AMR 2012/2013: Final Projects

0. **General Information**

A final project includes:

- studying some literature and/or documentation on a specific subject
- performing some simulations or numerical tests on an appropriate software platform (Matlab, ROS, V-REP, Webots, KiteLab,...); sometimes, experiments are involved
- writing a report
- making a presentation (with slides)

As a rule, each project must be carried out by a group of **3 students**. Projects are assigned to groups on a FIFO basis. Send me an e-mail message (directly, not through the Google Group) specifying **at least 3** projects in which your group is interested, with an order of priority, and the composition of the group. One or two-persons groups can also apply, but I reserve the right to merge them to a larger group. Once your group has been assigned a project, we will set up a meeting to discuss the project in detail.

The deadline for project application is **May 31**. Late applications will not be accepted. There will be three deadlines for turning in your projects: **June 30**, **September 30**, **December 31 (2013)**. To turn in your project, send me an e-mail with the report. Once a deadline is passed, I will fix a common date for presenting all the projects completed during the associated time window. I strongly recommend attendance to all presentations even if you are not directly involved.

Three larger projects (1, 2 and 3) are **shared** with **Robotics 2**; this means that they are simultaneously valid as final projects for both courses. In particolar, two groups can independently work on projects 1 and 3.

Some other projects are **shared** with **Medical Robotics**; those are not described in this document since they have already been assigned.

This is the list of the available projects:

1. **Romeo model in V-REP (shared with Rob 2, 2 groups accepted)**
2. **Modeling robots in V-REP (shared with Rob 2)**
3. **Simulation of a fleet of WMRs (shared with Rob 2, 2 groups accepted)**
4. **On-line replanning for humanoid robots**
5. **Visual localization and control for aerial vehicles**
6. **Humanoid footstep planner for 2D obstacle avoidance**
7. **NAO in V-REP**
8. **3D reconstruction from multiple robot views**
9. **Object decomposition for grasping**

A short description of each project follows.

1. Romeo model in V-REP

Synopsis
The aim of this project is to realize a model of the humanoid robot Romeo in V-REP. The 3D (mesh) model will be provided, while all kinematic and dynamic parameters of the robot can be obtained from the robot documentation. The second step of this project is to use the realized model to test a planning/control algorithm, e.g., a redundancy resolution algorithm that takes into account constraints at the joint level (other choices are possible). This step will require the computation of the kinematic of the robot (DH parameters) and the associated Jacobians.

Literature
Romeo documentation: http://projetromeo.com/romeo-documentation/index.html
Flacco and De Luca, "Optimal SNS Control of Redundant Robots under Hard Joint Constraints," 2013 IEEE International Conference on Robotics and Automation

Notes
Intermediate-level knowledge of C++ programming is desirable. **Shared with Rob 2, 2 groups accepted.**

Lab Supervisors
Marco Cognetti (cognetti@dis.uniroma1.it), Fabrizio Flacco (fflacco@dis.uniroma1.it)

2. Modeling robots in V-REP

Synopsis
The objective of this project is to implement a framework for creating V-REP robot models and perform a comparative analysis of the collision detection libraries of V-REP and Kite. In particular, a V-REP model should be realized for the KUKA LWR IV robot and for a mobile manipulator made of a nonholonomic base plus the KUKA LWR IV. The models will be composed by four components:

- a graphical representation of the robot valid for V-REP
- the association between the robot components and the mechanical joints
- a LUA script to run C++ functions in V-REP interacting with a GUI
- a C++ interface for the abstract representation of the robot

The LUA script and the C++ interface should be designed for a general robot, with particular attention to efficiency, inheritance and extensibility. The second part of this project concerns the comparative analysis of the collision detection library of V-REP with the collision detection library of Kite. In order to perform significant tests, some scenarios and case studies of relevant complexity should be conceived. The project should be concluded with the production of a short guide on how to create robot models in V-REP on the base of the implemented framework.

Literature
Reference manuals and API frameworks of Kite and V-REP.

Notes
Good programming skills in C++ are required. Previous knowledge of CAD modeling will be helpful but not mandatory. A CAD model of both the robots of interest is already available. **Shared with Rob 2.**

Lab Supervisor
Massimo Cefalo (cefalo@dis.uniroma1.it), Marco Cognetti (cognetti@dis.uniroma1.it)

3. Simulation of a fleet of WMRs

Synopsis

With reference to the I-Mule applied research project, funded within the Industria 2015-Made in Italy initiative, we are considering the automation of luggage transfer by a team of mobile robots substituting conventional conveyor belts in an airport check-in. Given a layout of a check-in and baggage handling area, a fleet of WMR of the unicycle type, a roadmap of available free channels connecting check-in positions to baggage loading bays or carrousels, X-rays security checking stations, recharging stations, and maintenance areas, simulate the typical operation of the automated transfer system under various conditions on arrivals of passengers at the check-in (statistical load) and rate of malfunctioning or emergency events. The project consists of an algorithmic part, dealing with the scheduling and navigation tasks of the WMRs and of a graphical part (based on the use of standard software such as Webots or similar) for visualizing in 3D the complete operation of the fleet.

Literature

I-Mule project documentation and deliverables.

Notes

Intermediate level of C++ programming knowledge is desirable. Active involvement of students is needed (no delay in execution), possibly developing into final master theses.
Shared with Rob 2, 2 groups accepted.

Lab Supervisor

Paolo Stegagno (stegagno@dis.uniroma1.it)

4. On-line replanning for humanoid robots

Synopsis

The goal of this project is to test algorithms for on-line replanning with humanoid robots. Given a trajectory computed by a motion planner, the robot has to be able to avoid moving obstacles and to replan on-line a new path for reaching the goal. The project includes a literature search for replanning techniques. Simulations using the NAO model in V-REP will be used to validate the methods.

Literature

NAO documentation

Baudouin et al, "Real-time Replanning Using 3D Environment for Humanoid Robot," IEEE-RAS International Conference on Humanoid Robots, 2011

Yoshida et al, "Reactive Robot Motion using Path Replanning and Deformation," 2011 IEEE International Conference on Robotics and Automation, 2011

Notes

Intermediate-level knowledge of C++ programming is desirable.

Lab Supervisor

Marco Cognetti (cognetti@dis.uniroma1.it)

5. Visual localization and control for aerial vehicles

Synopsis
The objective of this project is the on-board implementation of a Visual Simultaneous Localization and Mapping (V-SLAM) algorithm for a quadrotor vehicle. All the code is already available inside the Robot Operating System (ROS) framework. The final target is to perform some tests with the Pelican quadrotor (from Ascending Technology) and provide a feedback on the reliability of the pose estimation and control provided by the algorithm. Roadmap:
1. Learning ROS (www.ros.org)-
2. Understanding and implementing asctec mav framework, ethzasl ptam, ethzasl sensor fusion (provided in ROS by ETH Zurich), onboard the Pelican quadrotor.
3. Preliminary tests onboard: test of all the algorithms without propellers.
4. In-flight tests. Position control tests.

Literature
http://www.ros.org/wiki/ethz-asl
http://www.asctec.de/uav-applications/research/products/asctec-pelican
Some reference papers are already provided on the wiki pages of the above mentioned ROS packages. More general references about sensor fusion and SLAM will be provided.

Notes
Previous knowledge about vision is desirable. Knowledge of C/C++ is required for implementation. An attitude to problem solving will help in the experimental study.

Lab Supervisor
Lorenzo Rosa (rosa@dis.uniroma1.it)

6. Humanoid footstep planner for 2D obstacle avoidance

Synopsis

The objective of the project is to implement a vision-based controller allowing a humanoid robot to safely navigate in its environment by avoiding 2D objects. On the basis of visual information, an algorithm will extract the position of the obstacles w.r.t. the robot frame. Then, a reasonable sequence of footsteps will be properly generated in order to move the robot between the obstacles. The first part of the work will be a bibliographic research to identify reasonable strategies, possibly comparing different approaches. The project will be implemented as a C++ module which will exploit the NAO proprietary library to move the robot, and the OpenCV library for the real-time image processing. The module will be tested first in a simulation environment (Webots or V-REP) and then with the real robot NAO.

Literature

NAO online web documentation, http://users.aldebaran-robotics.com/
OpenCV online web documentation, http://opencv.willowgarage.com/wiki/
Webots online web documentation, http://www.cyberbotics.com/

Notes

Programming skills: C++, also desirable some knowledge of robot simulators and OpenCV library (not mandatory).

Lab Supervisor

Antonio Paolillo (paolillo@dis.uniroma1.it)

7. NAO in V-REP

Synopsis
The aim of the project is to test and validate the simulated NAO model for V-REP, recently developed by our group. The project will starts with the analysis of the existing model of the robot NAO in V-REP. This simulator is actually a work-in-progress and it seems to be more promising with respect to the actual supported simulator for NAO, i.e., which is based on Webots. Some additional sensors must be integrated in the simulator, such as the feet pressure sensors and the infrared range finders. A comparison study between the simulated and the real robot must be performed. Finally, a motion planning algorithm should be developed using the FCL library.

Literature
NAO documentation
FCL library (FCL and Motion Planning with Uncertainty)

Notes
Intermediate level of C++ programming knowledge is recommended.

Lab Supervisor
Marco Cognetti (cognetti@dis.uniroma1.it)

8. 3D reconstruction from multiple robot views

Synopsis
The idea of this project is to reconstruct a model of an object from multiple views taken by wheeled mobile robots equipped with a monocular camera. To this purpose, monocular SLAM algorithm such as PTAM or/and SceneLib2.0 will be used. The relative configurations among the robots are supposed to be known in advance or computed by a mutual localization system. The key point is that the reconstruction must be performed in real-time to keep up with the camera frame rate. The early part of the project will require a literature search. The algorithm will be tested in simulation; for this, both ROS-Gazebo and V-REP are valid choices. As an optional step, experiments may be performed using a group of Khepera-III.

Literature
PTAM documentation
SceneLib2.0 documentation

Notes
Intermediate level of C++ programming knowledge is desirable. A basic knowledge of ROS and real-time programming is a plus.

Lab Supervisors
Marco Cognetti (cognetti@dis.uniroma1.it), Paolo Stegagno (stegagno@dis.uniroma1.it)

9. Object decomposition for grasping

Synopsis

The aim of this project is to build a framework to decompose an object in several primitive components using images from an RGB-D camera. The core idea is to describe each component using superquadrics. Superquadrics are functions that, with few parameters, are able to describe a large number of shapes, including also deformations such as bending. Image processing will be performed using the PCL library. Once the decomposition is performed, identification of graspable objects is the objective. For example, object with handles represent good case studies. The methods will be tested in simulation: OpenRAVE, Gazebo or V-REP are possible choices.

Literature

Solina and Bajcsy, “Recovery of Parametric Models from Range Images: The Case for Superquadrics with Global Deformations,” IEEE Trans. on Pattern Analysis and Machine Intelligence, 1990

Leonardis et al, “Superquadrics for Segmenting and Modeling Range Data,“ IEEE Trans. on Pattern Analysis and Machine Intelligence, 1997

Notes

Good knowledge of C++ programming is recommended for this project. In addition, knowledge about image processing, geometry and segmentation is desirable but not mandatory.

Lab Supervisor

Marco Cognetti (cognetti@dis.uniroma1.it)