K. J. Somaiya College of Engineering, Mumbai-77
(Autonomous College Affiliated to University of Mumbai)

DESKTOP APPLICATION FOR MEDICAL IMAGE REGISTRATION AND FUSION

Made By

Mahi Dedhia
BTech Comps 2019-2023

Mentored By

Prof. Bhakti Palkar

Date: 22/07/2021 Place: Mumbai

CHAPTER 1: INTRODUCTION

1.1. PROBLEM DEFINITION

Development of a Desktop application to perform image registration and fusion on monomodal and multimodal medical images.

1.2. MOTIVATION

Image Registration is the determination of a one-to-one mapping between the coordinates in one space and those in another, such that points in the two spaces that correspond to the same anatomical point are mapped to each other. Registration process involves the estimation of optimal transformation that best aligns the objects of interest in the input images. In registration, one image (source image) is specially modified (translated, rotated, scaled, and deformed) relative to another fixed or the reference image.

Registration of medical images obtained with the same modality in different time-frames is usually required because of possible movements of the object (motion of a patient; changes in the positioning of the patient; cardiac or involuntary motion; growth of a structure; and soft tissue displacements due to breathing). Similarly, registration of medical images that have been obtained from different modalities may be extremely useful and is essential because one and the same structure of the imaged object is represented differently and these images hold different information and details of the same object.

Image Fusion reads several images of the same scene or objects and retrieves important information from them to put it into a single output image. Image generated by this method always gives more information than any of the input images which thereby improves quality and applicability of data. Multi-view, multi-modal, multi-temporal and multi-focus are the four ways in which image fusion can be performed. Mono modal images captured at the same time but from various viewpoints can be fused multi-view fusion methods. Multi-modal fusion is performed on images captured using various sensors.

In medical applications, Image fusion is commonly used term. Medical images from the same modality or multiple modalities such as CT, MRI, SPECT, PET can be merged using fusion to generate a more informative image.

Image registration and fusion help the experts in the diagnosis, in following up the diseases' evolution, and deciding the necessary therapies or treatment regarding the patient's condition.

Hence, an application dedicated for medical image registration and fusion can be an extremely useful tool for researchers and medical practitioners.

1.3. OBJECTIVE

To develop a desktop application to assist in analysis of different algorithms used to perform Image registration and Fusion on monomodal and multimodal medical images.

1.4. FEATURES

- Voxel based Rigid registration on monomodal medical images
- Manual Landmark/Control-point based registration on multimodal medical images by selecting 4-10 control points.
- Apply contrast enhancement on any or both of the input images if required.
- Perform IFCNN model based Image Fusion on the registered images.
- Save all the input, intermediate and result images.
- Wide view feature to view the input and result images in a new window for efficient comparison and analysis.

CHAPTER 2: LITERATURE SURVEY

[1] J. B. Antoine Maintz1 and Max A. Viergever. “An Overview of Medical Image Registration Methods” - States the different paradigms for voxel property based registration methods, different optimization procedures used in monomodal and multimodal registration, and multi-resolution approaches.

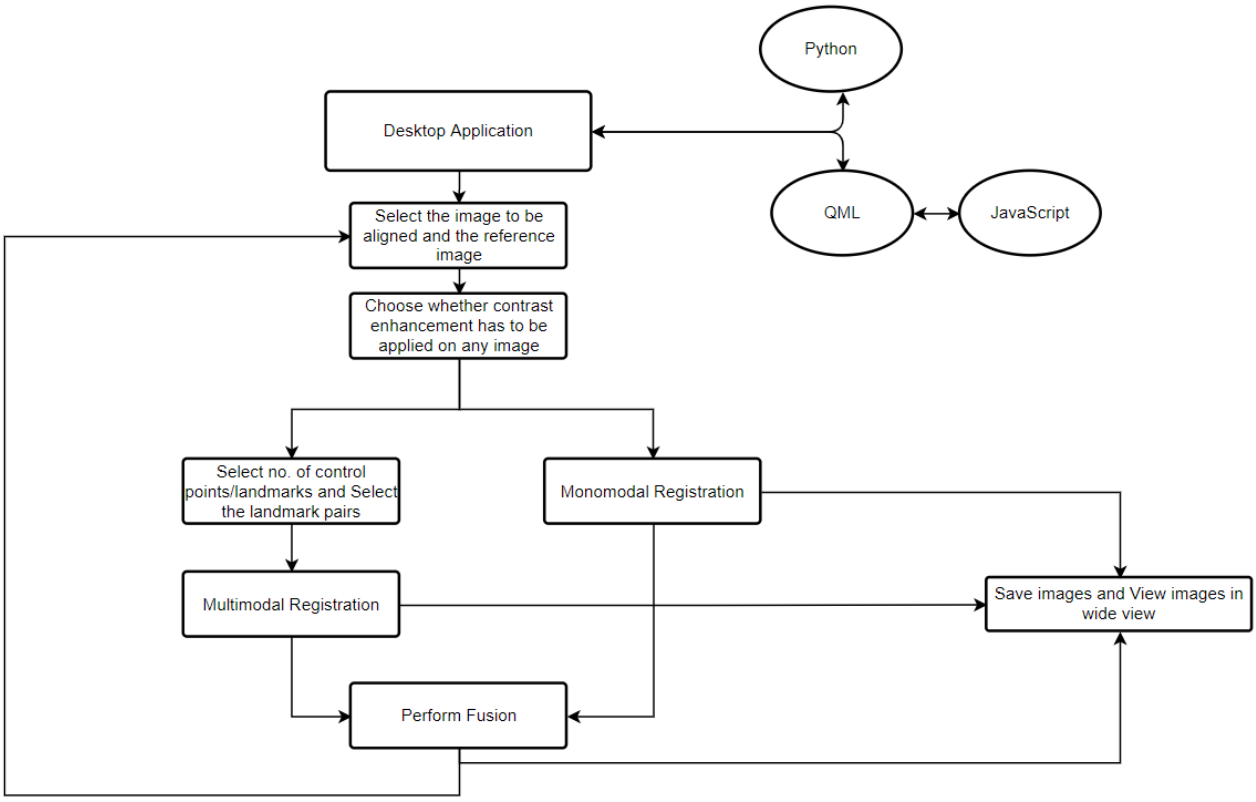
[2] Fatma El-Zahraa Ahmed El-Gamal, Mohammed Elmogy and Ahmed Atwan (2016). “Current trends in medical image registration and fusion” (p. 105): In Egyptian Informatics Journal, Volume 17 Issue 1 - Mentions the common voxel-based similarity measures for monomodal registration and entropy based similarity measures for multimodal registration.

[3] Alam, Fakhre & Ur Rahman, Sami. (2016). “Intrinsic registration techniques for medical images”. A state-of-the-art review. 30. 119-132 - Review and comparison of Intrinsic Registration methods – Landmark based registration, Segmentation based registration and Intensity (Voxel) based registration.

[4] Fereshteh S. Bashiri, Ahmadreza Baghaie, Reihaneh Rostami, Zeyun Yu, and Roshan M. D’Souza (2018). “Multi-Modal Medical Image Registration with Full or Partial Data: A Manifold Learning Approach” (p. 2-4). In Journal of Imaging, Volume 5 Issue 1 - States different approaches and techniques for monomodal and multimodal registration.

CHAPTER 3: PROJECT DESIGN

3.1. SYSTEM ARCHITECTURE



3.2. PROGRAMMING LANGUAGES USED

Python 3.9

QML

JavaScript

3.3. SOFTWARE DEVELOPMENT TOOLS

Application Development tools – Command Line Interface, VSCode Text Editor

System Architecture Diagram tool – Visual Paradigm

Documentation tool – Microsoft Word

3.4. FUNCTIONS IMPLEMENTED

1. Selection of input images:

The user can select the two input images. The allowed file formats include: jpeg/jpg, png and dicom. On selection, the select image and the filename are displayed on the screen. If the image is a dicom file, it is first converted to jpeg format and then displayed. The user can choose to apply contrast enhancement on any of the input images.

2. Monomodal Registration:

Once both images are selected, user can opt for monomodal registration and click register. The registered image will be displayed on the screen.

3. Multimodal Registration:

Once both images are selected, user can opt for multimodal registration. The user has to select the number of control points (default is 4) and then select the landmark pairs/control points on the images. The selected pairs are marked and displayed on the image. Once all

required points are added, the user can click on register and the registered image will be displayed on the screen.

4. Image Fusion:

Once the registration is done, the user can choose to perform fusion on the registered image and the reference image. This feature is not available unless the registration is done. The fused image will be displayed on the screen.

5. Save the images:

Only after registration or fusion is done, the user can save all the input images, intermediate images (eg. The image containing landmark points) and the result images on their desktop.

6. Wide View:

Only after registration or fusion is done, the user can view the images in a new window. This can help in efficient comparison and analysis of the result.

3.5. SOFTWARE REQUIREMENTS

- Python 3

Python packages that must be installed additionally using command

'pip install package-name'

- imageio==2.9.0
- itk==5.2.0.post2
- itk-core==5.2.0.post2
- itk-elastix==0.12.0
- itk-filtering==5.2.0.post2
- itk-io==5.2.0.post2
- itk-meshtopolydata==0.7.1
- itk-numerics==5.2.0.post2
- itk-registration==5.2.0.post2
- itk-segmentation==5.2.0.post2
- numpy==1.21.0
- opencv-python==4.5.3.56
- Pillow==8.3.1
- pydicom==2.1.2
- PyQt5==5.15.4
- PyQt5-Qt5==5.15.2
- PyQt5-sip==12.9.0
- torch==1.9.0
- torchvision==0.10.0
- typing-extensions==3.10.0.0

CHAPTER 4: IMPLEMENTATION DETAILS

4.1. TEST CASES HANDLED

Image Selection:

	Test Case	Solution Implemented
1.	If user clicks register button before selecting both the input images	A message asking the user to select both images is displayed
2.	If user changes the selected image before registration	The earlier created directory is deleted and a new one is created, the image sources of the both the images are replaced (unchanged image must be replaced because if landmark points were selected earlier, they must not be considered or displayed), the landmark points are re-initialized, the output section is reset to not display any image. The fusion, save and wide view features must be hidden.
3.	If user selects a new image after performing registration, or both registration and fusion.	

Monomodal/Multimodal Registration:

	Test Case	Solution Implemented
1.	If user switches to monomodal registration	The Add landmark pair button, and dropdown to select no. of control points are hidden and cursor sign is changed to a arrow pointer for the mouse area where images are displayed. The input images displayed are changed back to original (without landmark pairs visible if they were added)

2.	If user switches back to multimodal registration	The Add landmark pair button, and dropdown to select no. of control points are visible and cursor sign is changed to a cross pointer for the mouse area where images are displayed only if both the images are selected. The input images displayed are changed to show the landmark pairs on them already added by the user.

Landmark Selection

	Test Case	Solution Implemented
1.	If user tries to add a landmark pair without selecting a point on both the images	A message saying that the particular action cannot be carried out is displayed
2.	If user tries to click on register before adding selected no. of landmark pairs	
3.	If user tries to add a landmark pair after the selected no. of landmark pairs have already been added	
4.	If user tries to change the no. of control points to a number which is less than that of already added landmark pairs	
5.	If user tries to change the no. of control points to a number which is larger than that of already added landmark pairs	The value for no. of control points is changed
6.	If user selects a landmark point, and then resizes the window, the landmark point must be retained at the earlier selected point.	Formula used to get the absolute point on image

CHAPTER 5: CONCLUSION AND FURTHER WORK

5.1. CONCLUSION

- The desktop application was successfully developed for medical image registration and fusion with the features of monomodal registration, manual landmark-based multimodal registration, and IFCNN model based image fusion. The options to apply contrast enhancement on any of the input images, change the no of control points (between 4-10) have also been incorporated. Further, features to save the input and result images and view the images in a new window for efficient comparison and analysis have also been added.
- The current scope of image types includes jpeg/jpg, png and dicom images only.
- In case, any error occurs in the implementation of registration or fusion algorithm, the application may terminate.

5.2. FURTHER WORK

- The registration and fusion algorithms can be further changed to reduce errors in registration and fusion after analysis of the current algorithms used using this application.
- The application can be extended to further incorporate more options and implement registration, fusion and segmentation on different types of medical images for different medical applications.

Github link to the source code:

https://github.com/mahidedhia/Medical-Image-Registration-and-Fusion

REFERENCES

For building the application:

[1] Python documentation contains all the required information about the language and it's libraries and packages, how to use them, the code and syntax, and their uses and features.

https://docs.python.org/3/

[2] To get structured information about the QML programming language and it's components. QML (Qt Modelling Language) is a user interface specification and programming language.

https://doc.qt.io/qt-5/qtqml-index.html

https://doc.qt.io/qt-5/qmlapplications.html

https://www.youtube.com/watch?v=JxyTkXLbcV4&list=PL6CJYn40gN6hdNC1IGQZfVI707dh9DPRc

[3] To learn how to connect python to a QML application and their interaction to send and receive data and commands.

https://doc.qt.io/qtforpython/contents.html

https://medium.com/analytics-vidhya/how-to-build-your-first-desktop-application-in-python-7568c7d74311

https://python-qt-tutorial.readthedocs.io/en/latest/

[4] Stack Overflow is a collaboration & knowledge sharing SaaS platform. It is a widely used platform among programmers and developers to resolve the errors or simply find a coding solution to something they are stuck on. It can be used to ask questions, and to give and find solutions to everything regarding technology and programming.

https://stackoverflow.com/

[5] To learn, understand and implement various different features of python and it's packages.

https://www.geeksforgeeks.org/

https://www.tutorialspoint.com/index.htm

For medical image registration and fusion:

[6] To gain more insight into Medical image registration and fusion
https://www.sciencedirect.com/science/article/pii/S111086651500047X
https://depts.washington.edu/bicg/documents/MII_registration10.pdf
https://www.researchgate.net/publication/221902046_Medical_image_registration_A_review
https://www.researchgate.net/publication/284218111_Image_Fusion_Techniques_A_Review
http://sbisc.sharif.edu/~miap/Files/Medical%20Image%20Registration.pdf
[7] For monomodal registration algorithm used
https://github.com/InsightSoftwareConsortium/ITKElastix/tree/master/examples
https://elastix.lumc.nl/doxygen/parameter.html
[8] For multimodal registration algorithm used
https://github.com/ashna111/multimodal-image-fusion-to-detect-brain-tumors
[9] For fusion algorithm used
https://github.com/uzeful/IFCNN