Visual Tracking for Diagnostic Imaging

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Introduction

Visual attention is a selective activity of visual search. It stems from the limited ability of our biological visual system, and plays an important role in every aspect of visual processing, including feature detection, pattern recognition, object identification, and reasoning. The performance of visual search depends heavily on the strategy of deploying visual attention in response to different search tasks.

We present a new framework for capturing intrinsic visual search behaviours of different observers in image understanding by analysing saccadic eye movements in feature space. The method is based on the information theory for identifying salient image features based on which visual search is performed. We demonstrate how to obtain feature space fixation density functions. This allows a reliable identification of salient image features that can be mapped back to spatial space for highlighting regions of interest and attention selection. Practical search experiments have been performed to illustrate the theoretical framework of the proposed method including feature selection, hot spot detection, and the back-projection.

Detection of Visual Attention

The selection of visual attention is biased towards regions of interest. The correct identification of this bias in feature space requires the elimination of the scene-dependent projection bias, which is independent of visual search strategies and is influenced only by the relative abundance of different features within an image. In the framework of hot spot detection, the reliable identification of salient features from visual search scan paths relies on the calculation of feature space density obtained by normalising the feature space fixation distribution with the scene-dependent feature distribution. For visual search, a feature subset with large Kullback-Leibler value indicates that these features are preferred during visual search and therefore are salient. A simple forward selection algorithm is designed to reduce computational cost. Fixation density of selected features is calculated and feature points with higher fixation density value are considered to be hot. Once the salient features are identified, it is possible to identify regions in the original image that contains these features by back-projection.

Behaviour Analysis

Visual search tasks can be segmented into episodes that are representative of different cognitive strategies involved in the search. To this end, the Global-Focal mode has been used to characterise the cognitive side of visual search. The spatial dynamics of the eye movements are analysed through the introduction of reference lungs for the projection of the eye-tracking data. We demonstrate how the Earth Mover’s Distance (EMD) combined with anatomical normalisation can be used to compare scan paths in both spatial and feature domains for CT images of patients with diffuse lung diseases.

Conclusions

The method relies on the feature space analysis of scan paths. It has shown promising strengths in identifying intrinsic patterns of visual attention from scan paths that have no evident spatial characteristics. By approaching the problem from observations of how expert visual search takes place, it opens new possibilities for developing diagnostic decision support systems in medical imaging.

References