Abstract

Object Detection plays an essential role in many practical applications such as video analysis, image understanding, security, etc. Recent years have witnessed the breakthroughs of Deep Learning based methods in various applications in daily life images. Deep Learning-based methods achieve human-level performances on classification tasks for identifying successfully more than tens of thousands of categories such as animal species, vehicles, household objects, etc. However, deep neural networks are still limited in specific medical image domains. The neural networks often fail for reasons such as a small number of training data, difficulty characterizing the target objects, or a small number of differences among the target objects.

This study is motivated by the need for a comprehensive method for medical image domains to accelerate the diagnosis and treatment processes. However, the target objects of medical image domains often (i) have less visual information, (ii) have a small number of training data, and (iii) have various appearances. This dissertation detects objects with a few features appearing in medical images. This study assumes that each target category has enough distinctive features to identify even with a small number of features. Finding those distinctive features is essential to detecting objects with less visual information.

In the case of small training data, the problem becomes more difficult since the method must find the correct distinctive features within a few samples. A particular surrounding object may have a high probability of appearing along with the target object. With a small number of training samples, the deep neural network detectors view the background information to identify the objects. This study focuses on finding features that characterize the target objects rather than the unique background features to overcome the problem. The segmentation-driven mechanism is proposed to guide the detector to focus only on the regions of the target objects. The mechanism is integrated into a neural

network detector to form Segmentation-driven RetinaNet to filter out the background by the segmentation mask and then detect and identify the objects in the filtered image.

While the characteristic features are efficient for detection tasks, distinctive features are essential for identifying the objects. Detecting objects in grayscale images is also a challenging problem. Grayscale images with only one color channel have much smaller feature spaces than general color images. The objects in grayscale images are characterized only by outer shapes, connectivity, and the intensity of the pixels. The attention-driven mechanism is proposed by replacing the segmentation with the attention mask to guide the deep network in focussing on the distinctive features of the target objects.

Finally, this study explores the relationship among the various appearances of a target object category. An object category may have several appearances, and each appearance only shows some category features. In many cases, an appearance of one category may have more similarities to that of another category than its intraclass appearances. Motivated by the taxonomy of animals, this study investigates the hierarchical multi-label classifier and the category hierarchy structure. Training samples of each category are clustered concerning the appearances. Multiple labels following the category hierarchy structure are assigned to training samples. The hierarchical classifier is integrated with the Segmentation-driven RetinaNet to form a unified network for detection.

Experiments are conducted on realistic datasets from the protozoa and DNA Profiling domains as examples of objects with less visual information in color and grayscale images, respectively. Experiments show that the Attention-driven mechanism effectively guides the neural network detectors to find the distinctive characteristic features of the target objects. Even with at most five samples per subcategory for training, this study successfully trained the proposed method for detecting the protozoa in the micrographs. With 16 training samples, the proposed method achieves the highest performance on the DNA Profiling image dataset. Besides, the integrated hierarchical multi-label classifier boosts the detection performance for the polymorphism problems.

Keywords: Detection, **Segmentation**, **Identification**, **Protozoa**, **Genome Profiling**