

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

A thesis submitted for the degree of

**DOCTOR OF PHILOSOPHY**

*in*

The Departments of Computer Science & Psychology,  
The University of Adelaide, South Australia.

*by*

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January 11, 1999

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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

# Acknowledgements

## **I wish to express thanks to my academic supervisors.**

I thank Dr Michael Brooks of the Department of Computer Science, for accepting me as a PhD candidate and for our early discussions.

I thank Dr Chris Woodruff of the Defence Science & Technology Organisation (DSTO) for offering his expertise in visual psychophysical experimentation and for our many fruitful discussions. Dr Woodruff's guidance came at a time when I needed focusing, and I greatly appreciated his support.

I thank Dr Douglas Vickers of the Department of Psychology, for offering to become my principal academic supervisor, at a time when I realised my work fell largely under his academic discipline. I have relied on Dr Vickers in assessing my thesis as suitable for submission.

I thank Dr Nicholas Redding of DSTO for his encouragement and conscientiousness in spurring me on. He proof read my thesis drafts, with particular emphasis on the mathematical components, which was very helpful. Dr Redding gave considerable input into the development of my work discussed in Chapter 9.

I thank Dr Leighton Barnden, of the Department of Nuclear Medicine in the Queen Elizabeth Hospital (QEH) Adelaide, for his help and encouragement in carrying out the work in Chapter 8. I also appreciated the friendship he extended to me during my stay at the QEH.

## **I wish to thank others for contributions in some way to my work.**

I thank Dr Garry Newsam of DSTO for his very valuable comments during the course of my early experiments from inception to completion and for the use of his smooth zooming algorithm.

I thank the DSTO management for their support in allowing me to enrol for a PhD on a half time basis and facilitating my use of DSTO resources and time. In particular, I would like to thank Dr Roger Lough, Chief Land Operations Division, for granting general and financial support. I also thank Dr Tim French and Dr Jeremy Manton for allowing me time off to write up my thesis.

I thank my family for their support in keeping me going and in particular I thank my wife Barbara, to whom this thesis is dedicated. Her encouragement and loving devoted support allowed this work to reach fruition.

Finally, I like to acknowledge, that this thesis was completed through the Grace of God.

## **Work Performed by Others.**

All of the work discussed in this thesis, including experimental design, set up and running of experiments, computer coding and analysis has been performed solely by the author except in the following cases. Of course as has been already acknowledged, the work benefited from

discussions with my PhD supervisors.

I acknowledge the technical support of Mr Warwick Holen, who wrote the code to allow software control of the MPEG-2 play-back board used in the video experiments of Chapter 6 and who helped with video pre-processing.

I acknowledge the programming and technical support of Mr David Kettler, who developed the experimental software used for the work discussed in Chapter 9.

I acknowledge the assistance of Dr Philip Chapple, who under my suggestion, developed the Matlab code for the fractal simulation of image clutter used in Chapter 7.



# 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 expected 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.