UNIVERSITY REGISTRAR
VIRGINIA TECH

CM-8159 APPROVED
GCC: 4.27.23
CGPSP: 5.3.23

ENTERED 6.5.23 ~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:	2/8/23	*Department:*	Computer Science
Course Designator and Number (Cross-listed Course Designator and Number):	CS 5864		
Title of Course:	Learning-based Computer Vision	*Credit Hours:*	3
Course Transcript (ADP) Title (30 Characters & Spaces Maximum):	Learning-based Computer Vision		
Instructor and/or Departmental Contact:	Trey Mayo - Director of Graduate Programs		
Contact Phone:	X0780	*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%*_____)

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

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:***	Fall 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: Cliff Shaffer SABBF057372840	*Date*	3/22/2023
College Curriculum Committee Rep		*Date*	3/23/2023
College Dean or Designee		*Date*	3/23/2023

UNIVERSITY REGISTRAR
VIRGINIA TECH

Coversheet - Proposal for New and Revised Courses
(Use for non-Pathways courses)

Course Information

Catalog Description

Comprehensive introduction to modern computer vision. Fundamental concepts in computer vision and pattern recognition such as filtering, alignment, and matching. Survey of computer vision tasks, models, and learning techniques related to vision architectures, visual recognition methods, multimodal and generative models, and select advanced topics. Pre: 5805. (3H, 3C).

Learning Objectives

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

1. Analyze fundamental concepts in low-level image processing and how these concepts manifest in learning-based computer vision approaches;
2. Apply machine learning techniques in the context of computer vision;
3. Apply approaches for addressing classic vision problems such as object detection;
4. Understand the internal components of state-of-the-art computer vision architectures and critique trade-offs and design choices;
5. Utilize techniques for learning powerful vision representations in the absence of strong supervision;
6. Critically evaluate methods' strengths and weaknesses and propose new solutions to address them;
7. Synthesize current research trends and emerging topics in the field in order to discover research opportunities of interest;
8. Adapt learning-based computer vision methods to reason jointly on visual data and non-visual modalities;
9. Generate visual data using state-of-the-art generative architectures

Justification

Computer vision is a rapidly growing field which aims to build computational systems capable of automatically understanding images and video. Computer vision methods have diverse applications from perception for robotics and autonomous agents to description of visual content for the visually impaired. This course provides students with a broad survey of modern computer vision methods and techniques. Many existing computer vision courses focus on traditional methods stressing “low-level” vision techniques and aspects of computational photography, pattern recognition, and signal processing methods which leverage textures, edges, and gradients from images. In contrast, this course has a focus on the newer generation of computer vision approaches, which is overwhelmingly dominated by deep learning and machine learning techniques. Other courses in the Computer Science Department either provide necessary foundation material to undertake the proposed Computer Vision course (CS5805 Machine Learning), or do not cover vision topics in any depth (CS 5806 Machine Learning and CS5814 Deep Learning). Instead, these courses focus on fundamental aspects of deep or machine learning, providing students with background in model architectures generally, which could be applied to both natural language processing and vision. While both courses briefly touch on vision models, they do so at a much shallower level than the proposed course.

This course is taught at the 5000 level because it pulls from material covered in undergraduate degree programs in computer science, electrical and computer engineering, and mathematics to include data structures, algorithms, machine learning, and python programming. Students are required to be familiar with the statistical techniques and machine learning basics that are taught in CS 5805 - Machine Learning, which serves as a pre-requisite for this course.

Prerequisites and Corequisites

Pre: CS 5805 Machine Learning

Texts and Special Teaching Aids

No textbook is required as no single text covers all of the necessary information for the course, however, recommended texts include:

- Goodfellow, I., Bengio, Y., & Courville, A. (2016) *Deep learning*. MIT Press. https://www.deeplearningbook.org/
- Szeliski, R. (2022). *Computer vision: Algorithms and applications* (2nd ed.). The University of Washington. https://szeliski.org/Book/

Topic Syllabus

Topic	Percent of Course
1. Classical Topics and Fundamentals a. Field overview, growth, applications, historical development, common vision tasks, and current active research areas. (3%) b. Features and Filters (7%) i. Introduce fundamental concepts from image processing and show how to apply these concepts to various tasks as well as important theoretical concepts and their mathematical basis c. Grouping and matching (10%) i. Covers a variety of techniques for grouping visual features and the algorithms used for matching features to perform various image processing tasks d. Geometric vision (10%) i. Covers mathematical models relating the 3D world with 2D images from cameras and how to use those models to perform various tasks	30%
2. Computer Vision Today a. Basic concept review (5%) i. Review of fundamental concepts in deep learning as applied to vision, including various architectures and training techniques b. Vision architectures (5%) i. Introduce advanced vision architectures beyond CNNs, training techniques, and underlying principles c. Visual representation learning (10%) i. Covers various methods and techniques for learning representations of visual data which can be used for a variety of downstream tasks d. Object detection and semantic segmentation (10%) i. Covers both historical and state-of-the-art methods for detecting objects and segmenting visual data based on the data's semantic content e. Multimodal vision (10%) i. Methods for integrating and reasoning over multiple visual modalities or vision and another modality such as text, speech, or sensor data f. Generative vision (10%) i. Methods for generating images and videos using machine learning	50%
3. Advanced Topics (chosen contingent on time, student interest, and instructor choice): a. Saliency and eye-tracking b. Scene understanding, scene graphs and visual parsing c. Domain adaptation and generalization d. Visual knowledge representation e. 3d vision f. Video analysis and understanding g. Action recognition and pose estimation h. Robotics and computer vision i. Augmented reality and virtual reality j. Active learning k. Privacy and security in computer vision l. Real-time and efficient computer vision models m. Explainability and interpretability in computer vision n. Physics-based vision o. Emerging topics based on instructor choice	20%

Total: 100%

Old (Current) Topic Syllabus
N/A for new courses.

Department of Computer Science
620 Drillfield Drive
Torgersen Hall, Suite 3210
Blacksburg, Virginia 24061
P: (540) 231-0780
treymayo@vt.edu

March 22, 2023

To: Course Approval Committees

From: Trey Mayo, Ed.D. Trey Mayo Digitally signed by Trey Mayo Date: 2023.03.22 11:14:45 -04'00'
Director of Graduate Programs
Computer Science

The Department of Computer Science is requesting approval of a new course proposal CS5864 - Learning-Based Computer Vision. No new resources will be required in order to offer this course.