MTH 541/643: Statistical Theory II

Spring 2020

Instructor: Songfeng (Andy) Zheng

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Room and Time: Cheek 173, 11:15am – 12:05pm, MWF

Office and Hours: Cheek 22M, 9:00am – 11:00am and 2:00pm—3:00pm, Tuesday and Thursday; or by appointment. Office hours are offered for individual help and getting to know how you understand the material, so please use them.


Lecture notes on some topics will be available.

Course webpage:

http://people.missouristate.edu/songfengzheng/teaching/MTH541S20.htm will provide the download of various course materials, including the lecture notes, homework assignments, announcements, and data for exercises.

Objectives & Prerequisites: The course MTH 541 is devoted to statistical inference. Students will be equipped with statistical principle, theory and methodology when they leave the course; also students are expected to be able to solve practical application problems using computer programming language. The prerequisite for this course is Math 540 or equivalent, and students are expected to be familiar with calculus (differentiation, integral). Programming technique is not required but it is a plus. In this course, we will use the extensively used programming language in statistics, R, for statistical computation and simulation, and it is FREE! The website for downloading R is http://www.r-project.org/.

Please install and learn how to use R by yourselves! You can find tutorial materials by Google: just type in "R tutorial filetype:pdf", you will have a lot of tutorial files available. After we finish MLE part, I will show you how to use the basic commands of R by doing an example of MLE with R. For example:


Materials to be covered (tentative): Estimation (Method of Moment, Maximum Likelihood), the Properties of MLE, Sufficient Statistics, Evaluation of various
Estimators, Sampling Distributions of Estimators, Confidence Intervals, Hypothesis Testing, Computer Simulations for Estimators and Confidence Intervals.

Grading Policy and Studying Suggestions:

Homework: 20%  
Computer Assignment: 10%  
In-class 2 Tests: 30%  
Final Exam: 40%

Grading policy: A (>90%)  B (80 --- 89%)  C (70 --- 80%)  D (60 – 70%), F(<60%)

Final Exam date: 11:00 --- 1:00, Monday, May 11th, 2020.

Note: for students enrolled in MTH643, you are expected to finish one more question in each exam!

It is important that you read the text book(s) and lecture notes regularly, understand the problems worked out in the text and practice by doing the problems. Doing the homework problems is absolutely essential to get a better grade in this course. You are allowed to discuss the homework problems among yourselves or with me. However the final work handed in must be completely your own. Anyone who receives or gives an unauthorized aid on a homework or test is considered to be cheating.

A good way to learn a programming language is practice, practice, practice! I encourage you install R on your own computer and play it whenever possible. You are encouraged to discuss your problems in using the software, and also don’t forget internet is a very good coach in your study.

No make-up test or exam will be given under ordinary conditions. The only acceptable excuse for missing a test is an extreme emergency. However, you must obtain a written explanation from a physician, etc. If you cannot take the test on the scheduled day, you must contact me before the test date.

Emailing format:

Email is an important means to communication in everyday life as well as in this course. Due to the large amount of emails sent to me every day, and due to different courses I am teaching, I suggest you clearly write a subject in the email, and in the subject, clearly tell which course you are from. For example, a good email subject would be like

Subject: MTH 541: Q about #7 in HW2

Thus, I can quickly locate your problem and will reply quickly. Emails which don’t have a clear subject may be simple ignored!
Miscellaneous Notes:

**Attendance policy:** The University expects instructors to be reasonable in accommodating students whose absence from class resulted from: (1) participation in University-sanctioned activities and programs; (2) personal illness; or (3) family and/or other compelling circumstances. Instructors have the right to request documentation verifying the basis of any absences resulting from the above factors. Please see The University’s attendance policy can be found in the 2010-2011 Undergraduate Catalog at www.missouristate.edu/registrar/attendan.html.

**Academic integrity:** Missouri State University is a community of scholars committed to developing educated persons who accept the responsibility to practice personal and academic integrity. You are responsible for knowing and following the university’s Student Academic Integrity Policies and Procedures, available at www.missouristate.edu/policy/academicintegritystudents.htm. You are also responsible for understanding and following any additional academic integrity policies specific to this class (as outlined by the instructor). Any student participating in any form of academic dishonesty will be subject to sanctions as described in this policy. If you are accused of violating this policy and are in the appeals process, you should continue participating in the class.

**Nondiscrimination:** Missouri State University is an equal opportunity/affirmative action institution, and maintains a grievance procedure available to any person who believes he or she has been discriminated against. At all times, it is your right to address inquiries or concerns about possible discrimination to the Office for Equity and Diversity, Park Central Office Building, 117 Park Central Square, Suite 111, (417) 836-4252. Other types of concerns (i.e., concerns of an academic nature) should be discussed directly with your instructor and can also be brought to the attention of your instructor’s Department Head. Please visit the OED website at www.missouristate.edu/equity/.

**Disability Accommodation:** If you are a student with a disability and anticipate barriers related to this course, it is important to request accommodations and establish an accommodation plan with the University. Please contact the Disability Resource Center (DRC) (https://www.missouristate.edu/disability/), Meyer Library, Suite 111, 417-836-4192, to initiate the process to establish your accommodation plan. The DRC will work with you to establish your accommodation plan, or it may refer you to other appropriate resources based on the nature of your disability. In order to prepare an accommodation plan, the University usually requires that students provide documentation relating to their disability. Please be prepared to provide such documentation if requested. Once a University accommodation plan is established, you may notify the class instructor of approved accommodations. If you wish to utilize your accommodation plan, it is suggested that you do so in a timely
manner, preferably within the first two weeks of class. Early notification to the instructor allows for full benefit of the accommodations identified in the plan. Instructors will not receive the accommodation plan until you provide that plan, and are not required to apply accommodations retroactively.

**Cell phone policy:** As a member of the learning community, each student has a responsibility to other students who are members of the community. When cell phones or pagers ring and students respond in class or leave class to respond, it disrupts the class. Therefore, the Office of the Provost prohibits the use by students of cell phones, pagers, PDAs, or similar communication devices during scheduled classes. All such devices must be turned off or put in a silent (vibrate) mode and ordinarily should not be taken out during class. Given the fact that these same communication devices are an integral part of the University’s emergency notification system, an exception to this policy would occur when numerous devices activate simultaneously. When this occurs, students may consult their devices to determine if a university emergency exists. If that is not the case, the devices should be immediately returned to silent mode and put away. Other exceptions to this policy may be granted at the discretion of the instructor.

**Emergency Response policy:** Students who require assistance during an emergency evacuation must discuss their needs with their professors and Disability Services. If you have emergency medical information to share with me, or if you need special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible. For additional information students should contact the Disability Resource Center, 836-4192 (PSU 405), or Larry Combs, Interim Assistant Director of Public Safety and Transportation at 836-6576. For further information on Missouri State University’s Emergency Response Plan, please refer to the following web site: http://www.missouristate.edu/safetran/erp.htm

**Dropping a Class:** It is your responsibility to understand the University’s procedure for dropping a class. If you stop attending this class but do not follow proper procedure for dropping the class, you will receive a failing grade and will also be financially obligated to pay for the class. For information about dropping a class or withdrawing from the university, contact the Office of the Registrar at 836-5520.

**Changes to this syllabus:** The instructor reserves the right to make changes to this syllabus, and the changes will be announced in class and on the course webpage.
Tentative Lecture Schedule in Spring 2020 (MTH 541/643)

Lecture 1: Course policy statement. Review: experiments, events, discrete and continuous random variables and their distribution functions. Definition of Expectation and variance.

Lecture 2: Joint, Marginal, Conditional distributions, covariance, uncorrelated and independent. Formula for variance of sum of random variables. Moments, moment generating function and properties. Commonly used distributions and properties: Bernoulli.


Lecture 6: Example for MoM. Basic idea and formulation of Maximum likelihood estimation.

Lecture 7: Examples for MLE.

Lecture 8: More examples for MLE. Relation between MLE and Method of Moments.

Lecture 9: Invariant property of MLE, Examples. Necessity to use programming for MLE. Using R to find MLE.

Lecture 10: Using R to find MLE. Statistic: definition and the analogy to data compression, Intuition and mathematical definition about Sufficient Statistic.

Lecture 11: factorization theorem for sufficiency: statement, proof, and Examples.

Lecture 12: Property of sufficient statistic and Examples. MLE and sufficient statistic: proof and examples.

Lecture 13: Exponential family of probability distribution, identifying sufficient statistic. k-parameter Exponential family of probability distribution, Examples. Definition and Properties of Chi-square distribution, an example.

Lecture 14: Definition of t-distribution. Difference and similarity between N(0,1). Moments and moment generating function of t-distribution.


Lecture 16: Definition of T statistic, and Example of using t-distribution. Motivation for interval estimation, general steps for confidence interval, pivot and statistic.

Lecture 17: Examples for confidence intervals.

Lecture 18: Confidence interval for parameter in exponential distribution. One sided confidence interval, Example. Explanation of confidence level.


Lecture 23: Approximate confidence interval using asymptotic distribution, Example. Bootstrap for sampling distribution using R.

Lecture 24: Getting fisher information and approximate confidence interval; Bootstrapped confidence interval.

Lecture 25: Estimator evaluation problem, Mean square error: definition and decomposition to variance and bias. Examples for calculating MSE.

Lecture 26: Example for calculating MSE. Efficient estimator: definition and example.

Lecture 27: Judging efficiency by log-likelihood function, example. Efficient estimator and exponential family distribution model. Efficiency and relative efficiency


Lecture 29: Type I and II errors and rates. Test statistic, null distribution. rejection region, acceptance region. Example to illustrate the concepts about HT.

Lecture 30: Example to illustrate the concepts about HT. Z-test for the mean value of normal distribution.

Lecture 31: t-test for the mean value of normal distribution. Chi square test for the variance of normal distribution when the mean is known.

Lecture 32: General steps for HT. Chi square test for the variance of normal distribution with unknown mean value. Relation between CI and HT, example.

Lecture 33: Tail probability as p-value, example. p-values and calculation, examples.

Lecture 34: Hypothesis testing and confidence interval for the mean values of two normal distributions.

Lecture 35: Introduction to F-distribution. Using F-distribution to compare the variance of two normal models, CI for the variance ratio.

Lecture 36: Basic idea of Likelihood ratio test. Simple likelihood ratio test. Idea for composite hypothesis testing using Likelihood ratio.

Lecture 37: Likelihood ratio test and t-test, Likelihood ratio test and chi-square test.

Lecture 38: Likelihood ratio statistic and sufficient statistic. Asymptotic distribution of log likelihood ratio statistic and an example.

Lecture 39: Multinomial distribution: definition, probability function, marginal distribution, covariance. Pearson's Chi-square test: problem, intuition, test statistics, rule, and example.

Lecture 40: Pearson's chi-square for composite hypothesis, and example.