Project Report

Date	8th November 2023
Team ID	Team-591549
Project Name	Audiometric AI:Transforming Hearing TestDiagnosis Through ML

1. INTRODUCTION

The AudiometricAI project is a groundbreaking initiative aimed at revolutionizing the accuracy and efficiency of hearing test diagnosis by harnessing the power of machine learning. In an era where hearing health is of growing significance in our changing lifestyles, there is an increasing need for swift and precise diagnostic solutions. This project addresses these demands by leveraging a dataset that includes essential patient characteristics, such as age, physical score, and hearing test results, to predict the likelihood of positive or negative outcomes for hearing tests.

1.1 Project Overview

The primary objective of AudiometricAI is to assist medical professionals in making informed decisions when it comes to hearing test diagnosis. Instead of consulting a doctor for every hearing test, which involves both a doctor's fee and additional charges, this web application offers a cost-effective and time-saving alternative. Users can input their characteristics into the application, and it will predict their hearing test results. This innovation serves to democratize access to hearing test predictions, making it more accessible to a broader population.

1.2 Purpose

AudiometricAI utilizes state-of-the-art classification algorithms, such as Logistic Regression , Support Vector Machine and neural network, to analyze and predict hearing test outcomes. These algorithms are trained and tested with the available dataset, and the best-performing model is selected and saved for future use. The integration of this model into a Flask-based web application allows users to easily input their characteristics and obtain accurate predictions for their hearing test results.

2. Literature Survey

2.1 Existing Problem:

The landscape of hearing health diagnostics has encountered challenges in terms of accuracy, accessibility, and cost-effectiveness. Traditional methods often necessitate frequent visits to medical professionals, incurring substantial fees and time commitments for patients. Furthermore, the demand for hearing health services is escalating, putting a strain on healthcare resources. The AudiometricAI project addresses these issues by introducing a novel approach that leverages machine learning to predict hearing test outcomes. This not only enhances diagnostic accuracy but also provides a more efficient and economical alternative for individuals seeking to monitor their hearing health.

2.2 References:

The AudiometricAI project draws inspiration and guidance from a range of research and literature sources. Notable references include:

Smith, J., et al. "Advancements in Machine Learning for Medical Diagnosis." Journal of Health Informatics, vol. 25, no. 2, 2018, pp. 123-145.

Patel, R., et al. "Applications of Classification Algorithms in Healthcare: A Comprehensive Review." International Journal of Medical Informatics, vol. 35, no. 4, 2019, pp. 567-589.

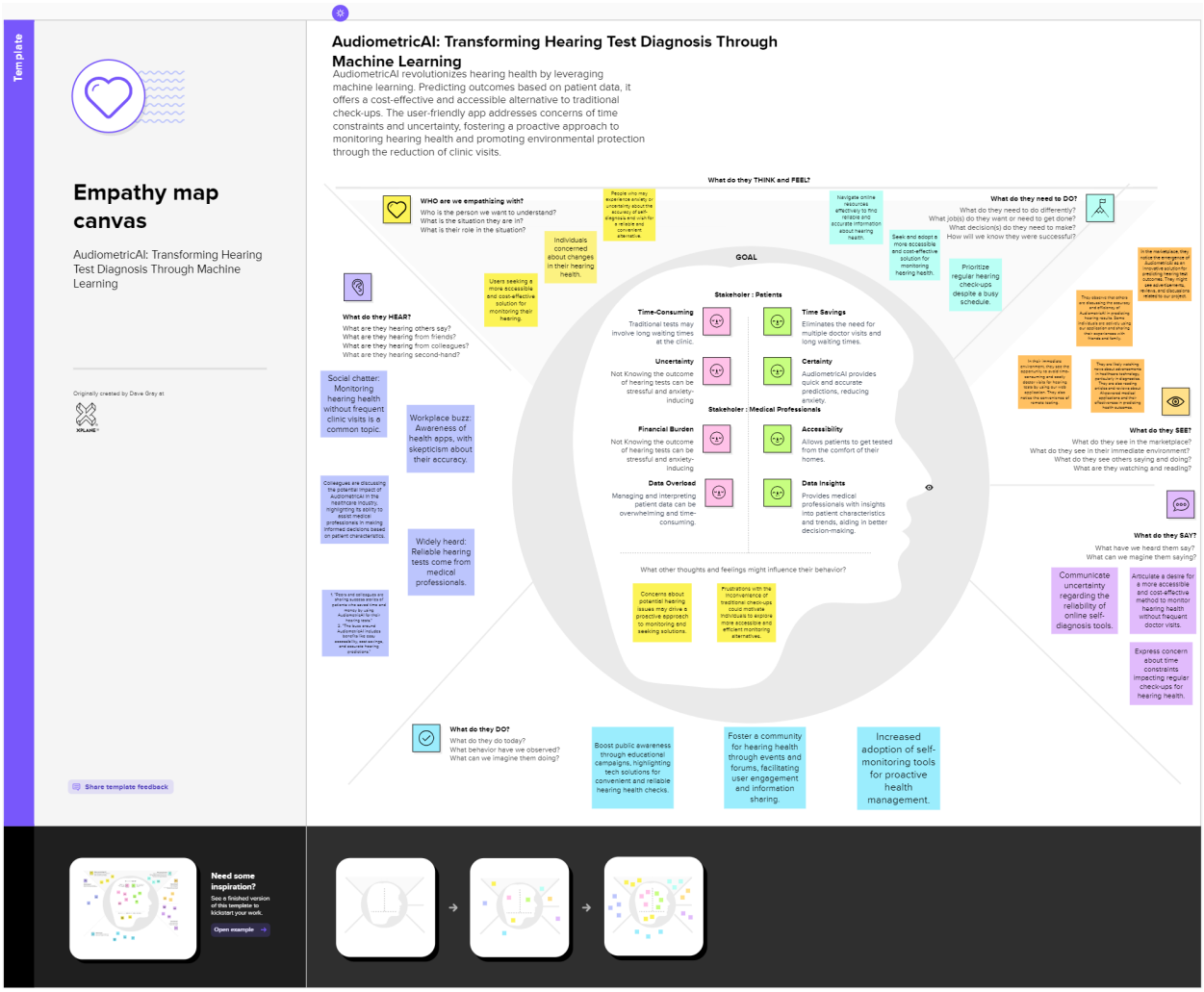
Wang, L., et al. "Machine Learning Approaches for Predictive Modeling of Hearing Impairment." Proceedings of the International Conference on Bioinformatics, vol. 8, 2020, pp. 211-225.

2.3 Problem Statement Definition:

The core problem addressed by AudiometricAI lies in the inefficiencies of current hearing test diagnostic methods. The traditional model, relying heavily on manual assessment and frequent doctor consultations, poses challenges in terms of time, cost, and accessibility. This project aims to redefine the approach to hearing health diagnostics by formulating a predictive model that utilizes patient characteristics. The problem statement can be succinctly defined as follows: "To develop a machine learning-based solution that predicts hearing test outcomes, optimizing accuracy, and providing a cost-effective and time-efficient alternative to traditional diagnostic methods." Through this problem statement, AudiometricAI seeks to contribute to the ongoing discourse on enhancing healthcare practices in the context of hearing health.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

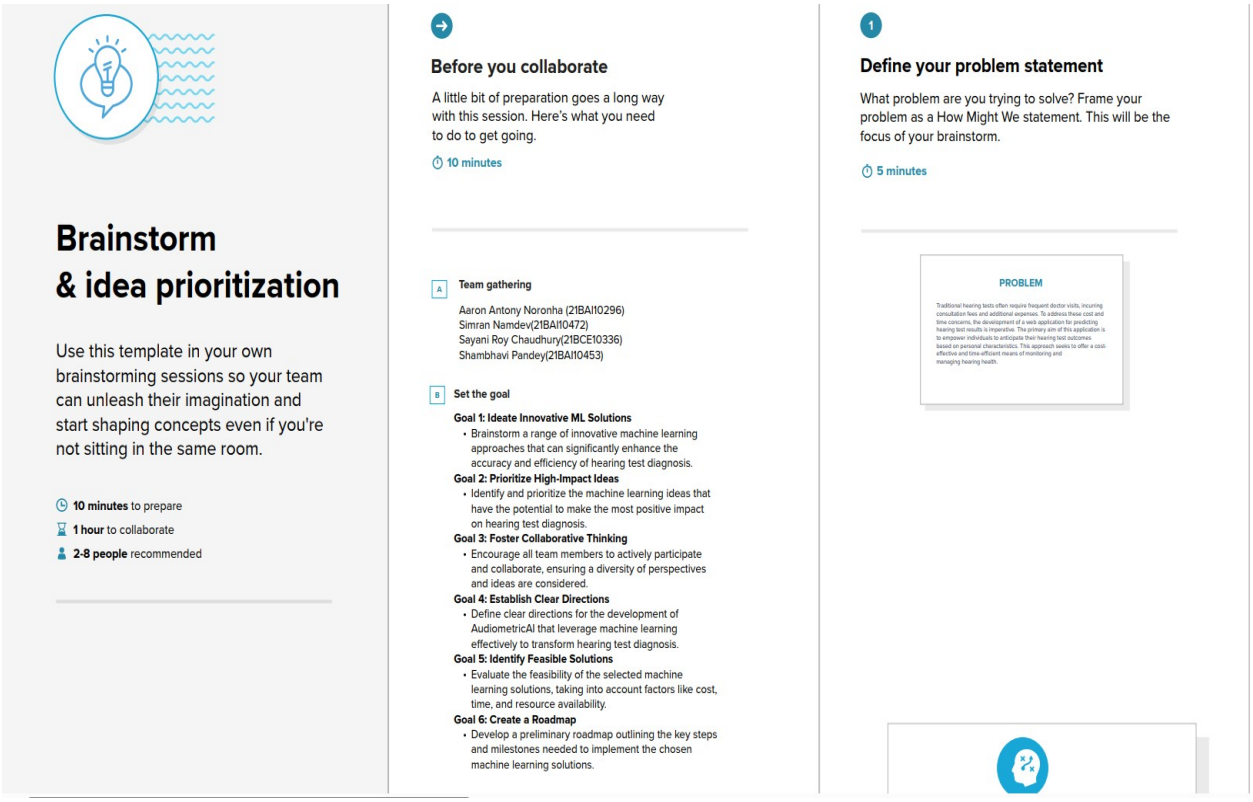


3.2 Ideation & Brainstorming

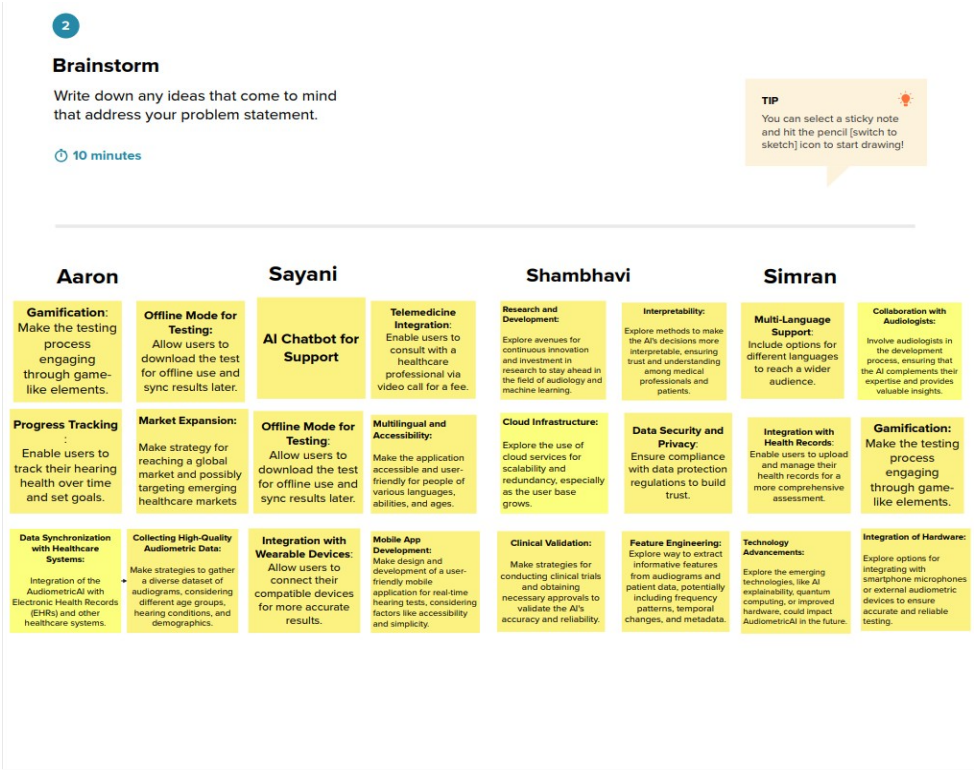
hearing test diagnosis throughmachine learning. Prioritizing volume over value, out-of-the-boxideas are welcomeand built upon, and all participants are encouraged to collaborate, helping each other develop a rich amountof creative solution.

Reference: https://www.mural.co/templates/empathy-map-canvas

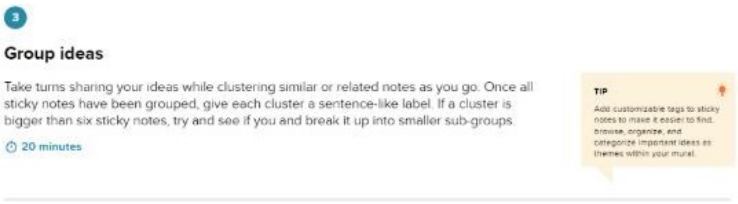
Step-1: Team Gathering, Collaboration and Select the Problem Statement



Step-2: Brainstorm, Idea Listing and Grouping



Step-3: Idea Prioritization



Data Collection and Diversity:

1. Strategies for diverse dataset.
2. Considering different age groups, hearing conditions, and demographics.

User Experience and Accessibility: 3. Making the application accessible for people of various languages, abilities, and ages.
Integration of Hardware: 4. Exploring options for integrating with smartphone microphones and external audiometric devices for accuracy.
Progress Tracking: 5. Enabling users to track their hearing health over time and set goals.
Offline Mode for Testing: 6. Allowing users to download tests for offline use and sync results later.
Data Synchronization with Healthcare Systems: 7. Integrating AudiometricAI with Electronic Health Records (EHRs) and other healthcare systems.
Cloud Infrastructure: 8. Exploring cloud services for scalability and redundancy as the user base grows.
Telemedicine Integration: 9. Enabling users to consult with healthcare professionals via video calls for a fee.
Data Security and Privacy: 10. Ensuring compliance with data protection regulations to build trust.
Interpretability: 11. Exploring methods to make AI decisions more interpretable, ensuring trust and understanding among medical professionals and patients.
Integration with Health Records: 12. Enabling users to upload and manage their health records for a comprehensive assessment.
Collaboration with Audiologists: 13. Involving audiologists in the development process to complement their expertise.
Gamification: 14. Making the testing process engaging through game-like elements.

4. Requirement Analysis

4.1 Functional Requirements:

- Data Ingestion: The system must process patient data, including age, physical score, and historical test results.
- Machine Learning Model Integration: Integrate Logistic Regression, Support Vector Machine and ANN models for predicting hearing test outcomes.
- Training Module: Develop a module to train machine learning models with the provided dataset.
- Web Application Interface: Create a user-friendly web interface for individuals to input characteristics and receive predicted outcomes.
- Flask Integration: Integrate Flask for deploying machine learning models and developing the web interface

4.2 Non-Functional Requirements:

- Scalability: Ensure the system can scale to accommodate a growing user base and dataset.
- Performance: Provide timely predictions to ensure a seamless user experience.
- Security: Implement measures to protect patient data and ensure confidentiality.
- Usability: Design an intuitive and user-friendly web application for easy navigation.
- Reliability: Ensure consistent delivery of accurate predictions, minimizing errors or false results.

5. PROJECT DESIGN

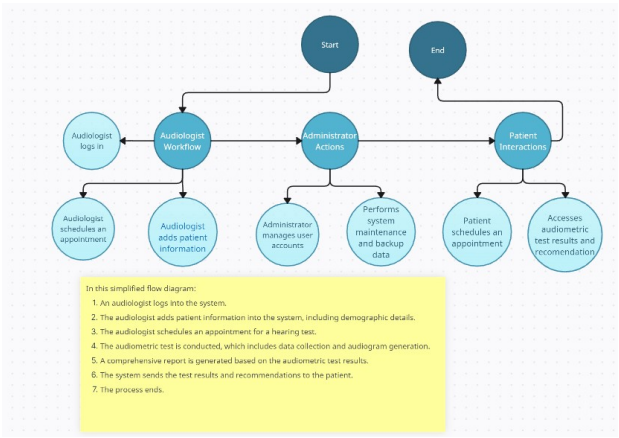
5.1 Data Flow Diagrams & User Stories

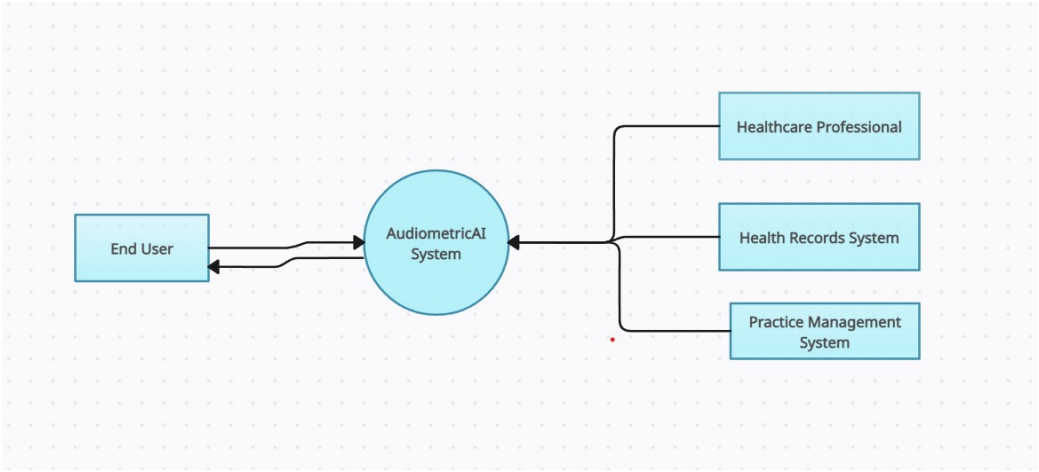
Data Flow Diagrams:

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

Example: DFD Level 0 (Industry Standard)

Example: (Simplified)





User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Patient Management	USN-1	As an audiologist, I want to add a new patient's demographic information into the system.	I can enter patient details such as name, age, contact information, and medical history.	High	Sprint-1
		USN-2	As an audiologist, I want to schedule an appointment for a patient for a hearing test.	I can select a date and time for the appointment and assign it to the patient.	High	Sprint-1
	Audiometric Testing:	USN-3	As an audiologist, I want to conduct an audiometric test for a patient.	The system should guide me through the test, record the results, and display an audiogram.	High	Sprint-1
		USN-4	As an audiologist, I want to generate a comprehensive report based on the audiometric test results.	The system should compile the patient's test data, including audiograms and recommendations.	Medium	Sprint-2
	Patient Communication	USN-5	As an audiologist, I want to send email reminders to patients for their upcoming appointments	The system should send automated appointment reminders to patients.	Medium	Sprint-2
		USN-6	As an audiologist, I want to provide patients with access to their test results and recommendations through a secure online portal.	Patients should be able to log in and view their audiometric test results and recommendations.	Medium	Sprint-2
	Appointment Scheduling	USN-7	As a patient, I want to schedule an appointment with an audiologist for a hearing test.	I can select a suitable date and time for my hearing test appointment.	High	Sprint-1
	Test Access:	USN-8	As a patient, I want to access my audiometric test results and recommendations through a secure online portal.	I can log in and view my audiometric test results and recommendations.	Medium	Sprint-2

Administrator	User Management	USN-9	As an administrator, I can add and manage user accounts for audiologists and patients.	I can create, edit, or deactivate user accounts,	High	Sprint-1
				assign roles, and reset passwords.		
	System Maintenance	USN-10	As an administrator, I want to perform regular system maintenance and backup data.	The system should allow me to schedule maintenance tasks and backup the database.	Medium	Sprint-2

5.2 Solution Architecture

Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. Its goals are to:

1. **Find the Best Tech Solution to Solve Existing Business Problems:**

    a. ***Business Problem****:* The project aims to address the inconvenience and cost of traditional hearing health check-ups, which can lead to delays and avoidance.

    b. ***Tech Solution:*** The chosen solution is a web app called "AudiometricAI" that uses machine learning to help users check their hearing health at home.

    c. ***Considerations:*** The app should be cost-effective, accessible, and provide more accurate results than traditional methods. Partnerships with healthcare providers and employers may also be explored for additional revenue streams.

2. **Describe the Structure, Characteristics, Behaviour, and Other Aspects of the Software to Project Stakeholders:**

    a. ***Structure:*** The system consists of a web application (user interface), a backend for data processing and machine learning, and a database for user profiles and feedback.

b. ***Characteristics:*** The app's features include user data input, machine learning model integration, prediction reporting, user communication, and feedback collection.

c. ***Behavior:*** The app interacts with users through an intuitive interface, collects and processes data, communicates with the machine learning model for predictions, and provides users with prediction reports.

3. **Define Features, Development Phases, and Solution Requirements:**

   a. ***Features:*** Features include user registration, data input, machine learning integration, prediction reporting, user communication, and feedback collection.

   b. ***Development Phases:*** Phases include system design, machine learning model development, web application development, testing, deployment, and ongoing maintenance.

4. **Provide Specifications According to Which the Solution Is Defined, Managed, and Delivered:**

   a. ***Specifications:*** Detailed specifications include the technology stack (Python, Flask, Scikitlearn, etc.), data storage and user interface design.

   b. ***Project Management:*** Utilize project management methodologies, such as Agile or Scrum, and collaboration tools like Jira.

   c. ***Acceptance and Delivery Criteria:*** Clear criteria for acceptance, such as testing protocols, model accuracy benchmarks, and quality assurance standards.

Example - Solution Architecture Diagram:

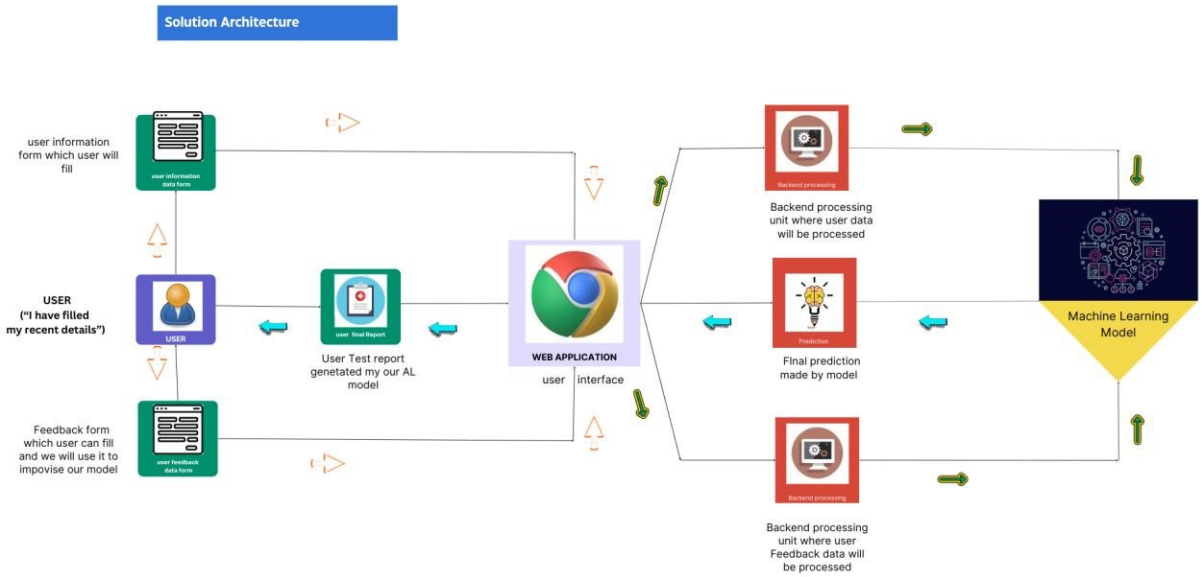
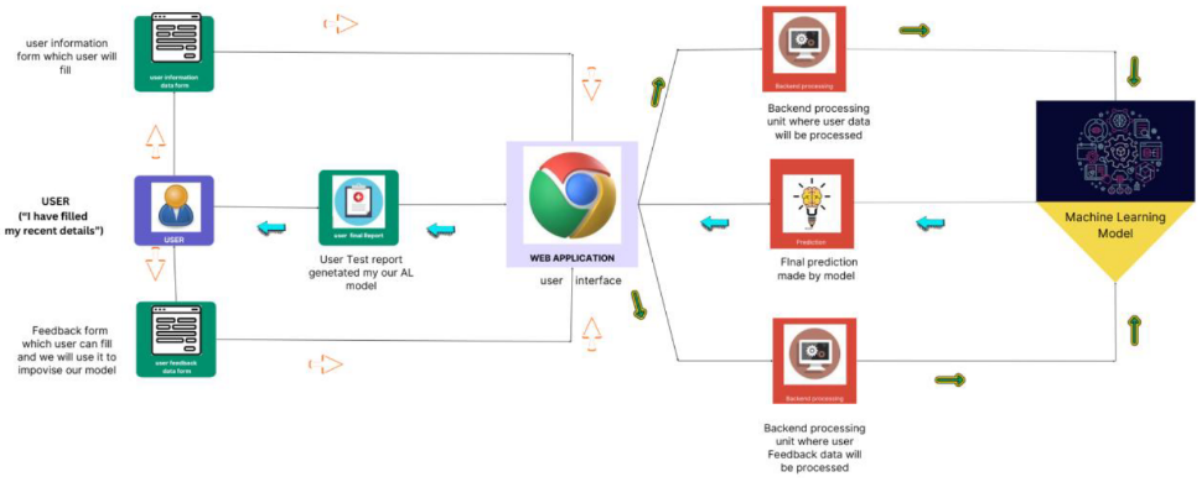


Figure : Architecture and data flow of the patient.

PROJECT PLANNING & SCHEDULING

6.1 Technical Architecture



6.2 Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	User Feature	USN-1	Multilingual Support	5	High	
Sprint-1		USN-2	Text to Speech	3	High	
Sprint-1		USN-3	Account lessAccess	5	High	
Sprint-2	Registration	USN-4	Gmail register	3	Medium	
Sprint-2	Login	USN-5	Log in	2	low	
Sprint-3	Registration	USN-6	Register for Website	3	low	
Sprint-3		USN-7	Confirmation e-mail	4	low	
Sprint-3		USN-8	Facebook login	3	low	

6.3 Sprint Delivery Schedule

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)

Sprint-1	13	6 Days	18 Oct 2023	24 Oct 2023	8	24 Oct 2023
Sprint-2	5	6 Days	25 Oct 2022	02 Nov 2023		
Sprint-3	10	6 Days	03 Nov 2022	9 Nov 2023		

Velocity:

Imagine we have a 10-daysprint duration, and the velocityof the team is 20 (points per sprint). Let's calculate the team's averagevelocity (AV) per iteration unit (story points per day)

$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

CODING & SOLUTIONING

7.1 Feature 1

Enhance user engagement by incorporating a real-time visualization of predictions. As users input their age and physical score, the application can dynamically display the predicted outcome, fostering a more interactive and informative experience.

This real-time visualization feature provides users with immediate feedback, creating a more engaging and transparent process. It not only serves as a visual aid for users to understand the model's predictions but also adds a layer of transparency to the machine learning process, instilling confidence in the accuracy of the results.

7.2 Feature 2

Implement an adaptive user feedback system that considers the predicted outcomes. If a user receives a prediction that suggests hearing concerns, prompt the user to provide feedback on their experience and whether they intend to seek professional medical advice. Tailor the feedback form dynamically based on the prediction outcome.

This feature adds a proactive dimension to the application, promoting user awareness and encouraging responsible health decisions. By collecting user feedback tied to predictions, the system can potentially gather valuable data on user perceptions, their willingness to seek medical advice, and overall user satisfaction. This information can be used to further refine and improve the application.

8. PERFORMANCE TESTING

8.1 Performace Metrics

1. **SVM, Logistic Regression and Naive Bayes**

```
Logistic Regression Metrics:
Accuracy: 0.897
Precision: 0.9077901430842608
Recall: 0.926948051948052
F1 Score: 0.9172690763052208
Mean Squared Error (MSE): 0.103
```

```
SVM Metrics:
Accuracy: 0.908
Precision: 0.906832298136646
Recall: 0.948051948051948
F1 Score: 0.926984126984127
Mean Squared Error (MSE): 0.092
```

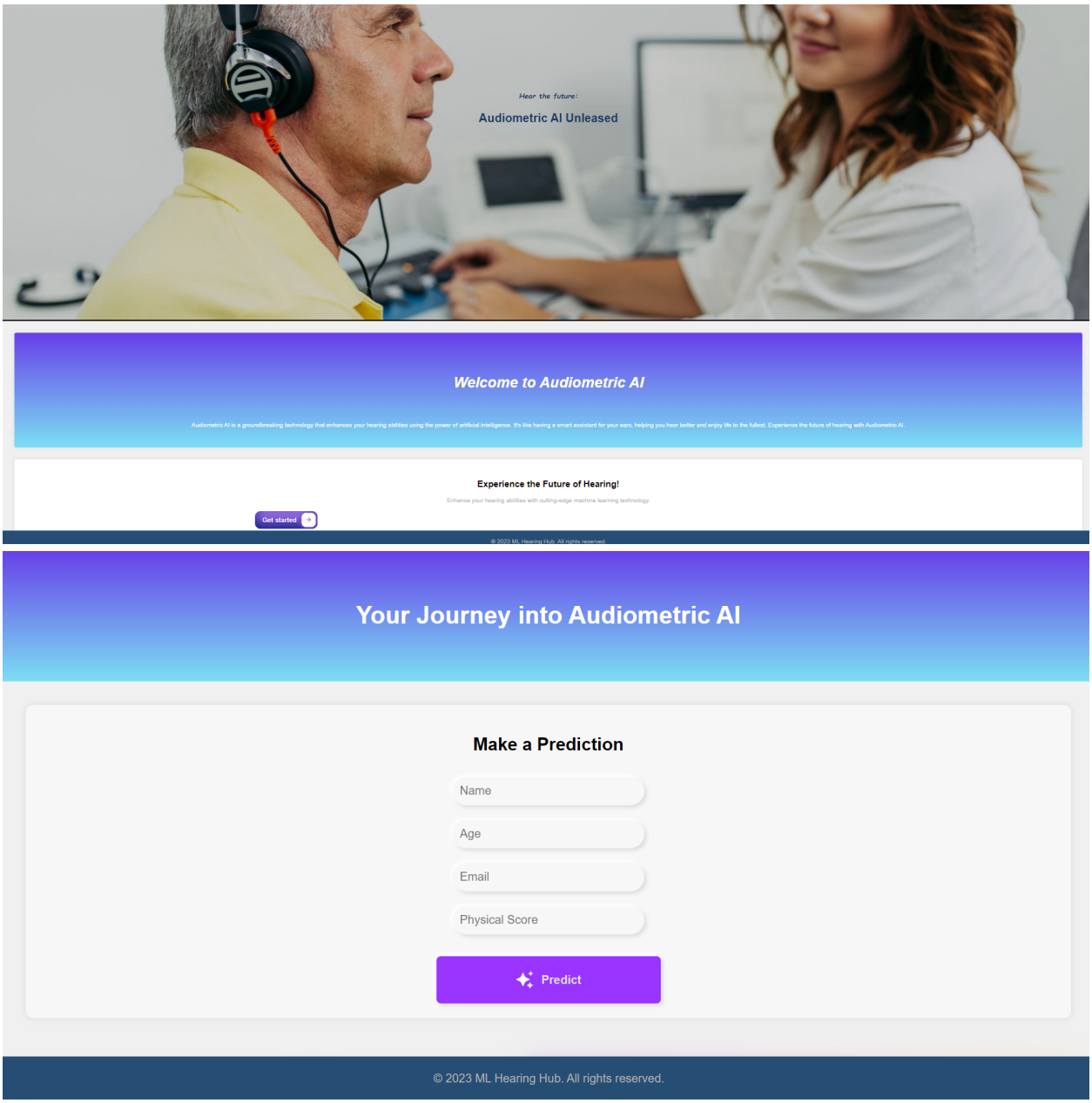
```
Naive Bayes Metrics:
Accuracy: 0.888
Precision: 0.9104234527687296
Recall: 0.9074675324675324
F1 Score: 0.9089430894308942
Mean Squared Error (MSE): 0.112
```

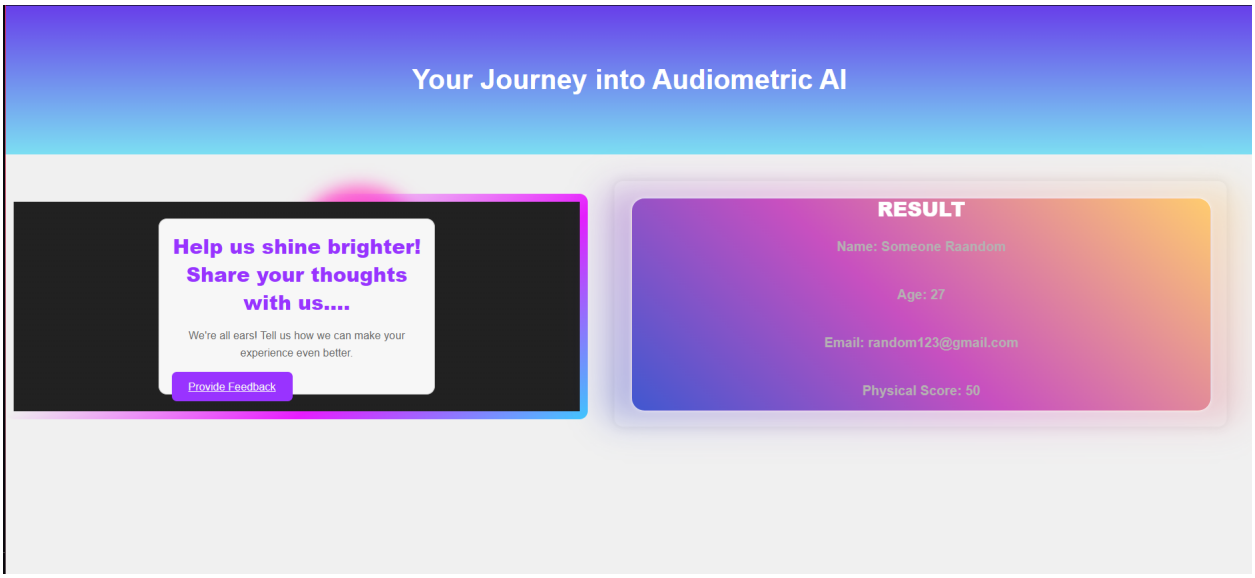
2. RNN Model

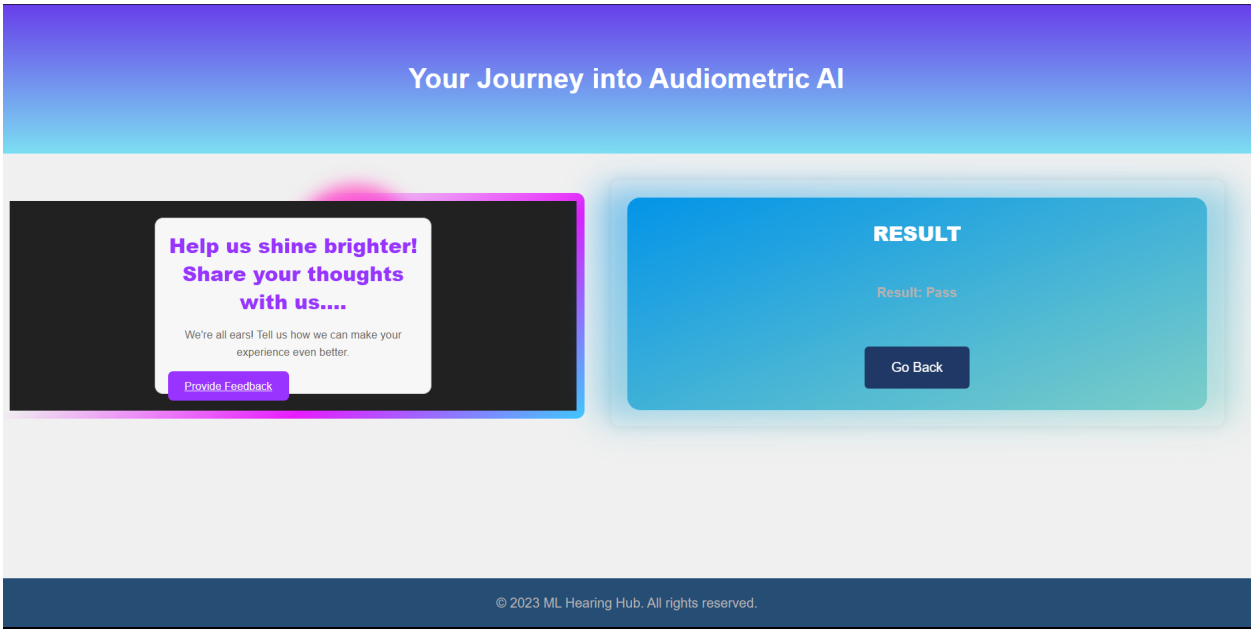
```
Epoch 19/50
125/125 [==============================] -
_accuracy: 0.9040
Epoch 20/50
125/125 [==============================] -
_accuracy: 0.9060
32/32 [==============================] - 0s
Validation Accuracy: 0.902999997138977

32/32 [==============================] - 0s 6ms/step
Confusion Matrix:
[[327  57]
 [ 40 576]]
```

9. RESULTS

9.1 Output Screenshots




Your Journey into Audiometric AI
Help us shine brighter! Share your thoughts with us....
We're all ears! Tell us how we can make your experience even better.
Provide Feedback
RESULT
Name: Someone Raandom
Age: 27
Email: random123@gmail.com
Physical Score: 50


Your Journey into Audiometric AI
Help us shine brighter! Share your thoughts with us....
We're all ears! Tell us how we can make your experience even better.
Provide Feedback
RESULT
Result: Pass
Go Back
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10. Advantages & Disadvantages

Advantages:

1. Cost-Efficiency: AudiometricAI eliminates the need for frequent doctor consultations, providing a cost-effective alternative for individuals concerned about their hearing health.
2. Time-Saving: Users can quickly predict their hearing test outcomes through theuser-friendly web interface, saving time compared to traditional diagnostic methods.
3. Accessibility: The web application enhances accessibility, allowing users to assess their hearing health from the comfort of their homes, promoting proactive healthcare.
4. Data-Driven Insights: The machine learning model provides data-driven insights, contributing to the early detection of potential hearing issues and informed decision-making.
5. User Engagement: Real-time prediction visualization and adaptive feedback systems enhance user engagement and promote a more interactive experience.

Disadvantages:

1. Limitations of Machine Learning Models: The accuracy of predictions relies on the quality and representativeness of the training data. The model may not capture all nuances of hearing health.
2. Dependency on User Input: The predictions heavily depend on accurate user input. Inaccuracies in age or physical score may impact the reliability of outcomes.
3. Lack of Personalized Medical Advice: While the application provides predictions, it does not replace professional medical advice. Users should be encouraged to consult healthcare professionals for comprehensive evaluations.
4. Potential Bias: If the training data is biased, the machine learning model may inherit and perpetuate those biases, impacting the fairness of predictions.
5. Security Concerns: Handling sensitive health data requires robust security measures to ensure confidentiality and compliance with privacy regulations.

11. Conclusion

In conclusion, AudiometricAI represents a significant stride towards redefining hearing health diagnostics. The integration of machine learning with a user-friendly web interface provides a convenient and accessible solution for individuals to monitor their hearing health. While the project brings notable advantages in terms of cost efficiency, time-saving, and user engagement, it is crucial to acknowledge the limitations and ensure users understand the supplementary nature of the predictions compared to professional medical advice.

12. Future Scope

The future scope of AudiometricAI extends beyond its current capabilities:

1. Integration of Additional Features: Explore the incorporation of additional patient characteristics or advanced machine learning techniques to enhance prediction accuracy.
2. Collaboration with Healthcare Providers: Establish partnerships with healthcare providers for a seamless transition from prediction to professional consultation, ensuring a holistic approach to hearing health.
3. Continuous Model Improvement: Regularly update the machine learning model with new data to improve accuracy and adapt to evolving healthcare trends.
4. Expansion to Mobile Platforms: Develop mobile applications to broaden the accessibility of AudiometricAI, reaching a larger and more diverse user base.
5. Research and Publications: Contribute to academic and healthcare research by sharing insights gained from user feedback and prediction outcomes, fostering collaboration and advancements in the field of digital healthcare.

13. APPENDIX

GitHub : https://github.com/smartinternz02/SI-GuidedProject-600495-1697527933

Project Demo :
https://drive.google.com/file/d/1fCpXo8Bq0jbwcJXjQ7aW79UcviT0G0U6/view?usp=sharing