

Algorithms for Defining Visual Regions-of-Interest: Comparison with Eye Fixations

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Abstract—Many machine vision applications, such as compression, pictorial database querying, and image understanding, often need to analyze in detail only a representative subset of the image, which may be arranged into sequences of loci called regions-of-interest, ROIs. We have investigated and developed a methodology that serves to automatically identify such a subset of aROIs (algorithmically detected ROIs) using different Image Processing Algorithms, IPAs, and appropriate clustering procedures. In human perception, an internal representation directs top-down, context-dependent sequences of eye movements to locate on similar sequences of hROIs (human identified ROIs). In this paper, we introduce our methodology and we compare aROIs with hROIs as a criterion for evaluating and selecting bottom-up, context-free algorithms. An application is finally discussed.

Index Terms—Eye movements, scanpath theory, regions of interest identification and comparison.

1 INTRODUCTION

Eye movements are an essential part of human vision because they must carry the fovea and, consequently, the visual attention to each part of an image to be fixated upon and processed with high resolution. An average of three eye fixations per second generally occurs during active looking; these eye fixations are intercalated by rapid eye jumps, called saccades, during which vision is suppressed. Only a small set of eye fixations, hROIs, human detected Regions-of-Interest, are usually required by the brain to recognize a complex visual input (Fig. 1, upper panels). We have been studying and defining a computational model of this complex cognitive mechanism based on intelligent processing of digital images.

Image processing algorithms, IPAs, are usually intended to detect and localize specific features in a digital image analyzing, for example, spatial frequency, texture conformation, or other informative values of loci of the visual stimulus. Applying an IPA to an image means transforming that image into a new range of pixel values defining the corresponding algorithm feature. Local maxima in the transformed image represent loci wherein that particular feature is particularly accentuated and they can, consequently, be used as a basis for identifying aROIs, algorithmically detected Regions-of-Interest. Many local maxima may be generated by an image transformation; therefore, a clustering procedure is required to reduce the initial large set of local maxima into a final small subset of aROIs (Fig. 1, lower panels).

aROIs and hROIs can be compared to each other through analysis of their spatial locations or structural binding and also analysis of the temporal order or sequential binding. The result of these comparisons measures the capability of an IPA, together with its clustering procedure, to predict hROIs. Thus, our aim is explicit and our measure quantitative. The overriding question is whether IPAs can treat an image in a fashion similar to human sequential glimpses.

In Section 2, the experimental protocol to acquire eye movement data is discussed in detail. Section 3 is devoted to defining a list of IPAs. The clustering and sequencing issue is considered and explained in Section 4. The computational and statistical platform used to compare hROIs and aROIs is introduced in Section 5. Top down vision and human scanpath are discussed in Section 6. In Section 7, the results of the comparisons are discussed and, finally, an application is presented in Section 8.

2 STIMULUS PRESENTATION AND EYE MOVEMENT MEASUREMENT

Computer controlled experiments presented pictures and carefully measured eye movements using video cameras [21]. An infrared source light was projected toward the eye of the subject, generating a bright Purkinje reflection on the cornea, reflection that was easy to track by a video camera and the eye-tracking server. The subject was instructed to watch the visual stimuli (for a duration of four seconds, plus a calibration period before and after data acquisition) on a computer screen which was socket-connected to the eye-tracking server. The subject was seated in front of the screen with his head secured onto an optometric chin-rest structure. The viewing distance was approximately 40 cm from the computer screen; stimulus size was an average of 15 cm x 20 cm, yielding a subtended visual angle of approximately 21 x 29 degrees, and the resulting accuracy

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