Human-Inspired Computational Models of Abnormality
Reasoning for Improved Categorization

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Abstract

In the past few years, there has been a tremendous amount of progress in
the field of computer vision. As of now, we have reliable object detectors and
classifiers that can recognize thousands of object categories. However, the
ultimate goal of computer vision is to build systems that can understand and
reason about images, far beyond scene categorization and object detection.
In this thesis, algorithms have been proposed to empower computers with
the human-level ability of detecting and reasoning about typicality of images.
Furthermore, abnormality of objects are detected and shown to be helpful to
increase the generalization capacity of discriminative object classifiers.

First, we addressed the problem of detecting abnormal objects and rea-
soning about their abnormality in terms of visual attributes, such as irregular
shape, texture or color. This attribute-based reasoning is inspired by human-
subject experiments that we conducted prior to building computational mod-
els. Although these models are trained without seeing any abnormal objects,
but are still capable of detecting and reasoning about abnormal cases at the
test time. We collected the first image dataset of abnormal objects, which we
used to validate the performance of our models.

Second, we consider the more challenging problem of recognizing atypi-
cality in images. We conducted large-scale human-subject experiments and
came up with a taxonomy of reasons that make an image look atypical. This
taxonomy has three main categories of abnormality reasons: Object-centric,
Scene-centric and Context-centric. Inspired by this taxonomy, we developed
probabilistic frameworks to model typical images, and find atypical images as
meaningful deviation from this model. We rank images based on how typical
they appear, detect atypical cases and reason about this decision similar to
human reasoning.

Third, we used the typicality scores of images and objects to improve the
generalization capacity of the state-of-the-art Convolutional Neural Networks
(CNN) for the task of object classification. We trained these CNN models based on a weighting loss function that incorporates in the typicality scores of samples. Our experiments showed that this training strategy results in more generalized classifiers, which can be applied even to the extent of abnormal images.

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