**Intelligent Tutoring System (ITS) Design**

ITSs are artificially-intelligent systems that interact with the learner and the instructional environment to provide optimal learning experiences through real-time feedback and selection of problems/scenarios to match the learning capabilities of the individual or team under instruction. ITSs may be used standalone, integrated with existing training systems or be incorporated into traditional classroom settings.

This course is intended to support graduate students in a variety of technical disciplines including, but not limited to computer engineers & scientists, modelers, simulationists, psychologists (human factors, cognitive, perceptual), instructional designers, educational technologists, and those interested in training and learning science.

The projects associated with this course are multi-disciplinary and the tools used to author and conduct evaluations can be learned quickly by non-computer scientists.

**Course Learning Objectives:**

- This course will provide hands-on opportunities to build skills required to:
  - author adaptive instructional elements (courses, lessons, concepts) resulting in deployable ITSs which can be used standalone or with a human instructor in the loop
  - analyze learner data and classify/predict learner states (e.g., emotions or performance)
  - evaluate the effectiveness of ITSs and their components

**Required Text:** *Building Intelligent Interactive Tutors: Student-centered strategies for revolutionizing e-learning* by Beverly Park Woolf; published by Morgan Kaufmann.

**Reference Texts:** *Design Recommendations for Intelligent Tutoring Systems* series (available as free pdfs or downloadable e-books on GooglePlay)

- *Volume 1: Learner Modeling* edited by Sottilare, Graesser, Hu, and Holden
- *Volume 2: Instructional Management* edited by Sottilare, Graesser, Hu, and Goldberg
- *Volume 3: Authoring Tools* edited by Sottilare, Graesser, Hu, and Brawner

**Week 1 Topics – Introduction (Monday, 22 August; 6pm – 7:50pm)**

- Review of Syllabus including Group Projects and Reports
  - Project primer: research ethics
- Introduction to Intelligent Tutoring Systems (ITSs)
  - Elements of Intelligent Tutoring Systems
  - Human vs. Machine-based Tutoring
  - Intelligent Tutoring Genres (e.g., cognitive, dialogue-based, model-tracing, shell)

**Week 2 Topics – GIFT, LEM, and Project Discussion (Monday, 29 August; 6pm – 8:50pm)**

- Introduction to the Generalized Intelligent Framework for Tutoring (GIFT)
  - Learning Effect Model (LEM) for Tutoring
- Project Discussion
  - Topics, Goals and Team Formation
• Project primer: how to ask good research questions
• Project primer: how to conduct effect size studies

Week 3 Topics – Machine Learning (part 1 - Monday, 5 September; 6pm – 8:50pm)
• Machine Learning and Intelligent Tutoring Systems
  ▪ Automatically build/expand learner and domain models
  ▪ Identify learner strategies
  ▪ Classify or predict learner states (e.g., performance, learning, affect)
  ▪ Select optimal instructional decisions
• Uncertainty in ITSs
• Machine Learning Techniques
  ▪ Bayesian Networks
  ▪ Reinforcement Learning
  ▪ Markov Models and Decision Processes

Week 4 Topics – Group Project Proposal Presentations (Monday, 12 September; 6pm – 7:50pm)

Week 5 Topics - Machine Learning (part 2 - Monday, 19 September; 6pm – 8:50pm)
• Machine Learning and Intelligent Tutoring Systems
  ▪ Reasoning about learner knowledge
  ▪ Evaluating reinforcement learning tutors
• Project Discussion
  ▪ Project primer: demonstration of the Waikato Environment for Knowledge Analysis (WEKA) tools for learner state classification

Week 6 Topics – Individual Learner Modeling (Monday, 26 September; 6pm – 8:50pm)
• Learner Modeling and the LEM
  ▪ Representing Learner Knowledge, Traits, and States
  ▪ Representing Misconceptions in Learner Models
  ▪ Real-Time Learner Modeling
    ▪ Methods for acquisition of learner data
    ▪ Methods for classification of learner states
    ▪ Resources for classification algorithms
  ▪ Long-term Learner Modeling
    ▪ Learning Records Stores (LRSs)
    ▪ Learning Management Systems (LMSs)
  ▪ Learner Modeling in GIFT
    ▪ Standard vs. Non-Standard Elements

Week 7 Topics – Instructional Models for ITSs (Monday, 3 October; 6pm – 8:50pm)
• Instructional Models (pedagogy and andragogy)
• Instructional Best Practices
  ▪ Modeling Behaviors of Human Tutors
  ▪ Instructional Models informed by Learning Theory
    ▪ Socratic, cognitive, constructivist, situated learning, social interaction
    ▪ Open Learner Models (metacognitive processes in instruction)
Instructional Models facilitated by Technology
- Rule-based
- Decision Trees
- Agent-based (virtual humans, emotive agents, probabilistic agents)
  - Dialogues (learner and virtual instructor)
  - Trialogues (learner, virtual instructor, virtual student)
- Multi-Agent Architectures for ITSs

Week 8 Topics – Domain Modeling & Assessments (Monday, 10 October; 6pm – 8:50pm)
- Dimensions of Domain Models: complexity, definition, and alignment
  - Complex processes
  - Well defined and ill defined tasks
  - Alignment of Behaviors in Tutoring and Work Environments
- Representing cognitive domains (e.g., problem solving, decision-making, optimization)
- Representing affective domains (e.g., value judgments)
- Representing psychomotor domains (e.g., individual sports, physical tasks)
- Representing social domains (e.g., team sports, collaborative tasks)
- Assessments: Formative, Interim, and Summative Assessments
- Project Discussion
  - Project primer: how to author effective assessments

Week 9 Topics – Project Workday (Monday, 17 October; no class)
- Groups work independently on project presentations and reports

Week 10 Topics – Authoring ITSs (Monday, 24 October; 6pm – 8:50pm)
- Elements of ITS Authoring
  - Learner Model Configurations
  - Domain Model Configurations
    - Defining Course Flow
    - Defining Course Learning Objectives or Concepts
  - Authoring Surveys, Checks on Learning and Assessments (Tests)
- Usability Heuristics for ITS Authoring Systems
- Project Discussion
  - Project primer: GIFT Authoring Tools

Week 11 Topics – Team Tutoring (Monday, 31 October; 6pm – 8:50pm)
- Project Discussion
  - Project primer: Conducting a meta-analysis
- Team Tutoring Meta-Analysis
  - The Seven C’s – Communication, Cooperation, Coaching, Cognition, Conflict, and Conditions
  - Team Performance, Learning, Satisfaction and Viability
- Modeling Teams
  - Representing Team Roles and Behaviors
  - Representing Team Tasks
• Big Data Analysis Methods
  ▪ Comparing and contrasting ITS technologies (tools and methods)
  ▪ Comparing one learner to other learners
  ▪ Comparing groups of learners
  ▪ Comparing instructional methods
  ▪ Understanding population norms
  ▪ Project Discussion
  ▪ Project primer: Big Data Analysis Tools: SPSS, Excel, AMOS and RapidMiner

Week 12 Topics – Project Workday (Monday, 7 November; no class)

• Groups work independently on project presentations and reports

Week 13 Topics – Group Project Presentations and Reports due (Monday, 14 November; 6pm – 7:50pm)

Week 14 Topics – Group Project Demonstrations (Monday, 21 November; 6pm – 7:50pm)

Week 15 Topics – Special Topics in ITS Design (Monday, 28 November; 6pm – 7:50pm)

Grading Rubric:

• Homework Assignments (20%)
• Group Project Proposal Presentation (10%)
• Group Project Presentation (20%)
• Group Project Report (40%)
• Group Project Demonstration (10%)