The Role of Prewhitening in Visual-Search Models of Human Observers

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Rationale

Mathematical observers use prewhitening to decorrelate statistical image noise during the target-detection process. That human observers can prewhiten has been indicated by past comparison studies with channelized Hotelling (CH) observers. Largely based on known-target detection at a fixed location, these studies have led to human-observer models in which channel prewhitening is degraded by added internal noise. A visual-search (VS) observer with intrinsic uncertainties may provide a more precise assessment of humans' prewhitening abilities.

Methods

Our VS observer applied a feature-based linear discriminant solely at candidate locations obtained from an initial image search. The observer was tested against humans in localization ROC (LROC) and location-known two-alternative forced-choice (2AFC) studies. These studies used images created with a statistical lumpy background model [from Rolland and Barrett] which simulated single-pinhole planar imaging of 2D phantoms with or without a Gaussian target. Pinhole size was the study variable for this abstract. With 2AFC images, the VS observer sought the maximally suspicious candidate within a search radius about the fixed location. The 2AFC study also included CH and NPWE (nonprewhitening + eye filter) observers that only analyzed the target center location. The CH and VS observers both used Abbey's sparse set of three difference-of-Gaussian channels/features. The VS observer applied different levels of prewhitening and performance-based adaptive feature selection (AFS).

Results

As shown in Fig. 1, the VS observer with full prewhitening gave close agreement with the 2AFC human results but overestimated human LROC performance. With partial prewhitening (or standardization), the VS observer gave close 2AFC agreement but underestimated human LROC performance. Standardization and AFS together produced good agreement in both studies.

Conclusion

Prewhitening and AFS may offer complementary means of specifying important features for a task. This initial work is being augmented with studies based on other variables such as background lumpiness, target geometry and diagnostic task.
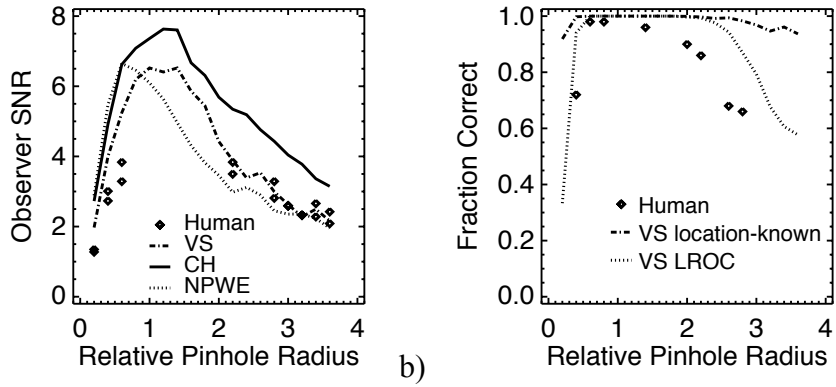
a) b)

Fig.1: Observer performance as a function of pinhole radius. a) SNRs obtained by transforming fractions correct from the 2AFC study. Note that two data points for the human observers [at pinhole radii 0.6 and 1.2] mapped to infinity. b) LROC fractions correct for human and VS observers [VS 2AFC performance also shown]. In both studies, the VS observer applied full channel prewhitening.