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University of Colorado

Department of Computer Science

Ph.D. Prelim Exam

Computational Modeling Of Complex Systems

The *Computational Modeling Preliminary Examination* focuses in the area of computational modeling and analysis of phenomena arising in complex systems. Computational modeling involves algorithms and simulations that provide a formal explanation or description of phenomena in the biological, behavioral, physical, or social sciences. The prelim exam spans all areas of computational modeling of complex systems, particularly artificial intelligence, robotics, cognitive science, social systems, bioinformatics, and chaotic systems. Some areas included are:

- psychological and neurobiological models of human behavior
- swarming behavior of simple agents
- analysis of social and biological networks
- collective dynamics and emergent phenomena
- robot planning
- dynamical modeling of complex nonlinear systems
- control of chaotic systems
- statistical and stochastic processes

The goal of the prelim exam is to evaluate the candidate's competence to analyze, evaluate, and integrate a well-delineated and active area of research. Typically, candidates will choose an area related to their likely dissertation topic. The exam is intended as an integral component of the Ph.D. education and dissertation writing, and not merely a hurdle to be jumped. Candidates are expected to achieve the following goals in the course of the prelim:

1. **Identify and delineate a focal topic of research.** The topic should be broad enough that contrasting approaches have been taken, but not so broad that it spans multiple unrelated subtopics that have only a superficial unification. The exam should begin with a clear description of the topic being addressed.
2. **Survey and review the literature.** The coverage should be comprehensive and sufficiently complete that researchers in the area would be unable to point to relevant and important papers published in refereed conference proceedings and journals that were not mentioned in the review.
3. **Synthesize and integrate the literature.** Candidates should provide their own synthesis of the literature, providing coherence and structure to what might otherwise appear as a jumble of individual approaches. Candidates should determine the best format for this synthesis. One typical structure is to lay out a space of approaches and to situate individual research publications in this space. Hierarchical and tree structured organizations are also frequently useful. The goal of the synthesis is to make explicit the relationships between various research publications in the topic. Often, a successful synthesis will point to holes in the research landscape and will suggest novel research directions.
4. **Summarize the literature.** The candidate should focus on the key ideas and approaches that were contributed by past research. The summary is a description of past work filtered by the candidate's perspective on the field. As such, many aspects of past work will not be terribly pertinent to the

candidate's perspective, and these aspects need not be presented. These irrelevant aspects may include what were key points in the original publication. The candidates' task is not to regurgitate the original work, but to impose their own theoretical spin that helps explicate how various bits of work are interrelated.

5. **Discuss directions for future research.** A well organized map of a research area occasionally suggests gaps in the literature. The prelim exam should end with a--possibly brief--discussion of directions for future research, informed by the review.

Our prototype of a good exam is a manuscript that could be published in a journal that includes review articles, such as *Reviews of Modern Physics, SIAM Review, Trends in Cognitive Science*, *Topics in Cognitive Science*, *Psychonomic Bulletin and Review*, *Swarm Intelligence*. Indeed, the judgment of pass/fail will be based on how close to a submission-ready manuscript the exam would be. We strongly encourage candidates to approach this exam, from the outset, with the plan to submit their paper for publication. Candidates should consult with their advisors to identify an appropriate journal well in advance of beginning the prelim, and the structure of the paper and the target audience should be informed by the choice of journal. The submission-ready criterion should give candidates a pretty clear idea of what the faculty are looking for. The exam should be written at a level appropriate for researchers in the broader area of artificial intelligence, and should not cover basic concepts that any graduate-level researcher in field would be familiar with. As preparation for the prelim, candidates should read published review articles to get a sense of the depth and sophistication with which research is presented. We are reluctant to specify page counts, but a typical journal review paper might be 15-20 pages as it appears in the journal. Whether or not candidates are successful in getting their prelim paper published, the prelim could be turned into a University of Colorado Technical Report, and we expect that the prelim will serve as the basis for an introductory chapter in the candidate's Ph.D. thesis, and to provide context for the thesis research.

Logistics of the prelim

The prelim consists of the following components:

- Review Paper - A written paper summarizing, evaluating, and synthesizing a coherent selection papers from the published research literature in the chosen area.
- Oral Presentation - A 20-minute presentation, followed by questioning by the prelim committee. If the student wishes more than 20 minutes for more detailed coverage, the committee can approve this request.

Candidates, along with their advisors, are responsible for forming a prelim committee of three faculty from the Computer Science Department and allied fields. These faculty will evaluate both the written and oral presentations. The candidate is responsible for inviting faculty to serve on the committee and obtaining approval of the topic, typically by writing a brief (1-3 paragraph) overview of the topic. With the committee's approval, the candidate can begin work on the prelim. We impose no time limit for writing, but typically the duration of work should be under a month. The oral presentation is scheduled once the committee has indicated its satisfaction with the written component of the prelim.

The prelim is administered on demand. Candidates can begin the process at any time during the academic year.

Successful completion of this examination satisfies the Area Exam portion of the Computer Science department's Preliminary Examination requirement.

Core faculty

The core faculty involved in the computational modeling prelim are

- Elizabeth Bradley
- Aaron Clauset
- Nikolaus Correll
- Clayton Lewis
- James Martin
- Michael Mozer

Faculty from outside of computer science who might be appropriate, depending on the candidate's topic, include:

- Matt Jones (psychology)
- James Meiss (applied math)
- Randall O'Reilly (psychology)
- Juan Restrepo (applied math)