OC4325 METOC for Warfighter Decision Making

Distinguished Professor Peter C. Chu

1. Prerequisites

OC/MR 3140 Probability and Statistics for Air-Ocean Sciences is a prerequisite.

2. Course Description

Advanced knowledge of decision analysis with applications to the U.S. Navy's three-tier (environment, performance, and decision) Battlespace on Demand, such as the Naval Ocean Analysis and Prediction (NOAP) systems (environment); acoustic undersea warfare, mine warfare systems (performance); and courses of action, search patterns, asset allocation, and risk quantification (decision). Basic theories include decision criteria (Hurwicz, Laplace insufficient reason, maximax, maximin, and savage minimax regret), decision trees, Bayesian networks, risk analysis, and utility. Applications include mine burial prediction using the Bayesian network, ensemble METOC prediction for decision making, automated optimum track ship routing, and contribution of environmental effects on missile systems. Prerequisite: OC/MR 3140

3. Course Objectives

This course offering is aimed at educating students in developing mathematical models and solution approaches to make optimal decisions in stochastic air-ocean environments. The course will benefit students from METOC, physical oceanography, meteorology, and USW curricula. At the end of this course, students will have learned the art and science of formulating stochastic decision making problems such as Bayesian methods, Markov decision processes, and game theories with application to three tiers of Battle Space on Demand: environmental, performance, and decision layers. Students will have also learned novel techniques to solve these problems.

4. Course Syllabus

Chapter 1 Introduction

1.1. Battle Space on Demand (Three Tiers)
1.2. Value of Information Created by Navy METOC Modeling/Prediction
1.3. METOC in Decision Analysis for Military Operations
1.4. Decision Matrix (or Payoff Matrix

Chapter 2 Review on Probability and Statistics

2.1. What Is Probability?
2.2. Probability and Statistics

2.3. Probability Distribution of Random Variables
2.4. Descriptive Measures of Probability Distribution Functions (PDF)
2.5. Discrete PDF
2.6. Continuous PDF
2.7. PDF from Sampled Data
2.8. Linear Regression

Chapter 3 Basic Theories of Decision Analysis

3.1. Types of Decision Making Environment
3.2. Problem Formulation
3.3. Decision Model
3.4. Payoff Table (Payoff Matrix)
3.5. Decision Making Under Uncertainty
- Hurwicz criterion
- Laplace insufficient reason criterion
- Maximax criterion
- Maximin criterion
- Savage minimax regret criterion

3.6. Decision Making Under Risk
3.7. Expected Opportunity Loss
3.8. Sensitivity Analysis

Chapter 4 Decision Tree Analysis

4.1. Five Steps in Decision Tree Analysis
4.2. Structure of Decision Tree
4.3. Complex Decision Tree

Chapter 5 Naval Ocean Analysis and Prediction

5.1. Overview
5.2. Atmospheric Modeling and Prediction
5.3. Ocean Modeling and Prediction
5.4. Model Uncertainty
5.5. Data Assimilation
5.6. Ensemble (Probabilistic) Prediction
5.7. Reliability of Ensemble Prediction
- Talagrand Diagram
- Reliability Diagram
- Brier Score
- Spread Skill

5.8. Numerical Issues & Principles in Ensemble Prediction
5.9. Modeling in the Performance Layer

Chapter 6 One Player Game (Decision) Theory in METOC

6.1. Games against Nature
6.2. Decision Problem without Risk or Uncertainty
6.3. Principle of Insufficient Reason
6.4. Principle of Expected Utility Maximization
6.5. Eisenhower before D-Day
6.6. Cardinal Payoffs
6.7. Dominance Principle

Chapter 7 Bayesian Decision Theory

7.1. Overview
7.2. Ellsberg Paradox
7.3. Bayesian Estimation: General Theory
7.4. Learning Probabilities
7.5. Bayesian Network
7.6. Application to Mine Burial Prediction
7.7. Application to Weather Forecasting

Chapter 8 Probabilistic METOC Prediction for Decision Making

8.1. METOC Decision Products
8.2. Use of Ensemble for Improving Decisions
8.3. Continuous Ranked Probability Score
8.4. Relative Operating Characteristic (ROC)
8.5. Potential Value Diagrams
8.6. Multi-variate Rank Histogram
8.7. Automated Optimum Track Ship Routing

Course Grade
Lab 30%
Mid-Term 25%
Final Exam 45%

Office Hours:

Educating students is my highest priority.
You may come to my office any time from 7:30 am to 6:30 pm.