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Evaluation of Image Quality

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ABSTRACT

This presentation outlines a general approach to the evaluation of display system quality for aviation applications. This approach is based on the assumption that it is possible to develop a model of the display which captures most of the significant properties of the display. The display characteristics should include spatial and temporal resolution, intensity quantizing effects, spatial sampling, delays, etc. The model must be sufficiently well specified to permit generation of stimuli that simulate the output of the display system.

The first step in the evaluation of display quality is an analysis of the tasks to be performed using the display. Thus, for example, if a display is used by a pilot during a final approach, the aesthetic aspects of the display may be less relevant than its dynamic characteristics. The opposite task requirements may apply to imaging systems used for displaying navigation charts. Thus, display quality is defined with regard to one or more tasks.

Given a set of relevant tasks, there are many ways to approach display evaluation. The range of evaluation approaches includes visual inspection, rapid evaluation, part-task simulation, and full mission simulation.

The work described today is focused on two complementary approaches to rapid evaluation. The first approach is based on a model of the human visual system. A model of the human visual system is used to predict the performance of the selected tasks. The model-based evaluation approach permits very rapid and inexpensive evaluation of various design decisions.

The second rapid evaluation approach employs specifically designed critical tests that embody many important characteristics of actual tasks. These are used in situations where a validated model is not available. These rapid evaluation tests are being implemented in a workstation environment.

EVALUATION

- Task Analysis
- Model-Based Evaluation
- Visual Inspection
- Rapid Laboratory Evaluation ←
- Part-Task Simulation
- Full Mission Simulation
- Flight Tests

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BASIC CONCEPT

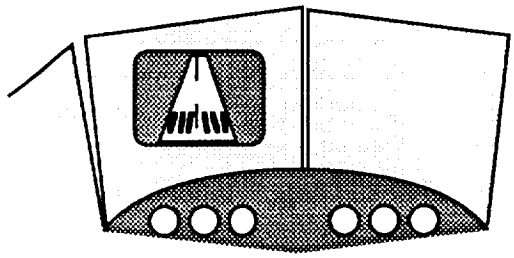

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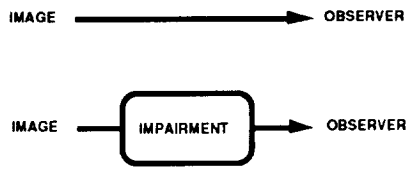
IMAGE QUALITY

Insertion Impairment



Examples: Insertion loss (attenuation), noise, delays, geometric distortions, etc.

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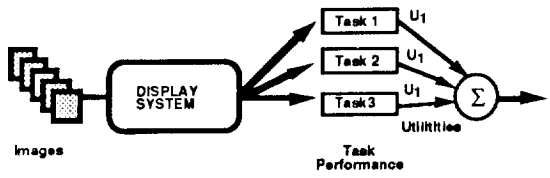
TASK-BASED IMAGE QUALITY METRIC

- Representative sample of images
- Performance measures
- Task utility



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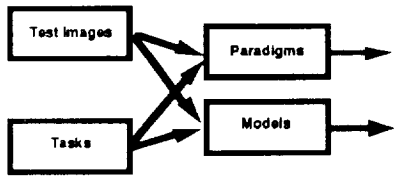
RAPID EVALUATION WORKBENCH

- Images: Test patterns
- Tasks: Detection, alignment
- Models: Prediction of performance
- Tests: Empirical Paradigms



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TASK ANALYSIS

- Runway acquisition (at distance 10,000 ft)
- Runway identification (at distance 6,000 ft)
- Runway location
- Runway orientation
- Aimpoint estimation
- Traffic detection
- Hazard (*e.g.*, runway incrusion) detection

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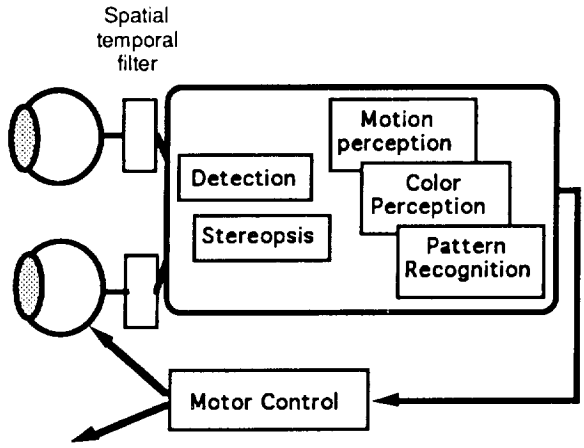
MODEL BASED EVALUATION HUMAN VISUAL SYSTEM



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EMPIRICAL TASKS

- Bar detection in noise
- Edge orientation
- Visual search
- Vernier alignment
- Optic flow perception (self-motion)
- Motion perception

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DISPLAY CHARACTERISTICS

- Field of view, perspective, symbology
- Temporal Resolution, update rate, delay
- Quantization (spatial & gray-level)
- Spatial resolution, stroke, raster
- Reliability, noise, masking
- Contrast, brightness, color
- Geometric distortions
- Display stabilization
- Registration

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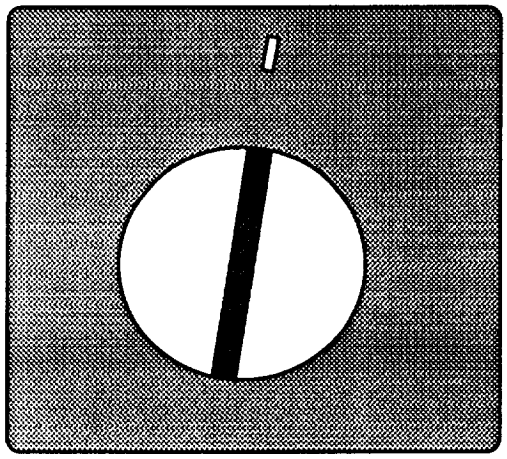
Rapid Evaluation Example



Task: Alignment of the bar and with the probe.

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EXAMPLE: SEARCH

Task: To find a target — the lighter bar

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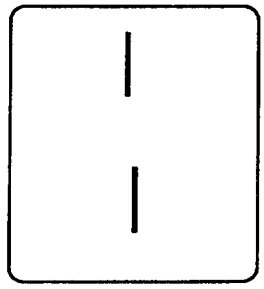
EXAMPLE: VERNIER ALIGNMENT



Task: To judge the relative position of the two vertical lines.

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SIMULATOR/FLIGHT PERFORMANCE

- Situational awareness
- Landing performance
- Landing dipersions
- Breaking performance
- Glideslope alignment
- Workload
- Training (Learning curves, retention)

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ARTIFACTS

- Geometric Illusions
  - Size
  - Distance
- Color illusions
  - Brightness
  - Color
- Motion illusions
  - Direction of moving objects
  - Direction of selfmotion

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SYMBOLOGY

- TYPE OF INFORMATION
  - Pitch bars
  - Glide slope
  - Velocity vector
  - Energy management
  - Wind conditions
  - Predicted path
- SYMBOL DESIGN AND SELECTION
- SYMBOLOGY CLUTTER

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