3D Model Binary Vision System

Requirement Specifications Document

Flap_Jacks

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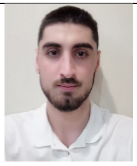
Rani Arraf	
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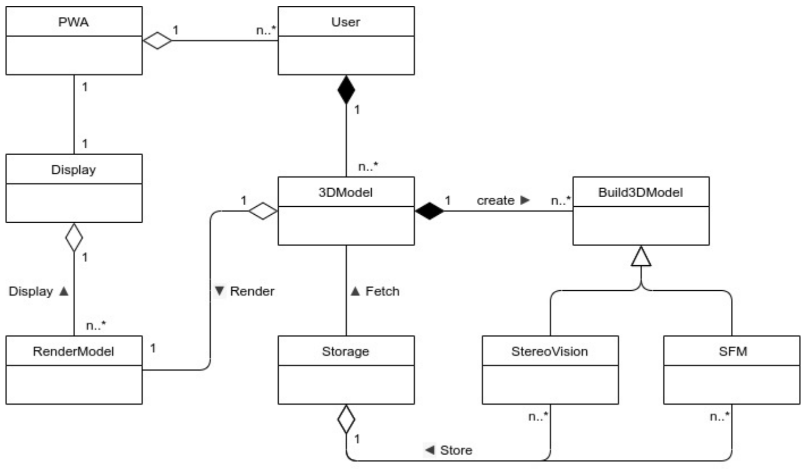
1 Introduction

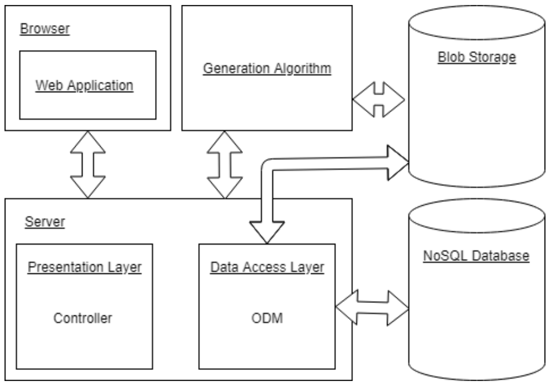
We are designing and making a mobile web application. The main purpose of this system is to scan a patients teeth using a camera, and processing this media into a 3D digital model that can be inspected. The model will then be stored and made available for retrieval at a later stage. The system will also be able to keep track of a doctors patients, as well as each visit that a patient makes to the dentist.

1.1 Domain model



2 Architectural Design

Our System uses a 2-Tier Architecture with a Client-Server Model. Since the system is a web-based application, responses will not be sent to the user unless they have sent a request through the User Interface of the website. The Controller Layer handles all of the users actions, and in turn communicates with the data access and process layers. The Data Access layer communicates directly with the database and accounts for all interactions regarding data retrieval from the database. The Client module is the web application that sends requests to the server module.



3 User Characteristics

As required by the client, there is one main user in mind when creating this project, however, the users may still expand from this.

3.1 Medical Professionals

These professionals are the main target for this project, focusing mainly on professionals in dental health. These users will make use of all of the subsystems provided by the web application, while focusing on the 3D renders of their patients teeth.

4 Functional Requirements

4.1 Use Cases

U1 Login

U2 Sign-up

U3 Add Patient

U4 View Patient

U5 Edit Patient

U6 Edit Details

U7 Logout

U8 Upload Media

U9 Render Model

U10 Inspect Model

U11 Export Model

U12 Record Media

U13 Upload STL

U14 Forgot Password

U15 New Visit for Patient

4.2 Requirements

R1 System must allow users to take their own video input

- **R1.1** The user should be allowed to operate a camera

R2 System must allow users to give prerecorded media as an input

- **R2.1** The user should be allowed to choose what type of media they are providing.
- **R2.2** The user should be allowed to change the media provided.
- **R2.3** The system should upload the selected media to the database.

R3 System must allow users to generate the model

- **R3.1** The system should distinguish the type of media provided.
- **R3.2** The system needs to do all the calculations for the 3D render.
- **R3.3** The system needs to create a mesh from the calculations made.
- **R3.4** The system should send the information of the render back to the web page to be rendered if requested.
- **R3.5** The web page should render the returned data

R4 System should allow the user to inspect a rendered model

- **R4.1** The user should be able to zoom in and out of the render for better perspective.
- **R4.2** The user should be able to rotate the render.
- **R4.3** The user should be able to look around in the rendered view and move to different positions (FPS Mode)

R5 System should be able to store things in the database

- **R5.1** The user should be able to save the render to a database.
- **R5.2** The user should be able to save the media to a database.

R6 System must be able to retrieve information from the database

- **R6.1** The user must be able to retrieve a render data from the database.

- **R6.2** The user should be able to see the media stored with the render data.

R7 System must be able to export the rendered model

- **R7.1** Generate a 3D Printable structure
- **R7.2** Save the structure to the user's device

R8 System should allow users to create an account

- **R8.1** Allow Users to choose a username
- **R8.2** Allow Users to choose a password

R9 Allow users to login

- **R9.1** System should allow a user to log in with valid credentials
- **R9.2** System should allow a user to logout
- **R9.3** System should allow a user to reset forgotten passwords

R10 System should allow users to update patients

- **R10.1** Allow a user to create a patient
- **R10.2** The user must be allowed to fetch relevant information about a patient such as stored renders of the patients mouth/teeth.
- **R10.3** The user must be allowed edit and update a patients information for example adding new models of their mouth/teeth.
- **R10.4** The user must be allowed to add new visits for a patient

R11 System should allow users to search for patients

- **R11.1** Allow a user to search for a patients name
- **R11.2** Allow a user to view one of the resulting patients information

4.3 Subsystems

4.3.1 Media System

Subsystem is comprised of the camera that will be used to record media, recording of the media and uploading this or prerecorded media to the database. This media will be input to the render algorithm.

4.3.2 Web Page

This is the platform that the user will interact with the overall system. It encompasses all UI as well as display functionality.

4.3.3 Storage

This subsystem controls all storage and retrieval of information from databases stored on the server.

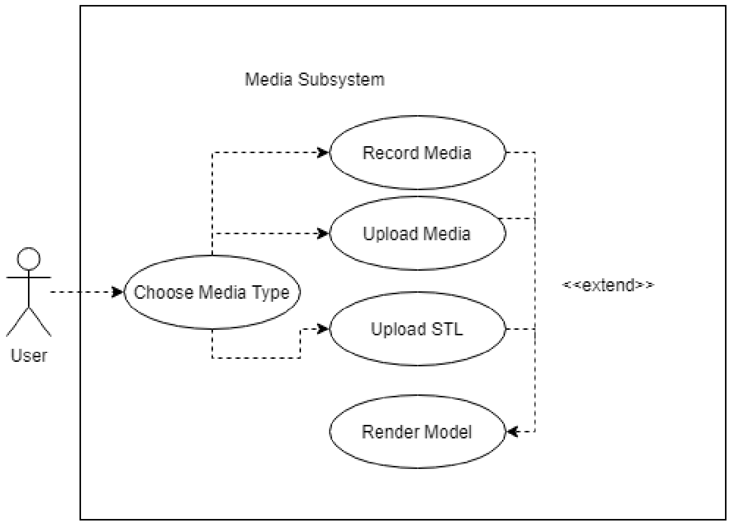
4.3.4 User Management

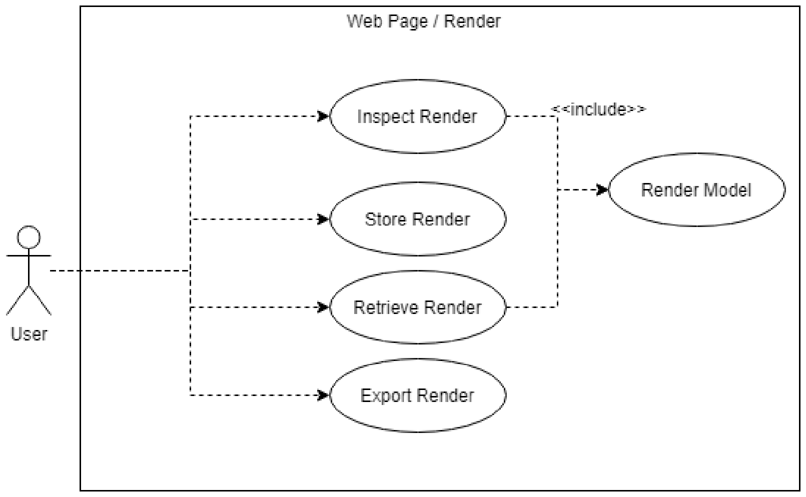
This subsystem encompasses all that is involved with creating users, logging into the system.

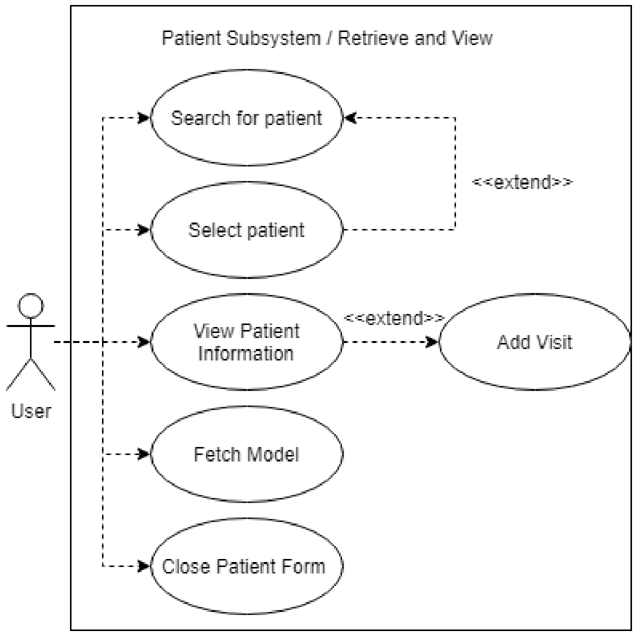
4.3.5 Patient Management

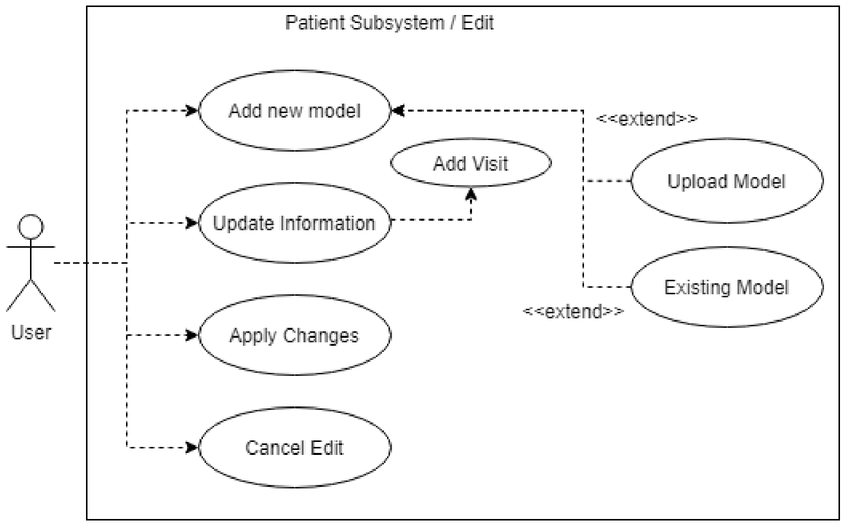
This subsystem encompasses all that is involved with creating patients and editing patient information.

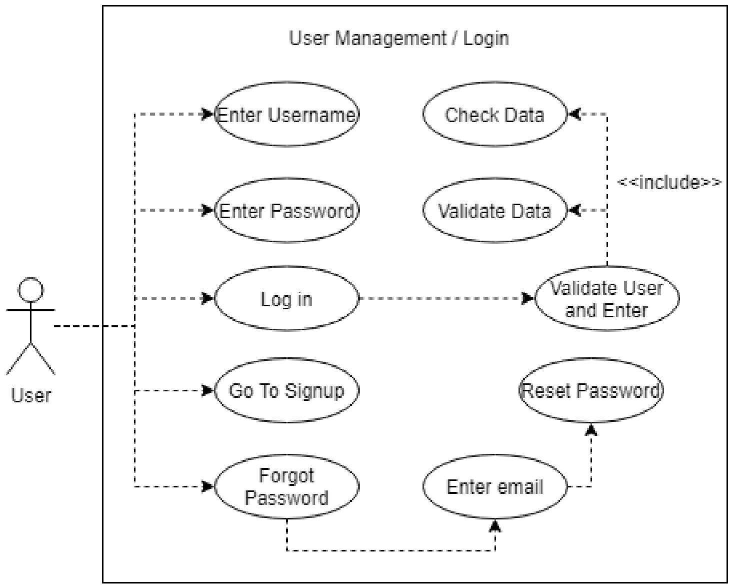
4.4 Use Case Diagrams

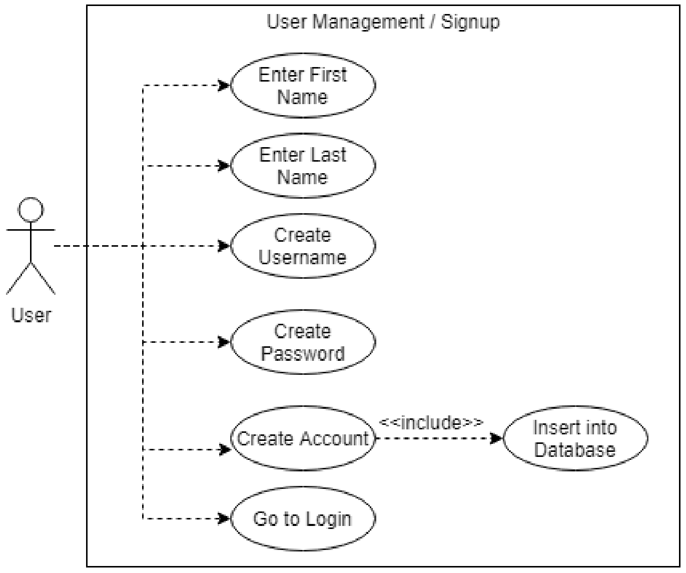





Patient Subsystem / Retrieve and View
Search for patient
Select patient
<<extend>>
View Patient Information
<<extend>>
Add Visit
Fetch Model
Close Patient Form
User


Patient Subsystem / Edit
Add new model
<<extend>>
Add Visit
Upload Model
Update Information
Existing Model
<<extend>>
Apply Changes
Cancel Edit
User





5 Quality Requirements

1 Performance:

The performance is very important in any aspect of the system we are developing. In the case of this project our performance will be the accuracy and the speed at which the render is computed and produced. We ideally would like to minimize the time taken to create the render and maximize the accuracy of the render. An important aspect to keep in mind is the camera used to take the media photo and the media type. Since the resolution of a camera can greatly impact the speed and accuracy of making the render.

The technology we will be using for this will be three.js for the rendering of the teeth. We will be using JavaScript to import the video data through an API so that the algorithm can easily take in the information and proceed with the rendering. The algorithm itself is coded with C++ because of the libraries it has to offer for the user. Those libraries allow for webgl data integration with the code.

2 Reliability:

One of the biggest frustrations that a user can experience is if an application freezes, crashes or gives incorrect results after spending precious time waiting for it to do its computations. We aim to prevent the application from breaking as much as we possibly can and to ensure that our results are accurate 95% of the time. To ensure that the application will not break, the server in our Client-Server architecture will handle all of the processing of the users input when it comes to rendering a model. This is so that the user device does not have to have the high computational power that is required to ensure results are generated and returned as quickly as possible without the application crashing from over-usage of RAM. We used MongoDB as this database integrates well with a webserver, which allows for data to be transferred and returned when requested from the server to the application. We also used restful API calls so that the calls to retrieve information are made to the server and the server then returns the required information to the client.

3 Security:

To demonstrate how the doctors will use the system the user will be required to log in. The user will therefore require a username and a password in order to use the system. This login information will be used when storing the media and the render info. This will ensure that we know which Doctor stored which information and prevent other doctors to be able to retrieve information that does not belong to them which will be a violation of doctor-patient-confidentiality.

The technology we used for this system is JavaScript and hash coding systems that converts the password in a non readable state. This will prevent malicious users from ever brute forcing the system. We will be using SSL encryption in the future to prevent any form of 'man-in-the-middle' attacks. Therefore, this will ensure that the data will end up being 93% secure. (40% from hashing; 30% correct data creation; and 23% SSL encryption)

4 Maintainability:

Maintainability refers to the ability of the system to be easily repaired. The system will be divided into smaller subsystems that will each be able to only do their individual tasks. Therefore if something breaks it will be easy to find the error in its subsystem. We will employ appropriate error messages so that the developer knows where and why the error occurred. With proper unit/integration tests it will be easy to monitor the working state of the system.

With the use of continuous integration software (Travis CI) successful repair action will be made easy. The tools used will ensure that meaningful commits are made to the repository by all active developers working on the project in parallel. The tools used will show developers whether their commits contain errors and are successful commits. If the commits contain errors, these errors can be quickly fixed and then rechecked relatively quickly by the developer ensuring that the code its maintained properly and working correctly.

Above Travis CI, we used a coding standard that places all relevant code in subsections. This allows for easy editing and manipulation of the code. With this in mind, it helps produce a maintainable system that offers system surveillance and system integrity.

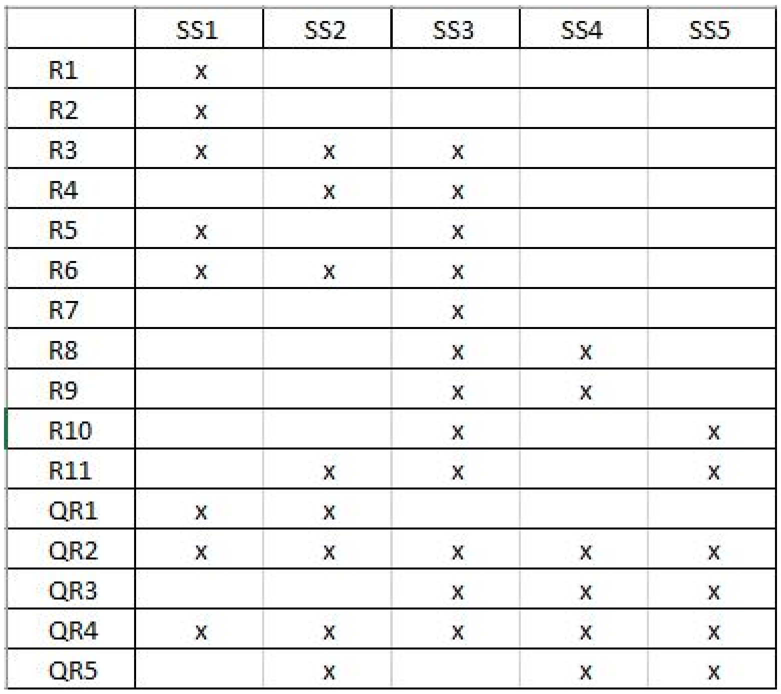
5 Usability:

The usability of a system is measured on how easy it is to use the product. Our system is usable after focus and effort has been placed in the fields of learn-ability, efficiency , satisfaction and error control.

Our system is easy to learn due to the linear and simple layout of the control flow and user actions. The learn-ability of the system is also enhanced with the minimal layout that shows clear action labels and proper headings. The system is also really memorable due to its unchanged design and easy flow of the layout. The system is efficient since the user can visually see the changes that happen to reach their goals. This is due to the atomic nature than we implement each user action to be able to see most changes as soon as they occur. We minimise the errors that a user can create by implementing verification's in both the front and back end to prevent system errors. The UI has been designed to feel a familiarity related to medical experts. Our system uses forms that can easily be understood.

The technology we used to create the usability of the system is HTML, Javascript and Node js. We implemented the architecture as a Client-Server architecture to handle all the user-requests. We use a Model-View-Controller in our API to handle the requests that the user makes and returns the results that the front end javascript receives and process for visual output to the users webpage.

6 Trace-ability Matrix



	SS1	SS2	SS3	SS4	SS5
R1	x				
R2	x				
R3	x	x	x		
R4		x	x		
R5	x		x		
R6	x	x	x		
R7			x		
R8			x	x	
R9			x	x	
R10			x		x
R11		x	x		x
QR1	x	x			
QR2	x	x	x	x	x
QR3			x	x	x
QR4	x	x	x	x	x
QR5		x		x	x

7 Technology Requirements

7.1 Web pages

The options we had for a markup language was HTML, Org-mode, Markdown and AsciiDoctor. AsciiDoctor has very limited output options and because our communication with the client via outputs is really important it was not a good option and therefore eliminated from the options to choose from. Although Org-mode is very flexible and has great sync support it is difficult to learn and because of the deadline being so close we removed it since the cost of learning the language would be too great.

Markdown is a great option but it is interpreted into HTML and would be inefficient where time is concerned and therefore we decided to use pure HTML 5 for our markup language for page development.

7.2 Frontend Scripting

Ruby, Python, Javascript, Typescript and jQuery were considered as possible scripting languages to use as our front end scripting language. Ruby had the disadvantage of having a slow run-time speed and our system is intended to be very efficient on the front end and therefore was eliminated. Python is not a good scripting language for multi-platforms and is not good for memory intensive tasks such that the rendering requires and therefore we removed it as one of our options. Type script is a higher level version of Java script and since jQuery is supporeted by JavaScript we decided to use Javascript to have a consistent language syntax with out Node.js API as well.

7.3 API

For our API we had the choices of using Node.js ,PHP, Python, Ruby, Java and Perl. For Perl and Python we ruled them out since Ruby was created as a replacement for these languages. Java web is used to create dynamic web pages from the server side but since we are populating the HTML dynamically on the front end using our scripting language with API calls we decided not to use java. Using PHP would be a huge security risk since it's open source and any one could have seen our source code and figured out how we stored our sensitive information and used brute force attacks to access those records, it is also not suitable for large applications and since our API is a large controller we ruled PHP out as one of our options.

Between Node and Ruby we decided to use Node because of its ability to create real time applications that are data-intensive due to its excellent I/O paradigm.

For the node API we use a set of NPM libraries that we installed. We use express to serve the results of the API calls back to the clients machine. Bycript is a library we use for encryption purposes due to its ability to randomly generate salts and still be able to compare a stored record that's encrypted with a record given. QRCode is used to generate QR codes that receptionists can use in order to make their job a lot easier. To communicate with out Mongo Database efficiently we use the mongoose library for its powerful built in queries and reliability. In order to store files of large binary data we use a package called mongoose-gridfs that allows us to store files in Mongo that is larger than its 16MB record limit by splitting these files into chunks that are stored. We use child-process in order to call our executable C++ program from the API with the parameters that they need. And finally we use fs in order to manage the files that are uploaded to our server.

7.4 Algorithm

For the algorithm we needed an imperative programming language that is both Object Oriented and procedural. Because of our familiarity with C++ and Java those where our first options. Since Java has many different JVM's, Java is in many aspects considered to be slower and was discouraged by our client, we opted to use C++ as our language for the algorithm.

To process the images and create a point cloud from them we considered using AliceCode , OpenCV and OpenMVG. Since AliceCode has very poor execution speed and is unreliable since the photos needed to be perfect we removed it from our list of options. OpenCV was considered but since it was too experimental it resulted in unreliable results. We chose OpenMVG because it was more reliable because of it broader control over how the algorithm interprets the images to 3D points.

7.5 Database

There are many different options of Databases. We had to choose between SQL, NoSQL (which includes MongoDB and Neo4j) and BlobDBs. The requirements of the project state that we need to store blob files, and SQL does not have this feature, so we decided to ignore SQL options. We also require the use of a schema to be manually stored, so the BlobDB options were also ruled out. This left us with a choice between MongoDB and Neo4j. We ended up choosing MongoDB because it is an extremely scalable and agile NoSql database that meets all of the requirements for storage that our system has.

7.6 Testing

7.6.1 Travis CI

We are using Travis CI as our continuous integration testing tool. Travis was the option we chose because it is easy to use and has a fast system for setting up. As we are using GitHub, Travis CI integrates really well with GitHub and allows for an automated testing system to be called when a commit is pushed to any branch in our repository.

7.6.2 Mocha

We chose Mocha as our unit and integration testing framework. Mocha is a JavaScript testing framework for NodeJS programs, featuring browser support, asynchronous testing, test coverage reports, and use of any assertion library (from which we used Chai). As our system runs off of a Restful NodeJS API mocha provides all the needed features to test our system thoroughly.

Mocha provides all the necessary packages to check code coverage, as well as perform performance tests.

7.6.3 Bechtest

Integrated performance testing for Mocha based unit testing. No special tests are needed for this package, as it uses the unit and integration tests already created. This allows for fast and easy performance checks on the system.

7.6.4 Sonar Cloud

SonarCloud is an online service to catch Bugs and Security Vulnerabilities in your Pull Requests that can be used to check code quality. This service links to Travis CI and can be easily used with out repository.

7.7 MediaDevices Web API

The MediaDevices interface provides access to connected media input devices like cameras and microphones, as well as screen sharing. In essence, it lets you obtain access to any hardware source of media data. This API allows for a video stream footage to be captured from a the dental device, so that the footage can be used to generate the 3-Dimensional tooth model.