FRAMEWORK FOR AUTOMATIC LABELLING OF ARTERIAL TREE FROM WB-MRA

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1. INTRODUCTION

Population based whole body MR (WB-MR) screening studies, for assessment of arterial diseases are being widely conducted nowadays. With large population studies come the mammoth task of manual annotation and analysis. A common practice for diagnosing arterial trees on WB-MR is conducting visual inspection on maximum intensity projection (MIP) images. By performing analysis on MIP images, the entire potential of WB-MR scans is not being fully utilized. A method for automatic extraction of 3D vascular tree would be very useful for arterial disease analysis and quantification.

2. METHOD

We present a framework that enables automatic extraction and labelling of the arterial vascular tree from WB-MR scans. The framework consists of 4 broad stages: 1) Bias correction and volume reconstruction of WB-MR scans; 2) Centerline extraction; 3) Multi-atlas based registration and label propagation and; 4) Graph-based labelling refinement. The stages consists of the following novel algorithms: (i) A specialized optimization constraint that minimizes the intensity difference between the pre- and post- contrast images in the contrast-free areas is developed for bias correction. (ii) Probability map of the "contrast" class, is used as the vessel enhanced image. (iii) A multi-atlas based registration strategy is developed to find anatomical relationship between an un-seen WB-MR vessel tree data and a set of labelled atlas datasets.

3. DATA

35 subjects were randomly selected from a population based cohort originating from the PIVUS study [1]. The WB-MR examination was performed on a 1.5T Gyroscan Intera scanner (Philips Medical Systems, Best, The Netherlands) divided into four stations. A total of 10 WB-MR scans were selected to be used as the training set and the remaining 25 as the test set. For each of the 35 scans ground truth vessel tree labels were manually generated using a semi-automatic tool. 32 vessel that are clinically important for arterial disease were considered.

4. EXPERIMENTS AND RESULTS

Four types of experiments were performed to evaluate the proposed method. (i) Accuracy of the centerline extraction step on the entire dataset. (ii) Comparing our bias correction and volume reconstruction approach to the traditional digital subtraction of pre- and post-contrast WB-MR scans on the entire datasets . (iii) Leave-one-out analysis on the training set to investigate various registration strategies. (iv) Comparing the accuracy of the automatically generated vessel segments using our complete pipeline to those obtained manually.

Analysis on the test dataset indicates that 69% of the vessel centerline tree in the head and neck region, 80% in the thorax and abdomen region, and 84% in the legs was accurately labelled. Segment-wise view is shown in Fig 2.

Table 1: Validation of the arterial tree extraction and comparison of our proposed method to digital subtraction approach.

Detection (%)	Bias corrected	Digital Subtraction
Complete segment	82.4	77.5
Partial segment	11.7	8.3
Missed segment	5.9	14.4
Leaked into non-vessels	6.8	10.3
Leaked into vessels	7.6	24.0

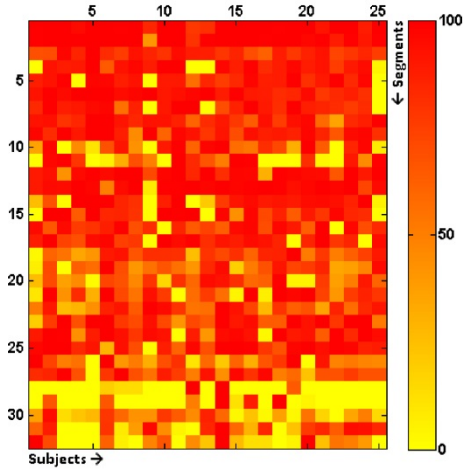

Fig 2. Detection and labelling accuracy for each of the 32 vessel segments over the entire test set.

5. CONCLUSION

In conclusion, we demonstrated the possibility of fully automated extraction and labelling the arterial tree. Such an automated framework has high potential to be used in WB-MR population based studies.

6. REFERENCES

[1] Lind, L., Fors, N., et al. (2005). A comparison of three different methods to evaluate endothelium-dependent vasodilation in the elderly the prospective investigation of the vasculature in uppsala seniors (PIVUS) study. Arteriosclerosis, thrombosis, and vascular biology, 25(11), 2368-2375.

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