

Statistical analysis of eye movement trajectories

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Eye movement refers to the voluntary or involuntary movement of the eyes. Eye trajectories explain human search behavior. It has been revealed that variations of these trajectories reflect the dynamics of the oculomotor system. Eye movement trajectories under free exploration contain a lot of noise with saccades and fixations. As a result eye movement trajectories cannot be treated as any other trajectory. It has been a challenge to analyze gaze during free exploration, preserving spatial and temporal characteristics of eye movements. Therefore, most of the experiments are carried in laboratories under restrictions. Here we address the problem of analyzing the binocular eye movement trajectory under free exploration, to understand the underlying patterns in the movement. First eye movement trajectory is mapped onto the unit sphere as a set of time indexed points. The obtained eye movement trajectories on the sphere are not simple curves and with repeated movements. Therefore, the whole trajectory was segmented using the speed at each time instance in order to obtain simple trajectories. For each segment, we have estimated a smoothed curve given by a set of time-indexed points on the sphere so that the estimated curve would approximate the data points best at given time instants while being regular as possible. These smoothed curves as cubic splines can be used to analyze patterns in the whole trajectory. Furthermore, the estimated curves as a set of time indexed points were used in interpolation and clustering. Distances between different curves are calculated using the geodesic distance on the unit sphere. Using the distance matrix of the segmented smoothed curves and the software called cystoscope, curves are grouped to obtain four different clusters. Each cluster from the binocular eye movement was analyzed for both left and right eye movement to obtain curves overlapped where both eyes move together in the same direction. These overlapped curves can be analyzed further to compare eye movement patterns in different individuals.

Keywords: Eye movements, Binocular eye movement, Trajectories, Smoothing splines, Segmentation