PhD CS Comprehensive Exam Written Component

For the written component of the PhD CS comprehensive exam, the student prepares a **critical** review (survey) of research literature on an active research topic selected by himself/herself. The report should **synthesize** the previous research in the target area with particular **emphasis on open problems.**

Ideally, the selected topic is in the area of research in which a student intends to focus their Ph.D. dissertation work. In this way, the survey satisfies not only the written component of the comprehensive exam, but it also gives the student an intimate and detailed understanding of the existing work in the targeted area of research and, more importantly, of the open problems that provide clear opportunities for the student to make contributions as part of their Ph.D. dissertation work. Though it is not ideal and is likely to cause delays in research progress, if the circumstances require, the student may change the PhD research area and/or advisor after passing the comprehensive exam, as long as (s)he meets the PhD time limit defined by the university to advance to the candidacy.

I. Conditions for Success

A successful written comprehensive exam must take into account all three characteristics highlighted above. Specifically, it must:

- present a critical review: it should provide not only original summaries of the contributions of the surveyed articles, but also comment on their strengths and weaknesses.

- provide a successful synthesis of the existing published research, as demonstrated in peer-reviewed research articles (published in journals, conferences, and workshops), in the selected/target area, and should have a substantial discussion on open problems in the area. This is most commonly achieved by developing appropriate and detailed *taxonomies* (see below).

- include a substantial discussion on open problems, as perceived by the student after a careful analysis of the surveyed articles.

Writing a good critical review is not a trivial task. The timeline of three months acknowledges that considerable effort is required by the student. During this time, the student is expected to collect published research articles addressing the selected topic, understand in detail the inherent assumptions, methodological contributions, advantages, and shortcomings of these articles, obtain a global understanding of the landscape of research in the selected topic, properly group and categorize published work in this global landscape along various pertinent dimensions, and identify open problems and areas of research that provide opportunities for making further methodological contributions to advance the state of the art in the selected research topic.

II. Format

The survey should be 8-10 pages long, should contain a minimum of 20 references in the bibliography section, and should be prepared according to the IEEE or ACM conference templates.

A template has been provided to help students get started. The template provides a skeleton that guides students on how they should structure their survey in order to demonstrate that they have obtained a critical understanding of the research landscape and the open problems in the targeted research topic. In it, the students will identify five major sections:

- Introduction:
    - General introduction to the area with motivation on the importance and applications. Links to the broader research area(s) indicated on the comprehensive exam application form.
    - Quick summary of the evolution of the area over the years. Cite seminal works.
    - Indicate various publication venues where the articles on this topic typically appear (list important journals and conferences in the area).
    - Summary of the contributions and organization of your paper·
- Preliminaries: Here, introduce the basic concepts, notations, and models that a computer scientist should know in order to follow the rest of the paper, even if they are working in a different area
- Area taxonomy: a taxonomy is the science of classification. It is the systematic arrangement of methods and systems used in the area. A common way to graphically represent the taxonomies is hierarchies, e.g., trees of features.

  Note: If the survey topic is multidisciplinary and bridges two or more areas, finding a single good taxonomy might occasionally prove challenging. In those cases, the student may consider presenting taxonomies for the areas involved and discussing how these areas overlap.

  See more about taxonomies below (in Section III).
- Taxonomy-based survey of the area: Now use the taxonomy from the previous section to organize your description of main work in the area. No academic publication is perfect; so you should discuss both the strengths and weaknesses/shortcomings of the articles you surveyed, based on your critical reading.
- Discussion of open problems: This is an important part of your written exam where you will convey your own ideas about the most important and pressing open problems in the area, with justification.

III. Resources

In order to embark on a research topic, the student needs to first understand the state of the art in the selected topic to be able to write a good survey of the field. This requires first a bibliographical search. Online resources (such as IEEE and ACM Digital libraries, Google Scholar, Pubmed, ISI Web of Knowledge) as well as Mason's library provide good resources and tools to do so. It should be added that the Google Scholar's "cited by" links that can be found below the seminal papers' records can reveal additional related papers.

Since writing a good survey is an important milestone for Ph.D. students in many disciplines, many online resources exist to help students get started and focused. Here is a non-exhaustive list:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3715443/
https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1003149
https://www.asbmb.org/asbmb-today/careers/120111/writing-a-scientific-literature-review-article

As mentioned above, a common strategy that is particularly useful in writing good surveys is the development of a **taxonomy**. A taxonomy refers to terminology that researchers develop in order to classify/categorize published research efforts in the topic of interest. Developing a taxonomy is highly useful for researchers, as it effectively provides them with the concepts needed to synthesize efforts, critically compare them along what is important, and identify open problems and areas for further research. This article, https://www.sciencedirect.com/science/article/pii/S0950584917300472, summarizes various taxonomies in software engineering literature.

IV. Examples of Good Surveys

It is always a good idea to read published surveys in order to obtain an understanding of the common structure that may help with how to write a good and informative survey. Existing surveys in the topic the student is targeting for their survey or in a related topic may also inform the student on an existing taxonomy that the student can refine or expand. Here are some informative, published surveys in various research areas of computer science:

Jie Zhou, Ganqu Cui, Zhengyan Zhang, Cheng Yang, Zhiyuan Liu, Lifeng Wang, Changcheng Li, Maosong Sun. Graph Neural Networks: A Review of Methods and Applications
https://arxiv.org/abs/1812.08434

Mao Y, You C, Zhang J, Huang K, Letaief KB. A survey on mobile edge computing: The communication perspective. IEEE Communications Surveys & Tutorials. 2017 Aug 25;19(4):2322-58.

Mahmood A, Shi K, Khatoon S, Xiao M. Data mining techniques for wireless sensor networks: A survey. International Journal of Distributed Sensor Networks. 2013 Jul 21;9(7):406316.

See also the ACM Computing Surveys journal for examples of published surveys.

The students should understand that as early-phase PhD students, they are not expected to deliver surveys of such depth and scope as the ones above (their survey is limited to 10 pages); however these examples should be carefully examined to get an appreciation of the prominent features of successful surveys.

V. Suggestions

1. One objective of this exam is to have the student demonstrate that (s)he has gained a good level of academic writing skills after completing 36 credits in the PhD program and reading several research papers. The quality of the writing (clarity, organization, readability, etc) is a very important aspect of a technical paper. Here is a list of common writing mistakes made by students that better be avoided.

Keep in mind that you may need to revise/proofread your article multiple times, and plan accordingly. A submission with poor writing will invariably lead to failure.

The writing center at Mason is a wonderful resource to obtain feedback on your quality of writing. Here is a direct link: https://writingcenter.gmu.edu/

You can use this resource and even make an appointment with a writing center tutor (in person or online) to obtain general feedback on drafts of your survey.

2. You must remember that this is an exam; so the document you submit must reflect your own thinking and writing skills. You must be the sole author of the document (while you are allowed to get high-level feedback about the quality of your writing from experts at the GMU writing center); so you should not seek help from anyone, including your advisor or fellow PhD students.

3. Avoid plagiarism, in all forms. Students are reminded that the survey that they are preparing to satisfy the written component of the comprehensive exam needs to reflect their own understanding and their own voice. The Mason Honor Code applies to the survey.
Students unfamiliar with the Honor Code should visit https://oai.gmu.edu/mason-honor-code/. The website includes important information on what plagiarism is and the various subcategories.

You are not allowed to copy sentences directly from already published articles (including the ones that you survey). If necessary, rewrite and summarize them in your own words. Use quotation marks and provide full citation right away if you want to include a very important phrase directly from a paper (this should be used very rarely, if at all).

Finally, the evaluation of the papers that you survey must be exclusively yours -- borrowing evaluation results from published articles that survey the same papers is not acceptable and will lead to failure. It is not necessary to be always 100% correct in your evaluations; but it is critical that you put a serious and honest effort in your survey.

4. Keep in mind that it is your task to identify the papers you will review in your survey (the most relevant papers on the critical review topic you indicated on the comprehensive exam application form). The "reading list" that you propose at the time of exam application, which is finalized by the department when the exam committee is formed, forms the basis for the oral comprehensive exam (not the written comprehensive exam). Of course, you can include some of the papers you intend to review in your survey in the initial reading list for the oral comprehensive exam, if you wish to.