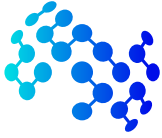


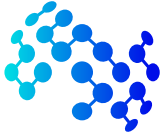
Core Courses Syllabi

CV702 - Geometry for Computer Vision

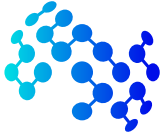
Title	Geometry for Computer Vision
Code	CV702
Loading	4 Credit-hours
Prerequisites	<ul style="list-style-type: none">• CV 701: Human and Computer Vision (or equivalent)• Hands-on experience with Python and Pytorch
Catalog Description	The course provides a comprehensive introduction to the concepts, principles and methods of geometry-aware computer vision which helps in describing the shape and structure of the world. In particular, the objective of the course is to introduce the formal tools and techniques that are necessary for estimating depth, motion, disparity, volume, pose and shapes in 3D scenes.
Goal	This graduate level course aims to familiarize students with the fundamental concepts and techniques of geometric computer vision and introduce to them several real-world computer vision applications involving geometry.
Content	This course covers the following major modules: (I) projective spaces and camera calibration, (II) epipolar geometry and multiview stereo (III) shape from X (IV) 3D machine vision applications.
Recommended Textbooks	<ol style="list-style-type: none">1. R. Hartley and A. Zisserman, <i>Multiple View Geometry in Computer Vision</i>, second edition, Cambridge, 2003. ISBN: 05215405182. Y. Ma, S. Soatto, J. Kosecka, and S. S. Sastry, <i>An Invitation to 3D Vision: from Images to Geometric Models</i>, Springer Science & Business Media, 2012. ISBN: 0387008934
Recommended References & Supplemental Material	Relevant research papers, tech reports, and surveys for each topic, where needed, are identified in the teaching plan ahead. In addition, the following textbooks will be useful: <ol style="list-style-type: none">1. E. Trucco, and A. Verri, <i>Introductory Techniques for 3D Computer Vision</i>, Prentice Hall, 1998. ISBN: 01326110822. C. Wöhler, <i>3D Computer Vision: Efficient Methods and Applications</i>, Springer Science & Business Media, 2012. ISBN 9781447141501



Teaching Week	Topics
1	Course Overview and Motivation Lecture <ul style="list-style-type: none">• Course introduction: historical context and applications of geometry for computer vision Lab <ul style="list-style-type: none">• A tutorial/refresher on Python and relevant deep learning libraries (e.g., Pytorch)
2	Optics and Digital Cameras Lecture <ul style="list-style-type: none">• Camera pipeline• Lenses and ray-tracing• Camera sensors: CMOS, CCD Lab <ul style="list-style-type: none">• Ray tracing for convex and concave mirrors and lenses at different focal lengths
3	Projective Spaces and Homography Lecture <ul style="list-style-type: none">• Introduction to projective spaces• Homogeneous coordinates in 2D+3D, points, lines, planes, templates (articulated, deformable), homographies Lab <ul style="list-style-type: none">• Assignment # 1 due
4	Optical Flow Lecture <ul style="list-style-type: none">• Optical flow: 2D point correspondences• Image alignment and tracking Lab <ul style="list-style-type: none">• Implement a feature based image registration algorithm
5	Camera Models and Camera Calibration Lecture <ul style="list-style-type: none">• Camera models• Single-view geometry• Camera calibration• Image stitching Lab <ul style="list-style-type: none">• Implement an algorithm to detect vanishing points



Teaching Week	Topics
6	Epipolar Geometry and Stereo Essentials Lecture <ul style="list-style-type: none">• Epipolar geometry• Stereo essentials• Fundamental matrices Lab <ul style="list-style-type: none">• Assignment # 2 due
7	Multiview Stereo Lecture <ul style="list-style-type: none">• Geometry of multiple views• Multiview stereo, triangulation and rectification Lab <ul style="list-style-type: none">• Write a function to triangulate pairs of 2D points in the images to a set of 3D points
8	Shape from X (Part- 1) Lecture <ul style="list-style-type: none">• Shape from X: Reflectance map, shape from shading, photometric stereo, shape from optical flow (moving camera, moving objects) Lab <ul style="list-style-type: none">• Implement an algorithm that reconstructs a surface using the concept of photometric stereo (Part 1- Compute Albedo)
9	Shape from X (Part- 2) Lecture <ul style="list-style-type: none">• Shape from X: Rotating camera, silhouettes, space carving, light stripe encoding Lab <ul style="list-style-type: none">• Implement an algorithm that reconstructs a surface using the concept of photometric stereo (Part 2 - Compute Normals)
10	Bundle Adjustment Lecture <ul style="list-style-type: none">• Bundle adjustment• Range/Depth image processing Lab <ul style="list-style-type: none">• Assignment # 3 due• Mapping to CLO• CLO2 (M), CLO3 (H), CLO6 (H)



Teaching Week	Topics
11	Graphics Lecture <ul style="list-style-type: none">Graphics: View interpolation, reconstruction of geometry, materials and lighting Lab <ul style="list-style-type: none">Given two consecutive frames of a video, synthesize the intermediate frame using context aware interpolation
12	Pose Estimation Lecture <ul style="list-style-type: none">Pose estimation from two imagesPose from 3D point correspondencesPose from projective transformationsPose from point correspondences Lab <ul style="list-style-type: none">Study geometry-aware 3D pose estimation using convolutional neural networks and submit a report
13	Virtual and Augmented Reality Lecture <ul style="list-style-type: none">Virtual reality (VR)Augmented reality (AR)3D vision applications in VR and AR Lab <ul style="list-style-type: none">Write a three page report to identify a new potential application of VR or AR and describe how you would develop and deliver your end solution
14	Robotics Lecture <ul style="list-style-type: none">Basics of robotics,Simultaneous localization and mapping (SLAM)SLAM applications in autonomous driving, unmanned aerial vehicles (UAVs) Lab <ul style="list-style-type: none">Assignment # 4 due
15	Guest Lecture & Review Lecture <ul style="list-style-type: none">Guest lecture on a trending topic Lab <ul style="list-style-type: none">Review and Exam Preparation