

AL658 - Inertial Navigation Algorithms

Day 1, Morning

Introduction to INS/GPS Integration

- Inertial navigation
- Integration architectures
- Example applications

Vectors, Matrices, and State Space

- Vectors and matrices
- State-space description (Linear Systems)
- Examples

Random Processes

- Random variables
- Covariance matrices
- Bias, random walk, Markov random processes

Afternoon

Filtering

- Filtering principles
- Least squares estimation
- **Computer Demo**

Kalman Filter

- Kalman Filter
- Filter Processing Example
- **Computer Demo**

Kalman Filter

- P,Q,R convergence
- Off-line analysis

Day 2, Morning

Inertial Sensors

- Accelerometer technologies
- Gyroscope technologies
- Technology survey

Inertial Sensor Calibration

- Error models of the sensors
- Calibration techniques
- Allan Variance

MEMS IMU

- MEMS Sensors
- IMU and its functions
- Simplified Error Models
- **Computer Demo**

Afternoon

GPS I

- GPS Overview
- Trilateration
- GPS Signal Structure

GPS II

- Ephemeris and Almanac Data
- Satellite Position Calculation
- GPS Errors

GPS III

- Pseudorange and Delta Range
- User Position calculation
- **Computer Demo**

Day 3, Morning

Navigation Coordinate Systems

- Earth model
- Coordinate systems
- Coordinate system transformations

Attitude Parameterizations

- Quaternions
- Direction Cosines
- Euler Angles

Inertial Navigation Mechanization

- Gravity model
- Rotational and translational motion eqns.
- Navigation equations

Afternoon

Coordinate and Attitude Demo

- **Computer Demo**

Navigation System Errors

- Perturbation error model
- Navigation error dynamics

Alignment Methods

- Static-Transfer alignment
- Simplified error analysis

Day 4, Morning

Loosely-Coupled INS/GPS Design

- Measurement processing
- Filter design and tuning
- Navigation systems update

Tightly coupled INS/GPS Design

- Measurement processing
- Filter parameter selection
- Pseudo-range and delta pseudo-range measurement models

Multi-Sensor Integration

- DR systems/GPS
- AHRS based navigation
- Terrain aiding
- Carrier phase differential integration

Afternoon

Extended Kalman Filter Example

- AHRS Error model
- Measurement processing

EKF Application

- **Computer Demo**

Numerical Considerations

- Keeping a covariance matrix, symmetric, and positive definite
- Sequential measurement processing

Day 5, Morning

Error Budget

- Error Budget Analysis
- Choice of Sensors

An Example Navigation System

- System Structure
- System Functions

An Example Navigation System

- System Functions
- Details

Afternoon

Applications

- MAVs
- Weapon systems
- Automobiles
- Etc.

Discussion Session