


| Learning Autonomy



# DUCKIETOWN

Official Information Guide





<b>Duckietown: Learning Autonomy</b> .....	<b>1</b>
<b>The Duckietown Project</b> .....	<b>3</b>
<b>Our Community and Team</b> .....	<b>5</b>
<b>The Duckietown Ecosystem</b> .....	<b>7</b>
<b>Example Curriculum</b> .....	<b>11</b>
<b>Getting Started</b> .....	<b>12</b>
<b>Duckietown for Research</b> .....	<b>13</b>
<b>Testimonials</b> .....	<b>15</b>

## Duckietown Profile

Duckietown is the state-of-the-art robotics and AI ecosystem for learning, teaching and doing research.

Bringing together hardware, software, cutting-edge tools and workflows, Duckietown demystifies and democratizes the science and technology of modern robot autonomy.

Duckietown provides tangible learning experiences that are accessible, engaging and fun, nurturing talents in our generation to shape the next generations fo autonomy.

“ AI and robotics are the most beautiful disciplines - it's mankind's attempt at creating artificial creatures that think and act like us.

AI and robotics will change our world. Everybody should understand the possibilities, the current status and how much is left to do. ”



BEAUTY

FUN

IMPORTANCE

CHALLENGES

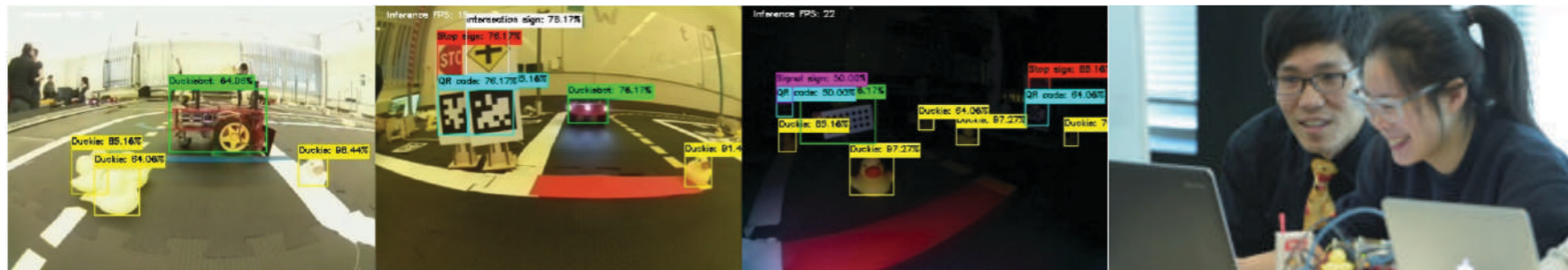
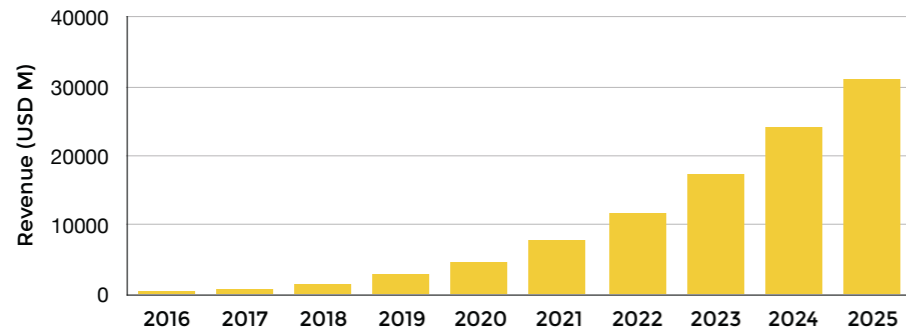
## The Robotics and AI revolution

The fourth industrial revolution has started: robotics and AI technologies are becoming increasingly part of our daily lives.

Existing educational systems are inadequate at producing enough qualified workforce or informed citizenry to support this revolution.

Duckietown provides an ecosystem that is versatile, open, engaging, and designed with state-of-the-art content, tools and workflows to transmit real-world skills and competence.

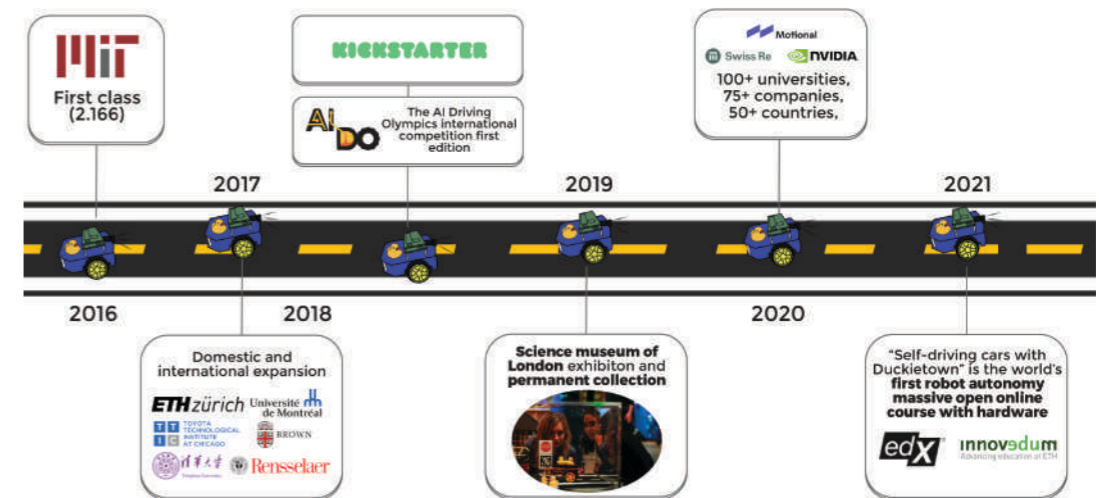
AI market worldwide



AI at Duckietown in action

## The history of Duckietown

Duckietown started as a class at the Massachusetts Institute of Technology in 2016, for the students of the Computer Science and Artificial Intelligence Laboratory (CSAIL) and is now a worldwide initiative to realize a new vision for AI and robotics education.



Duckietown is used in the classrooms and laboratories of some of the world's best universities: MIT, ETH, Imperial College, Tsinghua University, Oxford University, etc.

# OUR COMMUNITY AND TEAM



• Jacopo Tani, Ph. D.



• Prof. Liam Paull, Ph. D.



• Andrea Censi, Ph. D.



• Andrea Francesco Daniele



• Prof. Emilio Frazzoli, Ph. D.



SLACK MEMBERS

**2100**

UNIVERSITIES

**175**

COMPANIES & LABS

**115**

COUNTRIES

**62**

# THE HARDWARE



## Duckiebot

Duckiebots are minimal autonomy platforms: the simplest self-driving cars with which we can do real science. Designed through the years to meet the needs of teachers, professionals and researchers worldwide, Duckiebots are the top of line in their class.

- 👁️ **Sensing:** Camera, Encoders, IMU, Time of Flight
- 🖥️ **Computation:** Raspberry Pi, Jetson Nano
- 🔧 **Actuation:** DC motors, LEDs
- 📁 **Memory:** 64GB, class 10
- 🔋 **Power:** 5V, 10Ah



## Duckietown

Duckietowns are structured and modular environments built on two layers: road and signal, to offer a repeatable but flexible driving experience, without fixed maps.

- 🔧 **Modularity:** assemble and combine fundamental building blocks
- ✓ **Structure:** appearance specifications (colors, geometries) guarantee functionality
- 🏙️ **Smart City:** road and signal layers can be augmented with a network of smart traffic lights and watchtowers to create a real city-robot.



## Duckiedrone

Duckiedrones are fully-programmable DIY quadcopters designed to introduce younger audiences to automation science and technology through exciting flying machines.

- 👁️ **Sensing:** IR, Camera, IMU
- 🖥️ **Computation:** Raspberry Pi
- 🔧 **Actuation:** DC motors, LEDs
- 📁 **Memory:** 32GB, class 10

# LEARNING EXPERIENCE



## Our 3 pillars of software development

### Modularity

Containerization technology allows adding, mix and matching with extreme ease

### State of the art tools

Learning the tools used in industry is as important as the art of it.

### Open source content

“From a box of parts, to a robotic ecosystem, in only 1452 steps, without hiding anything”.

### Run a program wherever you want

The Duckietown software architecture uses ROS, Docker and Python to enable versatile workflows: in simulation (locally or on the cloud) as well as on Duckiebots in Duckietown Autolabs, or on Duckiedrones!

# THE DUCKIETOWN ECOSYSTEM

The Duckietown ecosystem is more than a sum of robots. It is a collection of tools and services seamlessly integrated with our hardware environment.

Duckietown bridges learners with instructors, online with offline, simulation with hardware, talents with institutions.

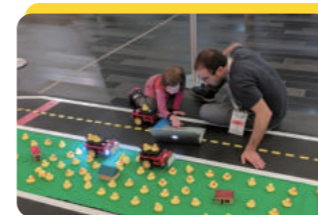


# WHO IS DUCKIETOWN FOR?

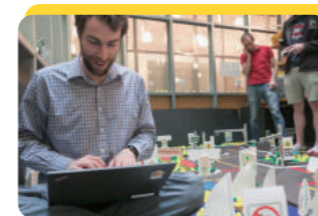
No matter how expert you are, Duckietown will help on your journey from discovery to mastery, for "Duckietown is a place of joy and relaxed introspection."



**Learners** can join offline classes with their instructors or learn in autonomy with Duckietown's massive open online course on edX.



**Instructors** benefit from Duckietown's class-in-a-box: the one-click solution for learning autonomy, inclusive of curricula, hardware, auto-grading and support for troubleshooting.



**Researchers** gain access to a programmable infrastructure for reproducible development and benchmarking of robotic agents, and an international competition featured at ICRA and NeurIPS.

# EXAMPLE CURRICULUM



## Operation tools

introduction to the basic tools

- Construction
- Configuration
- Operation
- Calibration

## Autonomy

Exploring real-world solutions to the challenges of robot autonomy -from theory to deployment

- Perception
- Control
- Planning
- Behaviours

## Machine Learning

Exploring AI methods and workflows for solving challenging autonomous tasks.

- Supervised Learning
- Reinforcement Learning

## System Development

set up an efficient software environment for robotics with state of the art

- ROS
- Git
- Docker
- Test/data driven development
- Open source dynamics

## Getting started has never been easier

Learners: join the "Self-Driving Cars with Duckietown" MOOC

Researchers: join the AI Driving Olympics

Instructors: get a class-in-a-box



## MASSIVE ONLINE OPEN COURSE

Self-Driving cars with Duckietown is the world's first robot autonomy MOOC with hardware!

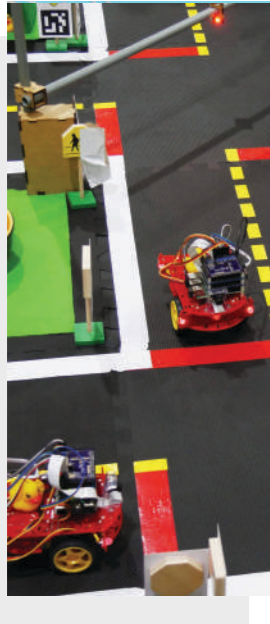
## AI DRIVING OLYMPICS

The AI-DO are an international scientific competition established in 2018 to benchmark the state of the art of machine learning approaches to solving self-driving cars technology challenges. AI-DO finals have been held at ICRA and NuerIPS.





# DUCKIETOWN FOR RESEARCH



## The DUCKIENet

The Decentralized Urban Collaborative Benchmarking Environment Network (DUCKIENet) provides an accessible and reproducible framework focused on autonomous vehicle fleets operating in model urban environments.

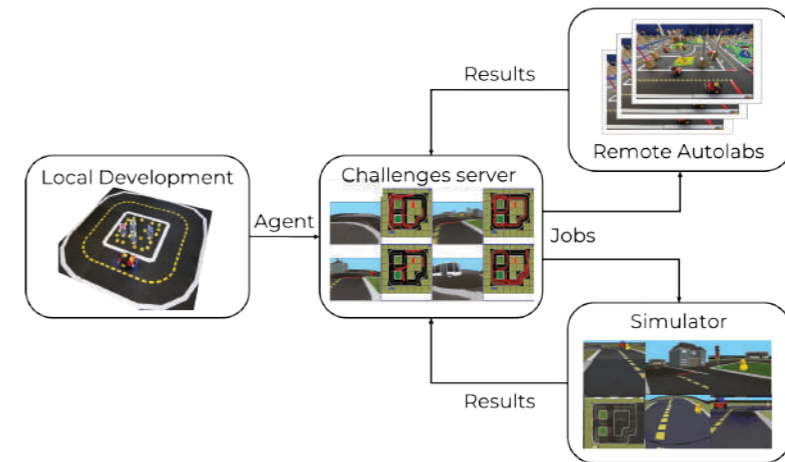
The DUCKIENet enables users to develop and test a wide variety of different algorithms and then deploy them locally in simulation, locally on a robot, in a cloud-based simulation, or on a real robot in a remote lab. In each case, the submitter receives feedback and scores based on well-defined metrics.

## The Duckietown Automated Laboratories

One of the central components of the DUCKIENet is the Duckietown Autolab (DTA), a remotely accessible standardized setup that is itself also relatively low-cost and reproducible.

DTAs include an off-the-shelf camera-based localization system. The accessibility of the hardware testing environment through enables experimental benchmarking that can be performed on a network of DTAs in different geographical locations.

The system is validated by analyzing the repeatability of experiments conducted using the infrastructure and show that there is low variance across different robot hardware and across different remote labs.



- **Looking forward**

In Duckietown we have the contention that there is a need for stronger efforts towards reproducible research for robotics, and that to achieve this we need to consider the evaluation in equal terms as the algorithms themselves. In this fashion, we can obtain reproducibility by design through the research and development processes.

- **Reproducible benchmarking in robotics**

As robotics matures and increases in complexity, it is more necessary than ever that robot autonomy research be reproducible.

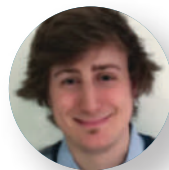
Duckietown offers a new concept for reproducible robotics research that integrates development and benchmarking from the beginning of the research/development processes.

# VOICE OF OUR MEMBERS



"Duckietown was much more than just a class, it was a hands-on deep dive into hardware, software, and systems integration, and, most of all, it was a blast!"

**Teddy Ort - Ph. D. Student, Massachusetts Institute of Technology (MIT)**



"If University were like learning how to play a new instrument, where lessons are the exercises and exams the final auditions, Duckietown would be the full-blown rock concert, where you play for your fans and look to your heroes with admiration."

**Gioele Zardini - Ph. D. Student, ETH Zurich**



"Spending the summer in Duckietown at MIT made me discover a completely new world: I understood that education can be a game and learning can be fun!"

**Valeria Cagnina - Young Entrepreneur**



"The Duckietown class is the autonomous driving pie: the filling is hardcore robotics, the casing is artificial intelligence, and as a plus, you get some funny ducks on top!"

**Manfred Diaz - Ph. D. Student, University of Montreal**

# VOICE OF THE EXPERTS

"Starting from MIT CSAIL, Duckietown has grown into a global initiative that is inspiring students around the world to learn about self-driving cars, as well as the science and engineering of autonomy."

**Prof. Daniela Rus - Director, Computer Science and AI Lab (CSAIL), MIT**



"Teaching the Duckietown class was a wonderful experience for me and my students. The materials are great and the hands-on experience with the robot really helps reinforce the curriculum."

**Prof. Matthew Walter - Toyota Technological Institute in Chicago (TTIC)**



"It is great to see Duckietown host the AI Driving Olympics at ICRA and N[eur]IPS. What a fun way to demonstrate the real challenges in building and deploying self-driving cars!"

**Prof. John Leonard - Massachusetts Institute of Technology**



The AI Driving Olympics is a great way to push the limits of deep learning on physically embodied systems."

**Prof. Yoshua Benjio - 2018 ACM A.M.Turing award winner, University of Montreal**

