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Performance Analysis of Image Processing Algorithms using Matlab for Biomedical Applications

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Abstract

Image processing is used in every sphere of life such as agriculture, remote sensing, wireless, medical etc. Biomedical imaging plays a vital role in the detection of diseases. Without image processing, it is not possible to detect diseases such as cancer, tumors etc. Medical equipment such as ultrasound, MRI, CT scan machine is totally dependent on image processing algorithms. Radiologists utilize these image processing algorithms to detect diseases and abnormalities. Matlab is a proprietary tool which is used by image architects in order to design these algorithms. Image processing algorithms designed using Matlab provides efficiency, accuracy, flexibility and timing constraints. The present paper addresses various image processing algorithms designed using Matlab. The performance of these algorithms is also analyzed visually as well as statistically in order to check the quality of images.

Index Terms: Matlab, PSNR, Mean, Median, Edge detection.

1. Introduction

   Image is formed by the combination of pixels. Image processing algorithms deal with the manipulation of these pixels. Image processing plays a vital role in the field of medical in order to detect artifacts and diseases. Image processing algorithms for biomedical equipment such as Ultrasound, MRI, CT scan machines are designed by image architects [40]. The radiologists utilize these algorithms to detect various diseases such as cancers, tumors etc [28].
   Matlab is a proprietary tool which is highly used in various biomedical applications due to its flexibility, accuracy and timing constraints. It is used for software as well as the hardware implementation of images. It can interact with proprietary as well as open-source softwares. Matlab is also utilized for FPGA implementation of images [37]. Also, it has inbuilt support for some open source hardwares. For the healthcare industry, it is very

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important to extract accurate information in order to detect diseases [19]. Hence Matlab is a very effective tool for biomedical applications.

Image processing algorithms are based on mathematical modeling. There are various types of image processing algorithms which are utilized by biologists. Most commonly used image processing algorithms are image inversion, enhancement and segmentation. For image inversion, the image is complemented in order to extract information stored in dark pixels. Image enhancement algorithms are designed in order to improve brightness and contrast of image [15]. There are various filters used for image enhancement. Image segmentation algorithms are designed to detect the area of interest. In biomedical imaging, image segmentation is done in order to detect diseases such as tumors [39]. Edge detection is one of the important methods of segmentation [32]. There are various types of operators used for detecting edges. These include Sobel, Prewitt, Robert and canny operator [34]. These algorithms are generally used in diverse biomedical applications.

2. Image processing Algorithms using Matlab

Image processing algorithms using Matlab are designed by writing script files which consist of programming. In Simulink, there is no need to write codes. It is very important to check the quality of images after applying the algorithms. Hence visual and statistical analysis is performed in order to check the quality of processed images. In this, we proposed commonly used algorithms of image processing and analyzed the performance using Matlab/Simulink. We have designed image processing algorithms using Simulink and also analyzed statistical parameters to detect performance of designed algorithms. Computer vision library of Simulink is used for designing image processing algorithms. The proposed methodology of image processing algorithms using Matlab is depicted in figure 1.
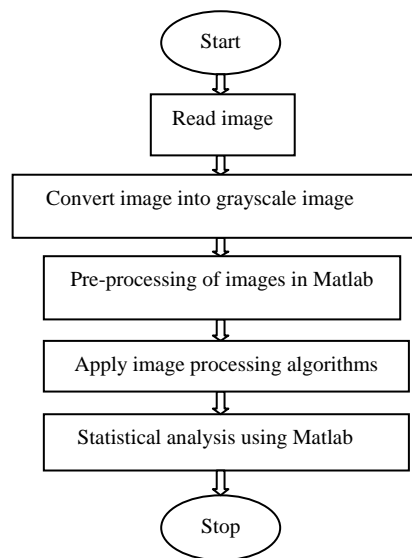

Fig.1. Design Flow of Image Processing Algorithms using Matlab

Images are first converted into grayscale images and then pre-processing is done in order to remove noises and then image processing algorithms are applied. The results of image processing algorithms using Matlab can be analyzed both qualitatively and quantitatively. Statistical analysis is done in order to check the performance of images quantitatively.

3. Performance analysis of images processing algorithms

Three types of algorithms are generally required which are image inversion, image enhancement and image segmentation for disease detection. The performance of image processing algorithms can be obtained by analyzing the results visually as well as by calculating statistical parameters of images such as mean, median, standard deviation etc.

3.1. Visual analysis using Matlab/Simulink

In this, we have design image processing algorithms using computer vision library of Simulink. Image inversion is used in order to obtain the information hidden in dark pixels. Image inversion using Simulink is depicted in figure 2.
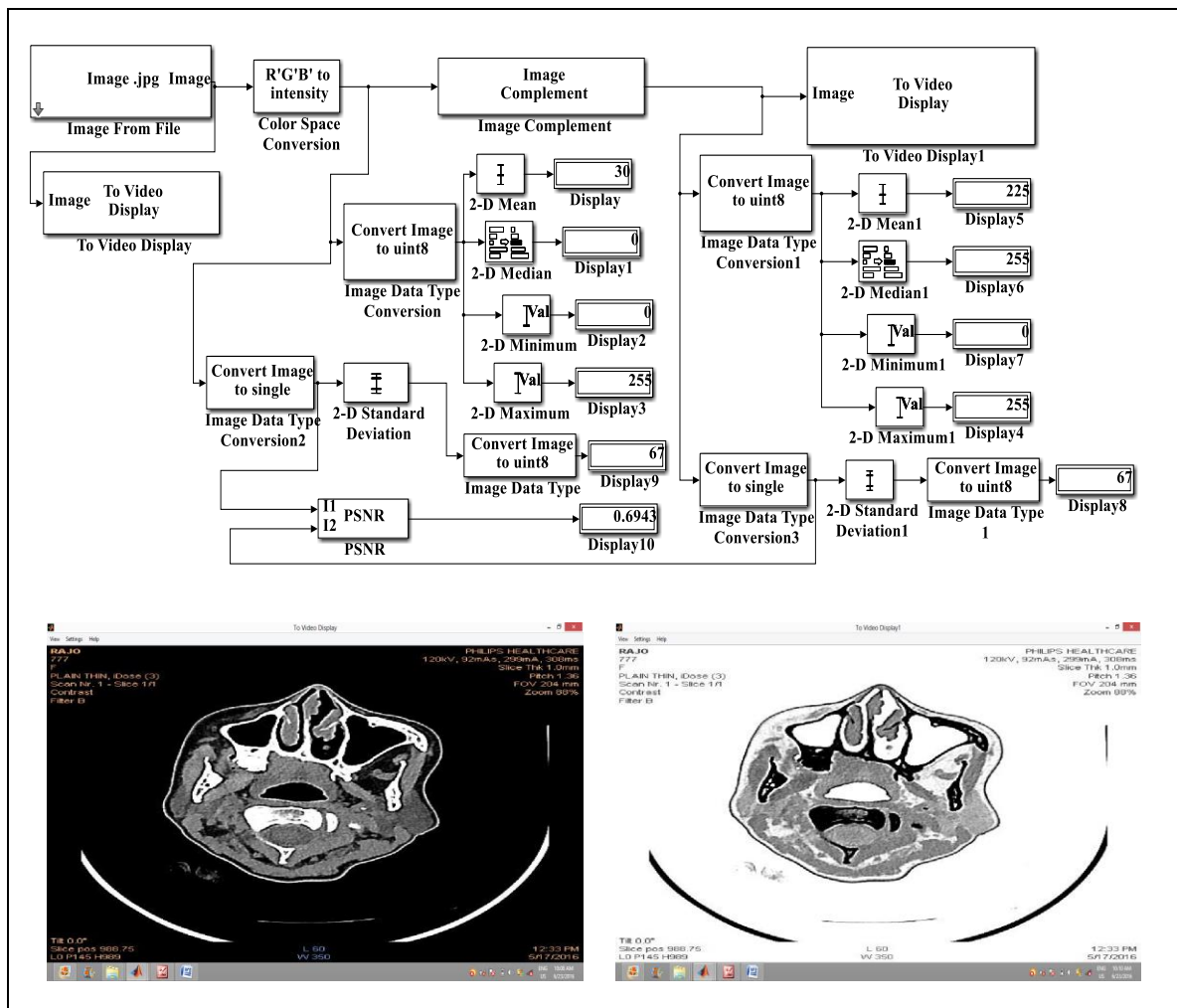

Fig.2. Image Inversion Model with Input and Output Image using Simulink

Image enhancement algorithms are designed in order to improve the brightness of images so that biologists can get accurate information from the images [9]. There are different methods of image enhancement such as filtering, thresholding and contrast stretching etc. Various filters can be used to enhance the quality of images. Filters are used to remove the noise. The median filter is a nonlinear filter. It works on the principal of statistical ordering i.e. the response of this filter depends on the order of the values of neighborhood pixels. The Simulink model for image enhancement using median filtering is depicted in figure 3.
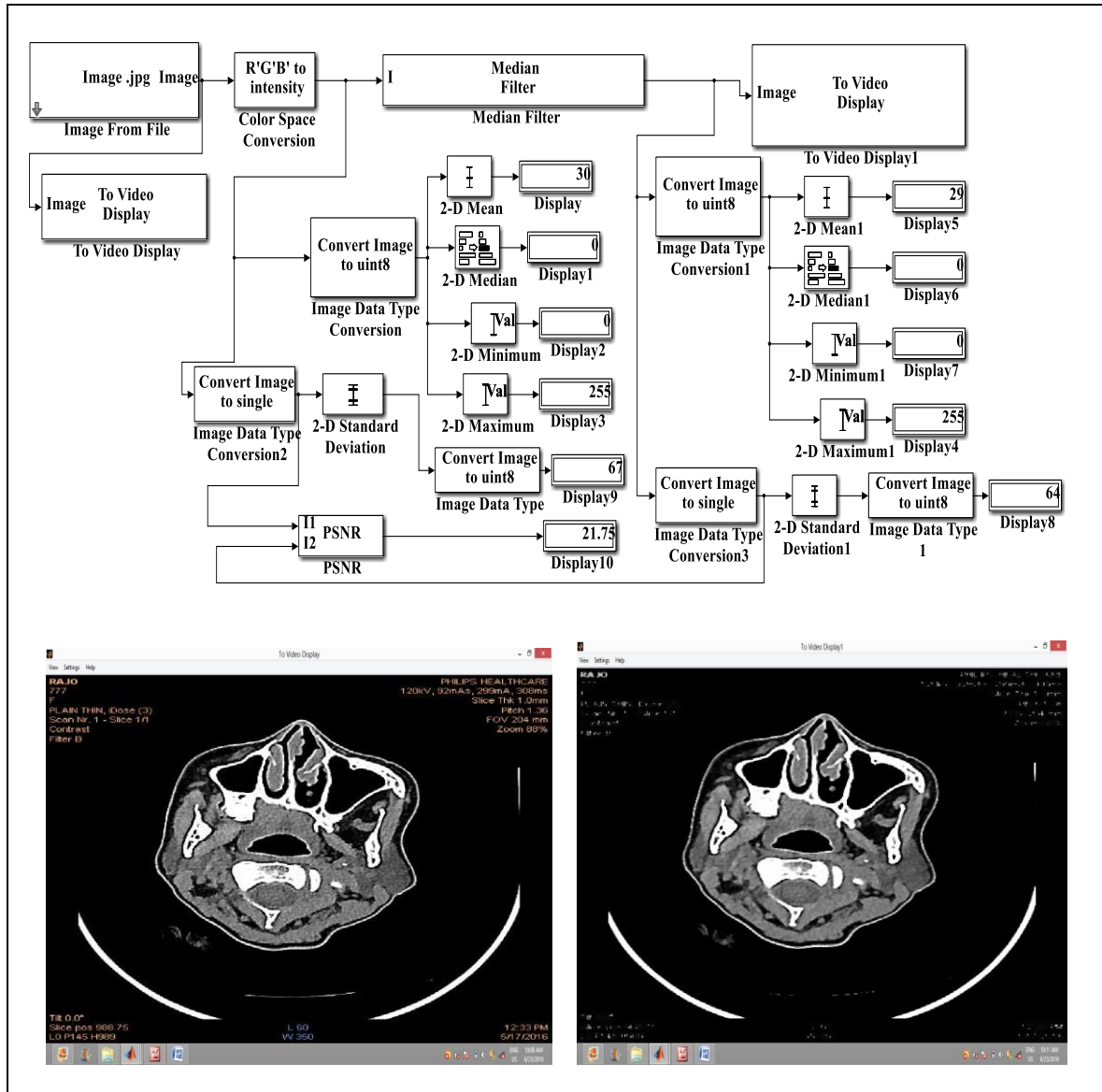

Fig.3. Image Enhancement Model using Median Filter with Input and Output Image using Simulink

Images can also be enhanced by adjusting its pixel values [31]. This can be achieved by adjusting the

contrast of images. This method is used for enhancement of dark images. Image enhancement using contrast adjustment is depicted in figure 4.
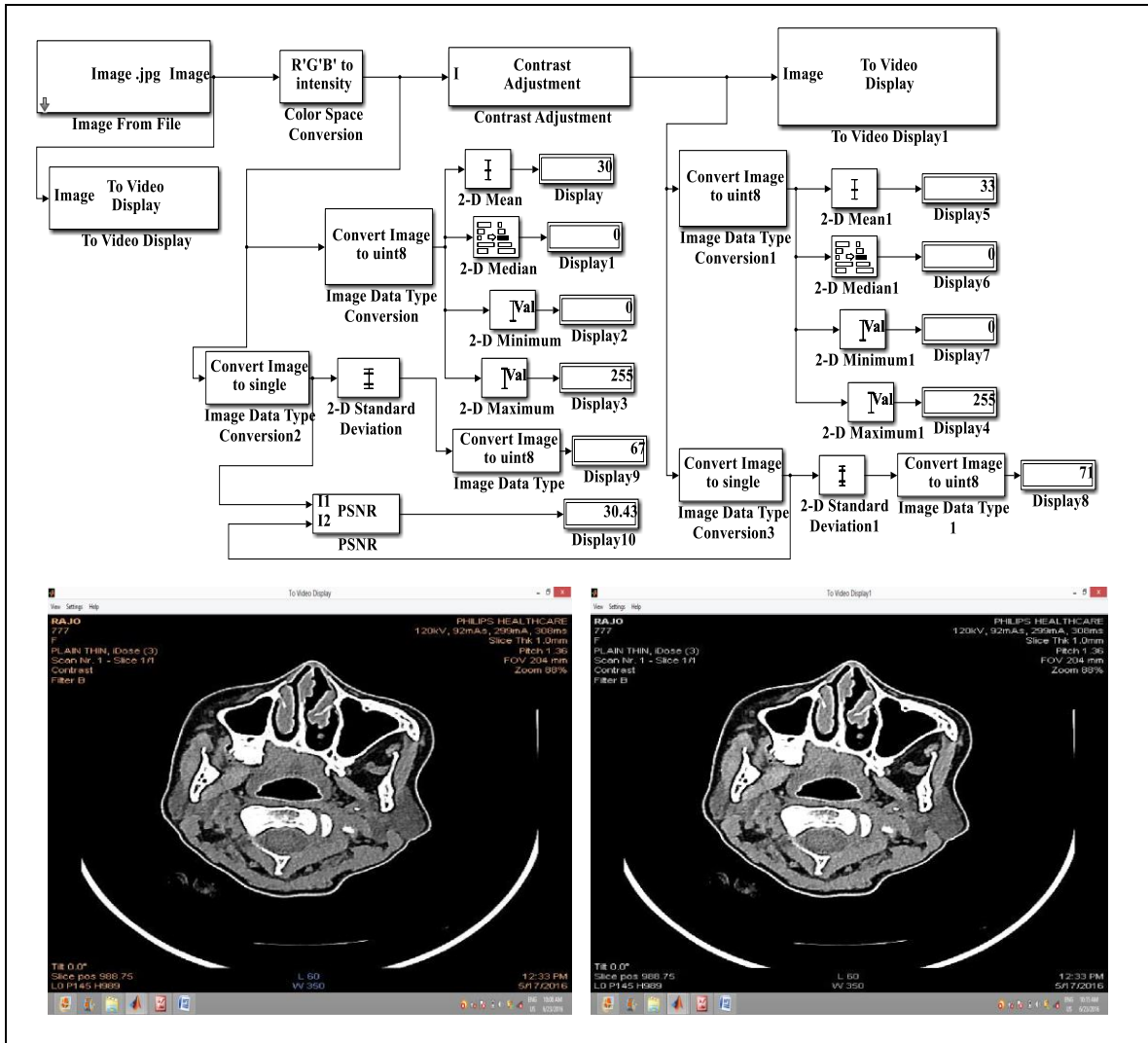

Fig.4. Image Enhancement Model using Contrast Adjustment with Input and Output Image using Simulink

Images enhancement algorithms are designed to improve the quality of image by sharpening the image [29]. The main objective of image enhancement is to change attributes of an image to make it more accurate for a specific application. One or more attributes of the image are modified in order to enhance the image. Image enhancement algorithms are broadly divided into two categories- spatial domain and frequency domain [2]. Thresholding is also used for image enhancement. It is also used for image segmentation. Thresholding image is a binary image which consists only either low or high value for corresponding pixel [36]. If the intensity is higher than a particular value called thresholding value then the image contain maximum value and if it is less than thresholding value then the value of processed image is zero. Simulink model for image enhancement using thresholding is depicted in figure 5.
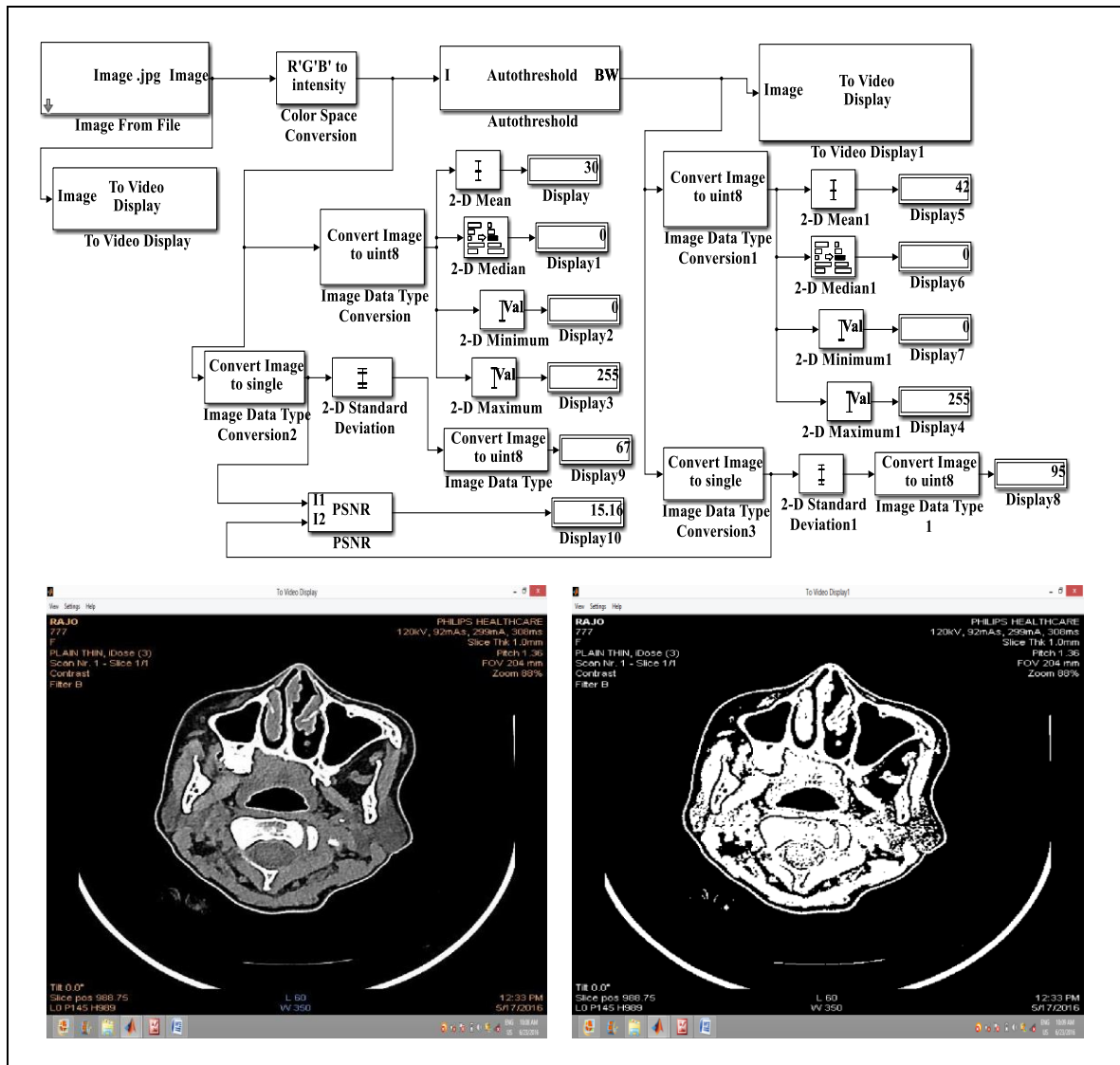
Fig.5. Image Thresholding Model with Input and Output Image using Simulink

Image segmentation [8] is the very important process used for detection of cancer, tuberculosis etc. There are various methods of the image which are used for different applications. Segmentation subdivides an image into its different parts. It is broadly divided into three categories - point, line and edge detection. There are various operators such as Sobel [17], Robert, Prewitt and canny etc which are used for designing edge detection algorithm. Edge detection using Sobel operator is depicted in figure 6.
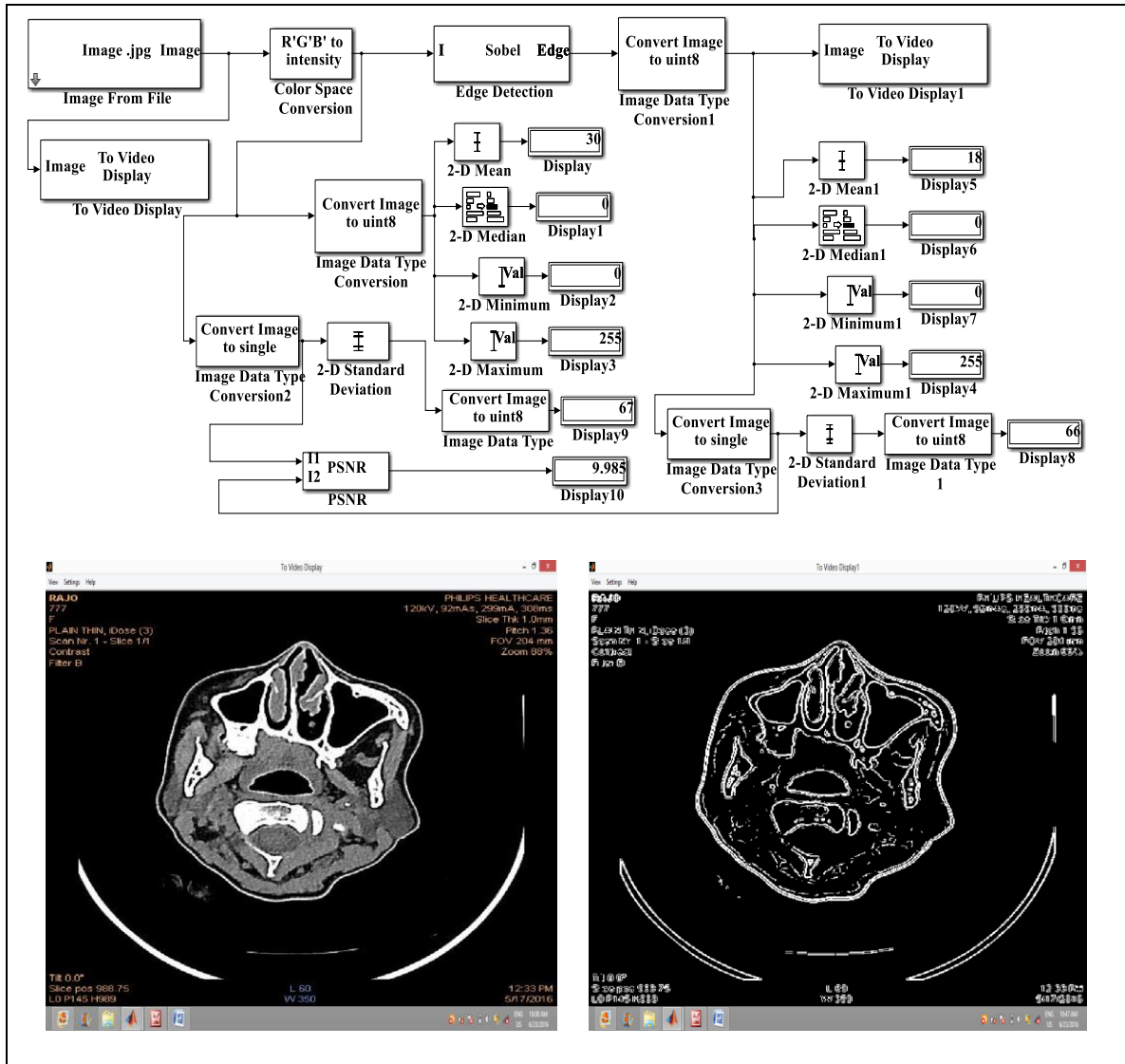
Fig.6. Sobel Edge Detection Model with Input and Output Image using Simulink

An edge is a defined as a boundary between two regions with different gray-level properties [16]. Edge detection algorithms play a crucial role to detect the exact location of desired areas. Different edge detection operators give different results visually as well as statistically [27]. It is very difficult to compare the performance of various operators. Image architects utilize various edge detection operators on the basis of the specific application. The Canny operator is also a very important operator which gives efficient results for edge detection [5]. Edge detection using canny operator is depicted in figure 7.
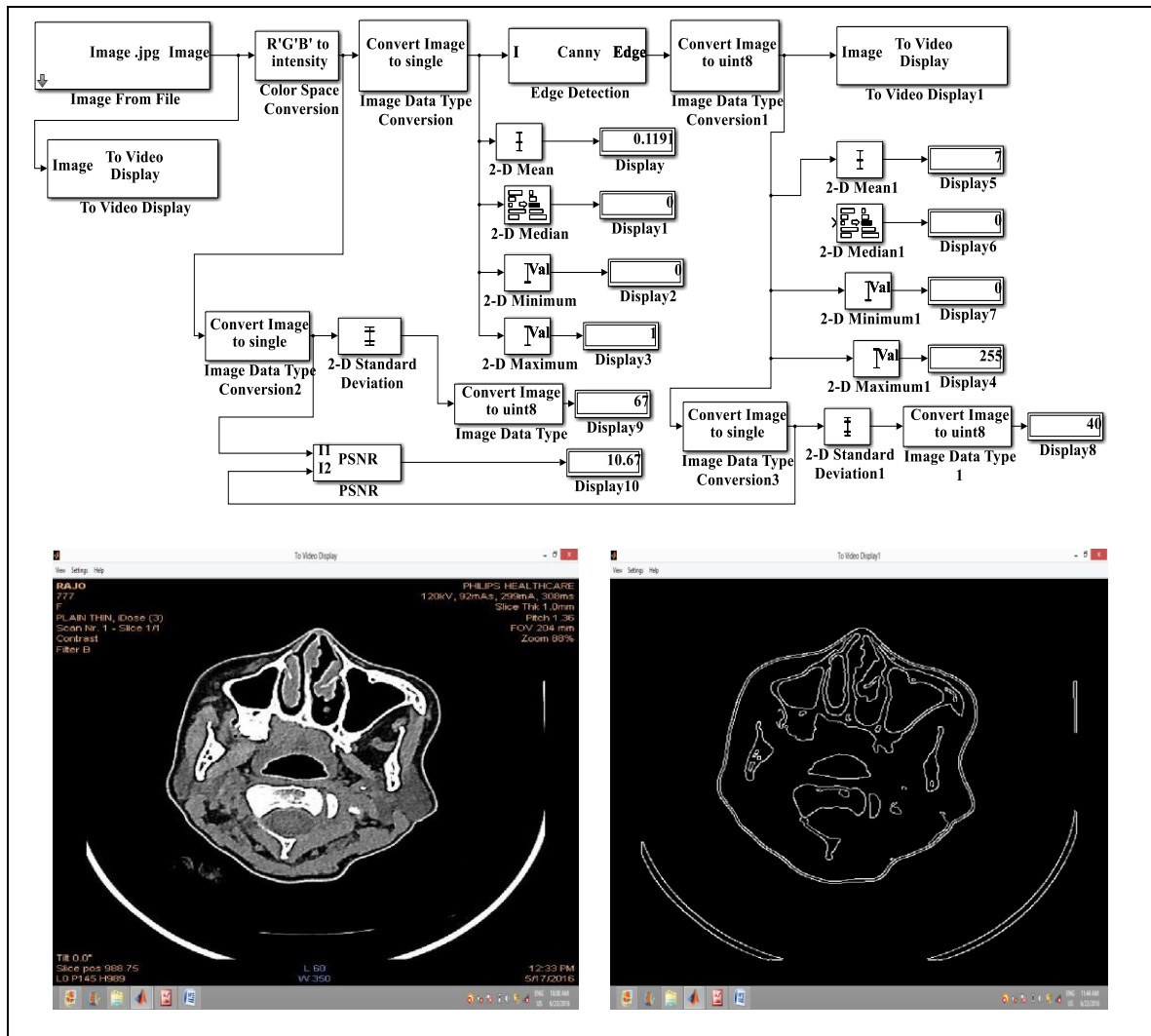
Fig.7. Canny Edge Detection Model with Input and Output Image using Simulink

Image processing algorithms are very important to analyze visually. But it is not only sufficient to analyze image visually because sometimes algorithms give similar result visually. Hence statistical analysis is done to detect the quality of applied algorithm.

3.2. Statistical analysis using Matlab/Simulink

Image processing algorithms such as image enhancement give same results visually. Hence it is not possible to detect the actual quality of images. Some mathematical parameters are calculated in order to check that which parameters provide better results [4]. Various statistical parameters are calculated using Simulink which can be utilized for calculating quality of proposed algorithms as depicted in table 1.

Table 1.Statistical analysis using Simulink

Sr No.	Image Processing Algorithm	Mean	Standard Deviation	Minimum	Maximum	PSNR wrt input image
1	Input Image	30	67	0	255	-
2	Image Inversion	225	67	0	255	0.6937
3	Image enhancement using median filter	29	64		255	21.75
4	Image enhancement using contrast adjustment	33	71	0	255	30.43
5	Image autothresholding	42	95	0	255	15.16
6	Sobel edge detection	18	66	0	255	9.985
7	Canny edge detection	7	40	0	255	10.67

Statistical parameters are used to detect the quality of applied image processing algorithms. These parameters determine that which algorithm provide better results as compare to other. Although results obtained from different algorithms sometimes appears to be same visually but they are actually different. So these parameters calculate the results statistically [38]. Mean calculates the average intensity values whereas standard deviation calculates the variation in the intensity values of pixels. The minimum value for all the algorithms is 0 which indicate the smallest element in a row or column and maximum value for all the algorithms are 255 which indicate the value of the maximum element in a row or column. PSNR is peak signal to noise ratio which indicates the quality of images. PSNR of image enhancement algorithm using contrast adjustment is 30.43 and for median filter, PSNR is 21.75. It indicates that image obtained using contrast adjustment gives improved image as compared to median filter. Similarly, PSNR of canny edge detection is 10.67 where as 9.985 for Sobel edge detection. It indicates image obtained from canny edge detection gives better results as compared to Sobel edge detection. Hence all these parameters play very crucial role in estimating the quality of images. These parameters are very important for image architects in order to select the best algorithm. Image architects utilize the most accurate algorithm for designing equipment.

4. Conclusion

Biomedical instruments play a pivotal role in the detection of various diseases. These instruments use image processing algorithms which are designed by image architects. Biologists utilize these algorithms to detect artifacts and abnormalities. Matlab is a proprietary tool which provides accuracy and flexibility and timing constraints for. Image architects use Matlab for designing image processing algorithms. In this paper, we have designed various image processing algorithms using Matlab/ Simulink such as image inversion, enhancement and segmentation. We have analyzed the performance of these algorithms visually as well as statistically. Contrast adjustment gives better quality image due to its high PSNR as compared to other image enhancement algorithms. Similarly, the canny operator gives better quality as compared to the sobel operator for edge detection. The statistical parameters are very important to determine the quality of used algorithm. Hence Matlab is very flexible, efficient and accurate tool for designing image processing algorithms for biomedical applications.

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