A Survey of Medical Image Processing Tools

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A Survey of Medical Image Processing Tools

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***Abstract*—A precise analysis of medical image is an important stage in the contouring phase throughout radiotherapy preparation. Medical images are mostly used as radiographic techniques in diagnosis, clinical studies and treatment planning. . Medical image processing tool are also similarly as important. With a medical image processing tool, it is possible to speed up and enhance the operation of the analysis of the medical image. This paper describes medical image processing software tool which attempts to secure the same kind of programmability advantage for exploring applications of the pipelined processors. These tools simulate complete systems consisting of several of the proposed processing components, in a configuration described by a graphical schematic diagram. In this paper, fifteen different medical image processing tools will be compared in several aspects. The main objective of the comparison is to gather and analysis on the tool in order to recommend users of different operating systems on what type of medical image tools to be used when analysing different types of imaging. A result table was attached and discussed in the paper.**

Keywords—computer vision; image processing; tools component;

I. INTRODUCTION

Image Processing is a form of information processing where the input and output are images, such as photographs or frames of video. Image Processing techniques usually process images as 2D signals and apply standard signal processing techniques to them. In general, image processing can be divided into digital image processing and medical image processing. This paper will focus on medical image processing tools. In medical fields nowadays, medical imaging and processing tools are playing crucial roles in many applications. Such applications take place throughout the clinical track of events; not only within diagnostic settings, but prominently in the area of preparation, carrying out and evaluation before surgical operations [1], therefore, the pros and cons of the medical image will directly influence the result of the diagnosis from a doctor to the patient. Besides that, medical imaging itself have noise and speckle like ultrasound, thus it will increase the difficulties of doctors' judgment. The goal of this paper is to gather up and analysis a variety of medial image processing tools in the market. To figure out which tools is open source, which tools is suitable to run on what operating system.

Many image processing tools have been created to carry out different function like the fig. 1 above, such as generic, registration, segmentation, visualization, reconstruction, simulation and diffusion

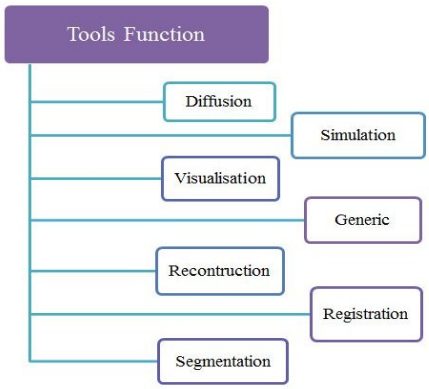

Fig.1. Tools' Function

II. FOUNDATION

As a foundation for the following survey and discussion, in this section, a brief introduction on medical image processing tools and medical image processing will be presented. The main functions of a medical image processing tool (MIP) will also be explained in this section.

A. Image Processing Tools

A major purpose of image processing is to improve the appearance of an image, thus, there is a lot of image processing tools. Image Processing Tools provides assistance to engineers and scientists with an extensive set of plugin, toolkit, functions, and apps for image processing, analysis. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. This figure below illustrates the type of image processing. Image processing can be divided into two main types, which is digital image processing tool and medical image processing tools.

B. Digital Image Processing tools

According to Solomon et.al, in the 2011 [2], digital image processing is the process of using computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data

and can avoid problems such as the build-up of noise and signal distortion during processing. Many of the techniques of digital image processing, or digital picture processing as it often was called, were developed in the at first 1960.

C. Medical Image Processing Tools (MIP)

Medical imaging is the technique, process and art of creating visual representations of the interior of a body for clinical analysis and medical intervention. Medical imaging seeks to reveal internal structures hidden by the skin and bones, as well as to diagnose and treat disease. Medical imaging also establishes a database of normal anatomy and physiology to make it possible to identify abnormalities. Although imaging of removed organs and tissues can be performed for medical reasons, such procedures are usually considered part of pathology instead of medical imaging. Thus, this paper will mainly focus on the survey of medical image processing tools. In the next section a rough overview of different types of image processing tools will be presented. The figure below illustrates the medical image processing tools that will be surveyed in part III.

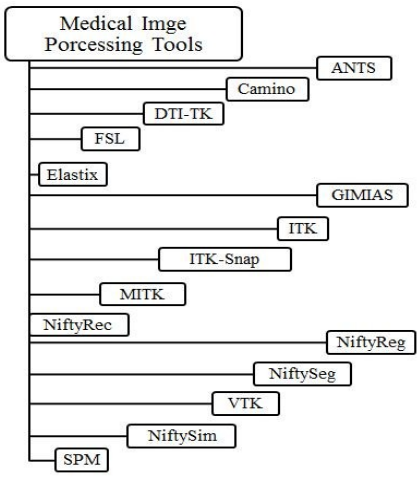

Fig.2. Tools of Medical Image Processing

D. Medical Images

In the modern medical field, medical imaging has undergone a major advancement. This technology is important as it can be applied before an actual surgery [1]. Over the years, different sorts of medical imaging have been developed, different type of medical image adapts different type of technology. Each of the medical images has their own advantages and disadvantages. The figure 2 above illustrates 15 types of medical image processing tools in the market.

III. SURVEY

There are several software tools available to perform medical image processing. The following section introduced 15 types of tools that are often used by researchers.

A. VTK

The Visualization Toolkit (VTK) is an open-source, freely available software system for 3D computer graphics, image processing and visualization. This tool is by Kitware, whose team currently is still performing future development to the toolkit, this tool offers professional support and consulting services for VTK. Besides that, VTK has an extensive information visualization framework, has a suite of 3D interaction widgets, supports parallel processing, and integrates with various databases on GUI toolkits such as QT and Tk [3].

B. ITK

ITK or Insight Segmentation and Registration is an open-source, cross-platform system that provides developers with an extensive suite of software tools for image analysis [4]. In addition, ITK provide leading-edge segmentation and registration algorithm in two, three and more dimensions, it is distributed as an open-source software package [17].

C. FSL

FSL (FMRIB Software Library) is created by Analysis Group, FMRIB, and OXFORD, UK. FSL is a comprehensive library of analysis tools for FMRI, MRI and DTI brain imaging data [5].

D. SPM

Statistical Parametric Mapping refers to the construction and assessment of spatially extended statistical processes used to test hypotheses about functional imaging data. These ideas have been instantiated in software that is called SPM. The SPM software package has been designed by Karl Friston for the analysis of brain imaging data sequences, such as fMRI, PET, SPECT, EEG and MEG [6].

E. GIMIAS

Graphical interface for medical image Analysis and Simulation (GIMIAS) is a workflow-oriented environment for solving advanced biomedical image computing and individualized simulation problems, which is extensible through the development of problem-specific plug-ins [7].

F. NiftyReg

NiftyReg is open-source software for efficient medical image registration. It has been mainly developed by member of the Translational Imaging Group with the Centre for Medical Image Computing at University College London, UK [8].

G. Elastix

Elastix is open source software, based on the well-known Insight Segmentation and Registration Toolkit (ITK). The software consists of a collection of algorithms that are commonly used to solve (medical) image registration problems. The modular design of Elastix allows the user to quickly configure, test, and compare different registration methods for a specific application [9].

H. ANTS

ANTS or Advances Normalization Tools is created by Brian B. Avants and currently maintained by Hands J. Johnson. An ANT is able to extract information from complex Dataset, and it is very useful for managing interpreting and visualizing multidimensional data [10].

I. NiftySeg

NifySeg is the one of the project developed at University College London, which is licensed under BSD license. It a tool which contains several programs to perform EM based segmentation of image n nifty or analyses format [8].

J. ITK-Snap

ITK-Snap is a software tool used to segment structures in 3D medical images, it is created by Paul Yushkevich. ITK-SNAP provides semi-automatic segmentation using active contour methods, as well as manual delineation and image navigation [11].

K. MITK

The Medical Imaging Interaction Toolkit or MITK is a software tool that combines the Insight Toolkit (ITK) and the Visualization Toolkit (VTK) with application framework. This software is under BSD-Style license [12].

L. NiftyRec

NiftyRec is a software project developed at UCL London, which provides code for tomographic reconstruction [13].

M. NiftySim

Nifty Sim is a high-performance nonlinear finite element solver, developed at University College London. A key feature is the option of GPU-based execution, which allows the solver to significantly out-perform equivalent commercial packages [14].

N. Camino

Camino is a software toolkit for diffusion MRI processing, it is able to do construction of processing pipelines that include modules from other software. At present, the microstructure imaging group at UCL lead development is doing the maintenance of the toolkit [15].

O. DTI-TK

DTI-TK is a spatial normalization and atlas construction toolkit optimized for examining white matter morphometry using DTI data. This software developed by Gary Zhang. In the year of 2011, a publication has been published in NeuroImage. It ranked DTI-TK as the top-performing tool in its class [16].

IV. Discussion

In this section, the survey of the fifteen medical image processing tools is tabulated in Table I. Analysis is done based on the following criteria. The table below shows comparison between the fifteen medical image processing tools listed.

TABLE I. COMPARISON OF IMAGE PROCESSING TOOLS

Image Processing Tool		VTK	ITK	FSL	SPM	GIMIAS	NIFTYREG	Elastix	ANTS	NiftySeg	ITK-Snap	MITK	NiftyRec	NiftySim	Camino	DTI-TK
Latest supported version		6.1	4.0	5.0	12	1.5	3.1	4.7	2.1	3.1	3.2	03	1.6.9	2.0	2.0	3.0
Date of last published		2014	2014	2014	2014	2013	2013	2014	2014	2014	2014	2014	2014	2014	2013	2011
System Interface (GUI)		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Imaging Supported	**MRI**		x	x	x	x	x	x	x	x		x	x	x	x	x
	Ultrasound					x	x	x		x		x		x		x
	X-ray					x	x	x		x		x				x
	fMRI			x	x	x		x	x			x			x	
	PET				x	x		x				x				x
	CT-Scan				x	x		x				x	x	x		
	EEG				x	x		x				x				x
	Mammogram					x	x	x		x		x			x	

Image Processing Tool		VTK	ITK	FSL	SPM	GIMIAS	NIFTYREG	Elastix	ANTS	NifySeg	ITK-Snap	MITK	NiftyRec	NiftySim	Camino	DTI-TK
	3D Images	x				x		x		x	x	x	x			x
Functions	**Generic**	x	x	x	x	x		x	x	x					x	
	Registration		x		x	x	x	x	x	x		x			x	x
	Segmentation		x		x	x		x		x		x	x	x	x	
	Visualisation	x				x	x	x			x	x	x	x	x	
	Reconstruction	x		x	x	x		x	x		x		x	x		x
	Simulation	x		x		x		x			xx		x	x		x
	Diffusion	x			x	x		x				x	x		x	x
System Language	**C#**			x							x					x
	C				x							x	x			
	C++	x				x		x								
	PHP													x		
	JAVA	x	x												x	x
	Python	x					x			x			x	x		
	VB.Net								x							
Standalone tool			x	x	x		x	x	x		x	x	x	x	x	
Plugin/ Integration		x		x						x				x		x
Framework						x										
Open Source		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Paid																
Platform	**Windows**	x	x	x	x	x	x	x	x		x	x	x	x	x	x
	Linux	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Mac OS X	x	x				x	x	x	x	x	x	x		x	x

Comparisons between the fifteen medical image processing tools are tabulated as above. The criteria for the comparisons are the latest versions of tool supported, system GUI supported, medical imaging (modalities) supported, tool function provided, languages of tools, type of tools, price and the type of platform to run in. standard to the users. In terms of tools' GUI, all fifteen type of tools provided interface control for users, thus the existence of GUI show user-friendly and convenient to beginner. All fifteen medical image processing tools have different supporting modalities. For instance, VTK only support 3D medical imaging, where SPM able to support 5 types of medical imaging which is MRI, fMRI, PET, CT-Scan, EEG. .Meanwhile, GIMIAS, Elastix and MITK support all type of medical images.

Moreover, each tool has different functionality, for example, NiftyReg have the least utility, it only support segmentation and visualization, while Elastix and Camino provided all functions in their tool. Followed by next discussion topic, which is the language used to develop the software tool. FSL, ITK-Snap, Camino and DTI-TK are C# tools, on the other hand, SPM, MITK and NiftySeg are language C tools. C++ tools are VTK, GIMIAS and Elastix.ITK,Camino and DTI_TK are JAVA tools, the rest tools like NiftyReg, NiftySeg, NiftyRec and NiftySim are python tools. Only ANTS built in VB.Net

All the medical image processing tools surveyed can work as a standalone tool while, VTK, FSL and NifySeg provides plugin or integration with another IDE tool such as Matlab. Only GIMIAS is framework. Most of the MIP tools

surveyed have free version to be used non-commercially, while others have free trial versions which expires after one to three months of usage. For some of the MIP tools to be fully utilized, it requires users to purchase a license to unlock the full function of the MIP tool. Most of the MIP tools can be installed in cross platform (Windows, Linux and Mac OS X) as long as that particular platform supports Java.

Based on the survey and user experience, the author would like to recommend Elastix for medical image processing, it is due to the tool provides the most user friendly and complete experience. It allow user to download the latest software tool version and the software have GUI interface. It also supports all type of imaging like MRI, ultrasound, X-ray and CT-scan. It supports a wide variety of function when performing image analysis and this tool can run as a standalone tool or be integrated with a wide variety of IDE such as Matlab, NetBeans, and Visual Studio. Elastix is an open source tool, user can download the latest version in their official web site, besides that, the web site also providing tutorials for beginner. Elastix is a complete MIP tools , it also has a wide option for importing and exporting result. For importing files, it supports Dicom, JPEG (.jpg), Bitmap (.bmp), PNG (.Png), and TIFF (.tif) version of medical image. Thus, the Elastix medical image processing tool provides a really complete function as an MIP tool with its wide variety of function provided and file type imports, exports and a lot of platform supported.

For users looking for a full featured experience, it is recommended to try out the Elastix for MIP tool. While users who are looking to just try out a segmentation or visualisation tool, it is recommended to try out the Camino. Camino is similar to Elastix, it supports all type of medical imaging and also provided all the listed function, however it only can be installed in window. Although Camino does not provide installer in other operating system, it serves as a good basic functional tool. Most of the MIP tools that are free for non-commercial use are marked as free from the table above. Free downloads are available from the respective tools' website. For the MIP tools that are not marked as free, it means that it requires user to purchase a license to use the particular MIP tool.

V. CONCLUSION

The following conclusions can be drawn from this research:

- Elastix and Camino is a potential tool in medical image processing.
- Gimias is another medical image processing tool that provided in framework.
- In this research, a survey paper has been completed with reviewing of 15 tools

In conclusion, this paper surveys on the existing tools of medical image processing and recommends several medical image processing tools to be applied on medical image analysis. The scope only includes medical image tools. Each medical image processing (MIP) tool has its own limitations. Hence this paper can be used as a reference. However, there are certain limitations for this review paper which is this paper only includes 15 MIP tools. Recommendation for future works includes improving the number of survey tool in the next paper.

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