The Duckietown Book

The last version of this book and other documents are available at the URL
http://book.duckietown.org/

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Part 1
The Duckietown project

Chapter 1
What is Duckietown?

1.1. Goals and objectives

Duckietown is a robotics educations and outreach effort.

The most tangible goal of the project is to provide a low-cost educational platform for learning autonomy, consisting of the Duckiebots, an autonomous robot, and the Duckietowns, the infrastructure in which the Duckiebots navigates.

However, we focus on the *learning experience* as a whole, by providing a set of modules teaching plans and other guides, as well as a curated role-play experience.

We have two targets:

1.

For **instructors**, we want to create a "class-in-a-box" that allows to offer a modern and engaging learning experience. Currently, this is feasible at the advanced undergraduate and graduate level, though in the future we would like to present the platform as multi-grade experiences.

2.

For **self-guided learners**, we want to create a "self-learning experience", that allows to go from zero knowledge of robotics to graduate-level understanding.

In addition, the Duckietown platform has been used as a research platform.

TODO: add references to papers submitted/published with it.

1.2. Results obtained so far

While we are at the early phases of the project, many people have been used the materials in the past year.

1.3. Why the duckies?

Why the duckies?

Compared to other educational robotics projects, the presence of the duckies is what makes this project stand out. Why the duckies?

We want to present robotics in an accessible and friendly way.

TODO: copy usual discussion from somewhere else.

TODO: add picture of kids with Duckiebots.

1.4. Learn about the platform

The best way to get a sense of how the platform looks is to watch these videos. They show off the capabilities of the platform.

TODO: add 4 “cool” videos currently in the home page

This video is part of the Red Hat documentary:

TODO: add Red Hat video

1.5. Learn about the educational experience ✎

These papers present a more formal description of the technical side of the projecrt as well as the educational side.

This paper [1] describes the course design for Duckietown: learning objectives, teaching methods, etc.

This video is a Duckumentary about the first version of the class, during Spring 2016. The Duckumentary was shot by Chris Welch.

TODO: Duckumentary about the release.

1.6. Learn about the platform ✎

The paper [2] describes the Duckiebot and its software. With 29 authors, we made the record for a robotics conference.

Chapter 2
Duckietown history and future

2.1. The beginnings of Duckietown

Duckietown started as an MIT class during Spring 2016.

2.2. Duckietown around the world

1) Duckietown High School

2.3. Coming up

In 2017, the class will be offered contemporaneously at:

- ETH Zurich
- University of Montreal
- University of Chicago

as well as:

CHAPTER 3

First steps

3.1. How to get started

If you are an instructor, please jump to Chapter 4.

If you are a self-guided learner, please jump to Chapter 5.

If you are a company, and interested in working with Duckietown, please jump to Chapter 6.

3.2. How to keep in touch

TODO: add link to Facebook

TODO: add link to Mailing list

TODO: add link to Slack?

3.3. How to contribute

TODO: If you want to contribute to the software...

TODO: If you want to contribute to the hardware...

TODO: If you want to contribute to the documentation...

TODO: If you want to contribute to the dissemination...

CHAPTER 4
Duckietown for instructors

CHAPTER 5

Duckietown for self-guided learners

TODO: to write

Chapter 6
Introduction for companies

TODO: to write

Chapter 7
Frequently Asked Questions

7.1. General questions

What is Duckietown?

Duckietown is a low-cost educational and research platform.

Is Duckietown free to use?

Yes. All materials are released according to an open source license.

Is everything ready?

Not quite! Please sign up to our mailing list to get notified when things are a bit more ready.

How can I start?

See the next section, Getting started.

How can I help?

If you would like to help actively, please email duckietown@mit.edu.

7.2. FAQ by students / independent learners

I want to build my own Duckiebot. How do I get started?

TODO: to write

7.3. FAQ by instructors

How large a class can it be? I teach large classes.

TODO: to write

What is the budget for the robot?

TODO: to write

I want to teach a Duckietown class. How do I get started?

Please get in touch with us at duckietown@mit.edu. We will be happy to get you started and sign you up to the Duckietown instructors mailing list.

7.4. FAQ by researchers

TODO: to write

Part 2
Building a Duckiebot

The trip begins with acquiring the parts. Here, we provide a link to all bits and pieces that are needed to build a Duckiebot and the Duckietowns.

In general, keep in mind that:

- The links might expire, or the prices might vary.
- In general, substitutions are OK for the mechanical components, and not OK for all the rest.

CHAPTER 8

Acquiring the parts for the Duckiebot (2017)

8.1. Chassis

We selected the Magician Chassis as the basic chassis for the robot (Figure 1).

We chose it because it has a double-decker configuration, and so we can put the battery in the lower part.

The price for this in the US is about USD 15-30.

Figure 1. The Magician Chassis

8.2. Camera

...

8.3. Bill of materials

Chassis	USD xxx
Camera	USD xxx

CHAPTER 9
Acquiring the parts for Duckietown (2017)

Part 3
Modeling

TODO:

Chapter 10
Kinematics of Duckiebot

TODO:

Part 4
How to contribute

Chapter 11
Contributing to this documentation

11.1. Where the documentation is

All the documentation is in the repository `duckietown/duckuments`.

The documentation is written as a series of small files in Markdown format.

It is then processed by a series of scripts to create this output:

- a publication-quality PDF;
- an online HTML version, split in multiple pages and with comments boxes.

11.2. Editing links

The simplest way to contribute to the documentation is to click any of the "✎" icons next to the headers.

They link to the "edit" page in Github. There, one can make and commit the edits in only a few seconds.

11.3. Comments

In the multiple-page version, each page also includes a comment box powered by a service called Disqus. This provides a way for people to write comments with a very low barrier. (We would periodically remove the comments.)

11.4. Installing dependencies for compiling the documentation

Let `DUCKUMENTS` be the base directory for the documentation.

Download the `duckuments` repo in that directory:

```
$ git clone git@github.com:duckietown/duckuments.git $DUCKUMENTS
```

Cd into directory:

```
$ cd $DUCKUMENTS
```

On Ubuntu 16.04, create a virtual environment usign `virtualenv`:

```
$ virtualenv --system-site-packages deploy
```

In other distributions you might need to use `venv`:

```
$ venv deploy
```

Activate the virtual environment:

```
$ source $DUCKUMENTS/deploy/bin/activate
```

Install some dependencies:

```
$ sudo apt-get install libxml2-dev libxslt1-dev
$ sudo apt-get install libffi6 libffi-dev
$ sudo apt-get install python-dev python-numpy python-matplotlib
```

Clone the `mcdp` external repository:

```
$ cd $DUCKUMENTS
$ git clone -b duckuments git@github.com:AndreaCensi/mcdp.git
```

Install it and its dependencies:

```
$ cd $DUCKUMENTS/mcdp
$ python setup.py develop
```

Depending on your system, you might need to install these other dependencies: (It should not be necessary on Ubuntu 16 given the `apt-get` commands above.)

```
$ cd $DUCKUMENTS
$ pip install numpy matplotlib
```

Ensure the latest version (>6) of `nodejs` is installed.

Run:

```
$ nodejs --version
6.xx
```

If the version is 4 or less, remove `nodejs`:

```
$ sudo apt-get remove nodejs
```

Install `nodejs` using the instructions at this page.

Next, install the necessary Javascript libraries using `npm`:

```
$ cd $DUCKUMENTS
$ npm install MathJax-node jsdom@9.3 less
```

Install PrinceXML from this page.

TODO: instructions for fonts

11.5. Troubleshooting installation problems ✎

1) Installing (`nodejs`) packages ✎

The only pain point in the installation procedure has been the installation of `nodejs` packages using `npm`. For some reason, they cannot be installated globally (`npm install -g`).

Do not use `sudo` for installation. It will cause problems.

If you use `sudo`, you probably have to delete a bunch of directories, such as: `RBROOT/node_modules`, `/.npm`, and `/.node_modules`, if they exist.

11.6. Compiling the documentation ✎

Make sure you have deployed and activated the virtual environment. Then:

```
$ cd $DUCKUMENTS
$ make duckuments-dist
```

This creates the directory `duckuments-dist`, which contains another checked out copy of the repository, but with the branch `gh-pages`, which is the branch that is published by Github using the "Github Pages" mechanism.

At this point, please make sure that you have these two `.git` folders:

```
$DUCKUMENTS/.git
$DUCKUMENTS/duckuments-dist/.git
```

To compile the docs, go in the `DUCKUMENTS` directory and run `make compile`:

```
$ cd $DUCKUMENTS
$ make all split
```

This creates the following files:

- `duckuments-dist/master/duckiebook.html` is a single-page HTML of everything.
- `duckuments-dist/master/duckiebook.pdf` is the PDF version.
- `duckuments-dist/master/duckiebook/index.html` is the first page of the version with each chapter on a different page.

11.7. Deploying the documentation ✎

To deploy the documentation, jump into the `DUCKUMENTS/duckuments-dist` directory.

Run the command `git branch`. If the out does not say that you are on the branch `gh-pages`, then one of the steps before was done incorrectly.

```
$ cd $DUCKUMENTS/duckuments-dist
$ git branch
...
* gh-pages
...
```

Now, after triple checking that you are in the `gh-pages` branch, you can use `git status` to see the files that were added or modified, and simply use `git add`, `git commit` and `git push` to push the files to Github.

CHAPTER 12

Features of the documentation writing system

12.1. Embedded LaTeX

You can use LaTeX math, environment, and references. For example, take a look at

$$x^2 = \int_0^t f(\tau)\ \mathrm{d}\tau$$

or refer to Proposition 1.

Proposition 1. (Proposition example) This is an example proposition: $2x = x + x$.

The above was written as in Figure 2.

```
You can use $\LaTeX$ math, environment, and references.
For example, take a look at

\[
    x^2 = \int_0^t f(\tau)\ \text{d}\tau
\]

or refer to [](#prop:example).

\begin{proposition}[Proposition example]\label{prop:example}
This is an example proposition: $2x = x + x$.
\end{proposition}
```

Figure 2. Use of LaTeX code.

TODO: other LaTeX features supported

12.2. Other interesting features

TODO: to write

12.3. Limitations

There are some limitations:

• Please use the string `&#36;` to write the dollar symbol $, otherwise it gets confused with LaTeX math materials. Also notice that you should probably use “USD” to refer to U.S. dollars

Chapter 13
Bibliography

[1] Jacopo Tani, Liam Paull, Maria Zuber, Daniela Rus, Jonathan How, John Leonard, and Andrea Censi. **Duckietown: an innovative way to teach autonomy.** In *EduRobotics 2016*. Athens, Greece, December 2016. pdf

[2] Liam Paull, Jacopo Tani, Heejin Ahn, Javier Alonso-Mora, Luca Carlone, Michal Cap, Yu Fan Chen, Changhyun Choi, Jeff Dusek, Daniel Hoehener, Shih-Yuan Liu, Michael Novitzky, Igor Franzoni Okuyama, Jason Pazis, Guy Rosman, Valerio Varricchio, Hsueh-Cheng Wang, Dmitry Yershov, Hang Zhao, Michael Benjamin, Christopher Carr, Maria Zuber, Sertac Karaman, Emilio Frazzoli, Domitilla Del Vecchio, Daniela Rus, Jonathan How, John Leonard, and Andrea Censi. **Duckietown: an open, inexpensive and flexible platform for autonomy education and research.** In *IEEE International Conference on Robotics and Automation (ICRA)*. Singapore, May 2017. pdf