Model-Based Design for Sensor Systems

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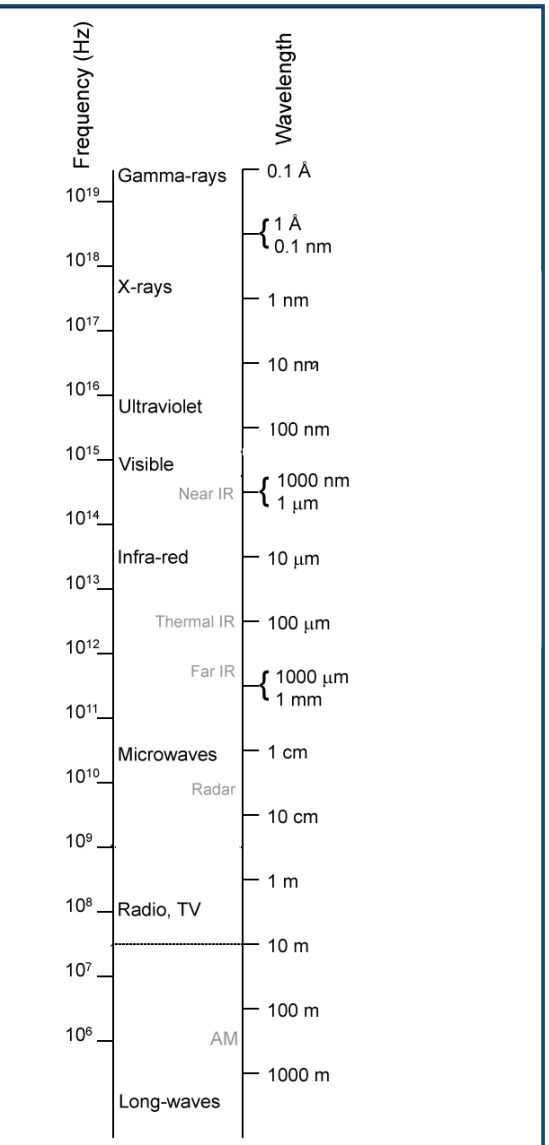
Agenda

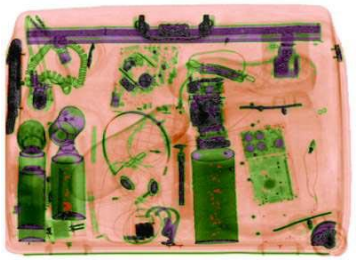
- Sensor Systems Overview
- System Level Design Challenges
- Components of Sensor Systems
  - Sensor Characterization and Calibration
  - Signal Processing Design and Implementation
  - Data Processing & Analysis

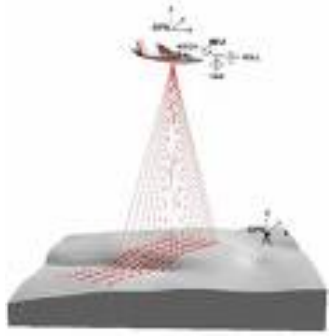
Sensor Classes

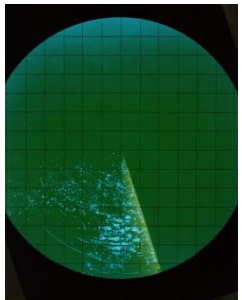


- X-Ray
- Optical
- Infrared
- Laser
- Electro-Magnetic
- Sonar
- Radar

Hyper-Spectral





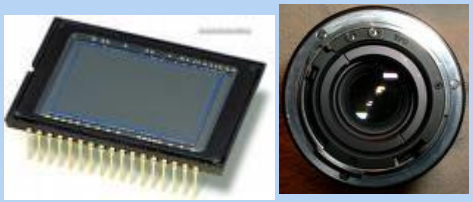


Sensing Applications

- Platforms
  - Naval
  - Space
  - Airborne

- Applications
  - Surveillance
  - Target Tracking
  - Reconnaissance

Sensor System Components



Sensor

Embedded Signal Processing

Analysis

Sensor System Development: Component Tasks




Sensor Characterization & Calibration

Fully understand sensor and its impact on signal processing and analysis.

Signal Processing Design & Implementation

Design system to read signals, process data, and present data to analysis algorithms.

Data Processing & Analysis

Perform intended function (identify, track, etc)

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System Level Tasks

- System integration
- System level debugging
- Test overall system against requirements

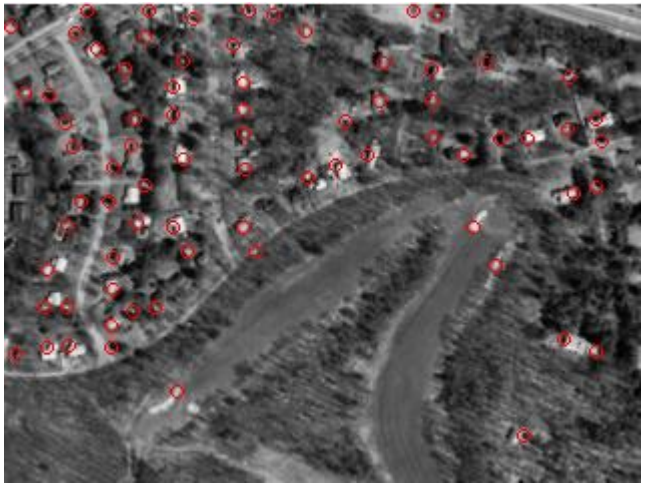
System Level Challenges




Challenges	Solutions
Find errors early	
Reduce dependency on SW and HW engineers for testing	
Speed up design iterations	
Meet requirements	

Demo: Sensor System

Video Mosaicking of Synthetic Aperture Radar (SAR) imagery



System Level Challenges




Challenges	Solutions
Find errors early	Simulate complete system before deploying to hardware
Reduce dependency on SW and HW engineers for testing	Automatic Code Generation, Link Products, Target Products
Speed up design iterations	Single environment for all phases
Meet requirements	Verification tools link design to requirements

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Sensor Characterization & Calibration Tasks

- Noise Characterization
- Spectral Response
- Parameterization (bandwidth, response time, etc)
- Color Calibration

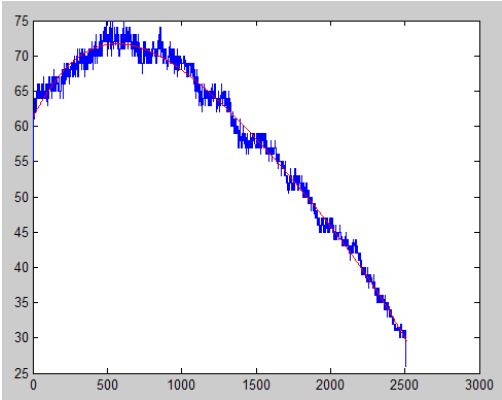
Sensor Characterization & Calibration Challenges

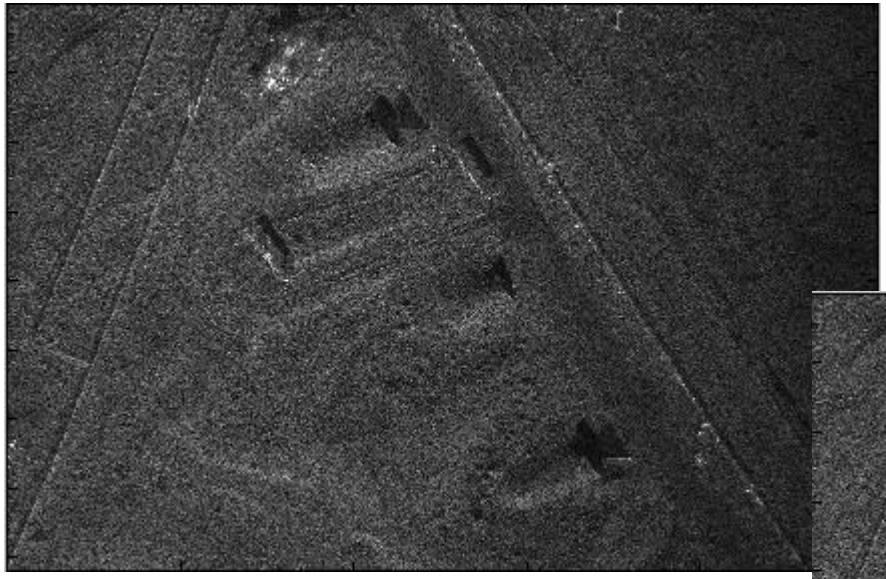


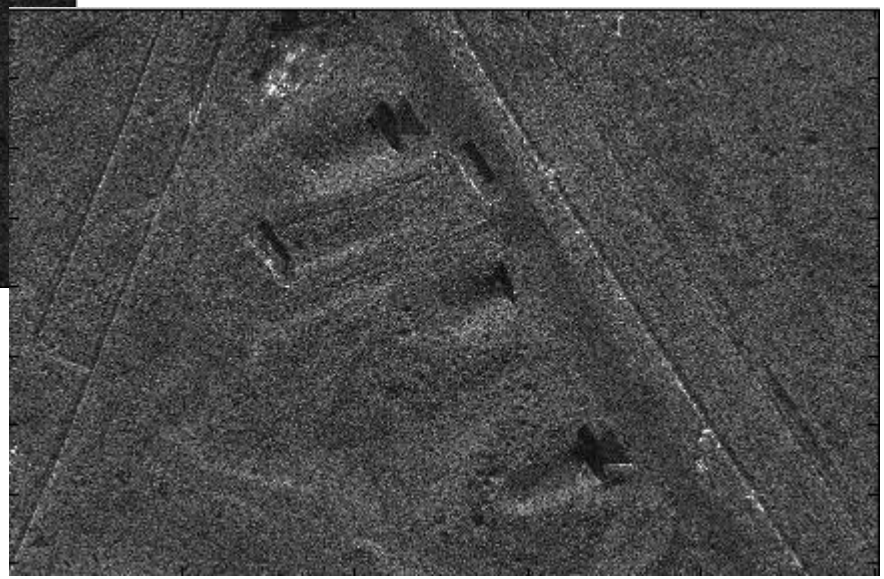

Challenges	Solutions
Quickly obtain sensor data	
Sensor characterization	
Design tests for analyzing sensors	
Analyze large data sets	
Automate tests	

Demo: Sensor Characterization & Calibration

Analysis of Antenna Roll-Off effects of Synthetic Aperture Radar (SAR) imagery







Sensor Characterization & Calibration Challenges




Challenges	Solutions
Quickly obtain sensor data	Image and Data Acquisition Tools
Sensor characterization	System Identification, Curve Fitting, etc
Design tests for analyzing sensors	Statistics Toolbox - Design of Experiments
Analyze large data sets	MATLAB, Statistics, Parallel Computing ,etc
Automate tests	MATLAB, Image and Data Acquisition

Signal Processing Tasks




- Sensor correction
  - Lens distortion
  - Gamma correction
  - Dead pixel correction
- Data reduction
- Optimizing for power consumption
- Fixed-point design

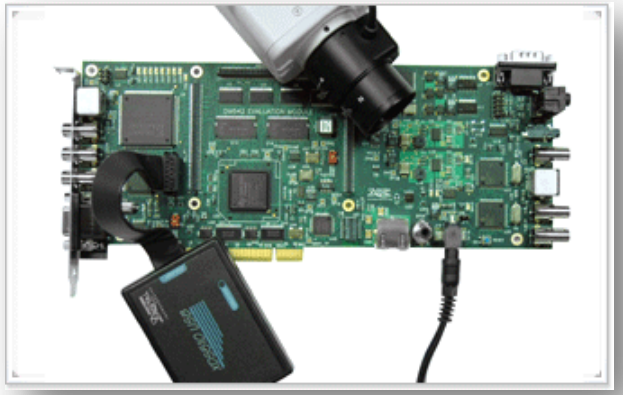
Signal Processing Challenges




Challenges	Solutions
Reduce time on verifying algorithms and filters	
Analyze algorithmic and performance tradeoffs	
Understand implementation effects	
Make implementation decisions before requirements are final	

Demo: Signal Processing

Analysis of Antenna Roll-off correction algorithm



Signal Processing Challenges




Challenges	Solutions
Reduce time on verifying algorithms and filters	Pre-packaged and tested algorithms and filter design tools
Analyze algorithmic and performance tradeoffs	Simulate and prototype algorithms
Understand implementation effects	Simulate effects of sample times & data types
Make implementation decisions before requirements are final	Quickly investigate and prototype architectures and hardware choices

High Level Analysis Tasks




- Target Detection
- Geo-referencing
- Tracking
- Sensor Fusion
- Classification

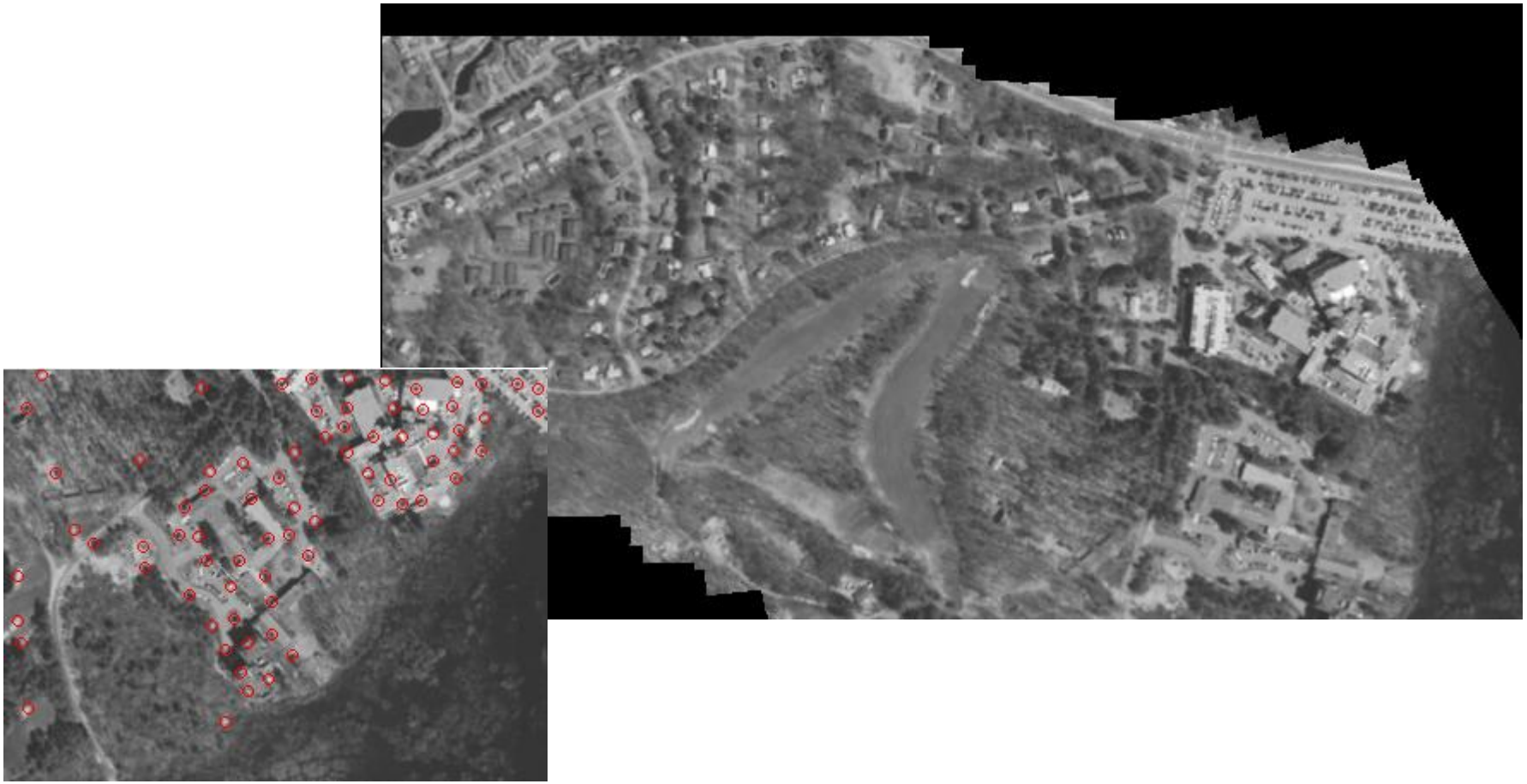
High Level Analysis Challenges




Challenges	Solutions
Avoid re-implementing standard image and video processing routines	
Test image processing algorithms and classification routines together	
Avoid use of multiple environments for each source in sensor fusion problems	
Reduce reliance on SW/HW engineers in order to test algorithms	

Demo: Higher Level Analysis

Video Mosaicking

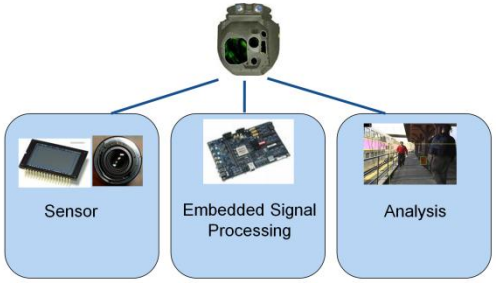


High Level Analysis Challenges




Challenges	Solutions
Avoid re-implementing image and video processing routines	Pre-packaged Image, Video, and Signal Processing Libraries
Test image processing algorithms and classification routines together	Statistical and Neural Network capabilities
Avoid use of multiple environments for each source in sensor fusion problems	Single environment for multiple sensor sources
Reduce reliance on SW/HW engineers in order to test algorithms	Desktop and real-time prototyping with Image Acquisition and Code Generation

Summary



- Single environment for all design stages
- Fully understand sensor before moving to design
- Quickly develop signal processing and analysis algorithms
- Prototype faster with desktop and real-time prototyping
- Fully understand design before moving to implementation