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Engineering Workstation: Sensor Modeling

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ABSTRACT

The purpose of the engineering workstation is to provide an environment for rapid prototyping and evaluation of fusion and image processing algorithms. Ideally, the algorithms are designed to optimize the extraction of information that is useful to a pilot for all phases of flight operations. Successful design of effective fusion algorithms depends on the ability to characterize both the information available from the sensors and the information useful to a pilot.

The workstation is comprised of subsystems for simulation of sensor-generated images, image processing, image enhancement, and fusion algorithms. As such, the workstation can be used to implement and evaluate both short-term solutions and long-term solutions. The short-term solutions are being developed to enhance a pilot's situational awareness by providing information in addition to his direct vision. The long term solutions are aimed at the development of complete synthetic vision systems.

One of the important functions of the engineering workstation is to simulate the images that would be generated by the sensors. The simulation system is designed to use the graphics modeling and rendering capabilities of various workstations manufactured by Silicon Graphics Inc. The workstation simulates various aspects of the sensor-generated images arising from phenomenology of the sensors.

In addition, the workstation can be used to simulate a variety of impairments due to mechanical limitations of the sensor placement and due to the motion of the airplane.

Although the simulation is currently not performed in real-time, sequences of individual frames can be processed, stored, and recorded in a video format. In that way it is possible to examine the appearance of different dynamic sensor-generated and fused images.

GOALS

- Tools for rapid development and evaluation of augmented vision systems
- Development of short-term solutions
- Simulation of sensor signals
- Signal and image processing
- Simulation of algorithms
- Error analysis
- Easy-to-use interface

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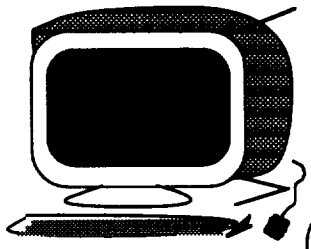
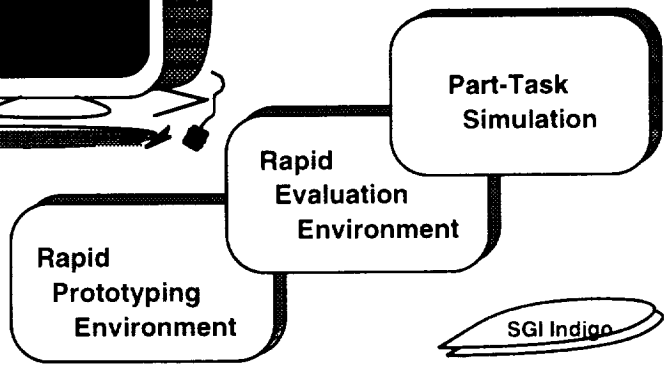
SYSTEM DEVELOPMENT ENVIRONMENT



ENGINEERING WORKSTATION



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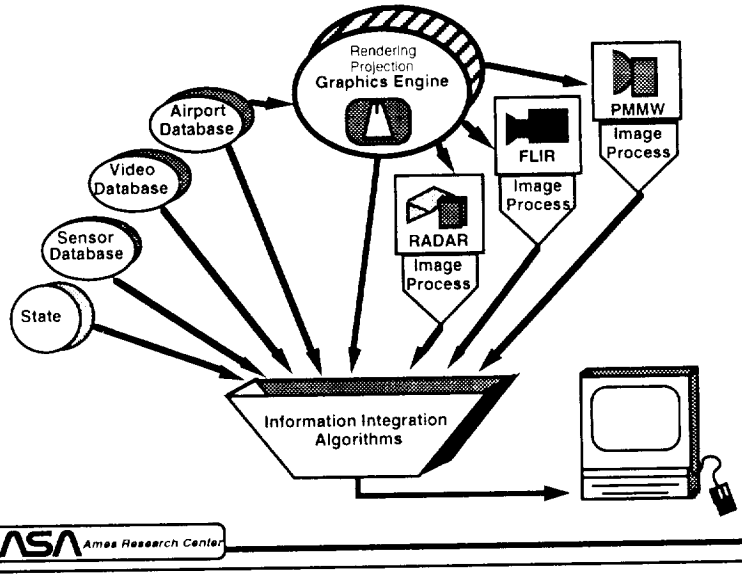
RAPID PROTOTYPING ENVIRONMENT



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SIMULATION: IMAGE GENERATION

- Database - A simple airport scene
- Objects, materials and illumination
- Atmospheric attenuation
- Computer graphics rendering
- Sensor signal simulation

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VISUAL IMAGE

- Simple airport scene
- Polygonal representation
- Simple lighting model
- Color image rendering

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SENSOR SIMULATION PHILOSOPHY

- Goal: Reduce simulation complexity
- Simulate critical characteristics
- Restricted viewing conditions
- Restricted environmental conditions
- Material specification -> Signal

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SENSOR CHARACTERIZATION

- Relationship between a visual and a sensor image
- Spatial response characteristics
- Temporal response characteristics
- Sensitivity and signal-to-noise ratio
- Stability: drift, changes in gain
- Atmospheric effects and attenuation
- Inhomogeneity of sensor image

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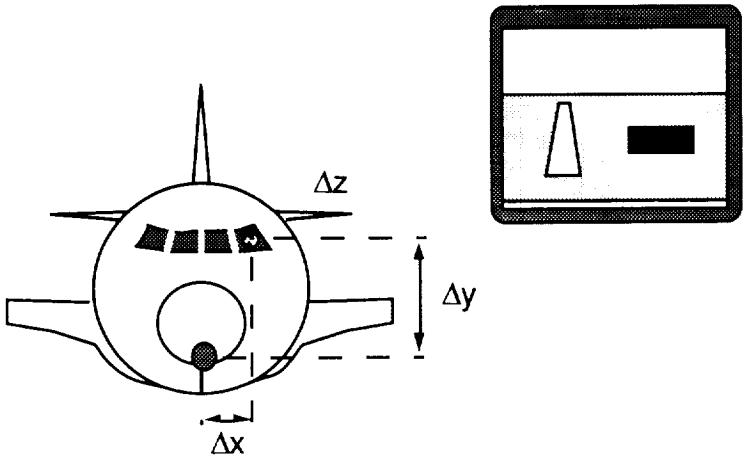
GEOMETRIC DISTORTIONS



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BEAM PROFILE

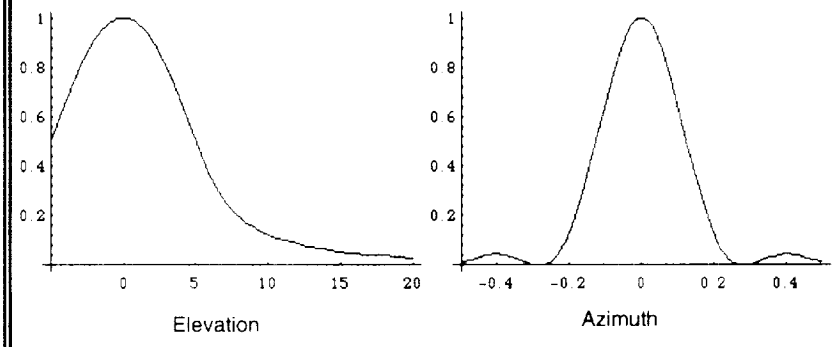

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IMAGE PROCESSING

- **HIPS Image Processing System**
- **Image Processing**
- **Special Algorithms**
- **Fusion**

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RADAR SIMULATION

- Assignment of material or radar cros section (RCS)
- Computer generated image - Rendering
- Beam profile calculations
- Compute Range using Hardware Z-buffer
- Scattering variability
- Gain control

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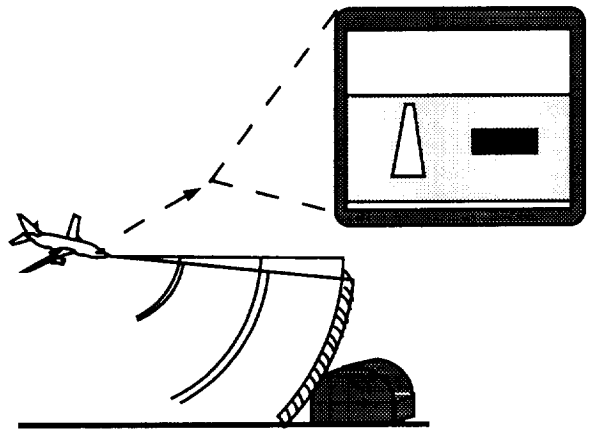
RADAR SIMULATION



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Passive Millimeter Wave (PMMW) SENSOR CHARACTERISTICS

- The following are examples of particular implementations of selected sensor models
- 16 x 16 Focal plane array
- Operating Frequency: 94 GHz
- Spatial Resolution: 6 Milliradians (1/3 degree)
- Minimum Resolvable Temperature: 1 Deg K
- Update rate: 10 Hz
- Noise Figure

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Passive Millimeter Wave (PMMW) SENSOR SIMULATION

Assumptions

- Uniform hot sky
- Runway, grass -> reflectivity specification
- Spatial modulation transfer function (MTF)
- Gaussian noise

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HIPS IMAGE PROCESSING SOFTWARE

- Modular, UNIX-based system
- Modifyable source code
- Self-documenting image files
- Built-in functions:
  - Filtering, edge-detection
  - Image transformations
  - Image statistics
  - Image compression

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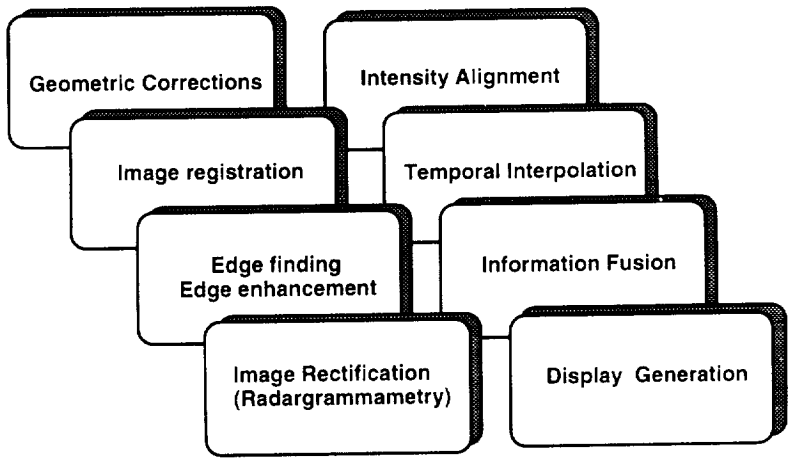
EXAMPLES OF ALGORITHMS



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USER INTERFACE

- Generate sequences of frames
- Menu-based interactions
  - Stop, examine a frame
  - Generate fog
  - Render PMMW image
  - Render radar image
  - Modify parameters
- Save images in HIPS Format

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III. SENSOR FUSION