

How to teach Robotics & ROS remotely

... using Zoom



Who is this webinar for?

- Professors/Teachers/Teacher assistants of undergrads/graduate students of robotics
- You need to prepare robotics course for 2021
- You are searching for remote robotics teaching solution due to COVID-19



What do we mean by teaching robotics?

- Robot action and perception
- Arm Kinematics
- Mobile Robots Kinematics
- Robot Dynamics
- Motion Planning and Control
- Robot Navigation
- Computer Vision
- ROS



We do not mean



We do mean



About Us

- 5 years teaching on The Construct Youtube Channel
- Almost 1.000 videos uploaded
- 1 ROS Online Class every week (for 3 years)
- Delivered 3 ROS conferences online (1 each year)
- Tens of webinars (like this one)



Stay with us to take a full live teaching experience including remote real robots!



- First, we'll see how to teach ROS & Robotics with zoom
- Provide solutions to problems
- Then we will do a class all together, including real robot lab



For teaching robotics remotely you need

1. Prepare the class
2. Deliver the theory
3. Provide some practice
4. Provide off-hours support
5. Evaluate students
6. Control students progress



You need to address these problems

- Preparing curriculum is hard work
- Students don't know Linux nor Python
- Installing ROS in students' computer
- Make students practice is difficult
- Evaluate them remotely is difficult





STEP 1

Prepare the class



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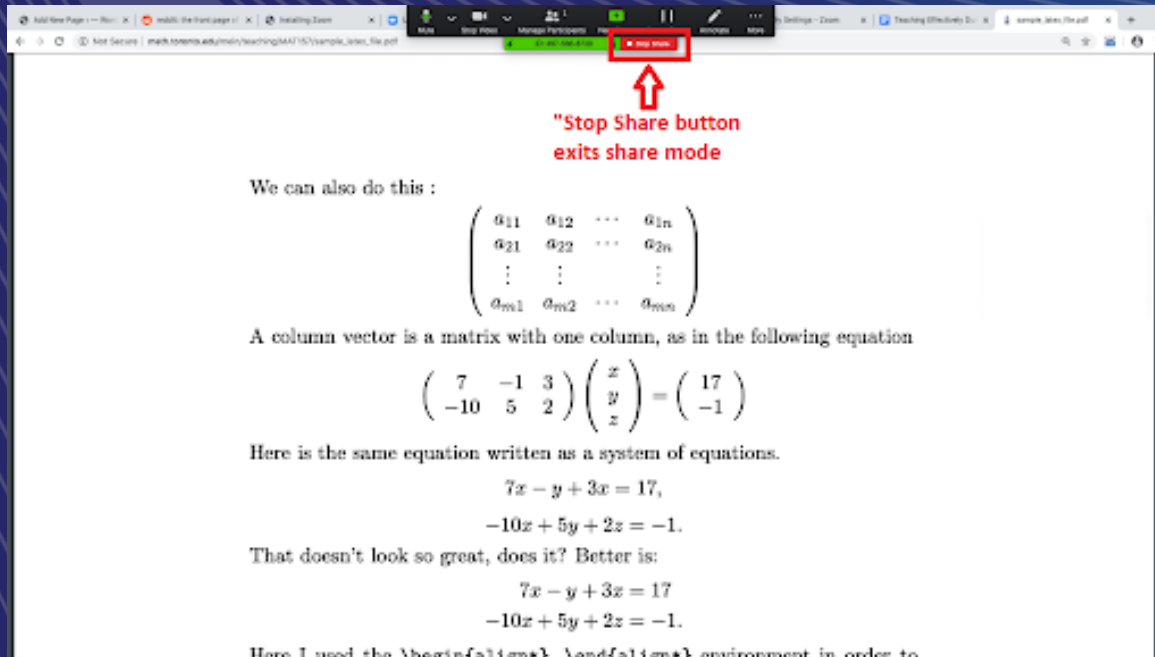
1st requirement

A platform to deliver and communicate with students in real time

- Must allow:
 - Sharing Screen (both teacher & student)
 - Live Chat (both written & voice)



For example: Zoom



We can also do this :

$$\begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{pmatrix}$$

A column vector is a matrix with one column, as in the following equation

$$\begin{pmatrix} 7 & -1 & 3 \\ -10 & 5 & 2 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 17 \\ -1 \end{pmatrix}$$

Here is the same equation written as a system of equations.

$$\begin{aligned} 7x - y + 3z &= 17, \\ -10x + 5y + 2z &= -1. \end{aligned}$$

That doesn't look so great, does it? Better is:

$$\begin{aligned} 7x - y + 3z &= 17 \\ -10x + 5y + 2z &= -1. \end{aligned}$$

Here I used the $\backslash begin{aligned}$ and $\back end{aligned}$ environment in order to



Zoom tutorial: <https://youtu.be/JIRfIUH8ENw>

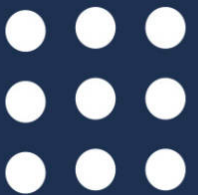
2nd requirement

- **Students must know about:**
 - Linux
 - Python
- **Make them take these free online courses:**
 - Linux for Robotics: <https://bit.ly/3gx6za7>
 - Python for Robotics: <https://bit.ly/36XldEs>
- **Make them take the exam and send evaluation to you**



3rd requirement

Provide an environment to practice

 ROS

+



GAZEBO



How to install ROS + Gazebo: option 1

- Install ROS on students' computer <http://wiki.ros.org/ROS/Installation>

ROS Installation Options

There is more than one ROS distribution supported at a time. Some are older releases with long term support, making them more stable, while others are newer with shorter support life times, but with binaries for more recent platforms and more recent versions of the ROS packages that make them up. See the [Distributions](#) page for more details. We recommend one of the versions below:

ROS Kinetic Kame

Released May, 2016

LTS, supported until April, 2021

This version isn't recommended for new installs.



ROS Melodic Morenia

Released May, 2018

LTS, supported until May, 2023

Recommended for Ubuntu 18.04



ROS Noetic Ninjemys

Released May, 2020

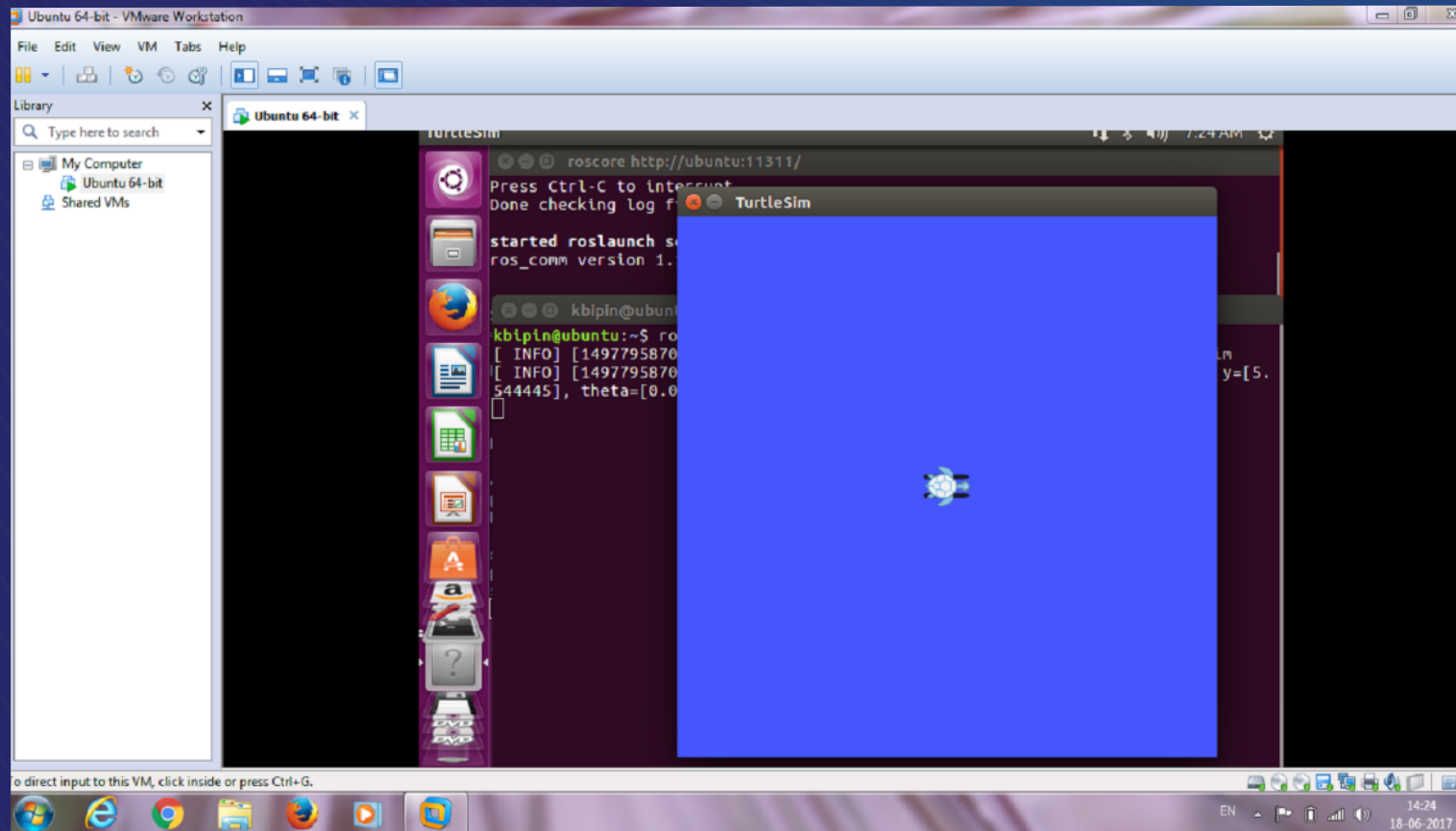
Latest LTS, supported until May, 2025

Recommended for Ubuntu 20.04



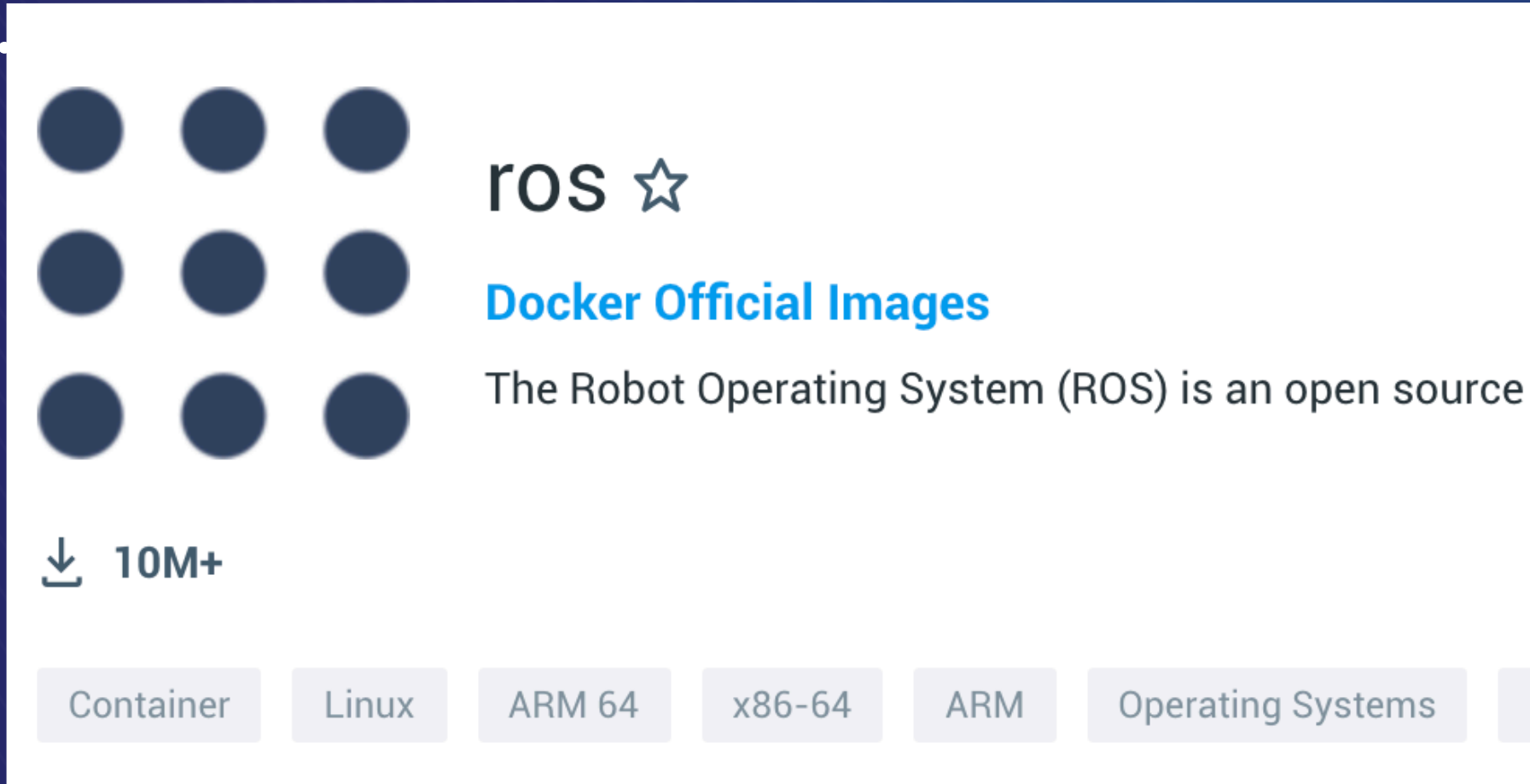
How to install ROS + Gazebo: option 2

- Provide a Virtual Machine with ROS https://youtu.be/59F6Jake_48



How to install ROS + Gazebo: option 3

- Provide a docker with ROS https://hub.docker.com/_/ros/



The screenshot shows the Docker Hub page for the 'ros' official image. On the left, there is a 3x3 grid of dark blue circles. To the right of the grid, the text 'ros' is followed by a star icon. Below this, the text 'Docker Official Images' is displayed in blue. Further down, a partial description reads 'The Robot Operating System (ROS) is an open source'. Below the description, there is a download icon and the text '10M+'. At the bottom, there is a row of tags: 'Container', 'Linux', 'ARM 64', 'x86-64', 'ARM', and 'Operating Systems'.

ros ☆

Docker Official Images

The Robot Operating System (ROS) is an open source

↓ 10M+

Container Linux ARM 64 x86-64 ARM Operating Systems



STEP 2

Teach the theory



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Option 1: create slides

- A fast method to create a ROS/robotics course based on slides...
 - Just search over internet and get one of the trillions available
 - for example, this one by ETH Zurich:
 - <https://bit.ly/35OqmLV>
 - Adapt them to your needs

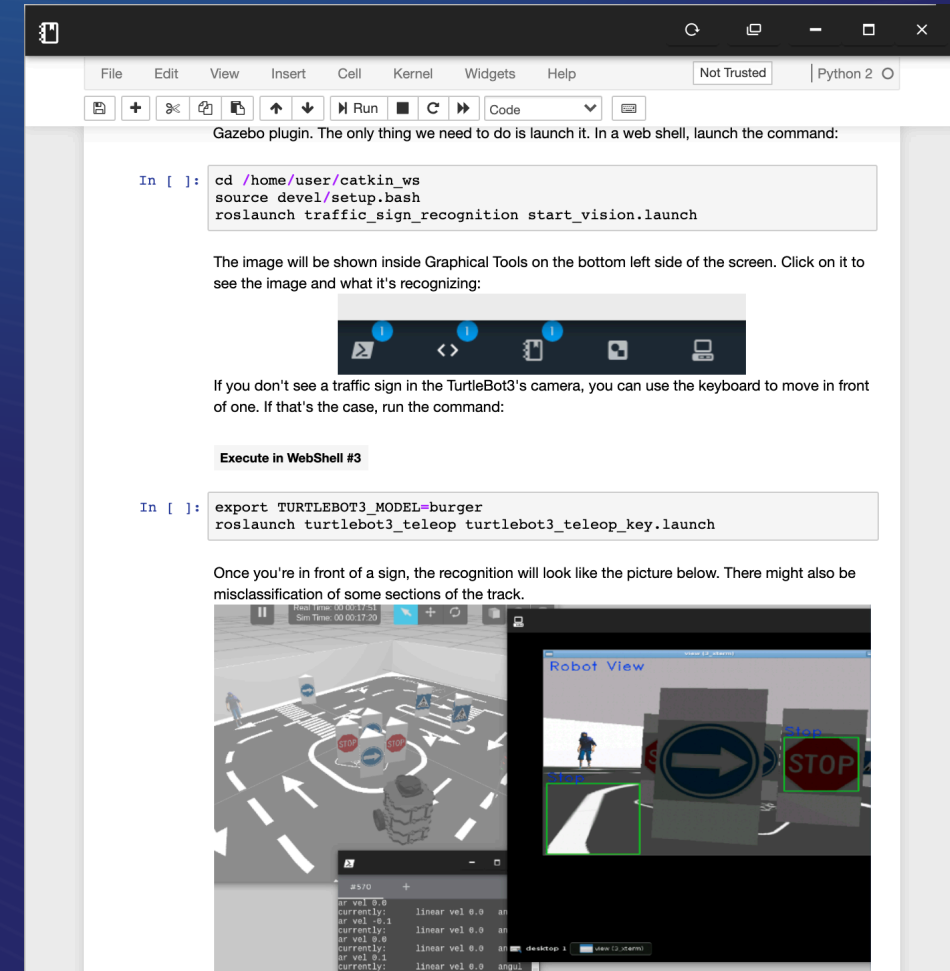


Option 2: create Jupyter notebooks

- * Jupyter notebooks can include code, images, videos, etc
- * Include exercises to be done during class

Jupyter how to tutorial:

<https://www.dataquest.io/blog/jupyter-notebook-tutorial/>



Connect to the real robot in RoBoX

Once you know the basics of the operation with a simulated version, it's time to use the real Turtlebot3 robot. For that you have to follow these simple steps:

STEP 3

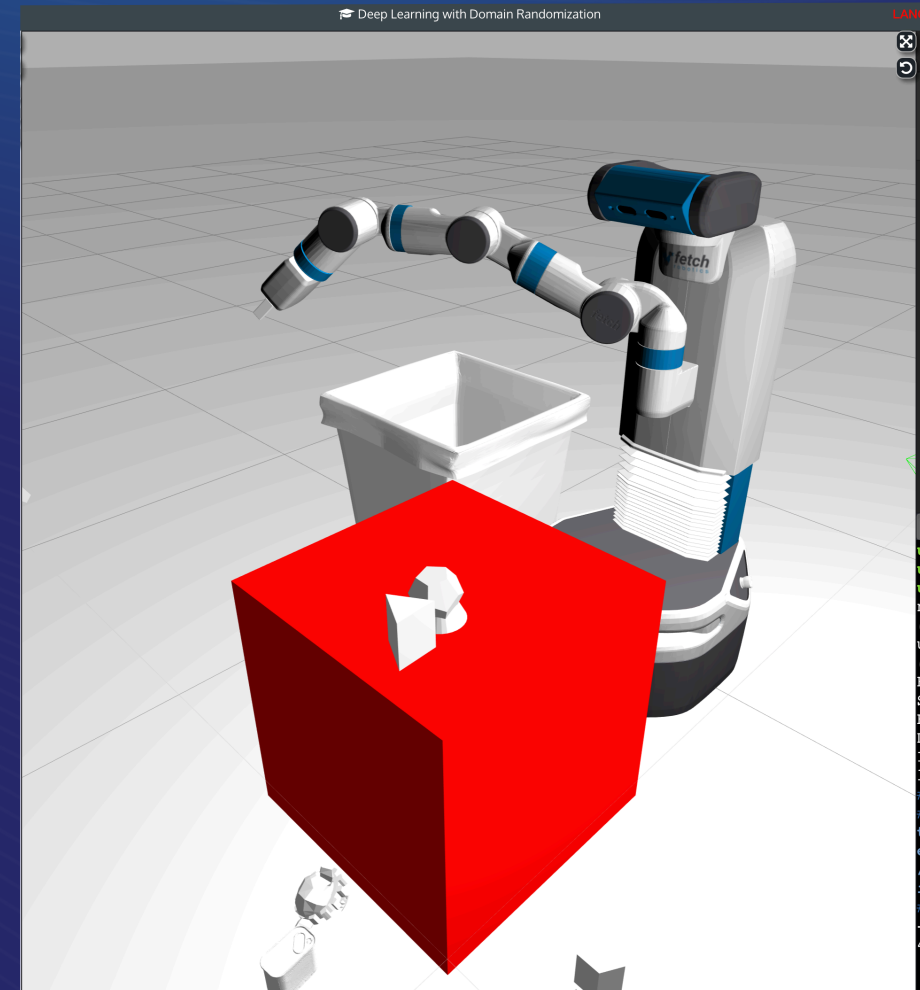
Provide Practice



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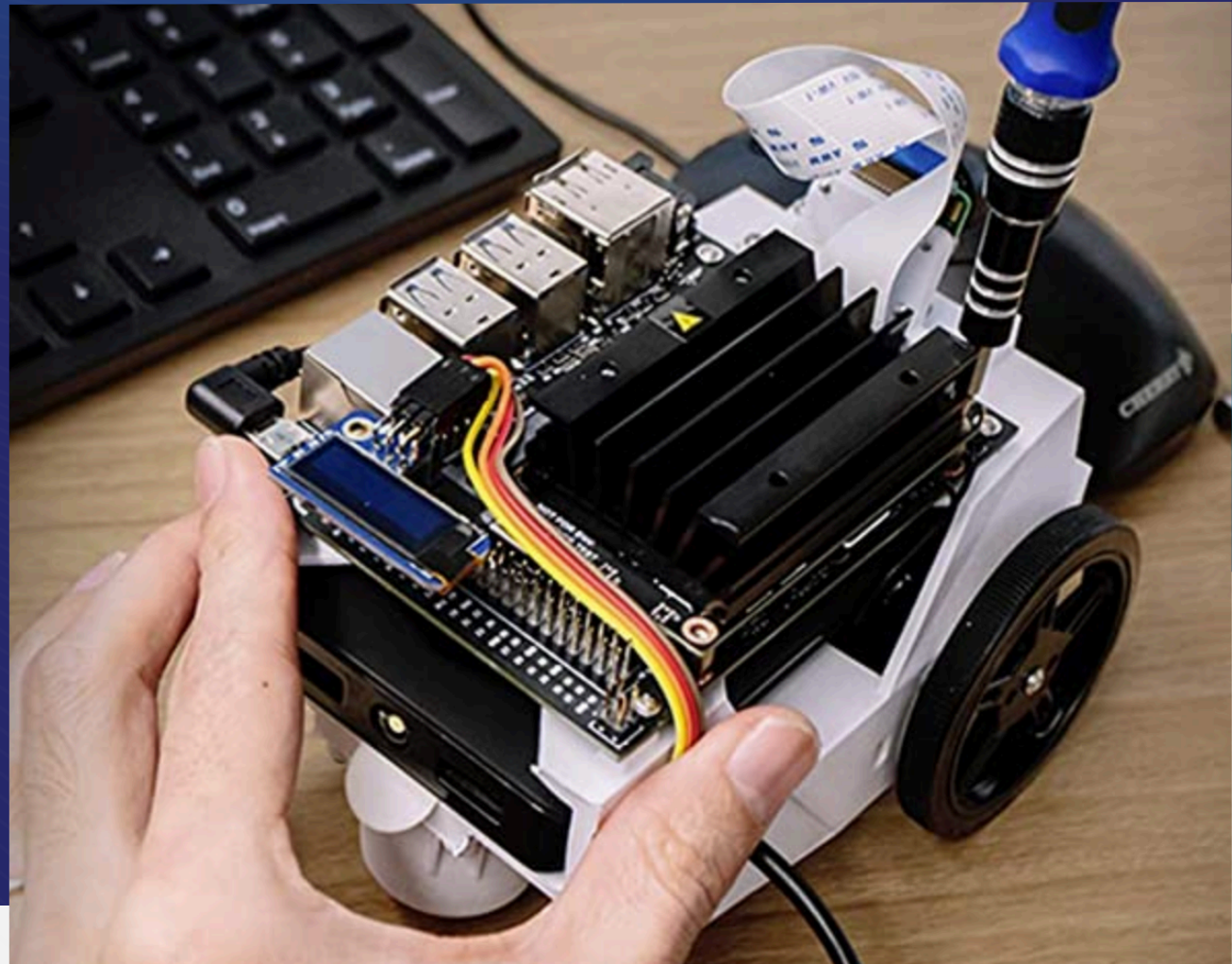
Simulated robots: use Gazebo/ROS robot sims

- Use the students ROS + Gazebo environment
- Check our repo of open source simulations:
- <https://bit.ly/2JRpH6U>



Real robots: Provide a real robot to each student

- Jetbot (around 200\$):
 1. Base system (110\$)
<https://amzn.to/2DBpDov>
 2. Additions for Jetbot (110\$)
<https://amzn.to/2XwJT1G>



Real robots: Provide a remote lab

1. Have a robot with internet access
2. Install a server in the robot
3. Add external camera
4. Connect to it from ROSDS

HOW TO SETUP:

<https://www.theconstructsim.com/remote-robot-lab/>





STEP 4

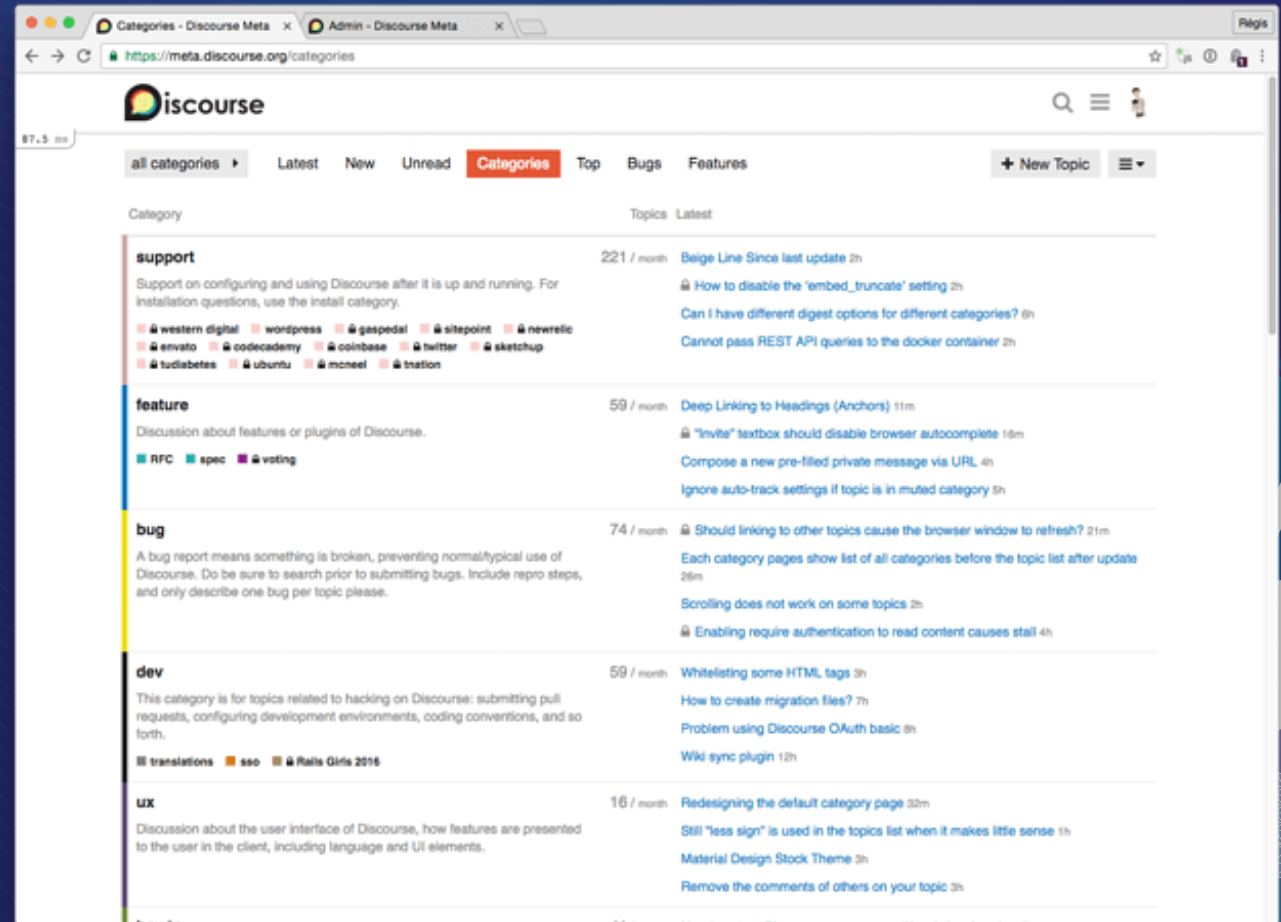
Provide Off-Hours Support



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Provide a Forum for Q&A

- Use the one provided by the University
- Or install a Discourse: <https://bit.ly/2C7vuS2>
- Do not use email for Q&A!





STEP 5

Evaluate the Students



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Exams based on doing ROS code

- **Advantages:**
 - They must apply their knowledge
 - Easy to detect when they copy
- **Drawback:**
 - Requires a lot of work on the teacher's side
 - Prepare the exams
 - Correct the exams



Exams based on doing ROS code

- Create Jupyter notebook exam
- Send it to students
- Students create code
- Students send code to you
- You review the code

Exam

- Create a package named *obst_avoidof< your_name>* which depends on *rospy* in the *catkin_ws* **(0.5 points)**
- Create a Python file named *avoidanceof< your_name>.py* that will contain your ROS code **(0.5 points)**
- Create a launch file named *start_avoidanceof< your_name>.launch* to launch the Python code **(0.5 points)**
- Subscribe to the laser topic with callback function named *get_lasersof< your_name>* and get all the ranges in a variable named *all_rangesof< your_name>* **(1.5 point)**
- Get the distance measured by the laser rays at 0°, 45° and -45° and store each one in global variables named *frontof< your_name>* (for 0°), *leftof< your_name>* (for 45°) and *rightof< your_name>* (for -45°) **(1.5 point)**
- Create a publisher that will send the velocity commands to the wheels **(1.5 point)**
- Create a loop control that sends the speeds to the wheels based on the values of the three ranges you got for 0°, 45° and -45° **(4 points)**
 - If the 45° is the smallest ray, then move a little forward plus turn to the right
 - If the -45° is the smallest ray, then move a little forward plus turn left
 - If none of the above:
 - If 0° is smaller than 0.3 then move back and rotate left
 - Otherwise, just move forward

An isometric illustration on the left side of the slide depicts a futuristic learning environment. It includes a robotic arm at the top left, a spherical robot with a camera lens, a person sitting on a wireframe chair using a laptop, a person standing and interacting with a large vertical screen, a circular platform with a central column, and a small car-like robot on a track at the bottom. The background features a dark blue gradient with a subtle pattern of thin, light blue lines.

STEP 6

Control Students Progress



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Control Students Progress

- **Manually keep a record:**
 - Who attends the class
 - Who asks questions
 - Who does the exercises





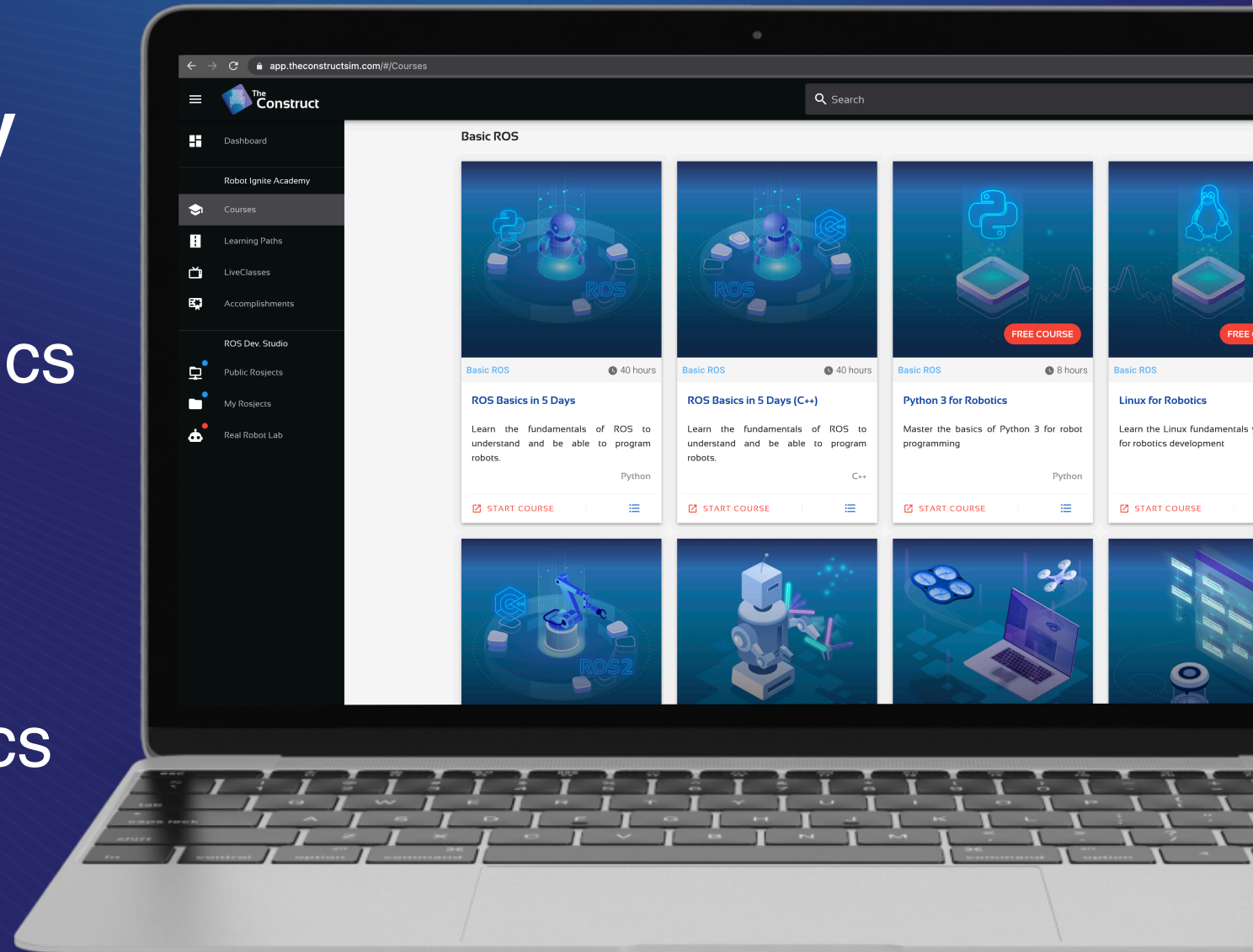
The Construct Full Online Solution For Teachers and Students



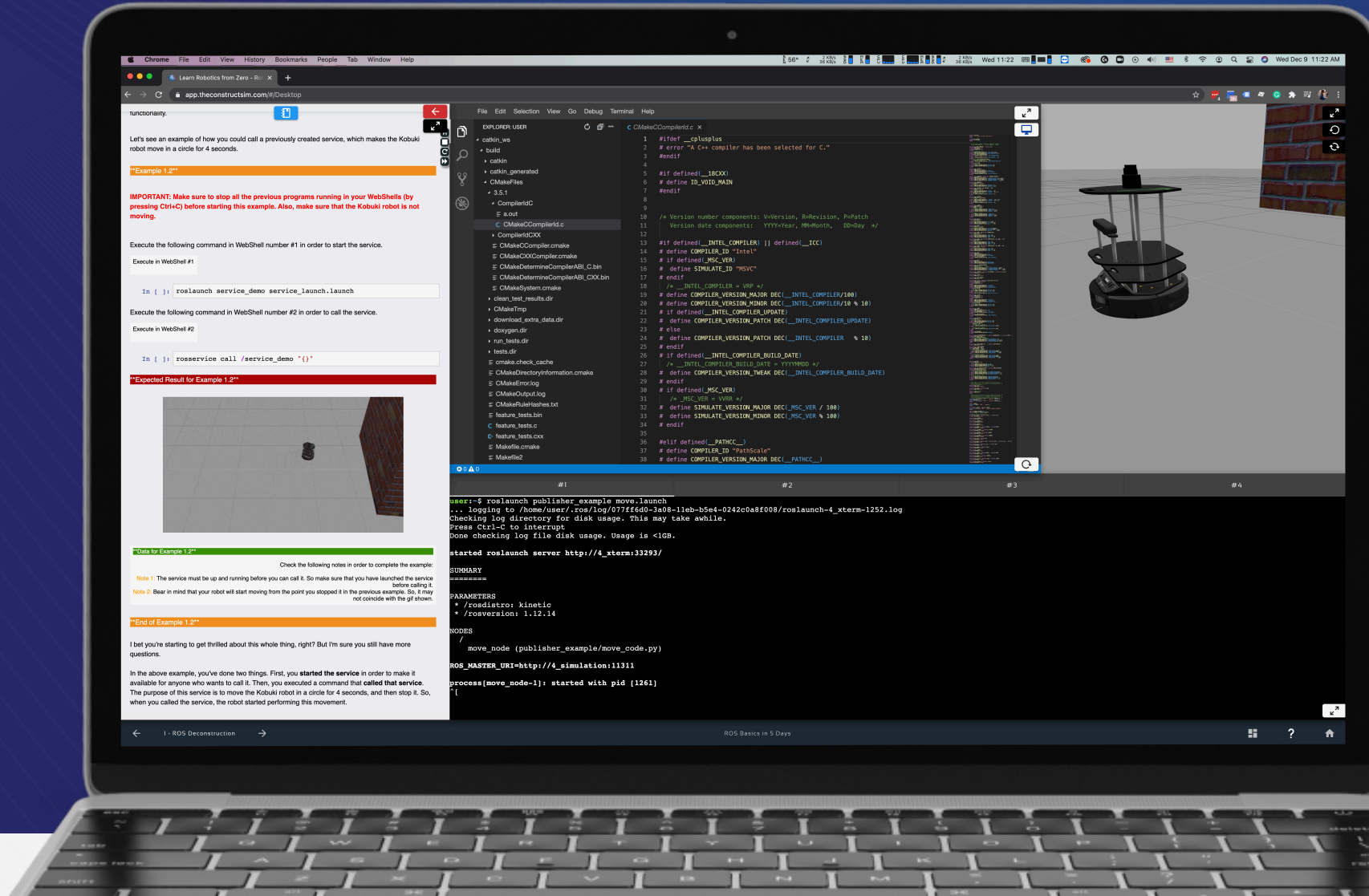
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Get all syllabus already created for you

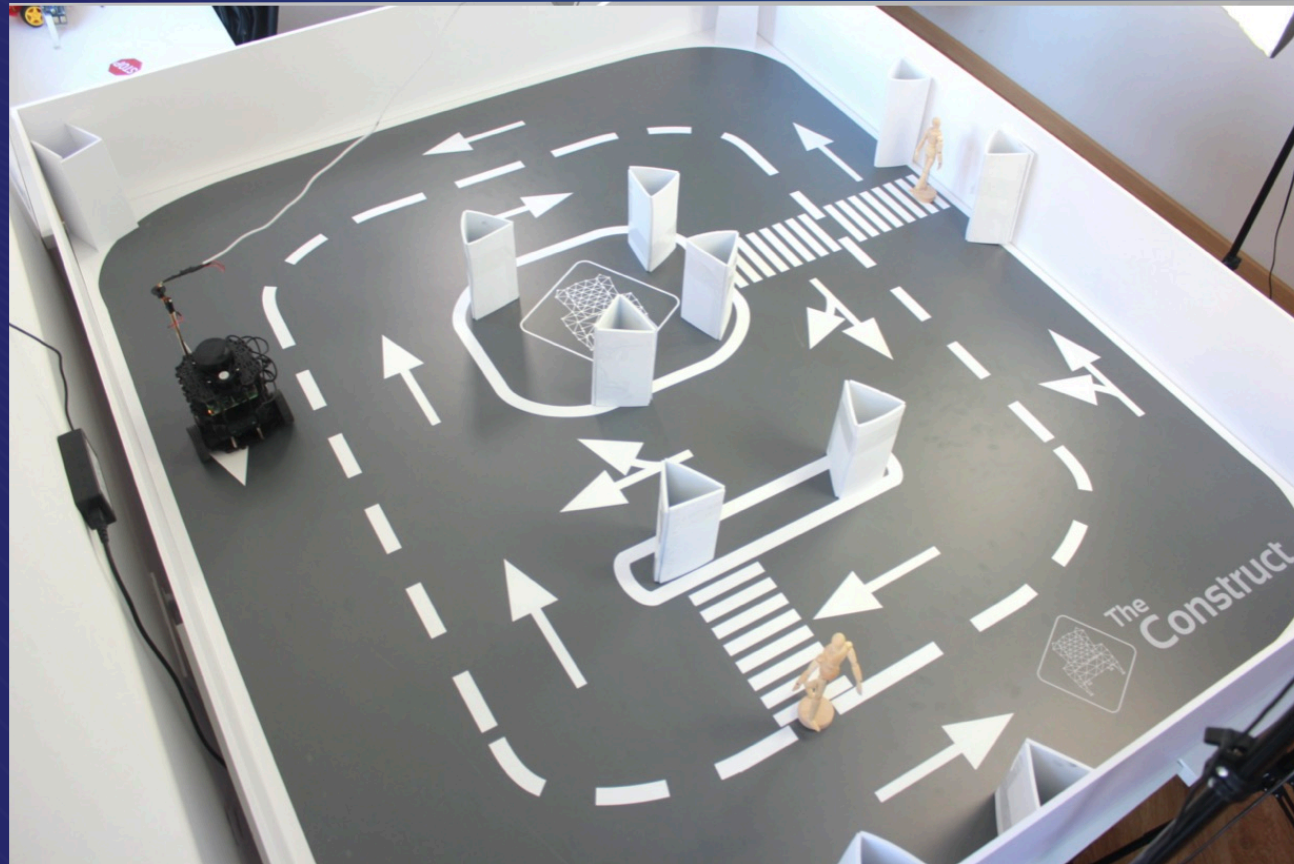
- * Mathematics for Robotics
- * Robot kinematics
- * Robot Dynamics
- * Kalman Filters
- * OpenCV for Robotics
- * ROS applied to Robotics
- * ...



Simulated robots on a web environment: no install

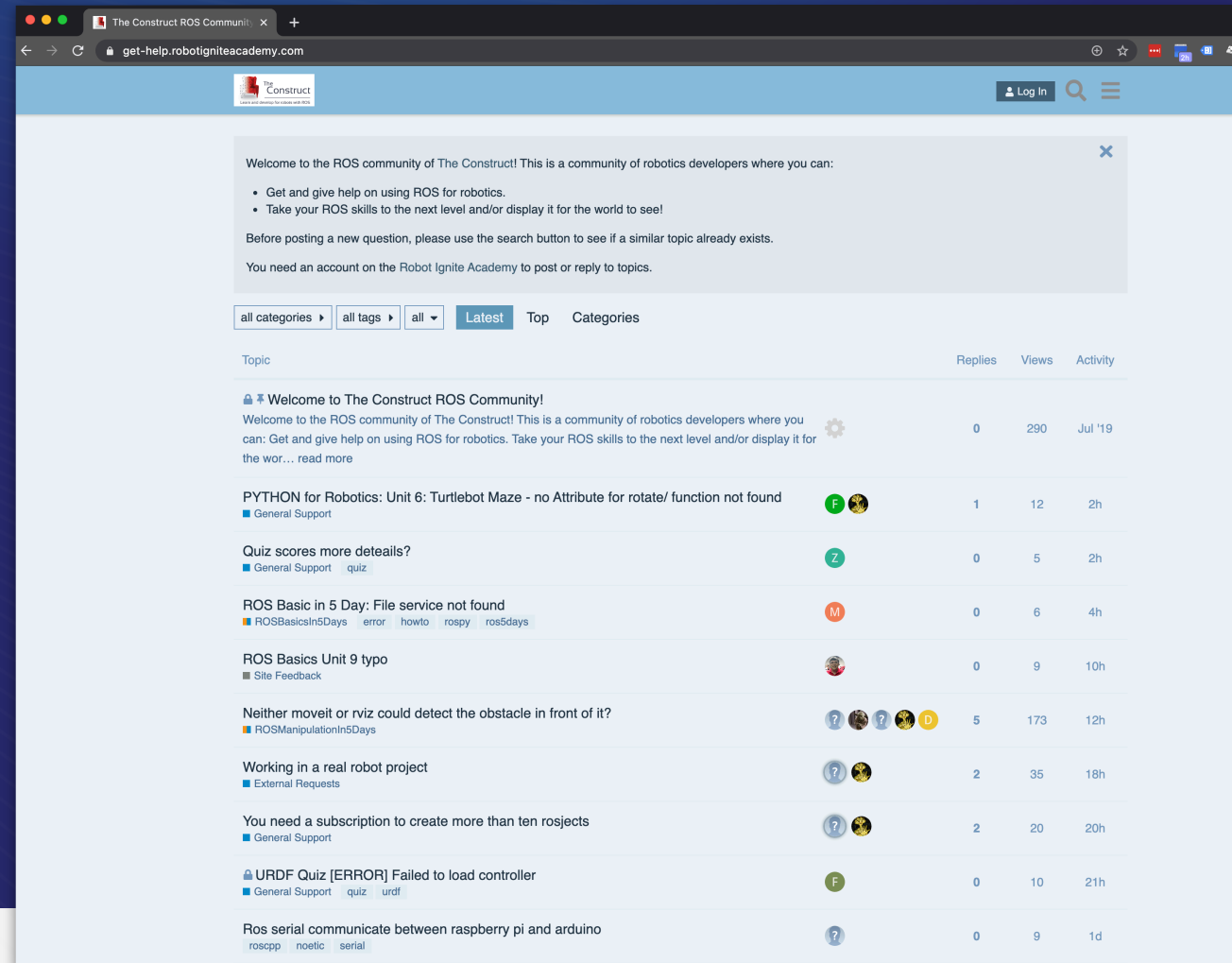


Remote Real Robot Lab Available



Off-Hours support for your students

- Forum answered by our team of ROS/Robotics experts.
- Answers within 24h on week days



Self-Corrected Exams Provided

- Exams already created
- Self-corrected
- Random exam to students to prevent copying (in preparation)

University of LaSalle Barcelona

Assigned 3

Full Name	Email
Amalia Rodriguez	tellezatwork+03@gmail.com
Ramon Sanpedro	tellezatwork+04@gmail.com

Available exams

- ☒ EXAM - Husky Robot Challenge of ROS Basics in 5 Days
- ☐ EXAM - Navigate a Husky Robot autonomously in an Outdoor Environment of ROS Navigation in 5 Days
- ☐ Perception exam of ROS Perception in 5 Days
- ☐ EXAM - Husky Robot Challenge of ROS Basics in 5 Days (C++)
- ☐ EXAM - Ultimate Code Foundation Challenge of Python 3 for Robotics
- ☐ EXAM - Ultimate Code Foundation Challenge of Linux for Robotics

Enabled Exams (1)

EXPORT TO CSV ADD MEMBER

Rows per page: 15 1-2 of 2

EXPORT TO CSV ADD MEMBER

Students' progress control panel

	Assigned	Remaining	Total					
	52	10	62		EXPORT TO CSV ADD MEMBER			
Full Name	Email	Total Hours	Exams Taken	Certificates	Added On	Is manager?	Details	Remove student?
Leeor Nehardea	lneharde@ucsd.edu	22.57 hours	None taken yet.	- None earned yet -	2020-07-30			
Haoru Xue	hxue@ucsd.edu	1.02 hours	None taken yet.	- None earned yet -	2020-07-31			
Jan Tengdyantono	jtengdya@ucsd.edu	59.83 hours	None taken yet.	- None earned yet -	2020-08-05			
Nathan Perkins	nperkins487@gmail.com	42.89 hours	None taken yet.	- None earned yet -	2020-08-05			
Lavita Zuo	x5zuo@ucsd.edu	22.67 hours	None taken yet.	- None earned yet -	2020-08-05			
Ryan Dunn	ryan.dunn729@gmail.com	18.59 hours	None taken yet.	- None earned yet -	2020-08-05			
Drew Britten	drewbrit10@gmail.com	15.29 hours	None taken yet.	- None earned yet -	2020-08-13			
Songyu Lu	sol009@ucsd.edu	46.71 hours	None taken yet.	- None earned yet -	2020-09-01			
Joshua Orozco	jorozco@ucsd.edu	3.45 hours	None taken yet.	- None earned yet -	2020-10-02			
Owen Cruise	ocruiase@ucsd.edu	3.53 hours	None taken yet.	- None earned yet -	2020-10-07			
Ethan Lerner	elerner@ucsd.edu	0.57 hours	None taken yet.	- None earned yet -	2020-10-07			
Benjamin Crawford	bcrawfor@ucsd.edu	0.18 hours	None taken yet.	- None earned yet -	2020-10-07			
Udai Kandah	ukandah@ucsd.edu	2.45 hours	None taken yet.	- None earned yet -	2020-10-07			
Dominic Nightingale	djnighti@ucsd.edu	16.20 hours	None taken yet.	- None earned yet -	2020-10-07			

Students' progress control panel



Ramon Sanpedro
tellezatwork+04@gmail.com

Added on
2020-12-07

Last activity
December 07, 2020,
19:08

Total learning hours
0.06 hours

Exams taken | Score
None taken yet.

Certificates
- None earned yet -

Lesson	Started on	Time spent
URDF Introduction	December 07, 2020, 19:05	0:02:04
Building the Visual Robot Model with URDF	December 07, 2020, 19:07	0:00:46
Using URDF for Gazebo	December 07, 2020, 19:08	0:00:49

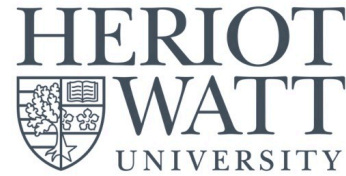
Rows per page: 15 1-3 of 3 < >

Advantages of Paid solution

1. Get all the material done ready to teach
 2. No need to install anything
 3. Get exams and corrections of them
 4. Include LinkedIn certificates
 5. We provide support to your students
 6. Follow student's progress
 7. Real robot lab ready
- Enjoy yourself teaching instead of wasting your time with the preparation



Some Universities Using Our Solution





“With The Construct, our students can jump right into ROS without all the hardware and software setup problem. And the best: they can do this from everywhere”

Steffen Pfiffner

Lecturer at University of Weingarten



**Now let's do an
example of a
Zoom class!**





Book a Demo

Have all your students learning ROS in less than a day!

REQUEST A DEMO





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