Supervisor	Mahmoud Mughavemi
Topic	Automatic registration for Image guided surgery for brain tumor resection
Title	Automated surface-based intraoperative registration for brain tumor resection using machine learning Elements: 1. Automated surface Segmentation: Obtaining Using CNN model that can determine a given feature (e.g. contour of eye)→ outputs feature parameters 2. image processing: Mapping patient face and creating a surface point cloud 3. Registration: of the intraoperative and preoperative point clouds
Synopsis (Background, Problem statement, Objectives)	**Background** With the progress in computer image vision technology, the mapping technique based on optical data has developed specially in the medical imaging field. One of the techniques used in mapping technology is use of stereoscopic cameras for surface-based registration, which is then visualized by overlaying it on 3D preoperative data (MRI, or CT) using either manual or automatic process. It is an interest to have a real-time automatic registration where traditional methods are inadequate. **Problem Statement** Traditional techniques make use of iterations and this manner is very slow where runtime in the tens of minutes are normal for common deformable image registration techniques even with an efficient implementation on the contemporary GPUs; while the practical use in clinical operations is real-time, and such a prolonged wasting time is not appreciated. This paper proposes utilizing deep learning to carry out the registration of face. **Objectives** 1 Evaluate the need for machine learning registration over traditional registration of surfaces. 2 Evaluate a technique for segmentation of face from the rest of head model. 3 Use reliable NN model (CNN or SAE or GAN or RNN or DRL) for registration based on facial features 4 Demo Registration with control model (control is the

	unsegmented model) <u>(Extra)</u> 5 Obtain 3D map of the face 6 Carryout registration based on extracted feature
Expected Outcomes	1 Develop a model that determines the contour of the eye socket 2 Determine an evaluation metric and method for the registration 3 Carryout registration of (pre-segmented) face
Equipment Needed	Personal computer, suitable programming language software (3D slicer-free) <u>(Extra)</u> image acquisition devices .

Complex Engineering Attributes

Assigned PLOs: PLO3 (WK5), PLO4 (WK8), PLO5 (WK6), PLO7 (WK7), PLO9, PLO11, PLO12

Attribute	**Complex Engineering Problems have characteristic WP1 and some or all of WP2 to WP7:**	**PLOs addressed?**	**Comments from FYP supervisor (*give examples / clarifications*)**
Depth of Knowledge Required	**WP1**: Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamentals-based, first principles analytical approach	PLO3, PLO4, PLO5, PLO7	Required the fundamental knowledge on various field of image processing and artificial intelligence, such as template matching, image enhancement and filtering as well as machine learning. Student needs to basically apply fundamental knowledge in image processing and artificial intelligence to solve a given design problem.
Range of conflicting requirements	**WP2**: Involve wide-ranging or conflicting technical, engineering and other issues	PLO3, PLO4	During the design process, student needs to demonstrate limitations that they encounter during the process, e.g. lighting, image size and acquisition distance.
Depth of analysis required	**WP3**: Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models	PLO7	Student need to understand the problem and apply suitable solution which may have been applied in similar problem but in different application
Familiarity of issues	**WP4**: Involve infrequently encountered issues	PLO5	The problem is unique thus requires innovative thinking and adoption of many existing designs which are not directly applicable to the given problem
Extent of applicable codes	**WP5**: Are outside problems encompassed by standards and codes of practice for professional engineering		Need to understand the strict medical imaging standards which can be encompassed for other sectors that use CV (e.g AV).
Extent of stakeholder involvement and conflicting requirements	**WP6**: Involve diverse groups of stakeholders with widely varying needs		Many types of surgery and workflows associated with cranial surgery, which results in wide range of requirements
Interdependence	**WP 7**: Are high level problems including many component parts or sub-problems		Includes both software and hardware design and has sub problems within each.

Proposal of FYP
Semester S1 2020/2021

Abdolraouf Rahmani
KIE170720

Automated surface-based intraoperative registration for brain tumor resection based on image processing ~~<using commercially available stereocameras>~~

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1 Introduction

~~The first part of your proposal is the initial pitch for your project, so make sure it succinctly explains what you want to do and why. It should:~~

~~Introduce the topic~~
~~Give background and context~~
~~Outline your problem statement and research question(s)~~
~~Some important questions to guide your introduction include:~~

~~Who has an interest in the topic (e.g. scientists, practitioners, policymakers, particular members of society)?~~
~~How much is already known about the problem?~~
~~What is missing from current knowledge?~~
~~What new insights will your research contribute?~~
~~Why is this research worth doing?~~
~~If your proposal is very long, you might include separate sections with more detailed information on the background and context, problem statement, aims and objectives, and importance of the research.~~

1.1 Background

With the progress in computer image vision technology, the mapping technique based on optical data has developed specially in the medical imaging field. One of the techniques used in mapping is use of stereoscopic cameras for surface-based registration, which is then visualized by overlaying it on preoperative data (MRI, US or CT).

1.2 Problem Statement

At present, there are several intraoperative registration methods such as manual, point-based, surface-based, volume-based and calibration-based.

<u>Manual</u>

First recorded usage was by Marescеaux in 2004 for laparoscopy which required an assistant to manually rotate and shift a preoperative CT scan until the view of the preoperative data approximately matched the image. Manual registrations may be facilitated by algorithmic components but for the most relies on human approximation. Such registration is easy to implement and more easily obtains clinical certification. On the other hand the method is extremely time consuming and the quality of registration depends on human ability.

<u>Point-base</u>

In point-based registration, a set of corresponding points (natural or artificial land-marks) are identified in the planning image and in the patient image or on the intraoperatively constructed surface, and a point-based registration is applied to register the data by matching the two points and making a single coordinate system. Artificial land marks such as surface-merged (SM) fiducial markers (FM) require time for appropriate placement_**NOT SURE HOW TRUE THIS IS AT THIS TIME**. Anatomical markers on the other hand don’t require any preparation, and if preparation is needed then it can be done long before the D-day without any significant drift error.

Anatomical systems build are anatomic specific and so a given system can't be applied across different regions, while for FM it is easier.

<u>registration methods/algorithms:</u>

1. FM:
2. AM:

<u>Surface-based:</u>

In surface-based registration (or shape-based regis- tration) intraoperative data—typically a surface mesh or a point cloud—is registered to the planning image based on geometrical shape information.

Surface registration can be roughly partitioned into three issues: choice of transformation, elaboration of surface representation and similarity criterion, and matching and global optimization. The first issue concerns the assumptions made about the nature of relationships between the two modalities, e.g. whether a rigid-body assumption applies, and if not, what type and how general a relation optimally maps one modality onto the other. The second issue determines what type of information we extract from the 3D surfaces, which typically characterizes their local or global shape, and how we organize this information into a representation of the surface which will lead to improved efficiency and robustness in the last stage. The last issue pertains to how we exploit this information to estimate the transformation which best aligns local primitives in a globally consistent manner or which maximizes a measure of the similarity in global shape of two surfaces.

This method is more seamless and can be utilized for general purpose registration.

Volume-based registration

In volume-based registration subsurface information, such as three-dimensional (3D) geometric information (e.g., the vessel geometry obtained from a computed tomography [CT] scan) is acquired during surgery and mapped to corresponding information from a 3D planning image.

Most surface-based registrations systems (such as 7D surgery) currently in use make use of costume made stereoscopic cameras and system components which increases expense for integration to surgical workflow. This paper proposes use of commercially available stereocameras -such as ZED or Intel's Realsense- for surface based intraoperative registrations for use in brain tumor augmented guided resection.

1.3 Objectives

1. Obtain 3D map of face using stero camera using appropriate reference frame
2. Using basic manual features, register the MRI to 3D image obtained
    1. carry out Target error estimation
3. Using deep learning (CNN) have the model automatically extract features and do registration
    1. Evaluate the model