

CT111 Introduction to Communication Systems

Lecture 1: Introduction

Yash M. Vasavada

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Overview of Today's Talk

- 1 Introduction
- 2 Course Mechanics
- 3 Why CT111?



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About Myself

- Instructor: Yash M. Vasavada
 - B.E. in Electronics and Communications from L. D. Engineering College, Gujarat University, Ahmedabad, India
 - M.S. and Ph.D. in Electrical Engineering from Virginia Polytechnic Institute and State University, Blacksburg, VA, USA
 - I was with Hughes Network Systems in Germantown, MD, USA until 2016
 - Beginning of the year 2016, I have been with DA-IICT



My Research

I am interested in

- the confluence of Machine Learning with Digital and Wireless Communications
- development of new algorithms, a study of their properties, and a study of their applications in communications, signal processing and artificial intelligence



Overview

- This is a (L : T : P : Cr) 3 : 0 : 3 : 4.5 Course.
- Lecture venue and time for Group A:
 - Group A: CEP 110, M 10 am; W 11 am; Th 9 am
 - Group B: CEP 102, M 11 am; W 10 am; Th 10 am
- Lab Sessions: Weekly labs and a project



Methods of Communications during the Semester

- You can contact me at:
 Office: FB-1, Room 1211
 Phone: 68261634
 Email: yash_vasavada@daiict.ac.in
- Assignments will be through the Moodle course page
- Announcements and other communication will be through Moodle as well as through DA-IICT email



Textbooks and Software

- ① Digital Communications, John Proakis, Fourth Edition.
- ② B. Sklar, Digital Communications, Second Edition.
- ③ S. Haykin, Digital Communications
- ④ **Introduction to Communication Systems, Upmanyu Madhow**, Cambridge University Press; First edition, 2015.
- ⑤ Digital and Analog Communication Systems, Leon Couch, Pearson Education, India, 6th Ed, 2001.
- ⑥ **Information Theory, Inference and Learning Algorithms, David J. C. MacKay**, Cambridge University Press; 1st edition, 2003.
- ⑦ S. Wicker, Error Control Coding for Digital Communication and Storage, 1994
- ⑧ S. Wilson, Digital Modulation and Coding
- ⑨ **D. Bertsekas and R. Gallager, Data Networks**, 2nd Edition
- ⑩ (Software) Matlab, Python (Jupyter iPython Notebook), C++



Use of Software

- In CT111, you will learn many new mathematical concepts. To gain full insight, the lecture sessions will need to be complemented by solving lab/homework assignments.
 - Some of these assignments will require analytical problem solving on your part
 - Many others will require you to develop programs and simulations in Matlab (or you can also use Python)
 - A suggestion:
 - ▷ Install Matlab license on your computer before the classes begin
 - ▷ If you are not familiar with Matlab, go through an introductory ramp-up tutorial of Matlab. For example, <https://in.mathworks.com/support/learn-with-matlab-tutorials.html> is a good place to start, however, there are many other excellent tutorials as well



Grading Categories

- ① Three Examinations: two mid-terms (**[20]%** weightage each) and one final **[30]%**
- ② Labs: students will be graded on the basis of the quality of the lab work done and lab attendance. The TA will perform this grading. **[12.5]%** weight.
- ③ Projects: one mid-term project. **[12.5]%** weight.
- ④ In-Class Quizzes (three to five). **[5]%** weight.
- ⑤ Promotions and Demotions
 - A single letter grade promotion: will be given to a few selected students who exhibit diligence, sincerity, proactiveness, resourcefulness, interest and curiosity toward the subject
 - A single letter grade demotion: will be given to those students who have a poor attendance record (e.g., less than **[75%]**) at the end of the semester
- **[Weightage]** of the above grade items is **subject to change**.
- Total marks out of 100 will be converted to a letter (performance) grade using a 10-point scale.
- The project and in-class quizzes will be group activities



Honor Code

Please submit the following pledge along with the submission of the project.

- I, [place your name and student ID here], declare that
 - the work that I am presenting is my own work
 - I have not copied the work (Matlab code, results, etc.) that someone else has done
 - Concepts, understanding and insights I will be describing are my own
 - Wherever I have relied on an existing work that is not my own, I have provided a proper reference citation
 - I make this pledge truthfully. I know that violation of this solemn pledge can carry grave consequences



Attendance Policy

- Your attendance in the lecture sessions and the Labs will be monitored.
- If your attendance is regular, that will help toward making a positive impression
- If your attendance is below [75%], you will receive a grade letter demotion



General Guidelines

A Contract between You and Me

- Step 1: Do **not** waste your time

- Do not skip lectures.
- Study regularly not at the last moment.
- Do not listen to rumors, your best friends, your seniors. This is a contract between you and me!

- Step 2: **Apply** yourself

- Read, read, read (we have a great library here)
- Practice, practice, practice (search for good end-of-the-chapter problems, do a lot of coding in Labs and Project, take a deep dive, do “what-if” experiments)

- Step 3: Search for your own **Why**



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General Guidelines

A Contract between You and Me

Step 3: Answer “Why”
(Enter a Virtuous Cycle)

Step 2: Apply Yourself
(Practice Continuously)

Step 1: No wasting the time



Escalate the Whys

- Start with Why
 - Escalate Them
 - Reach the Highest Level of Why
 - Find the simplest and the most satisfying answer to the highest why
- ▷ **Start With Why** Simon Sinek on TED Talks



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Highest Why

- Eklavya
- Interview of students
- Apple iPhone
- Gandhiji and Chauri Chaura incident



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Highest Why for CT-111

- Access to the Highest Why is reserved for those who strive for it
- You will need to
 - ▷ Study for the sake of learning the subject in and out
 - ▷ Get interested in the subject
 - ▷ Iterate on the above two and enter a positive cycle



Tips

① Read, read, read:

- become a voracious reader. Read from not one but many sources. Text books are the best - typically better than online search results.

② Solve:

- solve as many end-of-the-chapter problems as you can.

③ Make your own notes:

- summarize the main point of several paragraphs or a page of the textbook in your own hand-written note that summarizes your understanding.

④ Make note cards:

- note cards are snippets, compressed version of the notes written on a small rectangular card.

- ▷ Have three colors of these cards, easy (green), medium (yellow) and hard (red). The easy ones you flash them in front of you once a while to keep your memory sharp. The medium and hard ones - you flash them in front of you when you're sitting in the library or sitting on the lawn bench and you have some private time to do deeper thinking.



Tips

- ⑤ Properly space the study sessions:
 - Study in small intervals that are frequently repeated, rather than one long interval that is infrequent
- ⑥ Harness the power of the subconscious:
 - read just before going to bed, chew on it while falling asleep and think about it again the first thing in the morning
- ⑦ Change it up:
 - after mastering a topic, find a new way of thinking about it.
- ⑧ Get in the "zone"



Why CT111?

- Why to study CT-111?

- Because it's an inherently beautiful subject that you can fall in love with.
- Think of CT-111 not as a course, but instead as a sight-seeing tour (where I will be your tour guide)



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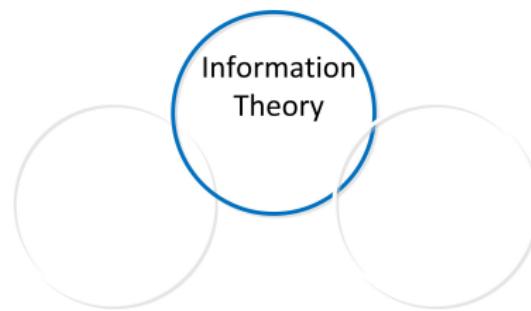


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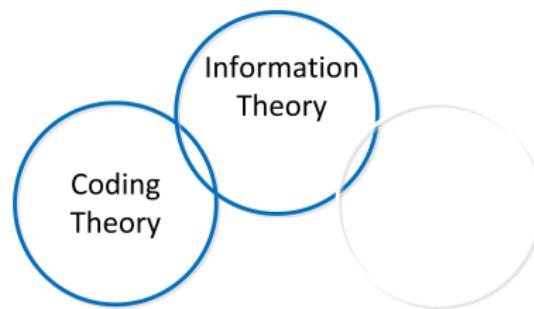
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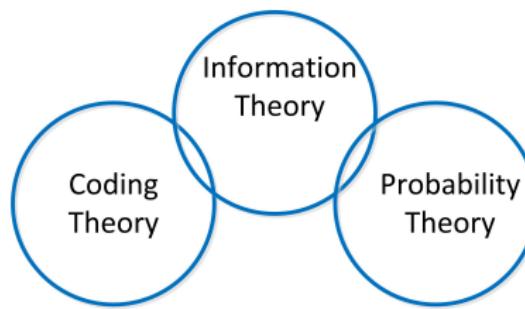
Topics of CT111



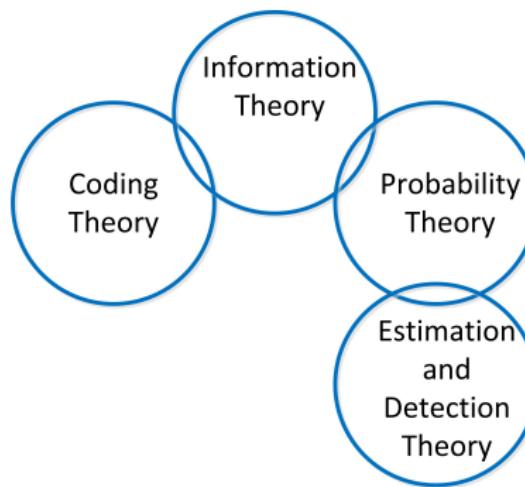
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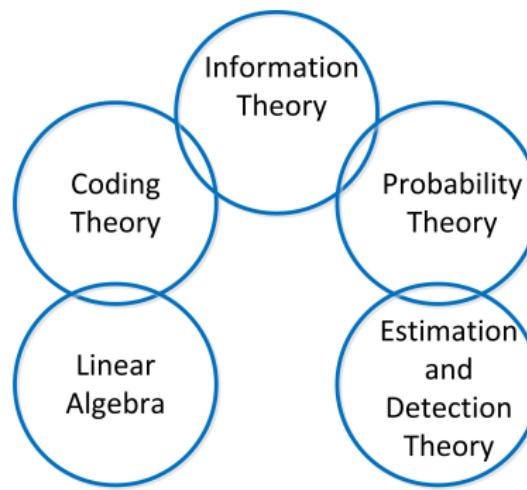
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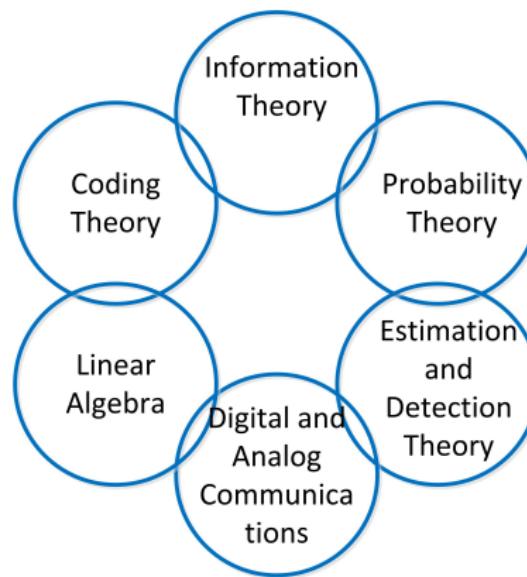
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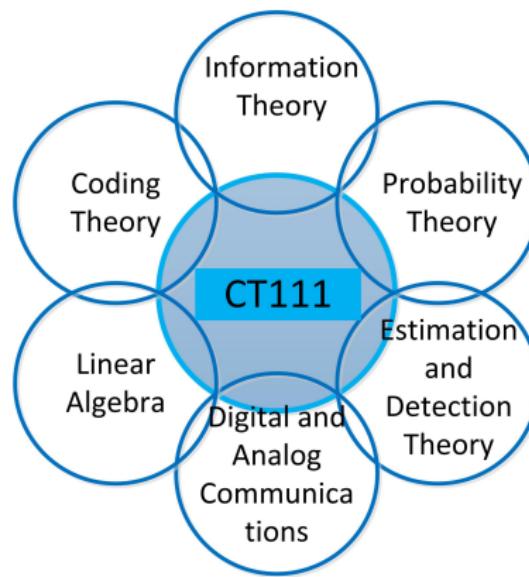
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Why CT111?

It's a Window to Great Intellectual Adventures!

Analog and Digital Communications: Designed to be a precursor to A&D.

Several lectures may have some overlap with A&D.

Coding Theory: cover block codes, convolutional codes, Turbo and LDPC codes. Describes the performance analysis and their application in the system design.

Wireless Communications: this course provides a detailed study on the statistical description of the wireless channel. The course also covers multiple wireless (2G/3G/4G) standards. CT-111 will provide an overview of the channel models, and will allow you to understand the basics of these various wireless standards.



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Information Theory: emphasizes the fundamental limits on the communications. In CT111, we will study the algorithms used at the transmitter and the receiver of the digital communication system that attempt to approach these limits.

Estimation and Detection Theory: provides a detailed mathematical background on the algorithms used at the receiver of a communication system. In this class, we will cover a part of this material.

Probability and Statistics for Engineers: this class serves as foundation course for all of the courses listed above. We will utilize some statistical concepts in CT111.



Probability, Estimation and Decision

- Suppose there exists a test to detect a disease, say D , whose prevalence is 0.01, i.e., the probability $P[D]$ that a person picked at random is suffering from D is 0.01.
- The test has a false positive rate of 0.05, i.e., if you don't have the disease, the probability that your test will still come out positive is 0.05.
- The test has a correct positive rate of 0.95, i.e., if you have D , the test will say with probability 0.95 that you have D .
- You take the test and the test result comes out positive. What is the probability that you actually have D ?



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Another Why for CT111

To Get in the 5G Game!

- The world is currently migrating from 4G to 5G
 - Perfect time to get on the board.
 - CT-111 would be the first step
- Let us see next what the research and the industry are targeting for



Why to Study CT111?

(5G Targets (by NGMN))

Broadband access in dense areas PERVASIVE VIDEO 	Broadband access everywhere 50+ MBPS EVERYWHERE 	Higher user mobility HIGH SPEED TRAIN 	Massive Internet of Things SENSOR NETWORKS 
Extreme real-time communications TACTILE INTERNET 	Lifeline communications NATURAL DISASTER 	Ultra-reliable communications E-HEALTH SERVICES 	Broadcast-like services BROADCAST SERVICES 

→ Reference: 5G White Paper, NGMN Alliance, Feb 2015



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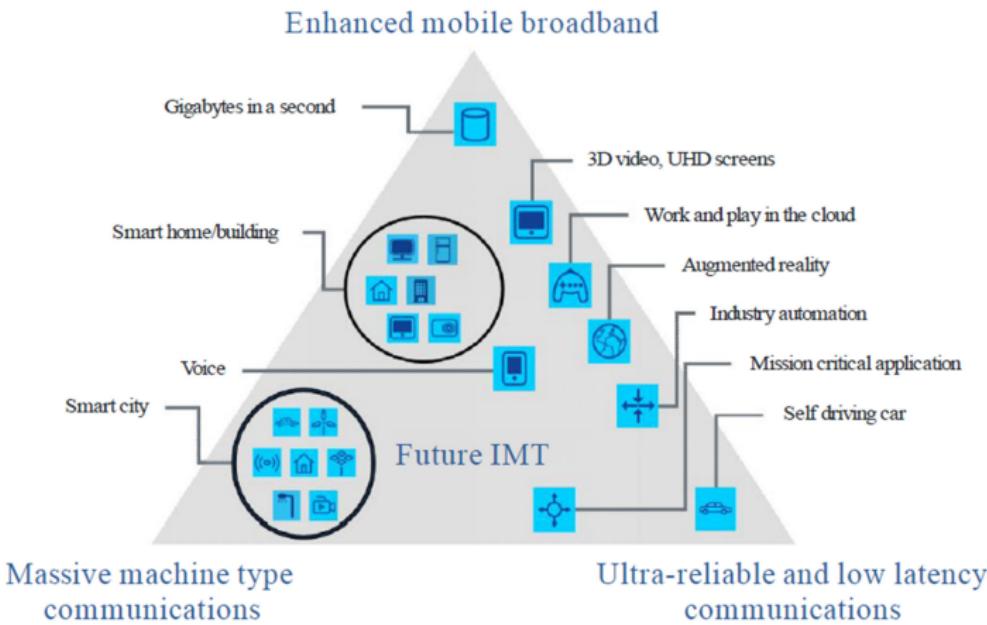
(5G Targets (by NGMN))

- Broadband Access in Dense Areas
 - Competitor to Cable TV
- Broadband Access Everywhere
 - Internet and phone calls in rural areas
- High Speed Mobility
 - Internet and phone calls in bullet trains and planes
- Massive Internet Of Things (IOT)
 - Connected devices that interact with each other
- Extreme Real Time Communications
 - Very fast, low latency, for autonomous vehicles, industrial automation, augmented reality
- Lifeline Communications
 - Mission critical applications, public safety
- Ultra Reliable Communications
 - Robotic surgery, surgeon located thousands of miles away, etc.



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(5G Targets (by ITU))



→ Reference: ITU-R M.2083-0

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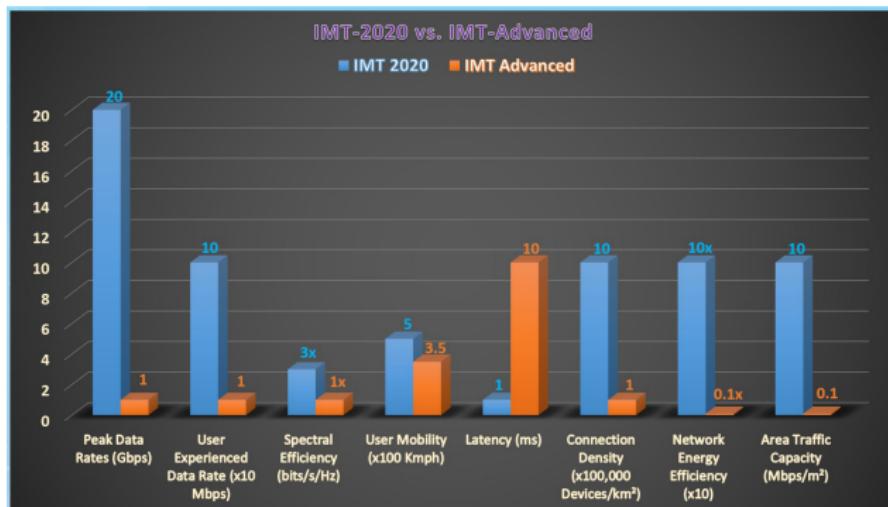
(5G Targets (by ITU))

- Enhanced Mobile Broadband (hologram)
- Critical Communications (drones and robots)
- Massive MTC (inventory control, flexible manufacturing)
- Network Operation that save energy
- Enhancement of Vehicle to Everything (autonomous driving)



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