Curriculum Structure and Graduation Requirements in the UAHuntsville M&S Degree Programs

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Keywords
Modeling and simulation education

Abstract

Modeling and Simulation (M&S) is increasingly important in the modern technological world. Nearly all aspects of engineering and the physical sciences already depend on M&S, and M&S is steadily finding more use in economics, politics, and social science. Concurrently, M&S is emerging as a distinct, cross-cutting, interdisciplinary academic discipline, and successful M&S degree programs are already well established at the University of Central Florida (Orlando FL) and Old Dominion University (Norfolk VA).

The University of Alabama System Board of Trustees gave final approval earlier this year to UAHuntsville's new graduate degree programs in M&S. Motivated by the extensive use of M&S in the North Alabama technical community, the university will offer M.S. and Ph.D. degrees in M&S, making it one of only three universities in the country offering M&S Ph.D. degrees. The UAHuntsville programs will provide students with broad exposure to many important modeling paradigms, simulation applications, professional practices, and supporting technologies. The new degree programs will be in full operation beginning with the Fall 2010 semester.

This paper will provide details regarding the degree programs. In particular, it will explain the curriculum structure and content for both degrees and detail entrance and graduation requirements.

1. INTRODUCTION

As Modeling and Simulation (M&S) becomes increasingly important in the modern world, there is a significant and growing need for practitioners, researchers, and faculty who have been broadly educated in M&S theory and practice. Concurrently there is an emerging confluence of on-going efforts to define and evolve a specification of the intellectual content of M&S as an academic discipline.

In response to those trends, university degree programs in M&S have been and are being developed. Successful M&S degree programs are already well established at the University of Central Florida (Orlando FL) and Old Dominion University (Norfolk VA). To address the need for M&S graduates in Huntsville and north Alabama, the University of Alabama in Huntsville (UAHuntsville) determined that graduate degree programs (both M.S. and Ph.D.) in M&S would be appropriate additions to the university's existing technology-centered academic offerings. The process of instantiating new M&S degree programs, which includes both curriculum design tasks and administrative approvals, is complete. UAHuntsville began accepting students and offering courses in the M&S degree program in the Spring semester (January) 2010.

This paper will report on the UAHuntsville M&S degree programs. After briefly summarizing the status of similar programs at two other universities, it will provide an overview of the UAHuntsville programs. This paper will cover program intent, curriculum structure and content, entrance and graduation requirements, and program status.[1]

2. OTHER M&S DEGREE PROGRAMS

The M&S degree program at Old Dominion University (Norfolk VA) was initiated in 1998. It is an interdisciplinary program; courses within the program are selected from multiple traditional academic departments and colleges. The program's current enrollment is approximately 130, and it produces about 20 M.S. and 4 Ph.D. graduates per year. The world's

[1] This paper is an informal introduction to the UAHuntsville M&S M.S. and Ph.D. degree programs. While information in this paper regarding program entrance requirements, graduation requirements, and courses is intended to be correct, this paper is not an official statement of program requirements. For that, please see the UAHuntsville catalog or official program documents.

first and third recipients of Ph.D.s specifically in M&S are graduates of this program.[2]

The M&S degree program at the University of Central Florida (Orlando FL) was initiated in 2002. As with the ODU program, it is an interdisciplinary program; courses within the program are selected from multiple traditional academic departments and colleges. The program's current enrollment is approximately 120, and it produces about 30 M.S. and 8 Ph.D. graduates per year.

3. UAHUNTSVILLE M&S DEGREE PROGRAMS

This section will review the intent, content, requirements, and status of the UAHuntsville M&S degree programs.

3.1. Program intent

The overall intent of the programs is to educate students in M&S as a coherent discipline, providing them with both specific skills and overarching conceptual frameworks that will allow them to perform effectively in any M&S context, regardless of application domain or modeling paradigm.

Students completing degrees in the program will have acquired professional skills in multiple areas of modeling and simulation, including the following:

1. Fundamental concepts of modeling and simulation, including modeling, abstraction, resolution, and validity
2. Modeling paradigms and methods
3. Verification and validation methods
4. Mathematics and statistics for M&S
5. Computing for M&S
6. Visualization and graphics
7. Human-computer interaction
8. Simulation system architectures
9. Simulation system implementation
10. Application-specific modeling and simulation practices
11. Simulation project management

The specific objectives of the UAHuntsville M&S Master's (M.S.) degree program are to prepare graduates for:

1. Practitioner positions in industrial and government organizations in M&S.
2. Research staff positions in industry, government, and academic research laboratories focused on M&S.
3. Ph.D. study in M&S.

The specific objectives of the UAHuntsville M&S Doctoral (Ph.D.) degree program are to prepare graduates for:

1. Research leadership positions in industry and government organizations in M&S.
2. Research leadership positions in academic research laboratories focused on M&S.
3. To prepare graduates for academic faculty positions in M&S.

3.2. Curriculum structure and content

Both the M.S. and Ph.D. programs have conventional academic structures in terms of credit hours and course requirements. A set of required core courses provide M&S students with a coherent disciplinary base. Beyond the core courses, each student thens select from additional elective courses to develop a concentrated expertise and research focus in some specialty within M&S.

However, the programs are unconventional in terms of the their interdisciplinary nature, reflecting the wide-ranging nature of the M&S discipline itself. The core courses, which were identified with assistance from the Graduate Program Directors of the M&S degree programs at the University of Central Florida and Old Dominion University, include courses that cover topics including introduction to modeling and simulation, systems simulation, mathematical modeling, systems engineering, and statistics.

Nearly all of the courses that make up the M&S degree programs are already offered at UAHuntsville. Because of the interdisciplinary nature of M&S, those courses are drawn from multiple traditional academic departments. This gives M&S students exposure to the range of applications, methods, and concepts that are relevant to M&S.

Table 1 summarizes the core and elective course requirements for the two programs.

Although most of the courses needed for the programs are already offered at UAHuntsville, a few new courses are needed. The new courses are:

1. MOD 501 Survey of Modeling and Simulation; First course in M&S program; survey of M&S discipline, including modeling methods, M&S environments, verification and validation, and applications.
2. MOD 520 Modeling and Simulation Data Strategies; Categories of data sets, data requirements, data modeling, and data acquisition for M&S applications.

[2] Dr. John A Sokolowski (graduated 2003) is now Director of Research and Interim Executive Director of the Virginia Modeling, Analysis, and Simulation Center at Old Dominion University and author of textbooks on M&S [1] [2]. Dr. Eric W. Weisel (graduated 2004) is now Chief Executive Officer of WernerAnderson, a private M&S research and services company.

3. MOD 591 Modeling and Simulation for Integrated Product Development; Use of M&S within the systems engineering process and as part of an integrated product development team.
4. MOD 620 M&S for Test and Evaluation; Practical and analytical methods for using M&S as part of formal test and evaluation.
5. MOD 625 Project Management for Modeling and Simulation; Types of M&S projects and applicable management techniques.
6. MOD 640 Continuous Systems Simulation; High-fidelity simulation of physical systems using continuous models.

Of these new courses, MOD 501 and MOD 520 have been taught previously at UAHuntsville as special topics courses as part of a M&S course development project [3], and MOD 501 is currently being taught during the Fall 2010 semester. MOD 625 and MOD 640 have been previously taught at Old Dominion University by a research faculty member now at UAHuntsville. MOD 591 was taught for the first time during the Summer 2010 semester.

Additional new M&S-specific courses will be added to the program over time as enrollment and student interests warrant. Possible future course topics include:[3]

1. Verification and Validation
2. Combat Modeling
3. Transportation and supply chain modeling

3.3. M.S. program admission and graduation

Admission to the M&S. M.S. program is in accordance with UAHuntsville requirements for master's programs as specified in the Graduate Catalog. Specific additional requirements for the M&S M.S. program include the following:

1. Completion of a Bachelor's degree in an appropriate and closely related field of study.
2. A minimum grade-point-average in undergraduate course work of 3.0/4.0.
3. A minimum total score of 1000 (verbal + quantitative) and a minimum of 3.0(analytical) on the aptitude test portion of the Graduate Record Examination.

Applicants are expected to have the following foundation knowledge for admission to the M&S M.S. program:

1. Mathematics fundamentals including differential and integral calculus, ordinary differential equations, calculus-based probability and statistics, and linear algebra.
2. Computing fundamentals including the algorithmic approach to problem solving, an object-oriented programming language such as C++ or Java, and data structures.

Graduation from the M.S. program require both completing a certain minimum number of course credit hours and satisfying several other requirements. There are two M.S. options, thesis and non-thesis. The thesis option requires completing a master's thesis, whereas the non-thesis option replaces the thesis with additional coursework requirements.

Credit hour requirements (thesis option):

- Core (required) courses — at least 18 hours
- Elective courses — at least 6 hours
- Master's thesis — at least 6 hours
- Total — 30 hours

Credit hour requirements (non-thesis option):

- Core (required) courses — at least 21 hours
- Elective courses — at least 12 hours
- Total — 33 hours

Other program completion requirements include:

- Comprehensive exam (completion of course work)
- Time limit (6 years from admission)

3.4. Ph.D. program admission and graduation

Admission to the M&S Ph.D. program is in accordance with UAHuntsville requirements for doctoral programs as specified in the Graduate Catalog. Specific additional requirements for the M&S Ph.D. program include the following:

1. Completion of a master's degree in an appropriate and closely related field of study (students who have completed 24 credits of graduate courses in an appropriate field may petition for direct admittance).
2. A minimum grade point average in graduate course work of 3.5/4.0.
3. A minimum total score of 1000 (verbal + quantitative) and a minimum of 3.0 (analytical) on the aptitude test portion of the Graduate Record Examination.

Applicants are expected to have the following foundation knowledge for admission to the M&S Ph.D. program:

1. Mathematics fundamentals including differential and integral calculus, ordinary differential equations, calculus-based probability and statistics, and linear algebra.
2. Computing fundamentals including the algorithmic approach to problem solving, an object-oriented programming language such as C++ or Java, and data structures.
3. Knowledge of the content from the core courses required in the M&S Masters Program

[3] Recommendations from the community regarding M&S course topics are encouraged.

(demonstrated by either completing those courses or other means approved by the Graduate Program Coordinator).

Graduation from the Ph.D. program will require both completing a certain minimum number of course credit hours and satisfying several other requirements that notably include completing a dissertation.

The Ph.D. program's credit hour requirements will be:

- Courses from M.S. program — at most 24 hours
- Core (required) doctoral courses — at least 18 hours
- Elective doctoral courses — at least 12 hours
- Doctoral dissertation — at least 18 hours
- Total — 72 hours

Other Ph.D. program completion requirements include:

- Preliminary exam (beginning of Ph.D. course work)
- Qualifying exam (completion of Ph.D. course work)
- Dissertation (at least 18 credit hours; must constitute novel and significant research)
- Academic residence (full-time one year or half-time four semesters)
- Continuous registration (at least 3 hours per semester during program)
- Time limit (5 years from Qualifying Exam)

For both the M.S. and Ph.D. programs, students who do not meet the stated admission requirements but otherwise show potential for graduate work in M&S may be admitted conditionally, with the expectation that they will meet the requirements through additional preparatory course work as determined by their advisor.

3.5. Distance education

The University of Central Florida and Old Dominion University both use distance education in their M&S degree programs with considerable success. UAHuntsville likewise plans to use distance education for its M&S degree programs. UAHuntsville has a highly successful distance education program in the Industrial and Systems Engineering and Engineering Management department, which offers complete degree programs via distance education. This experience will be extended to the M&S degree programs to make the programs accessible to the largest possible audience.

However, the M&S degree program is highly interdisciplinary and will draw on several departments for course offerings, not all of which have extensive experience with distance education. Introducing distance education to those departments for their courses within the M&S programs will be done incrementally so as to minimize disruption and give sufficient time for course conversion. Implementation of distance education offerings in the M&S degree programs will be done in the M.S. program first. In fact, two courses which will become part of the M&S degree program (one required core, one elective) have already been taught successfully via distance education. Once the entire M&S M.S. program is available via distance learning, conversion will continue with the Ph.D. program.

Distance education provides a convenient mechanism for institutional collaboration; courses taught by one institution can be offered at another via distance education at very low cost. This approach will be used to support collaboration with other institutions, including Old Dominion University and the University of Central Florida.

3.6. Status and plans

Several administrative approvals and milestones are required to create new degree programs as state university. At this writing (September 2010) the programs' statuses are as follows:

1. April 2009; UAHuntsville academic leadership decided to create M&S M.S. and Ph.D. programs.
2. June 2009; M&S M.S. and Ph.D. degree program proposals were approved by the University of Alabama System Board of Trustees.
3. September 2009; Alabama Council of Graduate Deans recommended approval of the M&S M.S. and Ph.D. programs to the Alabama Commission on Higher Education.
4. December 2009; M&S M.S. and Ph.D. degree program proposals were reviewed and approved by the Alabama Commission on Higher Education (ACHE).
5. January 2010; Final approval of the M&S M.S. and Ph.D. degree programs is given by the University of Alabama Board of Trustees.
6. Summer semester 2010; The first course specific to the program, MOD 591 M&S for Integrate Product Development, is offered.
7. Fall semester 2010; The M&S degree program is in full operation and students are being admitted.

Students currently enrolled in other UAHuntsville degree programs who wish to transfer to the M&S degree programs will be welcome to do so, as long as they meet the M&S programs' admission requirements.

Table 1. UAHuntsville M&S degree program courses.

	Core **(Required for all students)**	**Electives** **(Required as needed to satisfy credit hours)**
M.S.	MOD 501 Survey of M&S ISE 547 Introduction to Systems Simulation **or** CS 581 Modeling and Simulation I MA 565 Intermediate Mathematical Modeling CS 545 Introduction to Computer Graphics **or** CS 630 Artificial Intelligence I[4] ISE 627 Engineering Systems **or** CS 650 The Software Engineering Process ISE 690 Statistical Methods for Engineers	MOD 520 M&S Data Strategies MOD 591 M&S for Integrated Product Development MOD 620 M&S for Test and Evaluation MOD 625 Simulation Project Management MOD 640 Continuous System Simulation Other electives selected from M&S-related courses according the student's specific interests, and approved by the advisor.
Ph.D.	CS 548 Human-Computer Interaction **or** CS 645 Computer Graphics CS 582 Modeling and Simulation II CS 635 Computational Models of Cognition **or** CS 717 Advanced Algorithm Design and Analysis **or** CS 730 Artificial Intelligence II ISE 637 Systems Modeling & Analysis **or** ISE 726 Systems Modeling **or** CS 655 Formal Methods in Software Engineering **or** CS 750 Advanced Software Engineering Topics ISE 734 Value and Decision Theory **or** ISE 790 Advanced Statistical Applications	MOD 520 M&S Data Strategies MOD 591 M&S for Integrated Product Development MOD 620 M&S for Test and Evaluation MOD 625 Simulation Project Management MOD 640 Continuous System Simulation Other electives selected from M&S-related courses according the student's specific interests, and approved by the advisor.

[4] For the Non-Thesis Option, both CS 545 Introduction to Computer Graphics and CS 630 Artificial Intelligence I are required additional core courses

4. ACKNOWLEDGEMENTS

Financial support for the development of the UAHuntsville M&S degree programs was provided through generous grants from the Huntsville offices of two corporations: The Boeing Company and Science Applications International Corporation. Assistance with the preparation of the formal proposals required for degree program approval was given by several people at UAHuntsville, especially Dr. Debra M. Moriarity, Dean of Graduate Studies, and Dr. Daniel M. Rochowiak, Associate Professor of Computer Science. Their support is gratefully acknowledged.

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6. AUTHOR BIOGRAPHY

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Bradley C. Schricker is a Senior Engineer with Dynetics, Inc., currently working on numerous projects pertaining to Unmanned Aircraft System (UAS) simulation. He has 12 years of experience in modeling and simulation, focused in the areas of distributed simulation, discrete event simulation, and behavior representation. Mr. Schricker received a B.S. in Computer Science with a minor in Mathematics from Florida State University in 1998 and an M.S. in Modeling and Simulation from the University of Central Florida in 2007. He is currently pursuing a Ph.D., in Modeling and Simulation from the University of Alabama in Huntsville and expects to graduate in 2011.