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CM-7617 APPROVED
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12.9.22 ~BS

Coversheet - Proposal for New and Revised Courses

(Use for non-Pathways courses)

For CLE/Pathways courses, form can be found here: https://www.pathways.prov.vt.edu/proposal-forms.html

General Information			
Proposal Date:	1/31/22	*Department:*	Computer Science
Course Designator and Number (Cross-listed Course Designator and Number):	CS 6814		
Title of Course:	Science-Guided Machine Learning	*Credit Hours:*	3
Course Transcript (ADP) Title (30 Characters & Spaces Maximum):	Science-Guided Mach Learning		
Instructor and/or Departmental Contact:	Trey Mayo - Director of Graduate Programs		
Contact Phone:	(540) 231-0780	*Contact E-mail:*	treymayo@vt.edu
Please refer to Office of University Registrar for guidelines and policy requirements: https://registrar.vt.edu/governance.html			

Please count this course toward the following Scorecard Metrics areas:

☐ Study Abroad ☐ Service Learning ☐ Experiential ☐ Undergraduate Research

Scorecard Metrics Definitions can be found here: https://registrar.vt.edu/faculty-toolbox/scorecard-metrics.html

Please insert an X if this course should count toward First Year Experience:

☐ First Year Experience (FYE) *Include approval letter from FYE Director. More information can be found here:* http://www.fye.vt.edu

Select **ONE** of the following boxes
X New Course ☐ *Revised Course (*Revision > 20%* _____ *Revision < 20%* _____)

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Please include a summary of course revisions to the Justification section of proposal

A:	***Attach statement from Dean or Departmental Representative*** as to whether teaching this course will require or generate the need for additional departmental resources.			
B:	***Attach appropriate letters of support*** (e.g., prerequisite, corequisite, or cross-list memo) from affected departments and/or colleges.			
C:	***Effective Semester:***	Spring 2023		
D:	***Change in Title From:***			
	To:			
E:	***Change in Transcript Title (ADP) From:***		***To:***	
F:	***Change in Credit Hours From:***		***To:***	
G:	***Change in Lecture and/or Lab Hours From:***		***To:***	
H:	***Course Number(s) and Title(s) to be deleted from the Catalog with APPROVAL:***			

Approval Signatures			
Department Representative	DocuSigned by: Trey Mayo	*Date*	9/1/2022
College Curriculum Committee Rep		*Date*	9/21/2022
College Dean or Designee		*Date*	9/21/2022

Course Information

Catalog Description

Addresses specific advanced topics in science-guided machine learning (SGML). Seminal papers, book chapters, and recent developments in the field will be used as a source of material too new to yet be in a textbook. Detailed study of science-guided learning, science-guided model design, science-guided initialization, and hybrid-science-machine learning modeling. Student participation is in a seminar style format. Pre: Graduate standing. (3H, 3C)

Learning Objectives

Having successfully completed this course, the student will be able to:

1. Identify the category of SGML problems encountered in different scientific application contexts.
2. Critically analyze and contrast the strengths and weaknesses of SGML research strategies applicable for a scientific problem.
3. Identify similarities and differences between research methods developed in the field of SGML and apply in different application contexts.
4. Formulate and implement SGML methods to solve a real-world scientific problem.
5. Identify and present future research topics in the field of SGML.

Justification

Science-guided Machine Learning (SGML) is an emerging field of research that is rapidly gaining attention in the scientific and machine learning communities, as evidenced by the series of workshops, symposiums, and planning reports prepared by leading agencies on this topic. Research in KGML is referred to by several names in different communities, including 'physics-guided machine learning', 'physics-based machine learning', 'knowledge-guided machine learning', 'theory-guided data science', and 'physics-informed machine learning.' These terms describe the common goal of combining scientific knowledge (or theories or physics) with data-driven machine learning methods to accelerate scientific discovery. This course will impart the necessary training in SGML for students from diverse academic backgrounds to pursue interdisciplinary research at the intersection of machine learning and scientific domains. The course will introduce the current and advanced topics of SGML and provide a coherent perspective of research themes in SGML. These research themes will be illustrated using recent examples of cutting-edge research from diverse scientific disciplines. The course will also impart hands-on experience in conducting SGML research through a semester-long project, which will prepare them for future SGML research opportunities in academia, industry, and government agencies.

This course is placed at the 6000-level because it covers individual advanced topics that are appropriate for master's and PhD students and SGML is an emerging field that is constantly changing. Additionally, this course will support the pending Mechanics and Machine Learning Certificate as a core required course in machine learning. The course builds upon a foundation of computational algorithms and programming, multivariate calculus, differential equations, and probability and statistics.

Prerequisites and Corequisites

Pre: Graduate standing

Texts and Special Teaching Aids

Required: None. No specific textbook is required for this course because SGML is an emerging and changing field of research that is gaining the interest of those working in the machine learning fields.

Recommended:
Karpatne, A., Kannan, R., & Kumar, V. (2022). *Knowledge-guided Machine Learning: Accelerating discovery using scientific knowledge and data.* CRC Press. pp. 472.

Karpatne, A., Atluri, G., Faghmous, J.H., Steinbach, M., Banerjee, A., Ganguly, A., Shekhar, S., Samatova, N. & Kumar, V. (2017). Theory-guided data science: A new paradigm for scientific discovery from data. *IEEE transactions on knowledge and data engineering, 29*(10). pp. 2318-2331.

Topic Syllabus

Topic	**Percentage**
SGML Foundations	20%
SGML Problem Formulations and Research Methods	20%
Contemporary Applications of SGML	20%
Scientific Problem Identification and Application of SGML Research Methods	20%
Open Challenges and Future Prospects in SGML	20%
Total:	**100%**

Old (Current) Topic Syllabus

N/A

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Torgersen Hall, Suite 2000A
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shaffer@vt.edu

February 1, 2022

TO: Course Approval Committees

FROM: Cliff Shaffer 

Associate Department Head for Graduate Studies

RE: CS 6814

The Department of Computer Science is requesting approval for a new course proposal for CS 6814 "Science-Guided Machine Learning."
No additional resources will be required in order to offer this course.