CS1951R: Introduction to Robotics
Professor Stefanie Tellex

Build, Program, and Fly your very own Drone
Logistics

- Assignment 0 due tonight!
- Assignment 1 due on Thursday!
- 44 people applying for 30 spots so far
  - We will let you know if you are in by Wednesday night.
- Drone parts handed out on Thursday!
Robot/Environment Interaction

Perceptual data
- Images from a camera
- Range sensor from a LIDAR
- ...

Control System

Observations → World Model → Actions

External World

Actions
- Drive to a location.
- Pick up an object.
- ...

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Robot/Environment Interaction

Perceptual data
- Images from a camera
- Range sensor from a LIDAR
- Human input. e.g., “Go to the truck.”

Actions
- Drive to a location.
- Pick up an object.
- Communicative output. e.g., (“Which truck?”)
What is a robot?

- “A robot is a machine—especially one programmable by a computer—capable of carrying out a complex series of actions automatically.” (Wikipedia)

- Examples:
  - Cell phone?
  - Drone?
  - Car with cruise control?
  - Self-driving car?

- Sensors and actuators
Sensors

- Passive sensors
  - Camera
  - Odometry
  - Joint encoders

- Active sensors
  - Lidar
  - IR
  - Ultrasound
Actuators

- Electric motors
- Series elastic
- Brushless motors
Applications of Robotics
PR2

3-DOF Sensor Head
- Wide-angle color stereo
- Narrow-angle monochrome stereo
- LED texture projector
- 5MP Camera

Tilting Laser Range Finder

4-DOF Arm + 3-DOF Wrist

1-DOF Gripper
- Fingertip sensors

Wide-angle Camera

Telescoping Spine

Base Laser Range Finder

Servers

Steered and Driven Casters
Baxter

Note: Gripper plate to gripper plate measurement. Grippers and fingers will add dimension.

103"
(261 cm)

73"
(186 cm)

37"
(94 cm)
Torso only

70"
(178 cm)
Short pedestal DR

73"
(185 cm)
Tall pedestal

32.0"
(81 cm)
Asimo
Project Wing

1.5m WIDE X 0.8m TALL

PACKAGE

FIXED WING

ROTORS
Keepon
Scan the workspace with the wrist camera.
Applications of Drones
MAX-8 Utility UAV v1.2

Photo Mapping Package

Starting at $19,495.99

Now with improved vibration isolation for critical flight components and custom CNC mounting hardware, the MAX-8 V1.2 is even more rigid and reliable for repeated autonomous take-off-to-landing missions!
Recreation
Entertainment
IN 2015 WE PUT 100 DRONES IN THE SKY
Safety
Unmanned Aircraft Systems

Drone Users
The FAA warns unauthorized drone operators that they may be subject to significant fines if they interfere with emergency response operations. Flying a drone without authorization in or near the disaster area may violate federal, state, or local laws and ordinances, even if a Temporary Flight Restriction (TFR) is not in place. Allow first responders to save lives and property without interference.

An unmanned aircraft system (UAS), sometimes called a drone, is an aircraft without a human pilot onboard – instead, the UAS is controlled from an operator on the ground.

When you fly a drone in the United States, it is your responsibility to understand and abide by the rules.

FAA’s Hurricane Irma Update (Ingles/español)
The FAA updates travelers, general aviation pilots, and drone operators.
Midair Collision Over Hudson River

https://www.ntsb.gov/investigations/AccidentReports/Pages/AAR1005.asp
On August 8, 2009, at 1153:14 eastern daylight time, a Piper PA-32R-300 airplane, N71MC, and a Eurocopter AS350BA helicopter, N401LH, operated by Liberty Helicopters, collided over the Hudson River near Hoboken, New Jersey. The pilot and two passengers aboard the airplane and the pilot and five passengers aboard the helicopter were killed, and both aircraft received substantial damage from the impact. The airplane flight was operating under the provisions of 14 Code of Federal Regulations (CFR) Part 91, and the helicopter flight was operating under the provisions of 14 CFR Parts 135 and 136. No flight plans were filed or were required for either flight, and visual meteorological conditions prevailed at the time of the accident.
The National Transportation Safety Board determines that the probable cause of this accident was (1) the inherent limitations of the see-and-avoid concept, which made it difficult for the airplane pilot to see the helicopter until the final seconds before the collision, and (2) the Teterboro Airport local controller’s nonpertinent telephone conversation, which distracted him from his air traffic control (ATC) duties, including correcting the airplane pilot’s read back of the Newark Liberty International Airport (EWR) tower frequency and the timely transfer of communications for the accident airplane to the EWR tower. Contributing to this accident were (1) both pilots’ ineffective use of available electronic traffic information to maintain awareness of nearby aircraft, (2) inadequate Federal Aviation Administration (FAA) procedures for transfer of communications among ATC facilities near the Hudson River Class B exclusion area, and (3) FAA regulations that did not provide adequate vertical separation for aircraft operating in the Hudson River Class B exclusion area.
Figure 3. View of helicopter from airplane cockpit about 9 seconds before collision.
**Figure 4.** View of helicopter from airplane cockpit about 5 seconds before collision.
Figure 5. View of helicopter from airplane cockpit about 1 second before collision.
Causes of the Accident

- Inherent limitations of the see-and-avoid concept.
- The Teterboro Airport local controller’s nonpertinent telephone conversation.
Teterboro Airport plane crash kills 2 near NYC

USA TODAY NETWORK  Abbott Koloff, Mark Krulish, Scott Fallon, The (Bergen County, N.J.) Record

Published 5:39 p.m. ET May 15, 2017 | Updated 6:19 a.m. ET May 16, 2017
Special Rule for Model Aircraft

(P.L. 112-95, Section 336)

https://www.faa.gov/uas/programs_partnerships/uas_arctic/media/Sec_331_336_UAS.pdf
SEC. 336. SPECIAL RULE FOR MODEL AIRCRAFT.

(a) IN GENERAL.—Notwithstanding any other provision of law relating to the incorporation of unmanned aircraft systems into Federal Aviation Administration plans and policies, including this subtitle, the Administrator of the Federal Aviation Administration may not promulgate any rule or regulation regarding a model aircraft, or an aircraft being developed as a model aircraft, if—

(1) the aircraft is flown strictly for hobby or recreational use;
(2) the aircraft is operated in accordance with a community-based set of safety guidelines and within the programming of a nationwide community-based organization;
(3) the aircraft is limited to not more than 55 pounds unless otherwise certified through a design, construction, inspection, flight test, and operational safety program administered by a community-based organization;
(4) the aircraft is operated in a manner that does not interfere with and gives way to any manned aircraft; and
(5) when flown within 5 miles of an airport, the operator of the aircraft provides the airport operator and the airport air traffic control tower (when an air traffic facility is located at the airport) with prior notice of the operation (model aircraft operators flying from a permanent location within 5 miles of an airport should establish a mutually-agreed upon operating procedure with the airport operator and the airport air traffic control tower (when an air traffic facility is located at the airport)).

(b) STATUTORY CONSTRUCTION.—Nothing in this section shall be construed to limit the authority of the Administrator to pursue enforcement action against persons operating model aircraft who endanger the safety of the national airspace system.

(c) MODEL AIRCRAFT DEFINED.—In this section, the term “model aircraft” means an unmanned aircraft that is—

(1) capable of sustained flight in the atmosphere;
(2) flown within visual line of sight of the person operating the aircraft; and
(3) flown for hobby or recreational purposes.
FAA Safety Guidelines

- Fly at or below 400 feet
- Be aware of airspace requirements and restrictions
- Stay away from surrounding obstacles
- Keep your UAS within sight
- Never fly near other aircraft, especially near airports
- Never fly over groups of people
- Never fly over stadiums or sports events
- Never fly near emergency response efforts such as fires
- Never fly under the influence of drugs or alcohol
What is the definition of recreational or hobby use of a UAS?

Recreational or hobby UAS use is flying for enjoyment and not for work, business purposes, or for compensation or hire. In the FAA's Interpretation of the Special Rule for Model Aircraft, the FAA relied on the ordinary, dictionary definition of these terms. UAS use for hobby is a “pursuit outside one's regular occupation engaged in especially for relaxation.” UAS use for recreation is “refreshment of strength and spirits after work; a means of refreshment or division.”
How can I tell what class of airspace I'm in?
Under the Small UAS Rule (part 107) (PDF), operators must pass an aeronautical knowledge test to obtain a Remote Pilot Certificate. This test will quiz prospective operators on how to use aeronautical charts to determine airspace classifications. For reference, aeronautical charts and a Chart User's Guide are also available on the FAA's website. These charts are the FAA's official source of airspace classifications. Additionally, the FAA's B4UFLY app, which is designed to help recreational UAS flyers know where it's safe to fly, shows users if they are in controlled airspace (Class B, C, D, or E airspaces) in a given or planned location. If the app's status indicator is yellow ("Use Caution – Check Restrictions"), a user is in uncontrolled (Class G) airspace.
Frequently Asked Questions

If I'm just flying my UAS inside a building, do I have to register it?

If you're flying indoors, you do not need to register your unmanned aircraft as the FAA does not regulate indoor UAS use.
Educational Use of UAS

• A person may operate an unmanned aircraft for hobby or recreation in accordance with section 336 of the FAA Modernization and Reform Act of 2012 (FMRA) at educational institutions and community-sponsored events provided that person is (1) not compensated, or (2) any compensation received is neither directly nor incidentally related to that person’s operation of the aircraft as such events;

• A student may conduct model aircraft operations in accordance with section 336 of the FMRA in furtherance of his or her aviation-related education at an accredited educational institution.

• Faculty teaching aviation-related courses at accredited educational institutions may assist students who are operating a model aircraft under section 336 and in connection with a course that requires such operations, provided the student maintains operational control of the model aircraft such that the faculty member’s manipulation of the model aircraft is incidental and secondary to the student’s (e.g., the faculty member steps-in to regain control in an event the student begins to lose control, to terminate the flight, etc.).
Educational Use of UAS

“Therefore, we find that the use of small unmanned aircraft by students at accredited educational institutions as a component of science, technology and aviation-related educational curricula or other coursework such as television and film production or the arts more closely reflects and embodies the purposes of “hobby or recreational” use of model aircraft and is consistent with the intent of section 336 of the FMRA…. The student is, however, responsible for meeting and complying with all other elements required for lawful model aircraft operations pursuant to Section 336 of the FMRA, including the student not receiving any form of compensation (including reimbursement of costs, honorarium, etc..,) directly or incidentally to his or her operation of the model aircraft.”
Airspace Maps

http://knowbeforeyoufly.org/air-space-map/
# 2017 Brown Football Schedule

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<th>DATE</th>
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<th>NOTES</th>
<th>RESULT</th>
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<td>TV: Ivy League Network</td>
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Visual Flight Rule Charts

https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/vfr/

Safety

- Safety is everyone’s responsibility.
Safety Inside

- Equipment
  - Safety glasses
  - Gloves
  - Walls
- Checklists
Flying Checklist

- Am I connected to my drone, not someone else’s?
- Safety glasses?
- Do I have space to fly?
  - Flyaway possibilities?
  - Collision possibilities?
- Check the kill switch?
- Armed?