

Measuring and Modeling Shared Visual Attention

Jeffrey B. Mulligan, Human Systems Integration Division, NASA Ames Research Center
 Patrick Gontar, Institute of Ergonomics, Technische Universitat Munchen

Multi-person teams are sometimes responsible for critical tasks, such as flying an airliner. Here we present a method using gaze tracking data to assess *shared visual attention*, a term we use to describe the situation where team members are attending to a common set of elements in the environment. Gaze data are quantized with respect to a set of N *areas of interest* (AOIs); these are then used to construct a time series of N dimensional vectors, with each vector component representing one of the AOIs, all set to 0 except for the component corresponding to the currently fixated AOI, which is set to 1. The resulting sequence of vectors can be averaged in time, with the result that each vector component represents the proportion of time that the corresponding AOI was fixated within the given time interval. We present two methods for comparing sequences of this sort, one based on computing the time-varying correlation of the averaged vectors, and another based on a chi-square test testing the hypothesis that the observed gaze proportions are drawn from identical probability distributions.

We have evaluated the method using synthetic data sets, in which the behavior was modeled as a series of “activities,” each of which was modeled as a first-order Markov process. By tabulating distributions for pairs of identical and disparate activities, we are able to perform a receiver operating characteristic (ROC) analysis, allowing us to choose appropriate criteria and estimate error rates.

We have applied the methods to data from airline crews, collected in a high-fidelity flight simulator (Haslbeck, Gontar & Schubert, 2014). We conclude by considering the problem of automatic (blind) discovery of activities, using methods developed for text analysis.

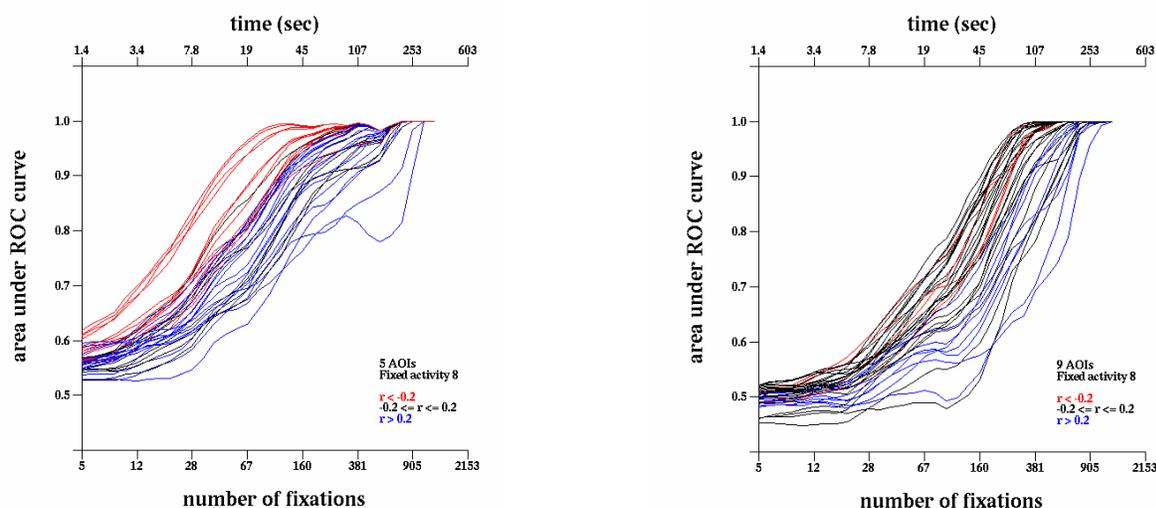


Figure 1: Plots showing area under the ROC curve for discrimination of synthetic activities having 5 (left) and 9 (right) areas of interest (AOIs). ROC curves are generated based on the distributions of chi-squared P values for sample records from identical activities, and independent activities. In all cases, 1000 or more fixations (4-5 minutes) are sufficient to reliably discriminate activities of up to 9 AOIs, but for activity pairs with negatively correlated asymptotic probabilities, reliable discrimination can be done in as little as 20 seconds. The results suggest the minimum duration that common behavioral activities must be sustained in order to be reliably detected statistically.

Haslbeck, A., Gontar, P., and Schubert, E. (2014). How Can Procedures and Checklists Help Pilots in Abnormal Flight Situations? in T. Ahram, W. Karwoski and T. Marek (eds.), *Proc. 5th Intl. Conf. Applied Human Factors and Ergonomics, AFHE 2014*, Krakow, Poland, 19-23 July, 2014.