

RESEARCH TOPIC PRIME3

EndoScore: A Computer Vision-Based Composite Predictive Score from Endoscopic Imaging in Gastrointestinal Oncology

Thematic field of the project

Artificial Intelligence and Computer Vision Applied to Non-Radiological Medical Imaging in Visceral Oncology

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Main field of interest

Artificial Intelligence

Abstract

Background. Endoscopic imaging is a cornerstone of diagnosis, staging, and surveillance in gastrointestinal (GI) cancers. Current clinical assessment relies heavily on operator-dependent visual interpretation, supplemented by discrete classification systems (e.g., Paris, NICE, Kudo) that capture only isolated morphological features. A unified, quantitative framework integrating multiple visual descriptors into a single predictive metric remains an unmet need. **Aim.** This project aims to develop and validate EndoScore, a composite predictive score generated through computer vision and deep learning analysis of standard endoscopic images. EndoScore will integrate heterogeneous visual features, including mucosal surface patterns, vascular architecture, lesion morphology, color-texture signatures, and contextual perilesional characteristics, into a single continuous score predictive of histopathological diagnosis, disease aggressiveness, and patient-relevant outcomes.

Methods. The study will leverage retrospective and prospective endoscopic image datasets from patients with esophageal, gastric, and colorectal neoplasms. A multi-task deep learning pipeline will be developed to extract and encode visual features from white-light and enhanced imaging modalities. Feature integration into a composite score will be achieved through supervised learning approaches benchmarked against histopathological ground truth and clinical follow-up data. Model interpretability will be ensured via explainability techniques

(e.g., attention mapping, concept-based explanations) to maintain clinical transparency. External validation on independent patient cohorts will assess generalizability and calibration. Expected impact. EndoScore is envisioned as a real-time, operator-independent decision-support tool capable of standardizing endoscopic risk assessment, reducing inter-observer variability, and enabling personalized clinical pathways, from biopsy guidance to treatment selection, in GI oncology. The project will also lay the methodological groundwork for extending composite AI scoring to other non-radiological imaging domains, including digital pathology.

Main technical approaches

1. Image Acquisition and Data Engineering

The project will require the design and curation of large-scale, annotated endoscopic image datasets sourced from institutional endoscopic archives and, where available, multicenter collaborations. This includes standardization of image quality, resolution, and metadata across different endoscopic platforms (white-light endoscopy, narrow-band imaging, linked color imaging). Robust data pipelines will be established for anonymization, labeling (lesion segmentation, morphological classification), and linkage to histopathological and clinical outcome data. Data augmentation strategies will be employed to address class imbalance and to improve model generalizability.

2. Computer Vision and Deep Learning

The core analytical framework will rely on convolutional neural networks (CNNs) and vision transformer (ViT) architectures for multi-task feature extraction from endoscopic frames. Transfer learning from large-scale pretrained models (e.g., ImageNet, domain-specific medical imaging foundation models) will be adopted to mitigate limited dataset size. Specific tasks will include lesion detection, semantic segmentation, morphological feature encoding (surface pattern, vascular architecture, lesion contour), and texture-color analysis. Self-supervised and contrastive learning approaches will be explored to learn robust visual representations from unlabeled endoscopic data.

3. Composite Score Construction and Statistical Modeling

Extracted visual features will be integrated into a unified composite score (EndoScore) through multivariate modeling techniques, including penalized regression, gradient-boosted ensemble methods, and neural network-based feature fusion. Score calibration and threshold optimization will be performed against histopathological ground truth (e.g., dysplasia grade, tumor staging, lymphovascular invasion) and clinical endpoints (e.g., recurrence, survival). Receiver operating characteristic (ROC) analysis, decision curve analysis, and net reclassification indices will be used to benchmark EndoScore against existing classification systems.

4. Explainability and Clinical Interpretability

To ensure clinical acceptability and regulatory alignment, the project will implement explainability methods including gradient-weighted class activation mapping (Grad-CAM), attention visualization, and concept-based explanation frameworks. These tools will allow clinicians to understand which visual features drive the composite score, supporting trust, auditability, and integration into endoscopic decision-making workflows.

5. Validation and Deployment Framework

Internal validation will follow rigorous cross-validation and temporal splitting protocols. External validation will be conducted on independent patient cohorts from collaborating centers to assess generalizability across endoscopic equipment, operators, and patient populations. The final deployment pipeline will be designed for real-time inference compatibility, with consideration for integration into existing endoscopic reporting systems.

Scientific references

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Type of contract

Scholarship of € 24.500 gross per year awarded by Istituto Clinico Humanitas. This sum is subject to IRPEF income tax and exempt from social security contributions.

Borsa di studio pari a € 24.500 annui lordi erogata da Istituto Clinico Humanitas. Importo soggetto a tassazione IRPEF ed esente da contribuzione previdenziale.