
INSULINK

DOCUMENTATION

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Idea

When Type 1 Diabetes[1] is diagnosed, a patient starts a new life with different eyes. From now on, the conception of food is completely different from the normal one, and the patient has to assimilate the big change and learn how to handle the disease. One of the most difficult but at the same time important things that the patient must learn, is the ***carbohydrates count*** and subsequently the correct insulin dose for a bolus [2]. InsuLink has been designed with the main purpose of giving an hand to Type 1 Diabetes patient with the calculation of the correct ***insulin doses*** and storing Glycemia values.

1.1 Main Goal

InsuLink main goal is to give a first support to the patient but only if combined with the doctor supervision. It is important to underline that this application is only defined by an algorithm, and in this kind of diseases ***each patient needs ad hoc treatments***.

\usepackage

or

\usepackage{package}



SECTION

Functionalities

Insulink offers some useful tools to keep track of the daily routine of a patient.

2.1 Food Scan

It is possible to scan a given Food BarCode and be redirected to the FoodDetails page with all necessary data.

2.2 Glycemia

Keep track of your daily Glycemia with intuitive charts and easily with the glycemia insertion tool.

2.3 Insulin Calculator

An algorithm (inside Insulin Calculator class) will retrieve last Glycemia, total amount of carbohydrates, sport activity and all essential data to calculate the optimal insulin dose for the given meal. A more detailed explanation can be found in the Insulin Calculator Section.

2.4 Calendar

The user can see a well detailed sight of all previous data, just choosing a date from the InsuLink calendar, that will retrieve all the informations about that day from the database.

SECTION

Screens and Navigation

The following provides a screenshot of the pages with a brief description of their use.

3.1 Screens

Home Home menu offers shortcuts to the main functionalities and a quick sight of the today glycemia with its intuitive charts.



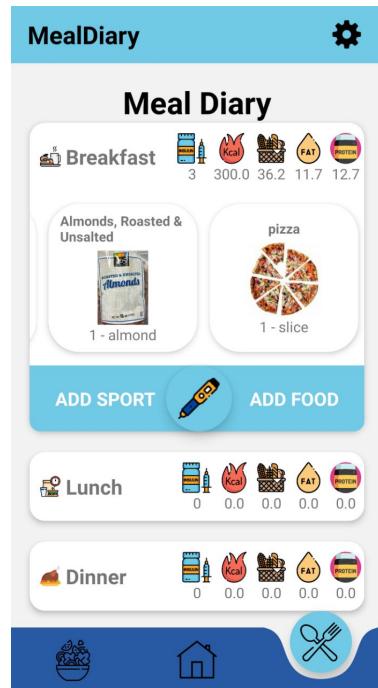
Search Search food or recipe for nutritional details or to add it in meal diary. User can easily modify the unit measure and quantity of food.



Glycemia PopUp Add glycemia quickly just using the menu shortcut or during the insulin calculation procedure. The value will automatically stored in Firebase.



Meal Diary Meal Diary can be used for both calculating daily total macro nutrients and insulin dose of each meal.

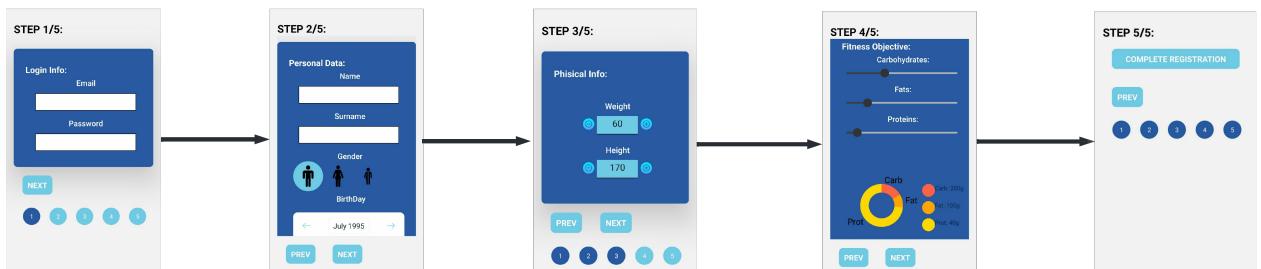


Calendar In calendar it will be possible to retrieve historical data by clicking on a date.

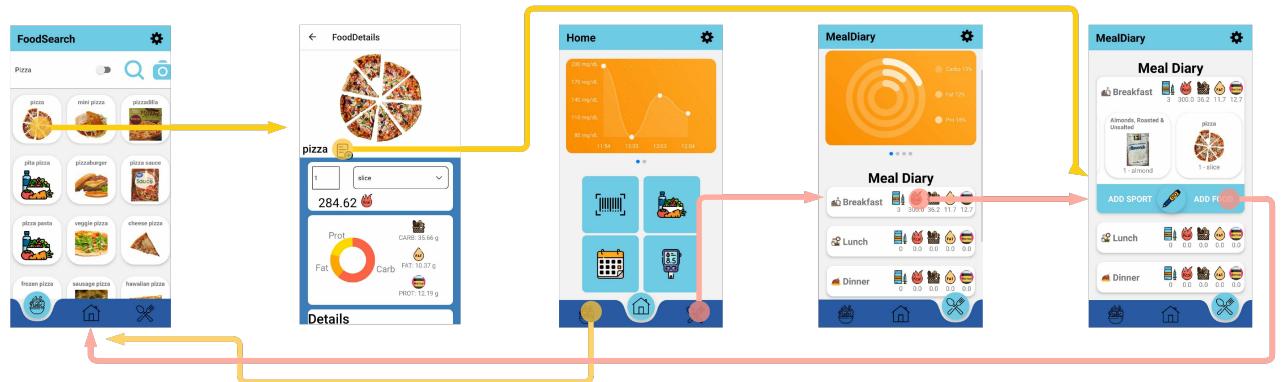


3.2 Navigation

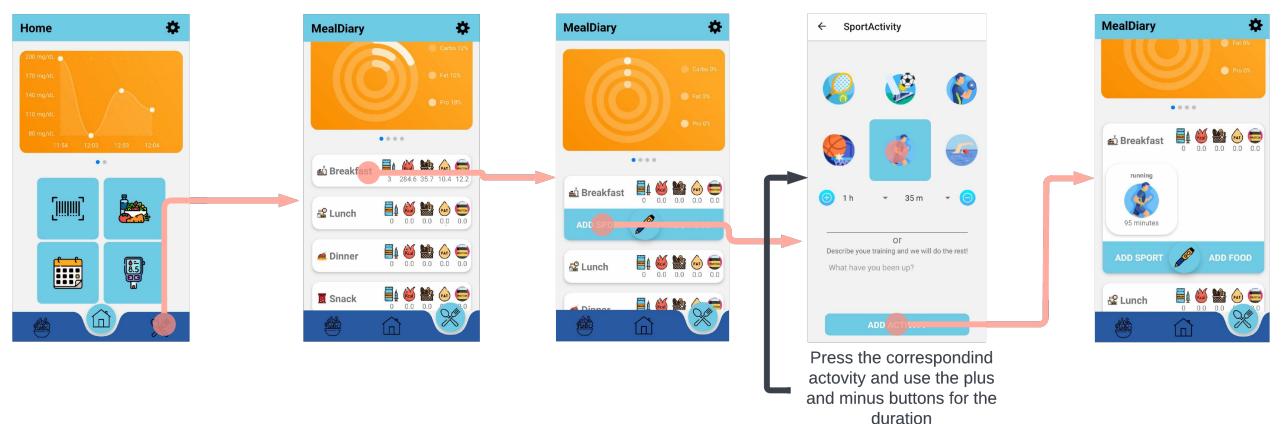
Registration



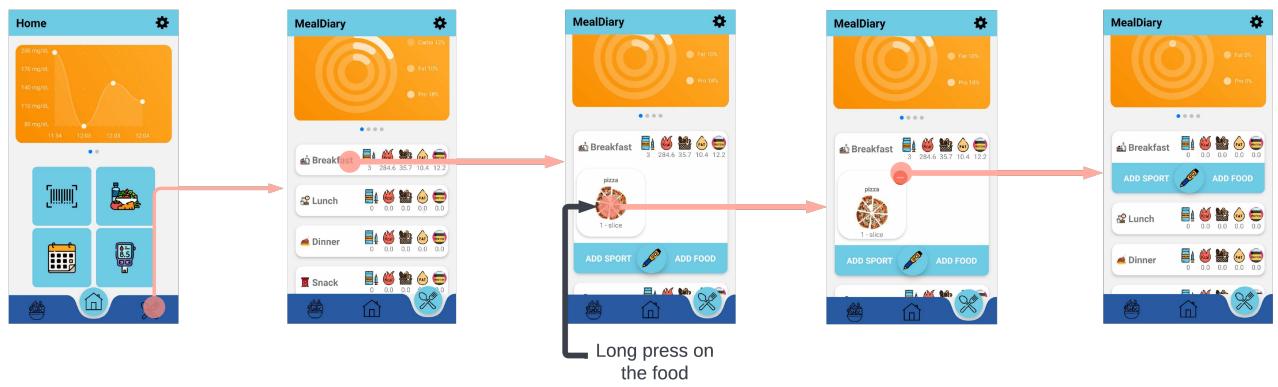
Search and Add Food



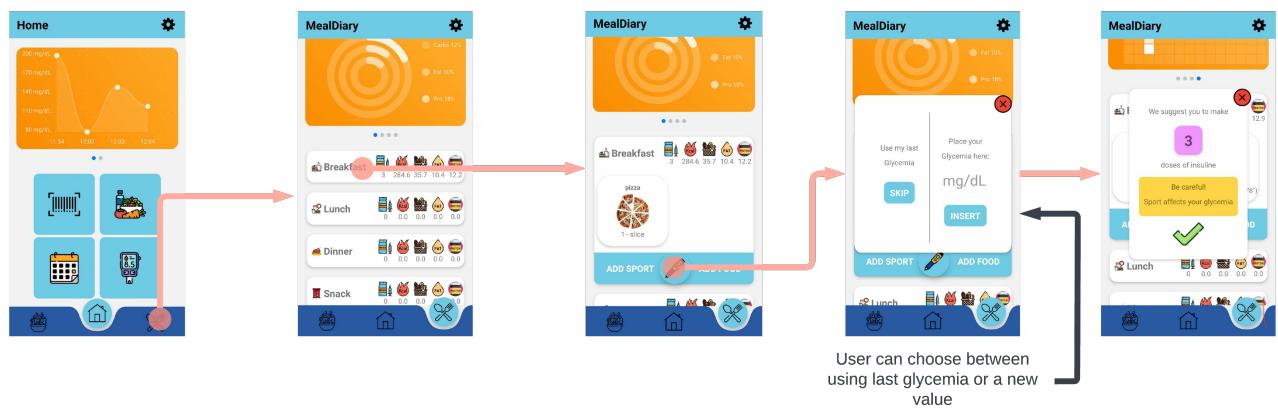
Add Sport



Delete Food



Calculate Insulin



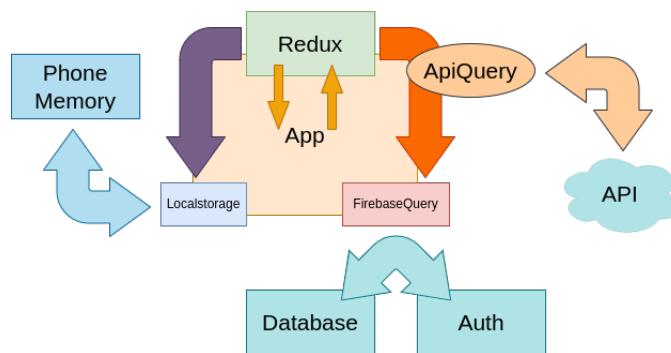
4

SECTION

Architecture

The technology used to make this app is react native [3]. In this chapter will be discussed the architecture of the app at an higher level (more details will be shown on next chapters).

4.1 UML app structure



4.2 Main components

The app is composed of 4 main internal components:

- **LocalStorage** manage access of app to local memory
- **FirebaseQuery** manage access of app to firebase database and auth
- **ApiQuery** manage communication of app with the API nutritionix
- **Redux** manage the interaction of user with app state

Those 4 components together allow the app state to be persistent both locally and remotely if the user close the app.

4.3 Ideal App Flow

- 1. User click on some buttons or search for something.
- 2. This trigger some internal functions.
- 3. Those function then can bring to 2 scenario (possibly mixed) :
 - Api query for some food/activity
 - Redux actions
- 4. Redux action then change the **runtime state** of app and, at the same time, change the remote firebase/localstorage state.
- 5. Finally usually there is a navigation to other page or go back to 1.

4.4 Folder Structure

\assets

Contains all images and components with a proper mapping.

\constants

All constants concerning the design and states of the app.

\customComponents

All buttons, charts and pickers specifically designed for the pages.

\pages

Folder with all pages of the app, using the custom components

\stateManager

Redux States for data managing with actions and reducers: macroTracker for meals and userReducer for the patient.

\utils

Logic of API, authentication, Firebase and Insulin Calculator

In the next 3 chapters all of those architectural components are explained more in details.

SECTION

API and Services

InsuLink uses different APIs to get all informations about food and storing user data.

5.1 Nutritionix

Nutritionix [4] is the API used to have a well detailed food database, with all important informations to have a completely working application.



Nutritionix support Natural Language, BarCodes and has a huge dataset with food and recipes. Here there're some functionalities offered by the standard plan:



Natural Language

Turn spoken text into precise nutrition analysis with our state-of-the-art natural language functionality.

[Try a live demo!](#)



Autocomplete Search

Your users will love our lightning fast autocomplete search. Try a demo below:



Common Foods

Our registered dietitian team started with the USDA database and supercharged it! In addition to USDA foods, our team has curated thousands of common international foods and recipes.

[Learn More](#)



Branded Foods

We have the largest branded food database in existence with over 742K grocery foods with barcodes and 185K restaurant foods.

[About our Database](#)



Dietitian Verified

We employ a full-time team of registered dietitians to help us verify our data and API procedures to ensure we can provide the strongest possible nutrition solution for your app.



Restaurant Geolocation

Send our API a lat/long coordinate, and we will return a list of nearby restaurant locations which have nutrition data available. We have a growing database of 209,882 restaurant locations.

[Try a live demo!](#)

Following section is dedicated to explain the API and our helper class `/utils/ApiQuery.js`

5.1.1 Api requests

\search/item GET (barcode)

Given upc code (standard use for barcodes) returns the food packaging details.

\search/instant GET (food query)

Given a user query (Food Search page) returns a list of possible foods and recipes.

\natural/nutrients POST (food to search details)

Given a food it retrieve its details.

\natural/exercise POST (sport query)

Given a sport query it retrieve the estimated calory.

5.1.2 Helper class

The technology used to execute API calls is **Axios**[5] helped by a custom method *doRequests(methods,path,parameter)* the used by other helper functions. Following a list of the api class methods:TODO

5.2 Firebase

Firebase [7] is a Google serverless platform for application development. It is a powerful tool to implement an app database and Google authentication, having many powerful tools to manage it.



All its requests and responses are implemented in the **src/utils/firebaseQuery.js** and **src/utils/auth.js**, two custom helper class.

SECTION

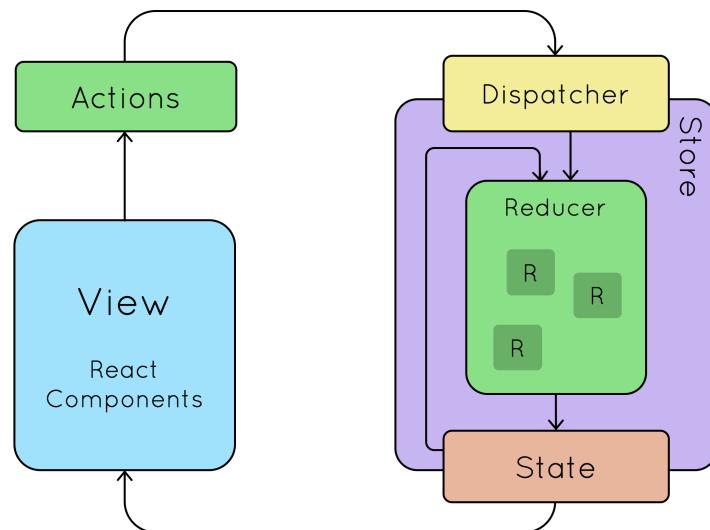
Redux States

To manage app states we opted for Redux library [9].



Redux is used mostly for application state management. In other words, Redux maintains the state of an entire application in a single immutable state tree (object), which can't be changed directly.

When something changes, a new object is created (using actions and reducers).



The main two reducers of the app are:

\userReducer

Contains all data about the user, including some additional fields such as Insulin Sensitivity Factor or CHO Ratio.

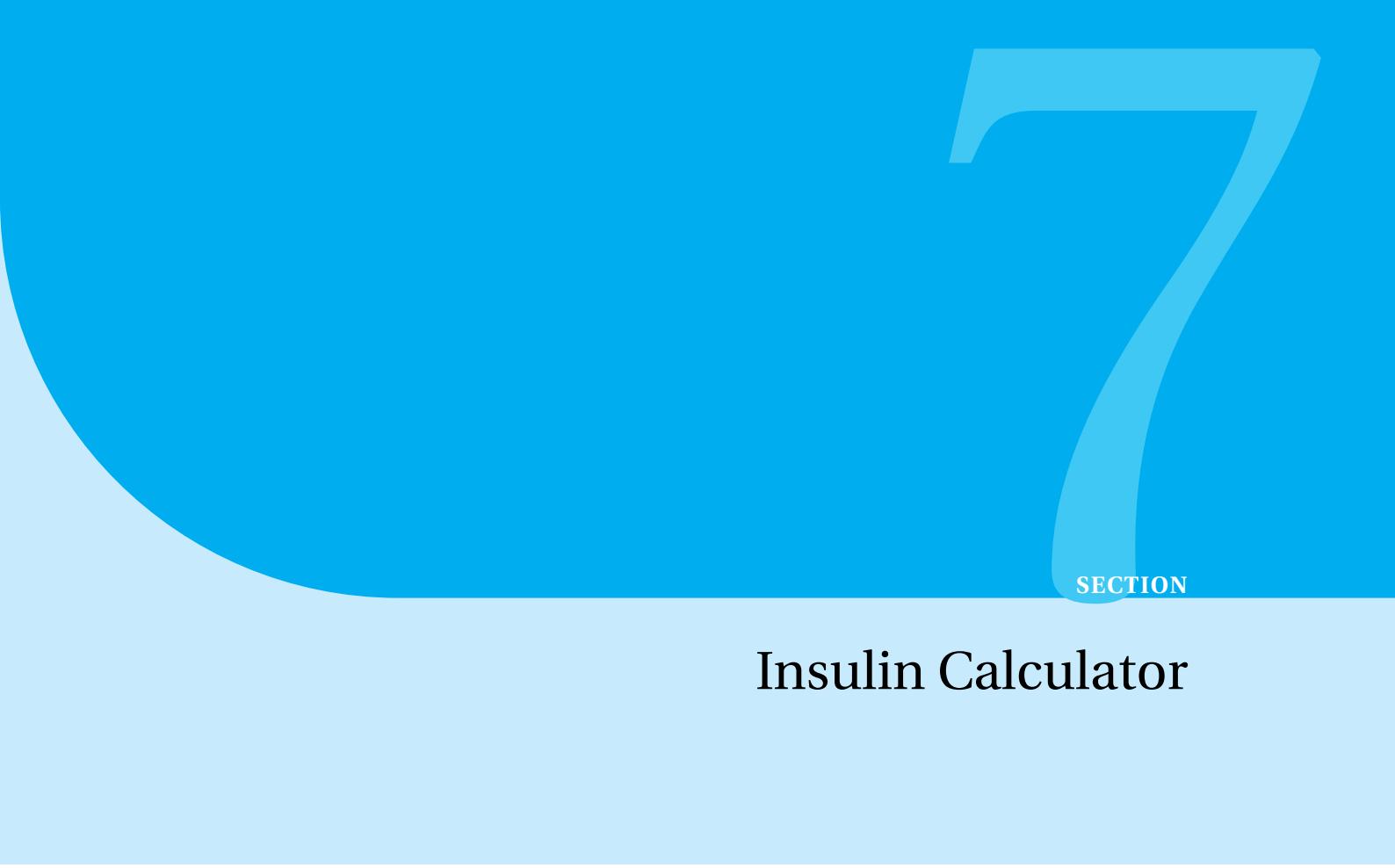
If not inserted these values will be calculated considering the patient weight.

```
status:loginStatus.unlogged, //logged,unlogged or pending
userId:"",
mustCompleteReg:false,
userData:{
  email:"",
  password:"",
  name:"",
  surname:"",
  weight:80,
  height:180,
  birthday:{},
  isf:0, //Insulin Sensitivity Factor
  choratio:0, //CHO Ratio
  glicemy:[], //Array of glucose misurations
  maxCarb:200,
  maxFat:100,
  maxProt:40,
}
```

\macroTracker

Stores informations about each meal and sport activity of the user. Additionally, contains the sum of total macros and calories spent during the day.

```
totMacro:{cal:0,carb:0,fat:0,prot:0},
meals:{
  breakfast:{foods:[],macro:{cal:0,carb:0,fat:0,prot:0}},
  lunch:{foods:[],macro:{cal:0,carb:0,fat:0,prot:0}},
  dinner:{foods:[],macro:{cal:0,carb:0,fat:0,prot:0}},
  snack:{foods:[],macro:{cal:0,carb:0,fat:0,prot:0}}
},
history:{
  empty:true,
  totMacro:{cal:0,carb:0,fat:0,prot:0},
  meals:{
    breakfast:{foods:[],macro:{cal:0,carb:0,fat:0,prot:0}},
    //...
  },
  activities:{
    breakfast:{sports:[],totCal:0},
    //...
  }
},
totCalBurned:0,
activities:{
  breakfast:{sports:[],totCal:0},
  //...
}
```



SECTION

Insulin Calculator

To understand the algorithm behind the Insulin Calculator, here're some basics:

- Approximately 40-50 percent of the total daily insulin dose is to replace insulin overnight, when you are fasting and between meals
- The other 50-60 percent of the total daily insulin dose is for carbohydrate coverage (food) and high blood sugar correction
- The bolus dose for food coverage is prescribed as an insulin to carbohydrate ratio. The insulin to carbohydrate ratio represents how many grams of carbohydrate are covered or disposed of by 1 unit of insulin.
- The bolus dose for high blood sugar correction is defined as how much one unit of rapid-acting insulin will drop the blood sugar.
- Sport Activity deeply influences the response to insuline and determine a less request of insulin in the patient.

Not considering sport activity, may lead the patient to a low bloodsugar value. Insulink checks if the user has done sport and suggests a new dose value with one unit less. This is not true for all patients, some may need even less amount of insulin.

7.1 Formulas

The main equation for the correct meal dose calculation is:

$$\text{CHO Insulin Dose} = \Sigma \text{ grams of CHO in the meal} / \text{grams of CHO disposed by 1 unit of insulin}$$

This happens in ideal conditions where glycemia is in the optimal interval.

Normally this is not the case: after a glucose misuration the patient could find an high blood sugar. In this case there's a ***correction dose***:

$$\text{High Blood Sugar Correction Dose} = \Delta (\text{Actual blood sugar} - \text{Target blood sugar}) \div \text{Correction Factor}$$

The result formula will be:

$$\text{CHO Total Dose} = \text{CHO Insulin Dose} + \text{High Blood Sugar Correction Dose}$$

Moreover, there's the sport activity to take into account and it will affect the value by decreasing it.

8

SECTION

Testing

To perform automated and personalized testing it was used Jest [6] and React Test Renderer [11]. It is a JavaScript Testing Framework that supports React Native. To do so it was used the mocking technique to check the behaviour of components.

Tests were contained inside:

__tests__

This folder is automatically detected by the jest configuration as the test folder

__mock__

This folder, combined with a setup.js file contribute to the mocking system of the app

8.1 Testing Strategy

The testing strategy is composed on a mix of 3 main technique:

- **Snapshots** to detect when static pages or redux states doesn't behave correctly
- **Widget test** for buttons/events/redux actions
- **Unit Testing** for our helper classes

The next chapters will be dedicated on the description of this strategy.

8.2 Folder Structure

\api-test

Unit testing on all the components that access to **API,localStorage or firebase**.

\redux-test

Snapshot testing on the **reducers results**.

\renders-test

Widget and Snapshot testing on all the **main pages and components** (static screenshot).

\utils

Unit testing on the most importants **utils classes**

8.3 Test Suites

The tests are subdivided into 16 suites

Utils class testing

As explained before, the app contain 2 important utilities class, this suit aim to apply Unit Testing on them

| | |
|---------------------|---|
| insuline-calculator | 1. Check correct calculation |
| input-checker | 1. Actual Registration Errors 2. Personal Info Errors 3. Physical Info Errors |

Firebase testing

An "Ad hock" class **CustomFirestoreMock** have been created to mock Firebase component. It contains a mock for doc,collection,get,set,data methods and allow to mock the return value of get() and data() functions.

| | |
|---------|---|
| getters | 1. Get User Data 2. Get Food Diary 3. Add Glicemy Data |
| setters | 1. Set Food Diary 2. Save User Data 3. Get Glicemy Data |

Api Helper testing

Axios class have been mocked using an "ad hoc" jest.fn() that return a Promise. TODO put here CODE OF AXIOS MOCK

| | |
|---------------------|--|
| Food related query | 1. Search for foods 2. Get Food Details 3. Get Food by barcode |
| Sport related query | 1. Get Activity calories |

Local Storage testing

As for the previous classes, also AsyncStorage needed mock but it comes already distributed with the original module. It is called **Async Storage Mock**, we stored an automatic import/mock inside the **mock folder**

| | |
|---------|---|
| getters | 1. Get User Data 2. Get Food Diary 3. Add Glicemy Data |
| setters | 1. Set Food Diary 2. Save User Data 3. Get Glicemy Data |

Redux testing

The redux testing was done by snapshotting the reducer output upon a certain input. Since reducers are **pure methods**, no mock was needed.

| | |
|--------------|--|
| macroReducer | 1. Add,Edit,Remove Food 2. Add,Remove Sport 3. Select Meal 4. Reset Diary |
| userReducer | 1. Login 2. Update Data 3. Add Glicemy 4. Logout |

Pages widgets and snapshots

For all main pages of our app we have a snapshot test + UI events testing. TODO TODO

CustomComponents snapshots

All the static custom components of the app have been tested with react-test-renderer + snapshot.
The following list show the tested components:

- WaitLoading
- CustomButton
- CustomImageButton
- CustomCalendar
- InputBlock
- InputContainer

Future Implementations

Insulink has been structured with the possibility of implementing new technologies inside it.

9.1 API

The API utils section of the code is easily changeable from one provider to another. Using a premium API would affect the performance but also the usability of the app.

9.2 Machine Learning and AI

Calculating the correct insulin dose is a really difficult problem. The factor that influences the output is not only the amount of carbohydrates eaten, but many other features: fats, sport activity, emotional condition and sometimes even the weather.

Moreover each patient needs specific treatments, and has a different resistance to insulin. Using Machine Learning in this field could be a smart way to correctly predict the optimal insulin dose.

9.3 NFC Glucose Meter

Some Glucose Meters use new technologies to simplify diabetic patients life. One famous example is FreeStyle Libre [8]. Using the NFC technology to retrieve glycemia helps not only in terms of time but also in visualization and store of data.

Once implemented, the user has just to bring the phone closer to the sensor and the app will check the glucose (and store it).



SECTION

References

[1] Diabetes Definition

https://en.wikipedia.org/wiki/Type_1_diabetes

[2] Bolus Definition

[https://en.wikipedia.org/wiki/Bolus_\(medicine\)](https://en.wikipedia.org/wiki/Bolus_(medicine))

[3] React Native

<https://reactnative.dev>

[4] Nutritionix

<https://www.nutritionix.com>

[5] Axios

<https://axios-http.com/docs/intro>

[6] Jest

<https://jestjs.io>

[7] Firebase

<https://firebase.google.com>

[8] FreeStyle Libre

<https://www.freestyle.abbott/us-en/home.html>

[9] Redux

<https://redux.js.org>

[10] Source for Insulin Calculator

<https://dtc.ucsf.edu/types-of-diabetes/type1/treatment-of-type-1-diabetes/medications-and-therapies/type-1-insulin-therapy/calculating-insulin-dose/>

[11] Source for React Test Renderer

<https://it.reactjs.org/docs/test-renderer.html>