Introduction

Mohammad Hadi

mohammad.hadi@sharif.edu

@MohammadHadiDastgerdi

Fall 2022

Overview

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Course Description

Statistical Optical Communication

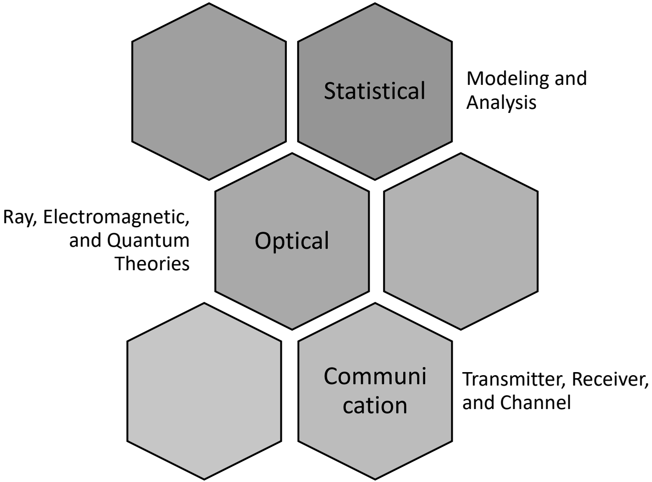

Figure: Puzzle of course title representing the main pillars of communications, optics, and statistics.

Communications

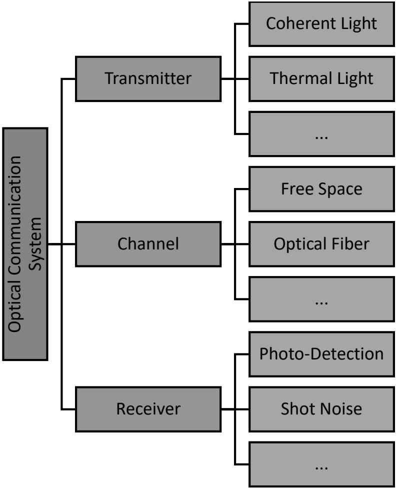

Figure: An optical communication system with its three fundamental blocks transmitter, channel, and receiver. For each fundamental block, two relevant topics are mentioned.

Optics

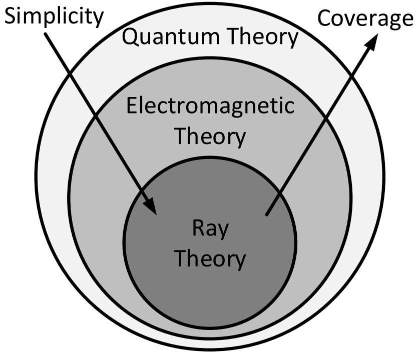

Figure: Coverage-simplicity tradeoff in optical theories.

1. Ray theory: $\partial \int_A^B n(\mathrm{r})dl = 0$
2. Electromagnetic theory: $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$
3. Quantum theory: $j\hbar\frac{\partial}{\partial t}\left|\Psi(t)\right\rangle = \widehat{H}(t)\Psi(t)$

Optics

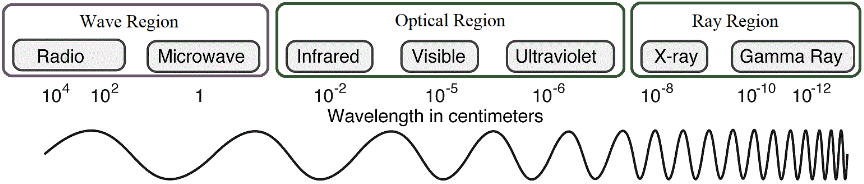

Figure: Electromagnetic spectrum with wave, optical, and ray regions.

- Typical applicability conditions
  1. Ray theory: $\lambda \ll$ system dimension and $h\nu \ll$ system sesitivity
  2. Electromagnetic theory: $h\nu \ll$ system sesitivity
  3. Quantum theory: Otherwise
- Optical region falls in boundaries of applicability conditions.

Optics

Ray Optics	Electromagnetic Optics	Quantum Optics
• Particle • Geometry • Deterministic	• Wave • Continuous • Deterministic	• Particle/Wave • Continuous/Discrete • Deterministic/Stochastic

Figure: Comparison of optical theories based on nature, math, and certainty.

- Discrete random process analysis, continuous deterministic differential calculus, and common geometric concepts are widely used in the course.

Statistics

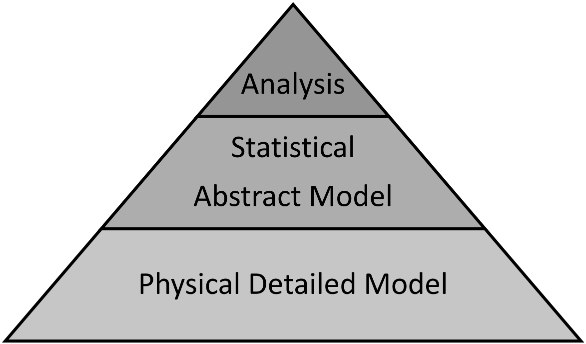

Figure: The course focuses mainly on statistical modeling and performance analysis as well as partially on physical modeling.

- The randomness may originate from information in the transmitter, noise in the channel, stochastic operation in the receiver, etc.

Example (Coherent light)

- Coherent light is physically described by lasing quantum theory.
- Coherent light is statistically described by Poisson random process.
- Coherent light is analytically described by average intensity.

Example (Photo-detection)

- Photo-detection is physically described by photo-detection quantum theory.
- Photo-detection is statistically described by Laguerre random process.
- Photo-detection is analytically described by mean photon number.

Course Requirements

Requirements

1. Basic Knowledge
   - Communications
   - Optics
2. Mathematical Tools
   - Differential Equations
   - Random Processes
   - Classical Geometry
   - Vector Analysis
3. Simulation Tools
   - MATLAB
   - Python
   - OptiSystem

Course Resources

Resources

1. Online teaching class on Sundays and Tuesdays, 12:00-13:30 in Bargh 301
2. Occasional online practicing class at CW virtual classroom
3. Course website at http://cw.sharif.edu
4. Telegram group at https://t.me/+zOfqSAjhgyJlMTM0
5. Personal website at http://sharif.edu/~mohammad.hadi/
6. Personal email to mohammad.hadi@sharif.edu

Course Contents

Contents

Course Assessment

Assessments

Item	Frequency	Contribution	Bonus
Work Assignments	5	20%	✓
Midterm Exam	1	25%	✗
Final Exam	1	30%	✗
Oral Exam	1	10%	✗
Software Project	1	10%	✓
Class Attendance	28	5%	✗

Table: Items involved in the course assessment. The specified contribution weights are tentative.

Course References

References

R. Gagliardi and Sh. Karp (1995)
Optical Communications
John Wiley & Sons

Joseph W. Goodman (2015)
Statistical Optics
John Wiley & Sons

Bahaa E. Saleh and Carl E. Malvin (2019)
Fundamentals of Photonics
John Wiley & Sons

G. Einarsson (1996)
Principles of Lightwave Communications
John Wiley & Sons

The End