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A Study of Open Source Toolkits of Image Processing for Healthcare Industry

Garima Sharma
Bhagat Phool Singh Mahila Vishwavidyalaya

Abstract- Image processing is used in every sector of life. The development of medical field is entirely contingent on image processing algorithms. Radiologists utilize these algorithms for detection of diseases such as tumors. These algorithms are designed using proprietary tools which enhance the cost of disease detection. In this paper, various open source toolkits for medical image processing such as ITK, VTK, VV, 3D Slicer, Bioi mage XD are explored. We have also performed various image processing operations such as inversion, enhancement and segmentation using these toolkits. These toolkits provide a cost effective solution to healthcare industry.

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Abstract- Image processing is used in every sector of life. The development of medical field is entirely contingent on image processing algorithms. Radiologists utilize these algorithms for detection of diseases such as tumors. These algorithms are designed using proprietary tools which enhance the cost of disease detection. In this paper, various open source toolkits for medical image processing such as ITK, VTK, VV, 3D Slicer, Bioi mage XD are explored. We have also performed various image processing operations such as inversion, enhancement and segmentation using these toolkits. These toolkits provide a cost effective solution to healthcare industry.

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I. Introduction

Medical imaging plays a pivotal role in detecting disease. Proprietary tools are utilized in order to design image processing algorithms [35]. But these tools are very expensive. Hence open sources are a good option for detecting disease as it provides cost effective solution. Open source softwares are those whose source code can be modified or enhanced by anyone. These are free of cost while proprietary software's are very costly and also it consist some restrictions regarding license availability. Open source softwares provide accurate and cost effective access to the scientist in order to provide the wealth of information. Open source toolkits are used to meet following constraints such as faster feature implementation, free of cost, fast fixes for security and multiple options for a given task and fast upgrades to new releases. Open source tools for image processing can be divided into two categories –general purpose [23] and application specific open source tools. General purpose open sources are Scilab [10] and Open CV (Open computer vision) [2]. Application specific tools are designed for some specific applications. For example the special designed toolkit for medical is not applicable in the field of agriculture and remote sensing etc. For medical image processing, there are some specially designed toolkits which performed operations on medical images. Although general purpose tools are very efficient but still they fails to perform operations such as image labeling and 4d visualization etc. These are some specially designed toolkits for radiologist which can perform all the operations required for medical field.

II. Types of Open Source Toolkits for Medical Image Processing

Application specific open source tools for medical image processing are of three types- programming based, Simulation-based and GUI based. Some open sources are in the form of toolkits and these toolkits can be interfaced with MATLAB/Simulink [29]. There are various types of open source toolkits for medical image processing as depicted in figure 1.

Author: Research Scholar Department of Electronics and Communication Engineering, Bhagat Phool Singh Mahila Vishwavidyalaya, Khanpur Kalan, Sonipat, Haryana, India.
e-mail: firstgarima4@gmail.com

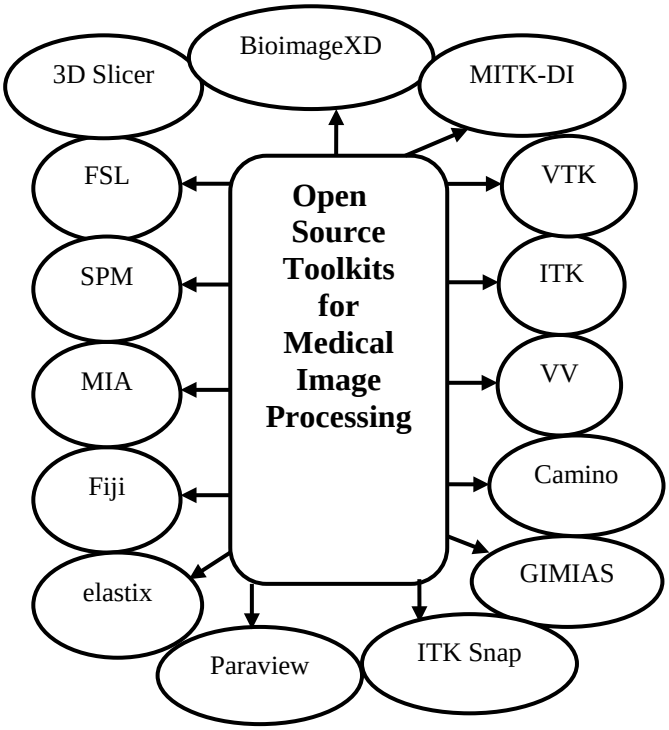

Figure 1: Classification of Open Source Toolkits

a) VTK

Visualization toolkit is free and open source software used for scientific visualization of medical images. It is cross platform software and runs on Windows, Linux, Mac and UNIX platforms and is written in C, C++ and python languages. It is licensed under BSD. It consist a wide variety of visualization algorithms and advanced modeling techniques. It is used in many commercial applications of medical and research and development.

b) ITK

Insight segmentation and registration (ITK) toolkit is open source software which is written in C, C++, FORTRAN and python languages. It is also cross-platform software. It requires CMAKE for its installation which is an open source software used for managing the build process of a software. It is used for segmentation and registration of medical images. In the medical environment, segmentation is used for extraction of data or some kind of disease while registration is used for combining information contained in CT scans and MRI. ITK is also used for visualization, analysis, image-guided surgery applications.

c) FSL

FSL stands for FMRIB Software Library is also open source software which consist a library for analysis of MRI, FMRI (functional MRI). Its size is 1.7 GB and is written in Python language and runs on PCs and apple. It can be run either from command line or from GUI (Graphic User Interface). It has application in analysis of brain imaging data.

d) SPM

SPM (statistical parametric mapping) is an open source for medical image processing which is written by using MATLAB. Also, it contains Matlab scripts, functions, data file. It can run on UNIX, Linux or windows. Its installation requires an operating system, Matlab 5.2.1 or later, ANSII C compiler, internet and a program to convert images into ANALYZE format. It is used for analyzing different medical image modalities such as PET, FMRI, ECG, SPECT, MEG. It is used for data analyses of brain imaging. It supports data sequence of different time interval of same images. It provides statistical parameters for functional imaging in order to test the hypothesis.

e) GIMIAS

GIMIAS stands for the Graphical interface for medical image analysis and simulation. It is written in C++ language and runs on windows and Linux platforms. It performs various image processing operations such as segmentation, Extraction of ROI, filtering etc. It supports DICOM format. It supports a variety of image modalities. It also has a movie control option. It provides multi slice view of medical images. It has applications in neurology, cardiac imaging and angiography imaging.

f) MIA

It is free and open source software which is an image processing toolkit. It is written in C++and distributed under GPLv3+ license. It is compatible with Linux and POSIX (portable operating system interface) which is based on UNIX operating system .MIA is

basically used for grayscale image processing. It has applications in many research scenarios and performs various tasks on 2D and 3D images such as PNG (portable network graphics), TIFF (tagged image file format) etc. It supports various external packages such as VTK (visualization toolkit data), IT++ which is a signal processing library etc. It is licensed under GNU GPL version 3.It requires a huge knowledge for software development [26].

g) 3D Slicer

Slicer is free and open source software written in C++, Python and QT languages. Its size is 200 MB and is compatible with Linux, Mac OS X and windows. It is distributed under BSD license and supports DICOM images. It is built on VTK. It also provides image registration and builds surface models from image labels, automatic segmentation and 3D visualization. It visualizes MRI data collection. It also supports different image modalities like FMRI and DTI.

h) Camino

Camino is a free and open source toolkit which is written in JAVA which makes it simple. It is designed for a UNIX style interface and compatible with Linux, windows, Mac operating system. It is distributed under Artistic license 2.0. For diffusion, it uses UCL Camino diffusion MRI toolkit. It contains very special cutting edge technique. Camino use data acquired either by using scanners or Camino's data synthesizers. Data obtained from scanners is not correct format hence, Camino rearranges that data. It uses a data pipeline model. Camino's output is in binary format. This software is generally used for detecting brain disorders.

i) ITK- Snap

ITK-snap is open source software leverages from ITK which supports medical image formats like DICOM etc. DICOM (digital imaging and communication in medicine) is a standard for handling and transmitting medical imaging information. It is distributed under GNU General Public License. It is cross platform and written in C++ language. It supports automatic segmentation in order to extract tumors in CT and MRI.

j) Paraview

Paraview is free and open source software. It is written in C, C++, FORTRAN, Python and compatible with Unix/Linux, Mac OS, Microsoft windows. It is distributed under BSD license. It is a multi-platform visualization application consist client-server architecture. It supports a variety of file formats including VTK.VTK is a set of libraries which provides data visualization and pipeline architecture. It was developed to analyze large data sets by using distributed memory resources.

k) VV

VV is free open source software which is implemented in C++ along with QT, ITK and VTK. It is distributed under BSD and Ce CILL-B license. It runs on Linux, windows, Mac OS (32 and 64 bits). For researchers, it is compatible with Linux while for clinicians used it on windows. It visualizes 2D, 3D, 4D images and is very fast and simple to use. It has application in visualization, fusion and placement of landmark. It also performs operations on images like cropping an image, pixel manipulation, image arithmetic and re sampling [33].

l) Fiji

Fiji is an open source whose main purpose is to distribute image processing packages based on ImageJ. ImageJ is an image processing program invented by National institute of health. It is written in java and performs operations like image reading, the creation of histogram and line profile, smoothing, geometric transformation etc. Fiji is compatible with Linux, Intel (32 and 64 bit) and windows but it has the least support for MacOSX/PPC. Fiji has applications in life science as it performs operations like segmentation, registration, visualization and other advanced level operations.

m) Bioimage XD

Bioimage XD is free and open source software which is written in C++ and python and distributed under General Public License. It is compatible with Mac operating system, Windows and Linux. It supports 2D, 3D, 4D and XD data. It performs operations like segmentation, filtering, visualization and qualitative analysis. It also supports on ITK and VTK for image processing and segmentation. It has various advantages like easy access, increasing scientific output.

n) Elastix

Elastix is open source software which is compatible with Linux and windows and Mac Operating system. It is highly configurable, easy to extend, reliable and suitable for a large amount of data. In this scripts are written. It is totally based on ITK and is multi-compiler. It supports various image formats such as hdr (Analyze), mhd (MetalO), nii (NIFTI), gipl, dcm (DICOM). But elastix not support DICOM directories directly. It is highly applicable for registration of medical images.

o) MITK-DI

Medical Imaging Interaction Toolkit -Diffusion Imaging is open source software is a part of MITK which is written in C++ and runs on windows, Linux and Mac operating system. It is an object-oriented toolkit and in the form of GUI. It is basically used for brain imaging. It also performs operations like pre-processing of diffused image, visualization and reconstruction. It is used for implementation of DTI [31].

III. Analysis of Image Processing Algorithms Using open Source Medical Toolkits

There are some open sorce toolkits specially designed for medical image processing [34] such as VV, 3D Slicer, Bioimage XD etc in which various image processing operations can be performed in addition to some additional operations which are required for analyzing medical images.

a) Image analysis using VV

There are various image processing operations can be performed in VV which is a 4D slicer. Image inversion is used to obtain information hidden behind white pixels. Image inversion using VV is depicted in figure 2.

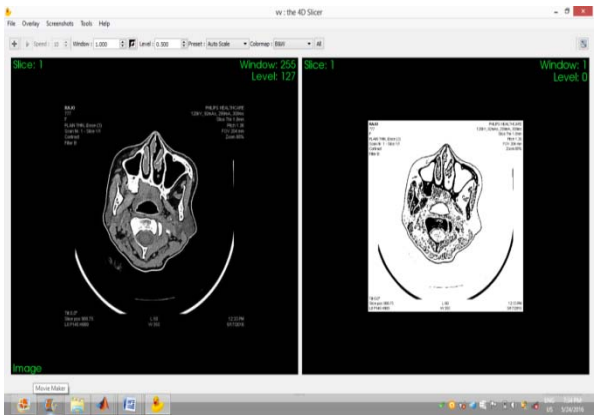

Figure 2: Image inversion using VV with input and output image

Image enhancement operation is performed in order to improve contrast of images. Image enhancement is very important for medical sector as it improve the visualization of images. Hence radiologists can easily detect abnormalities. There are various types of enhancement operations [27] such as mask processing, point processing, histogram based and frequency based operations etc. Image enhancement using VV is depicted in figure 3.

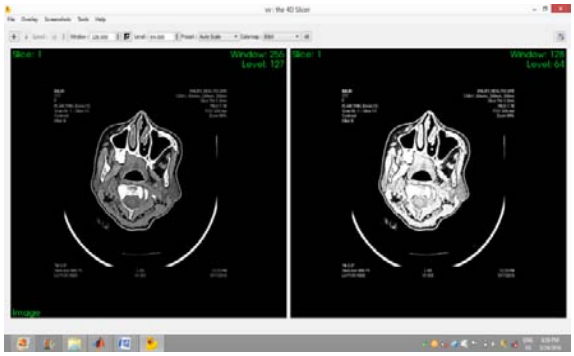

Figure 3: Image enhancement using VV with input and output image

VV performs various image processing operations. VV can perform operations on 2D, 3D and 4D images. Image segmentation plays very pivotal role in detecting location of tumors and artifacts [30]. Edge detection operation is a type of image segmentation operation can be performed using VV is depicted in figure 4.

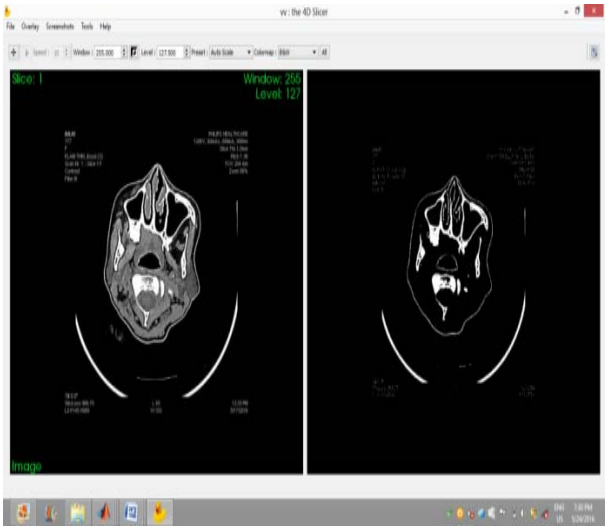

Figure 4: Image edge detection using VV with input and output image

b) Analysis of images using 3D Slicer

3D Slicer performs operations on 2D and 3D images. It support various image formats such as DICOM, PNG and JPEG etc. Image enhancement [25] using 3D slicer is depicted in figure 5.

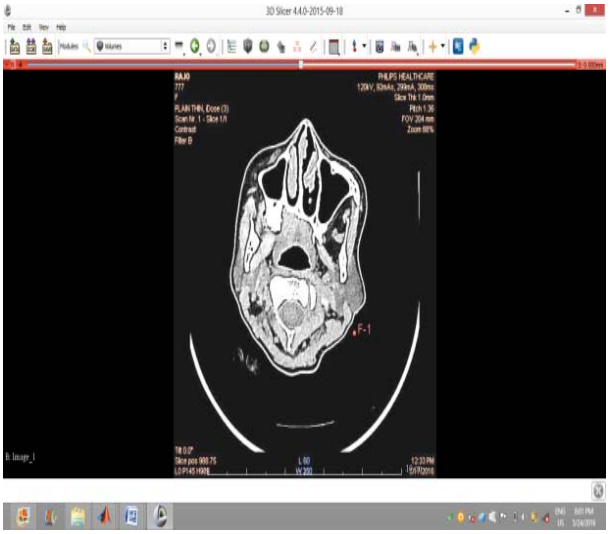

Figure 5: Image enhancement using 3D Slicer

Image thresholding operation which is a method of image segmentation can also be performed using 3D slicer as depicted in the figure 6.

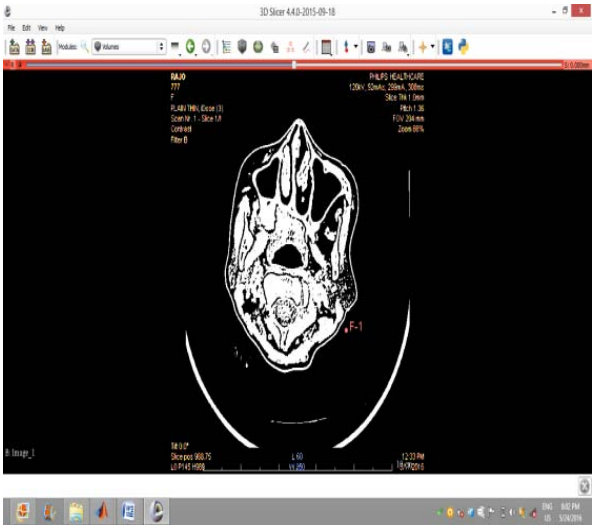

Figure 6: Image thresholding using 3D Slicer

Image segmentation is done in order to segment the tumors and other parts affected due to diseases [29]. Edge detection is a part of image segmentation. Edge detection using 3D Slicer is depicted in figure 7.

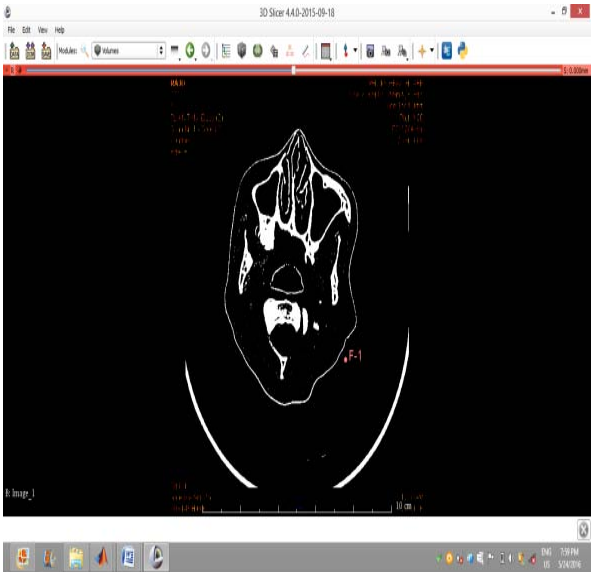

Figure 7: Image segmentation using 3D Slicer

3D Slicer can perform various image processing operations by using 2D as well as 3D images. There are varieties of operations which can be performed using 3D Slicer for detecting diseases.

c) Analysis of images using Bioimage XD

Bioimage XD performs operation on signal image and as well as on multiple images. Thresholding is also used in order to segment images. Image thres holding using Bioimage XD is shown in figure 8.

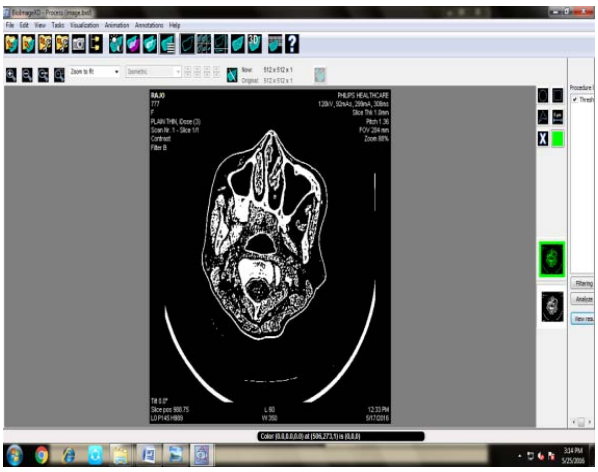

Figure 8: Image thresholding using Bioimage XD

The open source soft wares can also perform the same operations which can be performed using proprietary tools. Biologists directly utilize open sources toolkits for medical applications in order to detect abnormalities and disease. In this thesis, we have designed algorithms for image inversion, enhancement and segmentation using proprietary as well as open source soft wares.

IV. Conclusion

In summary, we have concluded that there are some specially designed open source toolkits for medical image processing such as ITK, VTK, GIMIAS, VV, 3D Slicer, Bioimage XD and elastix etc. We have performed image inversion, segmentation and enhancement operations using these toolkits and concluded that these toolkits can perform these operations with high speed and accuracy. These toolkits not only perform basic image processing operations such as 3D and 4D visualization. These toolkits are very beneficial for radiologist as they can detect tumors and artifacts easily. Hence we have designed a cost effective framework for health monitoring.

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