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| **Title:** | | Development AI assisted diagnostic system in coronary computed tomography angiography | | |
| **Purpose:** | | Discussion | | |
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| **Abstract:** | Coronary computed tomographic angiography (CCTA) is a sensitive and widely used noninvasive method for the detection and exclusion of obstructive coronary artery disease (CAD). CCTA remains challenging because of the required ECG-synchronized data acquisition, advanced post-processing and interpretation. These challenges limit its application in primary hospitals. Recently, an AI assisted diagnostic system of CCTA was developed, the main benefit of this system for clinic included automatic extraction of vessels from CTA images by a deep learning method, automatic recognition of coronary artery segments according to SCCT standard, automatic diagnosis of stenosis. Currently this system has been used in about twenty Level-3 hospitals in China. To evaluate its diagnostic performance, a national wide multi-center trial was carried out, over one thousand patients with CAD from 33 centers who underwent both CCTA and coronary angiography (CAG) examinations were included. The initial result based on 400 randomly selected patients showed that AI yielded a 53% and 59% time reduction on image reconstruction and diagnostic steps respectively. For detection of obstructive coronary stenosis at threshold of 50% at artery level, the system can achieve compatible diagnostic accuracy with experienced radiologists in Level-3 hospital in China. |

# Overview

To resolve the obstacles of CCTA’s application in primary hospitals, this project aims to develop an AI-assisted diagnostic system of CCTA that can perform automatic advanced post-processing and interpretation.

# Impact

Cardiovascular disease is the leading cause of death worldwide, coronary artery disease (CAD) accounting for half of all such deaths. Cardiovascular clinical care currently faces practical challenges pertaining to cost reductions in prevention and treatment, low cost-effectiveness, overutilization, inadequate patient care, and high readmission and mortality rates. Deep-learning AI is a new machine-learning technique has been proved to play a vital role in areas such as image recognition, it may help to increase the efficiency and accuracy of CCTA diagnosis and broaden its application, especially in primary hospitals.

# Existing Work

We have developed an AI assisted diagnostic system of CCTA, the main benefit of this system for clinic included automatic extraction of vessels from CTA images by a deep learning method, automatic recognition of coronary artery segments according to SCCT standard, automatic diagnosis of stenosis.

# Feasibility

This system has been used in about twenty Level-3 hospitals in China. To evaluate its diagnostic performance, a national wide multi-center trial was carried out, over one thousand patients with CAD from 33 centers who underwent both CCTA and CAG examinations were included. The initial result based on 400 randomly selected patients showed that AI yielded a 53% and 59% time reduction on image reconstruction and diagnostic steps respectively. For detection of obstructive coronary stenosis at threshold of 50% at artery level, the system can achieve compatible diagnostic accuracy with experienced radiologist in Level-3 hospital in China.

# Data Availability

There is no public dataset for CCTA, unlike lung nodule. We firstly constructed a training dataset, in which a total of consecutive 2000 coronary CT angiography (CCTA) examinations were included. Exclusion criteria included Percutaneous Coronary Intervention (PCI) or Coronary artery bypass grafting (CABG) surgery, poor quality images. Before model training, the aorta, coronary artery and plaques were labeled on each image by a multi-layer manually annotation system consisting of multiple layers of trained graders. A deep convolutional neural network was developed to achieve auto coronary segmentation and stenosis detection.

The process of our proposed Deep Convolutional Neural Network mainly contained two steps:

(1) Coronary tree segmentation. In this study, we adopted an improved 3-dimensional(3-D) U-Net architecture added a Bottle-Neck model for segmentation coronary arteries and aorta, then a Growing Iterative Prediction Network (GIPN) model was developed to solve the problem of vascular segmentation fracture, final the full coronary tree segmentation was obtained.

(2) Stenosis detection. Based on coronary tree segmentation, multiple planner reformat (MPR), curve plannar reformat (CPR), maximum intensity projection (MIP) and volume rendering (VR) images were reconstructed. To detect stenosis, we developed a 3D segmentation neural network and a one-dimensional sequence checking hybrid technique. Firstly, a 3D segmentation neural network was applied to MRP and CPR images to detect stenosis, and then a one-dimensional sequence checking algorithm was used to reduce false positive results.

# Benchmarking

To validate the clinical performance of this system, a national wide multi-center trial was carried out, over one thousand patients with CAD from 33 centers who underwent both CCTA and CAG examinations were included. Experienced cardiologists interpreted CAG images as ‘golden standard’ results. Experienced radiologists and AI interpreted CCTA images respectively. The diagnostic performances for radiologists and AI were evaluated compared with ‘golden standard’ results. The parameters for evaluating diagnostic performance included sensitivity, specificity, positive prediction value, negative prediction value and accuracy. The initial result based on 100 randomly selected cases showed that the system can achieve compatible diagnostic accuracy with experienced radiologists in Level-3 hospital in China.

# Organizer Details

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