# Online Research Seminar Syllabus

## 1. Overview

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| **Title** | Computer Vision for AR/VR | | |
| **Targeted Students** | Students interested broadly in computer vision and its applications in robotics, AR/VR, autonomous navigation, and 3D sensing | | |
| **Prerequisites** | **College Students** | Required course/Knowledge | Linear algebra, multi-variable calculus |
| | | Recommended Materials for preparing for the course | Introduction to Linear Algebra, by Gilbert Strang |

**2. Program Introduction and Objectives**

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| **Course Description** | This course introduces basic concepts in 3D computer vision, with a focus on geometry-based vision. The course will provide background on image representations, image transformations, and 3D reconstruction. Students taking this course should develop familiarity with fundamental concepts of modern geometry-based computer vision. |
| **Software/Tools (if any)** | Python (OpenCV, NumPy, SciPy) |

**3. Program Schedule**

| Week | | Lecture | Teaching fellow Session (lab/case study, etc.) | Assignment | Reading Materials |
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| 1 | **Topic** | **2D Transformations** | | | Szeliski textbook |
| | **Detail** | Classification of 2D transformations, linear estimation | Introduction to Python and OpenCV | | |
| 2 | **Topic** | **Homography Estimation** | | Homography estimation | Szeliski textbook |
| | **Detail** | Definition of homographies, the direct linear transform | Solving linear least squares problems and linear systems | | |
| 3 | **Topic** | **Single View Geometry** | | | Szeliski textbook |
| | **Detail** | Camera models, intrinsics and extrinsics, geometric calibration | Math problems on camera matrices | | |
| 4 | **Topic** | **Pose Estimation and Epipolar Geometry** | | 3D reconstruction | Szeliski textbook |
| | **Detail** | Triangulation, stereo, epipolar geometry, rectification | Math problems on stereo | | |
| 5 | **Topic** | **Fundamental Matrix Estimation** | | | Szeliski textbook |
| | **Detail** | Essential and fundamental matrices, eight-point algorithm | Math problems on epipolar geometry | | |
| 6 | **Topic** | **Final Project Discussion Session** | | | |
| | **Detail** | Discussion of problems in implementation of homography estimation and auto-stitching | Debugging common mistakes in homography estimation | | |
| 7 | **Final Oral Presentation and Written Reporting** | | | | |

**4. Problem Sets/Written Assignments/Quizzes**

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| **Total Number of Assignments** | 2 times |
| **Submission Deadline** | 7 Days after class |

**5. Final Oral and Written Project**

Image homographies for autostitching

Final projects will be group work. The goal of the project will be to build on what was developed in the first assignment, to perform autostitching for panoramic imaging.

Students are required to meet the following objectives before attending the session in Week 6:

- Apply homography estimation techniques to images provided by the instructors (completing all objectives in homework assignment 1).

**5.1 Final Oral Presentation**

- Oral Project Theme: Explanation of what was implemented and what data it was applied on.

- Oral Project Requirements: Short presentation (total time depends on number of students), showcasing of produced results on images captured by students.

**5.2 Final Written Report**

- Written Project Requirements: Explanation of the homography algorithm, estimation procedure, implementation; visualization of results.

**6. Suggested Future Research Fields/Direction/Topics**

This course focuses on geometry-based foundations. Those interested in computer vision should also explore machine learning and learning-based vision techniques. Additionally, background in computer graphics can be incredibly helpful for computer vision engineers and researchers.