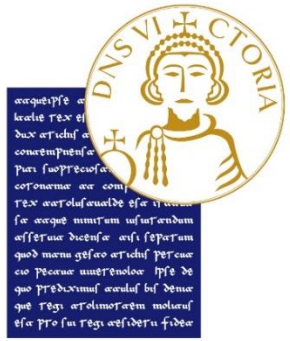


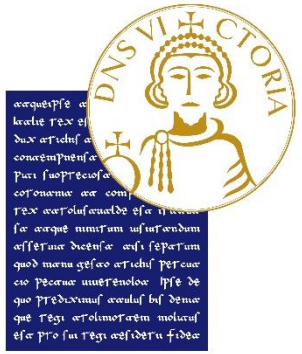
UNIVERSITÀ DEGLI STUDI DEL SANNIO Benevento

IEEE INSTRUMENTATION & MEASUREMENT SOCIETY®

A/D L.E.S.I.M.

MEASUREMENT FOR DRONES

Luca De Vito



SCOPE

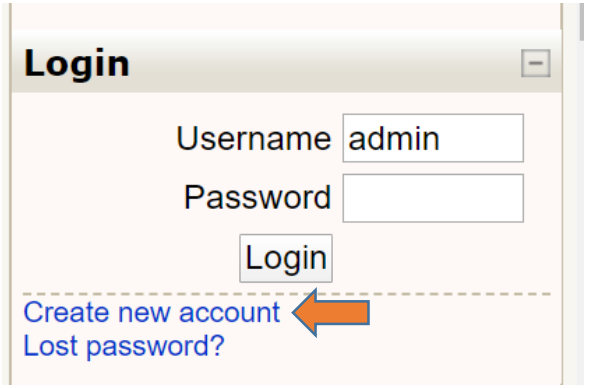
- The course aims to present the measurement technologies used in a drone, both for flight control and for the payload.
- In a first part, the drone architecture will be presented and the different sensors for flight control will be described, including inertial and navigation sensors. Some details about data fusion algorithms will be also given.
- Then the sensors used as payload will be studied, including LIDARs, visual cameras and thermal cameras. Some details about ultrasound and light sensors for automatic take-off and landing will be also given.
- A third part of the course will show how to collect data from the drone sensors to a ground control station and how to write a program that connects to the drone to get monitoring data.
- The last part of the course will deal with image acquisition and 3D reconstruction by aerial photogrammetry.
- The course will contain practical experiences on data acquisition from navigation sensors and LIDAR, development of monitoring software and 3D reconstruction by aerial photogrammetry.

COURSE MATERIAL

- Material is available on the Moodle portal:

  lms.misureremote.unisannio.it

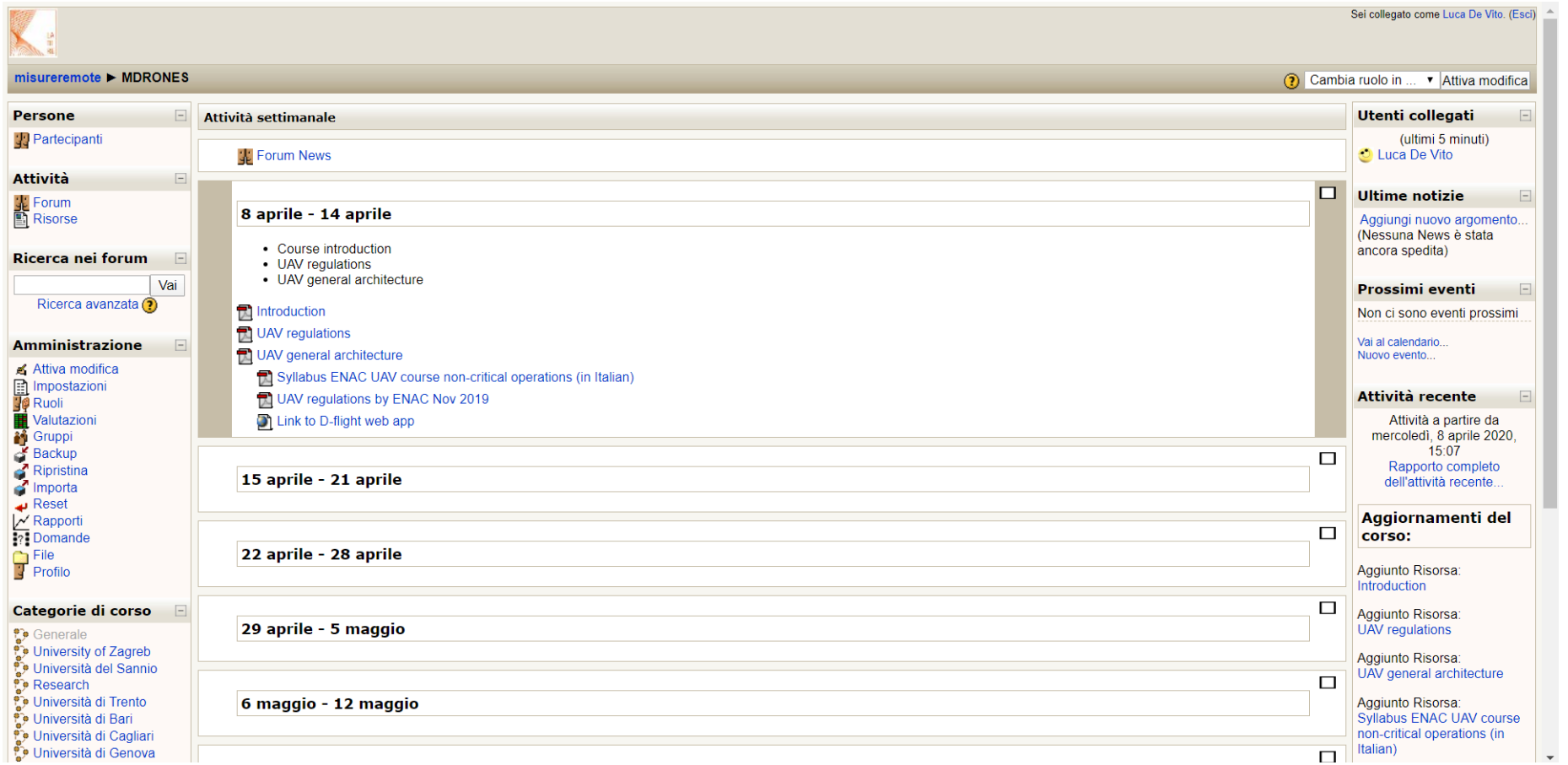
- It is necessary to log onto the portal
- If you don’t have the credentials not, you should register clicking the link:



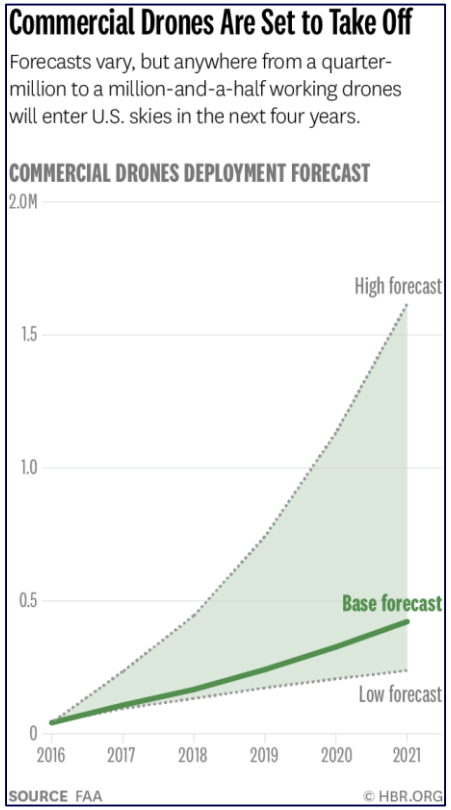
- After logging in, it is necessary to select the course Measurements for Drones (Ed. 2020) and access to the content, by inserting the enrollment key:

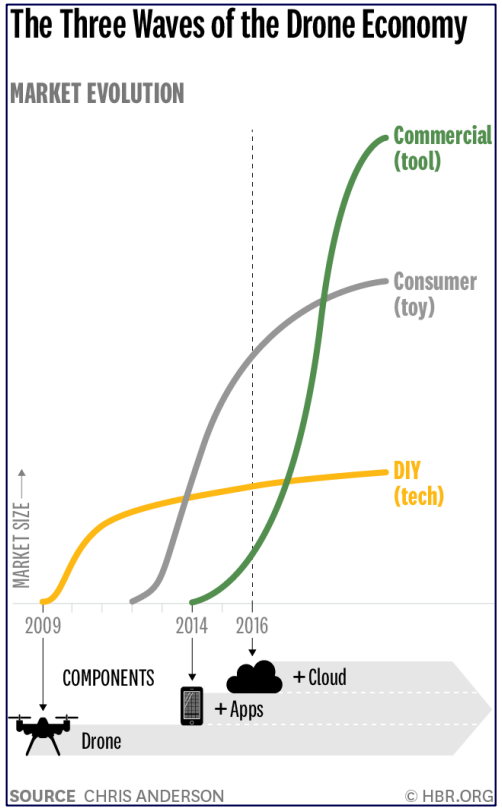
  mdrones2020

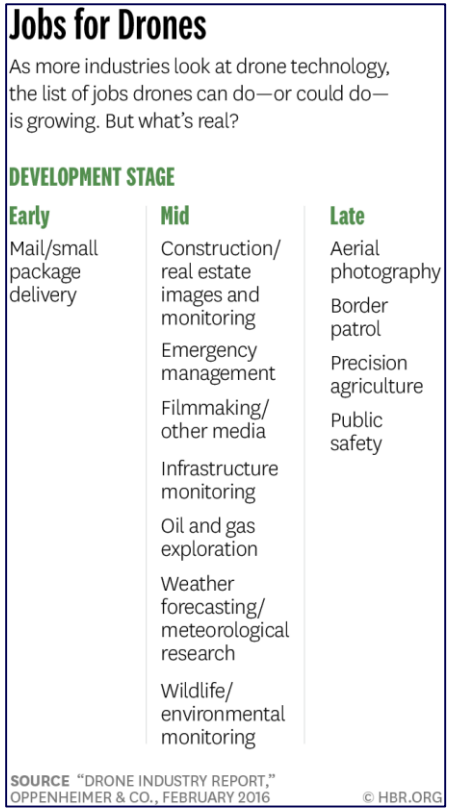
COURSE MATERIAL



PROFESSIONAL USE OF DRONES







- The professional use of drones is continuously growing.
- Most applications involve monitoring and **measurements.**

REALITY CAPTURE

- **“Reality capture”** is the process of digitizing the physical world by scanning it inside and out, from the ground and the air.
- Example:
  In Google Maps, data was captured by satellites, airplanes, and cars, and presented in 2-D and 3-D maps.
- Now that kind of mapping, initially designed for humans, is done at much higher resolution in preparation for the self-driving car.

http://www.atlatec.de/en/

DRONES AND MEASUREMENTS

- Industries have long sought data from above, generally through satellites or planes, but drones are better **“sensors in the sky”** than both.
- They gather higher-resolution and more-frequent data than satellites (whose view is obscured by clouds over two-thirds of the planet at any time), and they’re cheaper, easier, and safer than planes.
- Drones can provide “anytime, anywhere” access to overhead views with an accuracy that rivals laser scanning.

SYSMAP SenseFly

I&M APPLICATIONS OF DRONES (1)

Monitoring of photovoltaic systems

- Drone equipped with:
  - Video camera, for detecting cracks, yellowing, snail trails and brunt cells;
  - Thermal camera, for detecting high temperature regions on a photovoltaic module surface (hot-spot);
  - GPS receiver for measuring the position related to an identified failure.

I&M APPLICATIONS OF DRONES (2)

Structural health monitoring

- Drone equipped with:
  - Video camera;
  - GPS receiver.
  - Drone can be used for automatic monitoring and localization of damages.

I&M APPLICATIONS OF DRONES (3)

Power line inspection

- Drone equipped with:
  - Video camera, for detecting broken strand;
  - Infrared camera, for preventing breakage of the strands;
  - Ultra-violet camera, for detecting corona effects;
  - GPS receiver for measuring the position related to an identified failure.

https://www.dronevibes.com/tag/power-line-inspection/

I&M APPLICATIONS OF DRONES (4)

Environmental monitoring

- Drone equipped with:
  - GPS receiver;
  - A sensor board, which depends on the environment to monitor;
  - Example - The drone for water pollution monitoring:
  - Video camera and multi-spectral camera (sediment pollution, oil spill, red tide, and thermal pollution).

https://www.dronegenuity.com/drones-helping-marine-biologists/

MEASUREMENTS BY DRONES: UNCERTAINTY AND TRACEABILITY

- Drones have been recently proposed for the documentation of car accidents:
  - -80% of occupation time of the road;
  - -67% of measurement time
- Image data collected during the drone flight can be used to produce a 3D point cloud and distance and size measurements, with **unofficial and approximate accuracy** of 2-5 cm.
- In all cases when economic transactions or legal issues are involved, it is fundamental to provide the uncertainty of the measurement result through structured and traceable procedures.

How is measurement uncertainty assessed?

How is metrological traceability guaranteed?

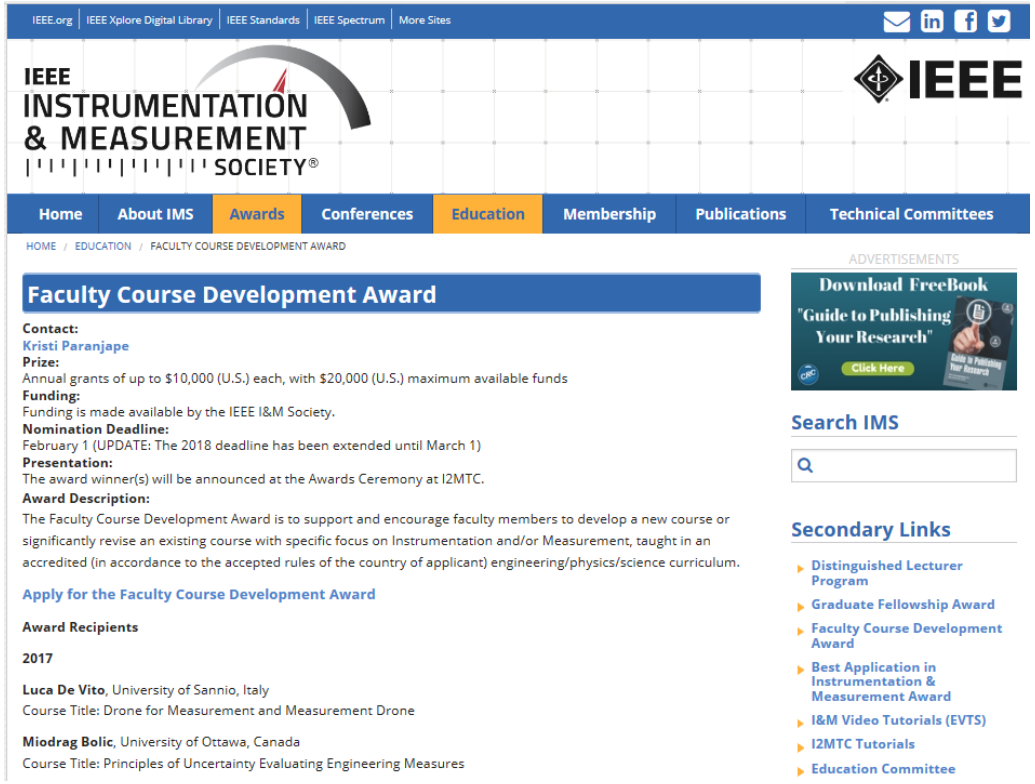
DRONES AS MEASUREMENT INSTRUMENTS

- Since drones are used to obtain measurements, they are **measurement instruments**.

- In particular, they are **mobile measurement instruments**, making measurements of physical quantities during the flight.

IEEE FACULTY COURSE DEVELOPMENT AWARD

- The proposal of this course was awarded with a $ 10,000 funding from the 2017 IEEE Instrumentation and Measurement IEEE Faculty Course Development Award.



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HOME / EDUCATION / FACULTY COURSE DEVELOPMENT AWARD

Faculty Course Development Award

Contact:
Kristi Paranjape
Prize:
Annual grants of up to $10,000 (U.S.) each, with $20,000 (U.S.) maximum available funds
Funding:
Funding is made available by the IEEE I&M Society.
Nomination Deadline:
February 1 (UPDATE: The 2018 deadline has been extended until March 1)
Presentation:
The award winner(s) will be announced at the Awards Ceremony at I2MTC.
Award Description:
The Faculty Course Development Award is to support and encourage faculty members to develop a new course or significantly revise an existing course with specific focus on Instrumentation and/or Measurement, taught in an accredited (in accordance to the accepted rules of the country of applicant) engineering/physics/science curriculum.

Apply for the Faculty Course Development Award

Award Recipients

2017

Luca De Vito, University of Sannio, Italy
Course Title: Drone for Measurement and Measurement Drone

Miodrag Bolic, University of Ottawa, Canada
Course Title: Principles of Uncertainty Evaluating Engineering Measures

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Secondary Links

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- Graduate Fellowship Award
- Faculty Course Development Award
- Best Application in Instrumentation & Measurement Award
- I&M Video Tutorials (EVTS)
- I2MTC Tutorials
- Education Committee

EQUIPMENT

DJI Phantom 4 Pro

- Weight: 1388 g
- Diagonal size: 350 mm
- Max flight time: ~ 30 min
- Hover Accuracy Range (vert.): ± 0.1 m
- Hover Accuracy Range (horiz.): ± 0.3 m
- 3-axis Gimbal with stabilization within 0.02°
- 20 Mpixel camera

Parrot Bebop 2 FPV

- Max flight time: ~ 30 min
- 14 Mpixel camera with digital stabilization

EQUIPMENT

Intel Aero RTF development platform

- Intel Aero compute board with Intel Atom x7 processor
- Linux operating system (Yocto or Ubuntu distro)
- Intel Aero flight controller running PX4

2 Ublox C94-M8P GNSS/RTK development boards

- Station and rover configuration
- 2 cm positioning accuracy

RP-LIDAR 360 Degree Laser Range Scanner

- 4000 samples/s 10Hz
- Range: 6m
- Rotation speed: 600 RPM
- Resolution: 0.9°

COURSE SCHEDULE

Date	Time	Hours	Topic description	Theory	Lab	Team-work
April 8, 2020	3-6 PM	3	Introduction to drones, UAV regulations, drone architecture, sensors for navigation	X		
April 22, 2020	3-6 PM	3	Sensors for mission (thermal camera, LIDAR, RGB-D), Mission planning, waypoints, flight data acquisition and analysis, Uncertainty of mission measurement, Lab: Acquisition of data from drone through QGroundControl.	X	X	
April 29, 2020	3-6 PM	3	Auonomous drone programming, Introduction to MAVLINK and DroneKit. Lab: Writing a simple code to run onboard of the drone.	X	X	
May 6, 2020	3-6 PM	3	Introduction to aerial photogrammetry, Camaera modeling, Camera calibration, Stereo-vision system, Stereo-vision calibrtion, 3D mapping, Pix4D, Uncertainty in 3D reconstruction. Lab: Writing a simple MATLAB program for 3D reconstructions from drone images.	X	X	
May 13, 2020	3-6 PM	3	Selection of teamwork proposals. Teamwork development.			X
May 20, 2020	3-6 PM	3	Teamwork development.			X
May 27, 2020	3-6 PM	3	Teamwork development.			X
June 3, 2020	3-6 PM	3	Teamwork development.			X