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Doutorado em Ciência da Computação Associação UFMA/UFPI

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A Method for Anomaly Classification of Endoscopic Images from the Entire Gastrointestinal Tract

Advisor: Prof. Dr. Anselmo Cardoso de Paiva

São Luís - MA
July, 2025

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Tese apresentada como requisito parcial para obtenção do título de Doutor em Ciência da Computação, ao Doutorado em Ciência da Computação, Associação UFMA/UFPI.

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A presente Tese de Doutorado foi avaliada e aprovada por banca examinadora composta pelos seguintes membros:

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Certificamos que esta é a versão original e final da Tese de Doutorado que foi julgada adequada para obtenção do título de Doutor em Ciência da Computação.

Prof. Dr. Anselmo Cardoso de Paiva
Orientador

Prof. Dr. Anselmo Cardoso de Paiva
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São Luís - MA, 14 de July de 2025

To the real ones.

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Although my name appears first on this work, and it will be by this name that this thesis will be indexed in the thesis and dissertation databases of this university and UFPI, and only by this name that it will be associated in academic text aggregators online (and possibly by my advisor's name as well, depending on the system), it would be a massive injustice to assume that this was an individual work. Over the last 4.5 years, which comprised my PhD (or 5 years, if you count the period I took courses as a special student), many have helped, supported, lifted me when I was down, encouraged, and motivated me. It is impossible to attribute this thesis solely to the work of a single individual. Therefore, I would like to dedicate this space to thank everyone who was part of this journey, not only making this work possible but also helping me become a better person.

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  By proofreading this, yeah, there's no universe where I can say that this thesis was the work of a single individual.

“We chose the path of Sisyphus, and asked for a bigger boulder.”

(Connor Conquers, 2024)

Abstract

The gastrointestinal tract is part of the digestive system and is essential for digestion. Digestive problems can be symptoms of chronic diseases such as cancer and should be treated seriously. Endoscopic examinations of the tract enable the detection of these diseases in their early stages, allowing for effective treatment. Although they are the gold standard for GI tract analysis, variations in operator performance limit their usefulness. Support systems for experts to detect and diagnose such pathologies are desired. The proposed method aims to develop a method capable of classifying endoscopic images as normal or with anomalies. The proposed method aims to develop a classification method capable of distinguishing between healthy and anomalous endoscopic images, identifying specific anomalies within the gastrointestinal tract, and classifying such pathologies in a three-step process. A Convolutional Neural Network, specifically EfficientNetV2M, is used for the initial step, which is responsible for distinguishing between healthy and anomalous images. A Deep Learning architecture based on MambaVision was used for the second and third steps of the proposed method to classify GI tract anomalies. The second stage is responsible for categorizing pathologies into groups to forward images to specific binary classification models in the third stage, which are trained to distinguish images between pathologies within each of these groups. This work uses a rarely used database, the ERS database, containing 89,195 labeled images of the entire length of the gastrointestinal tract with more than 100 labels. The results obtained for the first stage, achieved using a model based on the EfficientNetV2 architecture, yielded an average F1-Score of 88.15%. The MambaVision architecture model used for the proposed method's second stage obtained an average F1-Score of 76.10%. In contrast, the models for the last stage, responsible for classifying Cancer and Ulcer, Polyp and Other Pathologies, were 82.07% and 75.08%, respectively. When evaluating the proposed method end-to-end, an average F1-Score of 57.35% was obtained.

Keywords: Endoscopy, Colonoscopy, Binary Classification, Automatic Diagnosis.

Resumo

O trato gastrointestinal faz parte do sistema digestivo, fundamental para a digestão. Problemas digestivos podem ser sintomas de doenças crônicas como o câncer e devem ser tratados com seriedade. Exames endoscópicos do trato possibilitam a detecção dessas doenças em seus estágios iniciais, possibilitando um tratamento eficaz. Apesar de serem o padrão ouro para a análise do trato GI, variâncias na performance do operador restringem sua utilidade. Sistemas de apoio para especialistas detectarem e diagnosticarem tais patologias são desejados. O método proposto utiliza uma Rede Neural Convolucional, especificamente a EfficientNetV2M, na fase inicial, responsável por discriminar entre imagens saudáveis e com anomalias. Uma arquitetura de Aprendizado Profundo baseada em MambaVision foi utilizada na segunda e terceira fases do método proposto para classificar anomalias do trato gastrointestinal. A segunda fase é responsável por categorizar as patologias em grupos e encaminhar as imagens para modelos de classificação binária específicos na terceira fase, que são treinados para distinguir imagens entre patologias dentro de cada um desses grupos. Este trabalho utiliza uma base de dados raramente utilizada, a base de dados ERS, contendo 89.195 imagens rotuladas de toda a extensão do trato gastrointestinal com mais de 100 rótulos. Os resultados obtidos para a primeira etapa alcançados por um modelo da arquitetura EfficientNetV2, alcançou F1-Score médio de 88,15%. O modelo da arquitetura MambaVision utilizado pela segunda etapa do método proposto obteve F1-Score médio de 76,10%, enquanto os modelos para a última etapa, responsáveis em classficar entre Cancer e Ulcera, Pólipo e Outras Patologias, foi de 82,07% e 75,08%, respectivamente. Ao avaliar o método proposto de ponta a ponta, obteve-se um F1-Score médio de 57,35%.

Palavras-chave: Endoscopia, Colonoscopia, Classificação Binária, Diagnóstico Automático.