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Comparative Analysis of Embedded Systems for Anterior Cruciate Ligament (ACL) Magnetic Resonance Image (Mri) Diagnosis

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Abstract: Embedded system is one of the most common system as programming medium for image analysis. Three (3) type of programming medium used in diagnosis anterior cruciate ligament (ACL) magnetic resonance image (MRI), which are Mat Lab R2012 b, Open CV 3.0 and Python 2.7. The analyzed image are categorized into three (3) type of ACL injury, that is normal, partial and serious injury. Analyzing using different embedded system medium provide almost same result with some minor differences. The differences are depending on the process used and it is measured by matric of binary image. The end results in processing magnetic resonance image (MRI) indicate 95% similarities and 5% differences.

Keywords: ACL, MRI and Embedded System.

1. INTRODUCTION

This research study is a combination between two (2) study field that is medical (ACL) and engineering (image processing). Embedded were used to as a medium to process MRI and identify ACL region. As for identification ACL object, used to classify level of injury patient suffer. An embedded system is a computer system with a dedicated function within a larger image processing system, often with real time analyzing anterior cruciate ligament (ACL) magnetic resonance image (MRI) constraints. It is embedded as part of complete software often including MRI and three (3) embedded system, which is Matlab 2012 b, Python 2.7 and Open CV 3.0. Processing image using all three (3) embedded system with same algorithm and method.

Combination between medical and engineering technology could lead into new perspective. Image processing used to analyze the MRI, several techniques such as adjust contras, filtering, image conversion, and etc. applied to the image. Feature extraction technique could provide the data from the processing image and explain level of ACL injury.

2. BACKGROUND

a. Knee Injuries Diagnosis System

There are several types of diagnostic techniques in classifying the types and conditions of knee injuries. Currently, the method used is diagnostic tests. The medical expert uses one or more tests to determine the nature of a knee problem. In most cases, patients are given a primary diagnosis based on their medical history, physical examination, and imaging or other procedures. There are several steps or process in determining the ACL diagnosis system. The process starts with a medical history, where the patient's history is reviewed for further action.

b. Python

Python 2.7 is one of the mediums used to analyze MRI. It is a popular, general purpose, multi paradigm, open source and scripting language. It is designed to emphasize code readability and has a clean syntax with high-level data types. C-language is used as programming code, it is suited for effectiveness of processing ACL MRI and quick prototyping, while being powerful enough to write large applications in. Identification of ACL region is suitable since this medium is an open source, reference can easily get and minimum required storage.

c. Matlab

Matlab R2012b is widely used in all areas of applied image processing and mathematics algorithm. Matlab process software mechanism is built up around vectors and matrices. The software particularly useful for linear algebra, it is also a great tool for image processing image in series. Matlab graphic tools and can produce efficient pictures in both two-dimensional (2D) as required from ACL image. It used C- programming language and is one of the easiest programming languages for writing mathematical programs. Besides that, Matlab also has some toolboxes for signal processing, optimization and analyzing ACL MRI. Matlab also built in routines that enable a very wide variety of computation binary and grayscale signal.

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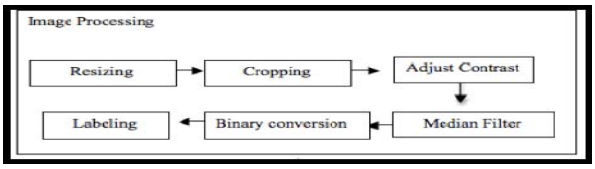
d. Open CV

Open CV 3.0 is an open source computer vision library in C language and it is optimized for real time ACL MRI processing application. Feature required from Open CV is image data manipulation that is feature extraction and basic image processing. It is functioning by matrix and vector manipulation linear algebra routines of process MRI. Since the medium is an open source, reference is easily to get and library source is compiled. The library is cross-platform, and runs on Windows, Mac OSX, Linux, PSP, VCRT (Real-Time OS on Smart camera) and other embedded devices.

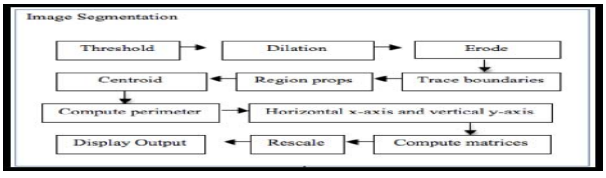
3. MATERIALS AND METHODS

An intelligent diagnostic system for detection of ACL tear and classification is applied in this research. For this research, the study on the ACL knee injury is the most important and crucial part in detecting and classifying the type of knee injury. The process flow involves all three phases mentioned earlier.

Firstly, the process starts with raw magnetic resonance (MR) image captured by radiographer at imaging department in Hospital Taiping. Then image processing, which involve processing steps of resizing, cropping, adjusting contrast, average filter, threshold and binary conversion. The processes continue with image segmentation. These phases involve steps of inversion binary image, dilation, binary threshold erosion and feature extraction. The process involved in the development of the knee injury system is shown in **Fig 1.0 (a) and (b)** show algorithm flowchart of basic image processing and image segmentation using three (3) programming medium that is Open CV 3.0, Python 2.7 and Matlab R2012b.



(a)



(b)

Fig 1.0: (a) Basic image processing (b) Image segmentation.

4. RESULT

All anterior cruciate ligament (ACL) magnetic resonance image (MRI) undergo two (2) phases, which is image processing and image segmentation. The input image from early process of basic image processing was raw MRI produced from imaging department at the Hospital Taiping. The raw image size is approximately 28 000 bytes, dimension of 437 x 500, color space is grayscale and color profile is generic gray gamma 2.2. **(Fig-2.0)** show raw image of normal ACL MRI.

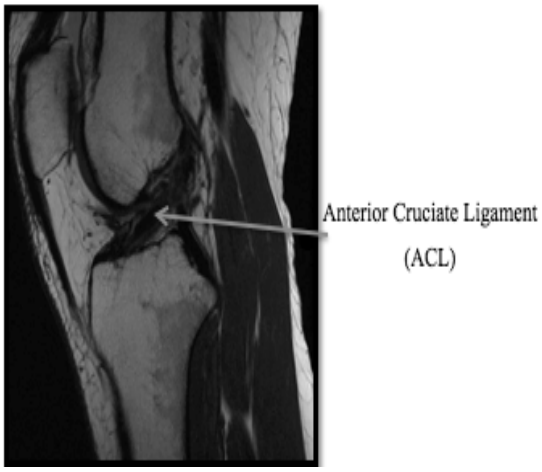


Fig 2.0: Raw image of normal ACL MRI.

The image segmentation process input image from basic image process phase. The segmentation processes continue up to final result. Figure 3.0 (a) (b) and (c) show result for process ACL raw image, whereby undergo phase of basic image processing and image segmentation discussed in methodology.

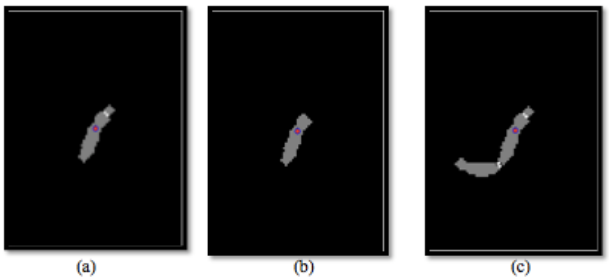


Fig 3.0: (a) Open CV, (b) Matlab R2012 b and (c) Python 2.7.

According to the image from figure 3.0 (a), (b) and (c) clearly show the ACL segmentation has some differences in shape, but same in size. This is due to interruption of unwanted signal (noise) occurring in ACL region. Method using by each medium is same but the syntax and process is different. Therefore, the variety of filtering unwanted signal is wide open depending on process used. Computer did not understand any of the images, converting image from figure 3.0 into summation binary pixel is required to identify the difference. Table 1.0 show summations of pixel occur at ACL region and figure 4.0 indicate comparison graph between Python 2.7, Matlab R2012 b and Open CV.

Table 1.0: Data for normal ACL a) Matlab b) Open CV c) Python

a)

Matlab		
Normal ACL		
Column	Total Pixel	Average pixel
1 (1 - 24)	5842	254
2 (25 - 48)	4991	217
3 (47 - 72)	4600	200
4 (73-96)	4186	182
5 (97 - 120)	4002	174
6 (121 - 144)	4600	200
7 (145 - 168)	4830	210
8 (169 - 192)	4347	189
9 (193 - 216)	4416	192
10 (217 - 240)	5060	220
11 (241 - 264)	4600	200
12 (265 - 286)	5658	246

b)

Open CV		
Normal ACL		
Column	Total Pixel	Average pixel
1 (1 - 24)	5865	255
2 (25 - 48)	5497	239
3 (47 - 72)	5336	232
4 (73-96)	4899	213
5 (97 - 120)	4554	198
6 (121 - 144)	5267	229
7 (145 - 168)	5520	240
8 (169 - 192)	5543	241
9 (193 - 216)	5083	221
10 (217 - 240)	5865	255
11 (241 - 264)	5083	221
12 (265 - 286)	5750	250

c)

Python		
Normal ACL		
Column	Total Pixel	Average pixel
1 (1 - 24)	5865	255
2 (25 - 48)	5313	231
3 (47 - 72)	5060	220
4 (73-96)	4600	200
5 (97 - 120)	4554	198
6 (121 - 144)	4600	200
7 (145 - 168)	4830	210
8 (169 - 192)	4600	200
9 (193 - 216)	4830	210
10 (217 - 240)	5060	220
11 (241 - 264)	5520	240
12 (265 - 286)	5865	255

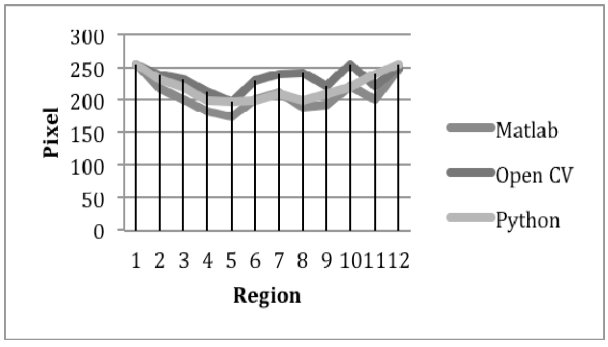


Fig 4.0: Comparison graph for normal ACL

Based from figure 4.0 show different graph based on three (3) different programming mediums that is Matlab, Open CV and Python. From the data plot, Matlab present clear differentiation between ACL region and background. As for python and open CV indicates normal distribution due to noise occur in the background of the image.

5. DISCUSSION AND CONCLUSION

According to this research study, Matlab R2012b is the suitable medium used for this research project. Characteristic contain in Matlab R2012b which can extract noise embed with background and eliminate it. As for Python and Open CV, does not have any specific syntax for extracting noise. In advance, different programming medium indicate different suitability of application. From the result, comparison data between those three (3) mediums and patient history made by medical expert show Matlab R2012 b has the most accurate decision of processing. The precision indicate of 95% (Matlab) , 93.8 (Open CV) and 94% (Python).

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