Eyes in The Sky: Drones for the Built Environment

Course Information
4.s28
Credit hours: 3-3-3 G/U
Tuesday 11 – 1 PM (Subject to change)
Location: 9-450A

Instructor Information
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TA: Mohanned ElKholy
Pilot: Dennis Fisher

Course Description

Drones are providing us with new ways to map, monitor, and measure our changing landscape. Advances in digital image processing enable one to go from flying a drone to working with accurate maps and 3D models in a matter of hours. This course examines the applications of drones in which the aerial perspective can be integrated into architecture, engineering and construction practice. In this course, students will gain hands-on experience with drone vehicles, sensors, image processing software and applications. Students will learn how to use drones to help them better understand our changing environment. With the proliferation of drones there are increasing opportunities to use drones for scientific remote sensing data acquisition and applications.

This course focuses on understanding the fundamentals behind acquiring imagery data with drone-based cameras (e.g. multi-spectral and thermal) and processing the data for various applications. Students will also get to know the fundamentals of open source and proprietary software packages as they relate to UAV technology, drone operations, flight planning and data collection and management as well as how to integrate resulting data into other software tools such as GIS, BEM and Python libraries. Recognizing the critical role that AI will play in defining the future international competition, many countries now regard AI as a national priority. The United States launched the American Artificial Intelligence Initiative in 2019 with the mission to promote its leadership in AI research, development, and application. One of the eight national strategies identified in this initiative is to “provide education and training opportunities to prepare the American workforce for the new era of AI”.

In this course, students will go through aerial data processing, mainly data collected from drones, including working with Orthomosaic, Digital Terrain models (DTMs), Digital Surface Models (DSMs), Point Cloud, and 3D mesh modeling. This course will also provide technical and applied knowledge on using drones for building assessment through aerial thermography and the use of UAVs in various applications. The course will also cover the technical foundation of enhanced data processing using AI, including image segmentation and object identification, and feature extraction basics using computer vision techniques in Python. Upon completion of this course, students will have theoretical and applied and technical knowledge that will aid them to use UAVs in various applications. This course is the extended version of Eyes in The Sky Workshop that was offered during IAP 2022, which resulted in 2D mapping of Briggs field and 3D modelling of Simmons Hall at MIT campus.

Students during field training with certified drone pilot. Briggs Field


Students 3D mapping and data processing work, Simmons Halls

Prerequisites/Co-requisites

- *Interest in UAVs and unmanned Vehicles*
- *Python knowledge is preferred*

What to expect in this course

This course will build both theoretical and technical knowledge for drone deployment as a mean for valuable urban data acquisition. The course will achieve these foundations through four modules:

1) Flight Operations and Drones Platforms,
2) Flight planning, image processing, & feature detection,
3) Drone Sensors and 3D modeling,
4) Computer Vision and Image processing

Sessions Schedule

(Hybrid, class sessions, Zoom and Field Training on Campus)

	Topic	
Week 1	**Overview /Flight Operations**	
	FAA Regulations Examples of Platforms - DJI, Skydio, Parrot, eBee, Wingtra, etc. Platform Components Command & Control Systems Positioning & Navigation Systems Flight Design & Flight App Options	**In Class & Zoom**
	Drones Application in Cities	
Week 2	**Drone Platforms and Sensors**	
	DJI Platforms - Enterprise vs Prosumer RGB & IR Sensors LiDAR Hyperspectral Imaging	**In Class & Zoom**
	Climatic Sensors & Uses **Drones Applications in Climate Change**	
Week 3	**Drone Capture Workflow**	**Field Training**
	Workflow - Data Capture, Retrieval, Review, Processing, Analysis	
Week 4	**Data Collection / Management (2D)**	
	Collecting 2D Data Map Accuracy Ground Control Points 3D Modeling DroneDeploy	**In Class & Zoom**
	Introduction to AI & Computer Vision **Setting up Python Environment**	
	Drone Operations Assignment 1: Flight Design	
Week 5	**Data Collection / Management (3D)**	
	2D Mission GCP Mission 3D Mission	**Field Training**
Week 6	**Data Management and CV**	
	Computer Vision in Image Analysis	**In Class & Zoom**

	Open CV and Image Processing Feature extraction and Segmentation Models	
	Computer Vision Models and Image Analysis **How to work with Image Data in Python (Intro Open CV and NumPy)**	
Week 7	**Data Processing (2D & 3D)**	
	Fundamentals of Mapping & Modeling Mapping Software Overview Aerial Photogrammetry (Guest Lecture from AirWorks) Using DronseDeploy's Map Engine	**In Class & Zoom**
	Thermal Image Analysis using OpenCV	
Week 8	**Data Processing – Flight Design and Processing Workflow**	
	Demonstrate Flight Planning Mission Design, Mission Execution, Processing Workflow	**Field Training**
	Drone Operations Assignment 2: Aerial Data Processing	
Week 9	**Data Processing - Review and Data Management**	
	Captured Data review Data Management	**In Class & Zoom**
	Feature Extraction in Image Data – Detection Models	
	Image Analysis Assignment 1: Detection models and 2D image data	
Week 10	**Thermal Imaging**	
	Intro to Thermal Imaging Thermal Sensors Flight Path Considerations Facade & Roof Inspections FLIR Tools	**Field Training**
	Submission of Exercise (A) and feedback **Image Manipulation using OpenCV and NumPy**	
Week 11	**Thermal Imaging - Flight Sessions (Pre-Sunrise or Post-Sunset)**	
	Flight Planning, Night Flight Considerations Façade Thermal Inspection using IR Group Project Data collection	**Field Training**
Week 12	**Thermal Imaging**	
	Did We Capture Meaningful, Actionable Data? Guest Lecture: Tarek Rakha (Thermal Imaging and Building Performance)	**In Class & Zoom**
	Setting Up pipeline for Final Project	
Week 13	**Final Review - What Did We Learn?**	
	Review of Captured Data What would we do differently?	**In Class & Zoom**
	Final Project Presentation	

Assessments

During this course, students will work in teams of to apply both theoretical and technical knowledge though flight planning and flight procedures to a mapping problem. Therefore, participation in the class will be essential to the success of this course. There are three key components designed to link flight operations, computer vision and urban data acquisition knowledge.

Weekly Attendance and Flight Training Sessions: 30%

Weekly participation is an essential component of the class. Field training sessions are all mandatory as they are designed to assist you in gaining the skillset required to design a drone flight, execute it and the final project. The breakdown of this component of the assessment is as follows:

- ***Class Attendance: 10%***
- ***Field training sessions: 10%***
- ***On-site flight Design and execution: 10%***

Data Processing with CV: 20%

In this assignment, you will have the freedom to choose between urban data or building data to apply object detection pipeline using CV. We will walk you through the entire pipeline from data cleaning, image augmentation, setting up object detection workflow and data management.

Final Project: 50%

The final project will involve data acquisition and analytics problem. We will have a case study for urban mapping and analytics using drones, however, students have the freedom to develop their own project of interest that include data collection with UAV, flight design with Drone Deploy, Data processing and image analytics using CV.

Course Expectations and Policies

Attendance: Regular class attendance and active engagement in class are essential and will help you better develop the right skillset needed for the final project. The five field training sessions will be used further to build the technical skillset on drone operations, flight design and planning, so all field training sessions are mandatory to attend. More than two missed sessions will be considered excessive, resulting in an NC grade. We welcome your thoughts throughout the course on how we might improve class processes that will encourage effective communication and dialogue.

Inclusivity Statement

MIT values an inclusive environment. Our intent for this class is that students from all backgrounds and perspectives to be equally-served by this course. We hope in this course to develop a supportive learning community that will foster rich discussions that are respectful for diversity, gender, identity, sexuality, religion, and culture. Any student who has difficulty in the class environment and believes this may affect their performance in the course is urged to contact us directly.

Special Accommodations and Disability Support Services

If you need disability-related accommodations, I encourage you to meet with me early in the semester. If you have not yet been approved for accommodations, please contact Student Disability Services at sds-all@mit.edu.
I look forward to working with you to assist you with your approved accommodations.

Mental Health

As a student, you may experience a range of challenges that can interfere with learning, such as strained relationships, increased anxiety, substance use, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may impact your ability to attend class, concentrate, complete work, take an exam, or participate in daily activities.

Undergraduates: Please discuss this with Student Support Services (S3). You may consult with Student Support Services in 5-104 or at 617-253-4861.

Graduate Students: Please reach out to the deans for personal support in the Office of Graduate Education.

For urgent or after-hours concerns, please contact MIT Police.