Estimated Templates for Forced-Localization Tasks in Ramp-Spectrum Noise

Craig K. Abbey[a], PhD, Frank W. Samuelson[b], PhD, Rongping Zeng[b], PhD, John M. Boone[c], PhD, Miguel P. Eckstein[a], PhD, and Kyle Myers[b], PhD.

[a]Department of Psychological and Brain Sciences, University of California Santa Barbara
[b]Division of Imaging Diagnostics and Software Reliability, United States Food and Drug Administration
[c]Departments of Radiology and Biomedical Engineering, University of California Davis

Rationale: In this study we examine localization performance in Gaussian random textures that simulate limiting effects in computed tomography (CT). These include blur from the system transfer function, background variability from normal anatomical structures, ramp-spectrum acquisition noise, and apodization used to control noise in the images. Understanding the effects of these components on how observers perform visual tasks in the images is important for optimizing tomographic imaging systems for best task performance and for validating such improvements through the use of model observers.

The classification image technique we use directly estimates the weighting function used by observers for forced localization tasks under the assumption of a scanning linear template. We are particularly interested in the effect of apodization on observer templates since this represents a point of control in the imaging process.

Methods: In this study we use the classification image approach to estimate scanning linear templates used by human observers in tasks that have different signal sizes, different amounts of background variability, and different levels of apodization. We also compute observer efficiency with respect to the ideal observer.

The classification image methodology uses noise fields from the incorrect localizations to build an estimate of the weights used by the observer to perform the task. The basic idea is that incorrect localizations occur in regions of the image where the noise field matches the weighting profile, thereby eliciting a strong internal response.

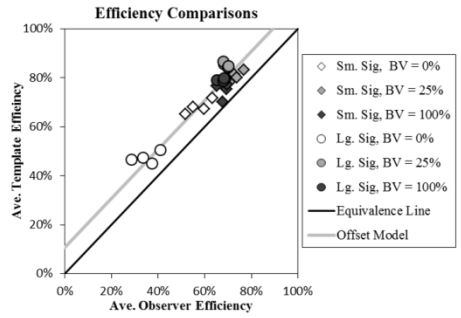

Fig. 1. Scatterplot of observer efficiency and template efficiency. The average efficiency of the observers in each task are plotted with the average efficiency to the estimated templates. The data are reasonably well fit (r^2 = 90.5%) by an offset of 10.8% in efficiency.

Results: Average observer efficiency varies substantially across the different conditions from 28% to 82%. The estimated templates offer some direct mechanisms for explaining this variability. As shown in Figure 1, when the templates are used as a scanning template model, they explain about 90% of the variability in the average observer efficiency data.

Conclusions: In these studies, the classification images are a useful way to characterize and investigate human observer performance. The information we find from this study may be used to construct model observers that utilize image information in ways that are similar to humans.