Sensor fusion for training doctors

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Abstract

My research is about stuff.

It begins with a study of some stuff, and then some other stuff and things.

There is a 300-word limit on your abstract.

Acknowledgements

Acknowledge all the things!

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Chapter 1

Introduction

Some stuff about things. [1] Some more things.

Inline citation: Anne Author. Example Journal Paper Title. *Journal of Classic Examples*, 1(1):e1001745+, January 1970

[2]

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Chapter 2

Background Information

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Chapter 3

Requirements and Analysis

This Chapter establishes the requirements and analysis for this work. The developments of the requirements is a crucial part of the analysis for almost all of the software development projects. This phase is extremely useful, as for it's flexibility - if things that are unnecessarily complicated are discovered, or are less important to the client, they can be disregarded or their importance could be downgraded so that they take less time. This is significantly useful for the implementation phase. This is also the easiest time to communicate with the client, while the subject matter is strictly textual, so any major issues or changes to the specifications can be established here.

3.1 Problem Statement

Design a web based application, that allows surgeons to register an operation, upload and view all the extracted data coming from the operating theatre's sensors.

3.2 Software Requirement Listing and Prioritization

This stage facilitates a comprehensive understanding of the client's needs and to appreciate the potential complexity of the system. Subsection 3.2.1 details the functional requirements of our system. Functional requirements show the behaviours of the system - what the client wants the system to do. Subsection 3.2.2 goes through the non-functional requirements, which affect the system's performance . The requirements were gathered through discussion with the client and also by continually iterating over what the application would be used for, so that additional focus should be given on the user needs.

As mentioned, the requirements have been divided into functional and non-functional [3]. They have also been prioritised according to the MoSCoW prioritisation technique [4], in order to guide the progress of the project and to ensure that a base-level application that achieved the goals of the project. The MoSCoW priorities refer to the order of design and development in order. Must have, Should Have, Could Have, and Won't have requirements.

3.2.1 Functional Requirements

ID	Functional Requirements	Priority
	Uploading a new Operation	
1	The platform shall support a User Interface that will allow the user to register a new operation	Must
2	The platform shall be able to take as input from the user, the hospital that the operation took place	Must
3	The platform shall be able to take as input from the user, the operating room that the operation took place	Must
4	The platform shall be able to take as input from the user, all the staff that participated in the operation	Must
5	The platform shall be able to take as input from the user, the type of the operation (Neuro-surgery, Hand surgery, Paediatric surgery etc.)	Must
6	The platform shall be able to take as input from the user, the specific patient that has under-gone the surgery including the patients unique identification number	Must
7	The platform shall be able to take as input from the user, all the video files that were produced during the operation	Must
8	The platform shall be able to take as input from the user, all the audio files that were produced during the operation	Must
9	The platform shall be able to take as input from the user, the file extracted from the patient's monitoring system	Should
10	The platform shall be able to record, store and distinguish data from different operating the-atres	Must
11	The platform shall be able to store all the input data from the user to a relational database	Must
12	The platform shall store all the data coming from an operation in a way that all relevant data of the operation could be extracted	Must
13	The platform shall be able to process the video, audio and patients monitoring files uploaded from the user	Must
14	The platform shall be able to extract all the meta-data from the input files (encoded date, size, duration, file type, file name, full file path)	Must
15	The platform shall be able to store the meta-data extracted from the input files, to the rela-tional database	Must
16	The platform shall be able to store the input files to an Azure Blob Storage Account	Must
17	The platform shall be able to link the files stored in the Azure Blob Storage with the relative operation identification number stored in the relational database	Must
	Searching for an Operation	
18	The platform shall support searching capabilities; the user of the platform must be able to search an operation/procedure using relevant criteria	Must

ID	Functional Requirements	Priority
19	The platform shall support filtering capabilities where the user can apply specific filters for an operation (hospital name, operating room number, from/to date, doctors name, patient's name, type)	Must
	Details of an Operation	
20	The platform shall be able to display a specific page where the user can see all the relative information and details of a specific operation	Must
21	The platform shall be able to retrieve all the relevant data from the operation (video data, microphone data, patient's monitoring system data etc.)	Must
22	The platform shall be able to convert the data coming from the different sensors to easily handled format (e.g. convert a variety of video input to .avi)	Could
23	The platform shall support the capability of switching to a specific moment in time and view all the recorded data at that moment	Could
24	The platform shall be able to present to the user all the data recorded from the sensors at the same time. For example it could be able to view the panoramic camera, the light camera, the heart rate, the temperature of the room through the common factor of time.	Could
25	The platform shall provide the media files' URL to the user in order for the user to have access to them and re-play them	Must

Table 3.1: Functional Requirements

3.2.2 Non Functional Requirements

ID	Non-Functional Requirements	Priority
26	The platform shall use web browser as its user interface	Must
27	The platform shall support new sensor adding or should require minimal work for new, unknown sensor adding	Should
28	The platform shall store all the input data in a way that they could be extracted for machine learning purposes (machine learn-able data)	Must
29	The platform shall be independent of the format of the input data	Should
30	The platform shall work on a wide range of operating conditions (screen size, internet connection, performance)	Must
31	The platform shall be a C# web application with an MySQL Database	Should
32	The System shall present search results within 5 seconds	Should

Table 3.2: Non-Functional Requirements

3.3 Domain Modelling

The domain model looks to identify the objects of a system in terms of the requirements. It provides a conceptual real-world view of the system and enables a simplistic overview of the system's functionalities in terms of the problem domain entities [5]. More specifically, the classes were derived from the requirements list where the identified entities were marked in bold. Therefore, it is now possible to create a simple draft domain model from these entities. Furthermore, objects which were deemed redundant from this iteration were also discarded to refine the list of entities. This initial model was then revised and additional domain objects were added. Similar to previous analyses, the domain model is therefore the result of an iterative process.

Following the refinement process, using the identified entities of the requirements list, the domain model was revised in order to find any unspotted domain entities that weren't already in the requirements list. Figure 3.1 shows the model that resulted after the various iterations. It is a summary of the responsibilities of the system on a general level and was the basis for constructing the use cases in subsection 3.4.

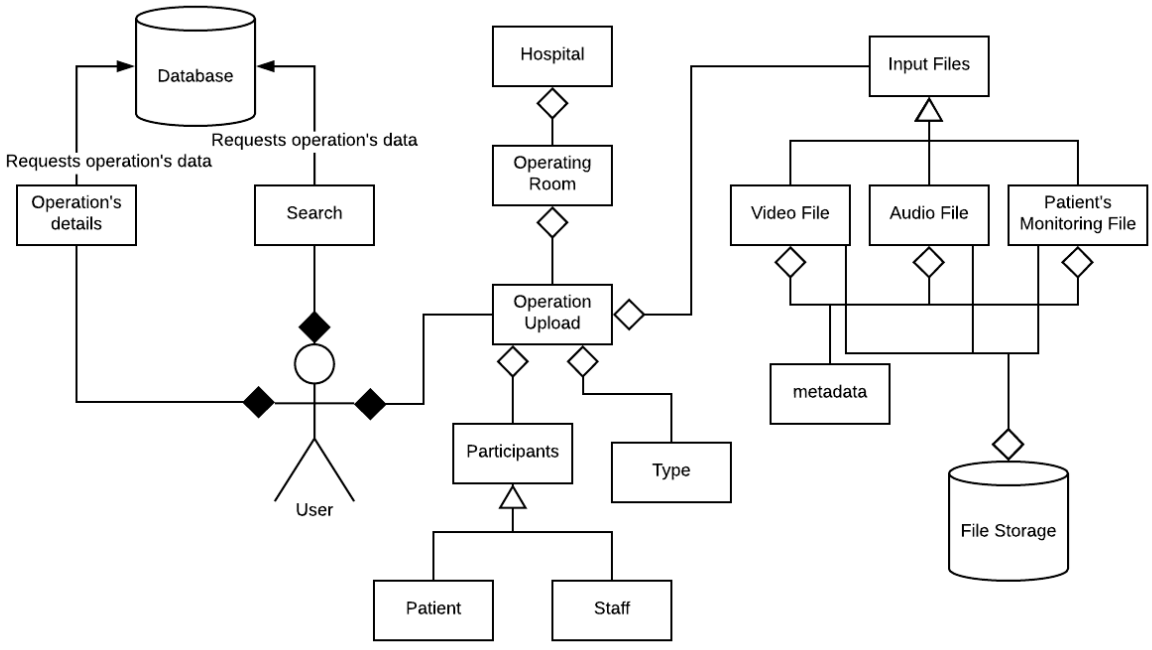

Figure 3.1: Conceptual model of the system's problem domain

3.4 Use Case Analysis

Following the domain modelling and the gathering of requirements analysed in sections 3.3 and 3.2 respectively, use cases were developed. The defined domain entities and requirements were used to construct the use cases and their basic relationships. The construction of the uses cases allows the solid organisation of the functional requirements of the project, in order to make sure that they meet the front-end requirements and also to make sure that they are fully encompassing. A use case describes a scenario where a user interacts with the application in order to achieve a specific outcome [6]. Use cases are described from the users point of view rather than a technical point of view. As such, use cases are very effective at visualising and communicating the final product to the client and incorporating the client's voice into the requirements of the project [7].
A complete overview of the identified use cases is shown in Table 3.3 and from Table 3.4 to Table 3.6, all the detailed specification for each use case are shown. Each specification includes details of each use case,the main flows, error flows, post-conditions, pre-conditions and the trigger event.

ID	**Use Case**
UC01	**Upload a new operation**
UC02	**Search for an operation**
UC03	**View operation detals**

Table 3.3: List of use cases

Use Case	Upload a new operation
ID	UC01
Brief Description	The user wishes to register the operation to the System
Preconditions	User must have all the necessary files and information of the operation
Main Flow	1. Home page is displayed 2. The User selects to register a new operation 3. The User enters the hospital name 4. The User enters the operating room number 5. The User enters all the staff that participated in the operation 6. The User enters the patient that underwent the surgery 7. The User enters the type of the operation 8. The User selects all the relevant video files 9. The User selects all the relevant audio files 10. The User selects the patient's monitoring file
Post Conditions	A new operation has been registered to the database and the files have been uploaded to the file storage
Alternative Flows	The User no longer wishes to upload yet the operation to the System and cancels the registration of the operation
Error Flow	1. The User does not enter any of the 1-7 fields and at least one input file 2. An error message is displayed
Trigger Event	The user chooses to add new operation

Table 3.4: Use Case 01 - Upload a new operation

Use Case	Search for an operation
ID	UC02
Brief Description	The User wishes to find an operation from the database
Preconditions	At least one operation must have been registered to the system
Main Flow	1. Home page is displayed 2. The 20 most recent uploaded operations are displayed 3. The User uses the Filters to input hospital name,operating room number, from/to date and participated staff 4. The filtered results are displayed, ordered by date (from most recent to oldest)
Post Conditions	The User can see the Operations that correspond to the Filters they have applied
Alternative Flows	The Operation that the User searches for and the Filters applied produce no results
Error Flow	None
Trigger Event	The User wishes to Search for an Operation

Table 3.5: Use Case 02 - Search for an operation

Use Case	View operation details
ID	UC03
Brief Description	The User can view the details of an Operation
Preconditions	1. At least one operation must have been registered 2. The User must have searched for an Operation
Main Flow	1. Home page is displayed 2. The User searches for an Operation 3. The User views the filtered results 4. The User selects the desired Operation 5.The User views the Operation details
Post Conditions	The Operation details are displayed to the User
Alternative Flows	The User does not wish to view the Operation details and so goes back to the home-page
Error Flow	System fails to report Operation Details
Trigger Event	The User wishes to view the details of a listed Operation

Table 3.6: Use Case 03 - View operation details

3.5 Use Case Diagram

The use case diagram which is depicted in Figure 3.2 is derived from the use case Listing which is basic foundation for the creation of the use case diagram.

3.6 Mock-ups

Analysis of the requirements and the use cases resulted in the creation of a series of mock-ups. The reason for creating the mock-ups is to ensure the realization of the requirements and pre-emptively identifying any issues. The mock-ups include only the “must have” and “should have” requirements as the could have requirements entail further investigation for feasibility.

The Use Cases and the analysis of the requirements identify 3 main views that were needed in the project. The first one is the “Add new Operation” View where the user can register a new operation to the system. This means that the user can enter all the details of a specific operation like the

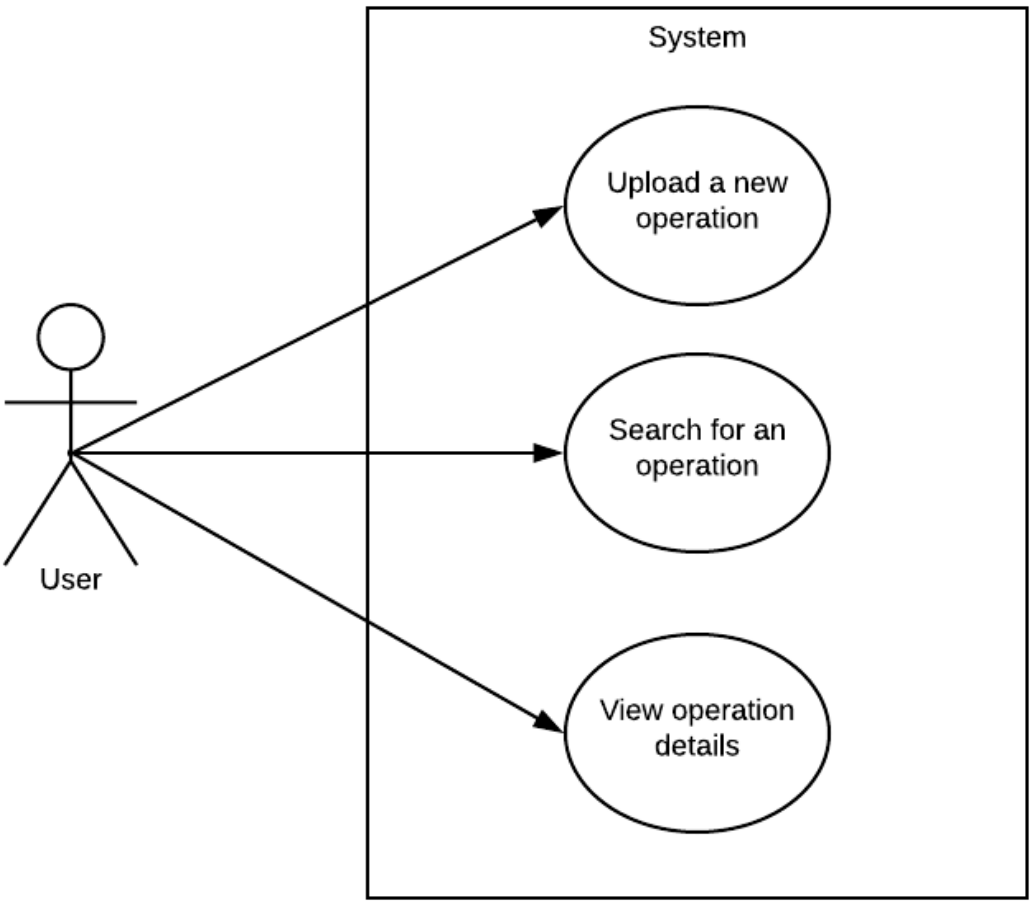

Figure 3.2: Use case diagram

hospital and the room that the surgical operation was performed, the patient's name, the participated staff and finally, the user can upload all the files that were produced from the sensors during the operation (video files, audio files & the patient's monitoring file).

The second one is the "Search for an Operation" view which is also the Home Page. This is the first screen that the user sees and it is used to display the 20 most recent uploaded operations, ordered by time. The user can also apply specific filters like hospital, operating room number, specific patient etc., in order to limit the result and find a specific operation of interest.

The third and last view is the "View Operation Details". After the user has selected the desired operation from the "Search fro an Operation" page, the operation details page is loaded where the user can see all the relative information of the operation, gathered in one page. The three aforementioned views are presented in the figures below.

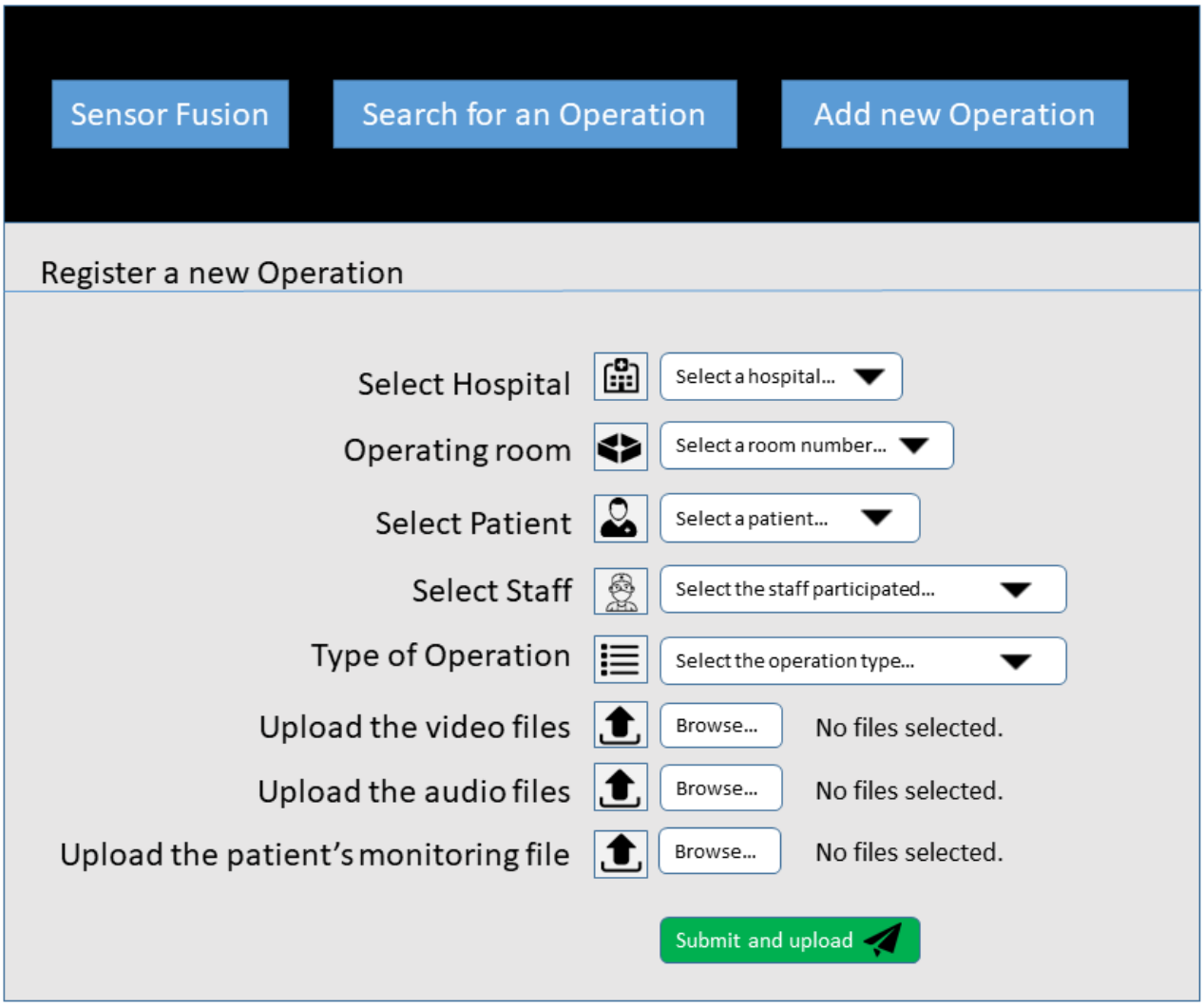

Figure 3.3: "Add new Operation" View

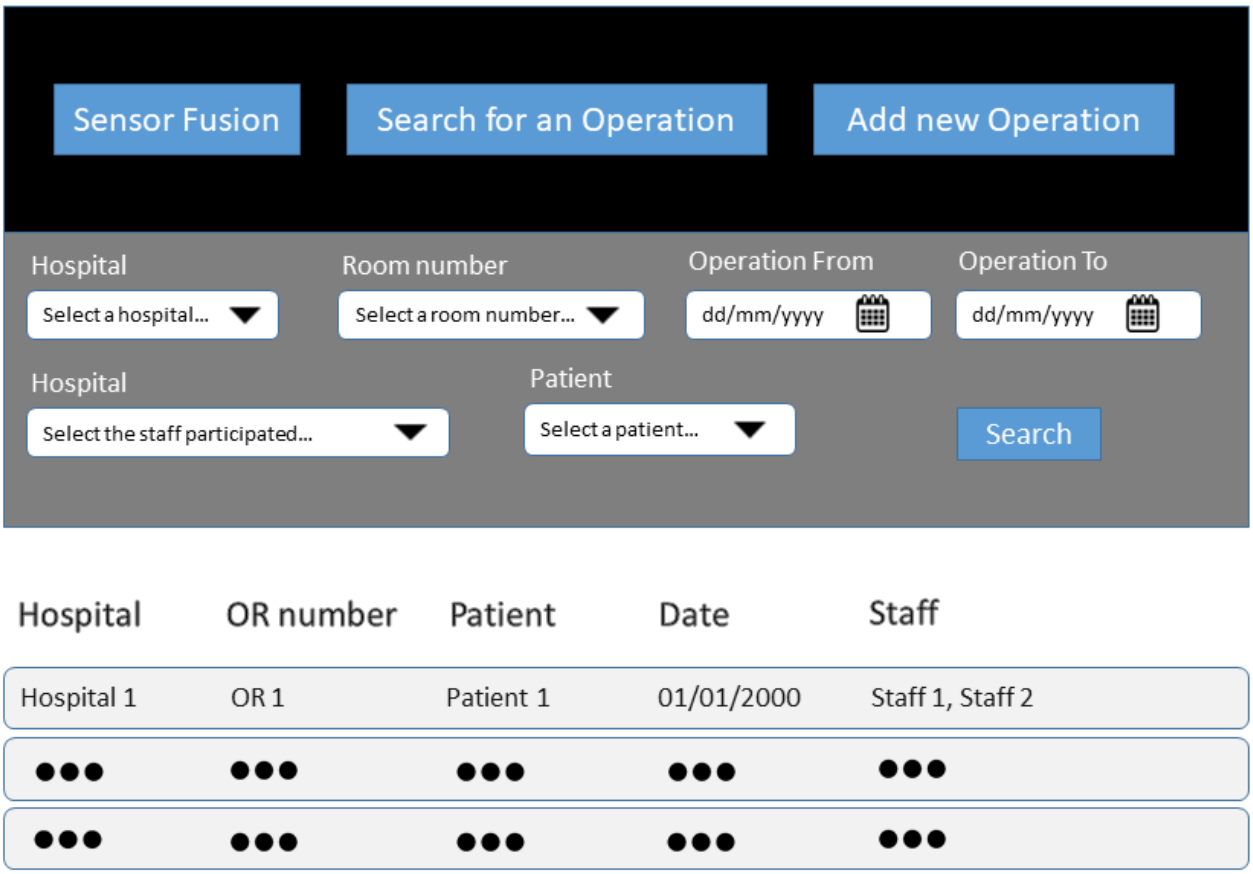

Figure 3.4: "Search for an Operation" View

Operation with Operation ID: xx

Properties	Details
Patient's full name	John Andersson
Hospital	Bernet General Hospital
Operating Room Number	102
Date started	02/08/2018 16:38:04
Duration	45.21 minutes
Type of operation	Endocrine Surgery
Staff participated	Nick Backhouse, Rebecca Anderson
Video source: 1	https://sensorfusionstorage.blob.core.windows.net/operation1/video1.mp4
Video duration	35.2 minutes
Size	423 Mb
Encoded Date	02/08/2018 16:38:04
Type	Mp4
Video source: 2	https://sensorfusionstorage.blob.core.windows.net/operation1/video2.mp4
●●●	
Audio source: 1	https://sensorfusionstorage.blob.core.windows.net/operation1/audio1.mp3
●●●	
Audio source: 2	https://sensorfusionstorage.blob.core.windows.net/operation1/audio2.mp3
●●●	
Patient's monitoring file	https://sensorfusionstorage.blob.core.windows.net/operation1/monitorFile
●●●	

Figure 3.5: "Operation Details" View

Chapter 4

Design

The analysis performed in Chapter 3 allows a full outline of the system requirements, the entities of the system and their assigned interactions, and leads onto the development of the full design of the software. The design phase starts with the design and the architecture of the system that is going to be built.

4.1 Architecture and System Structure

The system is a typical B/S (Browser/Server) framework with a client browser sending requests and responses and a Kestrel server which is the default cross-platform HTTP server for ASP.NET Core projects. The server is running c# (version 7.0) with a MySQL database. The server implementation listens for HTTP requests and surfaces them to the app as sets of request features composed into an HttpContext [8]. ASP.NET Core communicates with the MySQL database which is hosted in Azure. The structure of ASP.NET Core is shown in figure 4.1.

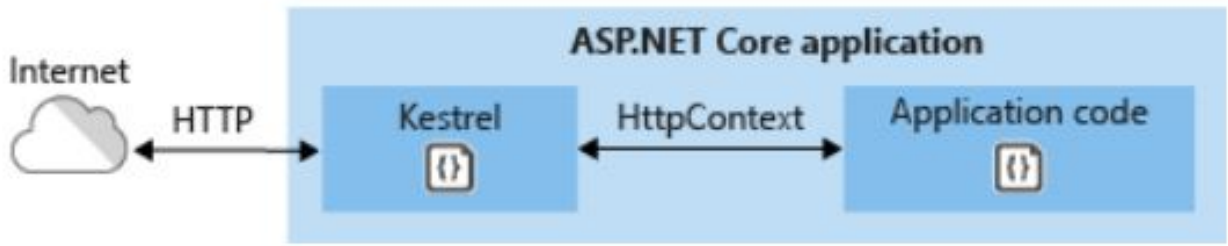

Figure 4.1: ASP.NET Structure

The architectural framework is divided into four basic tiers: front-end, back-end, database, and file storage.

1. **Front-End**: the front end is user interface where the user completes a series of operations to control the application which is supported by HTTP request and HTTP response. It contains HTML code, JavaScript, JQuery and CSS)

2. **Back-End** when a static HTTP response is received from the web browser, ASP.NET Core will create an HttpRequest object that contains the request data, and invoke the correspondent view to handle this object. After the handle process, it will create and return a new HttpResponse object to the front-end view.

3. **Database**: ASP.NET Core controls the MySQL relational database which is hosted in Azure.

4. **File Storage**: The files selected by the user are uploaded to Azure Blob Storage.

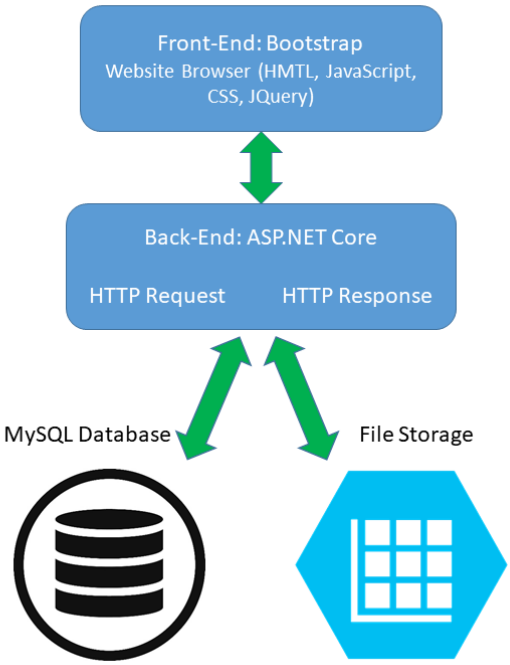

Figure 4.2: Application General Structure

4.2 Model-View-Controller Pattern

Due to the time limitations of the project the lack of experience in web designing, it was more appropriate to create a basic user interface and the devote the majority of the time to developing a robust back-end. Therefore, it was very important that the architecture of the application made a separation between the user interface and the back-end processing.

MVC framework is a one of the most popular design patterns which is motivated by the separation of the UI and the processing performed to generate it. The MVC has been conceptualised for many years, and thus it precedes the inception of web applications and therefore, many efforts at applying the model to web applications through frameworks have been controversial.

Since most of the time has been devoted into developing the back-end than the front-end of the application, it is quite likely that at some point in the future the front-end would be replaced with a more aesthetically pleasing one.

The Model-View-Controller (MVC) architectural pattern separates an application into three main groups of components: Models, Views, and Controllers. This pattern helps to achieve separation of concerns. Using this pattern, user requests are routed to a Controller which is responsible for working with the Model to perform user actions and/or retrieve results of queries. The Controller chooses the View to display to the user, and provides it with any Model data it requires [9].

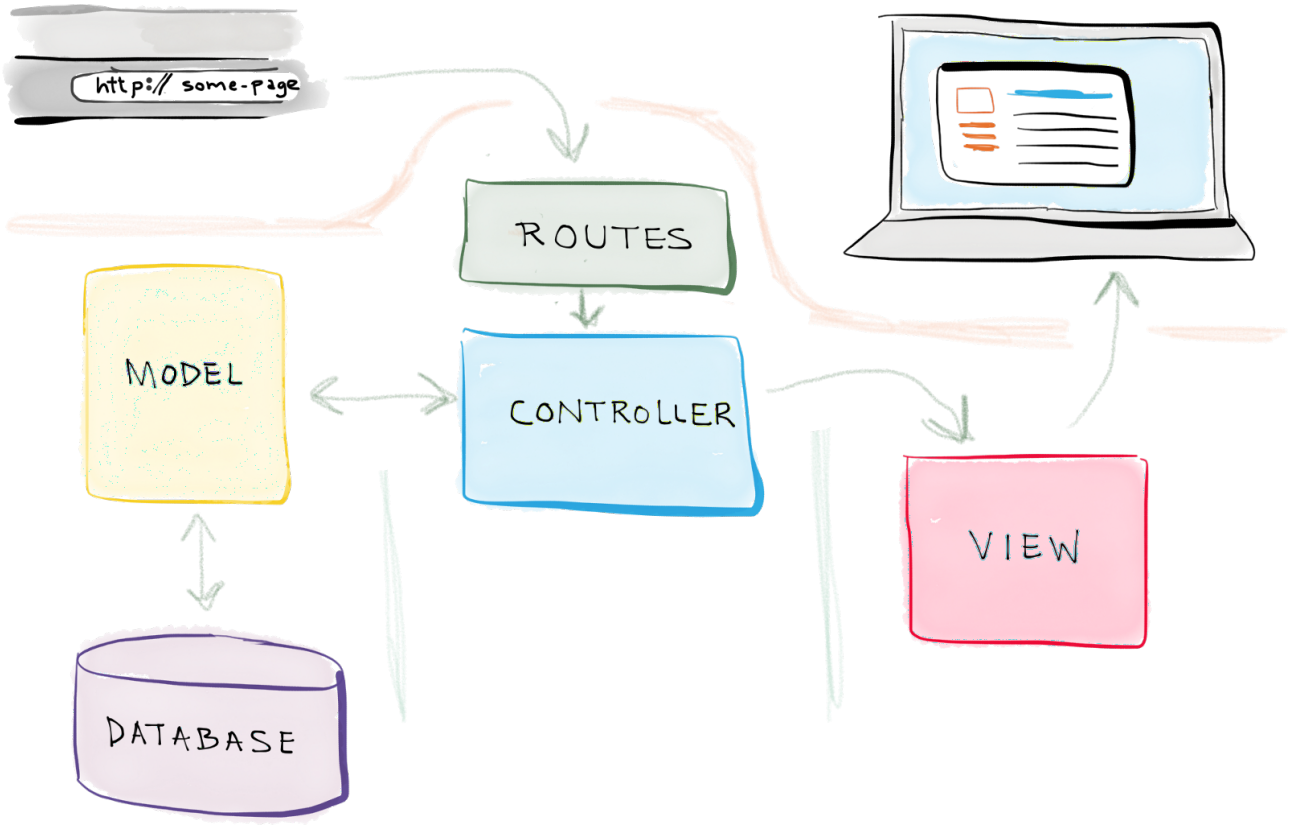

Figure 4.3: The Model-View-Controller Pattern of ASP.NET Core

4.3 Design Class Diagram

4.4 Database Design and ERD

Chapter 5

Implementation

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Chapter 6

Testing

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Chapter 7

Conclusion and Project evaluation

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Appendix A

An Appendix About Stuff

(stuff)

Appendix B

Another Appendix About Things

(things)

Appendix C

Colophon

This is a description of the tools you used to make your thesis. It helps people make future documents, reminds you, and looks good.

(example) This document was set in the Times Roman typeface using LaTeX and BibTeX, composed with a text editor.

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