Author's response to reviews

Title: A New Human Heart Vessel Identification, Segmentation and 3D Reconstruction Mechanism

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Author's response to reviews: see over
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Title: A New Human Heart Vessel Identification, Segmentation and 3D Reconstruction Mechanism

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Version: 2 Date: 6 August 2014
Author's response to reviews: see over
Reviewer's report
Title: A New Human Heart Vessel Identification, Segmentation and 3D Reconstruction Mechanism

Version: 2 Date: 12 June 2014

Reviewer: Seyed Hashem Davarpanah

Reviewer's report:
General

Major Compulsory Revisions
1- The paper is understandable but I think it needs proofreading.
   Done.

2- The structure of the paper is poor especially presentation of the proposed mechanism. The authors have mentioned that they introduce a new mechanism to detect the vessels and to develop a 3D vessel reconstruction model but how to perform each section is not clear. Although the mechanism is divided to 5 consequential steps and each step is discussed separately, I think it is required to get more specified the introduced methods and even each part of the algorithms is new or extended of an existing algorithm.
   The proposed mechanism and each section are elaborated more.

   The mechanism is divided to 5 consequential steps:
   Change the steps to 3 steps as it’s the main steps and then the details in the subsection of the III Method (a, b, and c)

3- It seems that compared to one channel data such as MR, CT, CTA using colour images increases the time complexity of the detection process while the authors claim that their method is faster. I appreciate if explain more.
   We have now included this sentence in the last paragraph in the Results and Discussion section (c) as the reviewer indicates.
   i.e. faster compare to other segmentation methods that deal with the same input data, i.e. colour images. In addition, no time required for converting to another colour space.

4- It seems that success rate of the vessel segmentation algorithm as the main contribution of this research is depended highly to the light condition and the quality of the acquired image and the contrast level between different heart tissues. It is appreciated explain how your mechanism is robust confront these conditions.
   The reviewer is correct and we have added this sentence to the vessel segmentation:
   These vessels with whitish surface colours are difficult to segment using current segmentation methods due to their being bloodless, covered by fat, and are affected by lighting reflections on the surface of the heart as its wet surface. The reflections affect the perception of the vessels. The reflection can be removed be the method proposed in [19].
Minor Essential Revisions

1- A section of steps one and two of the proposed mechanism which is refers to the image enhancement has not been explained. Which kind of enhancements have been applied?

   The enhancement was done using the Decorrelation stretch and the sentence in the text has been changed as follows:

   The Decorrelation stretch has found increasing usage over the past decade, especially in satellite images, such as images taken from a long distance or image features that are not easy to identify. The Decorrelation stretch used to enhance the image colour separation by maximizing the difference between different combinations of the three bands of RGB colour channels. To overcome the difficulties of the segmentation methods of the human heart surface vessel since it bloodless and effect by other factors, it is highly recommended an enhancement process for differentiating between surface colours to identify the vessels ROI.

2- Referring to a number of basic formula inside of the articles (equations 1 to 11) reduces the information value of the article. I suggest to eliminate them or write them in appendix.

   All the formula have been moved to the “Background section” as suggested by the second reviewer.

Level of interest: An article whose findings are important to those with closely related research interests

Quality of written English: Needs some language corrections before being Published

Statistical review: No, the manuscript does not need to be seen by a statistician.

Declaration of competing interests: None of the above items
Reviewer's report

Title: A New Human Heart Vessel Identification, Segmentation and 3D Reconstruction Mechanism

Version: 2 Date: 10 August 2014

Reviewer: Farsad Zamani Boroujeni

Reviewer's report:

General
In this paper, the authors presented mechanisms for enhancement, extraction and reconstruction of coronary arteries in photographs taken during the coronary bypass surgery. The authors used an image enhancement algorithm which is mainly based on de-correlation stretch technique followed by a semi-automatic segmentation strategy. They also proposed an algorithm for 3D reconstruction of the extracted surface vessels. The authors also compared their method with the other approaches.

Major Revisions
1. It is important to indicate the benefit of the whole system for novice surgeons.
   We have now included this sentence in the abstract as the reviewer indicates. The surface vessels of the human heart are important for the surgeons to locate the region where to perform the surgery and to avoid surgical injuries.

2. The authors should provide more details for describing the proposed algorithms, especially in section III parts (b) and (c).
   Change made as indicated by the reviewer.

3. A section should be included to describe the dataset, e.g. number of images, spatial resolution, number of gray levels, etc and the details of image acquisition process.
   We have now included this sentence in the methods section as the reviewer indicates.
   The data used in this research are real human heart colour images. The data was collected during open-heart surgery (cardiac surgery) under supervision of specialist cardiac surgeons. Moreover, the data for each patient was taken using Sony Cyber-Shot DSC-T30 Digital Camera, with a focal length between 38-114 mm, resolution 7.2 megapixels, and 3x optical zoom with aperture range f3.5-f10. In addition, the data saved in a standard JPG format for each image in a single folder for each patient. The patients were from different genders male and female with average age 56 years old.

4. The authors should define the performance quantities, e.g. accuracy, robustness, etc and the equations or methods used to measure them.
   We have now included this sentence in the methods section as the reviewer indicates.
   The proposed algorithms had been implemented and tested. Quantitative method were applied to determine the accuracy performance metric [22] of the RGB colour
space compare to other colour spaces. Moreover, using ground truth of the dataset, and the quantitative tests for this dataset given by the performance metric from Table 1.

<table>
<thead>
<tr>
<th>Actual \ Predicted</th>
<th>Segmented Vessels Correctly: Yes</th>
<th>Segmented Vessels Correctly: No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segmented Vessels Correctly: Yes</td>
<td>True Positive (TP)</td>
<td>False Negative (FN)</td>
</tr>
<tr>
<td>Segmented Vessels Correctly: No</td>
<td>False Positive (FP)</td>
<td>True Negative (TN)</td>
</tr>
</tbody>
</table>

\[
\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}
\] (12)

The evaluation started by manually creating a set of ground truths by labelling the vessel pixels in a set of the human heart images from different male and female patients with an average age of 55 years old. Then, the performance of the proposed method was compared with the other colour spaces.

5. The authors should include a section to compare the output of different segmentation algorithms shown in Figures 12 and 13.

We have now included this sentence in the Results and Discussion section as the reviewer indicates.

The proposed method goal is to obtain vessels ROI. Several factors make this goal hard to achieve with the current methods. A crucial aspect of segmentation methods is what are best suited to specific applications and type of data. No segmentation method is better than the others are for any purpose. Thus, we have to figure out what available method fits best into vessel ROI in terms of accuracy, speed, and reducing the amount of user interaction. The experimental results obtained in the previous sections could not accurately segment the vessels ROI. As illustrated in Figure 12 and Figure 13 a results of applying different segmentation methods using the human heart images, whereas these segmentation methods are design for a specific purposes and for specific input images.

Furthermore, Figure 12 results shows the ability of medical imaging applications to demonstrate some significant performance advantage (e.g. faster detection) over traditional methods. However, it also result with wrong vessels region detection. In the other hand, Figure 13 shows results of some general segmentation methods in which those methods depends on the input image types, which required different parameters to obtain a better results for different input image. It is unlikely that automated segmentation methods will ever replace experts, but they will likely become crucial elements of medical-image analysis.

Minor Revisions
1. The manuscript requires proof reading for typos and grammatical errors. For example, in line 11 of page 4, a verb is required after “Felkel et al”. In line 29 of page 4,
an infinitive should be used after “purpose of”. The authors should check the manuscript thoroughly.

We have now included this sentence in the Related Work section as the reviewer indicates.

Several studies have been published on the vessel segmentations. Reviews of vessel like structure in CTA images was proposed, whereas several vessel segmentation methods were introduced for the vessels in the human leg [13].

2. Explain the relationship between the robustness and the content of section V part a.

The following statements now appear in the first paragraph of the Results and Discussion of the paper:

a) Comparison with Respect to Different Types of Colour Spaces

Image segmentation objective is to partition a given input image into different regions. Colour segmentation approaches are based on monochrome segmentation approaches operating in different colour spaces. Humans perceive colour as a combination of Tri-stimulus R, G, and B, usually called primary colours. From R, G, B representation, we can derive other kinds of colour spaces by using either linear or nonlinear transformations as mention earlier. There are several studies trying to identify which is the best colour space to represent the colour information, but there is not a standard about which is the best choice. However, some researchers identify the best colour space for a specific task.

3. The authors should clearly describe the output of each step of the proposed framework shown in Fig.3 and how the output of one step was used as the input of the next step.

We have added this sentence to the Method section:

The input to the proposed method is a colour human heart image that has vessels on its surface as shown in Figure 4 (a). The enhancement process applied to the input image and then select the seed point from the vessels region for the vessel segmentation process as illustrated in Figure 4 (b). Moreover, Figure 4 (c) show the output of the segmentation process of the vessel ROI, which used as the input for the 3D vessel reconstruction process. Finally, curve-fitting process applied to the segmented vessel ROI, and then visualizing the 3D of the vessels over the 3D heart model in R3 space as shown in Figure 4 (d).

Discretionary Revisions

1- It is recommended to transfer the theoretical background and formulas from section V (discussion) to section I (background).

All the formula have been moved to the “Background section” as suggested by the reviewer.

Level of interest: An article of importance in its field

Quality of written English: Needs some language corrections before being published

Statistical review: No, the manuscript does not need to be seen by a statistician.

Declaration of competing interests:
Yes.
I was a graduate student and worked as a research assistant from 2009 to 2012 in Faculty of Computer Science and Information Technology, University Putra Malaysia. I do not have any other kind of competing interests in relation to this paper.