SPIE Courses

2012 Defense, Security, and Sensing

spie.org/dss12courses

23–27 April 2012

Baltimore Convention Center
Baltimore, Maryland, USA

SPIE®

SPIE Courses

Courses, relevant training, proven instructors.

The education you need to stay competitive in today's job market

- Take advantage of direct instruction from some of the biggest names in research and industry—learn from recognized experts
- Relevant courses on current topics and challenges, including including all-new content on energy harvesting, high dynamic range imaging, and ITAR/international trade.
- 12 new courses and workshops for 2012
- Earn CEUs to fulfill ongoing professional education requirements

Contents:

SPIE course instructors include world-renowned experts from industry and academia, often the authors of definitive texts in their areas of expertise.

IACET Continuing Education Units

SPIE has been approved as an authorized provider of CEUs by IACET, The International Association for Continuing Education and Training (Provider #1002092). In obtaining this approval, SPIE has demonstrated that it complies with the ANSI/IACET Standard which is widely recognized as the standard of good practice for continuing education.

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Get the training you need to stay competitive in today's job market:

Courses at SPIE Events offer an engaging experience for those who prefer face-to-face instruction, where interaction with the instructor and sharing information with other students provide increased value.

- 55 courses and workshops to choose from
- SPIE Student Members get 50% off courses

New Courses for 2012: NEW

SC967 **High Dynamic Range Imaging: Sensors and Architectures** (Darmont)

SC1052 **Optical Systems Engineering** (Kasunic)

SC1068 **Introduction to Night Vision** (Browne)

SC1069 **GPU for Defense Applications** (Humphrey)

SC1070 **Radar Waveforms and Signal Processing** (Welstead)

SC1071 **Understanding Diffractive Optics** (Soskind)

SC1072 **Statistics for Imaging and Sensor Data** (Bajorski)

SC1073 **Radiometry and its Practical Applications** (Grant)

SC1075 **Methods of Energy Harvesting for Low-Power Sensors** (Erturk)

SC1076 **Analog-to-Digital Converters for Digital ROICs** (Veeder)

SC1077 **Introduction to Optical Oceanography** (Hou)

WS1074 **Safely Navigating the Deep Waters of International Trade: Legal Best Practices** (Scarlott)

Defense, Homeland Security, and Law Enforcement

Emerging Technologies

Imaging and Sensing

SC713 **Engineering Approach to Imaging System Design** *(Holst)*
Mon. 8:30 am to 5:30 pm, $565 / $660 24

SC1073 **Radiometry and its Practical Applications** *(Grant)*
Mon. 8:30 am to 5:30 pm, $590 / $685 28
NEW

SC952 **Applications of Detection Theory** *(Carrano)*
Tues. 8:30 am to 5:30 pm, $515 / $610 11

SC720 **Cost-Conscious Tolerancing of Optical Systems**
Tues. *(Youngworth)* 8:30 am to 12:30 pm, $295 / $345 186

SC950 **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm,
Tues. $515 / $610 22

SC157 **MTF in Optical and Electro-Optical Systems** *(Ducharme)*
Tues. 8:30 am to 5:30 pm, $555 / $650 31

SC067 **Testing and Evaluation of E-O Imaging Systems** *(Holst)*
Tues. 8:30 am to 5:30 pm, $595 / $690 24

SC194 **Multispectral and Hyperspectral Image Sensors** *(Lomheim)*
Tues. 1:30 to 5:30 pm, $375 / $425 35

SC1071 **Understanding Diffractive Optics** *(Soskind)*
Tues. 1:30 to 5:30 pm, $330 / $380 25
NEW

SC1076 **Analog-to-Digital Converters for Digital ROICs** (Veeder)
Tues. 8:30 am to 12:30 pm, $29 / $345 20
NEW

SC1069 **GPU for Defense Applications** *(Humphrey)* 8:30 am to
Wed. 12:30 pm, $295 / $345 14
NEW

SC789 **Introduction to Optical and Infrared Sensor Systems**
Wed. *(Shaw)* 8:30 am to 5:30 pm, $515 / $610 32

SC206 **Polarized Light: A Practical Hands-on Introduction** *(Fisher)*
Wed. 8:30 am to 5:30 pm, $515 / $610 16

SC1031 **Radar Micro-Doppler Signatures - Principles and**
Wed. **Applications** *(Chen, Tahmoush)* 8:30 am to 12:30 pm,
$295 / $345 15

SC967 **High Dynamic Range Imaging: Sensors and**
Wed. **Architectures** *(Darmont)* 1:30 to 5:30 pm,
NEW $295 / $345 14

SC1000 **Introduction to Infrared and Ultraviolet Imaging**
Wed. **Technology** *(Richards)* 1:30 to 5:30 pm, $330 / $380 22

SC1070 **Radar Waveforms and Signal Processing** *(Welstead)*
Thurs. 8:30 am to 12:30 pm, $295 / $345 14
NEW

SC901 **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm,
Thurs. $515 / $610 35

SC946 **Super Resolution in Imaging Systems** *(Bagheri, Javidi)*
Thurs. 8:30 am to 5:30 pm, $515 / $610 15

SC995 **Target Detection Algorithms for Hyperspectral Imagery**
Thurs. *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610. 34

SC547 **Terahertz Wave Technology and Applications** *(Zhang)*
Thurs. 8:30 am to 12:30 pm, $295 / $345 13

SC154 **Electro-Optical Imaging System Performance** *(Holst)*
Fri. 8:30 am to 5:30 pm, $595 / $690 24

Information Systems and Networks: Processing, Fusion, and Knowledge Generation

SC1072 **Statistics for Imaging and Sensor Data** *(Bajorski)*
Mon. 8:30 am to 5:30 pm, $615 / $710 36
NEW

SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to
Tues. 5:30 pm, $515 / $610 11

SC994 **Multisensor Data Fusion for Object Detection,**
Tues. **Classification and Identification** *(Klein)* 8:30 am to 5:30 pm,
$585 / $680 173

SC901 **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm,
Thurs. $515 / $610 35

Innovative Defense and Security Applications for Displays

SC159 **Head-Mounted Displays: Design and Applications**
Tues. *(Melzer, Browne)* 8:30 am to 5:30 pm, $550 / $645 19

SC1069 **GPU for Defense Applications** *(Humphrey)* 8:30 am to
Wed. 12:30 pm, $295 / $345 14
NEW

SC967 **High Dynamic Range Imaging: Sensors and**
Wed. **Architectures** *(Darmont)* 1:30 to 5:30 pm,
NEW $295 / $345 14

SC1068 **Introduction to Night Vision** *(Browne)* 8:30 am to 12:30 pm,
Thurs. $295 / $345 19
NEW

IR Sensors and Systems

SC152 **Infrared Focal Plane Arrays** *(Dereniak, Hubbs)* 1:30 to
Mon. 5:30 pm, $295 / $345 23

SC278 **Infrared Detectors** *(Dereniak)* 8:30 am to 12:30 pm,
Mon. $410 / $460 23

SC713 **Engineering Approach to Imaging System Design** *(Holst)*
Mon. 8:30 am to 5:30 pm, $565 / $660 24

SC835 **Infrared Systems - Technology & Design** *(Daniels)*
Mon.-Tues. 8:30 am to 5:30 pm, $1035 / $1255 20

SC900 **Uncooled Thermal Imaging Detectors and Systems**
Mon. *(Hanson)* 8:30 am to 5:30 pm, $555 / $650. 21

SC1073 **Radiometry and its Practical Applications** *(Grant)*
Mon. 8:30 am to 5:30 pm, $590 / $685 28
NEW

SC1077 **Introduction to Optical Oceanography** *(Hou)*
Mon. 1:30 to 5:30 pm, $295 / $345 31
NEW

SC720 **Cost-Conscious Tolerancing of Optical Systems**
Tues. *(Youngworth)* 8:30 am to 12:30 pm, $295 / $345 31

SC950 **Infrared Imaging Radiometry** *(Richards)*
Tues. 8:30 am to 5:30 pm, $515 / $610 22

SC067 **Testing and Evaluation of E-O Imaging Systems** *(Holst)*
Tues. 8:30 am to 5:30 pm, $595 / $690 24

SC194 **Multispectral and Hyperspectral Image Sensors**
Tues. *(Lomheim)* 1:30 to 5:30 pm, $375 / $425 35

Laser Sensors and Systems

Optical and Optomechanical Engineering

Sensing for Industry, Environment, and Health

Sensor Data and Information Exploitation

SC160 Mon. **Precision Stabilized Pointing and Tracking Systems** *(Hilkert)* 8:30 am to 5:30 pm, $515 / $610 33

SC1072 Mon. NEW **Statistics for Imaging and Sensor Data** *(Bajorski)* 8:30 am to 5:30 pm, $615 / $710 36

SC994 Tues. **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 / $680 173

SC194 Tues. **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 to 5:30 pm, $375 / $425 35

SC1076 Tues. NEW **Analog-to-Digital Converters for Digital ROICs** (Veeder) 8:30 am to 12:30 pm, $29 / $345 20

SC158 Wed. **Fundamentals of Automatic Target Recognition** *(Sadjadi)* 8:30 am to 5:30 pm, $515 / $610 33

SC181 Wed. **Predicting Target Acquisition Performance of Electro-Optical Imagers** *(Vollmerhausen)* 8:30 am to 5:30 pm, $570 / $665 34

SC1031 Wed. **Radar Micro-Doppler Signatures - Principles and Applications** *(Chen, Tahmoush)* 8:30 am to 12:30 pm, $295 / $345 15

SC1035 Thurs. **Military Laser Safety** *(Marshall)* 8:30 am to 5:30 pm, $515 / $610 27

SC1070 Thurs. NEW **Radar Waveforms and Signal Processing** *(Welstead)* 8:30 am to 12:30 pm, $295 / $345 14

SC901 Thurs. **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm, $515 / $610 35

SC995 Thurs. **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610 34

Signal, Image, and Neural Net Processing

SC066 Mon. **Fundamentals of Electronic Image Processing** *(Weeks)* 8:30 am to 5:30 pm, $585 / $680 35

SC1072 Mon. NEW **Statistics for Imaging and Sensor Data** *(Bajorski)* 8:30 am to 5:30 pm, $615 / $710 36

SC952 Tues. **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610 11

SC994 Tues. **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 / $680 173

SC1076 Tues. NEW **Analog-to-Digital Converters for Digital ROICs** (Veeder) 8:30 am to 12:30 pm, $29 / $345 20

SC1070 Thurs. NEW **Radar Waveforms and Signal Processing** *(Welstead)* 8:30 am to 12:30 pm, $295 / $345 14

SC901 Thurs. **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm, $515 / $610 35

SC946 Thurs. **Super Resolution in Imaging Systems** *(Bagheri, Javidi)* 8:30 am to 5:30 pm, $515 / $610 15

SC995 Thurs. **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 / $610 34

Unmanned, Robotic, and Layered Systems

SC1077 Mon. NEW **Introduction to Optical Oceanography** *(Hou)* 1:30 to 5:30 pm, $295 / $345 31

SC952 Tues. **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 / $610 11

SC996 Tues. **Introduction to GPS Receivers** *(Zhu)* 8:30 am to 12:30 pm, $295 / $345 38

SC993 Wed. **Soil Physics For Non-Soil Engineers: Moisture, Thermal, and Dielectric Soil Properties Affecting IED Detection** *(Hendrickx)* 8:30 am to 5:30 pm, $515 / $610 37

SC1075 Wed. NEW **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 1:30 to 5:30 pm, $295 / $345 13

INDUSTRY WORKSHOPS

Business + Professional Development

WS609 Tues. **Basic Optics for Non-Optics Personnel** *(Harding)* 1:30 to 4:00 pm, $100 / $150 40

WS951 Wed. **Leading Successful Product Innovation** *(Carrano)* 8:30 am to 12:30 pm, $295 / $345 40

WS1074 Wed. NEW **Safely Navigating the Deep Waters of International Trade: Legal Best Practices** *(Scarlott)* 1:30 to 5:30 pm, $295 / $345 38

WS933 Thurs. **Complying with the ITAR: A Case Study** *(Scarlott)* 8:30 am to 12:30 pm, $295 / $345 39

WS846 Thurs. **Essential Skills for Engineering Project Leaders** *(Hinkle)* 1:30 to 5:30 pm, $295 / $345 39

Sign up today

Course fees increase after 6 April 2012

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April

Defense, Homeland Security, and Law Enforcement

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC719 **Chemical & Biological Detection: Overview of Point and Standoff Sensing Technologies** *(Gardner, Popa)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 11	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 11	SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 32	SC1068 **Introduction to Night Vision** *(Browne)* NEW 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 19	
		SC993 **Soil Physics For Non-Soil Engineers: Moisture, Thermal, And Dielectric Soil Properties Affecting IED Detection** *(Hendrickx)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 37	SC1035 **Military Laser Safety** *(Marshall)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 27	
		SC1075 **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* NEW 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 13	SC995 **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 34	
			SC547 **Terahertz Wave Technology and Applications** *(Zhang)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 13	

Emerging Technologies

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
	SC1071 **Understanding Diffractive Optics** *(Soskind)* NEW 1:30 to 5:30 pm, $330 Member / $380 Non-member, p. 25	SC1075 **Methods of Energy Harvesting for Low-Power Sensors** (Erturk) NEW 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 13	SC547 **Terahertz Wave Technology and Applications** *(Zhang)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 13	
	SC1076 **Analog-to-Digital Converters for Digital ROICs** (Veeder) NEW 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 20			

Daily Course Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
23 April	24 April	25 April	26 April	27 April

Imaging and Sensing

SC713 **Engineering Approach to Imaging System Design** *(Holst)* 8:30 am to 5:30 pm, $565 Member / $660 Non-member, p. 24	SC1071 **Understand-ing Diffractive Optics** NEW *(Soskind)* 1:30 to 5:30 pm, $330 Member / $380 Non-member, p. 25	SC1075 Methods of Energy Harvesting for Low-Power Sensors (Erturk) NEW 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 13	SC547 **Terahertz Wave Technology and Applications** *(Zhang)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 13	SC154 **Electro-Optical Imaging System Performance** *(Holst)* 8:30 am to 5:30 pm, $595 Member / $690 Non-member, p. 24
SC1073 **Radiometry and its Practical Applications** NEW *(Grant)* 8:30 am to 5:30 pm, $590 Member / $685 Non-member, p. 28	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 11	SC1069 **GPU for Defense Applications** NEW *(Humphrey)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 14	SC1070 **Radar** NEW **Waveforms and Signal Processing** *(Welstead)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 14	
SC1077: **Introduction to Optical Oceanography** *(Hou)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 31	SC720 **Cost-Conscious Tolerancing of Optical Systems** *(Youngworth)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 31	SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 32	SC901 **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 35	
	SC950 **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 22	SC206 **Polarized Light: A Practical Hands-on Introduction** *(Fisher)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 16	SC946 **Super Resolution in Imaging Systems** *(Bagheri, Javidi)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 15	
	SC157 **MTF in Optical and Electro-Optical Systems** *(Ducharme)* 8:30 am to 5:30 pm, $555 Member / $650 Non-member, p. 31	SC1031 **Radar Micro-Doppler Signatures - Principles and Applications** *(Chen, Tahmoush)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 15	SC995 **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 34	
	SC067 **Testing and Evaluation of E-O Imaging Systems** *(Holst)* 8:30 am to 5:30 pm, $595 Member / $690 Non-member, p. 24	SC967 **High Dynamic Range Imaging: Sensors and Architectures** NEW *(Darmont)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 14		
	SC194 **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 to 5:30 pm, $375 Member / $425, p. 35	SC1000 **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)* 1:30 to 5:30 pm, $330 Member / $380, p. 22		
	SC1076 **Analog-to-Digital Converters for Digital ROICs** NEW (Veeder) 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 20			

Information Systems and Networks: Processing, Fusion, and Knowledge Generation

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC1072 **Statistics for Imaging and Sensor Data** NEW *(Bajorski)* 8:30 am to 5:30 pm, $615 Member / $710 Non-member, p. 36	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 11		SC901 **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 35	
	SC994 **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 Member / $680 Non-member, p. 18			

Innovative Defense and Security Applications for Displays

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
	SC159 **Head-Mounted Displays: Design and Applications** *(Melzer, Browne)* 8:30 am to 5:30 pm, $550 Member / $645 Non-member, p. 19	SC1069 **GPU for Defense Applications** NEW *(Humphrey)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 14	SC1068 **Introduction to Night Vision** NEW *(Browne)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 19	
		SC967 **High Dynamic Range Imaging: Sensors and Architectures** NEW *(Darmont)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 14		

IR Sensors and Systems

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC713 **Engineering Approach to Imaging System Design** *(Holst)* 8:30 am to 5:30 pm, $565 Member / $660 Non-member, p. 24	SC720 **Cost-Conscious Tolerancing of Optical Systems** *(Youngworth)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 31	SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 32	SC892 **Infrared Search and Track Systems** *(Schwering)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 21	SC154 **Electro-Optical Imaging System Performance** *(Holst)* 8:30 am to 5:30 pm, $595 Member / $690 Non-member, p. 24
SC278 **Infrared Detectors** *(Dereniak)* 8:30 am to 12:30 pm, $410 Member / $460 Non-member, p. 23	SC950 **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 22	SC206 **Polarized Light: A Practical Hands-on Introduction** *(Fisher)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 16	SC1068 **Introduction to Night Vision** NEW *(Browne)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 19	
SC835 **Infrared Systems - Technology & Design** *(Daniels)* 8:30 am to 5:30 pm, $1035 Member / $1255 Non-member, p. 20		SC181 **Predicting Target Acquisition Performance of Electro-Optical Imagers** *(Vollmerhausen)* 8:30 am to 5:30 pm, $570 Member / $665 Non-member, p. 34	SC1035 **Military Laser Safety** *(Marshall)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 27	
SC1073 **Radiometry and its Practical Applications** NEW *(Grant)* 8:30 am to 5:30 pm, $590 Member / $685 Non-member, p. 1083	SC067 **Testing and Evaluation of E-O Imaging Systems** *(Holst)* 8:30 am to 5:30 pm, $595 Member / $690 Non-member, p. 24	SC993 **Soil Physics For Non-Soil Engineers: Moisture, Thermal, And Dielectric Soil Properties Affecting IED Detection** *(Hendrickx)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 37		
SC900 **Uncooled Thermal Imaging Detectors and Systems** *(Hanson)* 8:30 am to 5:30 pm, $555 Member / $650 Non-member, p. 21	SC194 **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 to 5:30 pm, $375 Member / $425 Non-member, p. 35	SC1000 **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)* 1:30 to 5:30 pm, $330 Member / $380 Non-member, p. 22		
SC152 **Infrared Focal Plane Arrays** *(Dereniak, Hubbs)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 23	SC1071 **Understanding Diffractive Optics** NEW *(Soskind)* 1:30 to 5:30 pm, $330 Member / $380 Non-member, p. 25			
SC1077: **Introduction to Optical Oceanography** *(Hou)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 31	SC1076 **Analog-to-Digital Converters for Digital ROICs** NEW (Veeder) 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 20			

Daily Course Schedule

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April

Laser Sensors and Systems

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC1032 **Direct Detection Laser Radar Systems for Imaging Applications** *(Richmond, Cain)* 8:30 am to 5:30 pm, $560 Member / $655 Non-member, p. 26	SC720 **Cost-Conscious Tolerancing of Optical Systems** *(Youngworth)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 31	SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 32	SC997 **High Power Laser Beam Quality** *(Ross)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 26	
SC167 **Introduction to Laser Radar** *(Kamerman)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 27	SC1071 **Understanding Diffractive Optics** NEW *(Soskind)* 1:30 to 5:30 pm, $330 Member / $380 Non-member, p. 25	SC1031 **Radar Micro-Doppler Signatures - Principles and Applications** *(Chen, Tahmoush)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 15	SC1035 **Military Laser Safety** *(Marshall)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 27	
SC160 **Precision Stabilized Pointing and Tracking Systems** *(Hilkert)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 33				

Optical and Optomechanical Engineering

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC010 **Introduction to Optical Alignment Techniques** *(Ruda)* 8:30 am to 5:30 pm, $890 Member / $1110 Non-member, p. 29 (Monday–Tuesday)		SC014 **Introduction to Optomechanical Design** *(Vukobratovich)* 8:30 am to 5:30 pm, $890 Member / $1110 Non-member, p. 29 (Wednesday–Thursday)		
SC156 **Basic Optics for Engineers** *(Ducharme)* 8:30 am to 5:30 pm, $555 Member / $650 Non-member, p. 30	SC720 **Cost-Conscious Tolerancing of Optical Systems** *(Youngworth)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 31	SC254 **Integrated Opto-Mechanical Analysis** *(Genberg, Doyle)* 8:30 am to 5:30 pm, $565 Member / $660 Non-member, p. 30	SC1052 **Optical Systems Engineering** NEW *(Kasunic)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 28	
SC1073 **Radiometry and its Practical Applications** NEW *(Grant)* 8:30 am to 5:30 pm, $590 Member / $685 Non-member, p. 28	SC950 **Infrared Imaging Radiometry** *(Richards)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 22	SC206 **Polarized Light: A Practical Hands-on Introduction** *(Fisher)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 16	SC220 **Optical Alignment Mechanisms** *(Guyer)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 29	
SC1072 **Statistics for Imaging and Sensor Data** NEW *(Bajorski)* 8:30 am to 5:30 pm, $615 Member / $710 Non-member, p. 36	WS609 **Basic Optics for Non-Optics Personnel** *(Harding)* 1:30 to 4:00 pm, $100 Member / $150 Non-member, p. 40	SC1000 **Introduction to Infrared and Ultraviolet Imaging Technology** *(Richards)* 1:30 to 5:30 pm, $330 Member / $380 Non-member, p. 22		
	SC1071 **Understanding Diffractive Optics** NEW *(Soskind)* 1:30 to 5:30 pm, $330 Member / $380 Non-member, p. 25			
	SC157 **MTF in Optical and Electro-Optical Systems** *(Ducharme)* 8:30 am to 5:30 pm, $555 Member / $650 Non-member, p. 31			

Monday	Tuesday	Wednesday	Thursday	Friday
23 April	24 April	25 April	26 April	27 April

Sensing for Industry, Environment, and Health

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC719 **Chemical & Biological Detection: Overview of Point and Standoff Sensing Technologies** *(Gardner, Popa)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 11	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 11	SC789 **Introduction to Optical and Infrared Sensor Systems** *(Shaw)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 32	SC901 **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 35	
SC1077: **Introduction to Optical Oceanography** *(Hou)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 31		SC1075 **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 13 NEW	SC995 **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 34	
			SC547 **Terahertz Wave Technology and Applications** *(Zhang)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 13	

Sensor Data and Information Exploitation

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC1072 **Statistics for Imaging and Sensor Data** *(Bajorski)* 8:30 am to 5:30 pm, $615 Member / $710 Non-member, p. 36 NEW	SC994 **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 Member / $680 Non-member, p. 18	SC158 **Fundamentals of Automatic Target Recognition** *(Sadjadi)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 33	SC1035 **Military Laser Safety** *(Marshall)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 27	
SC160 **Precision Stabilized Pointing and Tracking Systems** *(Hilkert)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 33	SC194 **Multispectral and Hyperspectral Image Sensors** *(Lomheim)* 1:30 to 5:30 pm, $375 Member / $425 Non-member, p. 35	SC181 **Predicting Target Acquisition Performance of Electro-Optical Imagers** *(Vollmerhausen)* 8:30 am to 5:30 pm, $570 Member / $665 Non-member, p. 34	SC1070 **Radar Waveforms and Signal Processing** *(Welstead)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 14 NEW	
	SC1076 **Analog-to-Digital Converters for Digital ROICs** (Veeder) 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 20 NEW	SC1031 **Radar Micro-Doppler Signatures - Principles and Applications** *(Chen, Tahmoush)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 15	SC901 **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 35	
			SC995 **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 Member / $610, p. 34	

Daily Course Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
23 April	24 April	25 April	26 April	27 April

Signal, Image, and Neural Net Processing

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC066 **Fundamentals of Electronic Image Processing** *(Weeks)* 8:30 am to 5:30 pm, $585 Member / $680 Non-member, p. 35	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 11		SC1070 **Radar Waveforms and Signal Processing** *(Welstead)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 14 NEW	
SC1072 **Statistics for Imaging and Sensor Data** *(Bajorski)* 8:30 am to 5:30 pm, $615 Member / $710 Non-member, p. 191 NEW	SC994 **Multisensor Data Fusion for Object Detection, Classification and Identification** *(Klein)* 8:30 am to 5:30 pm, $585 Member / $680 Non-member, p. 18		SC901 **Sensor Array Signal Processing** *(Rao)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 35	
	SC1076 **Analog-to-Digital Converters for Digital ROICs** (Veeder) 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 20 NEW		SC946 **Super Resolution in Imaging Systems** *(Bagheri, Javidi)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 15	
			SC995 **Target Detection Algorithms for Hyperspectral Imagery** *(Nasrabadi)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 34	

Unmanned, Robotic, and Layered Systems

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
SC1077: **Introduction to Optical Oceanography** *(Hou)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 31 NEW	SC952 **Applications of Detection Theory** *(Carrano)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 166	SC993 **Soil Physics For Non-Soil Engineers: Moisture, Thermal, And Dielectric Soil Properties Affecting IED Detection** *(Hendrickx)* 8:30 am to 5:30 pm, $515 Member / $610 Non-member, p. 37		
	SC996 **Introduction to GPS Receivers** *(Zhu)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 38	SC1075 **Methods of Energy Harvesting for Low-Power Sensors** *(Erturk)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 13 NEW		

Business + Professional Development Workshops

Monday 23 April	Tuesday 24 April	Wednesday 25 April	Thursday 26 April	Friday 27 April
	WS609 **Basic Optics for Non-Optics Personnel** *(Harding)* 1:30 to 4:00 pm, $100 Member / $150 Non-member, p. 40	WS951 **Leading Successful Product Innovation** *(Carrano)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 40	WS933 **Complying with the ITAR: A Case Study** *(Scarlott)* 8:30 am to 12:30 pm, $295 Member / $345 Non-member, p. 39	
		WS1074 **Safely Navigating the Deep Waters of International Trade: Legal Best Practices** *(Scarlott)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 38 NEW	WS846 **Essential Skills for Engineering Project Leaders** *(Hinkle)* 1:30 to 5:30 pm, $295 Member / $345 Non-member, p. 39	

Defense, Homeland Security, and Law Enforcement

Chemical & Biological Detection: Overview of Point and Standoff Sensing Technologies

SC719

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Monday 8:30 am to 5:30 pm

This course introduces chemical and biological detection, discrimination & identification techniques which are commonly utilized for military and civil applications. Standoff, (remote) and point detection, discrimination, and identification techniques are introduced with design parameters, performance models, and detection algorithms and sensor/data fusion techniques. A sampling of specific technology applications for chemical point, chemical standoff, biological point, and biological standoff sensing will be described. These technologies include Mass Spectrometry, Ion Mobility Spectrometry, Surface Acoustic Waves, Fiber Optic, Fourier Transform Infrared Spectrometry, Differential Absorption Lidar, Laser-Induced Fluorescence, Surface Plasmon Resonance, Antigen/Antibody Immunoassay, Polymerase Chain Reaction, Laser-Induced Breakdown Spectroscopy, Raman Spectroscopy and Lidar Backscatter systems. The course will include a brief overview of chemical and biological agents of interest and features which may be interrogated by detection systems.

LEARNING OUTCOMES

This course will enable you to:
- list and analyze chemical/biological detection and discrimination techniques
- describe the trade space for point and standoff detection
- estimate spatial, spectral, and temporal variations in chemical/biological media
- formulate fundamental design and performance equations for chemical/biological sensors
- compare mass and mobility techniques for point detection
- compare active and passive techniques for standoff detection

INTENDED AUDIENCE

This course is intended for those interested in the design and development of chemical and biological sensors and algorithms for applications ranging from military to industrial sensing. It is an overview course with a survey of a broad class of sensing and processing techniques. Mathematical models for the various sensors will be presented and discussed; however, this course does not require an in-depth understanding of the mathematical principles to appreciate the technological benefits of the various approaches. Some background in electro-optical and infrared systems is helpful, but not required.

INSTRUCTORS

Patrick Gardner is a Program Manager for Draper Laboratory, Florida Operations where he leads research & development projects for U.S. Special Operations and the Intelligence Community. He received a B.S. from the University of Florida and a M.S. and Ph.D. in Electrical Engineering from the Air Force Institute of Technology. He is a retired Lt. Colonel, U.S. Air Force, with 25 years of combined enlisted and commissioned active-duty service. From 1999-2003 Dr. Gardner was assigned to the U.S. Special Operations Command, MacDill AFB FL as a liaison officer for both the U.S. Air Force and the U.S. Dept. of Energy. In 2003 Dr. Gardner moved to General Dynamics Armament & Technical Products as Chief Scientist for Detection and Countermeasures. He is an adjunct professor for Western Carolina University and is a member of the University of North Carolina Defense Applications Group, a small team charged with addressing technology needs for Special Operations Forces.

Mirela Popa is an Engineering Manager at Chemring Detection Systems, Charlotte NC. With specific expertise in algorithm design and development for chemical and biological detection systems, she manages and has technical decision authority on Standoff Chemical Detection technology developed at Chemring. Previously Dr. Popa worked at FAAC, Inc. in the Simulation industry of flight & vehicles. She received her Ph.D. in Applied Mathematics from University of Colorado at Denver in 2002. Her graduate work in sensitivity analysis of coupled acoustic problems to structural boundary conditions was funded by a grant from the Office of Naval Research.

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Applications of Detection Theory

SC952

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

The fundamental goal of this course is to enable you to assess and explain the performance of sensors, detectors, diagnostics, or any other type of system that is attempting to give, with some level of confidence, a determination of the presence or absence of a “target.” In this case the term “target” may be a wide variety of types (e.g. a biological pathogen or chemical agent; or a physical target of some sort; or even just some electronic signal). We will rigorously cover the theory and mathematics underlying the construction of the “Receiver Operating Characteristic” (ROC) curve, including dichotomous test histograms, false positives, false negatives, sensitivity, specificity, and total accuracy. In addition, we will discuss in depth the theory behind “Decision Tree Analysis” culminating with an in class exercise. Decision tree analysis allows one to “fuse together” multivariate signals (or results) in such a manner as to produce a more accurate outcome than would have been attained with any one signal alone. This course includes two major in class exercises: the first will involve constructing a ROC curve from real data with the associated analysis; the second will involve constructing a complete decision tree including the new (improved) ROC curve. The first exercise will be ~30min in length, and the second will be ~60min.

LEARNING OUTCOMES

This course will enable you to:
- define false positives, false negatives and dichotomous test
- define sensitivity, specificity, limit-of-detection, and response time
- comprehend and analyze a dose-response curve
- construct and analyze a Receiver Operating Characteristic (ROC) curve from raw data
- define Positive Predictive Value (PPV) and Negative Predictive Value (NPV)
- analyze statistical data and predict results
- describe the process and theory underlying decision tree analysis
- construct and analyze a decision tree using real data
- construct a “Spider Chart” from system-level attributes
- interpret sensor performance trade-offs using a ROC curve

INTENDED AUDIENCE

This course designed for scientists, engineers, and researchers that are involved in sensor design and development, particular from the standpoint of complex data analysis. Application areas for which Detection Theory is most relevant includes biological detection, medical diagnostics, radar, multi-spectral imaging, explosives detection and chemical agent detection. A working knowledge of basic freshman-level statistics is useful for this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years' service; his decorations include the "Defense Superior Service Medal" from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007), and is an SPIE Fellow.

COURSE PRICE INCLUDES a free PDF copy of the report, *"Chemical and Biological Sensor Standards Study"* (Principal author, Dr. John C. Carrano.)

Terahertz Wave Technology and Applications

SC547

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

See p. 13 for full course description.

Introduction to Night Vision

SC1068

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

See p. 19 for full course description.

Soil Physics For Non-Soil Engineers: Moisture, Thermal, And Dielectric Soil Properties Affecting IED Detection

SC993

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 37 for full course description.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course level: Introductory
CEU .65 $515 Member Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 34 for full course description.

Methods of Energy Harvesting for Low-Power Sensors

SC1075 **NEW**

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 1:30 to 5:30 pm

See p. 13 for full course description.

Introduction to Optical and Infrared Sensor Systems

SC789

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 32 for full course description.

Military Laser Safety

SC1035

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 27 for full course description.

Emerging Technologies

Methods of Energy Harvesting for Low-Power Sensors

SC1075 **NEW**

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 1:30 to 5:30 pm

This course focuses on the transformation of mechanical energy into low-power electricity with an emphasis on vibration-based energy harvesting. A primary goal is to describe the methods of mechanical energy harvesting to use in low-power sensors. Piezoelectric, electromagnetic, electrostatic and magnetostrictive conversion mechanisms will be discussed along with the use of electroactive polymers. Special focus will be placed on piezoelectric materials due to their substantially large power density and ease of application at different geometric scales. System-level modeling and analysis, power density levels, storage devices, deterministic and random energy harvesting, kinetic energy harvesting, flow energy harvesting from aeroelastic and hydroelastic vibrations, acoustic energy harvesting and nonlinear energy harvesting for frequency bandwidth enhancement will be addressed.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental principles of mechanical energy harvesting from ambient vibrations
- explain the characteristics and relative advantages of different energy harvesting methods
- identify the concept of power density and differentiate the concepts of input power and the power density of an energy harvester
- distinguish between resonant and non-resonant energy harvesting as well as deterministic and random energy harvesting
- compare linear and nonlinear energy harvesting and classify their characteristics to construct the optimal energy harvester given the input energy characteristics
- combine other sources of energy input (e.g., wind or wave energy, kinetic energy in walking) with mechanical energy harvesting devices for multi-physics problems
- distinguish between the characteristics of conventional and unconventional storage components
- become familiar with recent advances and other methods in energy harvesting

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers from industry and academia who wish to learn about the fundamentals and recent advances in low-power energy harvesting. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Alper Erturk is an Assistant Professor of Mechanical Engineering at Georgia Institute of Technology. Over the past five years, he has published more than 70 articles in refereed international journals and conference proceedings on smart materials and dynamical systems, and a book titled Piezoelectric Energy Harvesting. He is an elected member of the ASME Technical Committee on Adaptive Structures and Material Systems and ASME Technical Committee on Vibration and Sound, and a member of ASME, AIAA, IEEE, SPIE, and SEM. Dr. Erturk received his Ph.D. in Engineering Mechanics at Virginia Tech.

Terahertz Wave Technology and Applications

SC547

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

See p. 13 for full course description.

Analog-to-Digital Converters for Digital ROICs

SC1076 **NEW**

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

See p. 20 for full course description.

Understanding Diffractive Optics

SC1071 **NEW**

Course level: Introductory
CEU .35 $330 Member / $380 Non-member USD
Tuesday 1:30 to 5:30 pm

See p. 25 for full course description.

Imaging and Sensing

Terahertz Wave Technology and Applications

SC547

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

A pulsed terahertz (THz) wave with a frequency range from 0.1 THz to 10 THz is called a “T-ray.” T-rays occupy a large portion of the electromagnetic spectrum between the infrared and microwave bands. However, compared to the relatively well-developed science and technology in the microwave, optical, and x-ray frequencies for defense and commercial applications, basic research, new initiatives and advanced technology developments in the THz band are very limited and remain unexplored. However, just as one can use visible light to create a photograph, radio waves to transmit music and speech, microwave radiation (MRI) or X-rays to reveal broken bones, T-ray can be used to create images or communicate information. This course will provide the fundamentals of free-space THz optoelectronics. We will cover the basic concepts of generation, detection, propagation, and applications of the T-rays, and how the up-to-date research results apply to industry. The free-space T-ray optoelectronic detection system, which uses photoconductive antennas or electro-optic crystals, provides diffraction-limited spatial resolution, femtosecond temporal resolution, DC-THz spectral bandwidth and mV/cm field sensitivity. Examples of homeland security and defense related projects will be highlighted.

LEARNING OUTCOMES

This course will enable you to:

- identify the proper optical sources of a THz beam, including femtosecond lasers and cw lasers

- distinguish and select the correct THz emitters, including photoconductive antennae, surface field screening and optical rectification
- appraise two dominant THz detectors: a photoconductive dipole antenna and an electro-optic sensor
- describe a THz system and optimize its performance in spatial and temporal resolutions, bandwidth and dynamic range
- construct a THz imaging setup and discuss the recent developments in 2D imaging and real-time & single-short measurement
- highlight recent advances of THz research and development from the academic and industrial sectors
- summarize state-of-the-art THz applications and predict new opportunities and applications

INTENDED AUDIENCE

This course is designed for researchers in academia and industry, who are interested in the mid-infrared and far-infrared pulsed THz radiation.

INSTRUCTOR

Xi-Cheng Zhang is Director of the University of Rochester Institute of Optics. Previously, he was a Professor and the Acting Head of the Department of Physics, Applied Physics, and Astronomy, a Professor of the Department of Electrical, Computer & System Engineering, Erik Jonsson Chair Professor of Science, and Director of the Center for Terahertz Research at Rensselaer Polytechnic Institute. Since 1982 he has been involved in ultrafast optoelectronics, especially the implementation of unique technical approaches for the generation and detection of THz beams with photonic approaches.

High Dynamic Range Imaging: Sensors and Architectures

SC967 **NEW**

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Wednesday 1:30 to 5:30 pm

This course provides attendees with an intermediate knowledge of high dynamic range image sensors and techniques for industrial and non-industrial applications. The course describes various sensor and pixel architectures to achieve high dynamic range imaging as well as software approaches to make high dynamic range images out of lower dynamic range sensors or image sets. The course follows a mathematic approach to define the amount of information that can be extracted from the image for each of the methods described. Some methods for automatic control of exposure and dynamic range of image sensors and other issues like color and glare will be introduced.

LEARNING OUTCOMES

This course will enable you to:
- describe various approaches to achieve high dynamic range imaging
- predict the behavior of a given sensor or architecture on a scene
- specify the sensor or system requirements for a high dynamic range application
- classify a high dynamic range application into one of several standard types

INTENDED AUDIENCE

This material is intended for anyone who needs to learn more about quantitative side of high dynamic range imaging. Optical engineers, electronic engineers and scientists will find useful information for their next high dynamic range application.

INSTRUCTOR

Arnaud Darmont is owner and CEO of Aphesa, a company founded in 2008 and specialized in image sensor consulting, the EMVA1288 standard and camera benchmarking. He holds a degree in Electronic Engineering from the University of Liège (Belgium). Prior to founding Aphesa, he worked for over 7 years in the field of CMOS image sensors and high dynamic range imaging.

GPU for Defense Applications

SC1069 **NEW**

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 8:30 am to 12:30 pm

This course teaches the basics of utilizing modern programmable graphics processing units (GPUs) for military applications. The modern GPU is a fully programmable parallel programming environment that performs computations an order of magnitude faster than the modern CPU. In this course, we will learn broadly about the architecture of the GPU, the appropriate situations where speedups may be obtained and gain an understanding of the tools and languages that are available for development. Programming is not a part of the curriculum.

We will also discuss the available GPU platforms, with an emphasis on rugged, deployable, and low-power offerings. Lastly, the bulk of the course will center on applications and case studies, with emphasis on applications we have produced, including: real-time image processing for the reduction of atmospheric turbulence, applied accelerated linear algebra, image enhancement via super resolution, computational fluid dynamics, and computational electromagnetics.

LEARNING OUTCOMES

This course will enable you to:
- summarize how a graphics processing unit functions
- describe the architecture of a modern compute-capable GPU
- describe which types of applications can be improved by the GPU, and to what degree
- determine the suitability of your algorithm for the GPU
- purchase a system well suited to your application
- assess the tools and languages available to the GPU programmer
- appreciate the applicability of the GPU to many defense industry applications via case studies

INTENDED AUDIENCE

Scientists, engineers, mathematicians, and management who are evaluating the graphics processing unit as a candidate to reduce computational time or costs. We will cover both large scale (e.g. clusters) and small-scale (e.g. low-power, deployable) applications.

INSTRUCTOR

John Humphrey, Jr. is a member of the Accelerated Computing Solutions group at EM Photonics. He earned his MSEE degree from the University of Delaware studying the acceleration of electromagnetics algorithms using custom hardware platforms. At EM Photonics, he launched a GPU research effort in 2005 with a GPU-based FDTD solver based on OpenGL methods and then later explored working in CUDA. Since then, he has worked on accelerated algorithms in a variety of fields, including linear algebra solvers and computational fluid dynamics engines.

Radar Waveforms and Signal Processing

SC1070 **NEW**

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

This course provides an introduction to the waveforms and signal processing techniques used in modern pulse radars. Emphasis will be on wideband waveforms. Discussion will include the role of both hardware and software in implementing the processing algorithms. Topics include: linear frequency modulated (LFM) waveforms; phase and frequency coded waveforms; pulse compression techniques; point spread function; doppler effects; ambiguity function; range resolution and bandwidth; waveform orthogonality and diversity; multiple-input, multiple-output (MIMO) processing; synthetic wideband techniques; range-doppler imaging. Examples from a high-fidelity simulation will illustrate the results.

LEARNING OUTCOMES

This course will enable you to:

- implement pulse compression techniques for both LFM and coded waveforms
- identify the advantages of stretch processing for LFM waveforms
- characterize waveforms using the point-spread and ambiguity functions
- determine doppler effects and range-doppler coupling
- compute range resolution from bandwidth
- apply waveform orthogonality to a MIMO architecture
- achieve synthetic wideband performance using a sequence of stepped-frequency waveforms
- explain why range-doppler imaging works

INTENDED AUDIENCE

This course is intended for engineers and scientists who are interested in a treatment of radar waveforms and signal processing from the perspective of real-world implementation. Undergraduate training in engineering or science is assumed. A basic acquaintance with the Fourier transform would be helpful.

INSTRUCTOR

Stephen Welstead has been analyzing and supporting the development of major radar systems for over two decades. He has designed and implemented digital signal injection systems for several ground- and sea-based radars. These systems stimulate the radars by providing simulated uncompressed waveform returns representing complex targets and environmental phenomenology. Dr. Welstead holds a Ph.D. in applied mathematics from Purdue University and is currently employed by Dynetics, Inc., in Huntsville, AL, as a Senior Research Analyst. He has taught several short courses and is the author of two technical texts, including one published by SPIE.

Radar Micro-Doppler Signatures - Principles and Applications

SC1031

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 8:30 am to 12:30 pm

This course explains basic principles and applications of the micro-Doppler signatures of radar targets. A micro-Doppler signature is a distinctive characteristic of the intricate frequency modulations generated from each component part of a target and is represented in the joint time and Doppler frequency domain. Micro-Doppler signatures provide unique target features that are complementary to those made available by existing methods.

The primary goals of the course are to describe the radar micro-Doppler effect, the mathematical and dynamic models of targets with various motions and the analysis of micro-Doppler signatures. The course will present current applications of radar micro-Doppler signature analysis to target detection, characterization, and classification. Radar data returned from rigid body motion and non-rigid body motion will be used in the presentation examples as well as simulations. Examples are shown from state-of-the-art radars in both anechoic chambers and realistic environments.

LEARNING OUTCOMES

This course will enable you to:

- describe the motion and Doppler effect resulting from rigid and non-rigid body motion
- determine the Micro-Doppler effect observed by a radar
- describe the radar EM scattering from a body with motion
- perform micro-Doppler processing, estimation, and analysis
- describe Mono-static, bi-static and multi-static micro-Doppler signatures
- evaluate the micro-Doppler of simple rigid body motions like a windmill or the rotating rotor blades of a helicopter
- interpret the micro-Doppler signature of human walking and various other various human motions
- compare and classify the micro-Doppler signatures of humans, vehicles, and animals
- model the multi-static micro-Doppler signature
- perform micro-Doppler signature classification
- explain the role of angle of motion and lookdown angle on micro-Doppler

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to understand the micro-Doppler effect in radar, the analysis of micro-Doppler signature of targets, and the applications of micro-Doppler signature for target recognition, identification, and classification. University professors, graduate students, and industry professionals are likely to benefit from this tutorial. Undergraduate training in engineering or science is assumed.

INSTRUCTORS

Victor Chen is internationally recognized for his work on micro-Doppler signatures and time-frequency analysis. He has published more than 130 papers and articles in books, chapters in books, journals and proceedings including the text “Time-Frequency Transforms for Radar Imaging and Signal Analysis” and the recent new text “Micro-Doppler Effect in Radar - Principles and Applications”. Dr. Chen is a Fellow of the IEEE.

David Tahmoush of the US Army Research Laboratory is contributing work on micro-Doppler signatures and classification analysis as well as example radar data. Dr. Tahmoush has published more than 30 papers and articles, and organizes the Workshop on Dismount Detection and Classification.

Super Resolution in Imaging Systems

SC946

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

This course provides an introduction to the signal processing methods used to increase image resolution. Specifically, it provides attendees with the practical knowledge to estimate the benefits of using super resolution in an imaging system as well as the guidance to select the right super resolution method for a given application.

The course is divided into three parts. In the first part, we describe the fundamental limits to resolution in an imaging system and establish the necessity of using signal processing as a mean to achieve super resolution. In the second part we focus on different super resolution techniques. Specifically, we cover defocus based techniques, zoom based techniques, photometry based techniques and edge enhancement based techniques.

In the third part of the course we provide some real life examples from various imaging fields to establish how the super resolution techniques work. The attendee will therefore benefit from a concise and realistic overview of current signal processing methods for super resolution, and thus be able to make the right decision when it comes to accessing the potential use of super resolution for a specific product development.

LEARNING OUTCOMES

This course will enable you to:

- explain the concept of point-spread function (PSF), modulation transfer function (MTF) and other key imaging functions along with the principles of image processing
- choose the right resolution enhancement method for your application from the range of available technologies in signal processing
- choose the right technology for the right performance/computation cost ratio
- compare the benefits and limitations of each resolution enhancement technology and describe the fundamentals of each method
- describe where signal processing for super resolution is applied today and where it may be applied tomorrow

INTENDED AUDIENCE

This course is intended for scientists, engineers, researchers, physicists, product development managers, directors of engineering, development engineers, or anyone who is interested in increasing resolution of imaging systems. The course helps the students to understand why, when and how to use signal processing to increase resolution in existing imaging systems and/or product lines and new product development programs, in order to decrease production costs, increase optical performance, or simply find new solutions to existing technological problems.

INSTRUCTORS

Saeed Bagheri (PhD) is a Senior Research Staff Member with Philips Research. Formerly, he was at the IBM Thomas J. Watson Research Center in Yorktown Heights, NY. He received his B.S. from Sharif University of Technology in 2004. Later that year he joined Massachusetts Institute of Technology for his graduate studies, where he graduated with two M.S. and a Ph.D. in 2007 majoring in Optics and Optimization. He has several refereed published articles as well as conference papers.

Bahram Javidi (PhD) is Board of Trustees Distinguished Professor at the University of Connecticut. He received his B.S. in Electrical Engineering from George Washington University and his M.S. and Ph.D. in Electrical Engineering from the Pennsylvania State University. Prof. Javidi is fellows of seven professional societies, including IEEE, OSA and SPIE. He has authored more than 720 technical publications, with a citation of over 8950 according to the WEB of Science [h-index=52]. He was awarded the Alexander von Humboldt Prize for senior US scientists. He has received the SPIE Gabor Award and SPIE Technology Achievement award.

Multispectral and Hyperspectral Image Sensors

SC194

Course level: Advanced
CEU .35 $375 Member / $425 Non-member USD
Tuesday 1:30 to 5:30 pm

See p. 35 for full course description.

Understanding Diffractive Optics

SC1071 **NEW**

Course level: Introductory
CEU .35 $330 Member / $380 Non-member USD
Tuesday 1:30 to 5:30 pm

See p. 25 for full course description.

Radiometry and its Practical Applications

SC1073 **NEW**

Course level: Introductory
CEU .65 $590 Member / $685 Non-member USD
Monday 8:30 am to 5:30 pm

See p. 28 for full course description.

Polarized Light: A Practical Hands-on Introduction

SC206

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

Covering introductory and intermediate topics in polarized light, simple explanations, and concepts are the emphasis of this hands-on course. There are demonstrations, and each participant receives two linear polarizers, a circular polarizer, a quarter-wave plate and a half-wave plate. Topics include: linear polarizers, mechanical strains, birefringence, orthogonality, circular polarization, matrices, reflective properties, practical applications, optical activity, and Faraday rotation. The goal of the course is that each participant retains a sound grasp of each concept, and the use of mathematics is kept to a minimum. Attendees learn to appreciate a light beam's "polarization degree of freedom," and how to use polarization-modifying elements to convert a beam's state of polarization from one form to another.

LEARNING OUTCOMES

This course will enable you to:
- understand the different states of pure polarization
- understand how to convert one state of polarization to another
- measure a given beam's state of polarization
- know how the different polarization-modifying elements (HWP, QWP, Faraday rotator, etc.) operate
- apply the proper polarization-modifying element to alter the state or polarization of a polarized beam
- learn how polarization changes upon reflection
- understand the difference between optical activity and Faraday rotation
- appreciate the interference of two orthogonally polarized beams
- appreciate the many practical applications associated with the control of the state of polarization
- specify what polarization element will be suitable for a particular function
- develop a fundamental picture of the meaning of circularly polarized light.

INTENDED AUDIENCE

This presentation is aimed at researchers, engineers, technicians, managers and others who wish to develop an intuitive grasp of polarization concepts.

INSTRUCTOR

Robert Fisher is the owner of RA Fisher Associates, LLC, his firm providing technical training in lasers and in optics, private consulting, and expert legal services. He has been active in laser physics and in nonlinear optics for the last 40 years. He has taught graduate courses at the Univ. of California, Davis, and worked at both Lawrence Livermore National Lab. and Los Alamos National Lab. He is an SPIE Fellow and an OSA Fellow, and was a 3-year member of SPIE's Board of Directors. He has served on the CLEO Conference Nonlinear Optics Subcommittee for 5 years, with two of those years as its chair. He has chaired numerous SPIE conferences. He was the Program Chair of the CLEO 2010 Conference and is General Chair of the CLEO 2012 Conference (now renamed CLEO: Science and Innovations).

MTF in Optical and Electro-Optical Systems

SC157

Course level: Introductory
CEU .65 $555 Member / $650 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 31 for full course description.

Analog-to-Digital Converters for Digital ROICs

SC1076 **NEW**

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

See p. 20 for full course description.

Introduction to Infrared and Ultraviolet Imaging Technology

SC1000

Course level: Introductory
CEU .35 $330 Member / $380 Non-member USD
Wednesday 1:30 to 5:30 pm

See p. 22 for full course description.

Infrared Imaging Radiometry

SC950

Course level: Advanced
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 22 for full course description.

Engineering Approach to Imaging System Design

SC713

Course level: Intermediate
CEU .65 $565 Member / $660 Non-member USD
Monday 8:30 am to 5:30 pm

See p. 24 for full course description.

Testing and Evaluation of E-O Imaging Systems

SC067

Course level: Advanced
CEU .65 $595 Member / $690 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 24 for full course description.

Electro-Optical Imaging System Performance

SC154

Course level: Intermediate
CEU .65 $595 Member / $690 Non-member USD
Friday 8:30 am to 5:30 pm

See p. 24 for full course description.

Cost-Conscious Tolerancing of Optical Systems

SC720

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

See p. 31 for full course description.

Introduction to Optical and Infrared Sensor Systems

SC789

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 32 for full course description.

Introduction to Optical Oceanography

SC1077 **NEW**

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Monday 1:30 to 5:30 pm

See p. 31 for full course description.

Sensor Array Signal Processing

SC901

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 35 for full course description.

Applications of Detection Theory

SC952

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 11 for full course description.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 34 for full course description.

Information Systems and Networks: Processing, Fusion, and Knowledge Generation

Multisensor Data Fusion for Object Detection, Classification and Identification

SC994

Course level: Introductory
CEU .65 $585 Member / $680 Non-member USD
Tuesday 8:30 am to 5:30 pm

This course describes sensor and data fusion methods that improve the probability of correct target detection, classification, and identification. The methods allow the combining of information from collocated or dispersed sensors that utilize similar or different signature-generation phenomenologies. Examples provide insight as to how different phenomenology-based sensors enhance a data fusion system.

After introducing the JDL data fusion and resource management model, sensor and data fusion architectures are described in terms of sensor-level, central-level, and hybrid fusion, and pixel-, feature-, and decision-level fusion. The data fusion algorithm taxonomies that follow provide an introduction to the descriptions of the algorithms and methods utilized for detection, classification, identification, and state estimation and tracking - the Level 1 fusion processes. These algorithms support the higher-level data fusion processes of situation and threat assessment.

Subsequent sections of the course more fully develop the Bayesian, Dempster-Shafer, and voting logic data fusion algorithms. Examples abound throughout the material to illustrate the major techniques being presented. The illustrative problems demonstrate that many of the data fusion methods can be applied to combine information from almost any grouping of sensors as long as they can supply the input data required by the fusion algorithm. Practitioners who want to identify the input quantities or parameters needed to implement data fusion will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify multisensor data fusion principles, algorithms, and architectures for new and existing systems
- describe the advantages of multisensor data fusion for object discrimination and state estimation
- select appropriate sensors for specific sensor and data fusion applications
- identify potential algorithms for target detection, classification, identification, and tracking
- formulate sensor and data fusion approaches for many practical applications
- compare the detection and classification ability of many data fusion algorithms to those available without data fusion
- acquire the skills needed to develop and apply data fusion algorithms to more complex situations

INTENDED AUDIENCE

Engineers, scientists, managers, systems designers, military operations personnel, and other users of multisensor data fusion for target detection, classification, identification, and tracking of airborne, ground-based, and underwater targets will benefit from this course. Undergraduate training in engineering, science, or mathematics is assumed.

INSTRUCTOR

Lawrence Klein specializes in developing multiple sensor systems for tactical and reconnaissance military applications and homeland defense. His interests also include application of sensor and data fusion concepts to intelligent transportation systems. While at Hughes Aircraft Company, Dr. Klein developed missile deployment strategies and sensors for missile guidance. As Chief Scientist at Aerojet ElectroSystems TAMS Division, he was responsible for programs that integrated active and passive millimeter-wave and infrared multispectral sensors in satellites and smart "fire-and-forget" weapons. At Honeywell, he designed passive millimeter-wave midcourse missile guidance systems and millimeter-wave sensors to trigger land mines. In addition to the course text, Dr. Klein has authored Millimeter-Wave and Infrared Multisensor Design and Signal Processing (Artech House, 1997), Sensor Technologies and Data Requirements for ITS (Artech House, 2001), and the Traffic Detector Handbook for the Federal Highway Administration (2006).

COURSE PRICE INCLUDES the text *Sensor and Data Fusion: A Tool for Information Assessment and Decision Making* (SPIE Press, 2004) by Lawrence A. Klein.

Statistics for Imaging and Sensor Data

SC1072 **NEW**

Course level: Introductory
CEU .65 $615 Member / $710 Non-member USD
Monday 8:30 am to 5:30 pm

See p. 36 for full course description.

Sensor Array Signal Processing

SC901

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 35 for full course description.

Applications of Detection Theory

SC952

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 11 for full course description.

Innovative Defense and Security Applications for Displays

Introduction to Night Vision

SC1068

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

Night vision devices have become ubiquitous in both commercial and military environments. From the very high end systems used for aviation, to the low-performance systems sold for outdoorsmen, these devices have changed the way their users operate at night. This course explains the basic principles behind night vision and discusses the different types of night vision devices, both "analog" and "digital". In addition to a survey of night vision devices, we also examine the inner workings of night vision systems and explain them in an easy to understand manner. We will discuss the design of night vision systems, both handheld and head mounted.

Although we will talk briefly about SWIR and thermal devices to differentiate them from night vision devices, this course is primarily aimed at visible and near infra-red (NIR) imagers. Imagery from both night vision cameras as well as thermal imagers will be presented and the differences between them will be compared/contrasted.

LEARNING OUTCOMES

This course will enable you to:

- identify the three basic components of a night vision imager: the sensor, the amplifier and the output component
- specify input optics (objective lenses) and output optics (eyepieces) for both analog and digital night vision devices
- explain the difference between VIS/NIR night vision, SWIR, MWIR and LWIR sensors as well as when each should be chosen
- differentiate the different generations of night vision goggles
- define appropriate light levels for night vision device testing
- describe new digital night vision devices and their advantages and disadvantages
- explain the important attributes of night vision systems and how they should be specified for "best value" performance
- predict night vision performance using NVESD models

INTENDED AUDIENCE

Scientists, engineers, technicians, procurement personnel or managers who wish to learn more about night vision devices. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Michael Browne is the Vice President of Product Development at SA Photonics. He has a Ph.D. in Optical Engineering from the University of Arizona's Optical Sciences Center. Mike has been involved in the design, test and measurement of night vision systems since 1986. At Kaiser Electronics, he led the design of numerous head mounted night vision systems including those for the RAH-66 Comanche helicopter and the USAF NVS program. He leads SA Photonics' efforts in the design and development of person-mounted information systems, including body-worn electronics, head-mounted displays and night vision systems. His current research includes investigations into the design of wide field of view night vision devices, binocular rivalry in head mounted displays, and smear reduction in digital displays.

Head-Mounted Displays: Design and Applications

SC159

Course level: Introductory
CEU .65 $550 Member / $645 Non-member USD
Tuesday 8:30 am to 5:30 pm

Head-mounted displays (HMD) and the military counterpart helmet-mounted displays, are personal information-viewing devices that can provide information in a way that no other display can because the information is always available for viewing. By making the imagery reactive to head and body movements we replicate the way humans view, navigate and explore the world. This unique capability lends itself to applications such as Virtual Reality for creating artificial environments, medical visualization as an aid in surgical procedures, military vehicles for viewing sensor imagery, aircraft simulation and training, and for fixed and rotary wing avionics display applications.

This course covers design fundamentals for head-mounted displays from the user's point of view starting with the basics of human perception, head and neck biomechanics, image sources, optical design and head mounting. We will also discuss the impact of user task requirements and applications on various HMD parameters, as well as a detailed discussion of HMD optical designs (pupil and non-pupil forming, see-through and non-see-through, monocular, biocular and binocular, exit pupil and eye relief).

From there we will delve into various image source technologies, discussing advantages and disadvantages of the various approaches and methods for producing color imagery, with their implications for use in the near-eye presentation of imagery. We will also discuss head/neck anatomy and biomechanics and the implications of HMD weight and center of gravity on crash and ejection safety. Also presented will be guidelines for preventing eye fatigue, neck strain, cybersickness and other adverse physiological effects that have been attributed to poor HMD design. Throughout the course, we will use examples of current HMD systems and hardware to illustrate these issues.

LEARNING OUTCOMES

This course will enable you to:

- define basic components and attributes of head-mounted displays and visually coupled systems
- describe important features and enabling technologies of an HMD and their impact on user performance and acceptance
- identify key user-oriented performance requirements and link their impact on HMD design parameters
- list basic features of the human visual system and biomechanical attributes of the head and neck and the guidelines to follow to prevent fatigue or strain
- identify key tradeoffs for monocular, binocular and biocular systems
- classify current image source technologies and their methods for producing color imagery
- describe methods of producing wide field of view, high resolution HMDs
- evaluate tradeoffs for critical display performance parameters

INTENDED AUDIENCE

This course is intended for managers, engineers and scientists involved in the procurement, evaluation, specification or design of HMDs for air or ground-based applications.

INSTRUCTORS

James Melzer is Manager of Research and Technology at Rockwell Collins Optronics, in Carlsbad, California. He has extensive experience in optical and displays engineering, and is an expert in display design for head-mounted systems, aviation life-support, and user interface. He has authored over 35 technical papers and holds four patents in HMD design. He was recently IPT lead for the US Army's Future Force Warrior and Air Warrior Integrated Headgear Product teams.

Michael Browne is the Vice President of Product Development at SA Photonics in San Francisco, California. He has a Ph.D. in Optical

Engineering from the University of Arizona's Optical Sciences Center. Mike has been involved in the design, test, and measurement of head mounted display systems since 1991. At Kaiser Electronics, Mike led the design of numerous head mounted display and rear-projection display systems, including those for the F-35 Joint Strike Fighter. Mike leads SA Photonics' efforts in the design and development of person-mounted information systems, including body-worn electronics, head-mounted displays and night vision systems. Mike's current research includes investigations into binocular rivalry in head mounted displays, simulator sickness prediction and prevention, and the design of wide field of view night vision systems.

COURSE PRICE INCLUDES the text *Head Mounted Displays: Designing for the User* (republished 2011) by James Melzer and Kirk Moffitt.

High Dynamic Range Imaging: Sensors and Architectures

SC967 NEW

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Wednesday 1:30 to 5:30 pm

See p. 14 for full course description.

GPU for Defense Applications

SC1069 NEW

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 8:30 am to 12:30 pm

See p. 14 for full course description.

Super Resolution in Imaging Systems

SC946

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 15 for full course description.

IR Sensors and Systems

Analog-to-Digital Converters for Digital ROICs

SC1076 NEW

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

This course surveys structure and operation of analog-to-digital converters (ADCs) implemented on digital readout integrated circuits (ROICs) and digital image sensors. Attendees will learn how to evaluate ADC architectures using basic figures of merit for use in different sensor formats. We will cover a wide range of cutting edge architectures and see published examples without delving into transistor level theory. We will survey both academia and industrial ADC architectures. From this survey attendees will discover the industrial design evolution convergence down to a few workhorse architectures and what lessons it imparts to the image sensor community. If you are interested in the digital ROIC revolution or if you ever interface with designers or evaluate digital ROIC proposals, then you will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- identify analog-to-digital architectures used for creating digital ROICs and image sensors
- calculate ADC architecture figures of merit important to image sensors
- evaluate ADC architecture compatibility with image sensor format and requirements
- infer the direction in which state-of-the-art digital image sensors are headed
- name the top ADC architectures used by commercial industry and explain how this knowledge benefits the image sensor industry
- stimulate your own creativity and help you develop new ideas and applications for digital ROICs and digital image sensors

INTENDED AUDIENCE

This course is intended for engineers and physicists with a background in basic electrical theory (electrical stimuli, resistors, capacitors and block diagramming) who wish to learn about analog-to-digital converter architectures and how they are applied to digital ROICs and digital image sensors. An undergraduate degree in science or engineering is assumed, and basic knowledge of electrical engineering will be particularly helpful.

INSTRUCTOR

Kenton Veeder is a ROIC design engineer, systems engineer, and part time detector physicist. He has been in the defense and commercial image sensor field for over 11 years and is the president of Senseeker Engineering Inc. in Santa Barbara, California. He has six patents and several publications, one of which earned the MSS Detectors best paper award in 2006. While working for Raytheon he was awarded recognition as Raytheon's 'Father of the Digital Focal Plane Array' and he and his team were given the company wide 'Excellence In Technology' award. Kenton earned his M.S. in electrical engineering from the Analog-and-Mixed Signal Center at Texas A&M University. Kenton is a member of SPIE and IEEE.

Infrared Systems - Technology & Design

SC835

Course level: Advanced
CEU 1.30 $1035 Member / $1255 Non-member USD
Monday-Tuesday 8:30 am to 5:30 pm

This course covers the range of topics necessary to understand the theoretical principles of modern infrared-technology. It combines numerous engineering disciplines necessary for the development of infrared systems. Practical engineering calculations are highlighted, with examples of trade studies illustrating the interrelationships among the various hardware characteristics.

This course is comprised of four sections:

Section 1: introduces the geometrical optics concepts including image formation, stops and pupils, thick lenses and lens combinations, image quality, and the properties of infrared materials.

Section 2: covers the essentials of radiometry necessary for the quantitative understanding of infrared signatures and flux transfer. These concepts are then developed and applied to flux-transfer calculations for blackbody, graybody, and selective radiator sources. Remote temperature calibrations and measurements are then used as an illustration of these radiometric principles.

Section 3: is devoted to fundamental background issues for optical detection-processes. It compares the characteristics of cooled and uncooled detectors with an emphasis on spectral and blackbody responsivity, detectivity (D*), as well as the noise mechanisms related to optical detection. The detector parameters and capabilities of single detectors and third generation focal plane arrays (FPAs) are analyzed. With this acquired background, Section 4 considers the systems-design aspects of infrared imagers. The impact of scan format on signal-to-noise ratio is described, and the engineering tradeoffs inherent in the development of infrared search and track (IRST) systems are explained. Figures of merit such as MTF, NETD, and MRTD of staring arrays are examined for the performance metrics of thermal sensitivity and spatial resolution of thermal imaging systems (TIS). Contrast threshold functions based on Johnson and visible cycles (often denoted as N- and V-cycles) are specified. The interrelationships among the design parameters are identified through trade-study examples.

LEARNING OUTCOMES

This course will enable you to:
- learn the principles and fundamentals of infrared optical design
- choose the proper infrared materials suite for your applications
- quickly execute flux-transfer calculations
- calibrate infrared sources and target signatures
- recognize the importance of background in thermal signatures
- have an appreciation for the capacity of infrared systems and learn the interaction of its critical components (optics, detectors, and electronics) in the production of a final infrared image
- assess the influence of noise mechanisms related to optical detection
- comprehend the fundamental response mechanisms and differences between cooled and uncooled single detectors as well as focal plane arrays (FPAs)
- comprehend the central theory behind third generation infrared imagers
- define and use common descriptors for detector and system performance (R, D*, NEP, NEI, MTF, NETD, and MRTD)
- estimate system performance given subsystem and component specifications
- apply design tradeoffs in both infrared search and track systems (IRST) and thermal-imaging systems (TIS)
- carry out the preliminary design of infrared systems for different thermal applications

INTENDED AUDIENCE

This course is directed to the practicing engineers and/or scientists who require both theoretical and effective practical technical information to design, build, and/or test infrared systems in a wide variety of thermal applications. A background at the bachelor's level in engineering is highly recommended. The participant should also have ample understanding of Fourier analysis and random processes.

INSTRUCTOR

Arnold Daniels is a senior lead engineer with extensive experience in the conceptual definition of advance infrared, optical, and electro-optical systems. His background consists of technical contributions to applications for infrared search & track, thermal imaging, and ISR systems. Other technical expertise include infrared radiometry (testing and measurements), infrared test systems (i.e., MTF, NETD, and MRTD), thermographic nondestructive testing (TNDT), optical design, precision optical alignment, stray light analysis, adaptive optics, Fourier analysis, image processing, and data acquisition systems. He earned an M.S. in Electrical Engineering from the University of Tel-Aviv and a doctorate in Electro-Optics from the School of Optics (CREOL) at the University of Central Florida. In 1995 he received the Rudolf Kingslake medal and prize for the most noteworthy original paper to appear in SPIE's Journal of Optical Engineering. He is presently developing direct energy laser weapon systems for defense applications.

COURSE PRICE INCLUDES the *Field Guide to Infrared Systems, Detectors, and FPAs, 2nd Edition* by Arnold Daniels (SPIE, 2010) and *Infrared Detectors and Systems* (Wiley, 1996) by Eustace L. Dereniak and Glenn D. Boreman.

Infrared Search and Track Systems

SC892

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

This short course provides an overview of the role that Infrared Search and Track systems (IRST) can provide in the protection of military and non-military platforms. All system aspects will be discussed, including the definition of the threat and associated scenarios, requirements, target signatures, background- and atmospheric effects, sources of false alarm, sensor design, signal processing algorithms, range performance, test and evaluation, situational awareness, sensor fusion. The applications include the defense of compounds, vehicles, helicopters, planes and ships as they are used in peace keeping and peace-enforcing operations. The threat includes small arms weapons, rocket propelled grenades, missiles, unmanned aerial vehicles, small surface targets, operating in complex, such as littoral, environments. The course provides quantitative analysis of target, background and atmospheric effects on IRSTs, and comparisons of different kinds of test measurement data.

LEARNING OUTCOMES

This course will enable you to:
- describe the relationship between the various system design aspects of IRST systems and the performance requirements
- know how to design a modern IRST sensor for a given set of requirements for a specific application
- make trade-offs between and optimize the choice of the various sensor parameters for minimum false alarm rate and maximum signal to clutter ratio
- have knowledge of how to test and evaluate IRST sensors and system concepts with realistic threats in a realistic environment

INTENDED AUDIENCE

Scientists, engineers, technicians, users and managers involved in the defense of military platforms. Undergraduate level of knowledge on physics, optics, electronics and signal processing is recommended.

INSTRUCTOR

Piet Schwering is senior scientist in the electro-optics department of TNO Defense, Security and Safety (Netherlands). He has 25 years of experience in infrared sensors for various applications and has been active in the development and testing of IRST systems for more than 20 years, and is well experienced in associated field trials on land and at sea. He has participated and chaired NATO Task Groups and participated in EDA joint projects. In the last decade he has presented numerous papers on IRST related topics with emphasis on system concepts, backgrounds, and signal processing. At present he is leading the TNO program for the development of electro-optics techniques for the next generation IRST.

Uncooled Thermal Imaging Detectors and Systems

SC900

Course level: Intermediate
CEU .65 $555 Member / $650 Non-member USD
Monday 8:30 am to 5:30 pm

The success of uncooled infrared imaging in commercial and military markets has greatly increased the number of participants in the field, and, consequently, the variety of products available and in development. The intent of this course is to provide attendees a broad view of the field as well as an in-depth look at important technologies. The course describes the fundamentals of uncooled IR imaging arrays, emphasizing resistive bolometric and ferroelectric/pyroelectric detectors, but also including a number of innovative technologies such as thermally activated cantilevers, thin films with temperature-dependent optical transmission properties, and thermal-capacitive detectors. Students will learn the fundamentals of uncooled IR sensors, how the various technologies operate, the merits and deficiencies of the different technologies, quantitative metrics for evaluating and comparing performance, and how key factors influence those metrics. The course also explores the limits of performance of uncooled IR imaging, as well as trends to be expected in future products.

LEARNING OUTCOMES

This course will enable you to:
- describe the operation of uncooled IR detectors and basic readout circuits
- evaluate performance in terms of responsivity, noise, noise equivalent temperature difference, minimum resolvable temperature, and response time
- gauge the fundamental limits to their performance, including temperature-fluctuation noise and background fluctuation noise
- compare theory with measured performance of the uncooled arrays
- evaluate practical issues and limitations of current technology
- ascertain the state of development of new IR technologies by asking the right questions
- differentiate well-developed concepts from ill-conceived notional concepts
- identify the uncooled IR technology best suited to your needs
- assess the performance potential of novel IR imaging technologies
- evaluate quantitatively the performance of a wide variety of uncooled IR detectors
- summarize construction details from the technical literature.

INTENDED AUDIENCE

This material is intended for engineers, scientists, and managers who need a background knowledge of uncooled IR technologies, for those who need to be able to evaluate those technologies for usefulness in particular applications, and for those working in the field who wish to deepen their knowledge and understanding. Anyone concerned with current and future directions in thermal imaging or involved in the development of IR detector technology or advanced uncooled IR system concepts will find this course valuable. The course has a significant mathematical content designed to illustrate the origin of the principles involved, but knowledge of the mathematics is not required to understand the concepts and results.

INSTRUCTOR

Charles Hanson has a Ph.D. in theoretical solid-state physics and, after retiring as CTO of L-3 Infrared Products, is an independent consultant in the fields of electro-optics and thermal imaging, with particular specialty in uncooled thermal imaging. He has held government and industrial positions in infrared imaging for more than 40 years. He is a past chairman of Military Sensing Symposia (MSS) Passive Sensors and is presently a member of the SPIE Infrared Technology and Applications program committee.

COURSE PRICE INCLUDES the text *Uncooled Thermal Imaging Arrays, Systems, and Applications* (SPIE Press, 2001) by Paul Kruse.

Infrared Imaging Radiometry

SC950

Course level: Advanced
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

This course will enable the user to understand how an infrared camera system can be calibrated to measure radiance and/or temperature and how the digital data is converted into radiometric data. The user will learn how to perform their own external, “by hand” calibrations on a science-grade infrared camera system using area or cavity blackbodies and an Excel spreadsheet provided by the instructor. The influences of lenses, ND and bandpass filters, windows, emissivity, reflections and atmospheric absorption on the system calibration will be covered. The instructor will use software to illustrate these concepts and will show how to measure emissivity using an infrared camera and how to predict system performance outside the calibration range.

LEARNING OUTCOMES

This course will enable you to:
- classify the measurement units of radiometry and thermography
- describe infrared camera transfer functions - electrical signal output versus radiance signal input
- determine which cameras, lenses and both cold and warm filters to select for your application
- assess effects of ND filters and bandpass filters on calibrations, and calculate which ND warm filter you need for a given temperature range of target
- perform radiometric calibration of camera systems using cavity and area blackbodies
- convert raw data to radiometric data, and convert radiometric data to temperatures
- measure target emissivity and calibrate emissivity into the system
- gauge and account for reflections and atmospheric effects on measurements

INTENDED AUDIENCE

This material is intended for engineers, scientists, graduate students and range technicians that are working with science-grade infrared cameras in the lab, on military test ranges, or similar situations.

INSTRUCTOR

Austin Richards is a senior research scientist at FLIR Commercial Vision Systems in Santa Barbara, and has specialized in scientific applications of infrared imaging technology for over 9 years. He holds a Ph.D. in astrophysics from UC Berkeley and is the author of the SPIE monograph *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology*.

Introduction to Infrared and Ultraviolet Imaging Technology

SC1000

Course level: Introductory
CEU .35 $330 Member / $380 Non-member USD
Wednesday 1:30 to 5:30 pm

The words infrared and ultraviolet are coming into much more widespread use, as ideas about the technology penetrates the public’s awareness and becomes part of popular culture through TV and film. In industry and academia, applications for infrared and ultraviolet cameras are multiplying rapidly, because both of the continued reduction in system cost as the technology penetrates the commercial marketplace, and the forward march of technology. At the same time, there is a fairly limited body of information about applications for these cameras. This is because camera manufacturers tend focus on the products themselves, not applications, and because most textbooks on IR and UV technology are outdated and tend to emphasize the basics of radiometry and detection by single detectors, not imaging applications.

This course gives a non-technical overview of commercial infrared and ultraviolet camera systems, the “taxonomy” of infrared and ultraviolet wavebands, and the wide variety of applications for these wavebands. The course relies heavily on interesting imagery captured by the presenter over the last ten years and uses a SPIE monograph written by the author as a supplementary textbook.

LEARNING OUTCOMES

This course will enable you to:
- identify the different wavebands of the infrared and ultraviolet spectrum and describe their differences
- gain familiarity with the different types of cameras, sensors and optics used for imaging in the infrared and ultraviolet wavebands
- describe some of the key imaging applications for different wavebands of the infrared and ultraviolet

INTENDED AUDIENCE

The course is suitable both for technology professionals and non-technical persons that are new to infrared and ultraviolet imaging and want a very basic, qualitative overview of the fields with minimal mathematics. Little to no mathematic background is required.

INSTRUCTOR

Austin Richards is a senior research scientist at FLIR Systems in Santa Barbara, CA. He holds a PhD in Astrophysics from UC Berkeley, and has worked in the commercial infrared industry for over 10 years. He is also the CTO of Oculus Photonics, a small company devoted to near-ultraviolet imaging systems manufacturing, sales and support. Richards is the author of the SPIE monograph *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* and an adjunct professor at the Brooks Institute of Photography in Santa Barbara.

COURSE PRICE INCLUDES the text *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology* (SPIE Press, 2001) by Austin A. Richards.

Infrared Focal Plane Arrays

SC152

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Monday 1:30 to 5:30 pm

The course presents a fundamental understanding of two-dimensional arrays applied to detecting the infrared spectrum. The physics and electronics associated with 2-D infrared detection are stressed with special emphasis on the hybrid architecture unique to two-dimensional infrared arrays.

LEARNING OUTCOMES

This course will enable you to:
- develop the building blocks of 2-D arrays
- explain charge transfer concepts of various architectures
- describe various input electronics circuits
- discuss testing techniques used in the IR for 2-D arrays
- provide an overview of current technologies
- demonstrate aliasing effects
- review room temperature arrays
- discuss dual band arrays

INTENDED AUDIENCE

This material is intended for engineers, scientists and project managers who need to learn more about two-dimensional IR arrays from a user's point of view. It gives the student insight into the optical detection process, as well as what is available to application engineers, advantages, characteristics and performance.

INSTRUCTORS

Eustace Dereniak is a Professor of Optical Sciences and Electrical and Computer Engineering at the University of Arizona, Tucson, AZ. His research interests are in the areas of detectors for optical radiation, imaging spectrometers and imaging polarimeters instrument development. Dereniak is a co-author of several textbooks and has authored book chapters. His publications also include over 100 authored or co-authored refereed articles. He spent many years in industrial research with Raytheon, Rockwell International, and Ball Brothers Research Corporation. He has taught extensively and is a Fellow of the SPIE and OSA, and a member of the Board of Directors of SPIE.

John Hubbs is an engineer with Ball Aerospace and Technologies.

Predicting Target Acquisition Performance of Electro-Optical Imagers

SC181

Course level: Advanced
CEU .65 $570 Member / $665 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 34 for full course description.

Multispectral and Hyperspectral Image Sensors

SC194

Course level: Advanced
CEU .35 $375 Member / $425 Non-member USD
Tuesday 1:30 to 5:30 pm

See p. 35 for full course description.

Infrared Detectors

SC278

Course level: Introductory
CEU .35 $410 Member / $460 Non-member USD
Monday 8:30 am to 12:30 pm

This course will provide a broad and useful background on optical detectors, both photon and thermal, with a special emphasis placed on the infrared detectors. Discussion of optical detection will be stressed. The fundamentals of responsivity (RI), noise equivalent power (NEPI) and specific detectivity (D*) will be discussed. These figures of merit will be extended to photon noise limited performance and Johnson noise limitations (RA product). Discussion of optical detector fundamentals will be stressed. To aid the attendee in selecting the proper detector choice, the detailed behavior of the more important IR detector materials will be described in detail. Newer technologies such as quantum well infrared photodetectors and blocked impurity bands as well as IR detectors will be covered briefly.

LEARNING OUTCOMES

This course will enable you to:
- understand optical radiation detection processes
- explain noise mechanisms related to optical detectors
- derive figures of merit for optical detectors
- compare BLIP condition to RA product performance
- evaluate and discuss HgCdTe detectors' unique features
- understand why room temperature thermal detectors are so important
- derive the wavelength dependence of detectors

INTENDED AUDIENCE

This class is directed at people who need to learn more about optical detectors from a user point of view. It will give the student insight into the optical detection process as well as what is available to application engineers, advantages, shortcomings, and pitfalls.

INSTRUCTOR

Eustace Dereniak is a Professor of Optical Sciences and Electrical and Computer Engineering at the Univ. of Arizona, Tucson, Arizona. His research interests are in the areas of detectors for optical radiation, imaging spectrometers and imaging polarimeters instrument development. Dereniak is a co-author of several textbooks and has authored book chapters. His publications also include over 100 authored or co-authored refereed articles. He spent many years in industrial research with Raytheon, Rockwell International, and Ball Brothers Research Corporation. He has taught extensively and is a Fellow of the SPIE and OSA, and a member of the Board of Directors of SPIE.

COURSE PRICE INCLUDES the text *Infrared Detectors and Systems* (Wiley, 1996) by E. L. Dereniak and G. D. Boreman.

Engineering Approach to Imaging System Design

SC713

Course level: Intermediate
CEU .65 $565 Member / $660 Non-member USD
Monday 8:30 am to 5:30 pm

This course discusses the three popular approaches to electro-optical imaging system design: spatial resolution, sensitivity (signal-to-noise ratio), and modulation transfer function (MTF) analysis. While often evaluated individually, all three must be considered to optimize system design. Usually, the dominant MTFs in machine vision devices are image motion (including random vibration of the sensor), optics (including aberrations), and the detector. For man-in-the-loop operation, the display and the eye are of concern and, in many situations, these limit the overall system performance.

Equally important, but often neglected is sampling; an inherent feature of all electronic imaging systems. Sampling, which creates blocky images are particularly bothersome with periodic targets such as test targets and bar codes. An engineering approach is taken. This course will provide numerous practical design examples (case studies) to illustrate the interplay between subsystem MTFs, resolution, sensitivity, and sampling.

LEARNING OUTCOMES

This course will enable you to:

- use approximations; often called ‘rules-of-thumb,’ or ‘back-of-the-envelope’ analysis
- identify the subsystem components that affect resolution and sensitivity
- determine if your system is resolution or sensitivity limited
- equivalently determine if your system is detector-limited or optics-limited
- determine which subsystem limits system performance and why
- understand sampling artifacts (Nyquist frequency limit, aliasing, Moiré patterns, and variations in object edge location and width)
- use MTFs, resolution, sensitivity, and sampling concepts for system optimization
- understand the trade-off between MTF and aliasing

INTENDED AUDIENCE

The course is for managers, system designers, test engineers, machine vision specialists, and camera users who want the best performance from their systems. It is helpful if the students are familiar with linear system theory (MTF analysis).

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference *Infrared Imaging Systems: Design, Analysis, Modeling and Testing* since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and IEEE and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Holst’s Practical Guide to Electro-Optical Systems* (JCD Publishing, 2003) by Gerald C. Holst.

Testing and Evaluation of E-O Imaging Systems

SC067

Course level: Advanced
CEU .65 $595 Member / $690 Non-member USD
Tuesday 8:30 am to 5:30 pm

This course describes all the quantitative and qualitative metrics that are used to characterize imaging system performance. While this course highlights thermal imaging systems, the concepts are generic and can be applied to all imaging systems (CCDs, intensified CCDs, CMOS, and near IR cameras). Data analysis techniques are independent of the sensor selected (i.e., wavelength independent). The difference lies in the input variable name (watts, lumens, or delta-T) and the output variable name (volts, lumens, or observer response). Slightly different test methodologies are used for visible and thermal imaging systems. Performance parameters discussed include resolution, responsivity, aperiodic transfer function, slit response function, random noise, uniformity, fixed pattern noise, modulation transfer function (MTF), contrast transfer function (CTF), minimum resolvable temperature (MRT), and the minimum resolvable contrast (MRC). The eye’s spatial and temporal integration allows perception of images whose signal-to-noise ratio (SNR) is less than unity. Since all imaging system spatially sample the scene, sampling artifacts occur in all imagery and therefore affects all measurements. Sampling can significantly affect MRT and MTF tests. Low SNR and sampling effects are interactively demonstrated. This course describes the most common testing techniques. Equally important is identifying those parameters that adversely affect results.

LEARNING OUTCOMES

This course will enable you to:

- write concise test procedures with unambiguous system specifications
- identify all appropriate test parameters
- describe the radiometric relationship between delta-T and spectral radiance
- differentiate between observer variability and system response during MRC and MRT testing
- describe the difference between the CTF and the MTF
- learn about the latest MTF measurement techniques
- discern the difference between poor system performance, peculiarities of the system under test, and measurement errors
- assess how sampling affects test results
- appreciate the benefits and short comings of fully automated testing
- identify parameters that can lead to poor results.
- learn about evolving standardized testing concepts

INTENDED AUDIENCE

The course is for managers, specification writers, and test engineers involved with all phases of imaging system characterization ranging from satisfying customer requirements to ensuring that specifications are unambiguous and testable.

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference Infrared Imaging Systems: Design, Analysis, Modeling and Testing since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Testing and Evaluation of Infrared Imaging Systems, Third Edition* (SPIE Press and JCD Publishing, 2008) by Gerald C. Holst.

Electro-Optical Imaging System Performance

SC154

Course level: Intermediate
CEU .65 $595 Member / $690 Non-member USD
Friday 8:30 am to 5:30 pm

While this course highlights thermal imaging systems, the concepts are generic and can be applied to all imaging systems (CCDs, intensified CCDs, CMOS, and near IR cameras). System analysis could be performed in the spatial domain. However, it is far easier to work in the frequency domain using MTFs. Subsystem MTFs are combined for overall system analysis. This is often called image chain modeling. Although the math is sometimes complex, the equations are graphed for easy understanding. With the Sept 2002 models (e.g., NVTherm), the minimum resolvable temperature (MRT) and minimum resolvable contrast (MRC) are coupled with the target signature and atmospheric transmittance to provide range performance predictions (target acquisition modeling). Three ranges are predicted: detection, recognition, and identification (often shorten to DRI). DRI ranges depend upon the subsystem MTFs, noise (primarily random and fixed pattern noise), the display, and the eye's response. The two-dimensional (fictitious) spatial frequency approach, three-dimensional noise model, and target discrimination metrics (Johnson's N50) are applied to performance predictions. The 2007 models (e.g., NVThermIP) employ contrast rather than MRT (MRC) for target acquisition and use V50 as a discrimination metric. Limitations and applications of NVTherm and NVThermIP are discussed with a brief demonstration of the models. Selection and optimization of a specific sensor depends upon a myriad of radiometric, spectral, and spatial parameters (e.g., target signature, atmospheric conditions, optics f-number, field-of-view, and detector responsivity). MTFs and their effect on imagery are interactively demonstrated. Spatial sampling is present in all cameras. Super-resolution reconstruction and microscan minimize sampling artifacts. Several optimization examples are discussed (case study examples).

LEARNING OUTCOMES

This course will enable you to:

- use the correct MTFs for image chain analysis
- describe the radiometric relationship between delta-T and spectral radiance
- compare the differences among scanning, staring, and microscan staring array performance
- recognize the limitations of back-of-the-envelope approximations such as resolution and sensitivity
- identify the subsystem (e.g., motion, optics, detector, electronics, and display) that limits performance
- appreciate limitations of range performance predictions (target acquisition predictions)
- determine if mid-wave (MWIR) or long-wave (LWIR) infrared is appropriate for your application
- appreciate the value of graphs rather than a table of numbers
- be conversant with the myriad of technological terms
- become a smart buyer, analyst, and/or user of imaging systems

INTENDED AUDIENCE

This course is intended for engineers, managers, and buyers who want to understand the wealth of information available from imaging system end-to-end analysis. It is helpful if the students are familiar with linear system theory (MTF analysis).

INSTRUCTOR

Gerald Holst is an independent consultant for imaging system analysis and testing. He was a technical liaison to NATO, research scientist for DoD, and a member of the Lockheed-Martin senior technical staff. Dr. Holst has chaired the SPIE conference Infrared Imaging Systems: Design, Analysis, Modeling and Testing since 1989. He is author of over 30 journal articles and 6 books (published by SPIE and/or JCD Publishing). Dr. Holst is a member of OSA and is a SPIE Fellow.

COURSE PRICE INCLUDES the text *Electro-Optical Imaging System Performance, Fifth Edition* (SPIE Press and JCD Publishing, 2008) by Gerald C. Holst.

Introduction to Night Vision

SC1068

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

See p. 19 for full course description.

Introduction to Optical and Infrared Sensor Systems

SC789

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 32 for full course description.

Soil Physics For Non-Soil Engineers: Moisture, Thermal, And Dielectric Soil Properties Affecting IED Detection

SC993

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 37 for full course description.

Cost-Conscious Tolerancing of Optical Systems

SC720

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

See p. 31 for full course description.

Understanding Diffractive Optics

SC1071 **NEW**

Course level: Introductory
CEU .35 $330 Member / $380 Non-member USD
Tuesday 1:30 to 5:30 pm

The first portion of the course will cover the fundamental principles of diffraction phenomena. Qualitative explanation of diffraction by the use of field distributions and graphs will provide the basis for understanding the fundamental relations and the important trends. Attendees will also learn the important terminology employed in the field of diffractive optics.

Next, the instructor will provide a comprehensive overview of the main types of diffractive optical components, including phase plates, diffraction gratings, binary optics, diffractive kinoforms, holographic optical elements, and photonic crystals. Finally, based on practical examples provided by the instructor, attendees will learn how modern optical and photonics instrumentation can benefit from incorporating diffractive optical components.

LEARNING OUTCOMES

This course will enable you to:

- acquire the fundamentals of diffraction, Fresnel and Fraunhofer diffraction, the Talbot effect, apodization, diffraction by multiple apertures, and superresolution phenomena
- become familiar with terminology in the field of diffractive optics,
- gain an overview of the main fabrication techniques
- describe the operational principles of the major types of diffractive optical components in the scalar and the resonant domains, diffraction efficiency, and the blazing condition
- get an overview of the various functions performed by diffractive optics components in optical systems
- compare the benefits and limitations of diffractive components

INTENDED AUDIENCE

This material is intended for engineers, scientists, college students, and photonics enthusiasts who would like to broaden their knowledge and understanding of diffractive optics, as well as to learn the numerous practical applications of diffractive optical components in modern optical instruments.

INSTRUCTOR

Yakov Soskind is the Principal Systems Engineer with DHPC Technologies in Woodbridge, NJ. He has been involved in optical systems' design and development for over 30 years. Dr. Soskind has been awarded more than 20 domestic and international patents, and has authored and co-authored several publications. His Field Guide to Diffractive Optics was recently published by SPIE Press (2011).

COURSE PRICE INCLUDES the *Field Guide to Diffractive Optics*, FG21 (SPIE Press, 2011) by Yakov Soskind.

Radiometry and its Practical Applications

SC1073 **NEW**

Course level: Introductory
CEU .65 $590 Member / $685 Non-member USD
Monday 8:30 am to 5:30 pm

See p. 28 for full course description.

Polarized Light: A Practical Hands-on Introduction

SC206

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 16 for full course description.

Military Laser Safety

SC1035

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 27 for full course description.

Laser Sensors and Systems

High Power Laser Beam Quality

SC997

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

This course covers definitions and applications of common measures of beam quality, including Brightness, Power-in-the-bucket, M^2, 'times diffraction limited', Strehl ratio, beam parameter product etc. Special emphasis will be given to choosing an appropriate beam quality metric, tracing the metric to the application of the laser system, and to various conceptual pitfalls which arise in this field. This course is especially applicable to novel lasers that may not have Gaussian modes, especially high energy lasers or unstable resonators. Material presented will come from general scientific literature as well as original work done by Dr. Sean Ross and Dr. William Latham, both from the Air Force Research Laboratory Directed Energy Directorate.

LEARNING OUTCOMES

This course will enable you to:
- convert between common measures of beam quality
- design an appropriate beam quality measure for your own laser application
- evaluate the suitability of commercial, black box beam quality analyzers for your application
- comprehend and take correct ISO 11146 M^2 measurements

INTENDED AUDIENCE

This course should benefit anyone with an interest in laser beam quality, including program managers, scientists and engineers who are not experts in the field.

INSTRUCTOR

T. Sean Ross has been with the Air Force Research Laboratory, Directed Energy Directorate, High Power Solid State Laser Branch since he received his PhD from the Center for Research and Education in Optics and Lasers (CREOL) in 1998. Research interests include nonlinear frequency conversion, high power solid state lasers, thermal management and laser beam quality. Beginning in 2000, frustration with commercial beam quality devices led to the work eventually presented in the Journal of Directed Energy, Vol. 2 No. 1 Summer 2006 "Appropriate Measures and Consistent Standard for High Energy Laser Beam Quality". This paper and its conference version (presented at the 2005 DEPS Symposium) have received awards from the Directed Energy Professional Society and the Directed Energy Directorate.

Radar Micro-Doppler Signatures - Principles and Applications

SC1031

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 8:30 am to 12:30 pm

See p. 15 for full course description.

Direct Detection Laser Radar Systems for Imaging Applications

SC1032

Course level: Advanced
CEU .65 $560 Member / $655 Non-member USD
Monday 8:30 am to 5:30 pm

As laser radar detection and ranging (LADAR) technologies continue to mature, more and more these systems are being applied to military, commercial and scientific applications. From simple time of flight range measurements to high resolution terrain mapping and 3-dimensional imaging, the utility of LADAR is being investigated across a wide range of applications.

In direct detection LADAR the measurements depend solely on the amplitude of the returned signal. This course is designed to teach students the basics of direct detection LADAR and how to transform customer or mission requirements into LADAR system performance specifications. Tools for modeling LADAR systems are introduced through the lecture material that allows quantification of important system performance metrics.

The course begins with the LADAR range equation and how it can be used to evaluate the impact factors such as atmospheric turbulence on LADAR performance. Students are introduced to direct detection LADAR modeling methods which help to explain how various LADAR subsystems affect LADAR range accuracy. A number of representative systems will be introduced as examples throughout the lectures. This course closely follows the included text *Direct Detection LADAR Systems*, SPIE Vol. TT85. The examples and problems presented in the book will be explored more fully during the course.

LEARNING OUTCOMES

This course will enable you to:
- compute the amount of laser power reflected from a target to a LADAR receiver
- calculate the expected signal to noise ratio obtained by a LADAR receiver
- determine the probability of detection and false alarm for different kinds of LADAR receivers
- explain the effects of atmospheric turbulence on LADAR system performance
- compare the performance of different algorithms for extracting range information from LADAR signals
- predict the effects of reflection from different surfaces on the performance of LADAR systems
- explain the functional differences between different types of 3-D LADAR systems.

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about how to evaluate the performance of direct detection laser radar systems and to quantify the impact that various effects have on LADAR performance as well as university professors who wish to offer courses in LADAR. Undergraduate training in engineering or science is assumed.

INSTRUCTORS

Richard Richmond worked in the Electro-Optics Technology Division of the Air Force Research Laboratory prior to his retirement in 2009. He was the Team Leader for Laser Radar Technology in the Multi-function Electro-optics Branch. Mr. Richmond has been the Project Engineer or Program Manager on numerous laser radar development and research efforts. Application areas of the various efforts have included both ground-based and airborne wind sensing, imaging and vibration sensing of hard targets, and remote chemical sensing. He has over 30 years experience in the development and application of laser based remote sensing, and is a Fellow of the MSS.

Stephen Cain is an associate professor of electrical engineering at the Air Force Institute of Technology. He received his B.S.E.E. from the University of Notre Dame in 1992, his M.S.E.E. from Michigan Technological University in 1994 and a Ph.D. in Electrical Engineering from the University of Dayton in 2001. He has served as a Captain in the United States Air Force, a Senior Scientist at Wyle Laboratories and a Senior Engineer at ITT/Aerospace and Communication Division. Dr. Cain has published a number of papers related to LADAR imaging and ranging and teaches a course on LADAR systems at AFIT.

COURSE PRICE INCLUDES the text *Direct Detection LADAR Systems* (SPIE Press, 2010) by Richard Richmond and Stephen Cain.

Introduction to Laser Radar

SC167

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Monday 8:30 am to 12:30 pm

This course explains the principles of operation and the basis of laser radar systems. An analytical approach to the evaluation of system performance is presented. This approach is derived from physical optics and from classical antenna theory. Practical applications for laser radar and alternative system architectures are described. Major system components are identified.

LEARNING OUTCOMES

This course will enable you to:
- identify the major elements of laser radar systems
- list important applications of laser radar
- predict the performance of real or conceptual systems
- estimate the effect of environmental factors on system performance
- formulate system level designs for common applications
- explain the critical issues affecting various classes of laser radars
- compare the laser radar approaches for selected applications

INTENDED AUDIENCE

This material is intended for engineers, managers, scientists, and students to become familiar with laser radar or to evaluate the performance of laser radar systems.

INSTRUCTOR

Gary Kamerman is the Chief Scientist of FastMetrix, Inc. and a Fellow of SPIE. He is the author of Laser Radar in the Infrared and Electro-Optical Handbook and the editor of the SPIE Milestone Series Laser Radar. He has designed, built and field tested laser radars for over 30 years and serves as a technical advisor to the Department of Defense, NASA and major international corporations.

Military Laser Safety

SC1035

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

This course explains the basic hazards associated with the use of lasers commonly encountered by military and law enforcement personnel, with particular emphasis on operation in an outdoor environment. Both laser classification and certification of laser products will be covered. The Department of Defense has an exemption from the Food and Drug Administration that allows manufacturers to produce military specific laser devices not available to the general public. The rules for using the Department of Defense exemption or obtaining a variance to purchase these special purpose products are explained.

LEARNING OUTCOMES

This course will enable you to:
- describe how a laser could cause personal injury to either the eye or skin
- describe how laser exposure limits were developed
- describe visual interference levels
- describe nominal ocular hazard distance and nominal skin hazard distance
- list differences in laser classification according to the:
  - Food and Drug Administration (FDA),
  - International Electrotechnical Commission (IEC), and
  - American National Standards Institute (ANSI)
- describe eye protection specifications for glasses and filters, such as optical density and visual transmission
- classify military applications of lasers, such as range finding, designating targets, dazzling
- manufacture and sell a federally compliant laser product
- learn the origin of the military exemption - 76 EL-01 DOD
- know whether your product meets the criteria for a military specific product
- know what features are required for a military specific product
- purchase a military specific laser product from a manufacturer
- dispose of a military specific laser product that has been manufactured under 76 EL-01 DOD
- evaluate the variance process for making a product not fully in compliance with federal product performance standards
- request evaluation of a system designed for joint military service use

INTENDED AUDIENCE

Engineers, scientists, technicians and managers involved in the development of laser-based defense related products who need to understand the regulatory process for certifying these devices. Military and civilian personnel, involved in operations, range safety, and procurement, who want to understand the safety issues involved with the field use of lasers.

INSTRUCTOR

Wesley Marshall has been involved with military laser safety for 40+ years and has been involved with the development of laser safety standards and military products. He has evaluated hundreds of military specific laser systems for optical hazards, and published over 40 articles in peer reviewed technical journals. He has taught laser safety courses for the US Army, SPIE, Occupational Safety and Health Administration, North Atlantic Treaty Organization, Laser Institute of America, and Rockwell Laser Industries. For over three years, he served as Manager for the Army Institute of Public Health, Laser/Optical Radiation Program (formerly known as CHPPM). He currently writes laser safety calculation software, and consults with DoD, DoD contractors, NASA, and other organizations. He chairs both the SAE G-10T Laser Safety Hazards Subcommittee and the American National Standards Z136 Analysis and Applications Technical Subcommittee, and actively participates in other comittees including the DoD Laser System Safety Working Group.

Precision Stabilized Pointing and Tracking Systems

SC160

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Monday 8:30 am to 5:30 pm

See p. 33 for full course description.

Understanding Diffractive Optics

SC1071

NEW

Course level: Introductory
CEU .35 $330 Member / $380 Non-member USD
Tuesday 1:30 to 5:30 pm

See p. 25 for full course description.

Introduction to Optical and Infrared Sensor Systems

SC789

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 32 for full course description.

Cost-Conscious Tolerancing of Optical Systems

SC720

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

See p. 31 for full course description.

Optical and Optomechanical Engineering

Optical Systems Engineering

SC1052 **NEW**

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

Optical Systems Engineering emphasizes first-order, system-level estimates of optical performance. Building on the basic principles of optical design, this course uses numerous examples to illustrate the systems-engineering processes of requirements analysis, feasibility and trade studies, subsystem interfaces, error budgets, requirements flowdown and allocation, component specifications, and vendor selection. Topics covered will include an introduction to systems engineering, geometrical optics, aberrations and image quality, radiometry, optical sources, detectors and FPAs, optomechanics, and the integration of these topics for developing a complete optical system.

LEARNING OUTCOMES

This course will enable you to:
- utilize the concepts and terminology of systems engineering as applied to optical system development
- calculate geometrical-optics parameters such as image size, image location, FOV, IFOV, and ground-sample distance (GSD)
- distinguish the various types of optical aberrations; estimate blur size and blur-to-pixel ratio, and their effects on MTF, ground-resolved distance (GRD), and image quality
- quantify radiometric performance, using the concepts of optical transmission, f/#, etendue, scattering, and stray light
- compare source types and properties; estimate radiometric performance; develop source-selection tradeoffs and specifications such as output power, irradiance, radiance, uniformity, stability, and SWaP
- compare FPA and detector types and properties; predict SNR performance combining optical, source, and detector parameters; develop detector-selection tradeoffs and specifications such as sensitivity, dynamic range, uniformity, operability, and SWaP (Size, Weight, and Power)
- explain optical component specifications; estimate thermal, structural, and dynamic effects on the performance of an optical system; utilize the results of STOP (structural, thermal, and optical) analysis and error budgets

INTENDED AUDIENCE

Intended for engineers, scientists, technicians, and managers who are developing, specifying, or purchasing optical, electro-optical, and infrared systems. Prerequisites include a familiarity with Snell's law, the lens equation for simple imaging, and the concepts of wavelength and wavefronts.

INSTRUCTOR

Keith Kasunic has more than 20 years experience developing optical, electro-optical, and infrared systems. He holds a Ph.D. in Optical Sciences from the University of Arizona, an MS in Mechanical Engineering from Stanford University, and a BS in Mechanical Engineering from MIT. He has worked for or been a consultant to a number of organizations, including Lockheed Martin, Ball Aerospace, Sandia National Labs, Nortel Networks, and Bookham. He is also an Adjunct Professor and Instructor at Univ. of Central Florida's CREOL - The College of Optics and Photonics, as well as an Affiliate Instructor with Georgia Tech's SENSIAC. This course is based on his textbook Optical Systems Engineering, published by McGraw-Hill in 2011.

Understanding Diffractive Optics

SC1071 **NEW**

Course level: Introductory
CEU .35 $330 Member / $380 Non-member USD
Tuesday 1:30 to 5:30 pm

See p. 25 for full course description.

Statistics for Imaging and Sensor Data

SC1072 **NEW**

Course level: Introductory
CEU .65 $615 Member / $710 Non-member USD
Monday 8:30 am to 5:30 pm

See p. 36 for full course description.

Radiometry and its Practical Applications

SC1073 **NEW**

Course level: Introductory
CEU .65 $590 Member / $685 Non-member USD
Monday 8:30 am to 5:30 pm

The first half of this course presents the basic quantities and units of radiometry and photometry. It describes radiometric laws and approximations including the inverse square and cosine power laws, and introduces the equation of radiative transfer. It provides an overview of optical radiation sources , blackbody radiation laws, and optical material properties including transmission, reflection, absorption, and emission. It surveys photon and thermal optical radiation detectors, instrumentation, and calibration.

The course's second half focuses on practical problem solving. It applies the concepts presented in Part I to calculate the amount of optical radiation reaching a system's entrance aperture or focal plane for a variety of source-receiver combinations. Its applications include problems in some or all of the following areas: solar thermal systems, sun and sky irradiance delivered to a collector, diffuse and specular signals in the thermal infrared, star sensing in the visible, and integrating spheres. It incorporates several examples from the associated text The Art of Radiometry.

LEARNING OUTCOMES

This course will enable you to:
- master the basics of radiometry and photometry and their systems of terminology and units
- master key radiometric laws and approximations

- describe the characterization of optical properties of surfaces, materials, and objects
- gain insight into basic properties of optical detectors and instrumentation
- identify approaches to problem-solving based on source and geometry considerations
- calculate the amount of radiation received from single and multiple sources
- compare point and extended source calibration methods
- qualify the limitations of your solution

INTENDED AUDIENCE

This course is designed for engineers and scientists dealing with electromagnetic radiation who need to quantify this radiation using international standard units and terminology. It is aimed at technologists seeking to gain familiarity with radiometric concepts in order to solve practical problems.

INSTRUCTOR

Barbara Grant is the author of the Field Guide to Radiometry (SPIE Press, 2011) and the co-author, with Jim Palmer, of The Art of Radiometry (SPIE Press, 2009). For more than twenty years she has utilized a systems engineering approach to radiometric problem solving in industries as diverse as aerospace and indoor tanning. She received the MS degree in Optical Sciences from the University of Arizona and two NASA awards for work on the GOES weather satellite imager and sounder. Her previous work for SPIE includes developing and chairing a special session on FLIR image analysis.

COURSE PRICE INCLUDES the text *The Art of Radiometry* (SPIE Press, 2009) by James M. Palmer and Barbara G. Grant.

Introduction to Optomechanical Design

SC014

Course level: Introductory
CEU 1.30 $890 Member / $1110 Non-member USD
Wednesday-Thursday 8:30 am to 5:30 pm

This course will provide the training needed for the optical engineer to work with the mechanical features of optical systems. The emphasis is on providing techniques for rapid estimation of optical system performance. Subject matter includes material properties for optomechanical design, kinematic design, athermalization techniques, window design, lens and mirror mounting.

LEARNING OUTCOMES

This course will enable you to:

- select materials for use in optomechanical systems
- determine the effects of temperature changes on optical systems, and develop design solutions for those effects
- design high performance optical windows
- design low stress mounts for lenses
- select appropriate mounting techniques for mirrors and prisms
- describe different approaches to large and lightweight mirror design

INTENDED AUDIENCE

Engineers who need to solve optomechanical design problems. Optical designers will find that the course will give insight into the mechanical aspects of optical systems. The course will also interest those managing projects involving optomechanics. Short course SC001, Optical System Design: Layout Principles and Practice, or a firm understanding of its content, is required as background to this course.

INSTRUCTOR

Daniel Vukobratovich is a senior principal engineer at Raytheon. He has over 20 years of experience in optomechanics, is a founding member of the SPIE working group in optomechanics, and is fellow of SPIE. He has taught optomechanics in 11 countries, consulted with over 50 companies and written over 50 publications in optomechanics.

Introduction to Optical Alignment Techniques

SC010

Course level: Introductory
CEU 1.30 $890 Member / $1110 Non-member USD
Monday-Tuesday 8:30 am to 5:30 pm

This course discusses the equipment, techniques, tricks, and skills necessary to align optical systems and devices. You learn to identify errors in an optical system, and how to align lens systems.

LEARNING OUTCOMES

This course will enable you to:

- determine if errors in the optical system are due to misalignment errors or other factors such as fabrication, design, or mounting problems
- recognize and understand the fundamental imaging errors associated with optical systems
- diagnose (qualitatively and quantitively) what is wrong with an optical system by simply observing these fundamental imaging errors
- use the variety of tools available for aligning optical systems, and more importantly, how to “tweak” logically the adjustments on these devices so that the alignment proceeds quickly and efficiently
- align basic lens systems and telescopes
- align more complex optical systems such as those containing off-axis aspheric surfaces, and maintain alignment using automatic mounting techniques

INTENDED AUDIENCE

This course is directed toward engineers and technicians needing basic practical information and techniques to achieve alignment of simple optical systems, as well as seemingly more complicated off-axis aspheric mirrors. To benefit most from this course you will need a basic knowledge of the elementary properties of lenses and optical systems (i.e. focal lengths, f/numbers, magnification, and other imaging properties) and a working knowledge of simple interferometry. Some familiarity with the basic aberrations such as spherical aberration, coma, and astigmatism will be helpful.

INSTRUCTOR

Mitchell Ruda Ph.D., is president of Ruda-Cardinal, Inc., an optical engineering consulting firm, located in Tucson, Arizona. He is a fellow of SPIE.

Optical Alignment Mechanisms

SC220

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Thursday 1:30 to 5:30 pm

This is a practical “how to” course dealing with the design and fabrication of precision optical alignment and adjustment devices. The course uses example optical systems to identify typical alignment requirements and provides a catalog of proven adjustment techniques.

LEARNING OUTCOMES

This course will enable you to:

- learn to assess degrees-of-freedom an optical element must have to align it in its system
- define range-of-adjustment vs. resolution-of-adjustment for these mechanisms
- identify appropriate design guidelines and pitfalls
- understand material choices, important tolerances, and mount stability
- determine where to get the hardware made.

INTENDED AUDIENCE

This course is intended to help the mechanical or opto-mechanical design engineer identify and characterize the degrees-of-freedom necessary to align an optical system and to provide him with a catalog of proven configurations. While the course primarily addresses small optics, the concepts apply to larger systems as well. A general knowledge of optics is required; familiarity with optical measurement and mounting techniques is highly recommended.

INSTRUCTOR

Robert Guyer specializes in the design and manufacture of precision opto-mechanical systems - lasers, gimbaled systems, stable optical mounts, and precision mechanisms. He is an SPIE Fellow and an Engineering Fellow at BAE Systems in Nashua, New Hampshire. His 50 years military, space, and commercial opto-mechanical product development experience was gained working at BAE Systems, RCA, GE, Lockheed Martin, and AFAB Group. Mr. Guyer is a registered Professional Engineer and committed Corvette enthusiast.

Integrated Opto-Mechanical Analysis

SC254

Course level: Advanced
CEU .65 $565 Member / $660 Non-member USD
Wednesday 8:30 am to 5:30 pm

This course presents opto-mechanical analysis methods to design, analyze, and optimize the performance of imaging systems subject to environmental influences. Emphasized is the application of finite element techniques to develop efficient and practical models for optical elements and support structures from early design concepts to final production models. Students will learn how to design, analyze, and predict performance of optical systems subject to the influence of gravity, pressure, stress, harmonic, random, transient, and thermal loading. The integration of optical element thermal and structural response quantities into optical design software including ZEMAX and CODEV is also presented that allow optical performance metrics such as wavefront error to be computed as a function of the environment and mechanical design variables. Advanced techniques including the modeling of adaptive optics and design optimization are also discussed. Examples will be drawn from ground-based, airborne, and spaceborne optical systems.

LEARNING OUTCOMES

This course will enable you to:
- efficiently model optical mounts, flexures, and metering structures
- design and analyze optical bonds including structural adhesives and RTV
- predict optical errors and line-of-sight jitter in random environments
- design and analyze vibration isolation systems
- perform thermo-elastic analysis of optical systems
- predict the effects of stress birefringence on optical performance
- develop diagnostic analyses and back-outs for test and assembly induced errors
- effectively model lightweight mirrors
- integrate thermal and structural results into optical models
- predict and represent the distortion of optical surfaces using Zernike polynomials
- model adaptive optics, predict system correctability and system performance
- use numerical optimization techniques to improve designs

INTENDED AUDIENCE

This course is intended for mechanical and optical engineers interested in learning about opto-mechanical analysis techniques and the use of modern software tools including finite element analysis and optical design software to design and analyze optical systems. Working knowledge or familiarity with finite element software and/or optical design software is recommended.

INSTRUCTORS

Victor Genberg has over 40 years' experience in the application of finite element methods to high-performance optical structures and is a recognized expert in opto-mechanics. He is currently President of Sigmadyne, Inc. and a Professor of Mechanical Engineering at the University of Rochestor where he teaches courses in optomechanics, finite element analysis, and design optimization. He has over 40 publications in this field including two chapters in the CRC Handbook of Optomechanical Engineering. Prior to founding Sigmadyne, Dr. Genberg spent 28-years at Eastman Kodak serving as a technical specialist for military and commercial optical systems.

Keith Doyle has over 20 years' experience in the field of optical engineering, specializing in opto-mechanics and the multidisciplinary modeling of optical systems. He has authored or co-authored over 30 publications in this field. He is currently employed at MIT Lincoln Laboratory as a Group Leader in the Engineering Division. Previously he served as Vice President of Sigmadyne Inc. and as a Senior Systems Engineer at Optical Research Associates. He received his Ph.D. in engineering mechanics with a minor in optical sciences from the University of Arizona in 1993.

COURSE PRICE INCLUDES the text *Integrated Optomechanical Analysis* (SPIE Press, 2002) by Keith Doyle, Victor Genberg, and Gregory Michels. The text includes an accompanying CD-ROM with examples.

Basic Optics for Engineers

SC156

Available in **ONLINE format**

Course level: Introductory
CEU .65 $555 Member / $650 Non-member USD
Monday 8:30 am to 5:30 pm

This course introduces each of the following basic areas of optics, from an engineering point of view: geometrical optics, image quality, flux transfer, sources, detectors, and lasers. Basic calculations and concepts are emphasized.

LEARNING OUTCOMES

This course will enable you to:
- compute the following image properties: size, location, fidelity, brightness
- estimate diffraction-limited imaging performance
- explain optical diagrams
- describe the factors that affect flux transfer efficiency, and their quantitative description
- compute the spectral distribution of a source
- describe the difference between photon and thermal detectors
- calculate the signal to noise performance of a sensor (D* and noise equivalent power)
- differentiate between sensitivity and responsivity
- explain the main factors of laser beams: monochromaticity, collimation, and propagation

INTENDED AUDIENCE

This class is intended for engineers, technicians, and managers who need to understand and apply basic optics concepts in their work. The basics in each of the areas are covered, and are intended for those with little or no prior background in optics, or for those who need a fundamental refresher course.

INSTRUCTOR

Alfred Ducharme is a professor of optics and electrical engineering in the College of Engineering and Computer Science at the University of Central Florida. He received a B.S. in Electrical Engineering from the University of Massachusetts - Lowell, and both a M.S. and Ph.D. in Electrical Engineering from the University of Central Florida - School of Optics (CREOL). Dr. Ducharme is the Program Coordinator for the 4-year undergraduate program in Photonics (BSEET-Photonics) offered by the Engineering Technology Department.

COURSE PRICE INCLUDES the text *Basic Electro-Optics for Electrical Engineers* (SPIE Press, 1998) by Glenn D. Boreman.

Polarized Light: A Practical Hands-on Introduction

SC206

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

See p. 16 for full course description.

Cost-Conscious Tolerancing of Optical Systems

SC720

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

The purpose of this course is to present concepts, tools, and methods that will help attendees determine optimal tolerances for optical systems. Detailed topics in the course apply to all volumes of systems being developed - from single systems to millions of units. The importance of tolerancing throughout the design process is discussed in detail, including determining robustness of the specification and design for manufacture and operation. The course also provides a background to effective tolerancing with discussions on variability and relevant applied statistics. Tolerance analysis and assignment with strong methodology and examples are discussed in detail. A short introduction is also provided for useful development and production tools like design of experiments and statistical process control. References and examples are included to help researchers, designers, engineers, and technicians practically apply the concepts to plan, design, engineer, and build high-quality cost-competitive optical systems.

LEARNING OUTCOMES

This course will enable you to:
- define variability and comprehend its impact on nominal systems
- utilize fundamental applied statistics in tolerancing
- construct tolerance analysis budgets
- perform detailed tolerance analysis
- summarize different design of experiment and statistical process control strategies

INTENDED AUDIENCE

This material is intended for managers, engineers, and technical staff involved in product design from concept through manufacturing.

INSTRUCTOR

Richard Youngworth is Founder and Chief Engineer of Riyo LLC, an optical design and engineering firm providing engineering and product development services. His industrial experience spans diverse topics including optical metrology, design, manufacturing, and analysis. Dr. Youngworth has spent significant time working on optical systems in the challenging transition from ideal design to successful volume manufacturing. He is widely considered an expert, due to his research, lectures, publications, and industrial work on the design, producibility, and tolerance analysis of optical components and systems. Dr. Youngworth teaches “Practical Optical System Design” and “Cost-Conscious Tolerancing of Optical Systems” for SPIE. He has a B.S. in electrical engineering from the University of Colorado at Boulder and earned his Ph.D. in optics at the University of Rochester by researching tolerance analysis of optical systems.

MTF in Optical and Electro-Optical Systems

SC157

Course level: Introductory
CEU .65 $555 Member / $650 Non-member USD
Tuesday 8:30 am to 5:30 pm

Modulation transfer function (MTF)is used to specify the image quality achieved by an imaging system. It is useful in analysis of situations where several independent subsystems are combined. This course provides a background in the
application of MTF techniques to performance specification, estimation and characterization of optical and electro-optical systems.

LEARNING OUTCOMES

This course will enable you to:
- list the basic assumptions of linear systems theory, including the concept of spatial frequency
- identify relationship between impulse response, resolution, MTF, OTF, PTF, and CTF
- estimate the MTF for both diffraction-limited and aberration-limited systems
- explain the relationship between MTF, line response, and edge response functions
- identify MTF contributions from finite detector size, crosstalk, charge transfer inefficiency, and electronics
- summarize the effects of noise

INTENDED AUDIENCE

Engineers, scientists, and managers who need to understand and apply the basic concepts of MTF to specifying, estimating, or characterizing performance. Some prior background in Fourier concepts is helpful.

INSTRUCTOR

Alfred Ducharme is a professor of optics and electrical engineering in the College of Engineering and Computer Science at the University of Central Florida. He received a B.S. in Electrical Engineering from the University of Massachusetts-Lowell, and both a M.S. and Ph.D. in Electrical Engineering from the University of Central Florida-School of Optics (CREOL). Dr. Ducharme is the Program Coordinator for the 4-year undergraduate program in Photonics (BSEET-Photonics) offered by the Engineering Technology Department.

COURSE PRICE INCLUDES the text *Modulation Transfer Function in Optical and Electro-Optical Systems* (SPIE Press, 2001) by Glenn D. Boreman.

Introduction to Infrared and Ultraviolet Imaging Technology

SC1000

Course level: Introductory
CEU .35 $330 Member / $380 Non-member USD
Wednesday 1:30 to 5:30 pm

See p. 22 for full course description.

Infrared Imaging Radiometry

SC950

Course level: Advanced
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 22 for full course description.

Basic Optics for Non-Optics Personnel

WS609

Available in **ONLINE format**

Course level: Introductory
CEU .20 $100 Member / $150 Non-member USD
Tuesday 1:30 to 4:00 pm

See p. 40 for full course description.

Sensing for Industry, Environment, and Health

Introduction to Optical Oceanography

SC1077 **NEW**

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Monday 1:30 to 5:30 pm

This course covers basic principles and applications of optical oceanography. The course is aimed to provide background information for those interested in exploring oceanography using optical techniques, including sensing and monitoring via remote sensing (passive and active), as well as traditional in situ sampling approaches. Ocean optics principles including absorption, scattering by both particles and optical turbulence, polarization and impacts on underwater imaging and communication are presented in theory and through examples. Typical sensors and platforms including unmanned underwater vehicles are introduced. Topics associated with data collection, processing, analysis, fusion and assimilation to ocean models are also discussed. This course can also be used as a refresher for recent advances in related areas. Anyone who wants to answer questions such as, "what are the issues oceanographers working on these days (that can benefit from our technology)?", "what does the ocean color tell us?", or "how far can we see in the water?" will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- grasp core concepts and fundamentals of oceanography, including major processes such as mixing and mixed layer depth, upwelling, red tide, currents, waves, euphotic zone, primary production, turbulence, SST, wind, altimetry, boundary layers and resuspention. The background information provided is the key to the understanding and appreciation of ocean sensing techniques and instrumentation developed.
- assess the basic principles and challenges associated with ocean sensing and monitoring with optical methods, including remote sensing and in situ sampling methods
- identify recent advances in sensing platforms including unmanned aerial/ underwater vehicles, and monitoring networks
- gain new understanding of visibility theory from a MTF perspective, which can be easily incorporated to imaging system design and evaluation
- calculate underwater visibility ranges under different turbidity and turbulence conditions

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn how to apply their technology to monitor 70% of the earth surface, to know more about how to quantify visibility, ocean color and other oceanic phenomenon such as currents, waves, temperature, wind and salinity. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Weilin (Will) Hou has been working on research and engineering projects in optical oceanography for the past twenty years, with primary focus on underwater visibility theories and imaging application, in situ and remote sensing of ocean phenomenon. He is currently an oceanographer and the head of the Hydro Optics Sensors and Systems Section at the U. S. Naval Research Laboratory. He earned his PhD in Optical Oceanography at the University of South Florida in 1997. He developed and co-chairs the SPIE Ocean Sensing and Monitoring conference and is the editor of 3 SPIE proceedings. He has 2 patents and numerous publications. He serves as a panel expert on underwater imaging for NATO and defense technology export control.

Terahertz Wave Technology and Applications

SC547

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

See p. 13 for full course description.

Methods of Energy Harvesting for Low-Power Sensors

SC1075 **NEW**

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 1:30 to 5:30 pm

See p. 13 for full course description.

Sensor Array Signal Processing

SC901

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 35 for full course description.

Chemical & Biological Detection: Overview of Point and Standoff Sensing Technologies

SC719

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Monday 8:30 am to 5:30 pm

See p. 11 for full course description.

Applications of Detection Theory

SC952

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 11 for full course description.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 34 for full course description.

Introduction to Optical and Infrared Sensor Systems

SC789

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

This course provides a broad introduction to optical (near UV-visible) and infrared sensor systems, with an emphasis on systems used in defense and security. Topics include both passive imagers and active laser radars (lidar/ladar). We begin with a discussion of radiometry and radiometric calculations to determine how much optical power is captured by a sensor system. We survey atmospheric propagation and phenomenology (absorption, emission, scattering, and turbulence) and explore how these issues affect sensor systems. Finally, we perform signal calculations that consider the source, the atmosphere, and the optical system and detector, to arrive at a signal-to-noise ratio for typical passive and active sensor systems. These principles of optical radiometry, atmospheric propagation, and optical detection are combined in examples of real sensors studied at the block-diagram level. Sensor system examples include passive infrared imagers, polarization imagers, and hyperspectral imaging spectrometers, and active laser radars (lidars or ladars) for sensing distributed or hard targets. The course organization is approximately one third on the radiometric analysis of sensor systems, one third on atmospheric phenomenology and detector parameters, and one third on example calculations and examination of sensor systems at the block-diagram level.

LEARNING OUTCOMES

This course will enable you to:
- understand and use radiometry for describing and calculating the flow of optical energy in an optical or infrared sensor system
- determine the radiometric throughput of sensor systems
- describe atmospheric phenomenology relevant to propagation of optical and infrared radiation
- explain how the atmosphere affects the performance of sensor systems
- use detector parameters with radiometric calculations to predict the signal received by passive and active sensors
- calculate signal-to-noise ratio for typical sensor systems
- understand real-world sensor systems at the block-diagram level
- explain the difference between and important concepts of passive reflection-based and emission-based imaging
- understand the basic operating principles of passive imagers and active laser radar (lidar/ladar) systems for distributed and solid target sensing

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who find themselves working on (or curious about) optical (uv-vis) and infrared sensor systems without formal training in this area. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw has been developing optical remote sensing systems and using them in environmental and military sensing for two decades, first at NOAA and currently as professor of electrical engineering and physics at Montana State University. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization's Vaisala Prize. He earned a Ph.D. in Optical Sciences at the University of Arizona. Dr. Shaw is a Fellow of both the OSA and SPIE.

Sensor Data and Information Exploitation

Statistics for Imaging and Sensor Data

SC1072 NEW

Course level: Introductory
CEU .65 $615 Member / $710 Non-member USD
Monday 8:30 am to 5:30 pm

See p. 36 for full course description.

Fundamentals of Automatic Target Recognition

SC158

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

This course is an overview of ATR systems, architecture, and components. Throughout the course various ATR sensors are discussed including: FLIR, SAR, LIDAR, and others. First, the course describes ATR system architecture. The course provides an overview of various ATR modules: preprocessing, image and signal enhancement, target detection, segmentation, feature extraction, and classifications. The course describes various features extraction techniques and classification methods, ranging from traditional statistical pattern recognition approaches to model-based techniques. The course presents an overview of advanced ATR concepts such as: multi-sensor systems, modeling and phenomenology, adaptive and neural net based methods, and other artificial intelligence techniques are described. Finally, we discuss evaluation techniques of ATR systems.

LEARNING OUTCOMES

This course will enable you to:
- have a broad understanding of ATR systems and technology
- have knowledge of current technology limitations
- describe key research areas and trends

INTENDED AUDIENCE

This course is for engineers entering the field or currently working in ATR, managers and marketing personnel, and program managers.

INSTRUCTOR

Firooz Sadjadi is a senior staff research scientist at Lockheed Martin Corporation where he is engaged in theoretical and experimental research related to Signal and Image Processing, automatic target recognition, target tracking and information fusion. He has served as the Chairman of the annual ATR Conference for the past 20 years. He has authored more than 150 publications, holds 11 US and International Patents and is the author of seven book chapters and editor of several books: Automatic Target Recognition Systems (2000), Sensor and Data Fusion (1996), Performance Evaluations of Signal and Image Processing Systems (1993), and The Physics of Automatic Target Recognition (2007). He received a BSEE from Purdue University in 1972, MSEE in 1974, and DEE in 1976 from the University of Southern California. He is a Fellow of SPIE.

Precision Stabilized Pointing and Tracking Systems

SC160

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Monday 8:30 am to 5:30 pm

This course provides a practical description of the design, analysis, integration, and evaluation processes associated with development of precision stabilization, pointing and tracking systems. Major topics include stabilized platform technology, electro-mechanical system configuration and analysis, and typical pointing and tracking system architectures.

LEARNING OUTCOMES

This course will enable you to:
- acquire the terminology of stabilization, pointing, and tracking systems and understand the common system architectures and operation
- define typical electro-mechanical configurations and key subsystems and components used in precision stabilization and laser pointing systems
- describe the primary systems engineering tradeoffs and decisions that are required to configure and design stabilization, pointing and tracking systems
- distinguish the performance capabilities of specific design configurations

INTENDED AUDIENCE

This material is designed for engineers and managers responsible for design, analysis, development, or test of electro-optical stabilization, pointing and tracking systems or components. A minimum BS degree in an engineering discipline and familiarity with basic control systems is recommended.

INSTRUCTOR

James Hilkert is president of Alpha-Theta Technologies, an engineering consulting firm specializing in precision pointing, tracking and stabilization applications for clients such as Raytheon, General Dynamics, Northrop Grumman, DRS, Atlantic Positioning and the U.S. Navy. Prior to founding Alpha-Theta Technologies in 1994, he spent 20 years at Texas Instruments Defense Systems (now Raytheon) where he designed inertial tracking and pointing systems for a variety of military applications and later managed the Control Systems Technology Center. He received the Dr. Engineering degree from Southern Methodist University and MSME and BSME degrees from Mississippi State University, is a member of ASME, AIAA and SPIE, and lectures on control systems at The University of Texas at Dallas.

Predicting Target Acquisition Performance of Electro-Optical Imagers

SC181

Course level: Advanced
CEU .65 $570 Member / $665 Non-member USD
Wednesday 8:30 am to 5:30 pm

This course describes how to predict and evaluate electro-optical (EO) imager performance. Metrics that quantify imager resolution are described. The detection, recognition, and identification tasks are discussed, and the meaning of acquisition probabilities is explained. The basic theory of operation of thermal imagers, image intensifiers, and video cameras is presented. This course describes how to quantify the resolution and noise characteristics of an EO imager. The theory and analysis of sampled imagers is emphasized. Image quality metrics are described, and the relationship between image quality and target acquisition performance is explained. The course provides a complete overview of how to analyze and evaluate the performance of EO imagers.

LEARNING OUTCOMES

This course will enable you to:
- describe what a target acquisition model does
- describe the operation of thermal sensors, video cameras and other EO imagers
- analyze the impact of sampling on targeting performance
- evaluate the targeting performance of an EO imager

INTENDED AUDIENCE

This course is intended for the design engineer or system analyst who is interested in quantifying the performance of EO imagers. Some background in linear systems analysis is helpful but not mandatory.

INSTRUCTOR

Richard Vollmerhausen recently retired from the Army's Night Vision and Electronic Sensors Directorate. He is currently consulting. Mr. Vollmerhausen is the developer of the current generation of target acquisition models used by the Army.

COURSE PRICE INCLUDES the text *Analysis and Evaluation of Sampled Imaging Systems* (SPIE Press, 2010) by Richard H. Vollmerhausen, Ronald G. Driggers, and Don Reago.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

This course provides a broad introduction to the basic concept of automatic target and object detection and its applications in Hyperspectral Imagery (HSI). The primary goal of this course is to introduce the well known target detection algorithms in hyperspectral imagery. Examples of the classical target detection techniques such as spectral matched filter, subspace matched filter, adaptive matched filter, orthogonal subspace, support vector machine (SVM) and machine learning are reviewed. Construction of invariance subspaces for target and background as well as the use of regularization techniques are presented. Standard atmospheric correction and compensation techniques are reviewed. Anomaly detection techniques for HSI and dual band FLIR imagery are also discussed. Applications of HSI for detection of mines, targets, humans, chemical plumes and anomalies are reviewed.

LEARNING OUTCOMES

This course will enable you to:
- describe the fundamental concepts of target detection algorithms as applied to HSI
- learn the procedure to use the generalized maximum likelihood ratio test to design spectral detectors
- describe the fundamental differences between different detection algorithms based on their model representations
- develop statistical models as well as subspace models for HSI data
- explain the difference between anomaly detection and classification
- distinguish between linear and nonlinear approaches (SVM and Kernel learning techniques)
- develop anomaly detection techniques for different environmental scenarios
- describe linear models and unmixing techniques for abundance measures
- plot ROC curves to evaluate the performance of the algorithms

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about target detection in hyperspectral, multispectral or dual-band FLIR imagery. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Nasser Nasrabadi is a senior research scientist (ST) at US Army Research Laboratory (ARL). He is also an adjunct professor in the Electrical and Computer Engineering Department at the Johns Hopkins University. He is actively engaged in research in image processing, neural networks, automatic target recognition, and video compression and its transmission over high speed networks. He has published over 200 papers in journals and conference proceedings. He has been an associate editor for the IEEE Transactions on Image Processing,IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions for Neural Networks. He is a Fellow of IEEE and SPIE.

Multispectral and Hyperspectral Image Sensors

SC194

Course level: Advanced
CEU .35 $375 Member / $425 Non-member USD
Tuesday 1:30 to 5:30 pm

This course will describe the imaging capabilities and applications of the principal types of multispectral (MS) and hyperspectral (HS) sensors. The focus will be on sensors that work in the visible, near-infrared and shortwave-infrared spectral regimes, but the course will touch on longwave-infrared applications. A summary of the salient features of classical color imaging (human observation) will also be provided in an appendix.

LEARNING OUTCOMES

This course will enable you to:
- understand many of the applications and advantages of multispectral (MS) and hyperspectral (HS) imaging
- describe and categorize the properties of the principal MS / HS design types (multi-band scanner, starers with filter wheels, dispersive, wedge, and Fourier transform imagers with 2D arrays, etc.)
- list and define the relevant radiometric radiometric quantities, concepts and phenomenology
- understand the process of translating system requirements into sensor hardware constraints and specifications
- analyze signal-to-noise ratio, modulation-transfer-function, and spatial / spectral sampling for MS and HS sensors
- define, understand and apply the relevant noise-equivalent figures-of-merit (Noise-equivalent reflectance difference, Noise-equivalent temperature difference, Noise-equivalent spectral radiance, Noise-equivalent irradiance, etc.)
- describe the elements of the image chain from photons-in to bits-out (photon detection, video signal manipulation, analog processing, and digitization)
- list and review key imager subsystem technology elements (optical, focal plane, video electronics, and thermal)
- formulate a detailed end-to-end design example of a satellite imaging scanning HS sensor
- provide an appendix that summarizes color imaging principles and sensor associated elements for human observation applications (e.g. color television, still cameras, etc.)

INTENDED AUDIENCE

Engineers, scientists, and technical managers who are interested in understanding and applying multispectral and hyperspectral sensors in advanced military, civil, scientific and commercial applications.

INSTRUCTOR

Terrence Lomheim holds the position of Distinguished Engineer at The Aerospace Corp. He has 32 years of hardware and analysis experience in visible and infrared electro-optical systems, focal plane technology, and applied optics, and has authored and co-authored 53 publications in these technical areas. He is a Fellow of the SPIE.

COURSE PRICE INCLUDES the text *CMOS/CCD Sensors and Camera Systems, 2nd edition* (SPIE Press, 2011) by Terrence Lomheim and Gerald Holst.

Sensor Array Signal Processing

SC901

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 35 for full course description.

Multisensor Data Fusion for Object Detection, Classification and Identification

SC994

Course level: Introductory
CEU .65 $585 Member / $680 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 18 for full course description.

Radar Waveforms and Signal Processing

SC1070

NEW

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

See p. 14 for full course description.

Radar Micro-Doppler Signatures - Principles and Applications

SC1031

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 8:30 am to 12:30 pm

See p. 15 for full course description.

Analog-to-Digital Converters for Digital ROICs

SC1076

NEW

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

See p. 20 for full course description.

Military Laser Safety

SC1035

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 27 for full course description.

Signal, Image, and Neural Net Processing

Fundamentals of Electronic Image Processing

SC066

Course level: Introductory
CEU .65 $585 Member / $680 Non-member USD
Monday 8:30 am to 5:30 pm

Many disciplines of science and manufacturing acquire and evaluate images on a routine basis. Typically these images must be processed so that important features can be measured or identified This short course introduces the fundamentals of electronic image processing to scientists and engineers who need to know how to manipulate images that have been acquired and stored within a digital computer.

LEARNING OUTCOMES

This course will enable you to:

- understand image storage, acquisition, and digitization
- become familiar with image transforms such as Fourier, Hough, Walsh, Hadamar, Discrete Cosine, and Hotelling
- understand the difference between the types of linear and non-linear filters and when to use each
- learn the difference between types of noise in the degradation of an image
- apply color image processing techniques to enhance key features in color and gray scale images
- recognize image segmentation techniques and how they are used to extract objects from an image
- understand software approaches to image processing
- demonstrate how to use the UCFImage image processing software program included with the course.

INTENDED AUDIENCE

This course will be useful to engineers and scientists who have a need to understand and use image processing techniques, but have no formal training in image processing. It will give the individual insight into a number of complex algorithms as it applies to several different applications of this very interesting and important field.

INSTRUCTOR

Arthur Weeks holds an associate professor position with the Dept. of Electrical and Computer Engineering at the Univ. of Central Florida. He recently left his position as a vice president of corporate technology to continue his research in image processing and bio-medical signal processing. He has published over 30 articles and three books in image processing.

COURSE PRICE INCLUDES the text *Fundamentals of Electronic Image Processing* (SPIE Press, 1996) by Arthur Weeks.

Sensor Array Signal Processing

SC901

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

The capture of data using an array of sensors is common in various wave propagation environments such as electromagnetic, underwater acoustics, ground surveillance, ultrasound and other modes. The processing of such sensor array data in space and time leads to meaningful information or output such as source localization, image reconstruction, range-velocity estimation, target identification etc. A variety of signal processing techniques have been developed since the early 1980s for achieving effective extraction of such information. New signal processing techniques are now being developed to handle emerging applications such as multi-input multi-output (MIMO) radar, millimeter wave imaging and Terahertz imaging. This course will provide an introduction to the principles of sensor array signal processing and its applications in defense and security.

Topics include:

- Sensor array configurations
- Far-field vs. near-field analysis, near-field focusing
- Array resolution and super-resolution
- Beamforming
- Direction finding, source localization and time delay of arrival estimation
- Subspace methods: MUSIC, ESPRIT
- Wideband processing
- Image reconstruction and synthetic aperture techniques
- Sparse sampling and compressive sensing
- Application to underwater acoustic arrays, synthetic aperture radar, phased array and smart antenna systems, target localization

LEARNING OUTCOMES

This course will enable you to:

- describe the various sensor array configurations used in different applications
- identify the types of information provided by signal processing of sensor array data
- determine performance limits of sensor arrays as a function of array configuration, source properties, and the signal processing algorithm
- evaluate relative advantages of the different processing algorithms as a function of the application

INTENDED AUDIENCE

Engineers and scientists with involvement or interest in the processing of sensor array data.

INSTRUCTOR

Raghuveer Rao earned his Ph.D. degree in Electrical Engineering from the University of Connecticut in 1984. He was a Member of the Technical Staff at Advanced Micro Devices Inc. from 1985 to 1987. He joined the Rochester Institute of Technology in 1987 where he is a Professor of Electrical Engineering and Imaging Science. He has also held IPA (Intergovernmental Personnel Act) appointments with the US Naval Surface Warfare Center and the US Air Force Research Laboratory, and visiting appointments with the Indian Institute of Science and Princeton University. Rao has served as an Associated Editor of the IEEE Transactions on Signal Processing and the IEEE Transactions on Circuits and Systems - II, and is currently an Associate Editor for the Journal of Electronic Imaging. He is a recipient of the IEEE Signal Processing Society's Young Author Best Paper Award. He is an elected Fellow of SPIE and a Fellow of the Center for Advanced Defense Studies.

Radar Waveforms and Signal Processing

SC1070 **NEW**

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

See p. 14 for full course description.

Statistics for Imaging and Sensor Data

SC1072 **NEW**

Course level: Introductory
CEU .65 $615 Member / $710 Non-member USD
Monday 8:30 am to 5:30 pm

The purpose of this course is to survey fundamental statistical methods in the context of imaging and sensing applications. You will learn the tools and how to apply them correctly in a given context. The instructor will clarify many misconceptions associated with using statistical methods. The course is full of practical and useful examples of analyses of imaging data. Intuitive and geometric understanding of the introduced concepts will be emphasized. The topics covered include hypothesis testing, confidence intervals, regression methods, and statistical signal processing (and its relationship to linear models). We will also discuss outlier detection, the method of Monte Carlo simulations, and bootstrap.

LEARNING OUTCOMES

This course will enable you to:

- apply the statistical methods suitable for a given context
- demonstrate the statistical significance of your results based on hypothesis testing
- construct confidence intervals for a variety of imaging applications
- fit predictive equations to your imaging data

- construct confidence and prediction intervals for a response variable as a function of predictors
- explain the basics of statistical signal processing and its relationship to linear regression models
- perform correct analysis of outliers in data
- implement the methodology of Monte Carlo simulations

INTENDED AUDIENCE

This course is intended for participants who need to incorporate fundamental statistical methods in their work with imaging data. Participants are expected to have some experience with analyzing data.

INSTRUCTOR

Peter Bajorski is an Associate Professor of Statistics at the Rochester Institute of Technology. He teaches graduate and undergraduate courses in statistics including a course on Multivariate Statistics for Imaging Science. He also designs and teaches short courses in industry, with longer-term follow-up and consulting. He performs research in statistics and in hyperspectral imaging. Dr. Bajorski wrote a book on Statistics for Imaging, Optics, and Photonics. He is a senior member of SPIE and IEEE.

COURSE PRICE INCLUDES the text *Statistics for Imaging, Optics, and Photonics* (Wiley, 2011) by Peter Bajorski.

Analog-to-Digital Converters for Digital ROICs

SC1076 NEW

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

See p. 20 for full course description.

Super Resolution in Imaging Systems

SC946

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 15 for full course description.

Applications of Detection Theory

SC952

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 11 for full course description.

Multisensor Data Fusion for Object Detection, Classification and Identification

SC994

Course level: Introductory
CEU .65 $585 Member / $680 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 18 for full course description.

Target Detection Algorithms for Hyperspectral Imagery

SC995

Course level: Introductory
CEU .65 $515 Member / $610 Non-member USD
Thursday 8:30 am to 5:30 pm

See p. 34 for full course description.

Unmanned, Robotic, and Layered Systems

Soil Physics For Non-Soil Engineers: Moisture, Thermal, And Dielectric Soil Properties Affecting IED Detection

SC993

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Wednesday 8:30 am to 5:30 pm

The course provides an overview of basic soil physics for the determination of moisture, thermal, and dielectric soil properties. The participants will be introduced to soils: their textural composition, location in the landscape, soil classifications. Different methods will be discussed to describe and quantify soil moisture conditions and how these affect soil thermal and dielectric properties. Finally, the course addresses how to judge the effect of soil moisture conditions on the signatures of thermal and radar sensors for IED detection.

LEARNING OUTCOMES

This course will enable you to:
- describe the basic soil physics that determine soil moisture conditions as well as thermal and dielectric soil properties
- identify soil information from readily available soil data bases for the prediction of thermal and dielectric soil properties
- predict soil moisture conditions with the open domain HYDRUS1D code
- combine basic soil information with soil moisture predictions from HYDRUS1D for the assessment of thermal and dielectric soil properties
- judge how different soil moisture conditions affect the signatures of thermal and radar sensors for IED detection

INTENDED AUDIENCE

Engineers, scientists, and military personnel involved in the development and deployment of improved sensors for IED detection. Especially, those who refer to all soils as “dirt” but feel a need to better understand the physics of IED-Sensor-Soil systems. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Jan Hendrickx is Professor of Hydrology in the Department of Earth and Environmental Science of New Mexico Tech. He received his M.S. degree in Civil Engineering and Irrigation from the Agricultural University Wageningen, The Netherlands, and earned his Ph.D. degree in Soil Physics at New Mexico State University. For more than thirty years his research has involved soil moisture dynamics using ground sensors, non-invasive geophysical methods, and satellite remote sensing algorithms as well as analytical and numerical hydrologic models. He and his research group at New Mexico Tech have explored the physics of IED-sensor-soil systems to better understand the effect of the soil environment on IED detection. Dr. Hendrickx has authored or coauthored 100+ refereed papers and book chapters. He served six years as Associate Editor for the Soil Science Society of America Journal. He is Fellow of the Soil Science Society of America and Fulbright Scholar.

Introduction to GPS Receivers

SC996

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Tuesday 8:30 am to 12:30 pm

This course is an introduction to the principles of the Global Positioning System (GPS) and GPS receivers. It includes a brief introduction to GPS and other related Global Satellite Navigation systems and the history of GPS receiver development. The architecture of a typical commercial GPS receiver will be explained, followed by a more detailed comparison of different types of receivers with respect to their performance, cost and special features. The newest technologies in GPS receivers will also be presented. The course will help to answer questions such as "Can I benefit from using GPS?", or "How do I choose the right GPS receiver for my application?"

LEARNING OUTCOMES

This course will enable you to:
- describe the principles of satellite navigation
- learn how GPS receivers work
- decide when and how GPS would help in your application
- compare the cost/benefit of different types of receivers
- choose the right receiver for the application
- combine GPS with other sensors
- know what to expect from future GPS receivers

INTENDED AUDIENCE

Current and potential users of GPS who are using, or may need GPS receivers for:
- Position calculation and surveying
- Surveillance and target tracking
- Precise time keeping
- Airborne, land-based and marine-based vehicle navigation
- Location, installation, initialization and calibration of other sensors

INSTRUCTOR

Zhen Zhu received a Ph. D. in Electrical Engineering from Ohio University, Athens, Ohio. Currently he is a Senior Research Engineer with the Ohio University Avionics Engineering Center and an adjunct assistant professor with the School of Electrical Engineering and Computer Science. He is a member of ION, IEEE and Sigma Xi. His research interests include GPS and augmentation systems, software radio technology, GPS interference and multipath, computer vision and laser based navigation, automatic navigation and guidance. He has also been involved in research of artificial intelligence, neural networks and machine learning.

Methods of Energy Harvesting for Low-Power Sensors

SC1075 NEW

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 1:30 to 5:30 pm

See p. 13 for full course description.

Introduction to Optical Oceanography

SC1077 NEW

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Monday 1:30 to 5:30 pm

See p. 31 for full course description.

Applications of Detection Theory

SC952

Course level: Intermediate
CEU .65 $515 Member / $610 Non-member USD
Tuesday 8:30 am to 5:30 pm

See p. 11 for full course description.

Professional Development Workshops

Business + Professional Development

Safely Navigating the Deep Waters of International Trade: Legal Best Practices

WS1074 NEW

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Wednesday 1:30 to 5:30 pm

If your company's sales activities, products or services come in contact with foreign jurisdictions, this is a must attend program. The stakes have never been higher. Anyone who wants to answer questions such as, "what are the legal pitfalls of doing business internationally?" or "what are best practices for engaging in global trade?" will benefit from taking this course. During this course the following topics will be addressed:
- Primer on international trade laws and regulations, including:
  - Foreign Corrupt Practices Act
  - Export Administration Regulations
  - International Traffic in Arms Regulations
  - Office of Foreign Assets Control Regulations
- Best practices for high tech companies designed to ensure compliance with the full panoply of U.S. international trade laws and regulations
- Protecting your intellectual property internationally, and considerations in establishing operations abroad
- Best practices for contracting with representatives, distributors, and suppliers
- Recent developments

During this fast-paced course you will be provided with cutting edge information designed to assist you in safely and effectively navigating the legal shoals of doing business internationally. Real world situations and lessons learned will be provided, as well as practical tips on best practices.

LEARNING OUTCOMES

This course will enable you to:
- identify various U.S. international trade regimes and how they impact your business
- protect and effectively utilize your intellectual property
- develop the key ingredients of an effective compliance program to deal with the full panoply of U.S. international trade laws and regulations
- enter into more effective and protective legal agreements with foreign parties
- avoid pitfalls and grow your business free of negative legal repercussions

INTENDED AUDIENCE

Owners, executives, scientists, engineers, and technicians that wish to learn how to grow business while effectively and efficiently navigating U.S. international trade laws and regulations. This course expands upon and is complementary to WS933 Complying with the ITAR: A Case Study, and WS1037 Advanced Topics in U.S. International Trade Law. Attendance at WS933 and/or WS1037 is helpful but not a prerequisite.

INSTRUCTOR

Kerry Scarlott is a Director at the law firm of Goulston & Storrs, and is an industry leader in International Trade, Export Controls and Compliance. His practice, based in Boston, MA and Washington, D.C., focuses on business law and international trade law, with particular expertise in assisting technology-based companies. He serves as general outside counsel to companies and entrepreneurs, providing guidance in connection with entity formation, debt and equity financings and private offerings, mergers and acquisitions, day-to-day commercial contract matters, strategic alliances, private label manufacturing, and intellectual property protection and utilization. Kerry has particular expertise in counseling technology-based clients in navigating the Export Administration Regulations (EAR) and the International Traffic in Arms Regulations (ITAR). He lectures and writes regularly on international trade matters, including export compliance, foreign distribution and sale of products, and related topics.

Complying with the ITAR: A Case Study

WS933

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 8:30 am to 12:30 pm

In the world of international trade, it's what you don't know that can hurt you. With the U.S. government's focus on homeland security and its increasing reliance on photonics for the development and production of defense-related products and services, your activities may well be subject to the ITAR.

This workshop will begin with a brief contextual overview of U.S. export controls, including the Export Administration Regulations, the ITAR, and special sanction programs administered by the Treasury Department's Office of Foreign Assets Control. We will then transition into a case study focused on the ITAR. Real world situations and lessons learned will be shared. Various aspects of the case study will likely be familiar to you in the context of your own experiences, allowing you to learn effectively how to spot ITAR issues before they negatively impact your business. You will also learn about current enforcement trends and best practices for avoiding violations.

LEARNING OUTCOMES

This course will enable you to:
- determine at least on a preliminary basis whether your products, services and/or technical data are subject to the ITAR
- know when a deemed export might arise and what to do about it
- communicate effectively with government and private contracting entities, including prime and subprime contractors, in order to know when the ITAR may apply
- determine what type of government license or approval must be obtained in particular circumstances
- implement best practices to handle ITAR-controlled products, services or technical data and avoid negative enforcement outcomes

INTENDED AUDIENCE

Owners, executives, managers and engineers engaged in photonics research, development or manufacturing activities.

INSTRUCTOR

Kerry Scarlott Kerry Scarlott is a Director at the law firm of Goulston & Storrs. With an office in Boston, MA and Washington, D.C., Kerry focuses his practice on business law and international trade law, with particular expertise in assisting technology-based companies. He serves as general outside counsel to companies and entrepreneurs, providing guidance in connection with entity formation, debt and equity financings and private offerings, mergers and acquisitions, day-to-day commercial contract matters, strategic alliances, private label manufacturing, and intellectual property protection and utilization. Kerry has particular expertise in counseling technology-based clients in navigating the Export Administration Regulations (EAR) and the International Traffic in Arms Regulations (ITAR). He lectures and writes regularly on international trade matters, including export compliance, foreign distribution and sale of products, and related topics.

Essential Skills for Engineering Project Leaders

WS846

Course level: Introductory
CEU .35 $295 Member / $345 Non-member USD
Thursday 1:30 to 5:30 pm

This workshop teaches skills needed to lead technical projects, drive innovation, and influence others. Attendees learn the difference between leadership and management, and how to develop specific leadership skills that are important to technical professionals who lead projects or need assistance from others to get things done. Participants engage in exercises that assess their individual leadership abilities and provide guidance for further skill development.

LEARNING OUTCOMES

This course will enable you to:
- become more influential
- improve your ability to effectively lead projects and teams
- identify leadership development goals specific to your individual needs
- get more support for ideas that will benefit your company
- build rapport with your boss and your peers

INTENDED AUDIENCE

This material is intended for early-career technical professionals who can benefit from improving leadership skills. The course is tailored for engineers and other technical professionals through the use of real-world case studies, exercises and examples pertaining to the experiences of individuals and teams involved in technology projects.

INSTRUCTOR

Gary Hinkle is President and founder of Auxilium, Inc. His experience includes a broad variety of management and staff assignments with small, medium, and large companies involved in the development and manufacturing of high-tech products. Gary led several high-profile projects including the development of a U.S. Army vehicle maintenance system, and he directed the development of 9-1-1 systems used in the majority of Public Safety Answering Points in the U.S. He also served as engineering manager for the world's best selling oscilloscope product line at Tektronix. His design and management experience spans the electronics, mechanical and software engineering disciplines.

COURSE PRICE INCLUDES a comprehensive workbook and email/phone follow-up with the instructor after the workshop to assist with implementation.

Leading Successful Product Innovation

WS951

Course level: Intermediate
CEU .35 $295 Member / $345 Non-member USD
Wednesday 8:30 am to 12:30 pm

The fundamental goal of this course is to answer the question: "How do I take an idea off the white-board and turn it into a windfall product?" We will explore and apply the principles of good leadership to create a culture of excellence within your organization-the most basic ingredient for success. A special emphasis will be placed on learning how to develop and construct an effective new project pitch using the instructor's "Disciplined Creativity" concept and framework. We will then describe the "Spiral Development Process" for rapid, effective, and successful prototype development, followed by an in-depth examination of the life-cycle approach to product development. This course will also enable you to conduct a "red teaming" exercise to identify competitive threats, identify weaknesses in your company, and most importantly, develop solution strategies. We will also place an emphasis on how to properly vet an idea and how to ask tough-minded questions designed to ferret out shortcomings.

LEARNING OUTCOMES

This course will enable you to:
- apply the key principles of leadership to create a culture of excellence for your organization
- develop a project "pitch" to champion your idea with venture capitalists, and funding agencies
- construct a "spiral development" process that is executable, manageable, and successful
- identify best practices for the life-cycle approach to product management
- conduct a "red teaming" exercise
- apply the principles of strategic planning to develop a successful technology roadmap
- conduct an "After Action Review" and distill out critical "lessons learned"
- demonstrate how to run an effective meeting
- formulate a "product requirements document"
- demonstrate effective project management skills
- define and list the key elements of "Design for Manufacturing"

INTENDED AUDIENCE

This course designed for R&D managers at all levels. It is also appropriate for other senior department managers with responsibility for aspects of product development (e.g. marketing, manufacturing, business development). Start-up companies, or anyone contemplating starting their own venture will find the material relevant and useful. Scientists and engineers aspiring to management track positions will also benefit from this course.

INSTRUCTOR

John Carrano is President of Carrano Consulting. Previously, he was the Vice President, Research & Development, Corporate Executive Officer, and Chairman of the Scientific Advisory Board for Luminex Corporation, where he led the successful development of several major new products from early conception to market release and FDA clearance. Before joining Luminex, Dr. Carrano was as a Program Manager at DARPA, where he created and led several major programs related to bio/chem sensing, hyperspectral imaging and laser systems. He retired from the military as a Lieutenant Colonel in June 2005 after over 24 years' service; his decorations include the "Defense Superior Service Medal" from the Secretary of Defense. Dr. Carrano is a West Point graduate with a doctorate in Electrical Engineering from the University of Texas at Austin. He has co-authored over 50 scholarly publications and has 3 patents pending. He is the former DSS Symposium Chairman (2006-2007) and is an SPIE Fellow.

Basic Optics for Non-Optics Personnel

WS609

Available in ONLINE format

Course level: Introductory
CEU .20 $100 Member / $150 Non-member USD
Tuesday 1:30 to 4:00 pm

This course will provide the technical manager, sales engineering, marketing staff, or other non-optics personnel with a basic understanding of the terms, specifications, and measurements used in optical technology to facilitate effective communication with optics professionals on a functional level. Topics to be covered include basic concepts such as interference, diffraction, polarization and aberrations, definitions relating to color and optical quality, and an overview of the basic measures of optical performance such as MTF and wavefront error. The material will be presented with a minimal amount of math, rather emphasizing working concepts, definitions, rules of thumb, and visual interpretation of specifications. Specific applications will include defining basic imaging needs such as magnification and depth-of-field, understanding MTF curves and interferograms, and interpreting radiometric terms.

LEARNING OUTCOMES

This course will enable you to:
- read and understand optical system descriptions and papers
- ask the right questions about optical component performance
- describe basic optical specifications for lenses, filters, and other components
- select the right off-the-shelf lenses, filters, and beam directing optics
- interpret optical data such as interferogram, MTF and aberration reports

INTENDED AUDIENCE

This course is intended for the non-optical professional who needs to understand basic optics and interface with optics professionals.

INSTRUCTOR

Kevin Harding has been active in the optics industry for over 30 years, and has taught machine vision and optical methods for over 25 years in over 70 workshops and tutorials, including engineering workshops on machine vision, metrology, NDT, and interferometry used by vendors and system houses to train their own engineers. He has been recognized for his leadership in optics and machine vision by the Society of Manufacturing Engineers, Automated Imaging Association, and Engineering Society of Detroit. Kevin is a Fellow of SPIE and was the 2008 President of the Society.

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