NEXT GENERATION CB HAZARD PREDICTION AND CONSEQUENCE ASSESSMENT WITH MULTI-ECHELON DECISION SUPPORT APPLICATIONS

Hybrid AI/ML Approach To Determine Chemical Warfare Agent (CWA) Exposure Using Ocular Biomarkers (OB).

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This work focuses on determining biomarkers of ocular exposure to chemical warfare agents (CWAs) utilizing noninvasive or minimally invasive techniques. The core concept revolves around detecting chemical exposure by analyzing ocular biomarkers from multiple data sources. These data sources, such as fundus photography, optical coherence tomography (OCT), and fluorescein angiography, offer extensive perspectives on the eye's exposure status by capturing varied aspects of its structure and functionality. Fundus imaging distinguishes itself with its ability to provide a detailed view of the eye's internal structures while being noninvasive. Fundus imaging has also been recently demonstrated using wearable devices, which lends itself to future live analysis in the field.

No readily accessible datasets link fundus images with chemical exposure, but datasets containing fundus images related to ocular diseases are available. The objective is to establish the connection between chemical exposure and ocular diseases. Once this linkage is defined, the aim is to recognize features within fundus images associated with ocular diseases, which can be correlated with chemical exposure. We have investigated two main approaches for detecting these features: utilizing image processing techniques and implementing deep learning models to assess their suitability for analyzing fundus images. Furthermore, we have examined the synthetic generation of fundus images to address the class imbalance issue encountered in deep learning applications.

Identifying and categorizing anomalies in fundus images into specific ocular conditions, which may further be linked to chemical exposures, can be achieved through image processing techniques or deep learning approaches. Deep learning techniques are known for their high accuracy, but lack transparency, as the intricate workings of these "black box" models remain largely unexplained. On the other hand, while limited to recognizing a select set of features, image processing methods benefit from a well-defined feature extraction process that clarifies the model's actions and decisions.

Image processing algorithms analyze these images to identify patterns, anomalies, and changes that may not be immediately visible to the human eye. Techniques such as edge detection, segmentation, and feature extraction are employed to isolate and evaluate specific components of the retina, including blood vessels, the optic disc, and the macula. The strength of image processing lies in its ability to provide precise, quantitative assessments of retinal features. The steps consist of detecting, enhancing, measuring, and segmenting retinal image features.

Deep learning leveraging large datasets of retinal images has demonstrated unparalleled proficiency in identifying and classifying the various stages of diabetic retinopathy with accuracy comparable to, and sometimes surpassing, that of human experts. These models are trained to detect subtle patterns and anomalies in retinal images, such as microaneurysms, hemorrhages, and exudates, critical markers of the disease's progression.

It is anticipated that a hybrid approach that combines the interpretability of image processing with the superior performance of deep learning models would lead to a more robust system. This system would excel not only in performance but also in being explainable and trustworthy.

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