ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, Vol 9(37), DOI: 10.17485/ijst/2016/v9i37/102081, October 2016 ISSN (Online) : 0974-5645

A New Approach for Recognition of Implant in Knee by Template Matching

C. Malathy[1], Uddipt Sharma[1], Ch Mayuri Naidu[1] and U.Uma Pratheebha[2]

[1]Department of Computer Science and Engineering, SRM University, Kattankulathur, Chennai - 603203, Tamil Nadu, India; malathy.c@ktr.srmuniv.ac.in, uddiptsharma@yahoo.com, mayuri.naidu08@gmail.com
[2]Department of Electronics and Communication Engineering, SRM University, Kattankulathur, Chennai - 603203, Tamil Nadu, India; Pratheebha1994@gmail.com

Abstract

Objectives: Implant replacement in knee is a major operation in which the joint is replaced by metallic implants. **Methods:** When changing the liner of knee implant, surgeon must know the type of implant used prior to the surgery. **Findings:** A new approach to identify the implant used in knee replacement operation using digital image processing techniques was proposed and implemented. The X-ray image was preprocessed and an image database of various implants with their specification was prepared. For testing the X-ray image was acquired and pre processed. After using various images processing operations on the X-ray image, the implant used in patient body was identified by the new approach template matching.

Keywords: Digital Image Processing, Implant Replacement, Template Matching, X-Ray Image

1. Introduction

Total Knee Replacement (TKR) is a major operation in which the joint is replaced by metallic implants. While changing the liner of knee implant surgeon must know the type of implant used prior to the surgery. Sometimes when post-surgery notes are not available, identification of implant is done manually which is time consuming and causes delay in urgent care of patient. The implant identification in patient without record is considered tough due to high mobility and large number of implant available in market. X-ray image of patient's Knee is used as input for the image processing and final matching with the existing implant that is available in market. There are many knee implant manufacturing companies with different design. Currently the radiograph image of the implant is sent to the expert or the manufacturers for identification which may not be accurate at all times and time consuming. The knee implant is divided in two components one attached to femoral bone and other attached to tibial bone. Between these two components there is liner which might have to be replaced with time. It is proposed to identify the implant used the radiograph image of the patient knee, image processing techniques and template matching was used.

Computer software[1] was developed to identify dental implants in patients' mouths using a range of criteria. An algorithm[2] was developed for medical image registration by template matching and was tested with noise and without noise. The method was based on Normalized Cross-Correlation.

An efficient technique was presented[3] to detect median filtering which is used in digital image for denoising and smoothing.

A computer system and methods[4] was developed to detect and identify implanted medical devices and surgical foreign objects from medical images. A technique for automatic detection of tumor[5] is discussed. A low-cost sensor to measure the angular change of the 'stump' socket, and that of the thigh movement[6] was developed to reduce the overall cost of the electronic knees. A complete assessment for post-market surveillance of total knee

*Author for correspondence

replacement was done[7] for improving polymer bearings through evaluation of clinical outcomes and analysis of prosthesis retrieved.

2. Method

The overall implant recognition process is divided in various steps and output of the first step is given as input to the next stage. The steps are

- Image smoothening
- Sharpening
- Noise cancellation
- Color inversion
- Segmentation
- Template Matching

We have used openCV[8] and python as our tool for image processing and entire process. OpenCV is open source computer vision library with programming function dealing with computer vision. The sample X-Ray image of knee is shown in Figure 1.

2.1 Image Smoothening

Image smoothening or image blurring is a process in which we make color transition in image so that the image looks more sharp and clear. It is easy to detect features from a sharp and crisp image rather than normal image. Image is blurred by coiling the image with the low pass filter kernel. OpenCV provides a function, cv2.filter2D () to coil a kernel with an image.

OpenCV provides four types of blurring techniques namely – Averaging, Gaussian Filtering, Median Filtering, Bilateral Filtering. We have used averaging and Gaussian filter for our X-ray image as the results obtained from these two are more useful than others.

2.1.1 Averaging

The idea of mean filtering is simply to replace each pixel value in an image with the mean ('average') value of its neighbors, including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings. Figure 2 shows the X ray image of knee after averaging.

Figure 1. Input X-ray.

2.1.2 Gaussian Filter

Instead of box filter of equal filter coefficients, a Gaussian kernel is used. Function used is cv2.GaussianBlur(). Width and height of the kernel specified should be positive and odd. The standard deviation in the X and Y directions should be specified, sigmaX and sigmaY. If either one is specified another one is taken the same. If both are zero, they are calculated from the kernel size. Gaussian Filtering is effective in removing Gaussian noise from the image which is shown in Figure 3.

2.2 Sharpening

It is a tool which derives its name from the fact that it enhances edges through a procedure which subtracts an unsharp, or smoothed, version of an image from the original image. The unsharp filtering technique is commonly used in the photographic and printing industries for enhancing edges. It is easy to detect edges and features from a sharp image. Implant edges will be clearly separated from bone and tissues after sharpening. Sharpened image is shown in Figure 4.

2.3 Noise Cancellation

Noise is a random variation in color and brightness in image. It is undesirable and has to be removed for

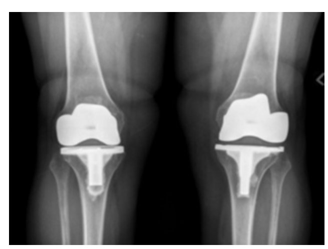

Figure 2. Averaging.

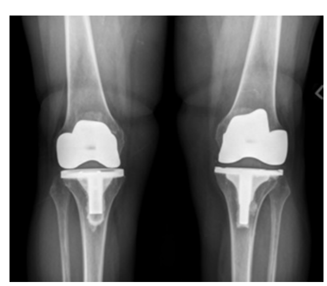

Figure 3. Gaussian Blur.

further processing and accurate results. Noise is generally considered to be a random variable with zero mean. Consider a noisy pixel, p=p0+n where p0 is the true value of pixel and n is the noise in that pixel. You can take large number of same pixels (say N) from different images and computes their average. Ideally, one should get p=p0 since mean of noise is zero. The image after noise cancellation is shown in Figure 5.

2.4 Color Inversion

As preprocessing is carried with X-ray image which is more like a black and white or grayscale image, the implant will be in light color when compared to its surrounding. Using color inversion, light implant can be converted to dark and its neighbor to light colors. This will make segmentation and edge detection easy and accurate. It is performed by color inversion tool in MS Paint as shown in Figure 6.

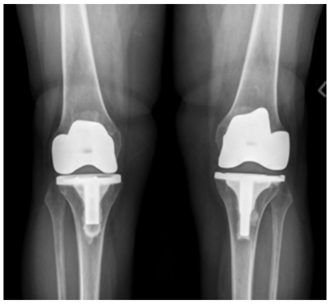

Figure 4. Image sharpening.

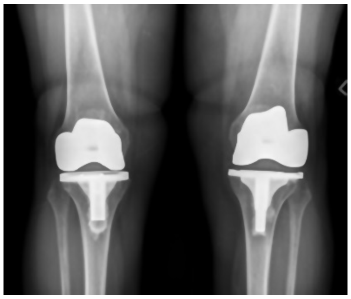

Figure 5. Noise cancellation.

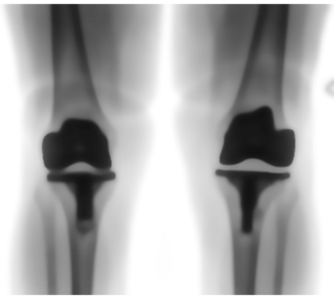

Figure 6. Color inversion.

2.5 Segmentation

Image Segmentation means partitioning image into various segments (sets of pixels). It makes image more simplified and easier to analyze.

The most basic type of image segmentation is Thresholding.

2.6 Thresholding

To differentiate the pixels, a comparison of each pixel intensity value with respect to a threshold was performed. After separation of the important pixels, it is set with a determined value for identification, for example 0 for Black 255 for White. To perform thresholding, the function cv2.threshold is used.

OpenCV provides five basic thresholding methods –

cv2.THRESH_BINARY, cv2.THRESH_BINARY_INV, cv2.THRESH_TRUNC, cv2.THRESH_TOZERO, cv2.THRESH_TOZERO_INV.

Depending on the values provided the result varies. Results with global thresholding are more useful to us in implant identification as compared to other thresholding.

Global thresholding Function- cv2.threshold(img,127,255,cv2.THRESH_BINARY)

An image with implant which is clearly visible and sharp edges for matching and recognition (pre processed) is obtained. Figure 7 shows the image after binary thresholding.

2.7 Template Matching

This is final step of the process in which the processed image that is obtained after various operation is used against an implant template to check which implant is there. Template Matching is a method for searching and finding the location of a template image in a larger image. An opencv function is used for this and It simply slides the template image over the input image and compares the template and patch of input image under the template image. The matching is done with all the

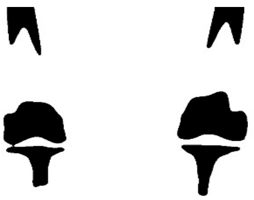

Figure 7. Binary thresholding.

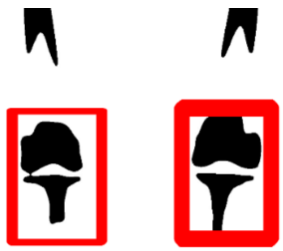

Figure 8. Template matching.

available implants and the implant with highest threshold value is selected as our result. the image shown in Figure 8 gives the image after the opencv function applied to pre-processed image.

3. Results

The application built works well with x-ray images. It works successfully on computer systems, laptops which have OpenCV library and python installed in them. It simply performs various image processing techniques on x-ray images to extract knee implant and then match it with the available implant templates in the file. This helps the doctor to find out the details of the knee implant without performing any operation; hence it is less time consuming and useful in emergency cases where replacement has to take place immediately. After matching the result shows the image with red border around the implant matched. The thickness of the red border depends on the threshold value with which it is matched. If threshold value is high, the red border is thin, whereas if threshold value is less red border is thick, which indicates that the implant doesn't match properly. This happens mainly in cases where both knees have implants of same material, but only one matches with higher threshold value and other with lower threshold value since the size and shape of the implant varies for both knees even though the material of implant used is same.

4. Conclusion

After matching the result shows that the image with red border around the implant matched. The thickness of the red border depends on the threshold value with which it is matched. If threshold value is high, the red border is thin, whereas if threshold value is less red border is thick, which indicates that the implant doesn't match properly. This happens mainly in cases where both knees have implants of same material, but only one matches with higher threshold value and other with lower threshold value since the size and shape of the implant varies for both knees even though the material of implant used is same. In future this can be implemented with large datasets.

This work can be extended to other types of images such as CT scan and MRI images. Here again some changes have to be made in choosing the techniques, since the amount of noise and crispiness may vary for these type of images. Doctor can directly input the x-ray image and get the details of the implant after all the processing on the screen with minimum supervision. Also whether the implant is present in the market or not can be displayed along with the manufacturer. If currently any manufacturer doesn't manufacture that particular implant, or it will take time and there is some emergency case, it will give alternate suggestions on what implant can be used.

The entire process carried out is shown in Figure 9.

Figure 9. Overall process for knee implant recognition.

5. References

1. Michelinakis G, Sharrock A, Barclay CW. Identification of dental implants through the use of Implant Recognition Software (IRS). International Dental Journal. 2006 Aug; 56(4):203–8.
2. Sarvaiya JN, Patnaik S, Bombaywala S. Image registration by template matching using normalized cross-correlation. International Conference on Advances in Computing, Control, and Telecommunication Technologies. 2009. ACT '09., Trivandrum: Kerala; 2009 Dec. p. 819–22.
3. Kirchner M, Fridrich JJ. On detection of median filtering in digital images. Memon et al, editors, Media Forensics and Security II, part of the IS&T-SPIE Electronic Imaging Symposium, Proceedings of SPIE; 2010 Jan.
4. Gluncic V. System and methods for identification of implanted medical devices and/or detection of retained surgical foreign objects from medical images. Rush University Medical Center[US/US]; 2013. p.1653.
5. Dixit V, Pruthi J. Review of image processing techniques for automatic detection of tumor in human liver. International Journal of Computer Science and Mobile Computing. 2014 Mar; 3(3):371–8.
6. Shaikh S, Malhotra A. Real time acquisition of stump angle as a feedback signal for development of low cost electronic knee prosthesis. Indian Journal of Science and Technology. 2016 Jan; 9(2):1–7.
7. Nunez L. Post-market surveillance of total knee replacement combining clinical outcomes and quantitative image processing techniques. All Theses Clemson University; 2014 Jan.
8. Open cv Docs [Internet]. [Cited 2016 Jan 01]. Available from: http://docs.opencv.org/.