

IMPERIAL COLLEGE LONDON

DEPARTMENT OF COMPUTING

An intelligent digital interface for sharing diagnostic medical imaging with patients

— BACKGROUND AND PROGRESS REPORT —

by
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1 Project Overview

1.1 Supervisors

My direct supervisor is Dr Fernando Bello, he is a computer scientist and engineer working at the intersection of medicine, education and technology. He is a Reader in Surgical Computing and Simulation Science at Imperial College London, where he co-directs the Centre for Engagement and Simulation Science, leading a multi-disciplinary research group aiming at building suitable models and simulations of clinical processes, including clinical examination, clinical diagnosis, interventional procedures and care pathways. Dr Bello proposed my project as entitled "An intelligent digital interface for sharing diagnostic medical imaging with patients".

I am also working with William Cox, which is currently working on a PhD project investigating the extraction of novel benefit from diagnostic radiological images through sharing images with patients.

Dr Bello and Mr Cox will be together supporting my project and providing me informations, feed-back and support for its realization.

1.2 Project Goal

The aim of this project is to create a graphical user interface (GUI) that allows MRI, CT-scan, X-Ray patients to access their datas, with different levels of benefits. Data acquisition through this interface should be valuable for patients.

Following the first meeting with my tutors I have been able to define main criteria of success concerning the creation of the interface:

- Patient should be able to understand provided images
- Patient could explore the data in different ways/ different images orientation
- Patient should have the possibility to ask questions to doctors/ specific assigned people

I have used those basis criteria to create further specifications to meet my supervisors needs.

Some tools are already existing but essentially for dorctors; my tutors are expecting me to create something similar to the existing available interfaces but in a version that is understandable/usable for a non clinical person. The idea is to look at existing interface designs and consider how they could be changed in order to make them user friendly for the specified user group more accessible/intuitive.

2 Background Work

2.1 Project field apprehension:

Towards the first meeting with my supervisors, Will have emailed me several documents in order to get myself familiar with the context of which my project is part of. Those documents included:

- William PhD late stage review report discussing the benefit of creating a patient oriented interface
- A Litterature review document called "Patient Health Record Systems Scope and Functionalities" [4]
- A Litterature review document called "Patient Portal Preferences: Perspectives on Imaging Information" [5]
- A research article entitled "Imaging informatics for consumer health: towards a radiology patient portal"

2.2 Project frame and specifications definition:

Before starting coding the interface, it is important to define the specifications in the most precise way with my tutors in order to be sure that the future produced work will fit their needs.

Specification should be done considering:

- Interface oriented specification:
 - Content
 - Functionalities
 - Design
- Data Providing:
 - What can be provided?
 - How to provide it?

2.3 DICOM Data familiarization

Imaging data are provided in a specific format called DICOM - Digital Imaging and Communication in Medicine. This is a standard format for storing and transmitting informatic data related to medical images. This has been widely adopted by most hospitals in order to standardise data transmission between different radiology tools, such as scanners servers, workstation, printers, network hardware and PACS - Picture Archiving and Communication System and different stakeholders.

DICOM data readers exist in open-source over the internet, my first work concerning those data is to explore existing readers and pick one that could suit my project.

2.4 Choose accurate implementation method:

I have been given the freedom to choose the language and tools that I will use to create the interface. Multiple GUI tools are provided on the Internet, along with tutorials and advices to create interfaces. Before starting to implement the interface it is important to choose the tool that will best fit my needs. Exploring the Internet, the idea is to make a short comparison between the current most famous tools and choose the one that I feel the most comfortable with.

3 LSEPI Checklist

| | Yes | No |
|---|-----|----|
| Section 1: HUMAN EMBRYOS/FOETUSES | | |
| Does your project involve Human Embryonic Stem Cells? | | x |
| Does your project involve the use of human embryos? | | x |
| Does your project involve the use of human foetal tissues / cells? | | x |
| Section 2: HUMANS | | |
| Does your project involve human participants? | x | |
| Section 3: HUMAN CELLS / TISSUES | | |
| Does your project involve human cells or tissues? (Other than from “Human Embryos/Foetuses” i.e. Section 1)? | | x |
| Section 4: PROTECTION OF PERSONAL DATA | | |
| Does your project involve personal data collection and/or processing? | x | |
| Does it involve the collection and/or processing of sensitive personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)? | x | |
| Does it involve processing of genetic information? | | x |
| Does it involve tracking or observation of participants? It should be noted that this issue is not limited to surveillance or localization data. It also applies to Wan data such as IP address, MACs, cookies etc. | | x |
| Does your project involve further processing of previously collected personal data (secondary use)? For example Does your project involve merging existing data sets? | x | |
| Section 5: ANIMALS | | |
| Does your project involve animals? | | x |
| Section 6: DEVELOPING COUNTRIES | | |
| Does your project involve developing countries? | | x |
| If your project involves low and/or lower-middle income countries, are any benefit-sharing actions planned? | | x |
| Could the situation in the country put the individuals taking part in the project at risk? | | x |
| Section 7: ENVIRONMENTAL PROTECTION AND SAFETY | | |
| Does your project involve the use of elements that may cause harm to the environment, animals or plants? | | x |
| Does your project deal with endangered fauna and/or flora /protected areas? | | x |

Figure 1: LSEPI Checklist - part 1

| | | |
|---|---|---|
| Does your project involve the use of elements that may cause harm to humans, including project staff? | | x |
| Does your project involve other harmful materials or equipment, e.g. high-powered laser systems? | | x |
| Section 8: DUAL USE | | |
| Does your project have the potential for military applications? | | x |
| Does your project have an exclusive civilian application focus? | x | |
| Will your project use or produce goods or information that will require export licenses in accordance with legislation on dual use items? | | x |
| Does your project affect current standards in military ethics – e.g., global ban on weapons of mass destruction, issues of proportionality, discrimination of combatants and accountability in drone and autonomous robotics developments, incendiary or laser weapons? | | x |
| Section 9: MISUSE | | |
| Does your project have the potential for malevolent/criminal/terrorist abuse? | | x |
| Does your project involve information on/or the use of biological-, chemical-, nuclear/radiological-security sensitive materials and explosives, and means of their delivery? | | x |
| Does your project involve the development of technologies or the creation of information that could have severe negative impacts on human rights standards (e.g. privacy, stigmatization, discrimination), if misapplied? | x | |
| Does your project have the potential for terrorist or criminal abuse e.g. infrastructural vulnerability studies, cybersecurity related project? | | x |
| SECTION 10: LEGAL ISSUES | | |
| Will your project use or produce software for which there are copyright licensing implications? | | x |
| Will your project use or produce goods or information for which there are data protection, or other legal implications? | x | |
| SECTION 11: OTHER ETHICS ISSUES | | |
| Are there any other ethics issues that should be taken into consideration? | | x |

Figure 2: LSEPI Checklist - part 2

4 Progress Sumarry

From now a large amount of work has been completed concerning the background and I'll be soon begin to develop a first prototype of the interface. Current achieved steps are defined below.

4.1 Project field apprehension

Before the first meeting with my tutors I have read the given documents in order to get familiar with the future project. I have also made some research appart relating relevant vocabulary and informations. Moreover, reading William PhD's report which measure the benefit of creating such a patient oriented interface I realized how profitable my future work could be to imaging patient.

4.2 Specification Definition

We have had several discussions with my tutors concerning their expectation according to the interface, following which we agreed on the project specifications - that might evolve during the realization of the interface.

- **Interface content:**

- The interface should display patient images - images will be provided in DICOM format, and translated so that the patient can read them.
- The interface must contain the clinical report and the simplifie version.
- A link to NHS website will be given, so that patient could find general informations about their condition
- Patient could get flag informations - to be filled by doctors - while exploring the images
- Any other relevant informations related to what the DICOM files provides could be added

- **Interface functionalities:**

The interface should provide:

- One doctor oriented window: so, they can fill in datas (images, report) and add flag to images at their convenience.
- One patient oriented window: read only data (no modification allowed) and the possibility for patient to chat with doctors.

My main concern - in the context of this project - is to focus on the patient oriented side and see how far I can lead this project. This part can be really time consuming as it might need to be oftently readapted following the needs of my tutors.

Also, William recently sent me detailed general specifications concerning the patient oriented interface content/functions - Appendix 1

- **Interface design:**

- Imaging display will depend on the provided images (MRI, CT) but not on the part of the body. Will also gave me on demand description concerning images to be display and the way to deal with it Appendix 2.
- Provide a side by side or other relevant organization that would allow the patient to get the images and the report together in a relevant way

- **Further precisions:**

- No access to any database will be provided for the current project (security issues)
- Access to the interface will be local, patient would be given (upon request) a CD with their images loaded on the interface; this wont change patient access to datas but should make them want to access it
- Interface should include user specification/precisions for patient
- Benefits/specifications will have to be defined before starting implementation
- Interface should be windows portable

- **Interface evaluation:**

At some point the interface should be evaluted by a panel of patient that would be ask to use it and make feedbacks.

4.3 GUI tool choice: Qt

A lot of tools are available on the Internet to create GUI interface such as Qt, WxWidget, GTK+, FLTK, FOX and some others. I couldn't compare all of them so I have decided to focus on Qt, WxWidget GTK+.

- Tools Comparison:

I looked accross the Internet to get some testimonies about the different tools and I tried to distinguish them following several criteria - see grid below. According to these criteria and considering that Qt is highly recommended for beginners, I have finally decided to use Qt for this project.

| Criteria\Interface | Qt | WxWidget | GtK+ |
|--------------------|------|----------|--------|
| Chat doc | +++ | + | ++ |
| Cross-Platform | Yes | Yes | Yes |
| Open Source | Yes | Yes | Yes |
| Langage | C++ | C++ | C++ |
| Flexibility | High | Low | Medium |
| Performance | High | High | High |
| Documentation | +++ | ++ | ++ |

Figure 3: LQt, WxWidget, GTK+ comparison table

- Qt familiarization:

In order to get used to this new tools I have decided to do Openclassroom tutorials [2]. Those tutorials have helped me to install QtCreator and to begin with some basic exercices to get familiar with Qt. I still have some tutorial to do at the current moment but I am feeling comfortable with it.

4.4 DICOM apprehension

DICOM files are containing a large amount of data and cannot be read so easily. Several readers are provided towards the internet. Currently I am planning to use QtDcm [1] that provide a reader suitable for Qt application, I have download the widget but the installation seems to be more complicated than I thought.

5 Project Plan

From now I need in the short term to complete my background work which I expect to be done on the 15th June, consisting now in:

- Getting familiar with DICOM readers and display DICOM images
- Finish Qt tutorials
- Create a grid concerning the informations to be display
- Look on the web existing interface to get on a idea of what I could do
- Make a design proposal

I am then aiming to propose to my tutors a first draft of the interface by the end of this month (30th June). The following month will be to precise content, featuring and discuss rearrangement as the interface is evolving. We agree with my tutors that the essential goal of my project will be to produce the patient oriented window because there is already a lot of work that can be done. If I have more time, I will use it to create the doctor oriented window.

6 Appendix

6.1 Appendix 1 - General Interface Specification

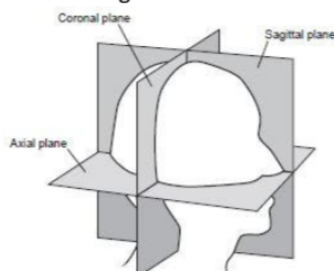
General requirements:

Initial interface (before opening imaging)

- Password control
- Disclaimer
 - For information only
 - Do not try to interpret
 - Any queries contact your healthcare professional
 - Some people may find seeing images of themselves upsetting, please consider whether you want to view them
 - Be aware that these images constitute your personal medical data – please be mindful of who you share them with
- ... any further which may be identified/emerge over course of the project
- Will need to be some thought given to how to make the functionality designed for clinicians accessible/useful to end user

Accompanying information

- Relevant abnormality information (from [patient.info](#))
- Report – could terms be linked to definitions?
- Simplified report
- Normal comparator/diagram
- FAQs
- ... any further which may be identified
- Ability to display:
 - Multiple studies. E.g. interval studies.
 - This is when an X-ray of a broken wrist is taken at the time of the accident and then another X-ray is taken 6 weeks later to see if it has healed
 - Helpful if these could be viewed side by side
 - Multiple images side-by-side (e.g. axial view (top to bottom view) & sagittal view (side to side view))
 - See diagram below for the imaging planes:



- Flagged image from a series opens first
 - It would be helpful to know how many times the user accesses the more detailed imaging vs how many times they only review the flagged image
- Highlight abnormality
 - Can be toggled on and off
- Hover over labels (anatomy)
- Annotations made by clinician
 - Can be toggled on and off
- Ability to remove any personal information/annotations (for users who want to share their image without revealing information)
- Ability to share image onwards (e.g. via email)
- ... any further which may be identified

Basic manipulations:

- Zoom
- Adjust contrast/brightness
- Invert greyscale
- Measure
- Ability to reset to original image appearance/undo manipulations
- ... any further which may be identified
 - Useful to have an explanation for each of these
 - Pop up box?
 - What they do/how they may affect the image appearance
 - Disclaimer/warning that changing the image appearance may make it look artificially abnormal

Interactivity

Contact information for queries

Chat functionality

6.2 Appendix 2 - Imaging Specification

Specific requirements by imaging modality:

Conventional X-ray

- The most common form of imaging
- Usually 2 images per body part imaged
 - e.g. Dorsi-palmar (DP) wrist (axial plane - top to bottom view) & lateral wrist (sagittal plane - side to side view)

- DP wrist :



- Lateral wrist:

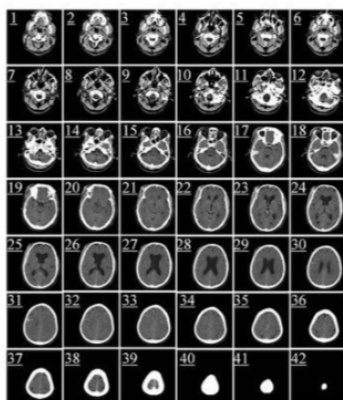


- May be more than one body part imaged
 - e.g. hand (2 images) & elbow (2 images)
- May occasionally contain more than 2 images, if initial 2 don't display all the information –
 - e.g. if a leg is longer than the image size, need 1 image for top of leg, 1 image for bottom of leg

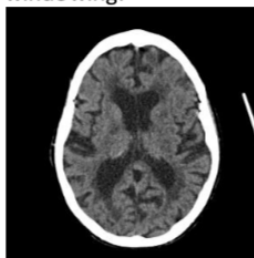
Computed tomography (CT)

Format information

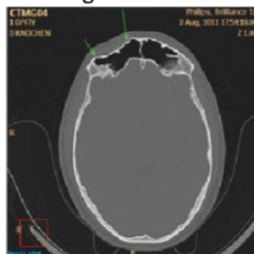
- Multiple images in series with sequential slices to cover all relevant anatomy
 - e.g. brain scan:



- May contain imaging in more than one plane/utilising windowing to highlight anatomical structures of different density
 - e.g. brain images in axial/sagittal/coronal plane
 - E.g. brain images which have been 'windowed' to show only the bone of the skull in order to make it easier to identify fractures
 - Normal windowing:



- Bone windowing:



Requirements for display

- Should be able to open the study with the 'flagged' image first. User can then view further imaging if necessary
- It would be helpful to know how many times the user accesses the more detailed imaging vs how many times they only review the flagged image

Magnetic resonance imaging (MRI)

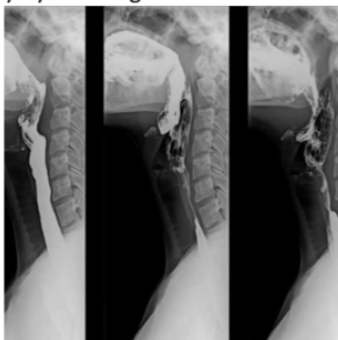
- Similar to CT
 - Can contain a lot of images which are arranged in sequences
 - Can have images displayed in different imaging planes
 - Different sequences show different parts of the anatomy by demonstrating different types of tissue (similar to windowing in CT)

Ultrasound (U/S)

- Similar to CT
 - Can contain a lot of images, although sometimes only 1 or 2
 - All images will be acquired in the same imaging plane

Fluoroscopy

- Similar to CT
- Can contain a lot of images
 - Images may be acquired in multiple anatomical planes
 - Images sequences may demonstrate time-lapse movement (similar to a video)
 - E.g. X-ray dye moving down the throat when swallowed



- Helpful to be able to present these images like a slideshow so that they look like a video

Other points:

I have access to limited DICOM datasets but I do have some CT studies and fluoroscopy

These are quite large files and come on a CD bundled with an existing DICOM viewer – do you have a preferred secure method for me to transfer this data to you?

I also have a large bank of conventional X-ray images which are in fw.png format. These should be easier to transfer. It would be good to use these, too.

7 Bibliography

- [1] Alexandre Abadie. *QtDcm: A Qt based C++ library for Dicom communication*. URL: <https://qtdcm.github.io/index.html>.
- [2] *Beginning with Qt*. 28/03/2018 (Last Update). URL: <https://openclassrooms.com/courses/programmez-avec-le-langage-c/compiler-votre-premiere-fenetre-qt>.
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- [6] *Why to use Qt*. URL: <https://stackoverflow.com/questions/123012/do-you-use-qt-and-why-do-you-use-it>.