ESE 326 Probability and Statistics

Instructor: Dr. Jinsong Zhang
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Green Hall, Room 1156B

Syllabus

General Information:

- **Office Hours:** Monday, Tuesday and Thursday, 9:00AM to 11:00AM, and by appointment

- **Textbook:** "*Introduction to Probability and Statistics*", 4th edition, by Milton and Arnold. ISBN 978-0-07-246836-6. Published by McGraw-Hill.

Grading Materials

Homework:

Homework will be assigned every week. Usually homework is assigned Thursday and due before the following Tuesday's class. Bring your finished homework to the **classroom** to turn it in before the class of the due date. Homework received within 24 Hrs past the due time will be treated as **late homework** and receive 50% credit. You have to submit your late homework to my office. The following is a schedule of homework assignments:

HW#	1	2	3	4	5	6	7	8	9	10	11	12
Date	08/31	09/07	09/14	09/21	09/28	10/05	10/12	10/26	11/02	11/09	11/16	11/30

Grading Materials

Tests:

A 30 minutes test will be given every two weeks covering topics discussed in the past period. The tests will be closed-book, closed-notes. However, you can prepare a one-page single-sided “chi chi” sheet for the test. The following is the schedule of the tests:

Test	1	2	3	4	5
Date	09/14	09/28	10/12	11/10	11/30

Grading Materials

Exams:

There will be a midterm exam and a final exam. All are closed-book, closed-notes. You are allowed to bring two pages of single-sided or one page double-sided “chi chi” sheets to the exams. There will be no make up for missed exams. If your miss of an exam is unexcused, you will receive a score of zero for the exam. The following is the schedule of the exams:

Midterm exam	10/19/2017 Thursday
Final exam	12/18/2017 1:00PM-3:00PM

Grading Materials

In-classroom assignments:

A ten-minute short assignments may be given in classes. Students will work as groups on these assignments.

Grade system: Your grade from this class will be based on the following grading materials:

Homework	20%
Tests	20%
In-class assignments	10%
Midterm Exam	25%
Final Exam	25%

Course Policies

Grading:

Your answers to any questions should be supported by **complete, clear, and accurate work**. **An answer with no work or large gaps in the work will receive minimal credit.**

Computer and Calculator Policy:

No power-on laptop computer is allowed in classroom. Calculators are allowed in tests and exams. However, the model of the calculator cannot be more advanced than TI 30.

Course Policies

Communications:
The best way to contact me is via email (jinsong.zhang@wustl.edu). I may make course related announcements through emailing the class. All course documents (assignments, solutions) will be posted on the Blackboard system under "**Course Documents".**
You are welcome to send me your comments on the course anytime!!!

Accommodations for Disabilities: If you need exam/test accommodations based on the impact of a disability, you must meet with me to finalize arrangements at least two days prior to the first test/exam. Last minute arrangements will not be permitted.

Academic Integrity: Academic integrity is extremely important. See the University Policies website at www.wustl.edu/policies/undergraduate-academic-integrity.html for a full statement of the university's policy on academic integrity. Cheating in any form will not be tolerated. The minimum penalty for cheating on an exam is a score of zero for that exam and notification to the engineering school's Discipline Committee. Other possible penalties include a semester grade of "F" and suspension or expulsion from Washington University.

Outline of the Course

Probability Theory + Statistics

What is probability theory?
Probability theory is the branch of (applied) mathematics concerned with the analysis of random phenomena.

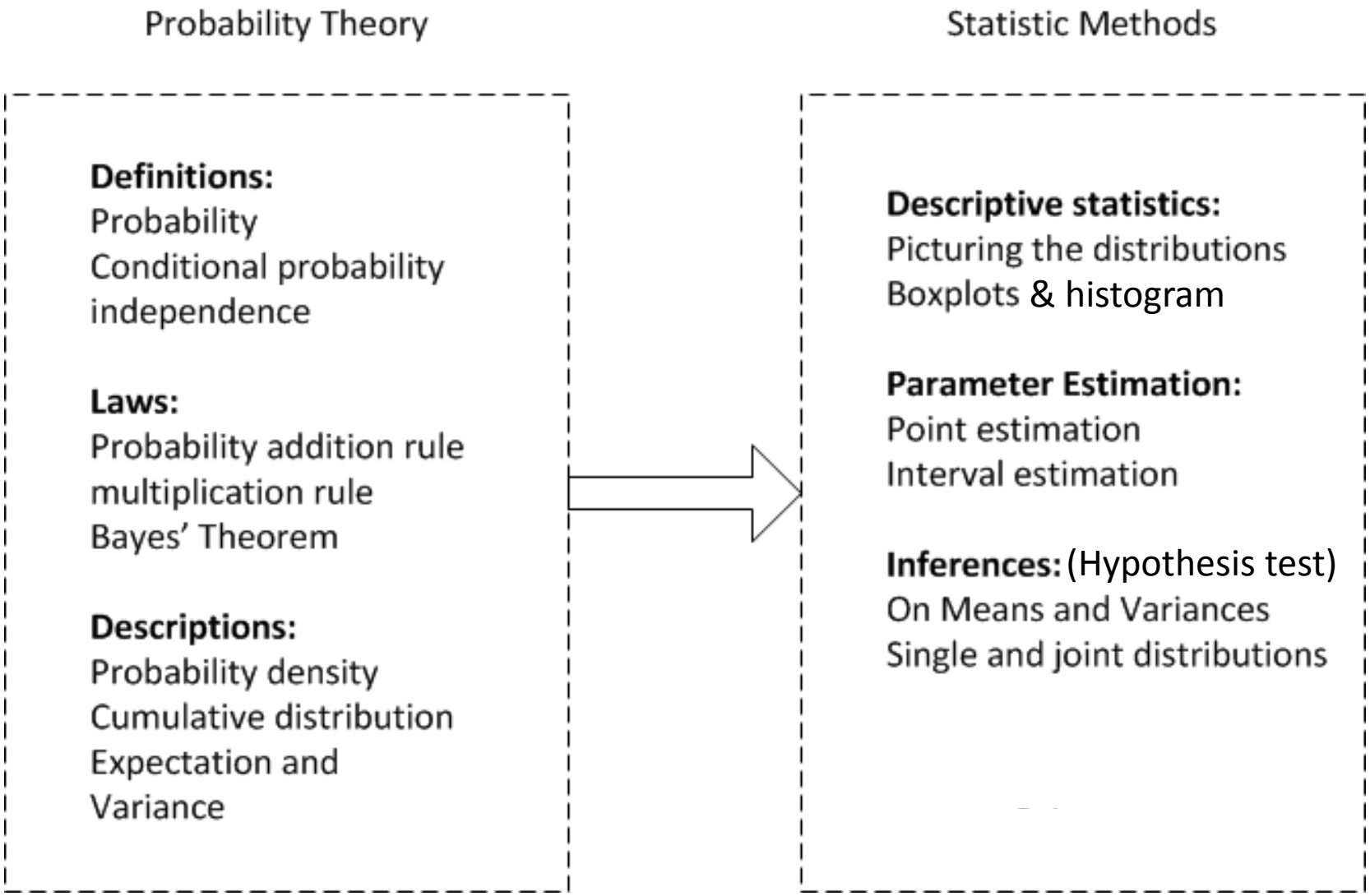
What is statistics?
Statistics is the (applied) mathematical science involved in the application of quantitative principles to the ***collection***, ***analysis***, and ***presentation*** of numerical data. The practice of statistics utilizes sampled data from some population in order to describe it meaningfully, to draw conclusions from it, and make informed decisions.

Outline of the Course

Other subjects related to this course:

- Signal processing/image processing
- Information theory(Coding theory)
- Communication systems
- Stochastic process and Kalman filtering
- State estimation and target tracking
- Machine learning: Pattern classification + artificial intelligence
- Big data
- Stochastic control
- more

Outline of the Course



Deterministic and Statistical Models

- A deterministic model always produce the same output from a group of given parameter values and initial state
  e.g., $y'' + 5y' + 6 = 2e^t, y'(0) = 0, y(0) = 0.$
  No uncertainty. *The results are totally predictable.*
- A statistical model describes how one or more random variables are related to one or more other variables.
  A ***random (stochastic) variable*** is a variable whose value is subject to variations due to chance. A random variable can take on a set of possible different values, each with an associated probability.
  The *randomness or uncertainty* in the model may be introduced by the physical phenomenon itself or from the measurement of the physical quantities.
- Statistical models are designed to deal with the degree of uncertainty presented in the results.

What is probability? (common sense)

- Probability in our daily life
  - “There is 0% chance of rain today ”
  - “The probability to have a T-storm today is 100%”
  - “The probability that the Dow Johns index will reach 23000 point within 2017 is less than 30%”
  - “The probability that a major earthquake happens in San Francisco within 30 years is 90%”
- Probabilities are numbers between $0\ and\ 1\ (percentage)$, inclusive, that ***reflect the chances of a physical event occurring***.
- Probabilities near 1 indicate that the event is extremely likely to occur. They do not mean that the event will occur, but that the even is considered to be a common occurrence
- Probabilities near 0 indicate that the event is not very likely to occur. They do not mean that the event will fail to occur, only that the event is considered to be rare.
- Probabilities near 0.5 indicate that the event is just as likely to occur as not
- Subjective and Objective probability

Some basic definitions related to probability

- **Random Experiment**

A random experiment is a process that results in an *observable* outcome that *cannot be predicted* in advance with certainty.

Example: Flipping a coin, rolling a die, measuring the diameter of a bolt, and measuring the breaking strength of a length of fishing line.

- **Sample space and sample points**

The set S that consists of all possible outcomes of the experiment is called the *sample space* of the experiment. An *element* of the set S is called a *sample point*.

Flipping a coin once: $S = \{H, T\}$
Rolling a six-face dice once: $S = \{1,2,3,4,5,6\}$
Flipping a coin two times: $S = \{HH, HT, TH, TT\}$
Measuring the length of steel pins whose lengths vary between 5.20 and 5.25 cm: $S = \{x | 5.20 < x < 5.25\}$

Note, the sample space can be *continuous* or *discrete*, the size of the sample space can be *finite or infinite.*

Some basic definitions related to probability

- **Sample space and sample point**

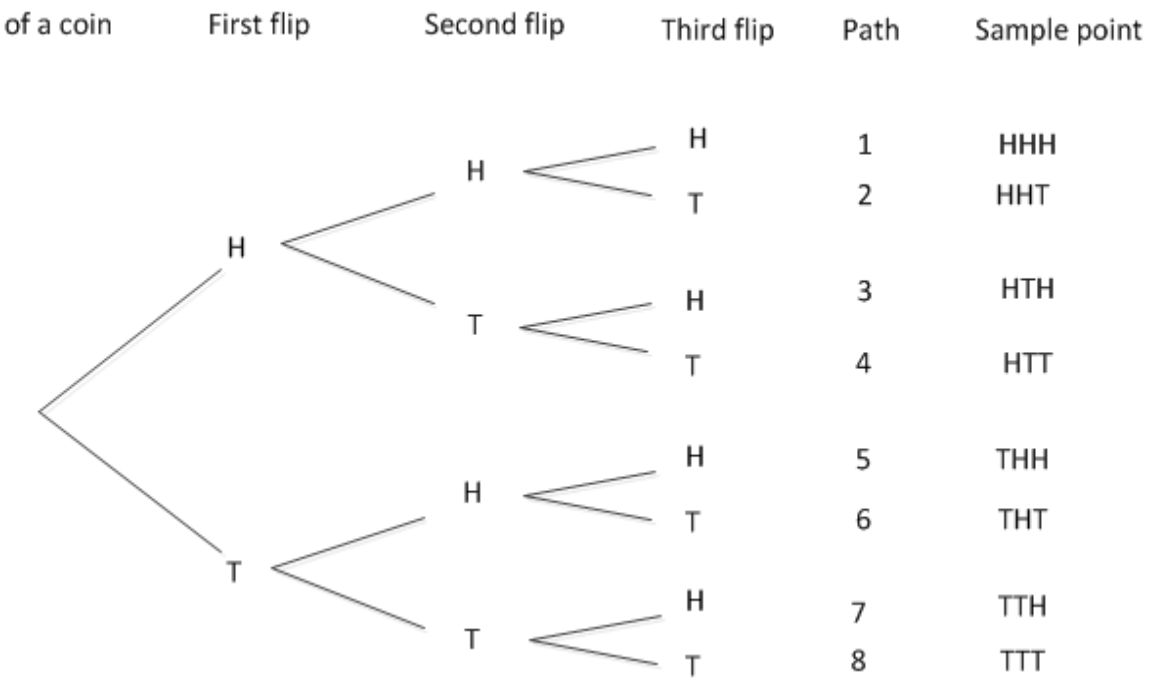
Example: Find the sample space of flipping a coin three times.

Solution: at any flip, a coin is in one of two states: Head (H) or Tail (T). A tree diagram can be created to represent all possible outcomes of flipping a coin three times.

Thus, $S = \{HHH, HHT, HTH, HTT, THH, THT, TTH, TTT\}$

Which include all possible outcome of flipping a coin three times.

Which path represent the outcome of all Tail?



Tree Diagram

Some basic definitions related to probability

- **Event**

Any **subset** A of a sample space is called an event. The empty set ∅ is called the *impossible* event; The subset S is called the *certain* event.

Example: The sample space of the experiment of flipping a coin three times is:

$$S = \{HHH, HHT, HTH, HTT, THH, THT, TTH, TTT\}$$

Use the set theory notations to represent the following events, i.e., listing the sample points that represent the occurrence of the event:

A: *Head* occurs in the first flip ; $A = \{HHH, HHT, HTH, HTT\}$

B: *Head* occurs in the second flip; $B = \{HHH, HHT, THH, THT\}$

C: *Tail* occurs in none of the flips ; $C = \{HHH\}$

Practice: (combining events)

The relative complement: $C' =$ $\{HHT, HTH, HTT, THH, THT, TTH, TTT\}$, Tail occurs in at least one flip

The union : $A \cup B =$ $\{HHH, HHT, HTH, HTT, THH, THT\}$, Head occurs in first ***or*** second flip

The intersection: $A \cap B =$ $\{HHH, HHT\}$, Head occurs in the first ***and*** the second flip

Some basic definitions related to probability

- **Mutually Exclusive Events**

Two events $A_1\ and A_2$ are mutually exclusive if and only if $A_1 \cap A_2 = \emptyset$. Events $A_1, A_2, A_3, \ldots$ are mutually exclusive if and only if $A_i \cap A_j = \emptyset\ for\ i \neq j$

Example: The sample space of the experiment of flipping a coin three times is:

$$S = \{HHH, HHT, HTH, HTT, THH, THT, TTH, TTT\}$$

The events:

A_1: *Head* occurs in the first flip; $A_1 = \{HHH, HHT, HTH, HTT\}$

A_2: *Tail* occurs in the first flip; $A_2 = \{THH, THT, TTH, TTT\}$

$A_1\ and A_2$ are mutually exclusive events because $A_1 \cap A_2 = \emptyset$