

Syringenator

Generated by Doxygen 1.8.16

<b>1 README</b>	<b>1</b>
1.1 Development Team Vulcan	1
1.2 Project Pages	2
1.3 Communication	2
1.3.1 Don't Clobber Other People's Work	2
1.3.2 Comment Your Work	2
1.4 Using Git	2
1.4.1 Work in Your Own Branch	2
1.4.2 Commit Your Work	3
1.4.3 Merge All the Latest Changes	3
1.4.4 Push Your Branch	4
1.4.5 Make a Pull Request	4
1.4.6 What not to do	4
1.5 HypoRobot Assignment	4
1.5.1 Terminology	5
1.5.2 Rules of the Game	5
<b>2 Installations</b>	<b>6</b>
2.1 librealsense	6
2.1.1 Downloads	6
2.1.2 Kernel source patching	7
2.1.3 Kernel Configuration	7
2.2 OpenCV	8
2.2.1 Dependencies	8
2.2.2 Python Virtual Environment	8
2.2.3 cmake	8
<b>3 Calibration</b>	<b>11</b>
3.1 Coordinate Systems	11
3.1.1 Image Cartesian	11
3.1.2 Floor Cartesian	11
3.1.3 Arm Cylindrical	12
<b>4 Todo List</b>	<b>12</b>
<b>5 Namespace Index</b>	<b>12</b>
5.1 Namespace List	12
<b>6 Class Index</b>	<b>12</b>
6.1 Class List	12

<b>1 README</b>	<b>1</b>
<b>7 File Index</b>	<b>12</b>
7.1 File List . . . . .	12
<b>8 Namespace Documentation</b>	<b>13</b>
8.1 Syringenator Namespace Reference . . . . .	13
8.1.1 Detailed Description . . . . .	14
8.1.2 Function Documentation . . . . .	14
<b>9 Class Documentation</b>	<b>18</b>
9.1 Syringenator.Target Class Reference . . . . .	18
9.1.1 Detailed Description . . . . .	19
<b>10 File Documentation</b>	<b>19</b>
10.1 src/controller/constants.hpp File Reference . . . . .	19
10.1.1 Detailed Description . . . . .	21
10.2 src/controller/controller.ino File Reference . . . . .	22
10.2.1 Detailed Description . . . . .	22
10.3 src/controller/Syringenator.hpp File Reference . . . . .	22
10.3.1 Detailed Description . . . . .	24
10.3.2 Function Documentation . . . . .	24
10.4 src/pi/constants.py File Reference . . . . .	26
10.4.1 Detailed Description . . . . .	28
10.5 src/pi/Syringenator.py File Reference . . . . .	28
10.5.1 Detailed Description . . . . .	30
<b>Index</b>	<b>31</b>

# 1 README

University of Washington

TCES 460

Winter 2019

## 1.1 Development Team Vulcan

Authors

Name	Email
Alex Boyle	<a href="mailto:boylea4@uw.edu">boylea4@uw.edu</a>
Ammon Dodson	<a href="mailto:ammon0@uw.edu">ammon0@uw.edu</a>
Alex Marlow	<a href="mailto:alexmarlow117@gmail.com">alexmarlow117@gmail.com</a>
Jake McKenzie	<a href="mailto:jake314@uw.edu">jake314@uw.edu</a>
Brooke Stevenson	<a href="mailto:brooks04@uw.edu">brooks04@uw.edu</a>

## Copyright

Copyright © 2019 by the authors. All rights reserved.

## 1.2 Project Pages

- [The Github Repo](#)
- [Documentation Website](#)

## 1.3 Communication

### 1.3.1 Don't Clobber Other People's Work

Since we're all working in the same space it is important to be courteous. Pretty much this comes down to not overwriting other people's work. If there is some real need to change something that already exists there should be a discussion between everyone involved.

### 1.3.2 Comment Your Work

Not everything will be obvious to everyone else. Write a paragraph for every non-trivial function. Write a detailed explanation any time you want to get clever with the code. Always put your name or initials on larger comments and blocks of code that you have written. That way it's easy to know who to talk to if there are questions.

## 1.4 Using Git

Git is a command-line tool for managing source code. Github is an on-line service that provides git remotes. A git remote is a remote copy of a git repository. Multiple people work in the same repository through the use of a single remote. The trick is to manage version conflicts intelligently.

Each team member should periodically merge master into their own branch to ensure that we are synced up. The master branch should only ever have merge commits and working code. I will try to enforce this with Github so that we don't make a mess. —ABD

### 1.4.1 Work in Your Own Branch

Each team member should create their own branch to work in. You may make as many branches as you like, just make sure you have one. You can create branches on the command line with:

```
$ git branch <branch-name>
```

To switch to your branch do:

```
$ git checkout <branch-name>
```

### 1.4.2 Commit Your Work

Commits are a permanent record of your work. They should be as small and purpose-driven as possible. Think: "can I write a couple lines that explains what I did?" To check for uncommitted changes, or check your status in general do:

```
$ git status
On branch ammon
Your branch is up-to-date with 'github/ammon'.  <- this is the remote
Changes not staged for commit:
  (use "git add/rm <file>..." to update what will be committed)
  (use "git checkout - <file>..." to discard changes in working directory)
    modified:   README.md
Untracked files:
  (use "git add <file>..." to include in what will be committed)
    docs/autotoc_md6.html
    latex/autotoc_md6.tex
no changes added to commit (use "git add" and/or "git commit -a")
```

You make a commit in two steps: first you stage the changed files that you want to include in this next commit.

```
$ git add <filename> <anotherfile>
```

Once you have staged a bunch of changes you can check your status again:

```
$ git status
On branch ammon
Your branch is up-to-date with 'github/ammon'.
Changes to be committed:
  (use "git reset HEAD <file>..." to unstage)
    modified:   README.md
Changes not staged for commit:
  (use "git add/rm <file>..." to update what will be committed)
  (use "git checkout - <file>..." to discard changes in working directory)
    modified:   Makefile
    deleted:    refman.pdf
Untracked files:
  (use "git add <file>..." to include in what will be committed)
    docs/autotoc_md7.html
    latex/autotoc_md7.tex
```

Once you are satisfied with what is currently staged you finish the commit by doing:

```
$ git commit
```

Git will automatically open a text editor where you can describe what the changes are. Make this a meaningful message since it will be the only thing that distinguishes this commit from hundreds of others.

You can also do:

```
$ git commit -m "<commit message>"
```

(-m is shorthand for --message command which tells other collaborators (and your future self) the nature of the change you just made. --Jake

### 1.4.3 Merge All the Latest Changes

The magic of git is being able to merge conflicting changes. Before you share your changes (pushing), you must pull the latest changes and merge them with yours. First pull the master branch:

```
$ git pull origin master
```

You will need to enter your password and git will tell you if there have been any changes. Git will attempt to merge the master branch into yours. If there are any conflicts it will tell you. Git will rewrite your files to include both versions of the conflicting code. To see which files are in conflict do:

```
$ git status
```

You have to open those files, find, and fix the conflicting versions. Once you think you are done, rebuild and test all the code. Look for any new errors and fix them. Once you are satisfied that the merge has been completed successfully add and commit your changes as usual.

### 1.4.4 Push Your Branch

Pushing your work to the remote allows everyone else to see it. You should merge master before pushing. To push do:

```
$ git push origin <your-branch>
```

### 1.4.5 Make a Pull Request

The master branch is where we integrate all the changes everyone is making. This is done through "pull requests". A pull request is a way for everyone to see and comment on new code. It will also allow us to only make merge commits to the master branch. If we work this way the master branch will always be clean and there will be less errors, lost work, and wasted time.

### 1.4.6 What not to do

- **Don't commit directly to master.** I've tried to setup Github to make this difficult or impossible, but in any case that it isn't protected properly nobody should be trying this anyway.
- **Don't –force** Read your error messages, they are usually very helpful. The force tag overwrites history and can easily erase work already done. If git complains there is a reason for it.

## 1.5 HypoRobot Assignment

### Author

Robert Gutmann, Ph.D.

If you've been paying any attention at all to current events you know that a major plague has descended on cities and counties throughout the country in the form of used and discarded hypodermic needles. Countless hours are spent cleaning up this mess. For instance, some schools are forced, for safety reasons, to send staff out to scour the playgrounds prior to children showing up.

Your task this quarter will be to design an autonomous robot that can help automate the arduous and sometimes dangerous job of spotting, retrieving, and disposing of hypodermic syringes.

Your robot will be a prototype, not a fully functional disposal robot, but it will have important technical features necessary on such a robot.

A second point is that we will be dealing with industrial (i.e. dull) syringes. These are typically used to disburse such things glue or solvents. They are commonly used in our labs to glue acrylic parts together. Anyone in the lab with a sharp needle will be immediately disqualified. Even so, if you would rather not design and test with any syringe, you may, with my written permission, use a ballpoint pen, a #2 pencil or a similar object of your choosing.

All testing will be done indoors on a flat surface.

### 1.5.1 Terminology

The following terms are used in this specification:

- The term “autonomous”, in this case, means that no commands can be transmitted to your robot from any outside agency (especially from a human or computer or other controller) and all sensors used in the contest must be physically attached to your robot. No wired connections are allowed between any outside agency and your robot.
- The term “course” refers to the area in which the contest takes place.
- The term “tape line” refers to an oval of white tape that runs from a start point around the oval, back to the start point (which is now the finish point). All targets will be placed outside of the oval.
- The term “target” refers to the object you are required to pick up and dispose of (syringe or, alternatively, a pen or pencil).
- The term “decoy” refers an object on the course that is not a target. A decoy will be less than 2 cm tall.
- The term “obstacle” refers to an object on the course that your robot must avoid running into. An obstacle will be at least 15 cm tall. A typical obstacle would be a cardboard box.
- The term “finish the course” will mean that your robot traverses the oval at least once. Note: Your robot will have to leave the tape line to pick up targets, but it should eventually either find another target or return to the tape line. The tape line is your navigation aid.
- The term “contact a target” will mean to touch a target with your pick-up mechanism in such a way as to move it. Note: moving a target with a robot wheel or track does not count as a contact.
- The term “participate” will mean that you either finish the course or contact a target.
- The term “acquire a target” means your robot has reported to its data logger that it has identified a target and reports an accurate position for that target. The term “acquire a decoy” means your robot has reported to its data logger that it has acquired a target that turns out to be a decoy.
- The term “pick up a target” refers to your robot picking up a target off the course surface.
- The term “dispose of a target” refers to your robot placing the target in container on your robot.
- A robot is “stationary” if its wheels are not rotating and its arm is not rotating about its vertical axis.

### 1.5.2 Rules of the Game

- You will be given two test runs, one per day over two class periods. The dates will be firmly established by midterm time.
- All tests will be conducted indoors.
- A somewhat different course may be laid out each day. The layout will consist of:
  - A tape line; this will serve as your navigation maker. Since we will be indoors, we won’t have GPS; the tape line will serve as your navigation reference.
  - A number of targets will be placed within 1 meter of the tape line; you will have to leave the tape line to pick up your targets.
  - A number of decoys will be placed within 1 meter of the tape line.

- A number of obstacles will be placed on the course. If you exactly follow the tape line you will not run into an obstacle; however, you may have to avoid obstacles as you maneuver away from the tape line to pick up targets.
- No human will be allowed on the course during a test run.
- Your robot must be autonomous.
- All test runs will be video 'taped.'
- The goal is to maximize your score according to the algorithm discussed below. The maximum score you achieve for any one day over the two days will be your final score.
- The scores for the entire class will be rank-ordered.
- You will be allowed ten minutes on the course for each test run. This will be strictly timed.
- Robot
  - You will be provided with
    - \* A basic robot chassis
    - \* Two motors with encoders and wheels
    - \* Two motor controllers (H-bridges)
    - \* A robotic arm
    - \* A battery pack with a power distribution unit
    - \* Distance sensors.
    - \* Line sensors
    - \* Data logger with SD card
  - You do not have to use this robot chassis or arm
  - You will need to supply your own processor(s)
  - You will need to supply your own cameras(s) and cables.
  - You may acquire additional mechanical or electronic parts for your robot.
  - If you plan to spend any money on your robot, you must get permission from me in writing first.
  - Your group has a strict budget of \$300, including any parts that you have already acquired and use on your robot (e.g., an Arduino).
- Rule 8 applies. Rule 8 comes from the official rules for the annual Race to Alaska (see <https://r2ak.com/official-rules/>). Rule 8 states, and I quote: If we decide it's necessary to consult a lawyer to figure out if you are disqualified or not, you are automatically disqualified. Play by the rules and live up to the spirit of the race. If you get cute and push the boundaries, we'll bring down the hammer.

## 2 Installations

### 2.1 librealsense

#### 2.1.1 Downloads

Update the system

```
sudo apt update
```



get the kernel headers so that we can compile new things

```
sudo apt install raspberrypi-kernel-headers
```

make sure that raspberrypi-kernel and raspberrypi-bootloader are at the latest versions

install git and other build tools

```
sudo apt install git build-essential -y
```

get the latest librealsense

```
git clone --depth 1 https://github.com/IntelRealSense/librealsense.git
```

Install Intel Realsense permission scripts located in librealsense source directory:

```
sudo cp config/99-realsense-libusb.rules /etc/udev/rules.d/ sudo udevadm control  
--reload-rules && udevadm trigger
```

get the source for the current kernel make sure version numbers match apt-cache

```
wget https://github.com/raspberrypi/linux/archive/raspberrypi-kernel\_1.20161215-1.tar.gz
```

extract it

```
tar -xzf raspberrypi-kernel_1.20161215-1.tar.gz
```

### 2.1.2 Kernel source patching

```
`LINUX_BRANCH=$(uname -r)  
# Construct branch name from distribution codename {xenial,bionic,..} and kernel version  
ubuntu_codename=`. /etc/os-release; echo ${UBUNTU_CODENAME}/*, /)`  
if [ -z "${ubuntu_codename}" ];  
then  
    # Trusty Tahr shall use xenial code base  
    ubuntu_codename="xenial"  
    retpoline_retrofit=1  
fi  
kernel_branch=$(choose_kernel_branch ${LINUX_BRANCH} ${ubuntu_codename})  
kernel_name="ubuntu-${ubuntu_codename}-${kernel_branch}"`
```

### 2.1.3 Kernel Configuration

Load the kernel configuration module

```
sudo modprobe configs
```

get a copy of the current kernel configuration

```
cp /proc/config.gz ./
```

decompress it

```
gunzip config.gz
```

put the configuration in the source tree

```
mv config linux-raspberrypi-kernel_1.20161215-1/.config
```

In the kernel directory update the config

```
make silentoldconfig
```

## 2.2 OpenCV

We used this [tutorial](#) with some modifications.

### 2.2.1 Dependencies

The tutorial's atlas installation is insufficient resulting in:

```
- Could NOT find Atlas (missing: Atlas_CLAPACK_INCLUDE_DIR)
```

Referring to [issue #10442](#) I did:

```
sudo apt install liblapacke-dev
```

### 2.2.2 Python Virtual Environment

I wanted to include the python virtual environment in the git repo so that it can be used by anyone. I am not sure if this is the preferred way to share virtual environments. We also won't lose it if the pi has to be rebuilt. so the .bashrc script reads:

```
export WORKON_HOME=$HOME/Desktop/Syringenator/src/pi/pyVirtEnv
source /usr/local/bin/virtualenvwrapper.sh
```

### 2.2.3 cmake

the cmake step then needs to be modified to accommodate:

```
cmake -D CMAKE_BUILD_TYPE=RELEASE \
-D CMAKE_INSTALL_PREFIX=/usr/local \
-D INSTALL_PYTHON_EXAMPLES=ON \
-D INSTALL_C_EXAMPLES=OFF \
-D OPENCV_EXTRA_MODULES_PATH= /Desktop/opencv_contrib-4.0.1/modules \
-D PYTHON_EXECUTABLE= /Desktop/Syringenator/src/pi/pyVirtEnv/syringenator/bin/python \
-D BUILD_EXAMPLES=ON \
-D WITH_OPENMP=ON ..
```

cmake reports:

```
- Looking for ccache - not found
- FP16 is not supported by C++ compiler
- Found ZLIB: /usr/lib/arm-linux-gnueabi/libz.so (found suitable version "1.2.8", minimum required is "1.2.3")

- Found ZLIB: /usr/lib/arm-linux-gnueabi/libz.so (found version "1.2.8")
- Checking for module 'gstreamer-base-1.0'
- No package 'gstreamer-base-1.0' found
- Checking for module 'gstreamer-video-1.0'
- No package 'gstreamer-video-1.0' found
- Checking for module 'gstreamer-app-1.0'
- No package 'gstreamer-app-1.0' found
- Checking for module 'gstreamer-riff-1.0'
- No package 'gstreamer-riff-1.0' found
- Checking for module 'gstreamer-pbutils-1.0'
- No package 'gstreamer-pbutils-1.0' found
- Checking for module 'gstreamer-base-0.10'
- No package 'gstreamer-base-0.10' found
- Checking for module 'gstreamer-video-0.10'
- No package 'gstreamer-video-0.10' found
- Checking for module 'gstreamer-app-0.10'
- No package 'gstreamer-app-0.10' found
- Checking for module 'gstreamer-riff-0.10'
- No package 'gstreamer-riff-0.10' found
- Checking for module 'gstreamer-pbutils-0.10'
- No package 'gstreamer-pbutils-0.10' found
- Checking for module 'libdc1394-2'
- No package 'libdc1394-2' found
- Checking for module 'libdc1394'
- No package 'libdc1394' found
```

```

- Looking for linux/videodev2.h
- Looking for linux/videodev2.h - found
- Looking for sys/videoio.h
- Looking for sys/videoio.h - not found
- Checking for module 'libavresample'
- No package 'libavresample' found
- Could not find OpenBLAS lib. Turning OpenBLAS_FOUND off
- Found Atlas: /usr/include
- Found Atlas (include: /usr/include, library: /usr/lib/libatlas.so)
- LAPACK(Atlas): LAPACK_LIBRARIES: /usr/lib/liblapack.so;/usr/lib/libcblas.so;/usr/lib/libatlas.so
- LAPACK(Atlas): Support is enabled.
- Could NOT find JNI (missing: JAVA_INCLUDE_PATH JAVA_INCLUDE_PATH2 JAVA_AWT_INCLUDE_PATH)
- Could NOT find Pylint (missing: PYLINT_EXECUTABLE)
- Could NOT find Flake8 (missing: FLAKE8_EXECUTABLE)
- VTK is not found. Please set -DVTK_DIR in CMake to VTK build directory, or to VTK install subdirectory with
  VTKConfig.cmake file
- OpenCV Python: during development append to PYTHONPATH: /home/big/Desktop/opencv-4.0.1/build/python_loader
- Caffee: NO
- Protobuf: NO
- Glog: NO
- freetype2: YES
- harfbuzz: YES
- Could NOT find HDF5 (missing: HDF5_LIBRARIES HDF5_INCLUDE_DIRS) (found version "")
- Module opencv_ovis disabled because OGRE3D was not found
- No preference for use of exported gflags CMake configuration set, and no hints for include/library directories
  provided. Defaulting to preferring an installed/exported gflags CMake configuration if available.
- Failed to find installed gflags CMake configuration, searching for gflags build directories exported with
  CMake.
- Failed to find gflags - Failed to find an installed/exported CMake configuration for gflags, will perform
  search for installed gflags components.
- Failed to find gflags - Could not find gflags include directory, set GFLAGS_INCLUDE_DIR to directory
  containing gflags/gflags.h
- Failed to find glog - Could not find glog include directory, set GLOG_INCLUDE_DIR to directory containing
  glog/logging.h
- Module opencv_sfm disabled because the following dependencies are not found: Eigen Glog/Gflags
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin128.sse2.cpp
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin128.sse3.cpp
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin128.sse3.cpp
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin128.sse4_1.cpp
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin128.sse4_2.cpp
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin128.avx.cpp
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin128.fpl6.cpp
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin128.avx2.cpp
- Excluding from source files list: <BUILD>/modules/core/test/test_intrin256.avx2.cpp
- Excluding from source files list: modules/imgproc/src/corner.avx.cpp
- Excluding from source files list: modules/imgproc/src/filter.avx2.cpp
- Excluding from source files list: modules/imgproc/src/imgwarp.avx2.cpp
- Excluding from source files list: modules/imgproc/src/imgwarp.sse4_1.cpp
- Excluding from source files list: modules/imgproc/src/resize.avx2.cpp
- Excluding from source files list: modules/imgproc/src/resize.sse4_1.cpp
- Excluding from source files list: <BUILD>/modules/dnn/layers/layers_common.avx.cpp
- Excluding from source files list: <BUILD>/modules/dnn/layers/layers_common.avx2.cpp
- Excluding from source files list: <BUILD>/modules/dnn/layers/layers_common.avx512_skx.cpp
- freetype2: YES
- harfbuzz: YES
- Excluding from source files list: modules/features2d/src/fast.avx2.cpp
- Checking for modules 'tesseract;lept'
- No package 'tesseract' found
- No package 'lept' found
- Tesseract: NO
- Excluding from source files list: modules/calib3d/src/undistort.avx2.cpp
- OpenCL samples are skipped: OpenCL SDK is required
-
- General configuration for OpenCV 4.0.1 =====
- Version control: unknown
-
- Extra modules:
- Location (extra): /home/big/Desktop/opencv_contrib-4.0.1/modules
- Version control (extra): unknown
-
- Platform:
- Timestamp: 2019-02-14T22:20:14Z
- Host: Linux 4.4.38-v7+ armv7l
- CMake: 3.13.3
- CMake generator: Unix Makefiles
- CMake build tool: /usr/bin/make
- Configuration: RELEASE
-
- CPU/HW features:
- Baseline:
- requested: DETECT

```

```

-         disabled:                VFPV3 NEON
-
- C/C++:
-   Built as dynamic libs?:        YES
-   C++ Compiler:                  /usr/bin/c++ (ver 5.5.0)
-   C++ flags (Release):           -fsigned-char -W -Wall -Werror=return-type -Werror=non-virtual-dtor
-                                   -Werror=address -Werror=sequence-point -Wformat -Werror=format-security -Wmissing-declarations -Wundef
-                                   -Winit-self -Wpointer-arith -Wshadow -Wsign-promo -Wuninitialized -Winit-self -Wno-narrowing
-                                   -Wno-delete-non-virtual-dtor -Wno-comment -fdiagnostics-show-option -pthread -fomit-frame-pointer
-                                   -ffunction-sections -fdata-sections -mfp16-format=ieee -fvisibility=hidden -fvisibility-inlines-hidden
-                                   -fopenmp -O3 -DNDEBUG -DNDEBUG
-   C++ flags (Debug):             -fsigned-char -W -Wall -Werror=return-type -Werror=non-virtual-dtor
-                                   -Werror=address -Werror=sequence-point -Wformat -Werror=format-security -Wmissing-declarations -Wundef
-                                   -Winit-self -Wpointer-arith -Wshadow -Wsign-promo -Wuninitialized -Winit-self -Wno-narrowing
-                                   -Wno-delete-non-virtual-dtor -Wno-comment -fdiagnostics-show-option -pthread -fomit-frame-pointer
-                                   -ffunction-sections -fdata-sections -mfp16-format=ieee -fvisibility=hidden -fvisibility-inlines-hidden
-                                   -fopenmp -g -O0 -DDEBUG -D_DEBUG
-   C Compiler:                    /usr/bin/cc
-   C flags (Release):             -fsigned-char -W -Wall -Werror=return-type -Werror=non-virtual-dtor
-                                   -Werror=address -Werror=sequence-point -Wformat -Werror=format-security -Wmissing-declarations
-                                   -Wmissing-prototypes -Wstrict-prototypes -Wundef -Winit-self -Wpointer-arith -Wshadow -Wuninitialized
-                                   -Winit-self -Wno-narrowing -Wno-comment -fdiagnostics-show-option -pthread -fomit-frame-pointer
-                                   -ffunction-sections -fdata-sections -mfp16-format=ieee -fvisibility=hidden -fopenmp -O3 -DNDEBUG
-                                   -DNDEBUG
-   C flags (Debug):               -fsigned-char -W -Wall -Werror=return-type -Werror=non-virtual-dtor
-                                   -Werror=address -Werror=sequence-point -Wformat -Werror=format-security -Wmissing-declarations
-                                   -Wmissing-prototypes -Wstrict-prototypes -Wundef -Winit-self -Wpointer-arith -Wshadow -Wuninitialized
-                                   -Winit-self -Wno-narrowing -Wno-comment -fdiagnostics-show-option -pthread -fomit-frame-pointer
-                                   -ffunction-sections -fdata-sections -mfp16-format=ieee -fvisibility=hidden -fopenmp -g -O0 -DDEBUG
-                                   -D_DEBUG
-   Linker flags (Release):
-   Linker flags (Debug):
-   ccache:                        NO
-   Precompiled headers:           YES
-   Extra dependencies:            dl m pthread rt
-   3rdparty dependencies:
-
- OpenCV modules:
-   To be built:                   aruco bgsegm bioinspired calib3d ccalib core datasets dnn dnn_objdetect dpm
-                                   face features2d flann freetype fuzzy gapi hfs highgui img_hash imgcodecs imgproc java_bindings_generator
-                                   line_descriptor ml_objdetect optflow phase_unwrapping photo plot python2_python_bindings_generator reg
-                                   rgbd saliency shape stereo stitching structured_light superres surface_matching text tracking ts video
-                                   videoio videostab xfeatures2d ximgproc xobjdetect xphoto
-   Disabled:                      world
-   Disabled by dependency:        -
-   Unavailable:                  cnn_3dobj cudaarithm cudabgsegm cudacodec cudafeatures2d cudafilters
-                                   cudaimgproc cudalegacy cudaobjdetect cudaoptflow cudastereo cudawarping cudev cvv hdf java js matlab ovis
-                                   python3_sfm_viz
-   Applications:                  tests perf_tests examples apps
-   Documentation:                 NO
-   Non-free algorithms:           NO
-
- GUI:
-   GTK+:                          YES (ver 3.18.9)
-   GThread :                      YES (ver 2.48.2)
-   GtkGlibExt:                   NO
-   VTK support:                   NO
-
- Media I/O:
-   ZLib:                          /usr/lib/arm-linux-gnueabi/libz.so (ver 1.2.8)
-   JPEG:                          /usr/lib/arm-linux-gnueabi/libjpeg.so (ver 80)
-   WEBP:                          build (ver encoder: 0x020e)
-   PNG:                           /usr/lib/arm-linux-gnueabi/libpng.so (ver 1.2.54)
-   TIFF:                          /usr/lib/arm-linux-gnueabi/libtiff.so (ver 42 / 4.0.6)
-   JPEG 2000:                     /usr/lib/arm-linux-gnueabi/libjasper.so (ver 1.900.1)
-   OpenEXR:                       build (ver 1.7.1)
-   HDR:                           YES
-   SUNRASTER:                     YES
-   PXM:                           YES
-   PFM:                           YES
-
- Video I/O:
-   DC1394:                        NO
-   FFMPEG:                        YES
-     avcodec:                     YES (ver 57.64.100)
-     avformat:                    YES (ver 57.56.100)
-     avutil:                      YES (ver 55.34.100)
-     swscale:                     YES (ver 4.2.100)
-     avresample:                  NO
-   GStreamer:                     NO
-   v4l/v4l2:                     linux/videodev2.h

```

```

-
- Parallel framework:      OpenMP
-
- Trace:                  YES (built-in)
-
- Other third-party libraries:
-   Lapack:               YES (/usr/lib/liblapack.so /usr/lib/libcblas.so /usr/lib/libatlas.so)
-   Eigen:               NO
-   Custom HAL:          YES (carotene (ver 0.0.1))
-   Protobuf:            build (3.5.1)
-
- OpenCL:                 YES (no extra features)
-   Include path:        /home/big/Desktop/opencv-4.0.1/3rdparty/include/opencvcl/1.2
-   Link libraries:      Dynamic load
-
- Python 2:
-   Interpreter:         /home/big/Desktop/Syringenator/src/pi/pyVirtEnv/syringenator/bin/python (ver
-   2.7.12)
-   Libraries:           /usr/lib/arm-linux-gnueabi/libpython2.7.so (ver 2.7.12)
-   numpy:
-     /home/big/Desktop/Syringenator/src/pi/pyVirtEnv/syringenator/lib/python2.7/site-packages/numpy/core/include
-     (ver 1.16.1)
-   install path:        lib/python2.7/site-packages/cv2/python-2.7
-
- Python (for build):     /home/big/Desktop/Syringenator/src/pi/pyVirtEnv/syringenator/bin/python
-
- Java:
-   ant:                 NO
-   JNI:                 NO
-   Java wrappers:       NO
-   Java tests:          NO
-
- Install to:             /usr/local
- -----
-
- Configuring done
- Generating done
- Build files have been written to: /home/big/Desktop/opencv-4.0.1/build

```

## 3 Calibration

### 3.1 Coordinate Systems

This robot, of necessity uses multiple sets of coordinates.

#### 3.1.1 Image Cartesian

This coordinate system is used to locate pixels and distance measurements in the images generated from the camera. It consists of a positive integer tuple horizontal and vertical. Its axes are at right angles, and its origin is in the upper left corner of the image. Its values are always positive and its units are pixels.

We may also consider the camera's depth value as the third member of the image coordinates. Its units should be meters.

#### 3.1.2 Floor Cartesian

This coordinate system is used to locate targets around the robot. It consists of a signed integer tuple fore-aft and port-starboard. Positive values are forward and starboard. Its axes are at right angles and its origin is directly below the origin of Image Cartesian. Its units of length are centimeters. Smaller units introduce unnecessary and likely unrealistic precision. Larger units would require this system to use floats.

### 3.1.3 Arm Cylindrical

This coordinate system is used to locate targets around the xArm. It consists of an unsigned integer tuple azimuth and range. Its origin is at the level of the floor and directly below the xArm axis of rotation. Its units are those convenient for the use of the arm, and its range of values is recorded in constants.in

## 4 Todo List

### File [Syringenator.py](#)

how do we initialize the robot run? a button press? –ABD

### Member [Syringenator.returnToLine \(\)](#)

do we need to check that we actually returned? how do we recover if dead reckoning fails? –ABD

## 5 Namespace Index

### 5.1 Namespace List

Here is a list of all documented namespaces with brief descriptions:

#### [Syringenator](#)

The top-level Pi program

13

## 6 Class Index

### 6.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

#### [Syringenator.Target](#)

A class to contain everything we know about an aquired target

18

## 7 File Index

### 7.1 File List

Here is a list of all documented files with brief descriptions:

#### [src/controller/constants.hpp](#)

Constants shared across the whole system

19

<a href="#">src/controller/controller.ino</a> The Arduino sketch	22
<a href="#">src/controller/Syringenator.hpp</a> Arduino controller code –ABD	22
<a href="#">src/pi/constants.py</a> Constants shared across the whole system	26
<a href="#">src/pi/Syringenator.py</a> This is the main control script	28

## 8 Namespace Documentation

### 8.1 Syringenator Namespace Reference

The top-level Pi program.

#### Classes

- class [Target](#)  
*A class to contain everything we know about an aquired target.*

#### Functions

- def [log](#) (arg)  
*Record system events for later analysis.*
- def [arduinoSend](#) (bytes)  
*Send serial data to the arduino.*
- def [arduinoReceive](#) ()  
*Wait some fixed time for the arduino to send one or more bytes.*
- def [imageCart2floorCart](#) (x, y, d)  
*Derive floor position from image data.*
- def [floorCart2armCylinder](#) (x, y)  
*Derive cylindrical coordinates, centered on the arm from cartesian coordinates centered on the camera.*
- def [scan](#) ()  
*A routine to take a picture and report back the closest target The Computer vision routine must be able to handle multiple targets in the image.*
- def [canBePicked](#) (t)  
*A routine to determine if the target is in position to be picked up.*
- def [moveCloser](#) (t)  
*Move the robot closer to the given target.*
- def [avoid](#) ()  
*avoid an obstacle*
- def [pickUp](#) (t)  
*Attempt to pickup and dispose the target.*
- def [returnToLine](#) ()  
*signl the arduino to return to the line.*
- def [lineFollow](#) ()  
*Follow the line.*

## Variables

- `bool onTheLine = True`  
*boolean indicating whether we are on the line*
- `bool obstacle = False`  
*boolean indicating that we have detected an obstacle*
- `target = None`  
*The currently aquired target.*

### 8.1.1 Detailed Description

The top-level Pi program.

### 8.1.2 Function Documentation

#### 8.1.2.1 `arduinoReceive()`

```
def Syringenator.arduinoReceive ( )
```

Wait some fixed time for the arduino to send one or more bytes.

#### Returns

a list of bytes

#### 8.1.2.2 `arduinoSend()`

```
def Syringenator.arduinoSend (
    bytes )
```

Send serial data to the arduino.

#### Parameters

<code>bytes</code>	one or more bytes of data to send to the arduino
--------------------	--

#### Returns

None



### 8.1.2.3 avoid()

```
def Syringenator.avoid ( )
```

avoid an obstacle

#### Returns

None

### 8.1.2.4 canBePicked()

```
def Syringenator.canBePicked (
    t )
```

A routine to determine if the target is in position to be picked up.

Calculates whether the center of the target bounding box is in the pickup area.

#### Returns

a boolean

### 8.1.2.5 floorCart2armCylinder()

```
def Syringenator.floorCart2armCylinder (
    x,
    y )
```

Derive cylindrical coordinates, centered on the arm from cartesian coordinates centered on the camera.

#### Parameters

<i>x</i>	the x-value of the point of interest on the floor
<i>y</i>	the y-value of the point of interest on the floor

#### Returns

a tuple (Azimuth, Range)

#### 8.1.2.6 imageCart2floorCart()

```
def Syringenator.imageCart2floorCart (
    x,
    y,
    d )
```

Derive floor position from image data.

##### Parameters

<i>x</i>	the x-value of the point of interest in the image
<i>y</i>	the y-value of the point of interest in the image
<i>d</i>	the distance value of the point of interest in the image

##### Returns

a tuple (x, y)

#### 8.1.2.7 lineFollow()

```
def Syringenator.lineFollow ( )
```

Follow the line.

this routine simply signals the arduino to execute its [lineFollow\(\)](#) routine

##### Returns

None

#### 8.1.2.8 log()

```
def Syringenator.log (
    arg )
```

Record system events for later analysis.

##### Returns

None

### 8.1.2.9 moveCloser()

```
def Syringenator.moveCloser (
    t )
```

Move the robot closer to the given target.

The `moveCloser()` routine attempts to approach the target by relatively small increments. Because the move routines may be interrupted by the obstacle avoidance ISRs and the risk of jamming the wheels etc. we cannot expect to be able to approach successfully on the first try. Hence `moveCloser()` should only move a relatively short distance before exiting to allow another loop through the scan cycle.

Should we spend effort trying to avoid running over decoys here?

This routine should check for `ARDUINO_STATUS_OBSTACLE`. then what?

This routine is likely where we will have the most issues. –ABD

#### Parameters

<i>t</i>	a <a href="#">Target</a> object containing the location of the target to be approached
----------	--

#### Returns

None

### 8.1.2.10 pickUp()

```
def Syringenator.pickUp (
    t )
```

Attempt to pickup and dispose the target.

This routine must determine orientation of the target. If this is not done by some OpenCV magic we can attempt it here using the raw image data and the bounding box.

Divide the longer dimension of the bounding box by some constant divisor. Scan along each of those raster lines twice. On the first pass calculate an average brightness (RGB values can be summed). The second pass will pick out points of greatest brightness. Find the centers of clustered bright pixels. We now have a set of points in cartesian space. Have Jake find the slope of the line of best fit.

The center can be estimated as the center of the bounding box, or the center of the points, the mean of both, etc.

Once the values for x, y, and m have been determined they will have to pass through a calibration transform to determine the arm a, r, o values. –ABD

#### Parameters

<i>t</i>	a <a href="#">Target</a> object containing the raw bitmap data
----------	--

**Returns**

None

**8.1.2.11 returnToLine()**

```
def Syringenator.returnToLine ( )
```

signl the arduino to return to the line.

**Todo** do we need to check that we actually returned? how do we recover if dead reckoning fails? –ABD

We disscussed the possibility of a timer on [lineFollow\(\)](#), that if the line has not been detected recently then we know we are off track and must recoves somehow.

**Returns**

None

**8.1.2.12 scan()**

```
def Syringenator.scan ( )
```

A routine to take a picture and report back the closest target The Computer vision routine must be able to handle multiple targets in the image.

It would be best if all targets are reported. Then this routine will determine the closest one to pursue. –ABD

**Returns**

a target object

## 9 Class Documentation

### 9.1 Syringenator.Target Class Reference

A class to contain everything we know about an aquired target.

### 9.1.1 Detailed Description

A class to contain everything we know about an aquired target.

The documentation for this class was generated from the following file:

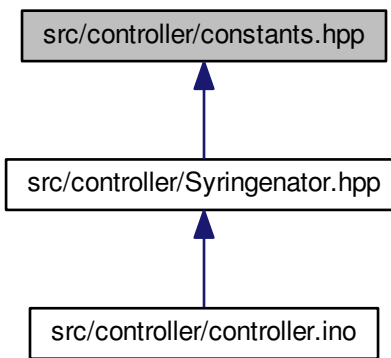
- [src/pi/Syringenator.py](#)

## 10 File Documentation

### 10.1 src/controller/constants.hpp File Reference

Constants shared across the whole system.

This graph shows which files directly or indirectly include this file:



#### Macros

- `#define ARM_AZIMUTH_MIN 0`  
*The minimum azimuth byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- `#define ARM_AZIMUTH_MAX 0`  
*The maximum azimuth byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- `#define ARM_RANGE_MIN 0`  
*The minimum range byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- `#define ARM_RANGE_MAX 0`  
*The maximum range byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- `#define ARM_ORIENT_MIN 0`

- The minimum orientation byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- `#define ARM_ORIENT_MAX 0`
  - The maximum orientation byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- `#define PICKUP_X_MIN 0`
  - The minimum target center x-value that allows a pickup.*
- `#define PICKUP_X_MAX 0`
  - The maximum target center x-value that allows a pickup.*
- `#define PICKUP_Y_MIN 0`
  - The minimum target center y-value that allows a pickup.*
- `#define PICKUP_Y_MAX 0`
  - The maximum target center y-value that allows a pickup.*
- `#define FWD_MAX_TICKS 200`
  - The maximum count of forward ticks used in `moveCloser()`*
- `#define ROT_MAX_TICKS 200`
  - The maximum absolute value of rotation ticks used in `moveCloser()`*
- `#define CAL_ROT_FACTOR 1`
  - Calibration factor used in rotation calculation.*
- `#define CAL_FWD_FACTOR 1`
  - Calibration factor used in forward calculation.*
- `#define ARDUINO_NULL 0x00`
  - A place holder for troubleshooting etc.*
- `#define ARDUINO_STATUS_ACK 0x01`
  - If the arduino needs to acknowledge something.*
- `#define ARDUINO_STATUS_READY 0x02`
  - If the arduino needs to indicate it is ready.*
- `#define ARDUINO_STATUS_PICK_FAIL 0x03`
  - Report that the pick failed.*
- `#define ARDUINO_STATUS_PICK_SUCCESS 0x04`
  - Report that the pick succeeded.*
- `#define ARDUINO_STATUS_ARM_FAULT 0x05`
  - Report a general arm failure.*
- `#define ARDUINO_STATUS_OBSTACLE 0x06`
  - Report an obstacle detected.*
- `#define ARDUINO_ROTATE 0x10`
  - serial command the arduino to rotate the robot, followed by one signed byte indicating magnitude and direction*
- `#define ARDUINO_MOVE 0x11`
  - serial command the arduino to advance the robot, followed by one signed byte indicating magnitude and direction*
- `#define ARDUINO_LINE_FOLLOW 0x12`
  - serial command the arduino to follow the line*
- `#define ARDUINO_AVOID 0x13`
  - serial command the arduino to avoid an obstacle*
- `#define ARDUINO_ARM_PARK 0x20`
  - serial command the arduino to call the park action sequence*
- `#define ARDUINO_ARM_DISPOSE 0x21`
  - serial command the arduino to call the dispose action sequence*
- `#define ARDUINO_ARM_PICKUP 0x22`
  - serial command the arduino to attempt a pick, followed by three bytes: azimuth, range, and orientation*

- #define `PORT_MOTOR_FWD` None  
*Arduino pin for port motor forward.*
- #define `PORT_MOTOR_REV` None  
*Arduino pin for port motor reverse.*
- #define `STBD_MOTOR_FWD` None  
*Arduino pin for starboard motor forward.*
- #define `STBD_MOTOR_REV` None  
*Arduino pin for starboard motor reverse.*
- #define `PORT_LINE_SENSE` None  
*Arduino pin for the port line sensor.*
- #define `STBD_LINE_SENSE` None  
*Arduino pin for the starboard line sensor.*
- #define `PORT_FWD_OBSTACLE` None  
*Arduino pin for the port forward obstacle sensor.*
- #define `PORT_AFT_OBSTACLE` None  
*Arduino pin for the port aft obstacle sensor.*
- #define `STBD_FWD_OBSTACLE` None  
*Arduino pin for the starboard forward obstacle sensor.*
- #define `STBD_AFT_OBSTACLE` None  
*Arduino pin for the starboard aft obstacle sensor.*
- #define `ARM_CONTROL` None  
*Arduino pin for communication with the xArm.*

### 10.1.1 Detailed Description

Constants shared across the whole system.

Includes constants used by both the arduino sketch and the the python script. The format of `constants.in` is three whitespace sparated columns:

[NAME] [value] [comments]

Any changes must be made in `constants.in` and followed by running:

```
make constants
```

—ABD

### Copyright

Copyright © 2019 by the authors. All rights reserved.

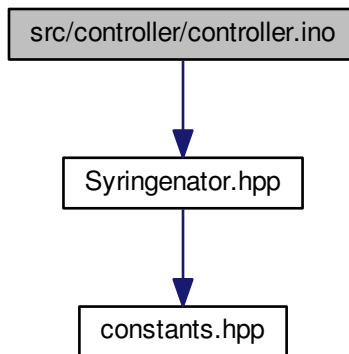
This file has been autogenerated, CHANGES MADE HERE WILL NOT PERSIST

## 10.2 src/controller/controller.ino File Reference

The Arduino sketch.

```
#include "Syringenator.hpp"
```

Include dependency graph for controller.ino:



### Functions

- void `setup` ()  
*Setup code here.*
- void `loop` ()  
*Controller loop code here.*

### 10.2.1 Detailed Description

The Arduino sketch.

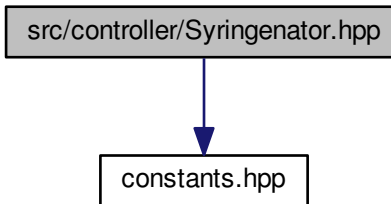
## 10.3 src/controller/Syringenator.hpp File Reference

Arduino controller code –ABD.

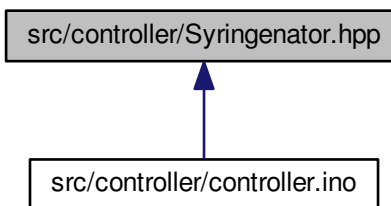


```
#include "constants.hpp"
```

Include dependency graph for Syringenator.hpp:



This graph shows which files directly or indirectly include this file:



## Functions

- void `lineDetector_ISR` (void)  
*A function to respond to a line detector being triggered.*
- void `obstacleDetector_ISR` (void)  
*A function to respond to a detected obstacle while under locomotion.*
- void `motorEncoder_ISR` (void)  
*Motor encoder ISR.*
- void `serialCommunication_ISR` (void)  
*A function to handle incoming communication from the pi.*
- void `moveRotate` (int ticks)  
*Rotate the robot around central axis rotate by running both motors at the same speed in opposite directions.*
- void `moveStraight` (int ticks)  
*Move the robot forward or reverse.*
- void `moveLineFollow` (void)

*Routine to follow the guide-line for some fixed interval.*

- void `armPark` (void)

*Move the arm to its parking position.*

- void `armDispose` (void)

*Routine to dispose of a syringe once it has been picked.*

- bool `armPick` (byte azimuth, byte range, byte orientation)

*Routine to attempt target pickup.*

### 10.3.1 Detailed Description

Arduino controller code –ABD.

#### Copyright

Copyright © 2019 by the authors. All rights reserved.

### 10.3.2 Function Documentation

#### 10.3.2.1 `armPark()`

```
void armPark (  
    void )
```

Move the arm to its parking position.

The parking position needs to leave a clear view of the pickup area, but also should move the center of gravity as far forward as possible to reduce drive wheel slippage.

#### 10.3.2.2 `armPick()`

```
bool armPick (  
    byte azimuth,  
    byte range,  
    byte orientation )
```

Routine to attempt target pickup.

This routine should attempt to close the claw completely and detect if an object as actually been grabbed. parameters should be bytes because they will have to be transmitted over serial from the pi. Ranges on these values TBD as convenient for the arm software, but must be recorded in the system constants file. –ABD

#### Parameters

<i>azimuth</i>	arm azimuth value
<i>range</i>	distance to the target
<i>orientation</i>	rotation of the target

**Returns**

true on successful pick, false otherwise.

**10.3.2.3 lineDetector\_ISR()**

```
void lineDetector_ISR (
    void )
```

A function to respond to a line detector being triggered.

The line detectors are mounted forward and inboard of the wheels. This function needs to reorient the robot to clear the sensor, but also to prevent the line from being hit again.

The simplest way to do this is to rotate the opposite wheel forward until the sensor clears. Because the sensor is forward of the wheel it will rotate away from the line as the opposite wheel moves forward. This should work as long as the curvature of the line is not too great.

This may need to be two routines, one for each sensor –ABD

**10.3.2.4 motorEncoder\_ISR()**

```
void motorEncoder_ISR (
    void )
```

Motor encoder ISR.

**10.3.2.5 moveLineFollow()**

```
void moveLineFollow (
    void )
```

Routine to follow the guide-line for some fixed interval.

This function assumes that we are already over the line

**10.3.2.6 moveRotate()**

```
void moveRotate (
    int ticks )
```

Rotate the robot around central axis rotate by running both motors at the same speed in opposite directions.

**Parameters**

<i>ticks</i>	sign indicates direction of rotation: positive is rotation to the right. magnitude indicates the number of encoder ticks on each motor.
--------------	---

### 10.3.2.7 moveStraight()

```
void moveStraight (
    int ticks )
```

Move the robot forward or reverse.

#### Parameters

<i>ticks</i>	number of encoder ticks to move. Sign indicates direction: positive is forward.
--------------	---

### 10.3.2.8 obstacleDetector\_ISR()

```
void obstacleDetector_ISR (
    void )
```

A function to respond to a detected obstacle while under locomotion.

There may be two cases to handle: whether we are line following, or aproaching. If we are line following we need to ensure that we don't lose the line while avoiding the obstacle.

This may need to be multiple routines, one for each sensor –ABD

## 10.4 src/pi/constants.py File Reference

Constants shared across the whole system.

#### Variables

- int `constants.ARM_AZIMUTH_MIN` = 0  
*The minimum azimuth byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- int `constants.ARM_AZIMUTH_MAX` = 0  
*The maximum azimuth byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- int `constants.ARM_RANGE_MIN` = 0  
*The minimum range byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- int `constants.ARM_RANGE_MAX` = 0  
*The maximum range byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- int `constants.ARM_ORIENT_MIN` = 0  
*The minimum orientation byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- int `constants.ARM_ORIENT_MAX` = 0  
*The maximum orientation byte value that can be passed to the arduino with ARDUINO\_ARM\_PICKUP.*
- int `constants.PICKUP_X_MIN` = 0

- The minimum target center x-value that allows a pickup.*
  - int `constants.PICKUP_X_MAX` = 0
- The maximum target center x-value that allows a pickup.*
  - int `constants.PICKUP_Y_MIN` = 0
- The minimum target center y-value that allows a pickup.*
  - int `constants.PICKUP_Y_MAX` = 0
- The maximum target center y-value that allows a pickup.*
  - int `constants.FWD_MAX_TICKS` = 200
- The maximum count of forward ticks used in `moveCloser()`*
  - int `constants.ROT_MAX_TICKS` = 200
- The maximum absolute value of rotation ticks used in `moveCloser()`*
  - int `constants.CAL_ROT_FACTOR` = 1
- Calibration factor used in rotation calculation.*
  - int `constants.CAL_FWD_FACTOR` = 1
- Calibration factor used in forward calculation.*
  - int `constants.ARDUINO_NULL` = 0x00
- A place holder for troubleshooting etc.*
  - int `constants.ARDUINO_STATUS_ACK` = 0x01
- If the arduino needs to acknowledge something.*
  - int `constants.ARDUINO_STATUS_READY` = 0x02
- If the arduino needs to indicate it is ready.*
  - int `constants.ARDUINO_STATUS_PICK_FAIL` = 0x03
- Report that the pick failed.*
  - int `constants.ARDUINO_STATUS_PICK_SUCCESS` = 0x04
- Report that the pick succeeded.*
  - int `constants.ARDUINO_STATUS_ARM_FAULT` = 0x05
- Report a general arm failure.*
  - int `constants.ARDUINO_STATUS_OBSTACLE` = 0x06
- Report an obstacle detected.*
  - int `constants.ARDUINO_ROTATE` = 0x10
- serial command the arduino to rotate the robot, followed by one signed byte indicating magnitude and direction*
  - int `constants.ARDUINO_MOVE` = 0x11
- serial command the arduino to advance the robot, followed by one signed byte indicating magnitude and direction*
  - int `constants.ARDUINO_LINE_FOLLOW` = 0x12
- serial command the arduino to follow the line*
  - int `constants.ARDUINO_AVOID` = 0x13
- serial command the arduino to avoid an obstacle*
  - int `constants.ARDUINO_ARM_PARK` = 0x20
- serial command the arduino to call the park action sequence*
  - int `constants.ARDUINO_ARM_DISPOSE` = 0x21
- serial command the arduino to call the dispose action sequence*
  - int `constants.ARDUINO_ARM_PICKUP` = 0x22
- serial command the arduino to attempt a pick, followed by three bytes: azimuth, range, and orientation*
  - `constants.PORT_MOTOR_FWD` = None
- Arduino pin for port motor forward.*
  - `constants.PORT_MOTOR_REV` = None
- Arduino pin for port motor reverse.*

- `constants.STBD_MOTOR_FWD` = None  
*Arduino pin for starboard motor forward.*
- `constants.STBD_MOTOR_REV` = None  
*Arduino pin for starboard motor reverse.*
- `constants.PORT_LINE_SENSE` = None  
*Arduino pin for the port line sensor.*
- `constants.STBD_LINE_SENSE` = None  
*Arduino pin for the starboard line sensor.*
- `constants.PORT_FWD_OBSTACLE` = None  
*Arduino pin for the port forward obstacle sensor.*
- `constants.PORT_AFT_OBSTACLE` = None  
*Arduino pin for the port aft obstacle sensor.*
- `constants.STBD_FWD_OBSTACLE` = None  
*Arduino pin for the starboard forward obstacle sensor.*
- `constants.STBD_AFT_OBSTACLE` = None  
*Arduino pin for the starboard aft obstacle sensor.*
- `constants.ARM_CONTROL` = None  
*Arduino pin for communication with the xArm.*

#### 10.4.1 Detailed Description

Constants shared across the whole system.

Includes constants used by both the arduino sketch and the the python script. The format of `constants.in` is three whitespace sparated columns:

[NAME] [value] [comments]

Any changes must be made in `constants.in` and followed by running:

```
make constants
```

–ABD

#### Copyright

Copyright © 2019 by the authors. All rights reserved.

This file has been autogenerated, CHANGES MADE HERE WILL NOT PERSIST

## 10.5 `src/pi/Syringenator.py` File Reference

This is the main control script.

## Classes

- class [Syringenator.Target](#)  
*A class to contain everything we know about an aquired target.*

## Namespaces

- [Syringenator](#)  
*The top-level Pi program.*

## Functions

- def [Syringenator.log](#) (arg)  
*Record system events for later analysis.*
- def [Syringenator.arduinoSend](#) (bytes)  
*Send serial data to the arduino.*
- def [Syringenator.arduinoReceive](#) ()  
*Wait some fixed time for the arduino to send one or more bytes.*
- def [Syringenator.imageCart2floorCart](#) (x, y, d)  
*Derive floor position from image data.*
- def [Syringenator.floorCart2armCylinder](#) (x, y)  
*Derive cylindrical coordinates, centered on the arm from cartesian coordinates centered on the camera.*
- def [Syringenator.scan](#) ()  
*A routine to take a picture and report back the closest target The Computer vision routine must be able to handle multiple targets in the image.*
- def [Syringenator.canBePicked](#) (t)  
*A routine to determine if the target is in position to be picked up.*
- def [Syringenator.moveCloser](#) (t)  
*Move the robot closer to the given target.*
- def [Syringenator.avoid](#) ()  
*avoid an obstacle*
- def [Syringenator.pickUp](#) (t)  
*Attempt to pickup and dispose the target.*
- def [Syringenator.returnToLine](#) ()  
*signl the arduino to return to the line.*
- def [Syringenator.lineFollow](#) ()  
*Follow the line.*

## Variables

- bool [Syringenator.onTheLine](#) = True  
*boolean indicating whether we are on the line*
- bool [Syringenator.obstacle](#) = False  
*boolean indicating that we have detected an obstacle*
- [Syringenator.target](#) = None  
*The currently aquired target.*

### 10.5.1 Detailed Description

This is the main control script.

It will run on the Raspberry Pi and direct all robot operations.

By convention each arduino command routine checks for arduino ready before starting, and logs arduino status on exit.

**Todo** how do we initialize the robot run? a button press? –ABD

#### Copyright

Copyright © 2019 by the authors. All rights reserved.



## Index

- arduinoReceive
  - Syringenator, [14](#)
- arduinoSend
  - Syringenator, [14](#)
- armPark
  - Syringenator.hpp, [24](#)
- armPick
  - Syringenator.hpp, [24](#)
- avoid
  - Syringenator, [14](#)
- canBePicked
  - Syringenator, [15](#)
- floorCart2armCylinder
  - Syringenator, [15](#)
- imageCart2floorCart
  - Syringenator, [15](#)
- lineDetector\_ISR
  - Syringenator.hpp, [25](#)
- lineFollow
  - Syringenator, [16](#)
- log
  - Syringenator, [16](#)
- motorEncoder\_ISR
  - Syringenator.hpp, [25](#)
- moveCloser
  - Syringenator, [16](#)
- moveLineFollow
  - Syringenator.hpp, [25](#)
- moveRotate
  - Syringenator.hpp, [25](#)
- moveStraight
  - Syringenator.hpp, [26](#)
- obstacleDetector\_ISR
  - Syringenator.hpp, [26](#)
- pickUp
  - Syringenator, [17](#)
- returnToLine
  - Syringenator, [18](#)
- scan
  - Syringenator, [18](#)
- src/controller/constants.hpp, [19](#)
- src/controller/controller.ino, [22](#)
- src/controller/Syringenator.hpp, [22](#)
- src/pi/constants.py, [26](#)
- src/pi/Syringenator.py, [28](#)
- Syringenator, [13](#)
  - arduinoReceive, [14](#)
  - arduinoSend, [14](#)
  - avoid, [14](#)
  - canBePicked, [15](#)
  - floorCart2armCylinder, [15](#)
  - imageCart2floorCart, [15](#)
  - lineFollow, [16](#)
  - log, [16](#)
  - moveCloser, [16](#)
  - pickUp, [17](#)
  - returnToLine, [18](#)
  - scan, [18](#)
- Syringenator.hpp
  - armPark, [24](#)
  - armPick, [24](#)
  - lineDetector\_ISR, [25](#)
  - motorEncoder\_ISR, [25](#)
  - moveLineFollow, [25](#)
  - moveRotate, [25](#)
  - moveStraight, [26](#)
  - obstacleDetector\_ISR, [26](#)
- Syringenator.Target, [18](#)