Studies on the Salient Properties of Digital Imagery that Impact on Human Target Acquisition and the Implications for Image Measures.

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by

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Declaration

I declare that this thesis is a record of original work and that it contains no material which has been accepted for the award of any other degree or diploma in any University.

To the best of my knowledge and belief, this thesis contains no material previously published or written by any other person, except where due reference is given in the text of the thesis.

I consent to this thesis being made available for photocopying or loan.

Gary J. Ewing
January 1999

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Work Performed by Others.

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Abstract

Electronically displayed images are becoming increasingly important as an interface between man and information systems. Lengthy periods of intense observation are no longer unusual. There is a growing awareness that specific demands should be made on displayed images in order to achieve an optimum match with the perceptual properties of the human visual system. These demands may vary greatly, depending on the task for which the displayed image is to be used and the ambient conditions. Optimal image specifications are clearly not the same for a home TV, a radar signal monitor or an infra-red targeting image display. There is, therefore, a growing need for means of objective measurement of image quality, where "image quality" is used in a very broad sense and is defined in the thesis, but includes any impact of image properties on human performance in relation to specified visual tasks.

The aim of this thesis is to consolidate and comment on the image measure literatures, and to find through experiment the salient properties of electronically displayed real world complex imagery that impacts on human performance. These experiments were carried out for well specified visual tasks (of real relevance), and the appropriate application of image measures to this imagery, to predict human performance, was considered.

An introduction to certain aspects of image quality measures is given, and clutter metrics are integrated into this concept. A very brief and basic introduction to the human visual system (HVS) is given, with some basic models. The literature on image measures is analysed, with a resulting classification of image measures, according to which features they were attempting to quantify.

A series of experiments were performed to evaluate the effects of image properties on human performance, using appropriate measures of performance. The concept of image similarity was explored, by objectively measuring the subjective perception of imagery of the same scene, as obtained through different sensors, and which underwent different luminance transformations. Controlled degradations were introduced, by using image compression. Both still and video compression were used to investigate both spatial and temporal aspects of HVS processing. The effects of various compression schemes on human target acquisition performance were quantified. A study was carried out to determine the "local" extent, to which the clutter around a target, affects its detectability. It was found in this case, that the excepted wisdom, of setting the local domain (support of the metric) to twice the expected target size, was incorrect. The local extent of clutter was found to be much greater, with this having implications for the application of clutter metrics. An image quality metric called the *gradient energy measure* (GEM), for quantifying the affect of filtering on Nuclear Medicine derived images, was developed and evaluated. This proved to be a reliable measure of image smoothing and noise level, which in preliminary studies agreed with human perception The final study discussed in this thesis determined the performance of human image analysts, in terms of their receiver operating characteristic, when using Synthetic Aperture Radar (SAR) derived images in the surveillance context. In particular, the effects of target contrast and background clutter on human analyst target detection performance were quantified. In the final chapter, suggestions to extend the work of this thesis are made, and in this context a system to predict human visual performance, based on input imagery, is proposed. This system intelligently uses image metrics based on the particular visual task and human expectations and human visual system performance parameters.