



Sensor fusion for training doctors

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Department of Computer Science

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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.

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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 its 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 [2]. They have also been prioritised according to the MoSCoW prioritisation technique [3], 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 undergone 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 theatres	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 relational 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 [4]. 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 section 3.4.

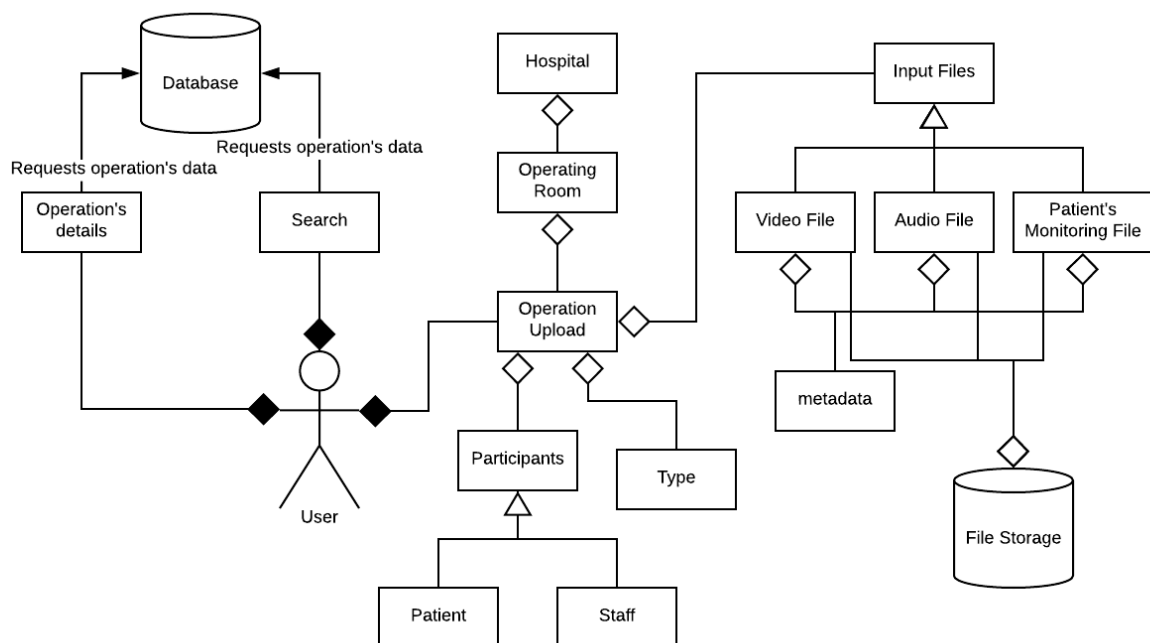


Figure 3.1: Conceptual model of the system's problem domain

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 [5]. 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 [6].

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 details

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	<ol style="list-style-type: none">1. Home page is displayed2. The User selects to register a new operation3. The User enters the hospital name4. The User enters the operating room number5. The User enters all the staff that participated in the operation6. The User enters the patient that underwent the surgery7. The User enters the type of the operation8. The User selects all the relevant video files9. The User selects all the relevant audio files10. 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	<ol style="list-style-type: none">1. The User does not enter any of the 1-7 fields and at least one input file2. 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 1. At least one operation must have been registered 2. The User must have searched for an Operation
Main Flow	<ol style="list-style-type: none"> 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

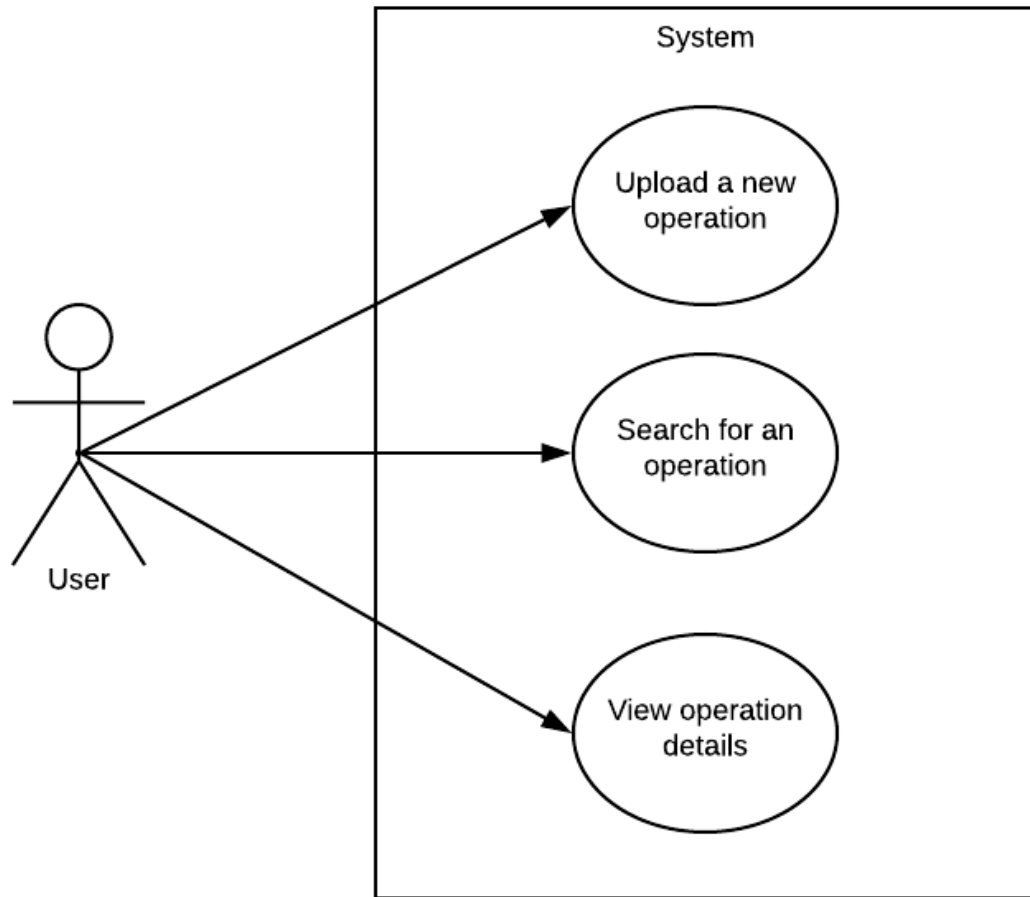


Figure 3.2: Use case diagram

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 for 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.


Sensor Fusion

Search for an Operation

Add new Operation


Register a new Operation

Select Hospital




Select a hospital... ▼

Operating room




Select a room number... ▼

Select Patient




Select a patient... ▼

Select Staff




Select the staff participated... ▼

Type of Operation



Select the operation type... ▼


Upload the video files



Browse...

No files selected.


Upload the audio files



Browse...

No files selected.

Upload the patient's monitoring file



Browse...

No files selected.

Submit and upload




Figure 3.3: “Add new Operation” View

Sensor Fusion

Search for an Operation

Add new Operation


Hospital

Select a hospital... ▼


Room number

Select a room number... ▼

Operation From

dd/mm/yyyy 

Operation To

dd/mm/yyyy 

Hospital

Select the staff participated... ▼

Patient

Select a patient... ▼

Search

Figure 3.4: “Search for an Operation” View

Sensor Fusion

Search for an Operation

Add new Operation

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 and Implementation

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 [7]. 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.

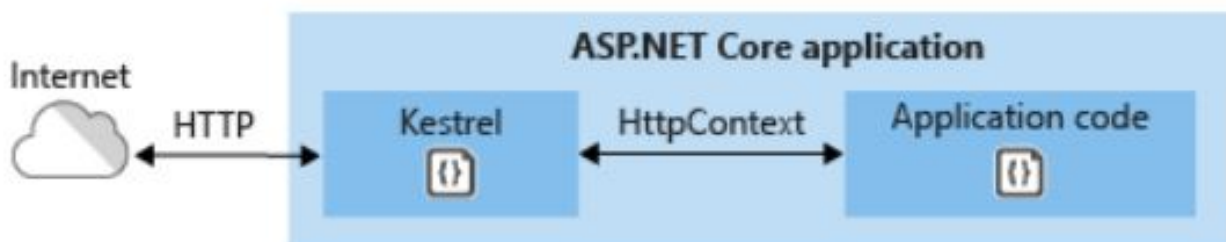


Figure 4.1: ASP.NET Structure

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.

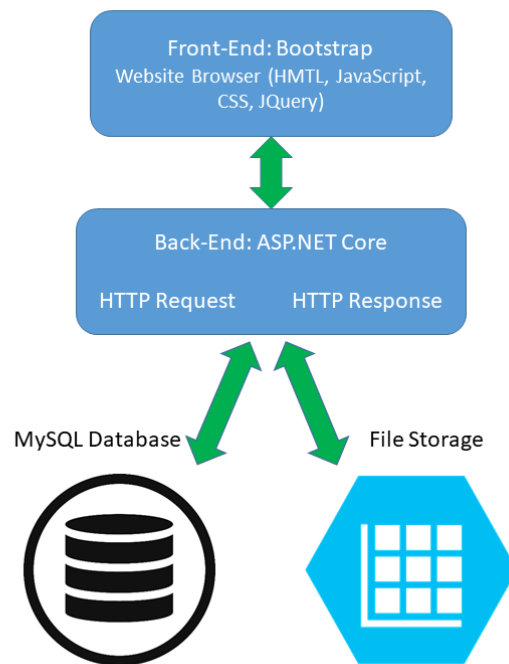


Figure 4.2: Application General Structure

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 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 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 [8]. 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].

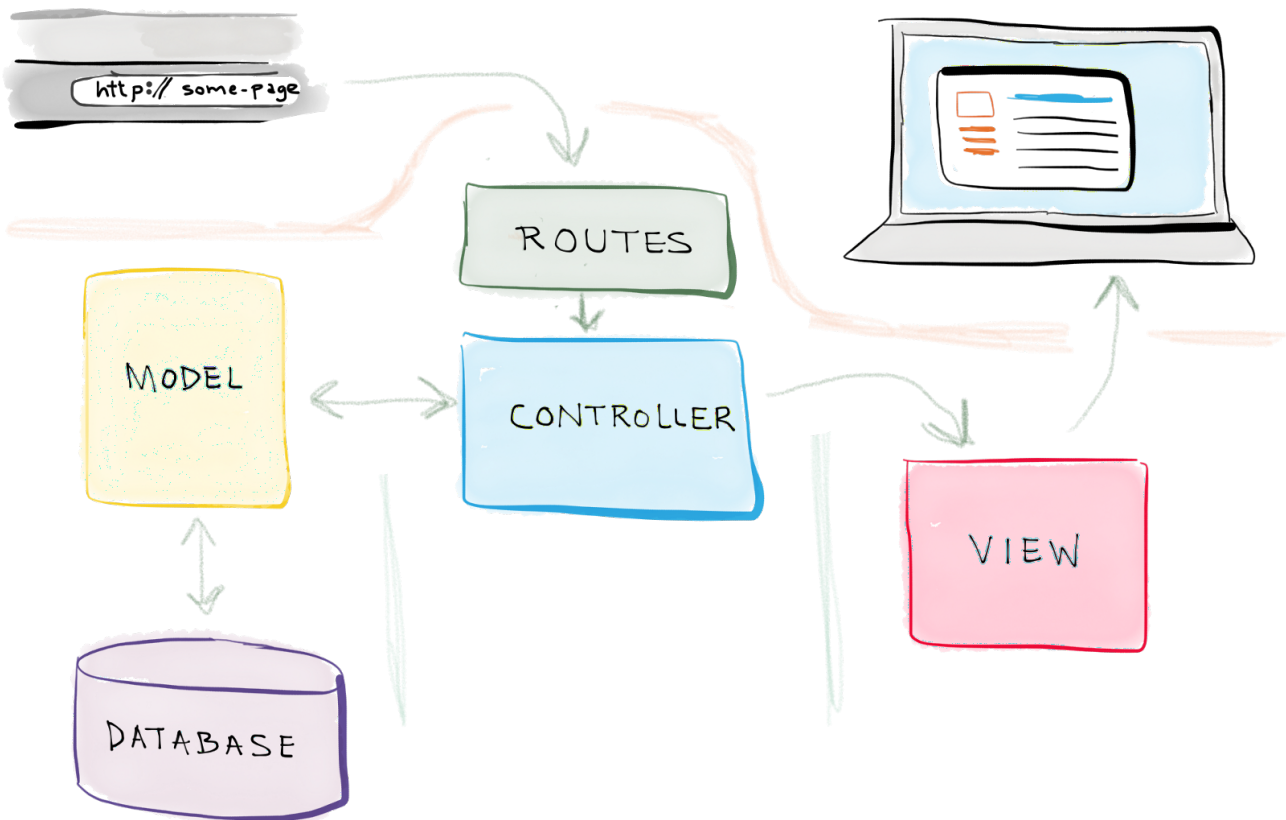


Figure 4.3: The Model-View-Controller Pattern of ASP.NET Core

The server-side MVC (Model-View-Controller) framework (as depicted in figure 4.3 has three core layers:

1. **The Model:** The Model in an MVC application represents the state of the application and any business logic or operations that should be performed by it. [9]. This is essentially a library of supporting methods which help the Controller in generating the data to pass to the View. Those methods are especially written to handle and populate data related to the particular View and are based on libraries of more generic functions built to provide helping functions to the Model tier.

2. **The View** Views are responsible for presenting content through the user interface. In ASP.NET Core Views use the Razor view engine which is a compact, expressive and fluid template mark-up language for defining views using embedded C# code. Razor is predominantly used to dynamically generate web content on the server and allows to cleanly mix server code with client side content and code. [9]. Razor view engine is also used for the opposite; embed c# code in HTML mark-up. As a general principle, there should be minimal, if not none, logic within the views, and any logic should be related to presenting the content/model, passed from the Controller.
3. **The Controller:** This is a set of classes that manages the relationship between the View and the Model [10]. It responds to user input, communicates with the Model, and “decided” which view to render and send back to the client side. Essentially, it controls the application logic for a particular unit and is responsible to call all the necessary methods from the Models in order to generate and pass the correct data to the View.

4.3 Design Class Diagram

The design class diagram represents a complete overview of the classes within the system, the methods they use and the links between them. One of the main aims of designing the class diagram, is to achieve high cohesion and low coupling. The design class diagram, shown in Figure 4.4 fully details all the internal entities of the system and maps the structure of the components of the software. As explained in subsection 4.2 the controller classes contain methods which are responsible for handling all entities of the system and updating specific states during their life-cycles, depending on the performed action. The notation used for this diagram is based on common industry notation for class diagrams [11] [12].

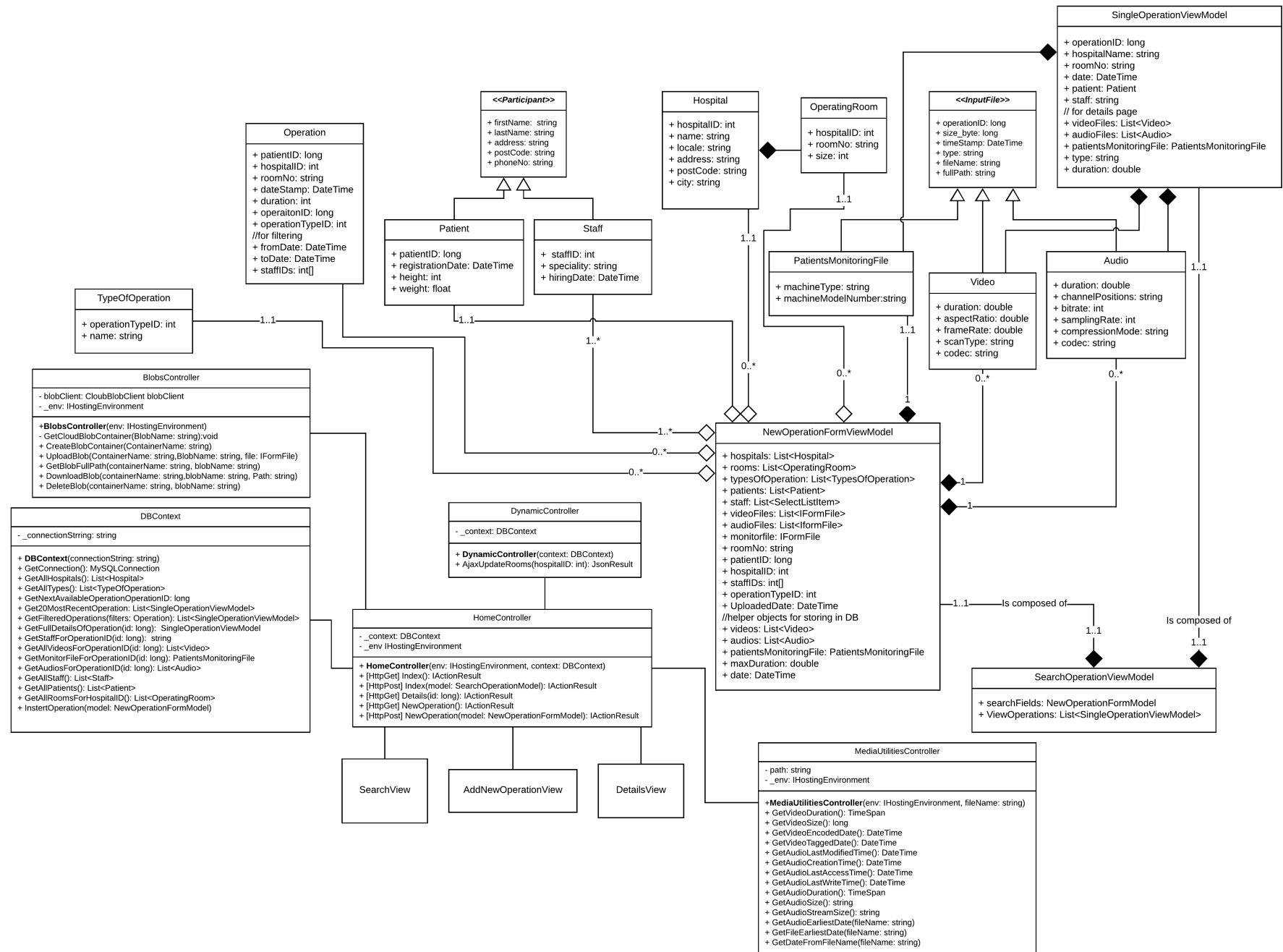


Figure 4.4: Design class diagram.

4.4 Database Design

4.4.1 Introduction

A database is a data repository where the data is managed and stored according to the data structure. It enables data sharing across an organisation, reduces data redundancy and increases data consistency. Database development doesn't have a unique way of implementing, and different data structures require different types of database. In regards to this application, the relational database was selected to represent the data structure. The main purpose of relational databases is to examine how data is related to each other. They translate the complicated data structure and data relationship into simple two-dimensional tables. In the relational model, data and relationships are represented as tables, each of which has a number of columns with a unique name.

Regarding this specific application, it was deemed that a MySQL [13] database is the most suitable relational database management system. MySQL is an easy to use, reliable, scalable and specifically designed and optimized for Web Applications. Although it requires additional configuration when the application is deployed in the server, it is powerful enough to support the extensive complexity that the current application needs.

4.4.2 Conceptual Schema

Conceptual modeling or conceptual database design is the process of constructing a model of the information use in an enterprise that is independent of implementation details, such as the target DBMS, application programs, programming languages, or any other physical considerations. This model is called a conceptual data model [14]. The Conceptual Schema is shown in figure 4.5.

4.4.3 Logical Schema

The logical database design phase maps the conceptual data model on to a logical model, which is influenced by the data model for the target database. The logical data model is a source of information for the physical design phase, providing the physical database designer with a vehicle for making trade-offs that are very important to the design of an efficient database [14]

While the conceptual model is independent of all implementation details, the logical model assumes knowledge of the underlying data model of the target DBMS. The Entity Relationship diagram (Figure 4.6) is created based on the analysis of logical schema. All attributes of every entity have been labelled in the diagram.

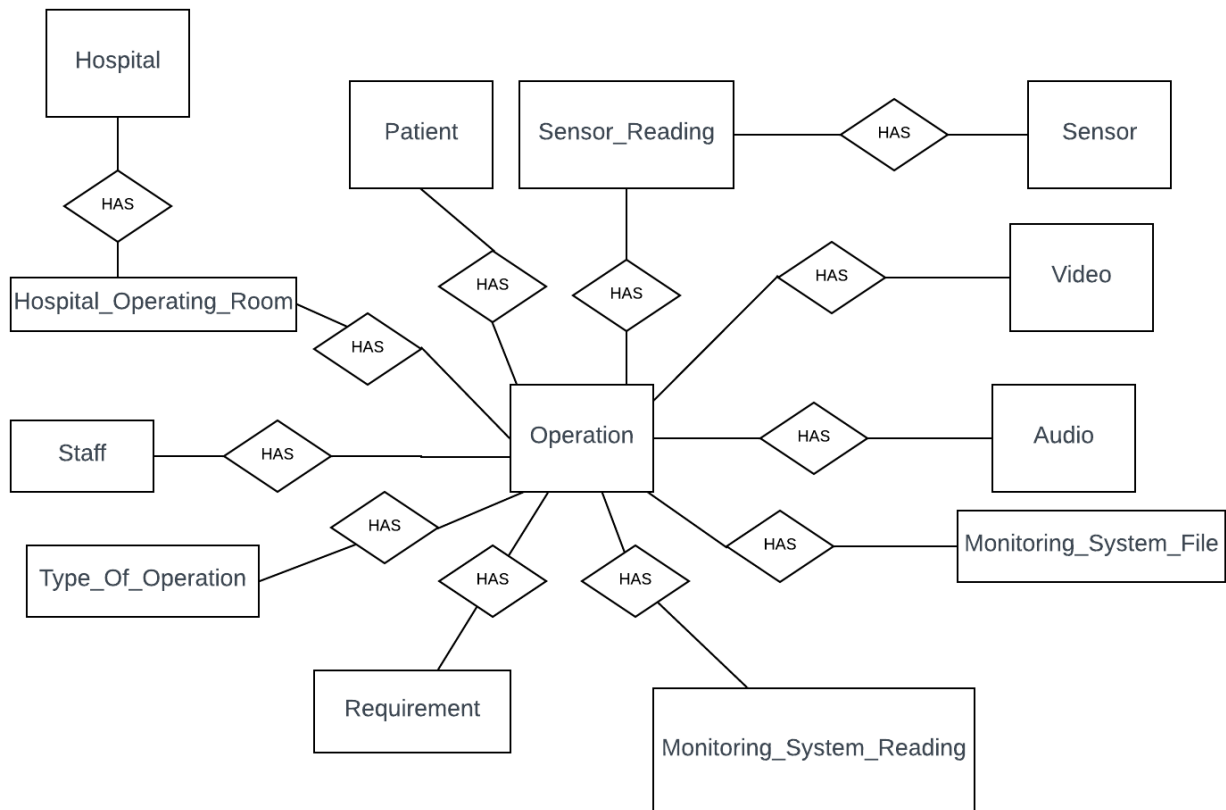


Figure 4.5: Conceptual schema

4.4.4 Physical schema

In this final phase of the database design methodology, the logical database design (entities, attributes, relationships, and constraints) has to be translated into a physical database design that can will be implemented using the target DBMS, which in this case in a MySQL database hosted in Azure. Each attribute in the physical schema (Figure 4.7) has constraints which prevent storing invalid data and quickens up the data validation process, requiring no additional code to rewrite the data validation interfaces. The physical database has been especially designed in order to require minimal work for new sensor adding. For example, if a new sensor is added in the future, the schema wouldn't have to be changed and a single row in the "Sensor" table is the only required action. Each sensor reading is recorded to the "Sensor_Reading" relation.

4.5 Pages Implementation

Since, the front-end part of the application is fairly straight-forward, the implementation stage will be split into three subsection which are also the three main views of the application. The first part of the implementation is the page where the user can upload a new operation, the second part is where

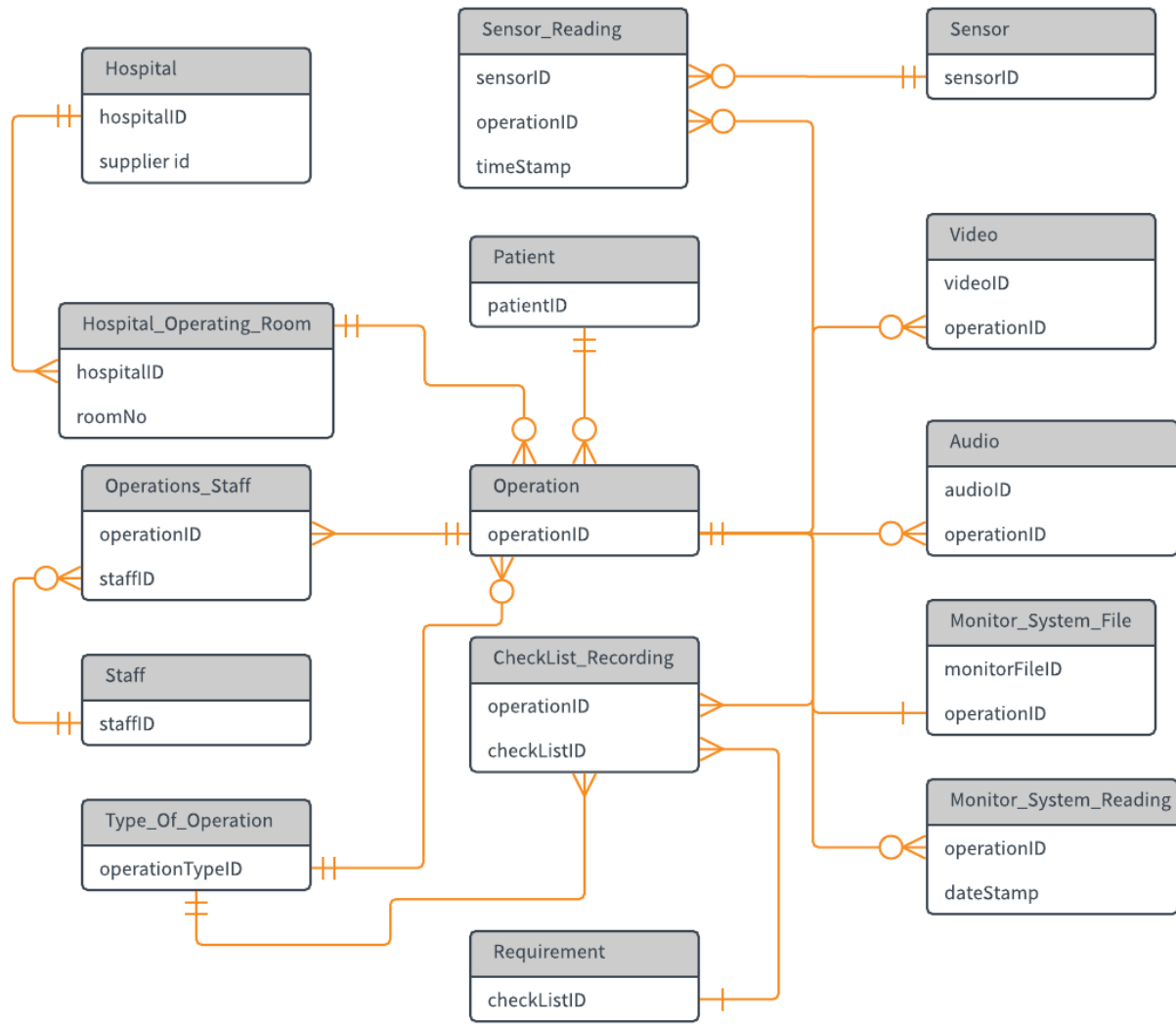


Figure 4.6: Entity-Relationship Diagram

the user can make a search for a specific operation stored in the relational database and choose an operation of their choice, and the third page is where the user can see all the details that are related to the specific operation. The application has a single Controller, which as mentioned in 4.2, is an interface between the Model and the View components, processes all the logic and incoming requests, manipulates data using the Model component and interacts with the Views to render the final output. In the HomeController of the application, there are three main methods that correspond to the three main views, which will be analysed in detail in the following subsections.

4.5.1 “Register new operation” Implementation

In this subsection, the process of registering a new operation to the system is explained. The HomeController of the application has two methods with exactly the same names (“New Operation”)

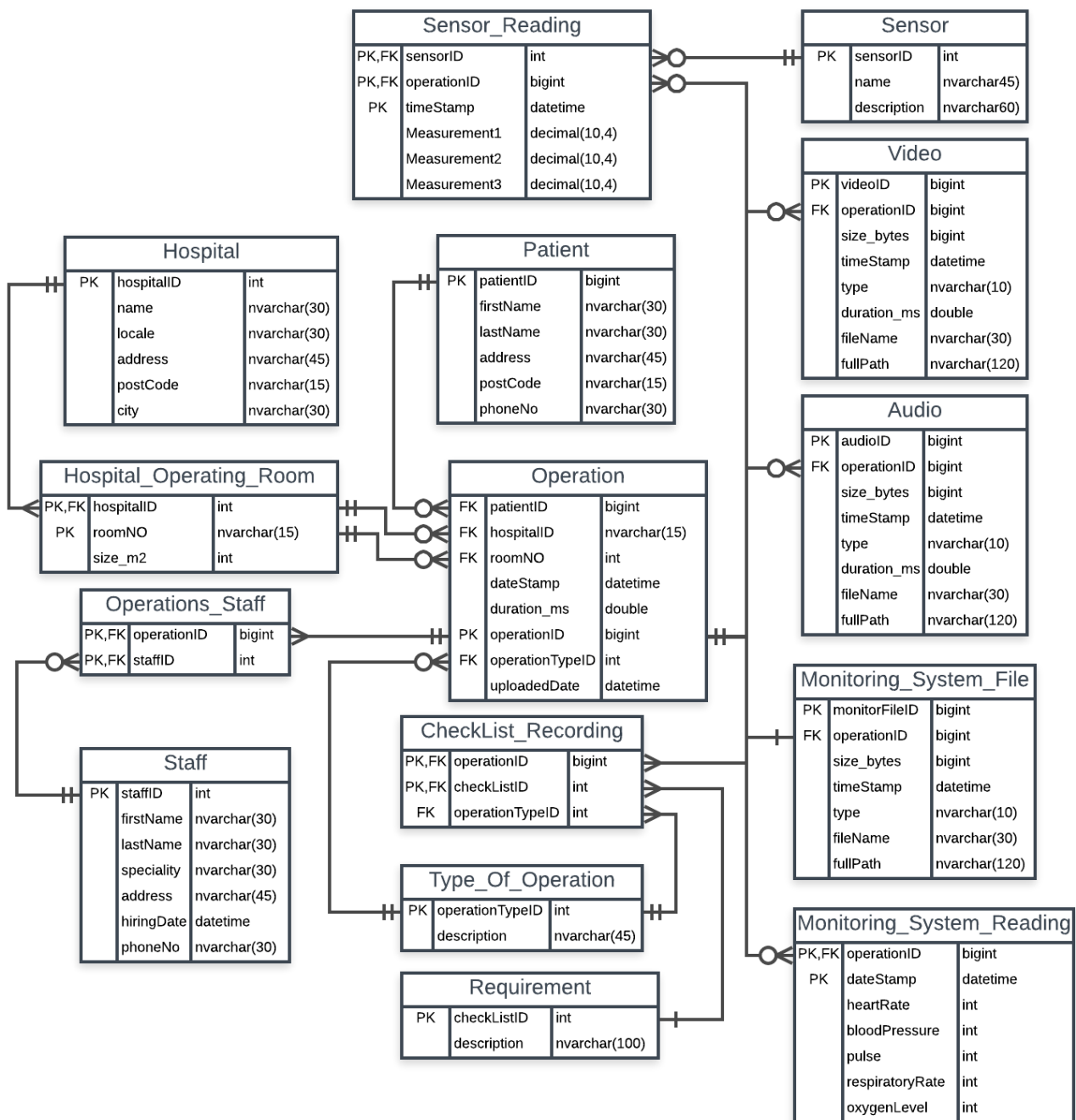


Figure 4.7: Physical database schema

that correspond to the `HttpGet` and `HttpPost` request from the client side. When the user selects to load the “Add new Operation” View, the `HttpGet` method is called from the Controller. Due to the fact that this page doesn’t require a already defined model of the application, a new `ViewModel` had to be created (“`NewOperationViewModel`”). At this stage, the controller instantiates the `ViewModel`, queries the database to load it and then passes it to the rendered View for display. The `HttpGet` method of the `HomeController` is shown in figure 4.8.

```
[HttpGet]
public IActionResult NewOperation()
{
    var model = new NewOperationFormModel();

    model.typesOfOperation = new SelectList(_context.GetAllTypes().Select(x => new SelectListItem { Value = x.operationTypeID.ToString(), Text = x.name }), "Value", "Text");
    model.staff = new SelectList(_context.GetAllStaff().Select(x => new SelectListItem { Value = x.staffID.ToString(), Text = "ID: " + x.staffID + " " + x.firstName + " " + x.lastName }), "Value", "Text");
    model.hospitals = new SelectList(_context.GetAllHospitals().Select(x => new SelectListItem { Value = x.hospitalID.ToString(), Text = x.name }), "Value", "Text");
    model.patients = new SelectList(_context.GetAllPatients().Select(x => new SelectListItem { Value = x.patientID.ToString(), Text = "ID: " + x.patientID + " " + x.firstName + " " + x.lastName }), "Value", "Text");
    SelectListItem default = new SelectListItem { Text = "Please select a room...", Value = "error", Selected = true };
    List<SelectListItem> defaultSelection = new List<SelectListItem>();
    defaultSelection.Add(default);
    model.rooms = defaultSelection;

    return View(model);
}
```

Figure 4.8: NewOperation (HttpGet Request)

After the model is passed to the view, all the information, in regards to the model, will be displayed. The user here, enters all the information related to the specific operation (hospital, operating room, participated staff) and uploads the input files that have been extracted from the sensors. The information entered from the user are passed to the server using the ASP.NET Core MVC Model Binding. Model binding in ASP.NET Core MVC maps data from HTTP requests to action method parameters. When MVC receives an HTTP request, it routes it to a specific action method of a controller. It determines which action method to run based on what is in the route data, then it binds values from the HTTP request to that action method’s parameters [15].

Before the web application posts back to the server, JavaScript validation has to be performed to ensure that the user conforms with the application’s requirements. More specifically, the user has to select a value from all the dropdown menus, and select at least one video file or one audio file or the patient’s monitoring system file. The user interface that the user uploads a new operation is shown in figure 4.9. It is important here to mention that the field “Operating Room” depends on the selection of the specific hospital and cannot be pre-populated. Therefore, a request had to be submitted to the server without posting back and so AJAX had to be used. The section where the client sends a request to the server, in order to query the database and return a JSON object is shown in figure 4.10. When the user has entered all the required fields and selected at least one input file for uploading, a `HttpPost` request is submitted to the server. As previously mentioned, model binding in ASP.NET Core easily binds the data coming from the View to the model, which is then passed back to the controller for manipulation. When the user submits the form, another method with the same name is

SensorFusion
Search for an Operation
Add New Operation
Contact

Register a new Operation

Select Hospital
+
Select a hospital...

Operating Room
Please select a room...

Select Patient
Select a patient...

Select Staff
Select Staff

Type of Operation
Select the operation type...

Upload the video files
Αναζήτηση...
Δεν επιλέχθηκαν αρχεία.

Upload the audio files
Αναζήτηση...
Δεν επιλέχθηκαν αρχεία.

Upload the patients monitoring system file
Αναζήτηση...
Δεν επιλέχθηκαν αρχεία.

Submit and Upload

© 2018 - SensorFusion

Figure 4.9: NewOperation Page

```

function UpdateRooms(val)
{
    var hospitalID = document.getElementById('HospitalDropDown').value;
    $.ajax({
        type: 'GET',
        dataType: "JSON",
        data: { hospitalID },
        url: 'Url.Action("UpdateRooms", "Dynamic")',
        success: function (result) {
            var dropdown = $('#RoomDropDown');
            dropdown.empty();
            dropdown.append($('

```

Figure 4.10: AJAX Call

called (“NewOperation”) which is responsible for the HttpPost requests and takes as input the ViewModel (NewOperationFormViewModel). After the server-side validation of the model has been successful, the controller must process and manipulate the incoming data, store the input files in the Azure blob storage and insert the new operation to the MySQL relational database. For the purpose of communicating with the database, an additional class has been created (DBContext). The

controller, takes as input the model originated from the View, manipulates the incoming data, and passes the same model to the “DBContext” class for updating the database. This is a very important issue, as the application had to follow the principle of separation of concerns. It is very critical here to mention that only the metadata extracted from the input files were stored to the MySQL database. The files themselves were only stored to a connected file storage account (Microsoft Azure Blob Storage). For this purpose, a new controller had to be created in order to store and retrieve the files from the file storage (BlobsController).

In regards to the extraction of the meta-data from the input files, additional NuGet packages and libraries (MediaInfo) had to be installed to the project. Furthermore, a dedicated class for processing, manipulating and extracting metadata from the files had to be created (“MediaUtilities”). This class enables the application to extract information from the input files that would have otherwise been almost impossible to gain. A very small sample of the obtained metadata include the exact starting date, the size of the files, codec used, encoded date, aspect ratio, frame-rate, duration of the media files and many more. The part where the application extracts the metadata from the media files is shown in figures

4.5.2 “Search for an operation” Implementation

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```

public class VideoInfo
{
    public string Codec { get; private set; }
    public int Width { get; private set; }
    public int Height { get; private set; }
    public double FrameRate { get; private set; }
    public string FrameRateMode { get; private set; }
    public string ScanType { get; private set; }
    public TimeSpan Duration { get; private set; }
    public int Bitrate { get; private set; }
    public string AspectRatioMode { get; private set; }
    public double AspectRatio { get; private set; }
    public string TaggedDate { get; private set; }
    public string EncodedDate { get; private set; }
    public long FileSize { get; private set; }

    public VideoInfo(MediaInfo mi)
    {
        Codec = mi.Get(StreamKind.Video, 0, "Format");
        Width = int.Parse(mi.Get(StreamKind.Video, 0, "Width"));
        Height = int.Parse(mi.Get(StreamKind.Video, 0, "Height"));
        Duration = TimeSpan.FromMilliseconds(int.Parse(mi.Get(StreamKind.Video, 0, "Duration")));
        Bitrate = int.Parse(mi.Get(StreamKind.Video, 0, "BitRate"));
        AspectRatioMode = mi.Get(StreamKind.Video, 0, "AspectRatio/String"); //as formatted string
        AspectRatio = double.Parse(mi.Get(StreamKind.Video, 0, "AspectRatio"));
        FrameRate = double.Parse(mi.Get(StreamKind.Video, 0, "FrameRate"));
        FrameRateMode = mi.Get(StreamKind.Video, 0, "FrameRate_Mode");
        ScanType = mi.Get(StreamKind.Video, 0, "ScanType");
        TaggedDate = mi.Get(StreamKind.Video, 0, "Tagged_Date");
        EncodedDate = mi.Get(StreamKind.General, 0, "Encoded_Date");
        FileSize = Int64.Parse(mi.Get(StreamKind.General, 0, "FileSize"));
    }
}

```

Figure 4.11: Extracting meta-data from video files

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4.5.3 “Operation Details” Implementation

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```

public class AudioInfo
{
    public string Codec { get; private set; }
    public string CompressionMode { get; private set; }
    public string ChannelPositions { get; private set; }
    public TimeSpan Duration { get; private set; }
    public int Bitrate { get; private set; }
    public string BitrateMode { get; private set; }
    public int SamplingRate { get; private set; }
    public string TaggedDate { get; private set; }
    public string EncodedDate { get; private set; }
    public string FileSize { get; set; }
    public string StreamSize { get; set; }

    public AudioInfo(MediaInfo mi)
    {
        Codec = mi.Get(StreamKind.Audio, 0, "Format");
        Duration = TimeSpan.FromMilliseconds(int.Parse(mi.Get(StreamKind.Audio, 0, "Duration")));
        Bitrate = int.Parse(mi.Get(StreamKind.Audio, 0, "BitRate"));
        BitrateMode = mi.Get(StreamKind.Audio, 0, "BitRate_Mode");
        CompressionMode = mi.Get(StreamKind.Audio, 0, "Compression_Mode");
        ChannelPositions = mi.Get(StreamKind.Audio, 0, "ChannelPositions");
        SamplingRate = int.Parse(mi.Get(StreamKind.Audio, 0, "SamplingRate"));
        TaggedDate = mi.Get(StreamKind.General, 0, "Tagged_Date");
        EncodedDate = mi.Get(StreamKind.General, 0, "Encoded_Date");
        FileSize = mi.Get(StreamKind.General, 0, "FileSize");
        StreamSize = mi.Get(StreamKind.Audio, 0, "StreamSize");
    }
}

```

Figure 4.12: Extracting meta-data from audio files

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Chapter 5

Testing

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Chapter 6

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 L^AT_EX and BibT_EX, composed with a text editor.

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