DIVERGENCE BETWEEN HUMAN AND DEEP NEURAL-NET PERFORMANCE IN LINE-DRAWING INTERPRETATION

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ABSTRACT

We focus here on a compelling instance of out-of-sample generalization by humans: Infants just a few months old exhibit the ability to classify line-drawing depictions of natural objects without any prior explicit training with such imagery. Would deep convolutional networks, which are reported to achieve near-human levels of classification performance with continuous-tone images, exhibit similar generalization to line-drawings after extensive exposure to natural inputs? We address this question by evaluating the classification performance of multiple state-of-the-art networks trained on natural images, on a specially constructed dataset of line-drawings and edge maps. Additionally, given past reports of the usefulness of recurrence for handling image information reduction, we examine whether its introduction significantly changes classification performance on these datasets. As a reference, and to validate the interpretability of our stimuli, we conducted analogous classification studies with 15 human participants on the datasets of line-drawings and edge maps. Experimental results are unequivocal. They show that despite near ceiling classification accuracy on the ILSVRC 2012 (ImageNet) dataset, feedforward as well as recurrent networks do not generalize to the line-drawing version of ImageNet samples. Their performance accuracy averages below 10% on line-drawings, and is dramatically worse than that of humans. Similar performance discrepancies were observed on our dataset of edge maps. This divergence of human and machine performance poses important questions about the roots of human proficiency on the one hand, and the architectural and developmental factors that limit deep networks from matching this proficiency. While a definitive resolution is awaited, we hypothesize that sensitivity to dynamic information may contribute to the human visual systems ability to generalize from natural images to line-drawings.