Image Analysis and Disease Stage Detection of Kidney Using DCE-MRI

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ABSTRACT

For accoutering assumptive anatomy and resolute, distinctive characteristics have been extrapolated using image processing. Literature survey reveals that, the processing steps like registration, segmentation are separately applied for extraction of consecutive decorum of DCE-MRI of kidney. To have simultaneous registration and segmentation of the kidney, a 4D model is described. For identification of kidney abnormal functioning and disease detection, the glomerular filtration rate (GFR) is a key factor. For our algorithm Dynamic contrast enhancement magnetic resonance imaging (DCE-MRI) is the imaging advancement, have been used before for measuring distinct parameters homologous to suffuse, capillary leakage, and convey rate in tissues of different organs and ail spotting. The novel approach permits us to automatically accomplishing a statistical anatomizing of different parameters from live cells using 4D-mdel. Conclusion of findings is accomplished by mean gray level ardency esoteric the kidney region. Disease identification and stage of identification is calculated automatically which is also verified with the Radiologist reports.

Keywords: *DCE-MRI, Kidney, Registration, Segmentation, GFR, CKD*.

1. INTRODUCTION

DCE-MRI of the kidney has advantages: i) Radiation exposure is not required ii) Three dimensional acquisitions are used iii) spatial resolution is superior.[8] Accompanied by difficulties like: i) low spatial resolution due to fast scanning, ii) selection of proper registration process, iii) choosing correct segmentation process.

In the existing system there is a huge work did on 2D and 3D model which contains registration, segmentation and compartment modeling but it consists of optimization trouble. Manual segmentation included the system so there is problem of handshaking errors. Also measuring of GFR is not provided in this work in the past. Robust image registration and segmentation are not provided in the system. Acute rejection and normal patients' classification cannot be done. There is no approach of combining registration and segmentation in the previous systems. Only an initial segmentation is assumed and this information is important in the combining registration and segmentation which can be used as input image, depends on the application. For serial segmentation and registration, a sequential approach is used. Boundary detection mechanism is not provided in the system. There is no approach toward diagnosis of renal diseases in the erstwhile.

In the proffered system, the optimization trouble can be overcome. Handshaking errors can be removed. This system gives robust image registration and segmentation. The combination of registration and segmentation will be done. Serial segmentation and registration can use in this system. This system also calculates the GFR value by using voxel deformations presented in the image. Also boundary area is disassociating by using the spatial mapping and segmentation on the area of the image. By using set of some standard rules, the diagnosis of various renal diseases of the kidney can be detected.

2. SYSTEM MODELLING AND DESIGN

1. Input Image: A breath-hold T1-weighted 3D single gradient recall echo (GRE) FLASH3D pulse sequence was used to obtain signal-intensity time inflection hinder rule of a little dose (2 ml) of a Gadolinium based contrast agent intravenously. They are nonlinearly affiliated to the observed signal intensities, but can be estimated by voxelwise measurements of the pre-contrast dalliance caliber R1, the interaction between R1 and [Gd] is linear for low [Gd]. The acquisition parameters for all examinations were SL/TE/TR = 6/3.71/8.3, SP = F30.0, FOV = 380*380, 410p*512I, for Tra, W = 378 & C = 157, and for Cor, W = 420, C = 173.

2. Original Image: Original Image is in Diacom form but for this project, this image is converted into jpeg form as various preprocessing steps are processed on jpeg image because of good results will get by these types of images.

3. Image Preprocessing: In image preprocessing, first length of the image is found out by using pixel size of image. Histogram equalization enhances the contrast of images by transforming the values in an intensity image. Threshold level is a regularized ardency value that belongs in the range [0, 1]. The threshold function uses Otsu's method, which cull the threshold to belittle the intraclass variance of the black and white pixels. The thresholding of image ignores any nonzero imaginary part of image. The inclination is deliberated using the derivative of a Gaussian filter. The approach uses two thresholds, to ascertain strong and weak edges, and entail the weak edges in the output only if they are connected to strong edges.

3. Feature Extraction: The Edge Detection to find the edges of objects in an image. This finds the pixel emplacement where the magnitude of the gradient of intensity is larger than a threshold value. These locations typically occur at the boundaries of objects.

4. ROI: Algorithm that gives more intuitive aftereffect and has better performance. It returns a binary image that can use as a mask for masked filtering.

5. Binary Gradient Mask: The binary gradient mask demonstrates lines of lofty compare in the image. Assimilated to the foremost image, discontinuity in the lines surrounding the object in the gradient mask. These direct discontinuities will dissolve if the Sobel image is dilated.

6. Dilated Gradient Mask: The binary gradient mask is dilated using the vertical edifice element followed by the horizontal structuring element.

7. Binary Image with Filled Holes: The dilated gradient mask shows the contour of the cell quite nicely, but there are still holes in the interior of the cell.

8. Cleared Bordered Image: The cell of interest has been successfully segmented, but it is not the only intension that has been found. Any objects that are joined to the edge of the image can be removed. The connectivity in the function was set to 4 to remove diagonal connections.

9. Segmented Image: Finally, in order to make the segmented object look natural, smoothen the object by eroding the image twice with a diamond structuring element.

10. Outlined Original Image: An alternate avenue for giving the segmented object would be to place an outline around the segmented cell.

11. PSNR: This ratio is often used as a quality measurement between the original and a compressed image.

$$PSNR = 10\ log_{10}\left(\frac{R^2}{MSE}\right) \qquad (1)$$

R is the maximum fluctuation in the input image data type. The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics used to compare image compression quality.

12. GFR: An added variable plot is used to determine the unique effect of adding a new term to a model. The plot shows the relationship between the part of the response unexplained by terms already in the model and the part of the new term unexplained by terms already in the model. The "unexplained" parts are measured by the residuals of the respective regressions. A scatter of the residuals from the two regressions forms the added variable plot.[2]

$$\text{GFR} = \text{sqrt(MSE)} \tag{2}$$

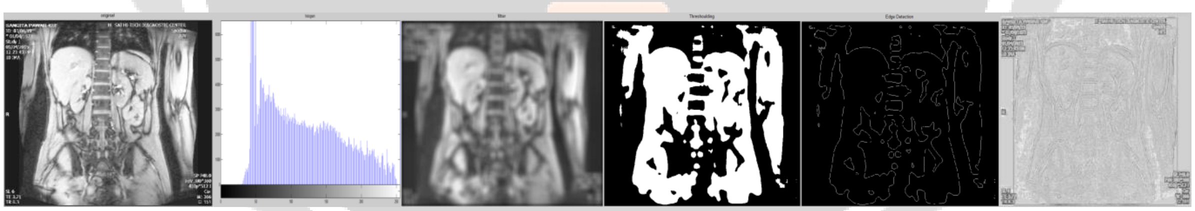
13. Quality of Image: The quality of the receiving pixels might vary with time and position. By specifying the WEIGHT array parameter with the function, specify that certain pixels in the image be ignored. To ignore a pixel, assign a weight of zero to the element in the WEIGHT array that corresponds to the pixel in the image. The algorithm converges on predicted values for the bad pixels based on the information from neighborhood pixels. The variation in the detector response from pixel to pixel can also be accommodated by the WEIGHT array. Instead of assigning a weight of 1.0 to the good pixels, can specify fractional values and weight the pixels according to the amount of the flat-field correction.[8]

$$\text{quality} = \text{mean(quality\_map)} \tag{3}$$

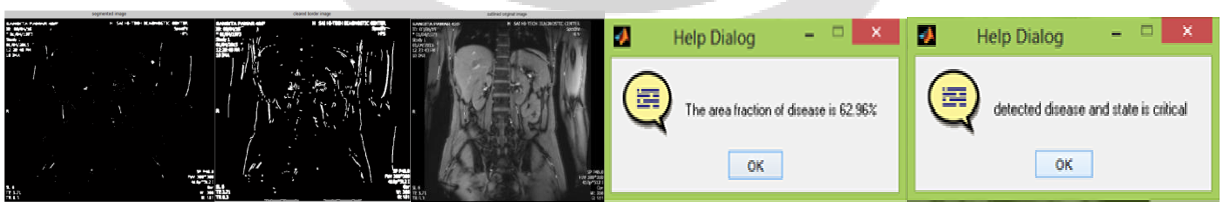
14. Diseased Area Fraction: The Area fraction is given in percentage area from the input image. From this area of fraction, stages can be calculated as per radiologists given by rules. Stages are divided in three types are normal, moderate and critical.

3. EXPERIMENTAL RESULTS

The proposed method initially carry out preprocessing on the image for removal of the noise and then further do the feature extraction using gradient technique which gives relatively good classification than others. The advantage lies in computations of PSNR, SNR, MAE, Quality measure, area fraction parameter which is not carried out until, which enable to decide the stage of disease infection.



(a) (b) (c) (d) (e) (f)



(g) (h) (i) (j) (k)

Figure. Various results (a) Original Image (b) Histogram (c) Filtration (d) Thresholding Image (e) Edge Detection (f) Features Extraction (g) Segmented Image (h) Clear Bordered Image (i) Outlined Original Image (j) Help Dialogue (results are verified from regular radiographer of 3T MRI Sai Hitech Diagnosis Center, Nashik and verified and approved by them)

TABLE : Various test results of patients:

Data Set	Area fraction (%)	Temporal Variation	PSNR (db)	GFR	Quality	SNR (db)	MAE	Result
1	50.49	9.98e014	17.32	34.84	0.2230	-7.44	6.360	Moderate
2	57.76	1.25e015	17.49	34.17	0.2385	-7.27	6.401	Critical
3	54.69	1.49e015	17.24	35.15	0.2608	-8.66	6.338	Moderate
4	62.96	1.49e015	17.57	33.83	0.2547	-7.18	6.365	Critical
5	53.45	1.28e15	17.29	34.96	0.2396	-8.57	6.316	Moderate

4. DISCUSSIONS

Generally, some new improvements have been proposed to help nephrologists in performing better and more accurate diagnosis of kidneys using DCE-MRI. The implementation of image processing techniques had been explored, together with the analysis and validation of proposed ideas. The contributions of the thesis are;

1. Development of a new vector graphic formation or image vectorization method. Degradation of DCE-MRI image by speckle noise can convoluted the analysis of the image during diagnosis, as well as restricting the image to be analyzed visually. Important features may not be extracted due to this condition.

2. Development of a new poly ROI algorithm for automatic generation of region of interest (ROI) of the kidney. To the best of knowledge, there are no other automatic algorithms available for kidney DCE-MRI images. This proposed algorithm can be implemented in real time DCE-MRI and help nephrologists in locating the correct position of the kidney.

3. Development of a new edge based approach of automatic detection and segmentation of kidney in DCE-MRI images, and the result has been fairly compared with other segmentation methods available. Compared to other available methods, this method is able to be executed in a very quick time with high accuracy.

This study is strictly technical, and its emphasis was influenced by the opinions of clinical collaborators. Improvements proposed in this study for the purpose of kidney abnormalities detection and classification can reduce manual measurement, improve consistency, reduce human intervention and operator dependency, avoid competency factor and human errors, while producing reliably meaningful images and measurement, so as to support future studies in a clinical setting.

5. CONCLUSION

This system will overcome the problems presented with 3D model. Also, GFR measurement can be done by using voxel deformation. Boundary detection can be done by using segmentation. Finally diagnosis of renal diseases will be carried out. RegSeg has a statistically higher average displacement field. RegSeg has a smaller MR-GFR deviation to the Iohexel measurement than any of the other method. Such method will likely be less prone to errors due to internal feedback control mechanisms between the various components of the algorithm.

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