Software Requirement Specification Document for Integrating Eye Pupil and ECG Analysis for the Detection of ADHD

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Table 1: Document version history

Version	Date	Reason for Change
1.0	2-Jan-2024	SRS First version's specifications are defined.
1.1	14-Jan-2024	All Diagrams Updated
1.2	8-Feb-2024	Update Overview and Class Diagram

GitHub: https://github.com/AbdullahRashad22/Eye-Pupil-and-ECG-Analysis-For-The-Detection-of-ADHD

Contents

Abstract

The proposed ADHD Detection System integrates eye pupil and electrocardiogram (ECG) analyses to enhance the accuracy of Attention-Deficit/Hyperactivity Disorder (ADHD) identification. Developed in response to the limitations of existing diagnostic methods, the system aims to provide a more objective and efficient approach to ADHD diagnosis. By leveraging a comprehensive dataset encompassing eye movement and ECG data, the system not only improves diagnostic precision but also contributes valuable insights into the cognitive and neural mechanisms associated with ADHD. The project's business context emphasizes the potential for this innovation to reshape healthcare outcomes, reduce misdiagnosis-related costs, and enable personalized treatment strategies. The combination of research and technology offers a holistic understanding of ADHD, presenting opportunities for targeted interventions and advancements in the field. The ADHD Detection System represents a paradigm shift in neurodevelopmental disorder diagnostics, aiming to positively impact individuals with ADHD by ensuring more accurate identification and tailored healthcare solutions.

1 Introduction

1.1 Purpose of this document

A System needs Specification (SRS) document is used to precisely specify a system's functional and non-functional needs. By outlining these requirements, the SRS document fosters a shared understanding of the goals and functions of the system. As a result, it is feasible to guarantee that all project participants comprehend its goals and can work together skillfully to produce high-caliber software that meets end-user requirements. For developers, designers, testers, and clients, the SRS document serves as an essential communication tool to establish a shared vision for the final product.

1.2 Scope of this document

This document contains comprehensive functional and non-functional requirements, Data design , class diagram , as well as the main system features. Also, this document discuss the Objectives, time plan and operational scenarios for our project.

1.3 Business Context

The "Business Context" within the introduction sets the stage for the ADHD Detection System by addressing its relevance in a broader business and healthcare perspective. In a rapidly advancing field, this system seeks to address the significant challenges associated with ADHD diagnosis. By integrating eye pupil and ECG analyses, it offers a promising solution to enhance the accuracy and efficiency of ADHD identification. In the business context, the availability of a comprehensive dataset contributes not only to improved diagnostic accuracy but also to advancements in understanding the cognitive processes associated with ADHD. This research and technology combination holds the potential to revolutionize healthcare outcomes, reduce misdiagnosis-associated costs, and ensure personalized and effective treatment for individuals with ADHD. The project's scope extends beyond traditional diagnostic methods, aligning with the evolving landscape of neurodevelopmental disorder research and intervention.

2 Similar Systems

2.1 Academic

- (De Silva et al..,2019) This paper addresses the effective identification of ADHD in early stages. We have used a rulebased approach to analyse the accuracies of decision tree classifiers in identifying ADHD subjects. The dataset consists of eye movements and eye positions of different gaze event types. The feature extraction process considers fixations, saccades, gaze positions, and pupil diameters. The decision tree-based algorithms have shown a maximum accuracy of 84 percent and classification rule algorithms have shown an accuracy of 82 percent using eye movement measurements. Thus, both algorithms have shown high accuracy with the rule-based component.[1]

- (Ayoubipour et al.., 2020) This study investigated the potential use of eye movements, analyzed through electrooculogram (EOG) signals, to examine differences in attention between individuals with Attention Deficit Hyperactivity Disorder (ADHD) and those without. The researchers utilized wavelet transform to decompose EOG signals from 30 healthy children and 30 children with ADHD while they performed an attention-related task. Key features, such as energy and standard deviation of wavelet coefficients, were computed and compared between the two groups using statistical tests. The results indicated significantly lower energy and standard deviation in the EOG signals' detail coefficients in children with ADHD ($p<0.001$), suggesting possible distinctions in high-frequency band activity between healthy and ADHD children. The study proposes practical applications for designing an EOG biofeedback protocol aimed at addressing or mitigating ADHD symptoms.[2]

- (Soysal et al,.2018)In a different study, researchers investigated the impact of background music in games on children with and without ADHD. They proposed an algorithm for measuring brain activity and developed the well-known serious game Tetris, featuring background music options of Beethoven, Mozart, or silence. EEG signals were recorded using a brain computer interface device to assess brain activity. The analysis of time- domain characteristics in the Alpha and Beta bands of EEG data revealed that different musical genres had varying effects on children's attention. Specifically, Mozart's music was linked to a decrease in Alpha-level brain activity coupled with an increase in Beta-level brain activity. In contrast, Beethoven's music resulted in heightened levels of both Alpha and Beta activities for children with ADHD.[3]

3 System Description

3.1 Problem Statement

Identifying Attention-Deficit/Hyperactivity Disorder (ADHD) accurately remains a significant challenge, often relying on subjective assessments prone to misdiagnosis. The existing diagnostic process, marked by its reliance on clinical interviews and behavioral observations, is time-consuming and may lead to inadequate treatment. This research addresses the pressing need for more effective interventions and a deeper comprehension of ADHD. By integrating eye pupil and ECG analyses, our project seeks to provide a solution that goes beyond subjective assessments, offering an objective, accurate, and personalized approach to ADHD identification. This innovative system represents a paradigm shift in ADHD diagnostics, aiming to improve precision, reduce the risk of misdiagnosis, and enhance healthcare outcomes for individuals grappling with ADHD.

3.2 System Overview

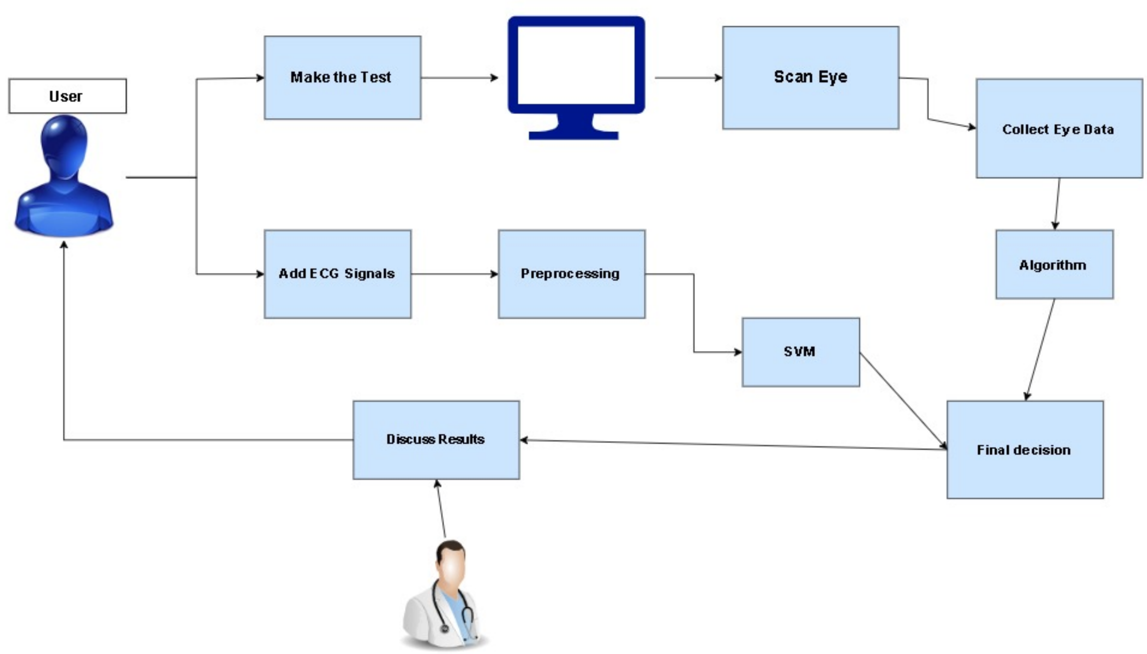

Figure 1: Overview Diagram

As shown in Figure 1 The user has to scan his eye pupil and give his ECG signals to be processed. The system will scan the eye movements and put it on machine learning algorithm and at the same time the system will analyze the ecg signals make some processing and classification and at the end the system will make the final result to know if the patient has ADHD or not.

3.3 System Scope

This project envisages the creation of an all-encompassing ADHD Detection System, integrating extensive datasets comprising eye pupil and ECG signals. The system's scope transcends traditional diagnostic approaches, offering a holistic solution that not only elevates the accuracy of ADHD identification but also provides invaluable insights into the cognitive and neural mechanisms associated with ADHD. Beyond aiding clinicians, this comprehensive tool serves as a pivotal resource for researchers, contributing to a deeper understanding of the disorder and fostering advancements in ADHD treatment methodologies.

3.4 System Context

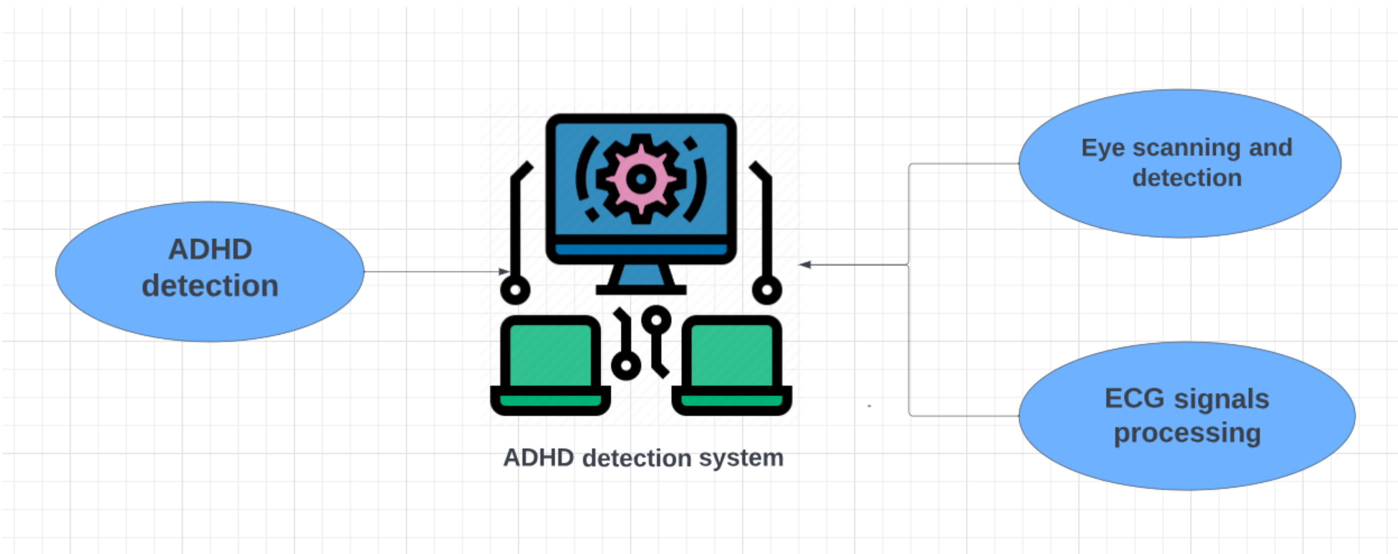

Figure 2: Context Diagram

3.5 Objectives

- Build a web application that detect ADHD.
- Applying a hybrid machine learning model for ADHD diagnosis using eye-tracking and ECG Signals .
- Achieving high classification accuracy and precision for the proposed model.

3.6 User Characteristics

- **Patients:** People that need know if they have ADHD or not.They should know how to use a website and communicate with the admins.
- **Healthcare Professionals:** Clinicians and mental health professionals who are seeking objective bio-markers for diagnosing ADHD and are interested in understanding the potential applications of mental health diagnosis.
- **Data Scientists and Machine Learning Practitioners:** Professionals with expertise in machine learning, particularly in the analysis of bio signals, who are interested in exploring the use of ECG data for classification tasks.
- **Students:** Those studying biomedical engineering, computer science, or related fields who are interested in understanding the application of machine learning in healthcare and its potential impact on mental health diagnosis.

These user groups may have varying levels of expertise in machine learning, biosignal analysis, and mental health diagnosis, and may approach the project with different objectives and perspectives.

4 Functional Requirements

4.1 System Functions

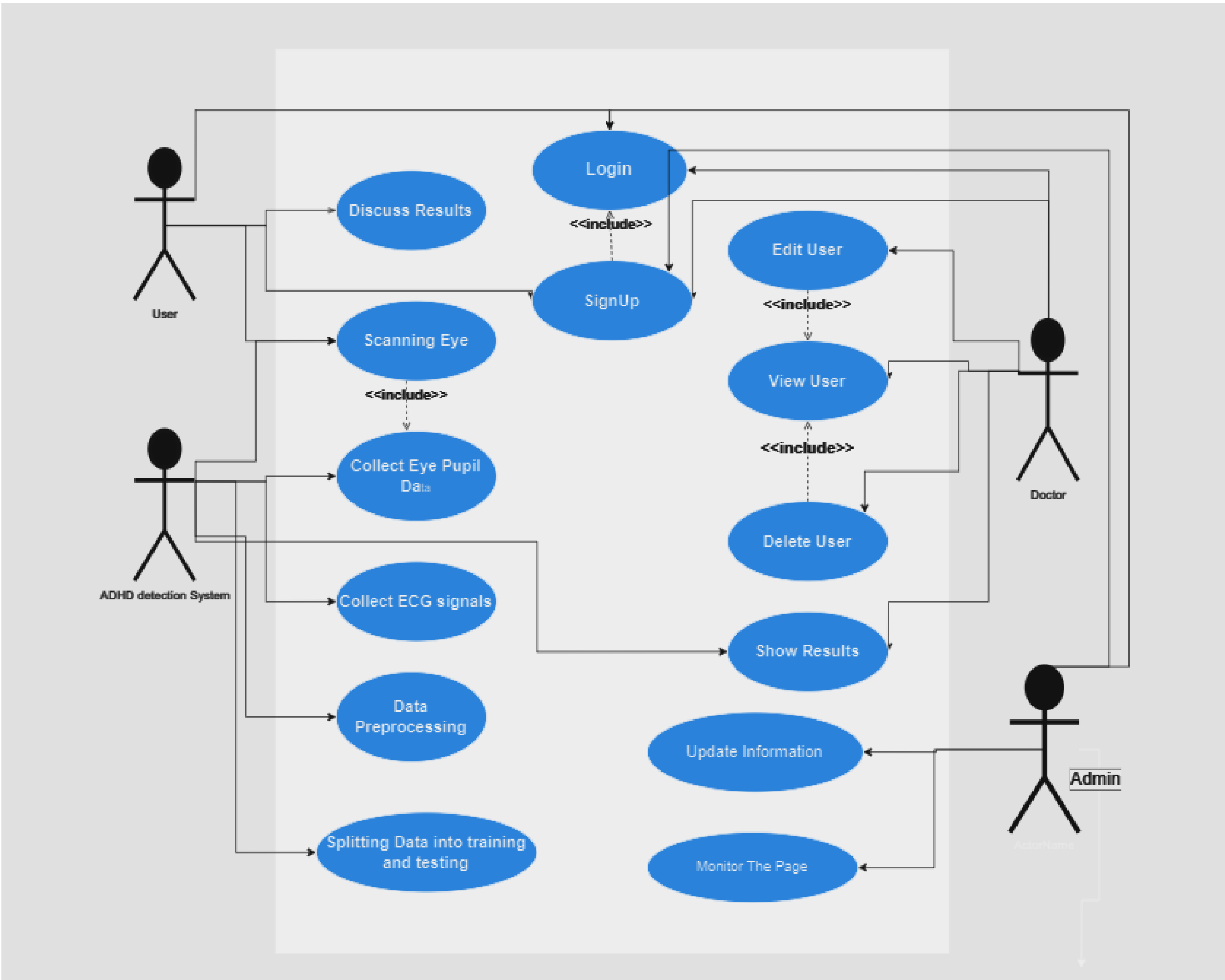

Figure 3 : Use Case Diagram

4.2 Detailed Functional Specification

1. **ID01** The user shall be able to login into their accounts.
2. **ID02** The user shall be able to sign up to create a new account.
3. **ID03** The user shall be able to discuss results with the doctor.
4. **ID04** The user shall be able to prioritize his criteria.
5. **ID05** The user shall be able to view their profile.

6. **ID06** The user shall be able to edit their profile.
7. **ID07** The user shall be able to logout from their account.
8. **ID08** The doctor shall be able to login into their accounts.
9. **ID09** The doctor shall be able to add, delete, edit, view users account.
10. **ID10** The doctor shall be able to search for all users.
11. **ID11** The doctor shall be able to logout from their account.
12. **ID12** The doctor shall be able to view results.
13. **ID13** The system shall be able to get ECG-Signals.
14. **ID14** The system shall be able to get Eye pupil data.
15. **ID15** The system shall be able to make processing.
16. **ID16** The system shall be able to scan eye.
17. **ID17** The admin shall be able to update user and doctors information.
18. **ID18** The admin shall be able to monitor the page.

5 Design Constraints

- The system as a web-based application should be connected to the internet.
- Data Availability: The project's success is contingent on the availability of high-quality ECG data and eye-tracking from individuals diagnosed with ADHD.

6 Non-functional Requirements

6.1 Security

Users passwords shall be encrypted by hashing functions to be securely saved in the database.

6.2 Scalability

The system should easily scale to accommodate any growth.

6.3 Availability

Access to the application should be available for users, and website functionality should remain unaffected during system maintenance.

6.4 Reliability

To make the web application reliable, the application should be accessible when needed and be modified and updated.

6.5 Usability

The system's usage and understanding will be straightforward, and its interface will be both adaptable and functional.

7 Data Design

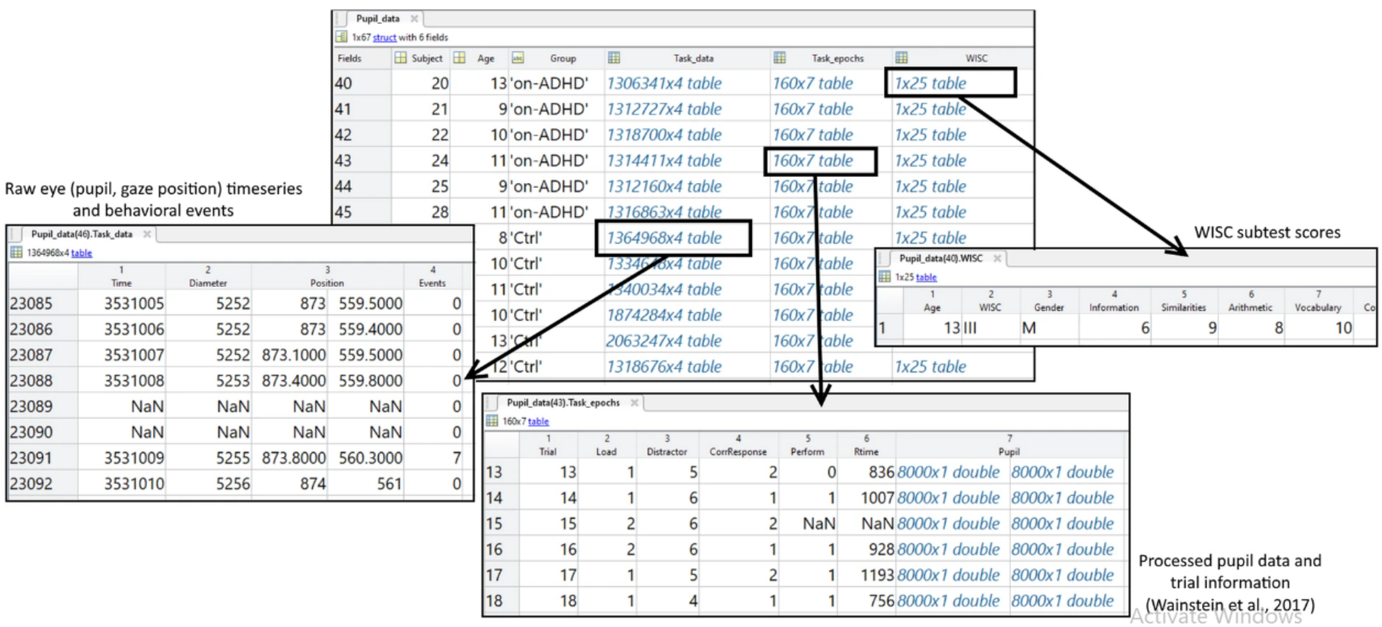

figure 4: Eye Pupil Dataset

The dataset includes data from a total of 50 children, with 28 ADHD-diagnosed patients and 22 non-ADHD-diagnosed children . A subset of 17 ADHD-diagnosed children performed the task twice, on and off medication, in two separate sessions .

The data are organized in a Matlab structure array called 'Pupil data'. The dataset contains information on pupil size, eye movements. The dataset also includes demographic information such as age and gender for both the ADHD and control groups .

A1 -0.11252183

	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL
281	-0.00965	0.044908	0.035506	0.061052	0.133116	0.108796	0.131447	0.21206	0.579818	0.960624	0.852501	0.889497	1.020146	1.180581	1.155526	1.251416	1.568995	2.190249	1.258576	1	
282	-0.18965	-0.16906	-0.17525	-0.0664	-0.04637	-0.07621	-0.0689	0.084489	0.327809	1.078185	1.475523	1.342718	1.23227	0.652312	0.0867	-0.23065	-0.01565	0.81531	-0.81202	1	
283	-0.24392	-0.20372	-0.14052	-0.20474	-0.18602	-0.01804	0.197014	0.95531	1.445284	1.094803	0.588008	-0.36014	-1.16132	-1.51867	-1.59257	-1.17978	-0.81843	-1.06512	-2.16047	1	
284	0.00186	0.002711	0.042579	-0.00913	0.040003	0.027733	0.109632	0.263813	0.62298	1.471131	1.7578	1.886385	2.270342	2.514729	2.018043	1.0893	0.706498	0.530949	-1.09348	1	
285	-0.27157	-0.24381	-0.19798	-0.28226	-0.28886	-0.29072	-0.28944	-0.2776	-0.2797	-0.18717	-0.20031	0.294749	0.84613	0.818114	1.190434	1.146895	0.960141	0.164364	0.330442	1	
286	0.010166	0.040926	-0.00144	0.066738	0.102099	0.090891	0.175282	0.315058	0.827959	1.59848	1.649533	1.492432	1.591485	1.41096	0.788903	0.378514	0.67799	1.278876	0.056673	1	
287	-0.15301	-0.18371	-0.22037	-0.18497	-0.24325	-0.1608	-0.05941	0.204666	0.7992	0.850396	0.800871	1.086116	1.090475	0.898527	0.860276	1.536581	1.852605	0.618098	-2.10553	1	
288	-0.30478	-0.22308	-0.24686	-0.32957	-0.22015	-0.1935	-0.18474	-0.12943	-0.08525	-0.11219	0.210645	0.751278	0.87225	1.536242	2.03253	2.320064	1.469294	0.821087	1.658203	1	
289	0.120212	0.058149	0.090873	0.092659	0.106724	0.089518	0.22188	0.477458	0.987681	1.336466	1.266816	1.443469	1.673813	1.550276	1.137756	0.863612	0.702984	0.890389	-0.18288	1	
290	-0.07716	-0.00409	0.088258	0.152176	0.20946	0.792269	1.188945	1.127097	0.592547	-0.20426	-1.09747	-1.5498	-1.58164	-1.19575	-0.8044	-0.61791	-1.31842	-2.13582	-2.89503	1	
291	-0.6029	-0.71037	-0.56951	-0.58682	-0.59087	-0.54401	-0.5996	-0.55272	-0.59771	-0.45502	-0.18724	0.392061	0.450228	1.006196	1.092245	1.303057	1.150097	0.790442	1.330896	1	
292	-0.26342	-0.4348	-0.42917	-0.37195	-0.3703	-0.36049	-0.31701	-0.31177	-0.39615	-0.35017	-0.18868	0.443063	0.924243	1.070206	1.759431	2.198114	2.102171	1.22812	0.733822	1	
293	0.566138	0.479913	0.291077	0.102511	0.018347	0.043036	0.038288	-0.16803	-0.44347	-0.90642	-1.62138	-2.32909	-3.04989	-3.62041	-4.21048	-4.04379	-3.05181	-2.80687	-0.87967	0	
294	0.019924	-0.2356	-0.39503	-0.42307	-0.52649	-0.74221	-1.00107	-1.3114	-1.70893	-2.15597	-2.64051	-3.21838	-3.65163	-3.8812	-3.92467	-3.16439	-2.22837	-1.83754	-0.37849	0	
295	0.499482	0.467861	0.376165	0.314001	0.265209	0.344465	0.584163	0.67477	0.476778	-0.16244	-0.93503	-1.65434	-2.43424	-3.47217	-4.28078	-4.62944	-3.79419	-2.85147	-1.74352	0	
296	0.127531	-0.01867	-0.23865	-0.3707	-0.5929	-0.63412	-0.44083	-0.51807	-0.70244	-0.89975	-1.44152	-1.86161	-2.32138	-2.88488	-3.53025	-4.41251	-3.90333	-3.56711	-1.53634	0	
297	0.3491	0.314709	0.232524	0.133485	-0.03023	-0.17074	-0.33206	-0.65026	-0.74444	-0.69528	-0.97922	-1.35397	-1.95205	-2.64039	-3.00028	-3.81249	-3.97336	-5.22195	-3.66179	0	
298	2.317922	2.495958	2.698535	2.94185	3.01225	2.817312	2.528001	2.319476	1.835616	1.089499	0.577825	0.211513	-0.04953	-0.29566	-0.94137	-1.71855	-2.30043	-2.67855	-2.85653	0	
299	0.629711	0.46404	0.385693	0.278781	0.235784	0.356212	0.573839	0.696533	0.475781	-0.05426	-0.6656	-1.3203	-2.0226	-2.72359	-3.42055	-3.7437	-2.95871	-2.305	-0.81526	0	
300	0.665594	0.53798	0.397585	0.245099	0.060807	-0.05388	-0.06894	0.06984	-0.11307	-0.35785	-0.77228	-1.29817	-1.83412	-2.60562	-3.14127	-3.71778	-3.22532	-2.46959	-0.90061	0	
301	0.26749	0.185967	0.002122	-0.26008	-0.43404	-0.67859	-0.97656	-1.06121	-1.27026	-1.56423	-1.91148	-2.36081	-2.84795	-3.35462	-3.71375	-4.33563	-3.96534	-3.81935	-2.09426	0	
302	0.367505	0.317156	0.371101	0.354012	0.147805	0.051644	-0.21339	-0.26054	-0.1234	-0.10698	-0.18857	-0.67408	-1.28602	-1.9021	-2.75385	-3.87444	-4.29676	-3.52426	-2.43717	0	
303	0.912421	0.732294	0.475706	0.439577	0.463022	0.37372	0.175971	-0.16347	-0.72285	-1.30379	-1.91666	-2.58235	-3.14604	-3.16878	-2.41859	-1.36305	-0.40504	0.000888	0.175958	0	

ecg (1)

Figure 5: ECG Dataset

The dataset used in this project consists of ECG data collected from patients at the Child Guidance Clinic in Singapore. The ECG data were collected using a standard 12-lead ECG system and were sampled at 500 Hz. The data were preprocessed by segmenting them into 2-second epochs, and each epoch was labeled according to the patient's diagnosis (ADHD,or not).

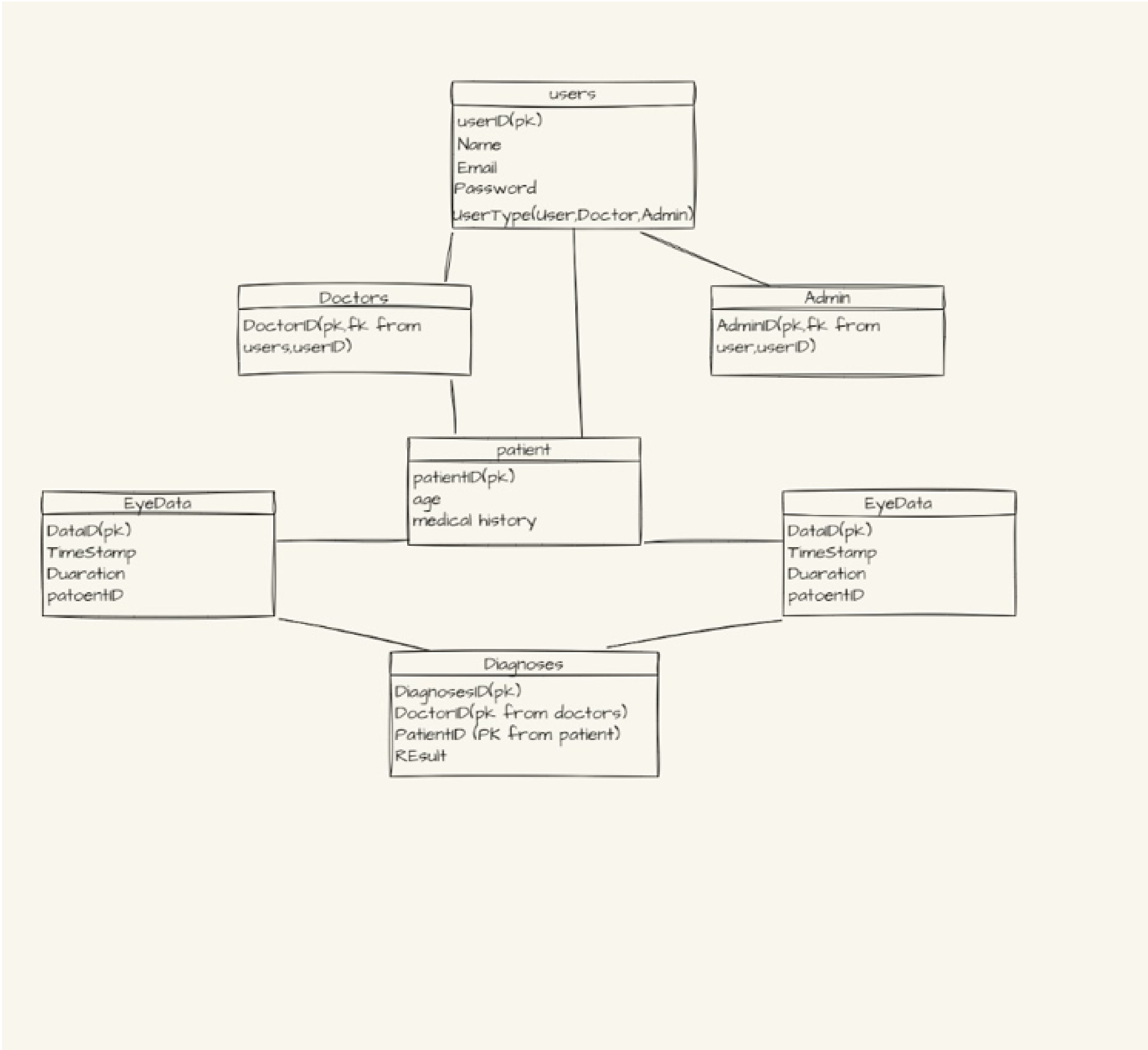

Figure 6: Database schema

8 Preliminary Object-Oriented Domain Analysis

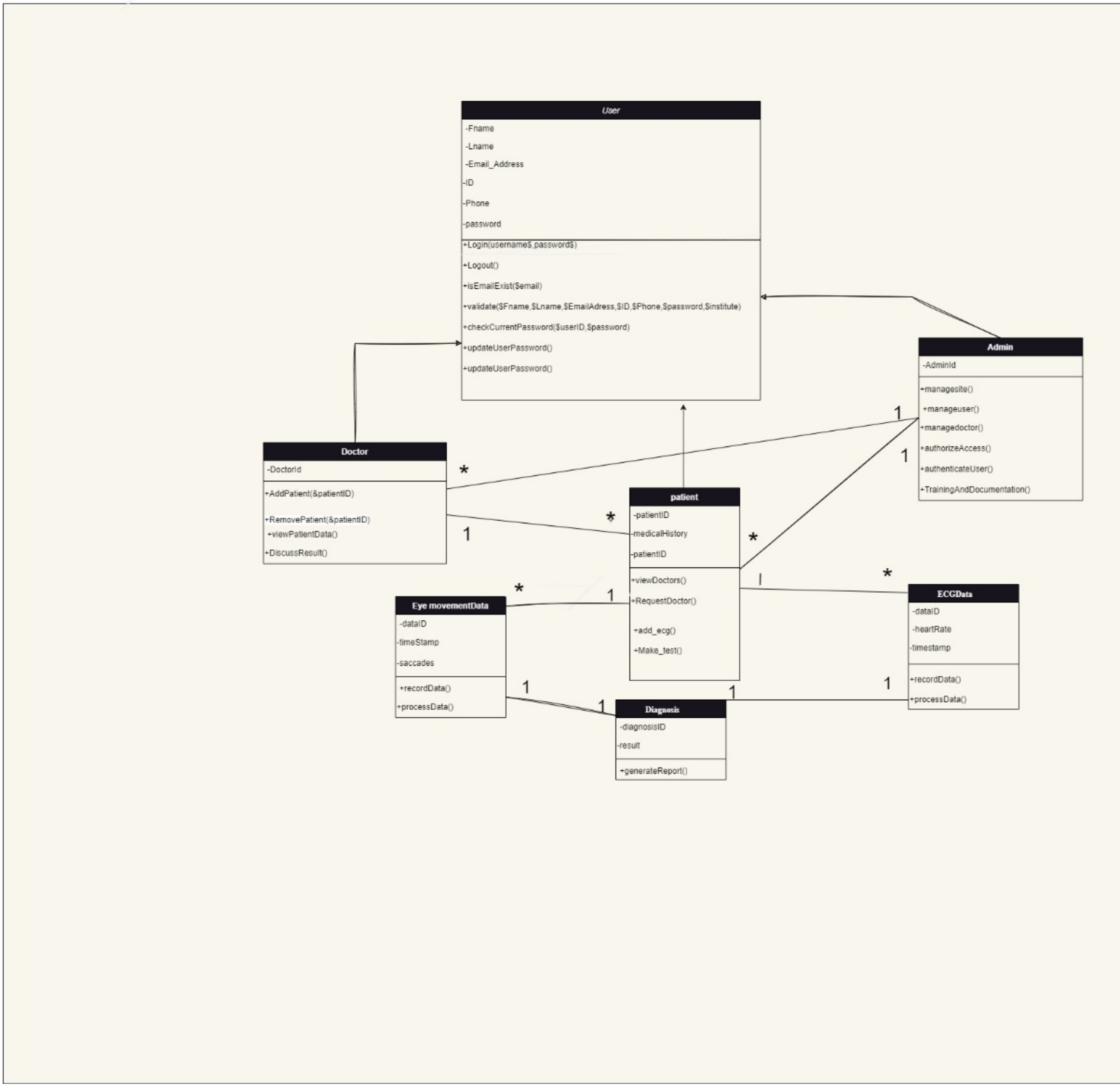

Figure 7: System Class Diagram

9 Operational Scenarios

1- User Registration and Login:

Scenario: A user, typically a clinician or healthcare professional, registers on the ADHD detection website. Operation: The user provides necessary information for registration. The website verifies and authenticates the user through a secure login process.

2-Patient Enrollment:

Scenario: The clinician enrolls a patient for ADHD assessment.
Operation: The clinician adds patient details and assigns tasks for eye tracking.

3- Data Capture:

Scenario: The patient undergoes the ADHD assessment by performing tasks involving eye tracking recording.
Operation: The website guides the patient through the tasks. Eye tracking data is captured and securely transmitted to the back end.

4- Data Prepossessing:

Scenario: Data from eye tracking and ECG signals are processed for analysis.
Operation: The system prepossesses data to remove noise and irrelevant information. Cleaned data is prepared for further analysis.

5-Data Analysis:

Scenario: The system analyzes eye tracking and ECG data to identify patterns associated with ADHD.
Operation: Feature extraction algorithms process eye tracking and ECG data. Analysis results are generated, highlighting potential ADHD indicators.

7- Report Generation:

Scenario: The clinician reviews the generated report.
Operation: The website compiles analysis results into a detailed report. The report includes insights, potential diagnoses, and recommendations.

8- Patient Feedback and Discussion:

Scenario: The clinician discusses the results with the patient.
Operation: The clinician accesses a user-friendly interface to discuss findings with the patient. The system may provide visualizations and explanations to enhance understanding.

10 Project Plan

Task	Assigned to	Progress	Start	End
Phase 2	**Software Requirement Specification Document**			
Abstract	Abdullah Eid	100%	4/1/2024	6/1/2024
Introduction	John Nader	100%	4/1/2024	6/1/2024
Similar Systems	Ahmed Waleed	100%	5/1/2024	6/1/2024
System Description	Ebram Joseph	100%	5/1/2024	8/1/2024
Functional Requirements	Ahmed Waleed	100%	6/1/2024	8/1/2024
Design Constraints	Ebram Joseph	100%	8/1/2024	10/1/2024
Non-functional Requirements	Ahmed Waleed	100%	9/1/2024	10/1/2024
Data Design	Abdullah Eid	100%	7/1/2024	9/1/2024
Preliminary Object-Oriented Domain Analysis	Ebraam Joseph	100%	8/1/2024	12/1/2024
Operational Scenarios	John Nader	100%	7/1/2024	10/1/2024
Project Plan	Abdullah Eid	100%	12/1/2024	13/1/2024
Appendices	John Nader	100%	11/1/2024	12/1/2024

Figure 8: SRS Time plan

11 Appendices

11.1 Supportive Documents

References

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