Ve401 Probabilistic Methods in Engineering

Spring 2019 Term Project 1

Date Due: 12:00 PM, Monday, the 8th of April 2019

General Information

The goal of this term project is to help you apply your new-found knowledge of probability theory and statistics in extended tasks that are beyond the scope of ordinary assignments. **It is strongly recommended that you do not leave the entire project to the last minute** but rather commence work on individual parts as soon as you are able to do so.

Group Work

You will be divided into groups of *4–5 students* each.

> Each group member must be familar with and have contributed to each part of the project report. **You may not divide up the work in such a way that only certain members are invovled with certain parts.** In the event of an Honor Code violation (plagiarism or other), all members of the group will be held equally responsible for the violation. Exceptions may only be made, at my discretion, in exceptional situations.

It is therefore all group members' duty to ensure that all collaborators' contributions are plausibly their own and to check on all collaborators' work progress and verify their contributions within reason.

Project Report

The term project will be submitted **electronically only** as a typed report. Handwritten submission will not be accepted! It is recommended that you use a professional type-setting program (such as LaTeX) for your report. Unless you are able to ensure a unified font size and style for formulas and text in Microsoft Word, use of Word is *not recommended*.

Grading Policy

This term project accounts for 20% of the course grade; it will be scored based on

- **Form (4 points):** Does the report contain essential elements, such as a cover page (with title, date, list of authors), a synopsis (abstract giving the main conclusions of the project), table of contents, clear section headings, introduction, clear division into sections and appendices with informative titles and bibliography (if applicable)? Are the pages numbered? Are the text and formulas composed in a unified font? Are all figures (graphs and images) clearly labeled with identifiable source?
- **Language (4 points):** Is the style of english appropriate for a technical report? Do not treat the project as an assignment and simply number your results like part-exercises. Your text should be a single, coherent whole. The text should be a pleasant read for anyone wanting to find out about the subject matter.

  Errors in grammar and orthography (use a spell-checker!) will be penalized. Make sure that the report is interesting to read. Avoid simply repeating sentences by cut-and-paste.
- **Content (12 points):** Are the mathematical and statistical methods and deductions clearly exhibited and easy to follow? Are the conclusions well-supported by the mathematical analysis? It is important to not just copy calculations from elsewhere, but to fully make them your own, adding details and comments where necessary.

All group members will receive the same grade for the term project. (Exceptions are possible in special circumstances.)

On Plagiarism

Study JI's Honor Code carefully. **Any** information from third parties (books, web sites, even conversations) that you use in your project must be accounted for in the bibliography, with a reference in the text. Follow the rules regarding the correct attribution of sources that you have learned in your English course (e.g., Vy100, Vy200). All members of a group are jointly responsible for the correct attribution of all sources in all parts of the project essay, i.e., any plagiarism will be considered a violation of the Honor Code by all group members. Every group member has a duty to confirm the origin of any part of the text.

The following list includes some specific examples of plagiarism:

- Use of any passage of three words or longer from another source without proper attribution. Use of any phrase of three words or more must be enclosed in quotation marks ("example, example, example"). This excludes set phrases (e.g., "and so on", "it follows that") and very precise technical terminology (e.g., "without loss of generality", "reject the null hypothesis") that cannot be paraphrased,
- Use of material from an uncredited source, making very minor changes (like word order or verb tense) to avoid the three-word rule.
- Inclusion of facts, data, ideas or theories originally thought of by someone else, without giving that person (organization, etc.) credit.
- Paraphrasing of ideas or theories without crediting the original thinker.
- Use of images, computer code and other tools and media without appropriate credit to their creator and in accordance with relevant copyright laws.

Analysis of Package Contents

The contents of food packages follow strict regulations. Any prepackaged food product must be prominently labeled with the amount of product (nominal content) that it contains. In order to verify that the nominal content coincides with the actual content, there exists a set of predefined rules [3] issued by the Chinese government. A copy of these rulkes has been uploaded to SAKAI.

In your report, summarize the testing rules set forth in [3, Section 4.3.2] and discuss the following:

i) In what way is the equation $\overline{q} \geq (Q_n - \lambda s)$ in Table 4 (Metrology and Inspection Sampling Plan) related to a confidence interval for the mean package contents? In what way does verifying this equation amount to a hypothesis test? Explain and formulate the hypothesis being tested.

ii) What is the signfiicance of the fifth column of Table 4? Analyze the numbers given there (0,0,1,3,5,7) mathematcially - how are they derived?

iii) The *non-central T distribution* is described in [2]. It is implemented in Mathematica as `NoncentralStudentTDistribution` [1]. Derive a formula for the OC Curve of the T test in terms of the cumulative distribution function of the non-central T distribution. Then use Mathematica to plot the OC curves corresponding to the test described in Table 4 of [3] for the various values of n. Coment on the power of the tests; what is the probability of detecting a shortfall of at least one standard deviation in package contents?

iv) Summarize and discuss the various statements of Section 5.3.2.

v) Obtain a sample of prepackaged food products of your choice (e.g., water bottles, packets of nuts or sweets, etc.) and perform tests to verify whether the actual package contents correspond to the nominal contents. Follow any relevant procedures outlines in [3]. (E.g., Appendices B and C discuss how to perform a proper weighing of samples, taking the tare into account.) Discuss your findings.

References

[1] E. W. Weisstein. Noncentral student's t-distribution. `http://mathworld.wolfram.com/NoncentralStudentst-Distribution.html` [Online; accessed 10-April-2014].

[2] Wikipedia. Noncentral t-distribution — wikipedia, the free encyclopedia, 2014. https://en.wikipedia.org/wiki/Noncentral_t-distribution [Online; accessed 10-April-2014].

[3] 全国法制计量管理计量技术委员会/定量包装商品净含量工作组. 定量包装商品净含量计量检测规则 (Rules of metrological testing for net quantities of products in prepackages with fixed content). Technical Report JJF 1070-2005, 中国计量出版社, 2005. http://www.ahhz.gov.cn/CountyOpennessContent/show/1078758.html [Online; accessed 22-March-2019].