

2026 年度 博士論文要旨  
**Abstract of doctoral dissertation  
submitted in the fiscal year of 2026**

論文題目 Title of dissertation in Japanese (optional)

冠動脈造影動画を用いた人工知能による急性冠症候群の責任病変検出と病態識別

英文題目 Title of dissertation in English

Culprit Lesion Detection and Pathogenesis Classification of Acute Coronary  
Syndrome in X-ray Angiography Images

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(要旨) Abstract of dissertation

Acute coronary syndrome (ACS) is a form of coronary artery heart disease, caused by coronary artery thrombosis that leads to a sudden reduction in coronary blood flow. X-ray coronary angiography (CAG) is the primary imaging modality used to assess coronary artery thrombosis. And this artery thrombosis is displayed as areas of narrowing or occlusions in X-ray images, referred to as coronary stenosis. Furthermore, the pathogenesis of ACS is primarily classified into two types: Plaque Rupture (PR) and Plaque Erosion (PE). In clinical practice, the cardiologist first localizes and recognizes stenosis in CAG images and subsequently distinguishes PR from PE corresponding to that stenosis, which is essential for enabling tailored therapeutic strategies. In this research, we address two key engineering tasks in CAG image analysis: stenosis detection and ACS pathogenesis classification. In particular, accurate identification of ACS pathogenesis (PR or PE) is of great clinical importance.

In the first part of this research, only a small CAG dataset was available, which severely limited the performance of deep neural networks. With insufficient training data, the network is unable to learn enough representative stenosis features for reliable object detection. As a result, neural networks tend to overfit, leading to increased detection errors. To address this issue, we incorporated ensemble learning into the one-stage detection framework YOLOv5 to automatically detect stenosis in X-ray CAG still images. Experimental results demonstrate that the proposed method, Ensemble-YOLOv5, achieves superior performance in recognizing and localizing culprit lesions.

In the second part, we aim to accurately detect stenosis across consecutive CAG frames. However, CAG images often exhibit ambiguous visual features due to their poor resolution, and the heart, lungs, ribs, and coronary vessels are captured simultaneously during X-ray imaging. Accurately recognizing and localizing stenosis in CAG images is already a challenging task, and additionally, some stenotic regions are inevitably affected by breathing and cardiac motion, causing them to become blurred and difficult to track, which often leads to missed detections. To address this challenge, we propose a framework called Temporal-Enhanced Stenosis Detection (TESD), which leverages temporal information across consecutive frames. The Kalman filter is employed here to track the stenosis that might be misdetected across CAG frames, thereby improving overall performance. TESP is a more robust and advanced approach, particularly for those vague and blurred ones that are neglected and undetected in conventional methods. To the best of our knowledge, this is the first study to investigate the application of the Kalman filter for temporal stenosis detection.

In the third part, we aim to classify PR and PE solely using CAG images. This task is of the greatest clinical importance in my research, as it enables tailored therapeutic strategies: patients with PR are typically treated with intracoronary stenting, whereas those with PE may be potentially managed conservatively without stenting. However, distinguishing PR from PE based solely on X-ray images remains a major challenge, even for experienced cardiologists, due to their subtle and often similar visual characteristics. To address this challenge, we proposed sequence contrastive learning (SeqCon) to extract discriminative visual representations in X-ray CAG images, which are then used in a downstream task to improve the performance of PR and PE classification. In experiments, SeqCon can effectively separate PR and PE into the high-level feature space using t-SNE visualization. For the interpretability of deep learning in ACS identification, the heatmap activations show that SeqCon consistently concentrates on the stenosis area with clinical expectations.

The clinical impact are follows: Our proposed method for stenosis detection is designed to assist cardiologists by reducing the need for repeated angiogram reviews and minimizing the use of contrast agent injections during CAG surgery. Reviewing multiple frames extends overall diagnostic time, and repeated contrast agent injections carry an associated risk of potential kidney failure for the patient. The proposed SeqCon is the first report to use contrastive learning for diagnosing the underlying mechanism of ACS in CAG images. Particularly, this study demonstrates that it can be feasible to distinguish between PR and PE solely based on CAG, thereby potentially reducing reliance on more invasive imaging modalities such as optical coherence tomography (OCT).

(注) 論文要旨：内容は4,000字程度とし、電子ファイル及び紙媒体で提出

The abstract of doctoral dissertation should be approximately 2,000 words and must be submitted in both electronic and printed formats.