrix calculus, probability, graph theory, and Python
- 2) Set up processing environment
 - a. Setting up AWS and GCS
 - b. Setting up necessary tools and libraries
 - c. Importing data set
- 3) Possible Data preprocessing (might not be needed)
 - a. Normalizing/standardizing data set
 - b. Removing null values
 - c. Determine vector or array for input layer
 - d. Split data set into training and test sets
- 4) Actual training of the model
 - a. Finding Neural Network to retrain
 - b. Constant retraining till satisfactory
 - i. Changing Depth
 - ii. Changing Activation Function
 - iii. Looking at Test MSE, Bias, Variance
 - c. Final Model selection
- 5) Model interpretability
 - a. Looking at heat map of weights
 - b. Dimensional reduction
 - c. Further tools/tests
- 6) Building user interfaces
 - a. Login screen with authentication
 - b. Easy to use or interpret displays or screens for results.

3.2 PROJECT MANAGEMENT/TRACKING PROCEDURES

We are planning on using agile because members of the group have used that style in previous classes/internships, so we feel the most comfortable using this style. We think agile will work best with our project because of its cycles. It is not linear like the waterfall style. The waterfall style could make us feel constricted and feel like we are veering off-course if we must go back to previous stages. Agile allows more flexibility and goes more for one feature at a time, which is less constricting and helps us not feel like we are behind if we need to go back to a previous step. We also feel sprints will help us achieve our goals easier and within a realistic timeframe. The daily scrums will also keep all members accountable for completing tasks.

We are planning on using Git and GitHub to track and share our progress with the group and professors. We all have experience with Git and GitHub, so we are the most comfortable using those tools. We also think it will be easier to work on the design/code of the project simultaneously using tools included with GitHub like push, pull, and merge. We can track our progress through issues and milestones.

3.3 PROJECT PROPOSED MILESTONES, METRICS, AND EVALUATION CRITERIA

In an agile development process, these milestones can be refined with successive iterations/sprints (perhaps a subset of your requirements applicable to those sprint).

Milestone 1: Learn about neural-networks

Milestone 2: Set up Processing environment with 100% usability

Milestone 3: Data Preprocessing – 95% of dataset usable and standardized (mean is at 0) along with creation of training and testing sets.

Milestone 4: Training of the Model till accuracy reaches 80%

Milestone 5: Model Interpretability – 70% interpretability of the model (Not only the weights and biases of the model)

Milestone 6: Building User Interface – 100% reliability

3.4 PROJECT TIMELINE/SCHEDULE

Gantt Schedule Chart for Team 13



Research AI Development	9/13/2023	10/9/23
-------------------------	-----------	---------

Research ML models for Neural Networks	10/9/2023	10/23/23
Set Up AWS and GCS	10/23/2023	10/30/2023
Set Up Tools and Libraries	10/20/2023	11/6/2023
Import Data Set	11/6/2023	11/10/2023
Standardize Data Set	11/10/2023	11/15/2023
Remove Null Values	11/15/2023	11/20/2023
Determine Vector or Array for Input Layer	11/20/2023	11/30/2023
Split Data Set Into Training and Test Sets	11/30/2023	12/4/2023
Find Neural Networks to Retrain	12/4/2023	12/15/2023
Retrain Until Satisfactory Results	1/15/2024	3/4/2024
Test Retraining Results	3/4/2024	3/18/2024
Final Model Selection	3/18/2024	3/22/2024
Interpret Heat Map of Weights	3/22/2024	3/27/2024
Interpret Changing Activation Function	3/27/2024	4/1/2024
Interpret Tests	4/1/2024	4/8/2024
Build Login Screen with Authentication	4/8/2024	4/17/2024
Build Easy to Use Screen that Displays Results	4/17/2024	4/26/2024

3.5 RISKS AND RISK MANAGEMENT/MITIGATION

- Not able to get access to dataset | Minimal risk | 0.2
 - Would have to try and simulate a medical dataset either using examples and resources from online sources.
- Not able to use AWS or GCP | No real risks | 0.0
 - Would have to get dedicated processing. We'd need to investigate purchasing hardware/GPUs for processing.
- Not able to use an existing Neural Network for retraining | Minimal risk | 0.2
 - We'd have to create our own Neural Network model.
 - Or switch to a different ML model.
- Not able to get access to TensorFlow/Keras framework | No Real risk | 0.0
 - We'd have to work with the client to decide on a new framework and library.
- Not able to reach accuracy with selected model | Medium Risk | 0.5
 - If our model doesn't train well on the dataset, we'll have to select a new model to retrain.

3.6 PERSONNEL EFFORT REQUIREMENTS

Task	Average Time Per Person (hours)
Individual knowledge and understanding of ML models specifically Neural Networks	12 – This is based on the team being new to neural networks, along with background subjects/material. This includes Logistic Regressions, Linear algebra, Matrix calculus, and probability.
Set up processing environment.	2 – This will mostly be setting up AWS, GCP and the framework library for neural networks.
Possible Data preprocessing (might not be needed)	10 – This is a rough estimate. More analysis of the dataset would be needed to determine an actual timeline, but we haven't gotten the dataset yet.
Actual training of the model	14 – This will also be dependent on the data and how well it will translate into our model.

Model interpretability	10 – This will be dependent on the data and the model we end up using as more depth will make the model harder to interpret.
Building user interfaces	4- I think this is a good estimate for a barebones interface and more time can be added if available.

3.7 OTHER RESOURCE REQUIREMENTS

Medical dataset of allergens from mayo clinic

Keras Library for Neural Network

AWS and GCP access/accounts

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:** The 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 – Convenient 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	<p>People with allergies benefit from improved diagnosis and personalized recommendations.</p> <p>Medical professionals can diagnose more efficiently, which can also reduce medical costs.</p> <p>Inaccurate diagnosis could lead to safety concerns. A medication or protocol that is incorrectly prescribed could lead to adverse drug reactions.</p>	<p>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 to treat patients more efficiently and patients would have faster results and shorter waiting times.</p>
Global, cultural, and social	<p>People are more prone to certain allergies based on their location and culture.</p> <p>Our system should support multiple languages, since allergies affect everyone regardless of language.</p>	<p>Diet preferences and substance restrictions in cultures would affect diagnosis and recommendations.</p> <p>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.</p>

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/acsp Photonics.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 bioproduct 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. Visual Studio and GitHub to write and maintain codebase

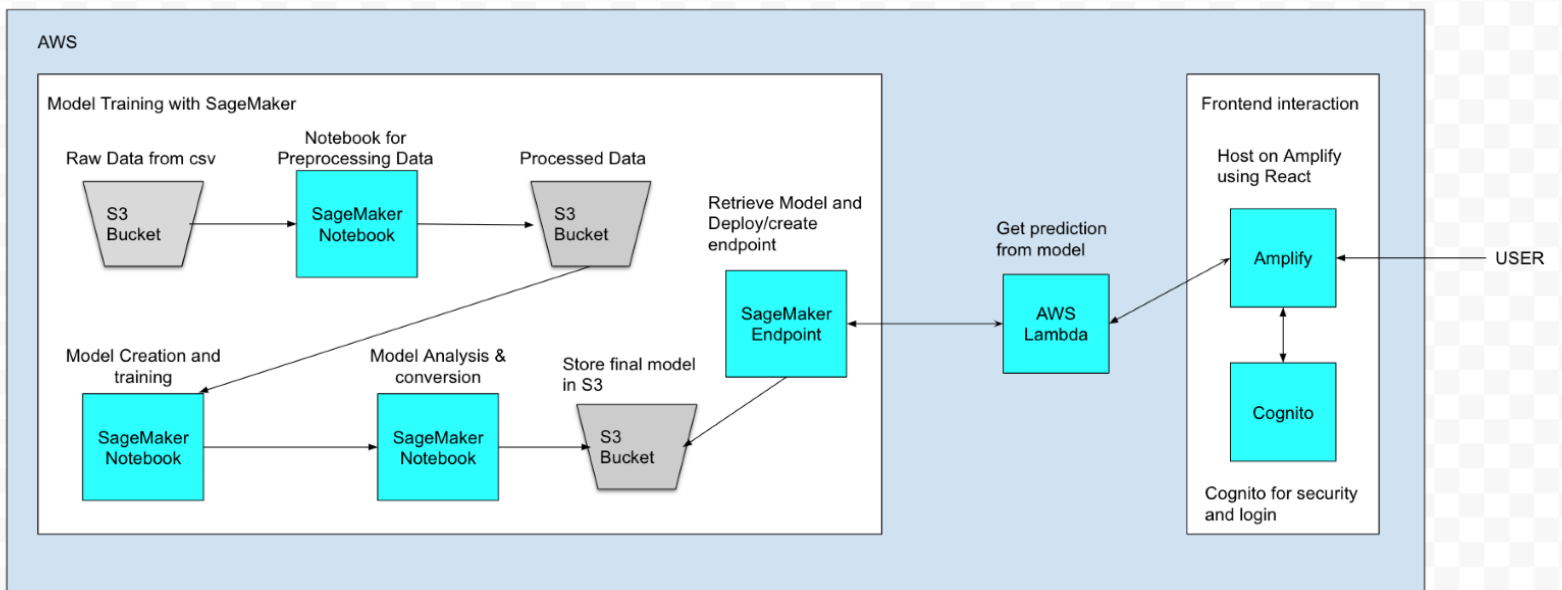
Large:

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



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 are 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 jupyter 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 an S3 bucket for storage and retrieval in AWS. Next 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 an 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 too 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

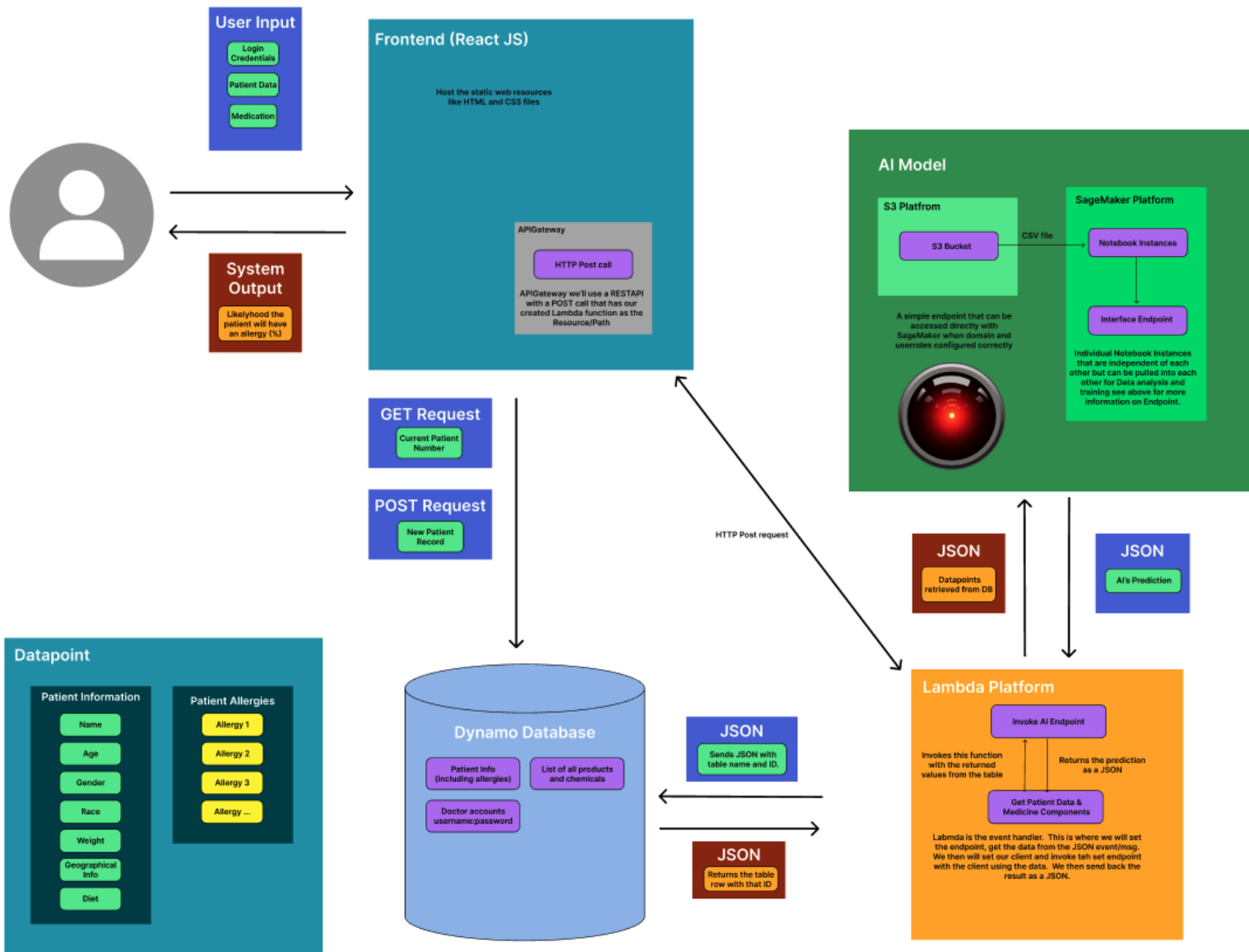
Our AI System is to be used by medical professionals mainly. The system will have in its database patient allergy and medical history. It is to be used by medical professionals to input a medication/treatment they want to prescribe to the patient, and the AI will output an allergic reaction risk percentage based on their allergy/medical history. If the percentage is low, the patient will most likely not have an allergic reaction to what the doctor wants to prescribe. If the percentage is high, there is a high likelihood that the patient will have an allergic reaction. This system will help with the doctor's decision-making process, making it more efficient and safer.

We believe since there is a recent uptick in humans having allergens today, allowing a collaborative aspect between the AI system and medical professionals could better help community health, not just a single patient. Less allergic reactions mean there is a happier and healthier population.

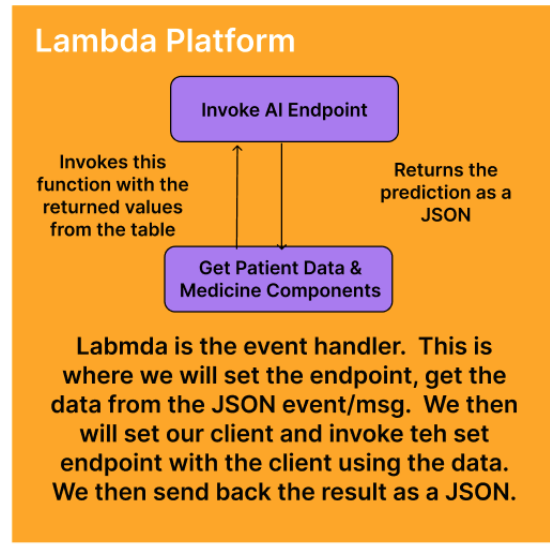
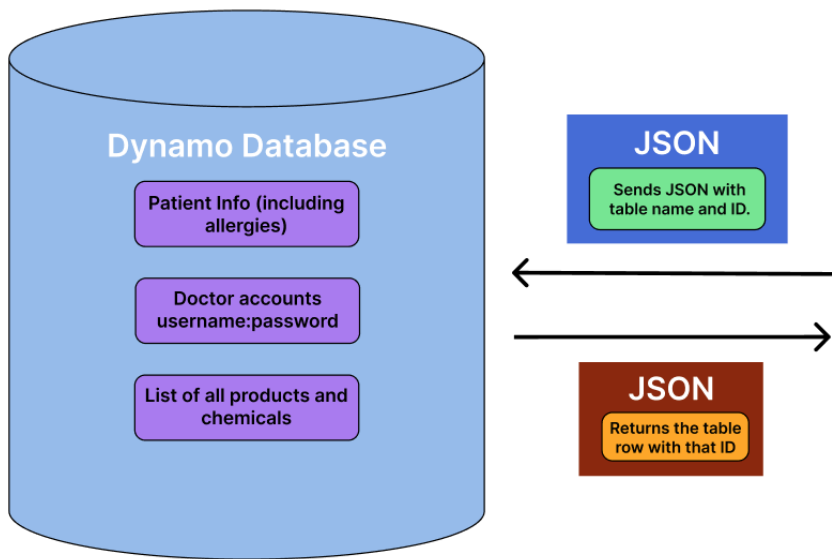
For right now, our current design meets the non-functional requirements. It also meets a majority of our functional requirements, but technology and programs will have their issues, as well as human error that will occur while creating this AI system. We believe we have met all the functional requirements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

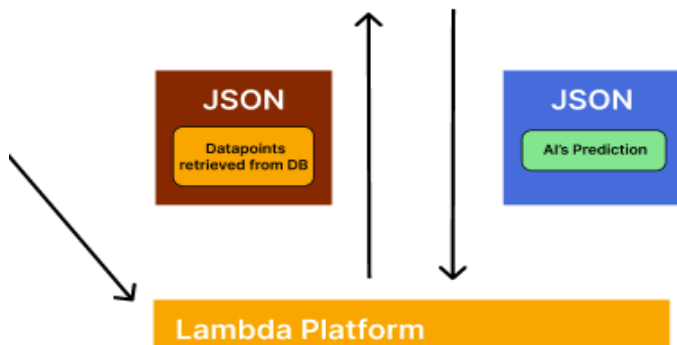
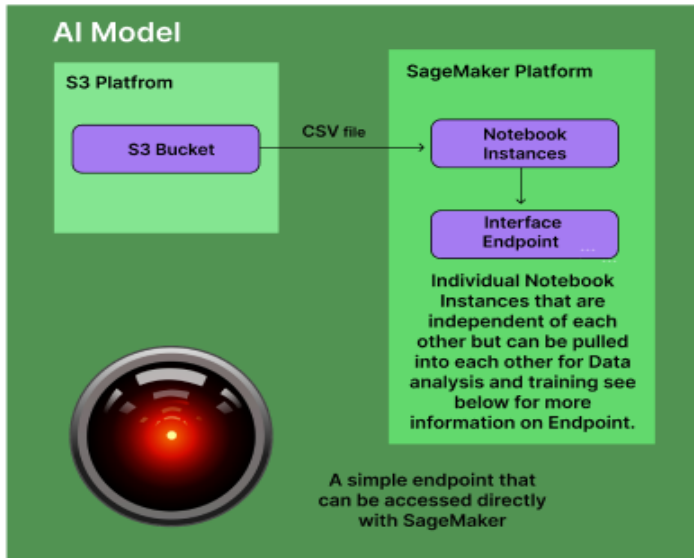
Design Visual and Description



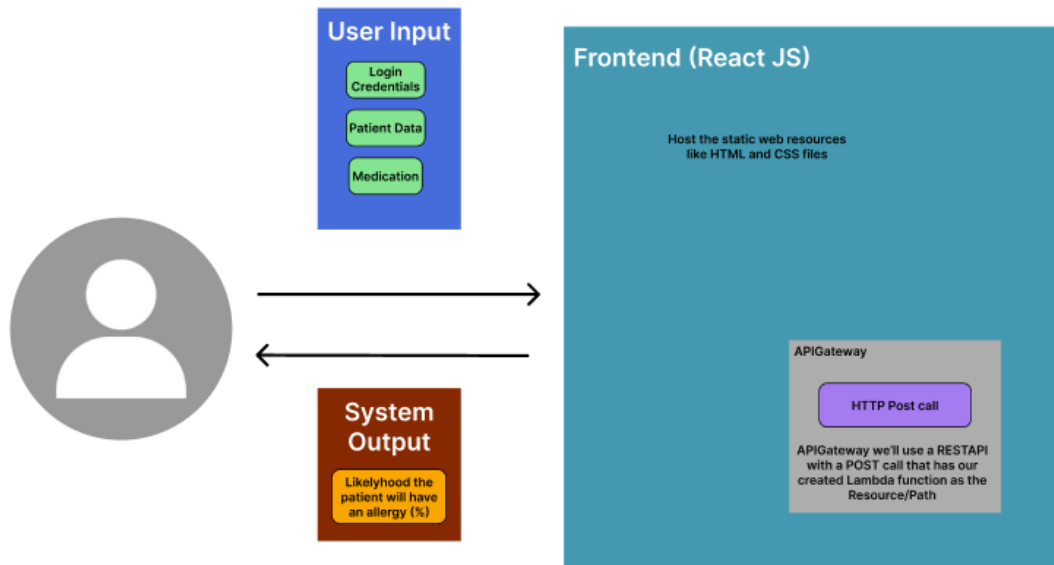
Our application will use AWS services. The user will interact with the web resources (HTML, and CSS) to interact with it. These interactions will be done using HTTP calls with API Gateway which will be received by AWS Lambda. These events will be handled by separate lambda functions which will handle interactions with the DB and AI model and will return our final prediction to the HTTP call for the frontend to display.



Our application will use APiGateway which will send a HTTP GET request that will trigger a lambda function which will create a client with the DynamoDB and using the Id from the event will retrieve the items from the table with that Id being the patient's information and the medications components. That function will then call on a child function that will interact with the AI models endpoint which will be explained below.



Above is our AI model interaction with the Lambda Platform. The AI model takes a JSON as input with the datapoints received from the database. This JSON includes the medication along with patient age, height, and other variables. After receiving the data from the lambda platform, sageMaker and s3 work in conjunction with each other to traverse and analyze the data. The output of the AI model is the prediction made by evaluating the patient's information through the neural network and outputting the percentage likelihood that the patient is allergic to that said medication. It's then returned all the way up to the HTTP call which is then returned to the front end.



The user interacts with our custom UI, which is very simple and will utilize a login page to better protect the patient’s data. The user demographic will be mostly doctors as well as many other medical fields that have the ability to prescribe medication. The patient data and medication in question are pushed to our frontend, where they are sent to the database to be analyzed. The user will have a number return to them which will be the likelihood of that medication being allergic to the patient in question.

4.8 TECHNOLOGY CONSIDERATIONS

AWS

- Strengths
 - Scalability – AWS allows for the scaling up and down of resources depending on demand and can allow for effective workload efficiencies.
 - Global – Has infrastructure/data centers all around the world allowing for low-latency
- Weaknesses
 - Complexity – Offers a wide range of services that can make managing all the configurations for specific cases demanding
 - Costs – Requires diligent monitoring of resources to ensure that there’s no unexpected expenses.
 - Outages – Though very rare AWS has had outages before which affect the availability of applications.
- Trade-offs
 - Performance Vs Cost - We need to balance having adequate performance/response times with keeping cost within the Free AWS price as we don’t have any funds for this project
 - Compliance Vs Flexibility – Since we’re within the AWS platform we need to conform to certain regulations/requirements. This can potentially affect the flexibility of how data is stored and processed.

Neural Networks

- Strengths
 - Adaptability – Can learn/determine complex relationships within the data
 - Ability to Learn – Can automatically learn/ teach itself based off training data

- Generalization - Is able to make predictions on new data that it hasn't seen before
- Versatility – Is able to be applied to a wide range of problems
- Weakness
 - Big Data – Requires large dataset to properly train that needs to be categorized
 - Computationally Expensive – Requires powerful hardware and long runtimes to train
 - Black Box Nature – Have complex internal structures that make them hard to interpret
- Trade-offs
 - Accuracy Vs Interpretability – We need to maintain a level of interpretability so that we're able to give the reasoning for our predictions as we can't be a total black box. This will limit our model sizes, which can affect the accuracy of the model, so we need to find a good balance here.
 - Bias Vs Fairness – Neural networks can learn biases that are present in the training data that can make them unfair. So, we need to make sure to test our model for biases along with accuracy before implementing.
 - Online Learning Vs Batch Learning – Online learning can allow for continuous adaptation to help with new cases and better predict for new cases but can become very sensitive to noise and may overfit. We decided for our cases that batch learning would be best as the continuous learning wouldn't allow us to be constantly analyzing it to make sure that its accuracy is still okay or that it's not biased.

4.9 DESIGN ANALYSIS

– Did your proposed design from 4.7 work? Why or why not?

Our proposed design, for the most part, has either met or exceeded our expectations from our original diagram and planning from 4.7. Although the entire design has not totally been implemented and connected our experience with the current design has been overall mostly positive with some minor changes here and there. With respect to the frontend, the overall design of the frontend has worked very well, and we will continue to follow the design in the future. However, there have been some changes specifically revolving around the relationship between the frontend and the databases. With us now having access to the full data we now have a better grasp of what exactly data is given and what data we need. Originally, we had one central database that would not only create user and receive user data with the frontend but would then send the data over to the AI model which in return would return the model's results and what the patient would be allergic to. Now we are considering a different ideology in respects to how the frontend and AI model interact with the databases and where exactly what data should be stored and where exactly it should be. In order to properly have a frontend and application where a user could sign the database, it needs to make sure this user information is stored and where exactly the patient information about each user is as well. Since we now have the dataset in which the AI model will be trained upon, we now understand that we do not know what to store this information with the user since these data points are not users and are not technically apart of the frontend. Some of the datapoints have changed as well as the original idea of the look and data that each datapoint stored has changed. Overall, the design and the model have stayed the same and we will continue to follow the diagram above. However slight changes will need to be made to ensure that connections between the different components will work and the data/inputs that is being passed between the components may need to change due to the more we have learned over the semester.

– What are your observations, thoughts, and ideas to modify or iterate further over the design?

Some of the connections between the different main components may need to be changed after we make further development in the project. It is important that components can "talk" to each other, but it is extremely important that the correct data can not only be passed to each component, but each component is able to handle the data correctly and efficiently. Due to our project's full design not being implemented it is hard to know exactly if each component and connection will efficiently be able to handle the original plan

and design. It will be of the utmost importance that we focus on the best possible connections and relationships between the different components to have the greatest amount of success. There have also been some thoughts revolving around the databases. It is important how we implement and use each database is correct but in the best possible manner for what we are doing. It is important we keep our user information separate from the patient information especially the patient info that is provided from use inside the data sheet and not the patient info that has been provided to us from the creation and survey of our application users. We are in a similar situation with respect to some of the inputs we are sending to the frontend and the AI model. Over time we have learned more about what the patient info will continue and since receiving the data we have a greater and better understanding about the inputs we need to send to the model and the inputs we can simply just save and put into our database and retrieve when need be.

5 Testing

5.1 UNIT TESTING

- Data Integration Units
 - Units to test: Data import, data processing, data security
 - Testing Approach: Providing sample data and verifying that the system correctly imports, processes, and secures data
 - Tools: Python (PyTest) or JUnit, Postman
- Allergy Reaction Prediction Units
 - Units to test: Reaction prediction accuracy
 - Testing Approach: Use cases with known allergens and medical histories to verify accuracy of reaction prediction
 - Tools: Testing scripts/frameworks
- User Interface Units
 - Units to test: User interface functionality, UX, UI design consistency
 - Testing Approach: Test UI for functionality with simulated user interactions; Test UX through user feedback; Test UI design for consistency with design guidelines
- Ethical and Legal Units
 - Units to test: Data privacy, security, patient confidentiality
 - Testing Approach: Test if the system complies with privacy and security regulations relevant to project and if the system maintains patient confidentiality
 - Tools: Manual reviews, security scanning tools
- Performance and Scalability Units
 - Units to test: System performance and scalability
 - Testing Approach: Test system performance under load, test scalability as data and user loads increase
 - Tools: Custom scripts, JMeter
- Error Handling Units
 - Units to test: Error detection and reporting
 - Testing Approach: Introduce errors and exceptions to see if system can identify and handle them appropriately
 - Tools: Custom error scripts, logging tools for error detection

5.2 INTERFACE TESTING

Since our project focuses on the training and learning of our AI (Artificial Intelligence) model our interfaces are limited to the user experience and interaction. Most of the heavy work is done behind the scenes but it does not mean our interfaces should be ignored and not focused heavily upon to ensure a quality and safe experience. Our users will need to be able to plug in, access, and retrieve their data. This experience is our interface. Users will need to be sure that our project handles their medical history and data safely and that the experience is quick and easy. Since a major goal of this project is to change the way and total experience allergies are discovered it is important that we do just that by making the experience pleasant and safe.

Our main interface is our website which needs to be secure which users need to be able to use quickly and easily. The main composition of one interface is plugging in user information and medical history to have our AI model predict any allergens. This user experience and interface will need to be tested in three ways

1. The data that is being entered is correct and used properly
2. That data is secure and safely used avoiding a breach in security
3. Inputs are easy to understand and enter avoid little confusion

A second composition of our interface will be the actual results that are given to the user. Although not an overly complex interface it is still of the most importance that two criteria is met

1. The results are easily accessible and easy to read
2. The results are correct, and the AI model is producing the correct output, and the correct output is being sent to the user
3. The results are secure and safely stored in the websites data

Tools:

Postman- helps create, build, and use APIs, will be used for more generic testing making sure requests and data are being properly sent and received

Selenium- UI automation testing, will allow for testing of our interface across multiple browsers

WebdriverIO- small and lightweight component tests

Katalon Studio- uses other testing software and APIs but is a good place to have an "all-in-one" experience

5.3 INTEGRATION TESTING

We will be using a hybrid integration testing, but it will mostly be bottom up.

At the current moment, there are only two critical paths. The first path is Amplify to Cognito for login authentication and Amplify to our AI model endpoint. These handle the requirements for security and allow user interaction with our AI model. New paths could be created depending on how we implement our backend with the data servers.

- Frontend/Web application to AI model instance. This path will go through multiple components being:
 - Amplify to LambdaFunction
 - LambdaFunction to SageMakerNotebook Endpoint (Kernel Gateway)
- We will first start the bottom up going with just LambdaFunction and our Notebooks Endpoint. This can be tested using just AWS SDK (software development kit). For this we'd create a simple python file to run locally. We'd create a client and some test data that we'd know the output from by running against the AI model locally. Then all we'd need to be connect our client to the lambda endpoint feed in the test data invoke the call and assert that the value returned is as we'd expect.
- Next, we will integrate Amplify into our testing. Our testing will be very similar to earlier testing of using test data for a call and then asserting that the response is the correct response both unit and

value wise the only difference will be we will be using Amplify mock function to simulate our POST calls.

- Frontend/Web application to Cognito.
 - Amplify to Cognito
- For this testing we will be reusing the amplify mock functions to mock calls to Incognito. We will be testing the GET call of retrieving a user's identity token when they sign in.

We do not need any real integration testing for our model training as this can all be done locally till you have your model, and then you need to host it on an instance with a gateway.

5.4 SYSTEM TESTING

The primary goal of system testing would be to validate that the system functions according to our requirements, specifically with regards to the turnaround time and accuracy of results. Our system level testing strategy starts with module testing and ensuring each individual component of our design works. After having insurance that our system components work, validating the functionality and developing unit tests to test performance will be implemented. This will allow us to test edge cases and ensure that the information coming back from our system is in a timely manner. This will be tied too closely to the requirements for a majority of the tests, but edge cases might deviate slightly from our requirements.

In regard to end-to-end testing tools, we plan on using JUnit to perform a lot of these tests since they can make testing fully automated. The specific unit, interface, and integration tests will be closely tied to performance. We plan on implementing unit tests to cover any variability in the AI, as well as making sure that it has an output as well. We also plan on using SQL Unit for the database which will help us isolate any potential problems we may face with undesirable results from our design.

To coordinate our test cases, we will use either TestRail, qTest or Katalon Studio to manage the organization of our test cases as well as generate test reports. The feedback from the tests will be crucial to the success of our project in regard to maintaining timeliness as well as verification that the system and each individual component are responsive in an appropriate manner.

5.5 REGRESSION TESTING

To ensure that new additions do not break the old functionality, we employ version control and continuous integration practices through tools like GitHub.

- All new code will be pushed into its own branch, and when it's complete, the branch will request to merge into main
- Each merge request will require two reviewers to be able to be merged into main

We need to ensure the stability and performance of implemented critical features, particularly the diagnostic AI system, to prevent any degradation in its accuracy and functionality.

5.6 ACCEPTANCE TESTING

Our team will create and maintain comprehensive documentation that clearly outlines the design requirements and how they are addressed in the system. This documentation will be used as a reference point for our client to ensure that the original requirements are met. In addition, we will create a prototype of our AI system, which will allow the client to interact with the system and verify that all functional and

non-functional requirements have been met. This level of involvement from the client ensures that the final product aligns with their expectations.

5.7 SECURITY TESTING (IF APPLICABLE)

Our project will require security testing since the system will be handling sensitive data like patient records which are required to be confidential. To test the security of our system, we will complete the following:

- Vulnerability Assessment
 - Scan the system for vulnerabilities and security issues
- Authentication and Authorization Testing
 - Ensure authentication and authorization of users is working correctly
- Data Encryption and Transmission Testing
 - Ensure that when sensitive data is encrypted at rest and transit that it's protected
- Security Compliance Testing
 - Assess if the system adheres to HIPAA and other relevant standard/regulations
- Session Management Testing
 - Verify sessions are secure and not easily exploitable
- Database Security Testing
 - Assess the security of the database to prevent breaches
- Security Awareness and Training
 - Train on security practices and relevant possible threats on the system
- Incident Response Testing
 - Prepare to respond to security incidents effectively
- Secure Configuration Testing
 - Ensure servers, databases, etc. are securely configured and are protected from common security threats.

5.8 RESULTS

Unit testing will result in all unit's listed working properly and accurately so the AI system will run smoothly and provide accurate predictions to the user. Our unit testing plan ensures compliance by making sure the AI model and all other parts of the system will perform efficiently for the user while the AI accurately makes predictions.

Interface testing will result in the website interface being able to collect data and produce prediction results correctly, securely, and easily. Our interface testing plan ensures compliance for a secure, quick, and user-friendly experience for the user while also meeting the project's main goals of predicting allergy reaction to products.

Integration testing will result in all critical paths and components communicating properly with each other. This testing ensures compliance with requirements by verifying that the integration points of the AI model are working as expected and are meeting the security and functionality requirements.

System testing will result in better performance, accuracy, and robustness of the system overall, as well as specifically with the AI model. System testing is in compliance with the requirements of the project because it validates that the entire system is running as accurately and efficiently as possible, resulting in the allergy predictions made the AI to be more accurate.

GitHub will prevent regression by using a continuous integration that prevents new code breaking existing functionality. This is in compliance with our requirements because it ensures that new features and changes won't negatively impact the stability and performance of the allergy prediction.

Acceptance Testing will result in proving that our design for the allergy predicting AI is in compliance with our project requirements. Testing will go over the outlines of the design to make sure all requirements are included and will go over how the requirements are implemented into the system.

Security testing will result in all aspects of the security of the user and patient data used will remain secure and protected. This testing will be in compliance with our requirements by demonstrating the system's commitment to handling sensitive data securely and adhering to relevant standards and regulations, like HIPPA.

In conclusion, our comprehensive testing design validates the design of our allergy predicting AI aligns perfectly with the intended goals and requirements for the project. Our testing efforts will culminate in a robust and reliable AI allergy prediction system. The system will not only perform efficiently and accurately, but it also will uphold standards of security, usability, and compliance with our project requirements. As we move forward, the foundation of our design ensures a trustworthy experience for users.

6 Implementation

1. Kick-off meeting – Week 1-2
 - a. Assemble the team together to discuss semester objectives and timeline
 - b. Outline member responsibilities
2. AI model Development – Week 3-7
 - a. Preprocess and clean the dataset
 - b. Develop the machine learning model, incorporating patient information and chemical compositions of treatments
 - c. Train and validate the model using the prepared datasets
3. Integration and Testing – Week 8-10
 - a. Integrate the developed model into the AI system
 - b. Conduct rigorous testing to ensure the system's functionality, accuracy, and reliability
 - c. Address any bugs or issues identified during testing
4. User Training and Documentation – Week 11-12
 - a. Develop UI and UX
 - b. Create comprehensive documentation of how medical professionals will use the AI system
5. Ethical, Regulatory Compliance, and Security – Week 13-14
 - a. Conduct an ethics review of the project, addressing any ethical considerations
 - b. Ensure that the project complies with relevant healthcare data protection regulations
 - c. Ensure the system and dataset are secure
6. Implementation and Feedback – Week 15-16
 - a. Deploy the system in a controlled environment with a limited user group
 - b. Make necessary adjustments to improve the system based on user feedback

7 Professionalism

This discussion is with respect to the paper titled “Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment”, *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 AREAS OF RESPONSIBILITY

Area of Responsibility	Definition	NSPE Canon	SE code of ethics
Work Competence	Perform work of high quality, integrity, timeliness, and professional competence.	Perform services only in areas of their competence; Avoid deceptive acts.	1.03: Ensure they are qualified, by an appropriate combination of education and experience, for any project on which they work or propose to work.
Financial responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustee	1.07: Ensure realistic estimates of cost, scheduling, personnel, and outcome on any project which they work or propose work and provide risk assessment for these estimates.
Communication Honesty	Report work truthfully, without deception, and understandable to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts	6.08: Be accurate in stating the characteristics of software on which they work, avoiding not only false claims but claims that might reasonably be supposed to be deceptive, misleading, or doubtful.
Health, Safety, Well-being	Minimize risks to safety, health, and well-being of stakeholders.	Hold paramount the safety, health, and welfare of the public	2.02: Approve software only if they have a well-founded belief that it is safe, meets specifications, has passed appropriate tests, and does not diminish the quality of life or harm the environment.
Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees.	7.03: Credit fully the work of others.
Sustainability	Protect environment and natural resources locally and globally.	N/A	2.02: Approve software only if they have a well-founded belief that it is safe, meets specifications, has passed appropriate tests, and does not diminish the quality of

			life or harm the environment.
Social Responsibility	Produce products and services that benefit society and communities.	Conduct themselves honorably, responsibly, ethically, and lawfully to enhance the honor, reputation, and usefulness of the profession	6.10: Obey all laws governing their work, insofar as such obedience is consistent with the public health, safety, and welfare

7.2 PROJECT SPECIFIC PROFESSIONAL RESPONSIBILITY AREAS

For each of the professional responsibility area in Table 1, discuss whether it applies in your project’s professional context. Why yes or why not? How well is your team performing (High, Medium, Low, N/A) in each of the seven areas of professional responsibility, again in the context of your project. Justify.

Area of Responsibility	Does it Apply?	Team Performance
Work Competence	Does Apply – Our team is providing an application that will be used to support medical professionals.	High – Our team has conducted ourselves professionally and is looking to develop competent AI.
Financial responsibility	Doesn’t Apply – Our project isn’t meant for the market more for proving theoretical.	NA
Communication Honesty	Does Apply – We can’t deceive our users as they’ll be using this to provide medical care. So, we could harm patients if we deceive medical professionals.	High – Our only client so far is a professor and we’ve been completely honest and don’t have any deceptive practices in the application.
Health, Safety, Well-being	Does Apply – Our use will be in the medical field. Our project will be used to support/improve public health.	High – Throughout the whole process we’ve focused on how we can best support medical professionals so that they themselves can give the best care to their patients.
Property Ownership	Does Apply – We’ll have medical information from Mayo Clinic. So, we’ll have to make sure we’re properly ensuring their information is protected.	High – We’ll have our information stored on the backend and will only be retrievable/editable by users with signings.
Sustainability	Doesn’t Apply – Our resources will be from AWS.	NA

Social Responsibility	Does Apply – We are looking to make an application that will help support medical professionals so that they can provide better care to their patients.	High – We've looked into laws and practices for medical applications so that we follow rules and practices.
------------------------------	---	---

7.3 MOST APPLICABLE PROFESSIONAL RESPONSIBILITY AREA

Health, Safety, and Well-being – We feel that this is what we should be focusing on the most as this is the heart/purpose of our entire application. Our main goal of the project is supporting medical professionals so that they can give the best medical care.

8 Closing Material

8.1 DISCUSSION

- Personalized Prescription Recommendations
 - The AI system provides personalized allergy reaction risk percentages for patients based on correlations in their medical history. This percentage allows doctors to prescribe a more personalized and efficient treatment to the patient. The main result is an optimized treatment plan that aims to minimize the risk of allergic reaction.
- Enhanced Decision Support for Healthcare Professionals
 - Healthcare professionals, such as allergists and doctors, benefit from a data-driven decision support tool. The AI system assists them in making more informed and personalized decisions when prescribing treatments, taking into account a patient's unique medical history.
- Improved Patient Safety and Outcomes
 - The primary outcome is an improvement in patient safety and treatment outcomes. By incorporating detailed patient information and analyzing correlations with allergies, the project aims to reduce the likelihood of adverse reactions, contributing to a safer and more effective healthcare experience for individuals.
- Efficiency in Treatment Planning
 - The project results in increased efficiency in the treatment planning process. Healthcare professionals can leverage the AI system to quickly assess potential risks and benefits of prescribed treatments, streamlining decision-making and allowing for more focused and personalized patient care
- Benefits Public Health
 - The implementation of a personalized allergy risk assessment system provides substantial benefits to public health. Harnessing advanced AI, the project tailors risk assessments based on individual patient medical history and allergies, aiming to significantly reduce the likelihood of adverse reactions and complications. This individualized risk evaluation enhances patient safety and satisfaction while contributing to the overall efficiency of healthcare delivery. Ultimately, the project's emphasis on personalized risk assessment, efficiency, and informed decision-making elevates the standard of care, positively impacting public health by promoting precise and effective healthcare practices.

8.2 CONCLUSION

What we have done so far for this project is overall we have created a detailed plan on how we are going to develop the AI. We have created visuals and milestones to keep us on track to complete all our goals next semester. Our main goal for next semester is to create a working AI system that will output an allergy reaction risk percentage based on what product was inputted into the system. To complete this main goal, we have set smaller goals or milestones that we will complete one by one next semester until we reach our end goal.

Our goal for this past semester was to set up an efficient plan for next semester so we can create the AI as seamlessly as possible. Some constraints we faced this semester that made it more difficult to make an efficient plan was that we were not given access to the dataset that we will be using next semester. This would've been beneficial as it would've helped our understanding of the project and would have helped us with visuals. Another constraint was coordinating time to create the plan. Most of our group members are

full-time students and are also working, so creating a schedule that worked for everyone was difficult. Although we faced these difficulties, we still achieved our goal and completed this thorough plan for developing the allergy detecting AI system.

8.3 REFERENCES

- [1] “The world’s largest technical professional organization dedicated to advancing technology for the benefit of humanity.,” IEEE, <https://www.ieee.org/> (accessed Nov. 28, 2023).
- [1] O. for C. R. (OCR), “Your rights under HIPAA,” HHS.gov, <https://www.hhs.gov/hipaa/for-individuals/guidance-materials-for-consumers/index.html> (accessed Nov. 28, 2023).
- [1] “AIS standards,” IEEE Standards Association, <https://standards.ieee.org/initiatives/autonomous-intelligence-systems/standards/> (accessed Nov. 28, 2023).
- [1] “IEEE SA - IEEE Standard - Health Informatics--device interoperability part 40102: Foundational--Cybersecurity--capabilities for Mitigation,” IEEE Standards Association, <https://standards.ieee.org/ieee/11073-40102/7680/> (accessed Nov. 28, 2023).
- [1] R. Park, “Ai allergy,” Devpost, <https://devpost.com/software/ai-allergy> (accessed Nov. 28, 2023).
- [1] Y. Wu et al., “Label-Free Bioaerosol Sensing Using Mobile Microscopy and Deep Learning,” ACS Publications, <https://pubs.acs.org/doi/10.1021/acsp Photonics.8b01109> (accessed Nov. 29, 2023).

8.4 APPENDICES

8.4.1 Team Contract

Team Name _____ Team 13 _____

Team Members:

- 1) _____ Zoe Davis _____
- 2) _____ Josh Dutchik _____
- 3) _____ Michael Koopmann _____
- 4) _____ Jack Gray _____
- 5) _____ Blake Friemel _____
- 6) _____ Eric Christensen _____
- 7) _____
- 8) _____

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:

Our team will meet every Tuesday at 5pm virtually.

2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):

Preferred method of communication is text message. Group chat has already been created and a discord server is also created for communicating and sharing links

3. Decision-making policy (e.g., consensus, majority vote):

If there is an issue the group can't agree on, we will allow both sides to share their reasoning. After, we will have a vote. Once a side has been chosen it is the one, we go with.

4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):

Person keeping minutes switches every week on a rotation. Minutes will be shared by email.

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:

Everyone should attend every meeting. If someone can't attend a meeting a message needs to be sent to our group chat. Everyone should be on time for meetings.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

Everyone should be doing an equal amount of work. If a member of the team has extenuating circumstances that make it to where that can't put in an equal amount of work, a discussion needs to be had with the team.

3. Expected level of communication with other team members:

Everyone should be able to respond to a message within 24 hours.

4. Expected level of commitment to team decisions and tasks:

Everyone should be committed to meeting team deadlines and assignment deadlines. If there is a reason a member can't meet a deadline or is falling behind, a discussion needs to be had with the group.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):

Josh Dutchik: Documentation and frontend support

Zoe Davis: Team organization and frontend work

Micheal Koopmann: Client interaction

Jack Gray: Testing

Eric Christensen: Individual Component Design and Testing

Blake Friemel: Backend work and testing

2. Strategies for supporting and guiding the work of all team members:

A strategy we can practice for the support and guidance of all group members is having a weekly or consistent checkup where group members can discuss what they have been working on and any problems they have run during the project's process. By constantly checking in with group members, there is a continuous support of the current group members' work.

3. Strategies for recognizing the contributions of all team members:

One strategy we can practice for the recognition of contributions from team members is during our meet-up time take time during the meeting to acknowledge and celebrate group members' accomplishments. If our group celebrates and shows appreciation for group members when milestones are hit, group morale and motivation will be much more positive.

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.

Josh Dutchik: Has worked with embedded systems for over a year. He has the most expertise with writing and debugging embedded system code and functionality. He has not worked with AI outside of some free learning so provides a fresh and new understanding of AI and how we will implement some of the technologies in our final project.

Zoe Davis: Has some previous experience with Python. Frontend work is her strength, but also has experience doing backend work. She hasn't done any work similar to building an AI, but has experimented with AI in her free time. For example, she had ChatGPT come up with color schemes that she could use to decorate her living room. As the sole woman on the team, she brings a unique and diverse perspective, enhancing the group's creativity and problem-solving capabilities.

Michael Koopmann: Has experience coding in Python and working with Machine Learning models both supervised and unsupervised. Also, has slight experience working with frontend and website design. I've had experience with model selection and cleaning/selecting data which I think will be important for this project.

Jack Gray: Has experience in software engineering and computer engineering. Has experience in front end and back end. Most comfortable working with java and data structures.

Eric Christensen: Has had significant experience with Embedded systems as well as java and python applications. Has limited experience with frontend development as well as neural networks.

Blake Friemel: Has knowledge of computer science and engineering topics. Has experience coding with Python but is best at working with Java. Also has backend programming experience. I have not had any experience with coding or training an AI, but the primary reason I chose this project is to gain that experience.

2. Strategies for encouraging and support contributions and ideas from all team members:

Communication is the key to our group. We are setting a standard that all team members have a valid and equal voice when contributing ideas and support to the project's final goal. Letting each group member have their own voice, ideas, and contributions are both encouraged and supported by every group member. Every group member needs to understand that their ideas and contributions are both heard and valid.

3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)

The first step in identifying and resolving group members' issues is to voice their concerns. The affected group members need to inform and make known the issues they are having with the project and its environment. Once the problem has been identified and all group members are aware of the problem, the group needs to take the time to solve the problem together. If it is a problem with the group members themselves, communication needs to occur to solve the friction between members. If a problem is more with the environment surrounding the project, group members need to collaborate to solve the issue at hand.

Goal-Setting, Planning, and Execution

1. Team goals for this semester:

We hope to improve our ability to conduct collaborative work. This includes things such as communication, scheduling, breaking up problems into manageable and efficient tasks, proper documentation, and working deadlines. We also want to learn more about AI. Some topics we hope to learn would be the different models of AIs, their pros and cons, and how to pick the correct model for a situation.

2. Strategies for planning and assigning individual and team work:

One strategy for planning and assigning teamwork is during our meet-up time we make sure each group member has something assigned they can be working on. Work will be assigned based on certain group members' experience, skills, and expertise. We will ensure that each group member is assigned a task within their scope.

3. Strategies for keeping on task:

A strategy our group will practice for staying on task is making sure each group member has a dedicated time throughout the week that is designated for the project and its design. The strategy will ensure that each group member not only can complete their part but has a consistent time to work and provide constant continuation towards the project's completion and stay on task.

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?

If there is a member not meeting the guidelines we have stated in this contract, then we will have either an in-person or online meeting to discuss our issues and hear the member's side of the story. We will also discuss ways to improve.

2. What will your team do if the infractions continue?

If infractions continue, our team will set up a meeting with the professor. With the professors' help, we can hopefully get the infractions to stop. And in meeting with the professor, the professor would now be aware of the situation.

a) *I participated in formulating the standards, roles, and procedures as stated in this contract.*

b) *I understand that I am obligated to abide by these terms and conditions.*

c) *I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.*

- 1) _____ Zoe Davis _____ DATE _____ 9/10/23 _____
- 2) _____ Blake Friemel _____ DATE _____ 9/10/23 _____
- 3) _____ Michael Koopmann _____ DATE _____ 9/10/23 _____
- 4) _____ Jack Gray _____ DATE _____ 9/10/23 _____
- 5) _____ Joshua Dutchik _____ DATE _____ 9/10/23 _____
- 6) _____ Eric Christensen _____ DATE _____ 9/10/23 _____
- 7) _____ DATE _____
- 8) _____ DATE _____