PÔSTER - RESUMO - SENSORES E BIOSSENSORES

IMAGE ANALYSIS AND MACHINE LEARNING TECHNIQUES APPLIED TO MATERIALS, SENSORS, AND BIOSENSORS

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Currently, machine learning techniques are widely adopted across various fields as fundamental tools for recognition and detection tasks. Although these methodologies are already consolidated in the analysis of biological and medical data, as well as in the characterization of conventional materials for industrial purposes — ranging from quality control of metal alloys to the monitoring of manufacturing processes — few studies explore the use of images of advanced materials, such as state-of-the-art sensing units.

These materials, essential in critical applications such as precision medical diagnostics and environmental monitoring, exhibit complex visual variability and subtle morphological patterns when observed through microscopic imaging. In this scenario, recent works by the author and collaborators have investigated the application of computer vision and machine learning techniques in the analysis of microscopy images of advanced materials, such as biosensors. These studies focus on detection and diagnostic tasks, such as the identification of prostate cancer biomarkers and SARS-CoV-2 sequences, using machine learning models applied to scanning electron microscopy (SEM) images of genosensors.

Initial results are encouraging, demonstrating that the application of machine learning algorithms to the processing of this type of imagery achieves high detection accuracy. This capability paves the way for the identification of viruses or biomarkers without the need for complex laboratory instruments — especially if optical microscopes are coupled to smartphones — suggesting that this alternative could become a viable reality in the future.

Despite the promising results, the nature of these images, composed of complex microtexture patterns, requires highly discriminative computational methods to characterize the structural nuances necessary for automated recognition. In this context, significant challenges persist, such as the scarcity of annotated data, uncertainty in class labeling, and the need to handle chromatic variations and non-linear textural patterns.

Such challenges stimulate the development of new computational approaches, including synthetic data generation (data augmentation) and self-supervised learning. While the former seeks to artificially expand the sample set through transformations or models that preserve physical properties, self-supervised learning allows the AI model to learn deep representations of the images from the raw data itself, without relying on manual labels.

In this sense, the goal is to consolidate robust computational tools for the structural characterization and monitoring of the physicochemical properties of these materials. Thus, it is expected to promote a symbiosis between theory and application: while the practical challenges of materials science act as catalysts for new AI methodologies, theoretical advances result in effective solutions for automated analysis, establishing a "win-win" relationship that drives both fields of knowledge.

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