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SOFTWARE DESIGN DESCRIPTION

for

Atom – Brain-Computer Interfacing using Electroencephalography

Version 2.0

By

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Revision History

Name	Date	Reason for changes	Version
Dr. Yasir Faheem (Supervisor)	4th December, 2019	- Inclusion of comments from previous evaluation - Image labelling according to type of Model/Diagram/Figure - Description of text covered under any particular heading - Add conclusion to the document	1.0
FYP – I Committee	14th December, 2019	-	

Application Evaluation History

Comments (by committee) ***include the ones given at scope time both in doc and presentation**	**Action Taken**
- Related system Analysis spacing	Added some space above the table
- Following modules lack specificity: - Account Handling module - Specialized Control Training module - EEG Feature Extraction module - Database handling module	Added more specifics on each and every one of the modules
- Use case diagrams not according to convention	Followed Sommerville convention for the use case diagrams by keeping action lines outside the boundaries and limiting complex models
- Missing captions from use case tables	Added captions to use case tables
- Incomplete functional requirements	Added more definition to the requirements
- Blank page in the document	Blank pages removed
- Fixes for activity diagrams: Account Handling activity diagram branch usage instead of fork/merge User Analytics and Statistics activity diagram redundant processes Boundary inclusion in Use case models Sequence diagrams positioning and rotational fixes	Activity diagrams fixed
- Revise Class Diagrams for new updated implementation	Revisions made

Supervised by

Dr. Yasir Faheem

Signature_____

1. Introduction

Our project deals with the domain of Brain-Computer interface and Cognitive Electrophysiology. As the name suggests it uses brain to give input and reads its input by tapping into the electric mode pf communication that our neuron use to communicate all the thoughts and functionalities, we are able to perform. The field is growing, and the possibilities are endless. The fundamental idea is to use this EEG incorporated BCI to target issues relating to human activities, specifically enhancing the attention span to improve focus in daily activities such as reading and others with similar brain involvement. The methodology we've chosen to achieve said claim can be divided into two streams; entertainment incentivized training and specialized controlled training, achieved by mini-games and a book reader respectively, where-in both these utilities are taken use of by the BCI to be built

This document will specify the hardware and the software aspects while also discussing the compatibility of different platforms and the integration of different modules that come together to make the whole project.

2. Design Methodology and Software Process Model

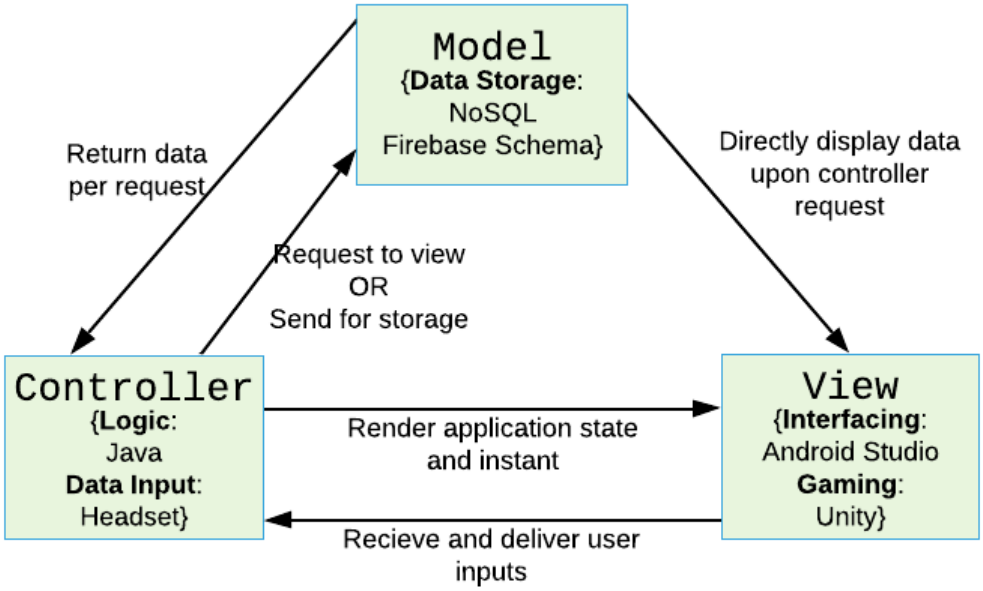
Since this project belongs to the same framework of research to the branches of Human-Computer Interaction like Social Networking, Augmented Reality, etc., our design methodology is primarily based around the focus of keeping the entire design user-experience-centric. It should pertain to accessibility, easy intractability, and minimalistic user interface provision. Regarding the process model, the software we are supposed to build is in close interaction with uncommon hardware and a rarely used peripheral device i.e. the brain, we are working in an Agile Development process model where our focus is on immediate prototype deployment and simultaneous self-induced testing and criticism.

System Overview

Since the primary choice to deploy Atom is to release an application or software on a platform which a mass majority of users are comfortable and familiar with, we've streamlined production on smartphone and due to technical barriers, the pre-dominant choice is Android. According to convention, Android targeted software are inherently followers of the Model-View-Controller paradigm, and in addition to that, the below diagram begins to concretize by providing further insight into each block. An implied improvisation on this architecture is the inclusion of the headset with the controller and not allocating another block for the peripheral to prevent breaking standard convention, although an accurate visualization might consider this as a separate block.

2.1 Architectural Design

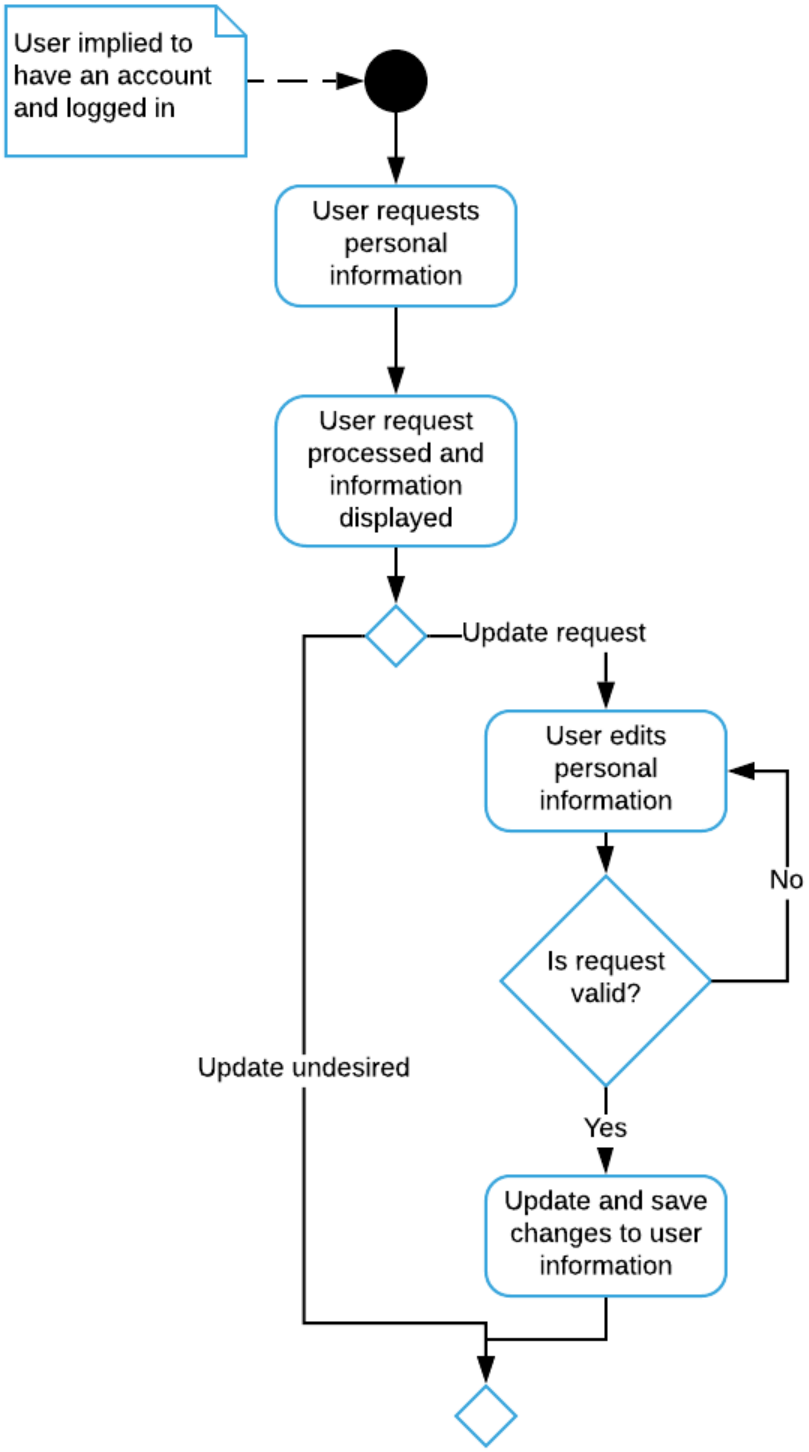
The following presents the block diagram of Atom:



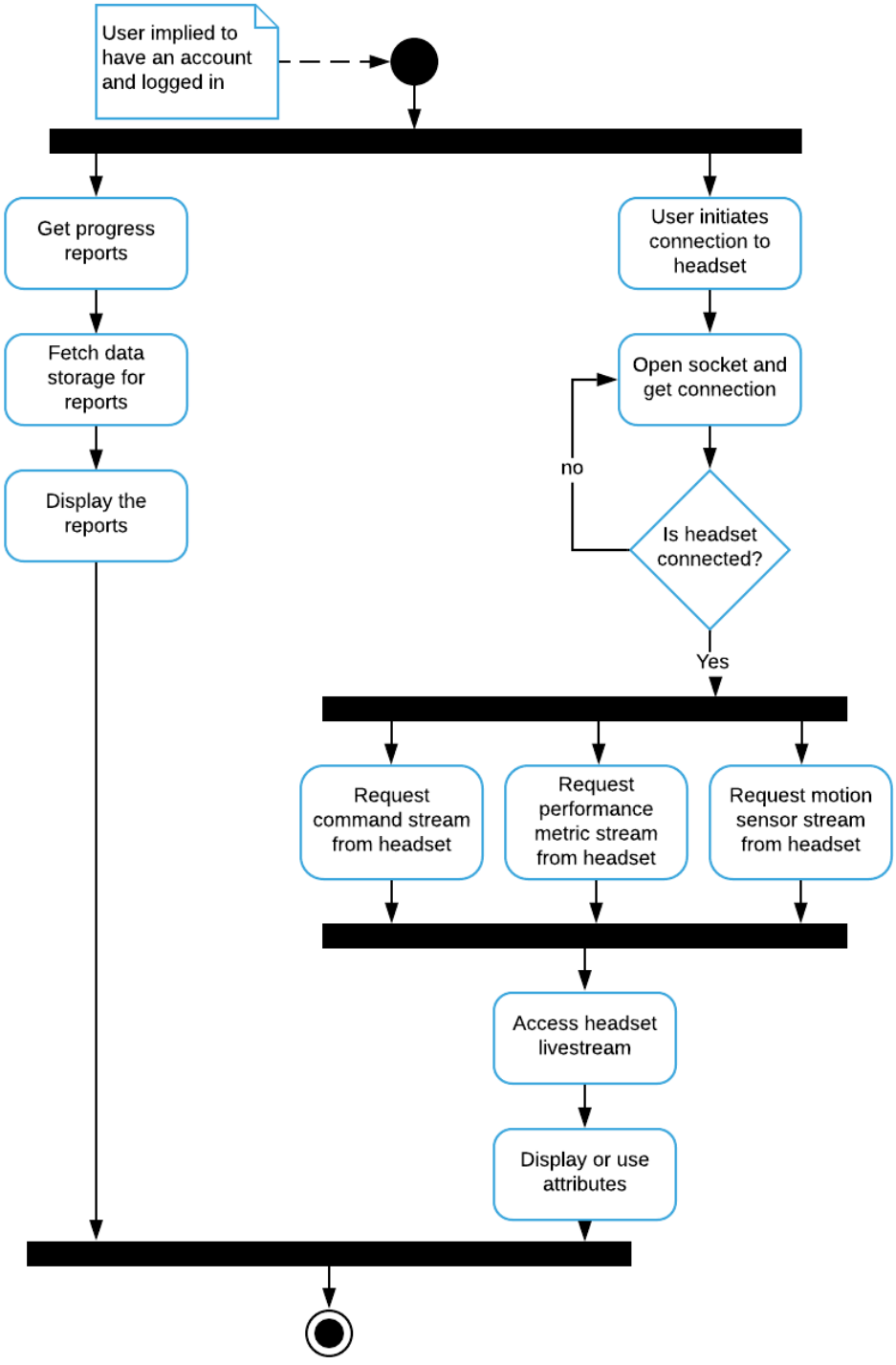
Architectural Model 1 Atom in MVC

2.2 Process Flow/Representation

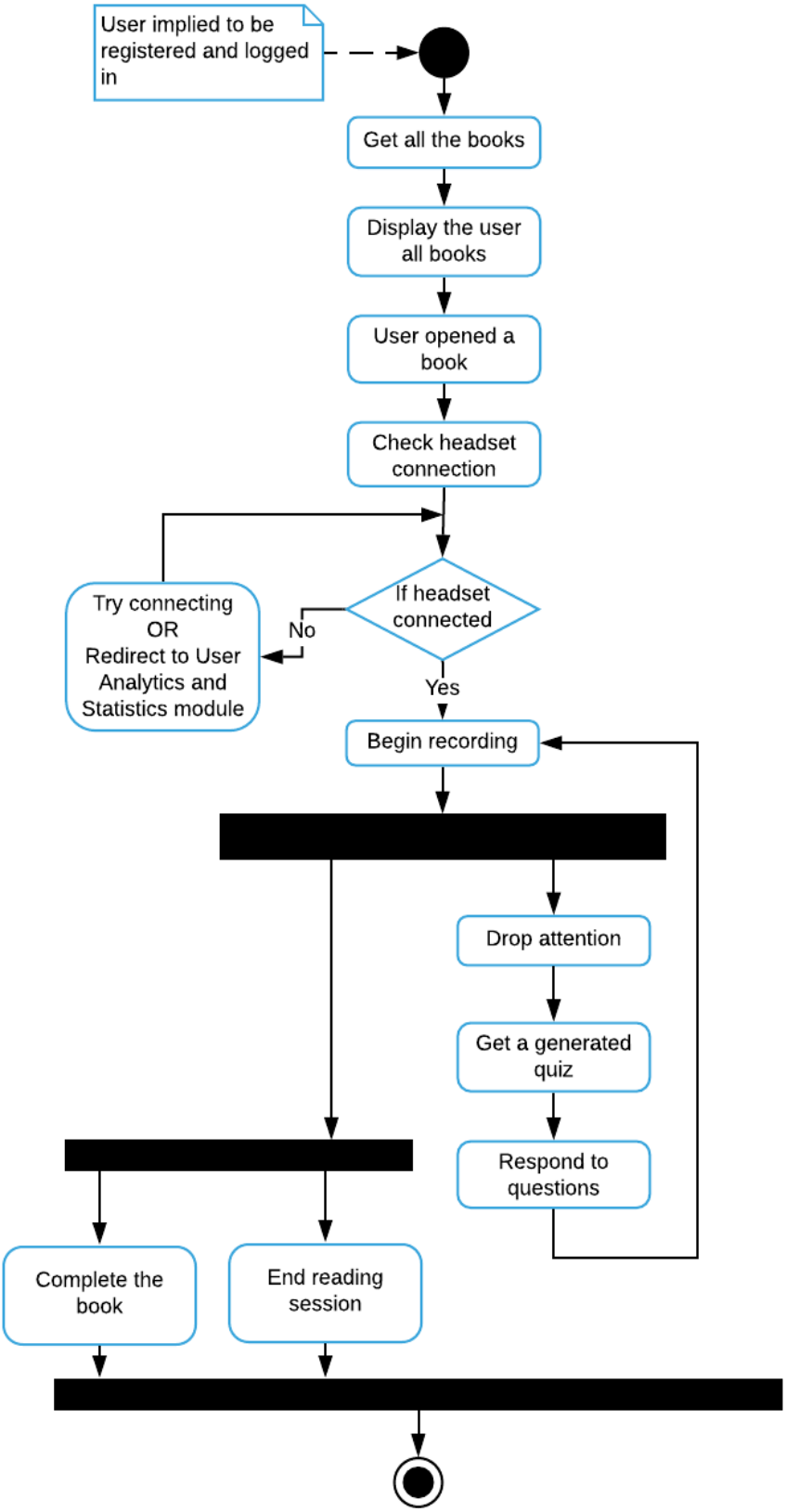
The following section will provide Activity Diagrams for specific actions that the user can conduct based on the specific modules:



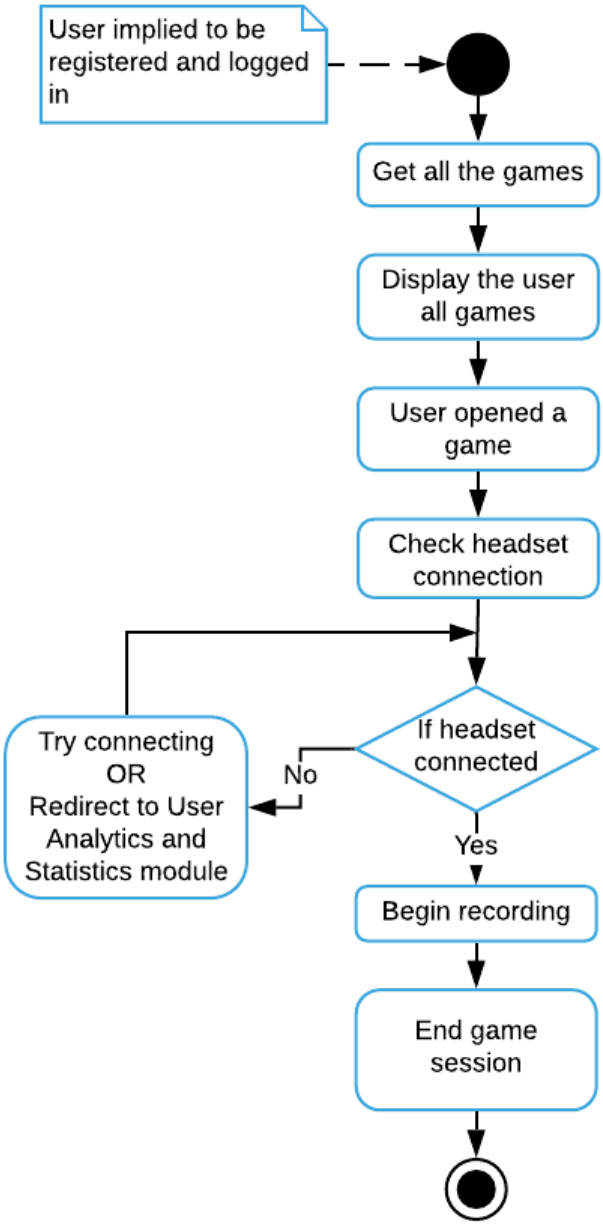
Activity Diagram 1 Account Handling Module



Activity Diagram 2 User Analytics and Statistics



Activity Diagram 3 Specialized Control Training



Activity Diagram 4 Entertainment Incentivized Training

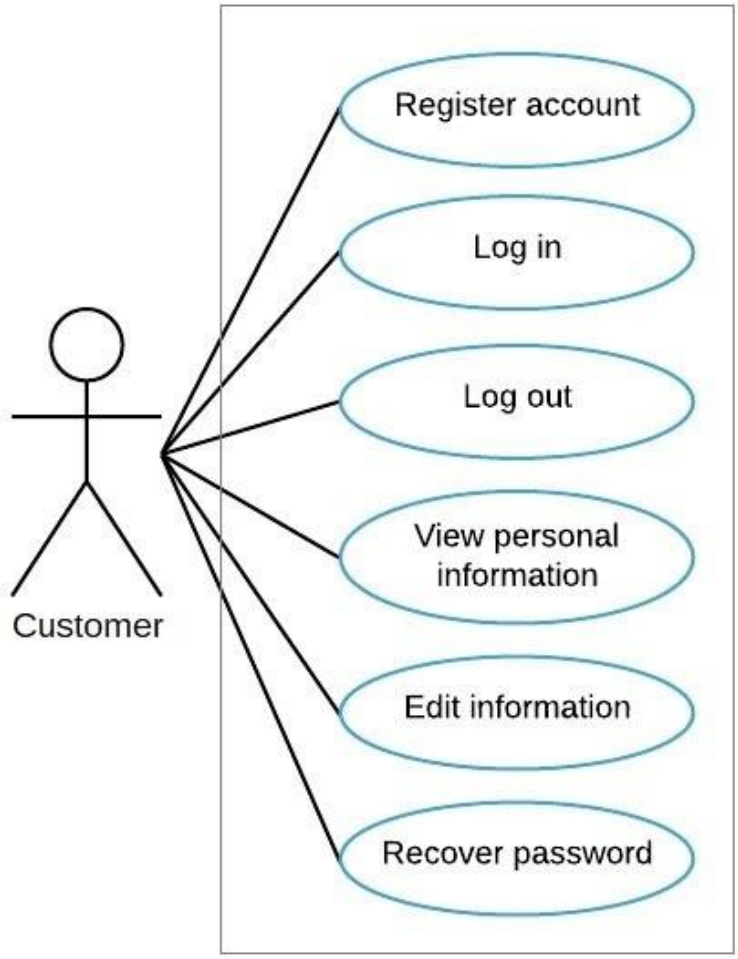
3. Design Models

In consideration of the previous models and to further clear away the design abstraction, the following section presents:

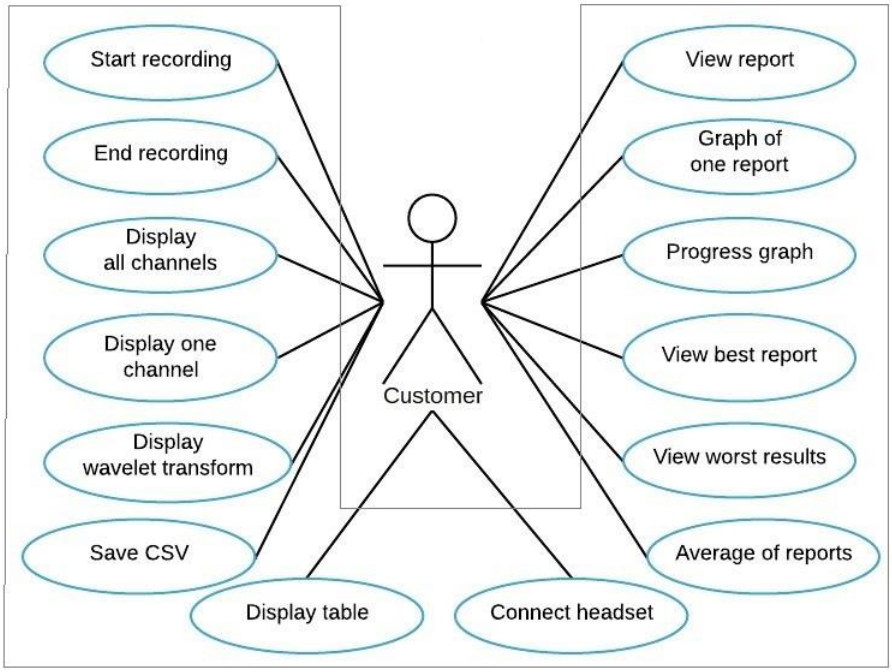
- Use case Models
- Sequence Diagrams
- Class Diagram

3.1 Use Case Models

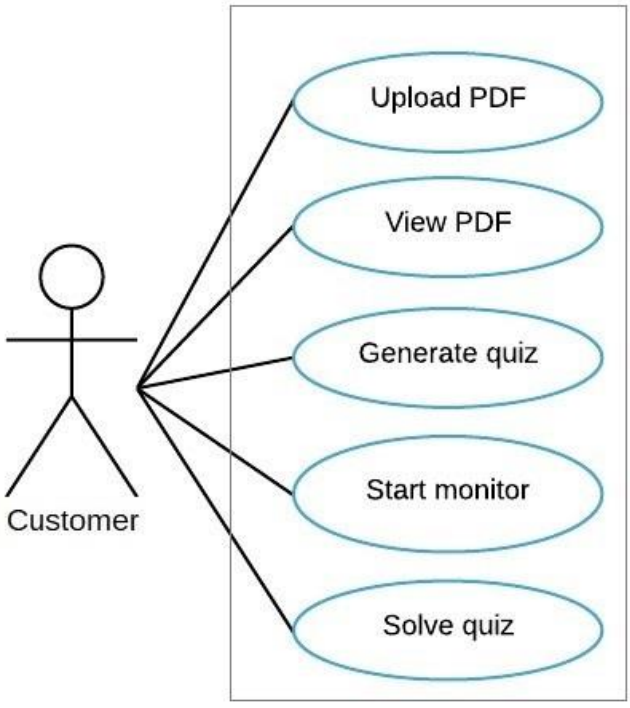
The use case models of Atom:



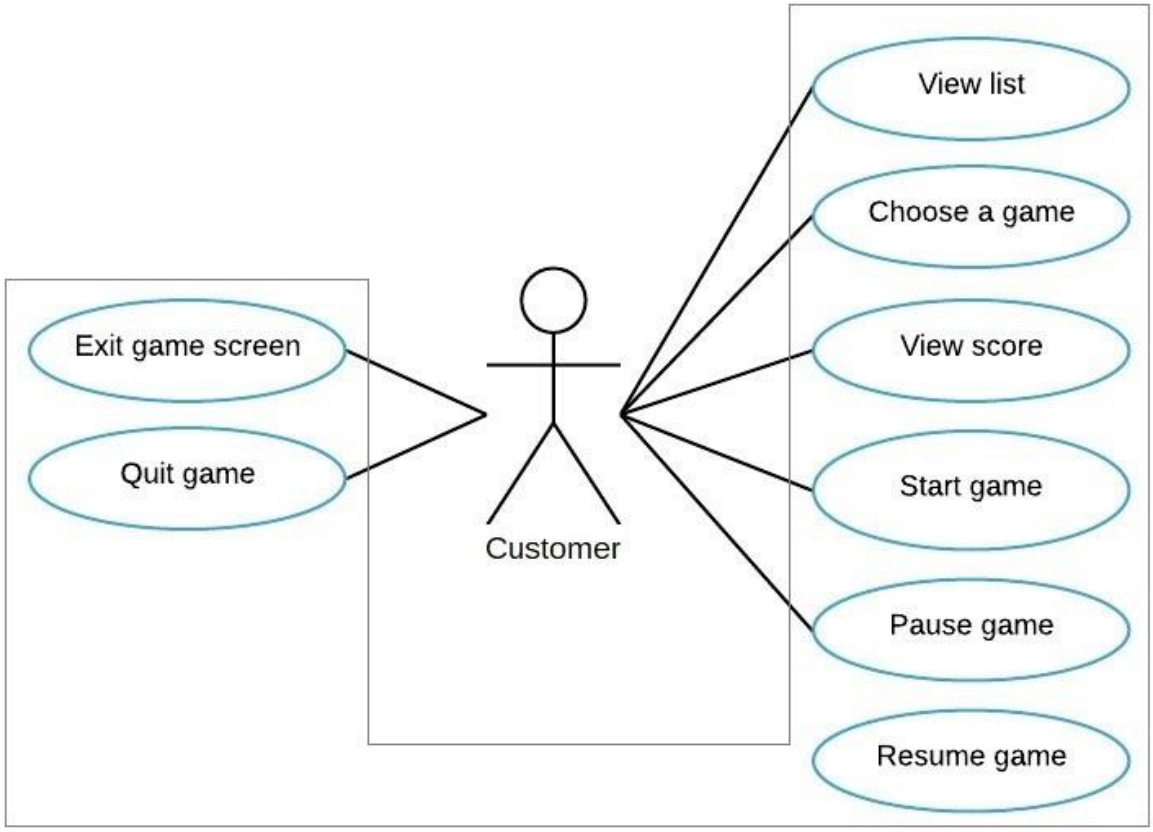
Use case Model 1 Account Handling module



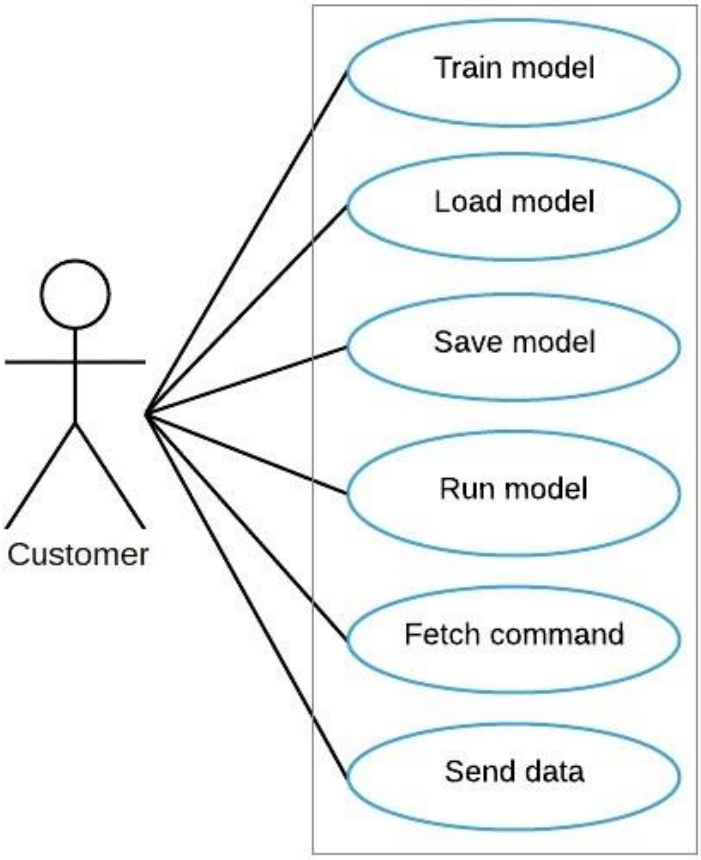
Use case Model 2 User Analytics and Statistics module



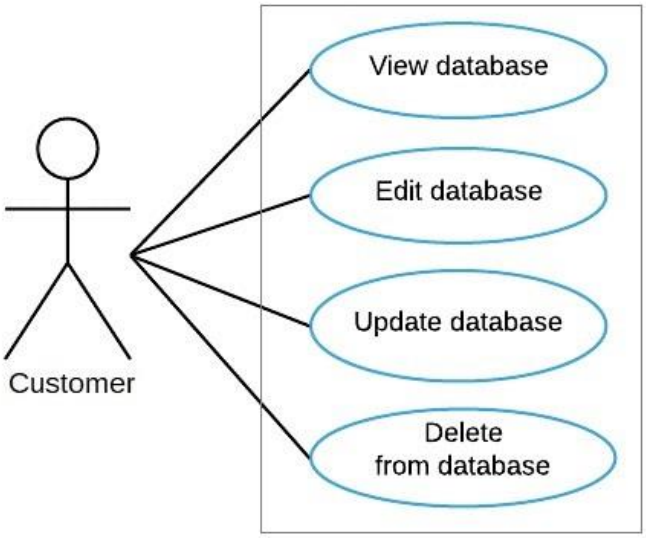
Use case Model 3 Specialized Control Training module



Use case Model 4 Entertainment Incentivized Training module



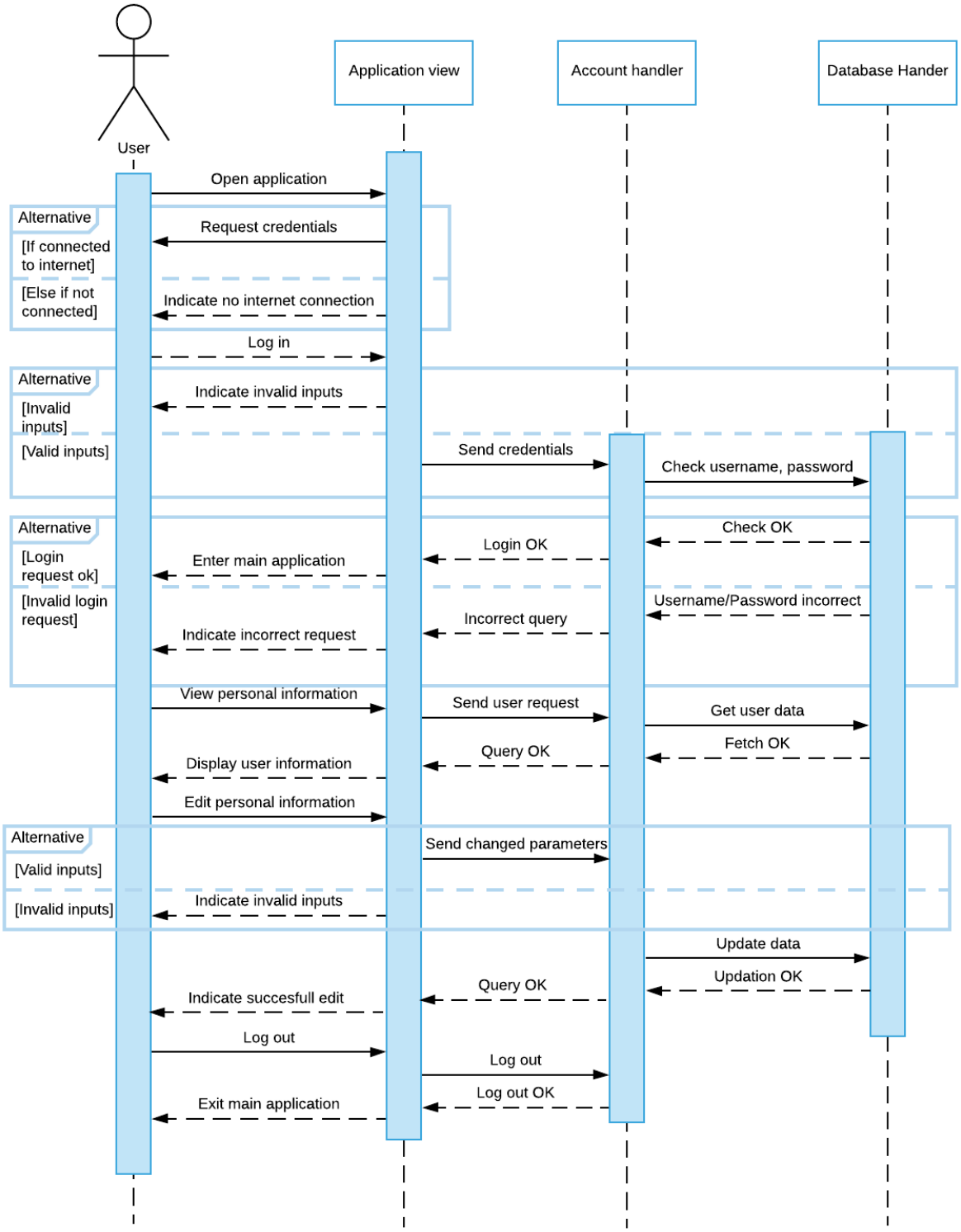
Use case Model 5 EEG Feature Extraction module



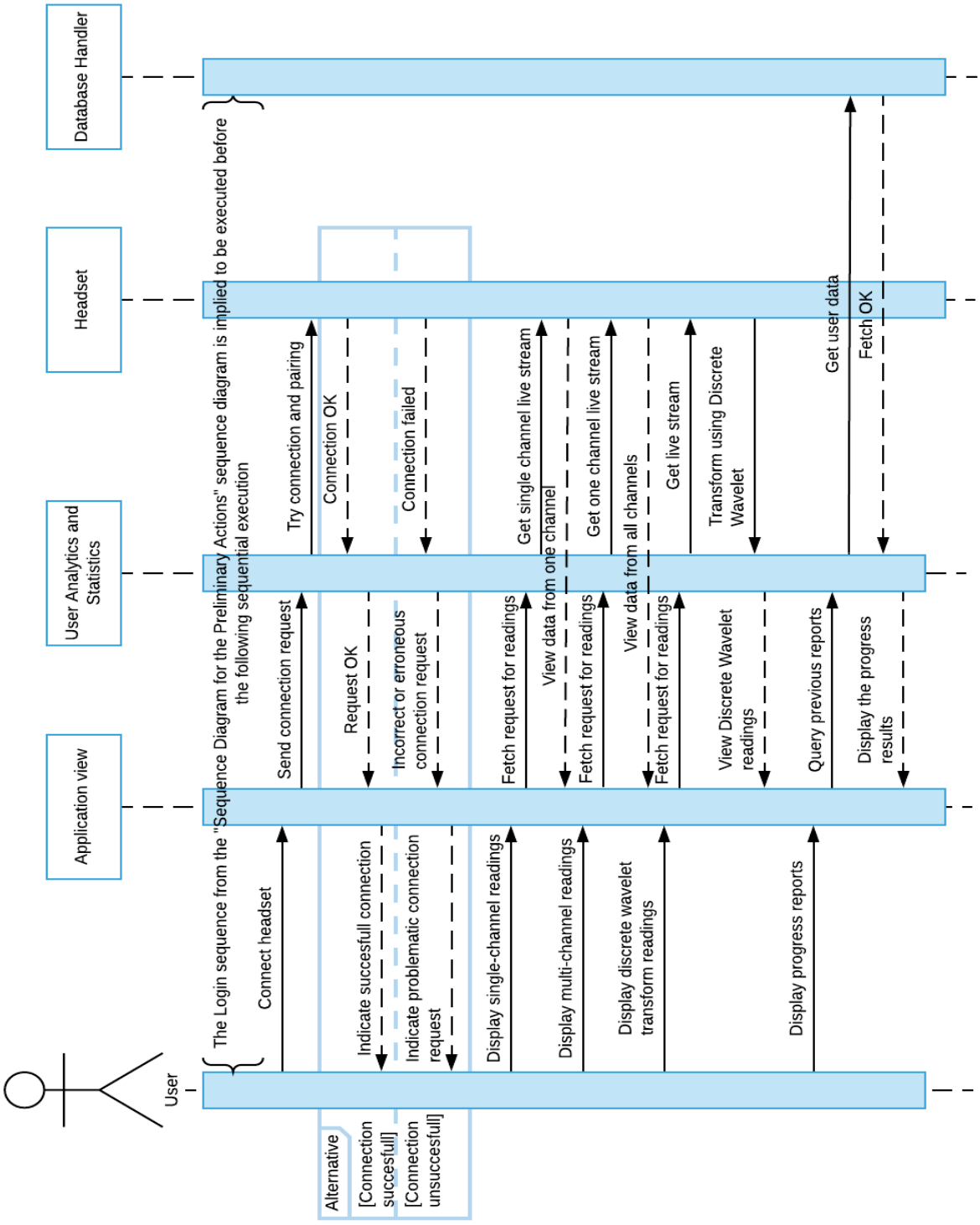
Use case Model 6 Database Handling module

3.2 Sequence Diagrams

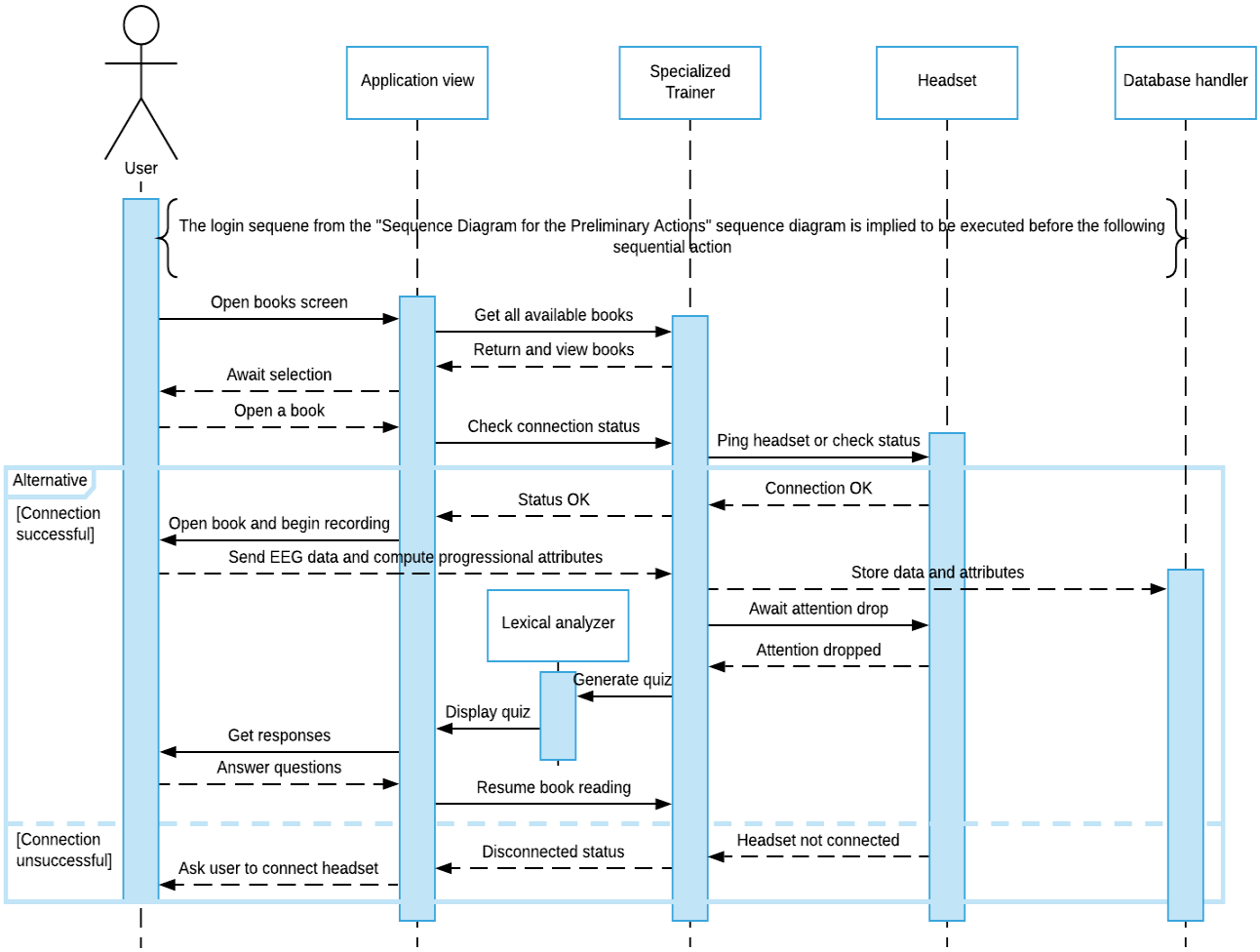
The sequence diagrams of Atom:



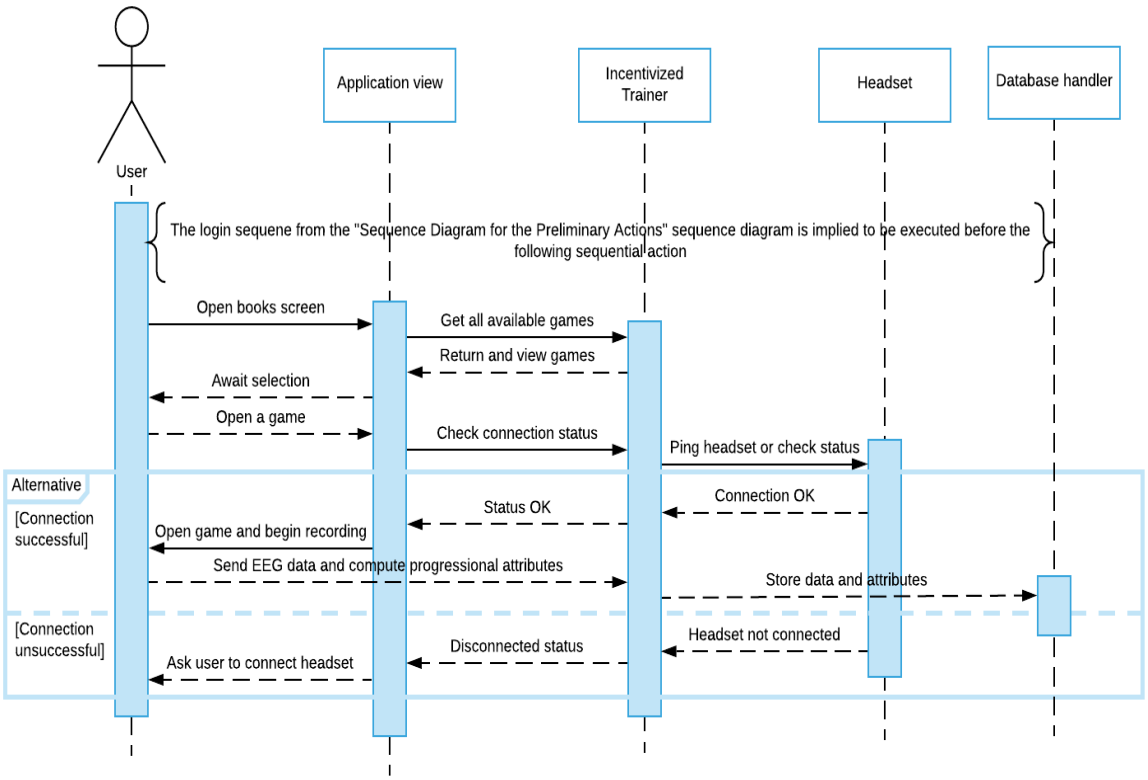
Sequence Diagram 1 Preliminary use cases


Database Handler
Headset
User Analytics and Statistics
Application view
User
The Login sequence from the "Sequence Diagram for the Preliminary Actions" sequence diagram is implied to be executed before the following sequential execution
Connect headset
Send connection request
Try connection and pairing
Request OK
Connection OK
Incorrect or erroneous connection request
Connection failed
Get user data
Fetch OK
Fetch request for readings
Get single channel live stream
View data from one channel
Fetch request for readings
Get one channel live stream
View data from all channels
Fetch request for readings
Get live stream
Transform using Discrete Wavelet
View Discrete Wavelet readings
Query previous reports
Display the progress results
Indicate succesfull connection
Indicate problematic connection request
Display single-channel readings
Display multi-channel readings
Display discrete wavelet transform readings
Display progress reports
Alternative
[Connection succesfull]
[Connection unsuccesfull]

Sequence Diagram 2 User Analytics and Statistics use cases



Sequence Diagram 3 Specialized Control Training use cases

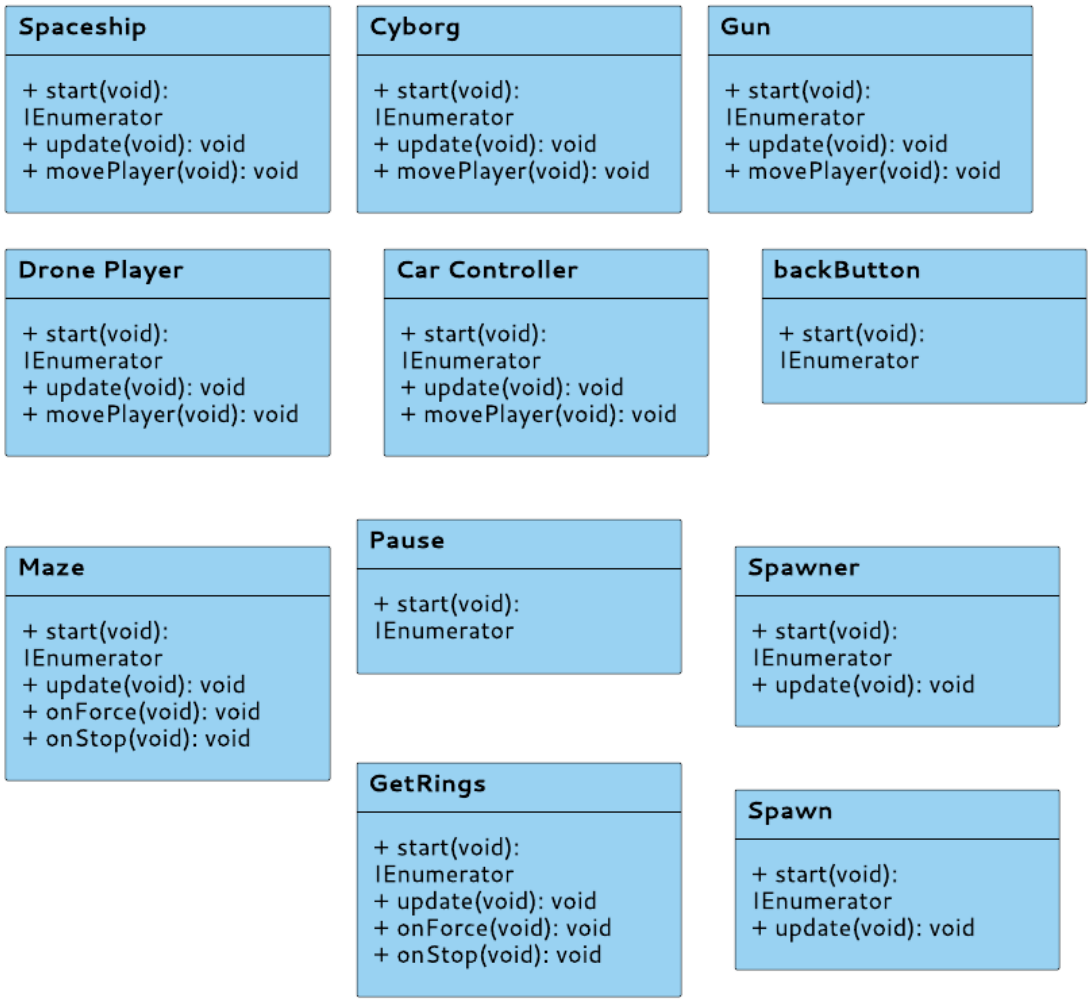


Sequence Diagram 4 Entertainment Incentivized Training use cases

3.3 Class Diagram

The class diagram for the Android application for Atom:

Class Diagram 1 Atom Class Diagram – Android End



Class Diagram 2 Class Diagram for Atom - Unity End

4. Data Design

This section contains the JSON schema as an alternative to ERD Diagram since the storage mechanism that will be used is a NoSQL Storage Methodology:

```
{
      {
            "$schema" : " " ,
            "$id" : ,
            "Title" : "Users" ,
            "description" : "all the accounts created",
            "Type" : "object",
```

```
        "Properties" :
        {
              "Username" : {
                    "Description" : "name of the user",
                    "Type" : "String"
                    }
              "Email" :  {
                    "Description" : "email of the user",
                    "Type" : "String"
                    }
              "Password" :  {
                    "Description" : "password for the authentication",
                    "Type" : "varchar"
                    }

              "Contact" :  {
                    "Description" : "phone number of the user",
                    "Type" : "num"
                    }

              "profileImg" :  {
                    "Description" : "picture of the user",
                    "Type" : "Jpg , png"
                    }

        },
        "Required" : ["username", "email", "password" , "contact"  ]
}
{
        "$schema" :  ,
        "$id" : ,
        "Title" : "Admin" ,
        "description" : "all the accounts of admins",
        "Type" : "object",
        "Properties" :{
              "AdminID" :  {
```

```
                        “Description” : “Id assigned by the system for admin access”,
                        “Type” : “String”
                        }

                “AdminPass” :  {
                        “Description” : “password for admin authentication”,
                        “Type” : “varchar”
                        }

        },
        “Required” : [“adminID”, “adminPass”  ]
}


{
        “$schema” : “ “ ,
        “$id” : ,
        “Title” : “Games” ,
        “description” : “all the games in the application”,
        “Type” : “object”,
        “Properties” :{
                “gameName” :  {
                        “Description” : “name of the  game”,
                        “Type” : “string”
                        }

                “gameID” :  {
                        “Description” : “random ID assigned to the game”,
                        “Type” : “num”
                        }

        },
        “Required” : [“gameName”, “gameID”  ]
}
```

```
{
	“$schema” : “ “ ,
	“$id” : ,
	“Title” : “Scores” ,
	“description” : “scores recorded of all the users ”,
	“Type” : “object”,
	“Properties” :

	{
		“Username” :  {
			“Description” : “name of the user”,
			“Type” : “string”
			}

		“gameID” :  {
			“Description” : “ID of the game ”,
			“Type” : “num”
			}

		“Score” :  {
			“Description” : “score of the user ”,
			“Type” : “num”
			}

	},
	“Required” : [“username”, “gameID”  , “score” ]
}


{
	“$schema” : “ “ ,
	“$id” : ,
	“Title” : “Recordings” ,
	“description” : “all the recording files”,
	“Type” : “object”,
	“Properties” :{
```

```
                    “userName” :  {
                          “Description” : “name of the user”,
                          “Type” : “string”
                          }

                    “recordingID :  {
                          “Description” : “random ID assigned to the file by system”,
                          “Type” : “num”
                          }

                    “recordingLink” :  {
                          “Description” : “link of the file uploaded in the database
                    storage”,
                          “Type” : “string”
                          }

            },
            “Required” : [“username”, “recordingID”  , “recordingLink” ]
      }
}
```

4.1 Data Dictionary

FieldName	DataType	DataFormat	FieldSize	Description	Example
username	string	text	Not specified	Full name of the user	“Kinza arshad”
email	string	text	Not specified	Email of the user	“maida@gmail”
password	VarChar	text	Not specified	Password for user authentication	“mustafa”
contact	num	text	Not specified	Phone number of the user	“03321576652”
profileImg	String	text	Not specified	Link of the profile uploaded on the database storage	“ “
adminId	String	text	Not specified	Id assigned by the developers to the admins	“kinza@gmail”
adminPass	VarChar	text	Not specified	Admin password assigned to adminID for authentication	13718847262”
gameName	String	text	Not specified	Name of all the games in the application	“ball_jump”
gameID	num	text	Not specified	Game ID assigned to the game to identify it	“01’
score	num	text	Not specified	Score to keep track of	“20”

				progress of the users	
recordingID	num	text	Not specified	RandomID assigned by the system to the recording file	"0318487101"
recordingLink	String	text	Not specified	link of the file In the storage	" "

5. Algorithm & Implementation

The major algorithms in form of pseudocode:

KNN:

```
Classify(X,Y,x)
X= training data
Y= class labels of X
x= unknown sample

For i =1 to m
      Compute Distance d(Xi , x)
Compute set I containing indices for the k smallest distances d(Xi , x)
Return majority label for {Yi where i belongs to I)
```

DWT:

```
Public static int[ ] discreteWaveletTransform( int[ ] input){
      //this function assumes that input.length= 2^n , n>1
      Int[ ] output = new int[ input.length ];
      For (int length = input.length / 2 & length= length/2){
            //length is the current length of the working area of the output array
            //length starts at half of the array size and every iteration is halved
until it is 1
            For (int i=0 ; i<length ; ++i){
```

```
                    Int sum= input[ i*2 ] + input[ i*2+1 ];
                    Int difference= input[ i*2 ] - input[ i*2+1 ];
                    Output[ i ]= sum;
                    Output[ length+i ]= difference;
}
if(length == 1){
      Return output;
}
system.arraycopy(output,0,input , 0, length);
      }
}

For i in range (X):
      coeffs= discreteWaveletTransform(X)
      cA1 , cD1= coeffs
      coeffs2= discreteWaveletTransform( cA1)
      cA2, cD2 = coeffs2
      coeffs3= discreteWaveletTransform( cA2 )
      cA3 , cD3= coeffs3
      coeffs4= discreteWaveletTransform(X)
      cA4 , cD4= coeffs4
      coeffs5= discreteWaveletTransform( cA4 )
      cA5 cD5= coeffs5

      For j in range(16):
            Processed [ i ] [ j ] [ 0 ] = cA5[ j ]
            Processed [ i ] [ j ] [ 1 ] = cD1[ j ]
            Processed [ i ] [ j ] [ 2 ] = cD2[ j ]
            Processed [ i ] [ j ] [ 3 ] = cD3[ j ]
            Processed [ i ] [ j ] [ 4 ] = cD4[ j ]
            Processed [ i ] [ j ] [ 5 ] = cD5[ j ]
```

GAME:

```
//updata is called once per frame
```

```
Void update(){
	readData();
	//makePieces();

	for( int i=0 ; i<Input.touchCount ; i++){
		if(Input.GetTouch(i).phase == TouchPhase.Began){
			//construct a ray from current touch coordinates
			transform.Translate( 0, 2, 0);
		}
	}
}
Void readData(){
	//read data from the port
}
Int makePieces(){
	// make the pieces in to 500 rows to make small samples
	Int r= callModel(tempArray);
	Return r;
}
Int callModel(Array tempArray){
	//call the model and get input
	Return 1;
}
```

PDFViewer:

```
//Declare buttons
//open default ACTION_GET_CONTENT  from android to select pdf
//create chooser
//get result code and check if it is OK
//load pdf
```

Sign-in:

```
//initialize the buttons
//initialize Paper(remembers username and  password) library
//set up the onClicks on buttons
//get the text from the EditTexts
//check if the information user entered is null
//remember the username and password on Paper
//initialize firebase database
//check if the table Users exists
//check if the email exists
//check if the password is correct
```

Sign-up :

```
//initialize the buttons
//initialize Paper(remembers username and  password) library
//set up the onClicks on buttons
//get the text from the EditTexts
//check if the information user entered is null
//initialize firebase database
//check if the table Users exists
//check if the email exists
//start the default ACTION_GET_CONTENT for GalleryPick
//if pic upload is successful then upload it to database storage
//create a HashMap of all the data
//upload the data on database
//If upload is successful then start activity login
//remember the username and password on Paper
```

6. Software requirements traceability matrix

This section should contain a table that summarises how each software requirement has been met in this document. The tabular format permits one-to-one and one-to-many relationships to be shown.

Table 1 Requirements Traceability Matrix

Req. Number	Ref. Item	Design Component	Component Items
FR01	Sign-in	register	`onClick()`
FR02	Sign-up	register	`createAccount()` `validateInformation()`
FR03	Name	register	`oncreate()` `createAccount()`
FR04	Email	register	`oncreate()` `createAccount()`
FR05	Password	register	`oncreate()` `createAccount()`
FR06	Contact	register	`oncreate()` `createAccount()`
	Profile	register	`oncreate()` `uploadImg()`
FR07	Database Input	register	`validateInformation()`
FR08	Success-Register	register	`validateInformation()`
FR09	Failure-Register	register	`validateInformation()`
FR10	Logout	HomeFragment	`onCreate()` `onClick()`
FR11	Edit	header_file	`onCreate()` `onClick()`
FR12	Name-Edit	edit	`onCreate()`
FR13	Email-Edit	edit	`onCreate()`
FR14	Password-Edit	edit	`onCreate()`

FR15	Contact-Edit	edit	onCreate()
FR16	Confirm-Edit	edit	onCreate()
FR17	Database-update	edit	onCreate() editInformation()
FR18	Success-Edit	edit	onCreate() editInformation()
FR19	Failure-Edit	edit	onCreate() editInformation()
FR20	View	HomeFragment	onCreate() onClick()
FR21	List-View	userAnalytics	onCrete() onClick()
FR22	View-Button	userAnalytics	onCreate() onClick()
FR23	Display-Reports	userAnalytics	onCreate() onClick() displayReports()
FR24	Sign-in	MainActivity	onCreate() onClick()
FR25	Sign-up	MainActivity	onCreate() onClick()
FR26	Email	MainActivity	onCreate()
FR27	Password	MainActivity	onCreate()
FR28	Success-Login	MainActivity	onCreate() LoginUser() AllowAccessToAccount()
FR29	Failure-Login	MainActivity	onCreate() LoginUser() AllowAccessToAccount()
FR30	Slide profile	Dashboard()	onCreate() setInformation()
FR31	Forgot password	MainActivity	onCreate() onClick()

FR32	Recovery email	recovery	onCreate()
FR33	New password	recovery	onCreate()
FR34	Confirm-password	recovery	onCreate() generateNewPassword()
FR35	graph	userAnalytics	GenerateGraph()
FR36	Progress graph	userAnalytics	generateProgressGraph()
FR37	Display-EEG	userAnalytics	displayEEG()
FR38	View-worst	reports	onCreate() onClick()
FR39	Average-reports	reports	onCreate() onClick()
FR40	Display-Channels	userAnalytics	onCreate() onClick()
FR41	Channels	userAnalytics	displayChannels()
FR42	Start-Recording	recordingEEG	startRecord()
FR43	Pause-Recording	recordingEEG	pauseRecord()
FR44	End-Recording	recordingEEG	endRecord()
FR45	DWT	userAnalytics	onCreate() onClick()
FR46	Save-csv	recordingEEG	Save()
FR47	Success-save	recordingEEG	Save()
FR48	Failure-save	recordingEEG	Save()
FR49	Table	userAnalytics	generateTable()
FR50	Connect	headsetSettings	Connect()
FR51	Dis-connect	headsetSettings	Dis-connect()
FR52	Success-headset	headsetSettings	Connect()
FR53	Failure-connect	headsetSettings	Connect()

FR54	Start-exploring	bookshelf	`onCreate()` `onClick()`
FR55	Open-gallery	bookshelf	`onCreate()` `onClick()`
FR56	Click-file	bookshelf	`onCreate()` `onClick()`
FR57	Scrollable-pdf-display	bookshelf	`onActivityResult()`
FR58	Generate-quiz	bookshelf	`onCreate()` `onClick()`
FR59	Display-quiz	quiz	`generateQuiz()`
FR60	Monitor	bookshelf	`onActivityResult()`
FR61	Success-monitor	bookshelf	`onActivityResult()`
FR62	Failure-monitor	bookshelf	`onActivityResult()`
FR63	Solve-quiz	DisplayQuiz	`onCreate()` `onClick()`
FR64	Display-question	DisplayQuiz	`onCreate()` `onClick()`
FR65	Choose-quiz-option	DisplayQuiz	`onCreate()` `onItemClickListener()`
FR66	done	DisplayQuiz	`onCreate()` `onClick()`

FR67	Display-scores	DisplayQuiz	`onCreate()`
			`onClick()`
			`displayScores()`

FR68	Save-score	quiz	`onCreate()`
			`onClick()`
			`saveScore()`

FR69	View-list	HomeFragment	`onCreate()` `onClick()`
FR70	Display-gamelist	games	`diaplayGames()`
FR71	View-score	unityActivity	`getLatestScore()`

FR72	Display-gamescore	games	onCreate() onClick() getScores()
FR73	Pause-game	player	Update() Pause()
FR74	Start-game	player	Update() Start()
FR75	Touch-Input	unityActivity	Update()
FR76	Headset-Input	player	Update() getData() makePeices()
FR77	Resume-game	player	Update() Resume()
FR78	Quit-game	player	Update() Quit()
FR79	Exit-game-screen	player	Update() Back()
FR80			
FR81	Delete-database	adminHome	onItemClickListener() delete()
FR82	Success-database-delete	adminHome	onItemClickListener() delete()
FR83	Failure-database-delete	adminHome	onItemClickListener() delete()
FR84	View-database	adminHome	getData() display()
FR85	Failure-database-view	adminHome	getData() display()
FR86	Update-database	adminHome	onItemClickListener() update()
FR87	Success-database-update	adminHome	update()

FR88	Failure-database-update	adminHome	`update()`
FR89	Edit-database	adminHome	`onItemClickListener()` `edit()`
FR90	Success-database-edit	adminHome	`Edit()e`
FR91	Failure-database-edit	adminHome	`Edit()`

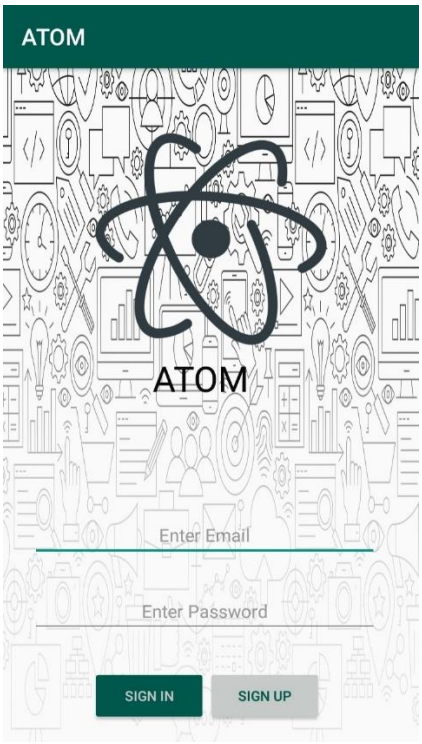
7. Human interface design

This section is a view into the primary build of the working application interfaces:

8.2 Screen objects and actions

registerActivity:

This activity has inputs in the from of EditTexts and ImageView .It allows you to pick an image from the gallery and add name, email, password, contact . when sign-up is pressed a new user is created in the database and login activity is opened. If the user already has an account he/she can click sign-in button and go back to sign-in activity.



Interface 1 Register Activity

sign-in Activity:

This activity has inputs in the form of EditTexts to enter an already existing account. When the user presses sign-in , the system authenticates the username and password from the database and if the authentication is successful takes the user to the Dashboard . If the user doesn't have an account he/she can click sign-up and go to the sign-up page to register.

Dashboard Activity:

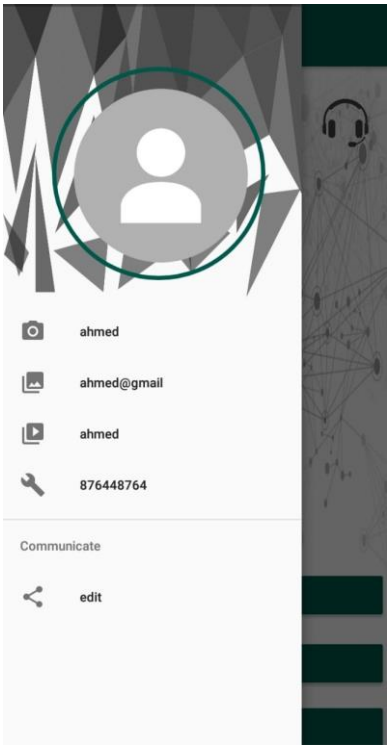
This activity has two ImageView buttons that take us to the reading exercise and the gaming exercise which are the core features of our application .The headset icon on the top right shows if

the headset is connected or not . The buttons on the bottom are User Analytics , Headset Settings , Log-out . The User Analytics button takes us to an activity which lets us view the data in different formats . The Headset Settings opens an activity that lets us see the connection status and signal strength with our headset. The logout buttons logs the system out and deletes data from the paper.

Interface 2 Dashboard Activity

Drawer Activity:

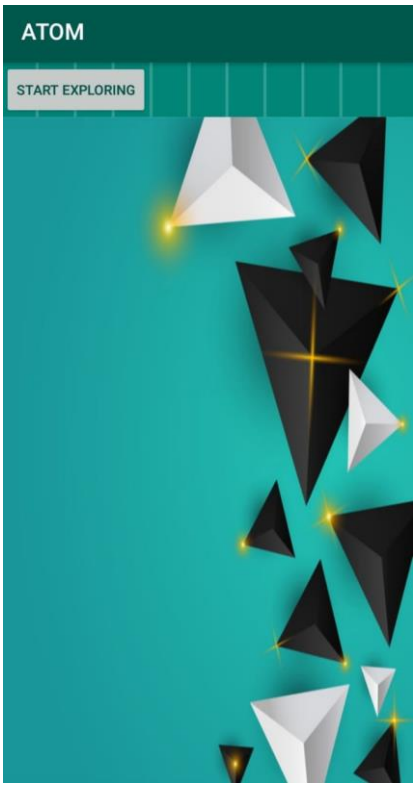
This activity has all the Profile information . It gets all the data from from the firebase database in realtime against the username that is logged-in.



Interface 3 Drawer Activity

Bookshelf Activity:

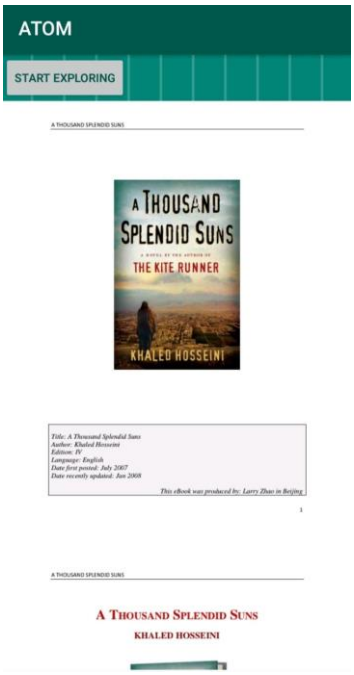
This activity has one button that calls the default choose file action to let the user choose a .pdf file.



Interface 4 Bookshelf Activity

PDFViewer Activity:

This activity loads the pdf from the page one and lets the user scroll the pdf file .



Interface 5 Book Reader Activity

GameList Activity:

This activity has the Icons of all the games in the listformat . on click the icon takes the user to a unity activity so he/she can play the game.

Interface 6 Game List Activity

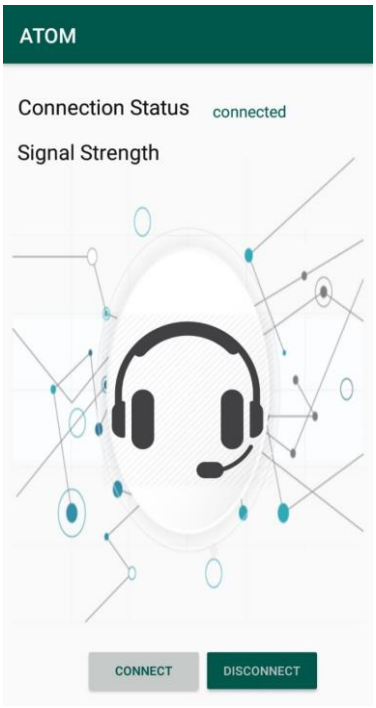
Game:

This activity has the game with a ball that can jump.

Interface 7 Game Activity

Headset Settings:

This activity shows the connection status and signal strength . It also provides with two buttons connect and disconnect from the headset.



Interface 8 Headset Settings Activity

8. Conclusion

The document tends to present and define the design specification of Atom. It defines the high-level Architecture of the application using the Architectural block diagram up to the low level sequences and activities using the corresponding diagrams and concretizes code using the class diagram presented and the algorithms and implementation techniques presented above. This document will be used as a standpoint for further development into the project leading into a stable and compelling application.