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[1,2]V. M. Sineglazov,
[3]M. R. Holovatskyi

INTELLIGENT SYSTEM FOR DETERMINING THE DEGREE OF STENOSIS IN PATIENTS WITH CORONARY ARTERY DISEASE

[1]State University "Kyiv Aviation Institute", Ave. Lubomir Husar, 1, 03058, Kyiv, Ukraine
[2]V.M.Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine Akademika Hlushkova Ave, 40, Kyiv, Ukraine
[3]National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute," Ave. Beresteysky, 37, Kyiv, Ukraine

Abstract. The paper presents an intelligence-based approach for detecting and grading coronary stenosis in ischemic heart disease, combining coronary artery segmentation, stenosis segmentation, and multi-class classification of lesion severity within a unified deep learning pipeline. A U-Net model highlights vessels, a second U-Net model isolates narrowing, and a ResNet classifier assigns stenosis degrees. Semi-supervised principles reduce the need for extensive annotations, gradually refining pseudo-labels for higher accuracy.

Keywords: coronary artery disease, stenosis, deep learning, classification.

Deep convolutional architectures have shown high potential for analyzing medical images, even when only limited or partially annotated data is available. Our system addresses three main tasks for the automated assessment of coronary artery disease: coronary artery segmentation, stenosis segmentation, and multi-class classification of stenosis severity.

The system performs preliminary image processing that includes denoising, contrast stabilization via mild filtering using a DnCNN-like model, and morphological operations. This processing generates pixel-level masks with labels ranging from 0 to 25, corresponding to various coronary branches and stenotic regions [1, 2]. Additionally, techniques such as histogram equalization and morphological smoothing are applied to further enhance image consistency under varying contrast and acquisition conditions [3, 4].

The segmentation component is implemented using a U-Net-based architecture that isolates vascular structures, effectively highlighting the coronary arteries while suppressing background noise.

A second segmentation module refines the detection of stenotic areas by focusing on class 25, representing stenosis, with all other pixels designated as non-stenotic. To overcome overfitting on the small labeled dataset, a pseudo-labeling pipeline was incorporated; the dataset was divided into labeled and unlabeled subsets, and a baseline model was used to generate high-confidence pseudo-masks for the unlabeled images. These pseudo-labels were combined with the original annotations, and the model was retrained for 500 epochs [5–7, 10–15].

A ResNet-based classifier is employed to further analyze the segmented stenosis regions by categorizing them into severity levels—mild, moderate, or severe—based on local morphological features. This classifier, fine-tuned on the CADICA dataset, achieves high accuracy and robustly differentiates among severity grades [1, 4, 8, 9].

In summary, our pipeline significantly reduces annotation efforts while preserving anatomical fidelity, delivering a robust and clinically viable solution for the automated assessment of coronary lesions. Our approach has demonstrated improved sensitivity and specificity in detecting subtle vascular abnormalities.

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Sineglazov Victor Mykhailovych. ORCID 0000-0002-3297-9060. Doctor of Engineering Science. Professor. Head of the Department of Aviation Computer-Integrated Complexes.
Faculty of Air Navigation Electronics and Telecommunications, State University "Kyiv Aviation Institute", Kyiv, Ukraine.
E-mail: svm@nau.edu.ua

Holovatskyi Mykhailo Ruslanovych. ORCID 0009-0005-1221-6460. MSc Student.
Department of Artificial Intelligence, Institute for Applied System Analysis, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine.
E-mail: mihailx136@gmail.com

Інтелектуальна система визначення ступеня стенозу у хворих на ішемічну хворобу серця

Анотація: У роботі розглянуто комп'ютеризований підхід для виявлення та градації ступеня коронарного стенозу при ішемічній хворобі серця, що базується на поєднанні сегментації коронарних артерій, сегментації стенозу та багатокласової класифікації у єдиній глибинній нейронній архітектурі. Модель типу U-Net виділяє судинні структури, а спеціалізована мережа визначає локальні зони звуження, після чого ResNet-класифікатор розрізняє ступені ураження. Використання напівкерованих (semi-supervised) принципів дає змогу зменшити обсяг необхідної розмітки, ітеративно вдосконалюючи псевдо-мітки для підвищення точності.

Ключові слова: ішемічна хвороба серця, стеноз, глибоке навчання, класифікація.

Синєглазов Віктор Михайлович. ORCID 0000-0002-3297-9060. Доктор технічних наук. Професор. Завідувач кафедри авіаційних комп'ютерно-інтегрованих комплексів. Факультет аеронавігації, електроніки і телекомунікацій, Державний університет «Київський авіаційний інститут», Київ, Україна.
E-mail: svm@nau.edu.ua

Головацький Михайло Русланович. ORCID 0009-0005-1221-6460. Магістрант.
Кафедра штучного інтелекту, Інститут прикладного системного аналізу, Національний технічний університет України "Київський політехнічний інститут імені Ігоря Сікорського", Київ, Україна.
E-mail: mihailx136@gmail.com