

### Small project for the Robotics course 2018-2019

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#### Premise

- The 'small' project is mandatory to access the theory exam
- In alternative the student can chose a more complex project (to be defined with the coordinator of the course)
- The time to realize the project is between 3-9 hours.
- The work will be organized in teams of 2-4 students (depending on the total number of students)
- There is no grade ('voto')
- The hardware will be provided during the laboratory hours or upon agreement with the lab tutor.
- All the students that decide for the 'small project' must send a mail to <u>bogdan.maris@univr.it</u> until 10-th of November 2018



# Goals of the image-guided therapy and medical robotics tutorial

- To demonstrate the typical steps of an image-guided therapy (IGT) or medical robotics procedure.
- To learn in a hands-on manner using a LEGO Mindstorms EV3, a LEGO phantom and sophisticated medical image processing and IGT software (3D Slicer).
- The example procedure that we will use to do this is a needle biopsy.
- To learn about the registration step in IGT and medical robotics.
- To learn about the following steps in IGT and medical robotics in a hands-on manner:
  - Imaging
  - Preoperative planning
  - Targeting and tracking
  - Navigation

#### The example procedure that we will use to do this is a needle biopsy.



#### Precautions

- The project is inspired by the tutorial at the link:
  - <u>https://www.slicer.org/wiki/Slicer3: Image\_Guided\_Therapy\_(IGT)</u>

But:

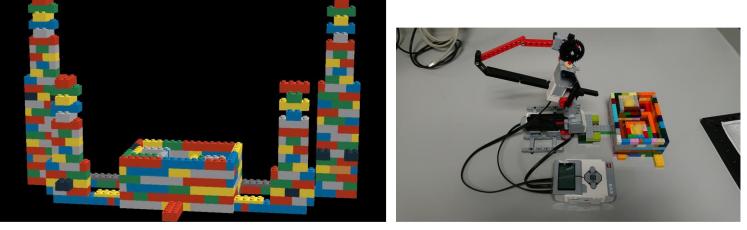
- Different robot kit (newer)
- Updated version of 3DSlicer
- Different plug-in, provided on the internet page of the Robotics class:

http://www.di.univr.it/?ent=oi&aa=2018%2F2019&codiceCs=S71&codins=10877&cs=417&disc r=&discrCd=&lang=en

- The phantom hasn't change from the previous version but the old LEGO kit is not anymore available (we use the new kit LEGO 10698).
- The task consists in the *manual registration* of the robot and targeting of selected points
- The 'towers' of the phantom (see next slide are optional but can be built for *automatic registration* -> 'trenta e lode'...but remember: no grade :-).

## Instruction to build the robot and the phantom

- In the folder Instructions:
  - RobotAssemblyInstructions.pdf
  - PhantomAssemblyInstructions.pdf
  - MiscAssemblyInstructions.pdf (important: identify the connections of the motors and the name of the angles that will later define the DOF of the robot!)





Phantom

**Robot and Phantom** 

Robot

### Software

- For the lego brick (called EV3 from now on):
  - Install ev3dev (using a memory card provided), following the instructions: <u>http://www.ev3dev.org/docs/getting-started</u>
  - The brick must be connected to the internet (use the USB port and the instructions):

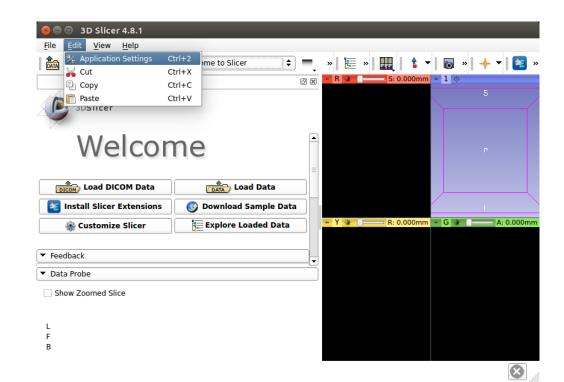
http://www.ev3dev.org/docs/tutorials/connecting-to-the-internet-via-usb/

• Copy and paste the files from the Python folder into EV3 device (hint: you may use SSH commands; in Windows install 'Putty').



### Software (PC, Linux, ...)

- Download Slicer: <u>www.slicer.org</u> (this workshop works on 4.8 version and similar versions)
- Open the 'Application Settings' by clicking 'Edit->Application Settings':



• Go to the 'Modules' tab:

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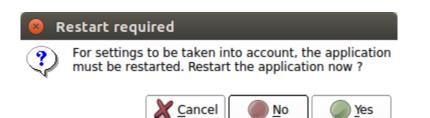
 Add a path under Additional Module Paths which points to the folder named LegoWorkshop (downloaded from the page of the Robotics course) in this repository:

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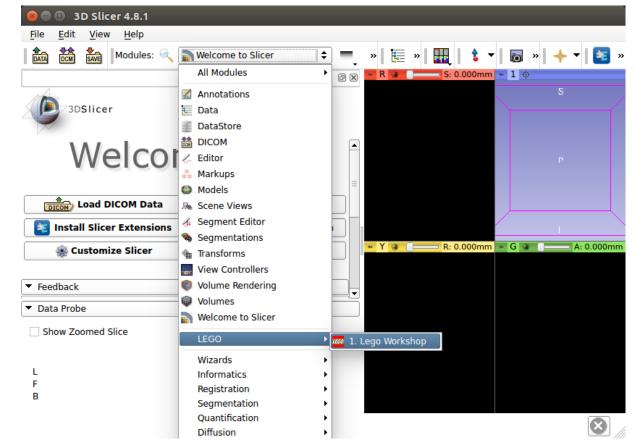
• The directory should be then in the list

• This will require a reboot of the program to take effect:





• To use the module, load it from the Modules menu:



 Make sure that under `LegoWorkshop - Configuration` the server address matches the address of your brick, (probably `ev3dev.local`).



- If `ev3dev.local` doesn't work, get the IP of the EV3 from the menu `WirelessAndNetowrks->AllNetowrkConnections->[Wired or other]->IPv4`.
- If the module loaded correctly it should look something like the following:

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Download the CT volume of the LEGO phantom (<u>http://wiki.na-mic.org/Wiki/images/6/69/000003.SER.zip</u>) and extract it somewhere. Now open that data with `File->Add Data` and point to the first file in the series:

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#### • Click 'OK'. Now, you should see the CT scan of a LEGO phantom:



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 Then add a Fiducial to the point you want to target by clicking on the icon with the red dot and blue arrow:

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• Then click somewhere you want the robot to probe, and then choose the fiducial namespace (`F`) and that position will displayed on the list:

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 Then choose which point(s) you want the robot to 'probe' by ticking the box next to them. When you are ready (and assuming you are running `lego-workshop.py`), press the `Go` button:

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• This should make the robot move!

- The previous calibration was already programmed into Slicer, but what happen if you have to move the robot somewhere else around the phantom?(while still having it within range of the injector)
- This is done by performing a manual registration through the selection of at least 3 fiducials and getting measurements of how those relate to the robot in the real world

• Select a set of at least 3 fiducials and press the 'Replace Calibration Points' button (hint: use 'Update' after the selection of fiducials):

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 Note that the inject motor's encoder is spotty, and sometimes doesn't work so it is currently not implemented (`lego-debug.py` will either show 0 or a huge number), so you have to measure the distance from the orange circle of the upright large motor to your calibration point in millimeters, and that value will be `Dst`:

robot@ev3dev:~/lego-igt-workshop\$ Python/lego-debug.py

Press the touch sensor to read the motor positions

WARNING! The inject motor does not seem to work, you will have to measure that manually

Dst Azm Elv

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• Enter those numbers into the table:

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• Then press the `Rerun Calibration` button to get a new calibration:

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• Now, you can test out your new calibration

 Note that if you think something is wrong you can set `Check\_Calibration=True` in `LegoWorkshop.py` and if you run Slicer from a terminal you can get the details of the linear algebra, including the RMSE which (if you used more than 3 points) lets you know how well the calibration points agree on a registration (see also the previous lesson for details on how to register a set of points).

## Automatic registration of the robot (advanced task)

- The robot can be equipped with an ultrasonic sensor, which can be used to sense the phantom and perform a fully automated registration (similar to how registration is done in the OR). However, this has not been implemented in the code, so it is up to you to take on this challenge. Good luck!
- Follow this tutorial:

https://na-mic.org/wiki/File:AnAccessibleHandsOnTutorialSystemForIGTAndMedicalRobotics.pdf

### Assesment of targeting accuracy (the output of the project)

- Evaluate the target accuracy of the manual registration algorithm
- Evaluate the accuracy of the advanced registration algorithm
- The output of the project will be given by the results table and evenually a manual registration test in real-time

