

Internship Training in Robotics Lab: Exploring Robotics through hands-on experience

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ABSTRACT

This article presents the future work for an internship in the Robotics and Spatial Systems Laboratory (RASSL). This work is different from robotics lessons because it is a practical work. It enables one to put knowledge into practice and learn robots by experience. It enables one to discover very interesting robotics applications. This internship enables the study of different robots: from the Nao robot to mechanism design and applications by way of mobile robots like PantherBot and IGV. Each robot has special features, consequently new knowledge in many fields will be acquired.

Keywords: internship, robotics lab, humanoid robot, mobile robot, mechanism

1. Introduction

1.1 RASSL

The Robotics and Spatial Systems Laboratory (RASSL) is dedicated to the development of robotic mechanical systems that generate spatial (i.e. 3-dimensional) motion and force transmission [1]. The lab seeks to advance the design methodologies for these challenging systems as well as techniques for their utilization in industrial and consumer applications. The vision of RASSL is to be the world leader in the research and development of novel 3-dimensional robotic mechanical systems. The mission of RASSL is to educate engineers in cutting-edge research and development of 3-dimensional robotic mechanical systems by conducting research, building & testing prototypes, and publishing the findings.

1.2 Internship purpose

The goal of the internship is to study different robots: a humanoid robot, mobile robots and a mechanism. Hands-on learning during an internship provides real-world experience [2].

Studied robots will be:

- Nao, a humanoid robot, by using Choregraphe, a programming tool for basic instructions and then Python language in order to program the robot.
- PantherBot, a general purpose mobile robot platform for autonomous navigation and teleoperation.
- Intelligent Ground Vehicle (IGV), an autonomous robot.
- SCUD Linkage, a S-C-U Dual Four-Bar Linkage.

2. Nao Robot

2.1 Nao Robot Overview

Nao is an autonomous, programmable humanoid robot developed by Aldebaran Robotics, a French robotics company [3]. This company is among the worldwide leaders in human robotics. They developed several humanoid robots including Nao, Romeo and then Pepper in collaboration with Softbank, a Japanese company. These robots have several goals: Nao is for programming, teaching and research; whereas Romeo is designed to explore and further research into assisting elderly people and those who are losing their autonomy [4]; and Pepper is designed to be a life companion and for customer relations.



Figure 1. Nao

Aldebaran Robotics began to develop Nao robot in 2004 with Project Nao. There have been several upgrades to the robot platform: for example the 2011 Nao Next Gen and the 2014 Nao Evolution. Currently it's the 5th version. The different Nao

platforms evolved from 14 to 25 degrees of freedom. A specific robot was created for the Robocup competition with 21 degrees of freedom. Nao robots are used in many academic institutions worldwide for research and teaching. According to Aldebaran Robotics, about 10.000 robots are in use around the world.

Nao has 7 senses for natural interaction [5]:

- **Moving:** 25 degrees of freedom and a humanoid shape that enable him to move and adapt to the world around him. His inertial unit enables him to maintain his balance and to know whether he is standing up or lying down.
- **Feeling:** The numerous sensors in his head, hands and feet, as well as his sonars, enable him to perceive his environment and get his bearings.
- **Hearing and speaking:** With his 4 directional microphones (for voice recognition and sound localization) and loudspeakers (for multilingual text-to-speech synthesis), Nao interacts with humans in a completely natural manner, by listening and speaking.
- **Seeing:** Nao is equipped with two cameras that film his environment in high resolution, helping him to recognize shapes and objects.
- **Connecting:** To access the Internet autonomously, Nao is able to use a range of different connection modes (WiFi, Ethernet).
- **Thinking:** We can't really talk about "Artificial Intelligence" with Nao, but the robots are already able to reproduce human behavior.

Nao is piloted by a Linux-based operating system called NAOqi OS. This OS powers the robot's multimedia system. There is also a graphical programming tool called Choregraphe, which is easy to use.

2.2 The use of Nao

2.2.1 Choregraphe

First Nao has to be connected with Choregraphe. The interface is very clear (See Figure 2).

In the upper part, there is a toolbar with many functions: create, open or save a project; connect or disconnect the robot; start or stop the motion; set the volume of Nao's speakers; activate or deactivate the animation mode; set on or off the stiffness of all joints of the robot; indicate the level of the battery.

On the left side, there is a box library panel which includes all the elementary boxes you need to create your first behaviors. Those boxes are ordered by their category of action (motion, LEDs, etc) or their function in the diagram (flow control, templates of boxes, etc).

In the middle, there is the flow diagram panel. This is the place to compose Nao's behaviors. In the box path, there are the different levels of the Flow diagram. Boxes from the box library panel can be added and then the boxes need to be connected with the input and output borders located on the right and on the left side.

On the right side, there is the robot view which displays the current position of the joints of the robot.

More advanced panels can be found in the "View" Menu.

2.2.2 Basic operations

After creating a project, a behavior can be created in order to make Nao talk, walk, dance, etc. Creating a behavior is easy, simply add desired boxes to the flow diagram panel. All basic operations are listed in the box library panel. This section is divided into several categories: Audio, Behavior, Communication, Data Edit, Flow Control, LEDs, Math, Motions, Sensing, System, Templates, Trackers, Vision, World Representation.

There is also a Pose library panel with basic poses: StandZero, StandInit and Stand. It enables to easily access standard key positions to create a behavior.

2.2.3 Python programming

In the previous part, all boxes are easy to use because the code is already written. However there are "script boxes" (See Figure 3) which enable to code in Python our functions. Any Python module can be imported and any Python function can be used as in any Python script.

2.3 Proposed Plan for Nao Robot

Firstly Choregraphe will be used to try all functionalities of this software in order to find out all Nao's abilities. Secondly once Nao's abilities are known, Python scripts will be written to program Nao. It will enable the creation of new postures. Creating a choreography could be a good way to teach to use the robot. Programming Nao in order to walk in the lab, to go around the lab would be interesting. Programming Nao to be able to detect the person in front of him among lab members using vision algorithms would be interesting too. Finally the objective is to write lessons or activities in order to discover and to use Nao, Choregraphe and Python programming.

3. PantherBot

3.1 PantherBot Overview

The PantherBot (See Figure 4) consists of the PowerBot mobile robot base, manufactured by MobileRobotics, Inc.TM, and a 6-DOF robotic arm, manufactured by Schunk Intec [8]. The PantherBot base has the ability to autonomously map terrain, plot coordinates, as well as perform miscellaneous functions at a certain location after a full map is acquired by using the MobilEyesTM, and Mapper3 TM software in conjunction with its on-board sonar sensors and laser range finder. The software can also stream live footage from the PantherBot's two cameras mounted on board, one on the PantherBot's base and one adjacent to the parallel gripper on the robotic arm to monitor the arm's movements remotely over 802.11b WiFi. To give the PantherBot the ability to map out a building, it must be able to gain access to doors and be able to travel between floors. To do that, two tools were designed to perform two basic tasks - one to push buttons and one to open doors. The tools were designed such that they would be tailored to the hardware of the F. W. Olin Engineering Complex at Florida Institute of Technology for ensured repeatability.

3.2 Proposed Plan for PantherBot

The objective is to do some activities using PantherBot in order to learn basic operations of this robot and important parameters: plan resolution for narrow spaces with obstacles, rotational speed of the robot, etc. Mapper-3 will be used in order to create or edit a map,

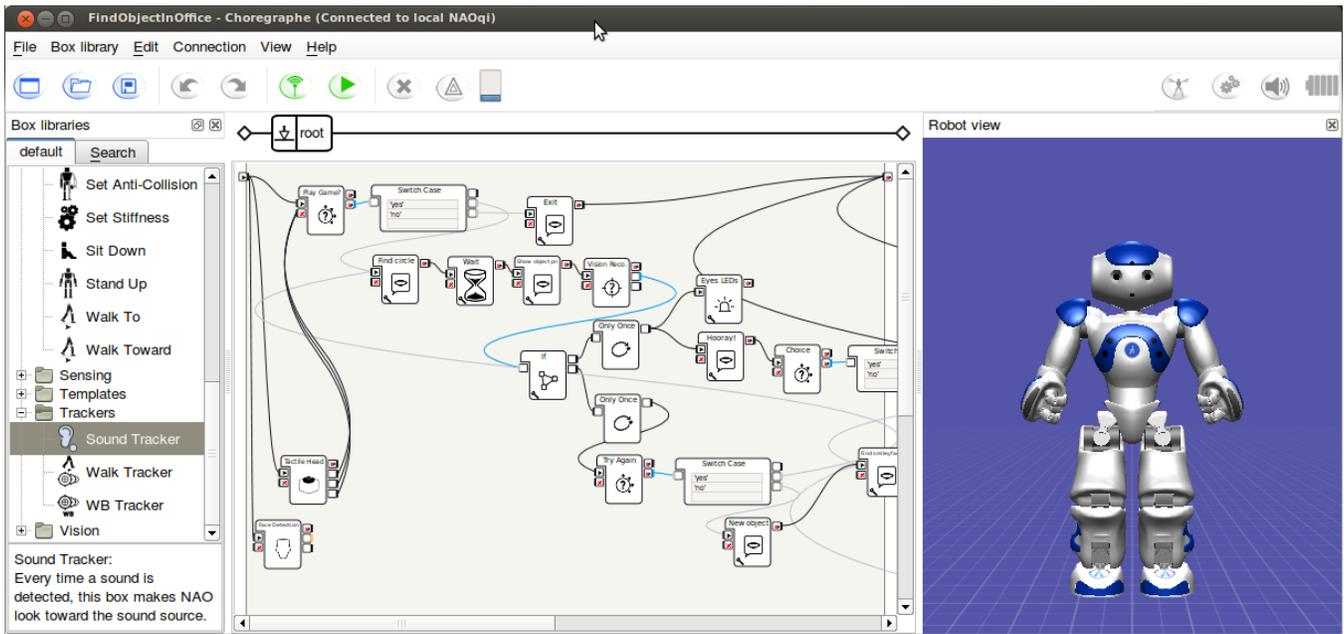


Figure 2. Choregraphe interface [6]

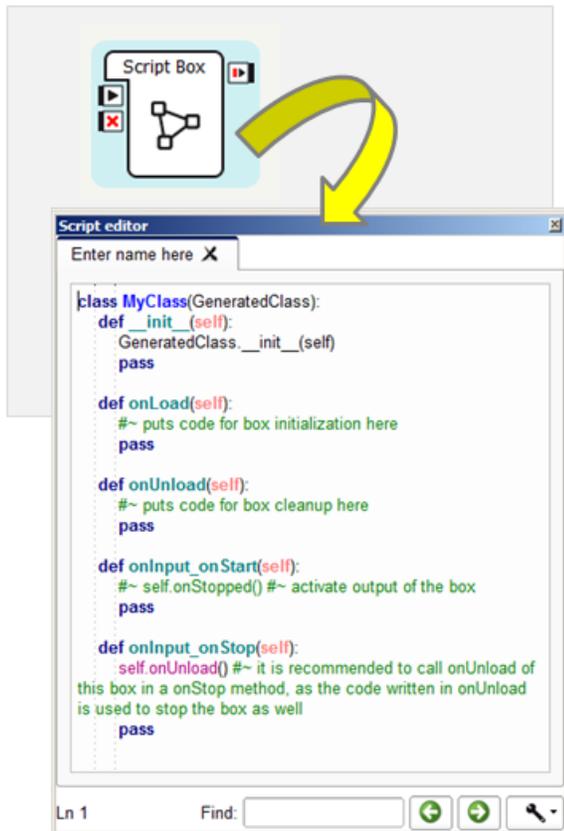


Figure 3. Python programming [7]

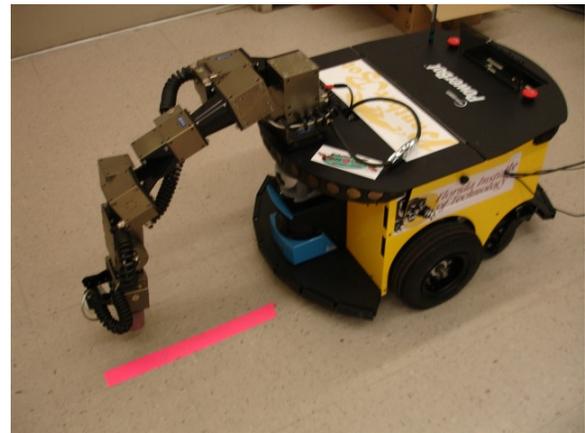


Figure 4. PantherBot with Schunk Robotic Arm [8]

for example a map of the lab building. The robot arm will be used too.

These experiments will enable to understand software and parameters of this robot.

4. Intelligent Ground Vehicle

4.1 IGV Overview

The Intelligent Ground Vehicle (IGV) (See Figure 5) project began as a senior design project of which the goal was to create an autonomously navigated vehicle to be entered into the Intelligent Ground Vehicle Competition (IGVC), which is an engineering challenge that the main goal is to design a robot with artificial intelligence to autonomously navigate through a course full of obstacles such as barrels, pot holes, and sand traps [9]. The robot is equipped with a SICK LMS291-S05 laser range finder (LiDAR), a digital compass, two servo drives with encoder feedback, and a 24V

(DC) supply for up to 2 hours of autonomous operation. Instead of building a mobile robot that runs on a specific field, right now this project is being modified in order to be more generally functional so that at the end of this project the IGV should be able to navigate through outdoor environments to a designated destination with a given GPS waypoint coordinate only.



Figure 5. Intelligent Ground Vehicle

4.2 Proposed Plan for IGV

With the Intelligent Ground Vehicle, the objective is to understand how the system works. The IGV, made by students, is a combination of hardware (motors, servo drives, etc) and software (ROS). Using the IGV will enable to have more knowledge in this field.

5. SCUD Linkage

5.1 SCUD Linkage Overview

The S-C-U Dual Four-Bar Linkage (See Figure 6), or SCUD Linkage, is a biologically inspired design for articulating the leg in a mechanical walking machine or for manipulating an end effector along a rigid, planar surface [10]. It is difficult to use closed linkages to deal with certain industrial tasks. It is very difficult for planar linkages to generate the desired complex spatial trajectories created by the serial chain robots. A motivation of this research is to design a better and more reasonable linkage mechanism for spatial surface tasks. Due to the features of these specified tasks, the mechanism designed should have the following characteristics:

- Be able to generate general spatial motions with a targeted and efficient approach.

- Perform spatial surface tasks with better repeatability and stability than traditional serial chain robots.
- Be simple to manufacture while being more cost effective than serial chain robots.

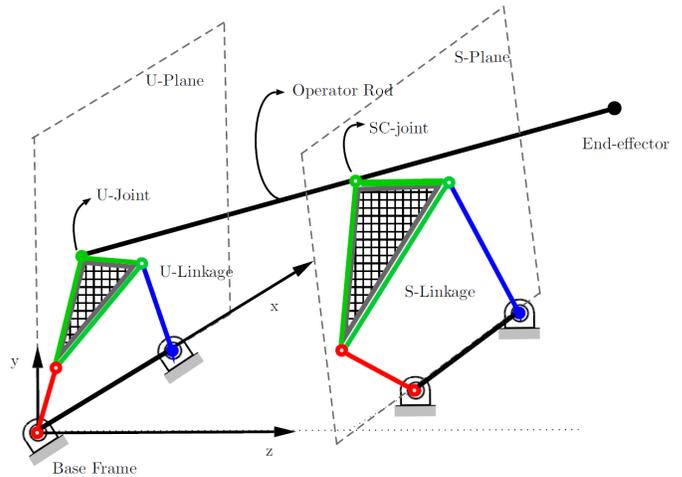


Figure 6. An example SCUD Linkage [10]

To generate fixed spatial curves and surfaces, the novel mechanism should have multiple degrees of freedom and at the same time, make it targeted and efficient for finite fixed curves or surfaces, the degrees of freedom should be reduced to two. To have better repeatability and stability, the novel mechanism should be a classification of spatial closed linkages to utilize their mechanical properties. Returning to the locomotive source of inspiration, a series of SCUD Linkages could be used to generate the motion of a hexapod walking machine.

5.2 Proposed Plan for SCUD Linkage

The biological inspired mechanism has known industrial uses as a single entity. When they are combined together, the SCUD Linkages can form a walking machine (See Figure 7) as the original inspiration intended. Six SCUD Linkages can be combined to form a walking gait hexapod machine. This walking gait hexapod features a low center of gravity, versatility over adverse terrain, and six degrees of freedom to move in a variety of gaits.

The objective is to produce such a prototype walking machine. 3D printers and other additive manufacturing technologies will be utilized to manufacture the piece parts. This work will enable to build a real mechanism.

6. Conclusion

The study of these robots will establish new teaching platforms in humanoid robotics, mobile robotics and mechanisms. Hands-on experience is the best way for learning. This internship enables the learning of other projects too, for example the use of a robot arm.

All work made during this internship will be very useful for future works. Learning through hands-on experience will be an advantage for future studies.

7. Acknowledgments

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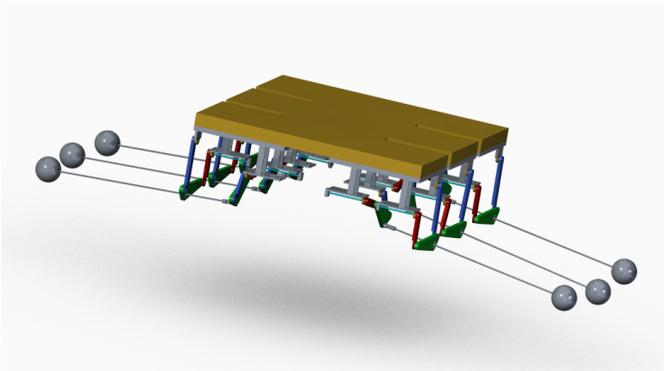


Figure 7. An example SCUD Linkage [10]

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