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Quality Metrics for Sensor Images

Al Ahumada
NASA Ames Research Center

Methods are needed for evaluating the quality of Augmented VIsual Displays (AVID). Computational quality metrics will help summarize, interpolate, and extrapolate the results of human performance tests with displays. The FLM Vision group at NASA Ames has been developing computational models of visual processing and using them to develop computational metrics for similar problems, for example,

1) Display modeling systems use metrics for comparing proposed displays (Martin, Ahumada, and Larimer, 1992; Lubin, 1993).

2) Halftoning optimizing methods use metrics to evaluate the difference between the halftone and the original (Mulligan and Ahumada, 1992).

3) Image compression methods minimize the predicted visibility of compression artifacts (Peterson, Ahumada, and Watson, 1993; Watson, 1993).

The visual discrimination models take as input two arbitrary images A and B, and compute an estimate of the probability that a human observer will report that A is different from B. If A is an image that one desires to display and B is the actual displayed image, such an estimate can be regarded as an image quality metric reflecting how well B approximates A (Watson, 1983; Nielsen, Watson, and Ahumada, 1985).

There are additional complexities associated with the problem of evaluating the quality of radar and IR enhanced displays for AVID tasks.

One important problem is the question of whether intruding obstacles are detectable in such displays. Although the discrimination model can handle detection situations by making B the original image A plus the intrusion, this detection model makes the inappropriate assumption that the observer knows where the intrusion will be. Effects of signal uncertainty as studied by Pelli (1985), for example, need to be added to our models.

A pilot needs to make his decisions rapidly. Our models need to predict not just the probability of a correct decision, but the probability of a correct decision by the time the decision needs to be made. That is, the models need to predict latency as well as accuracy. Luce and Green have generated models for auditory detection latencies. Similar models are needed for visual detection.

Most image quality models are designed for static imagery. Watson has been developing a general spatial-temporal vision model to optimize video compression techniques. These models need to be adapted and calibrated for AVID applications.

Radar images especially are characterized by high levels of noise. Although detection and discrimination models have been developed for noisy images (Legge, Kersten, and Burgess, 1987; Barrett, 1992), their features have not been integrated into our current models.

Models have been developed within our group to predict a pilot's 3D heading estimate from a video display (Perrone, 1992; Heeger and Jepson, 1992). These models can be developed into quality measures relating to the pilot's ability to gather dynamic orientation information from such displays.

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