AMR 2013/2014: 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, GAZEBO, ROS, V-REP,...)
• 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 applying for a project is **June 6**. Late applications will not be accepted. There will be three deadlines for submitting your projects: **July 10**, **September 30**, **December 31 (2014)**. To submit 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.

A short description of each project follows.

1. NAO and ROMEO in V-REP

Synopsis
The aim of this project is to test and validate two V-REP simulation models developed by our group for the humanoids NAO and ROMEO. The project starts with the analysis of the existing NAO model. A first objective is to optimize the code and add some features to the model, like the IMU sensor. A second objective is to develop a similar model for ROMEO (a very basic model for V-REP is already available). A final comparison of the dynamic performance of the two simulated robots is expected.

Literature
NAO documentation
ROMEO documentation
V-REP documentation

Notes
Good C++ programming skills are desirable.

Lab Supervisor
Marco Cognetti

2. Elastic strips

Synopsis
Elastic strips are a framework for deforming, in real-time, a given robot path in such a way that it is collision-free. The basic idea is that the original path generates an attractive force while the obstacles in the scene deform the path. The first objective of the project is to implement the method so as to replicate the results in the literature. The application to humanoid robots will then be considered.

Literature
Brock and Khatib, “Elastic Strips: A Framework for Motion Generation in Human Environments”, International Journal of Robotics Research, 2002

Notes
Intermediate-level C++ programming skills are desirable.

Lab Supervisor
Marco Cognetti

3. Object 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.

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 Supervisor
Marco Cognetti

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 Int. Conf. on Humanoid Robots, 2011
Yoshida et al, “Reactive Robot Motion using Path Replanning and Deformation,” 2011 IEEE Int. Conf on Robotics and Automation, 2011

Notes
Intermediate-level C++ programming skills are desirable.

Lab Supervisor
Marco Cognetti

5. Path planning among movable obstacles

Synopsis
The project consists in the analysis and implementation of a motion planning algorithm for problems in which the robot is allowed to move some of the obstacles in the environment (movable obstacles) if they obstruct its way to the goal. The considered environment is planar and the robot is allowed only to translate. The solution approach is based on randomized motion planning techniques. Graphical rendering of the solution path is required.

Literature
van den Berg et al, “Path Planning among Movable Obstacles: a Probabilistically Complete Approach," 8th Int. Workshop on Algorithmic Foundation of Robotics, 2008

Notes
Requires MATLAB or C++ programming skills (either is fine).

Lab Supervisor
Marilena Vendittelli

6. Humanoid walking motion generation: A comparison

Synopsis
One way of generating walking motions for humanoid robots is based on the use of a simplified linear model called the Linear Inverted Pendulum Model. The basic approach consists in solving a boundary value problem for a forced linear unstable system. Depending on which conditions are imposed to this problem (e.g. fixed initial state or fixed pre-specified input or family of inputs) different solutions arise. The aim of the project is to make a critical comparison of the available choices, including a quantitative assessment based on simulated experiments on NAO.

Literature
Private notes

Santacruz and Nakamura, “Walking motion generation of humanoid robots: Connection of orbital energy trajectories via minimal energy control,” IEEE/RAS Int. Conf. on Humanoid Robots, 2011.
Morisawa et al, “A Biped Pattern Generation Allowing Immediate Modication of Foot Placement in Real-time," IEEE/RAS Int. Conf. on Humanoid Robots, 2006.

Notes
Intermediate-level C++ and MATLAB programming skills are required.

Lab Supervisor
Leonardo Lanari

7. Robot motion planning with soft task constraints

Synopsis
T-RRT is a variation of the RRT method which can generate collision-free robot motions that are suboptimal with respect to an assigned cost function. The objective of this project is to implement in V-REP a plugin that uses T-RRT for solving planning problems in the presence of soft task constraints, i.e., task constraints that are considered satisfied when executed within a certain tolerance. The idea is to use the task error as a cost function to guide the evolution of T-RRT.

Literature
Private notes
Jaillet at al, “Transition-based RRT for path planning in continuous cost spaces,” 2008 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, 2008
V-REP documentation

Notes
Good C++ programming skills are desirable.

Lab Supervisor
Massimo Cefalo

8. Manipulation planning with soft task constraints

Synopsis
The goal of this project is to analyze, implement and test a method for solving manipulation planning problems in the presence of soft task constraints, i.e., task constraints that are considered satisfied when executed within a certain tolerance. The planner used in this method is essentially a bidirectional RRT planner. The algorithm must be implemented in C++ as a V-REP plugin.

Literature
Kunz, Stilman, “Manipulation planning with soft task constraints,” 2012 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, 2012
V-REP documentation

Notes
Programming skills in C++ are required.

Lab Supervisor
Massimo Cefalo

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 and Valerio Modugno

10. Eulerian Video Magnification

Synopsis
Eulerian Video Magnification is a filtering algorithm that is able to reveal temporal variations in videos that are difficult or impossible to see with a naked eye and display them in an indicative manner. One possible application of this method is to allow a robot to monitor vital signs of elderly or sick people. The goal of the project is to study and implement the method, with special attention to the role of the free parameters that control the behavior of the filter.

Literature
Wu et al, "Eulerian Video Magnification for Revealing Subtle Changes in the World", SIGGRAPH 2012

Notes
A good programming skill is recommended for this project. In addition, knowledge about image processing, with matlab or other programming language are useful.

Lab Supervisor
Valerio Modugno

11. Quadrotor dynamic modeling and motion planning in V-REP

Synopsis
The goal of this project is to implement and test in V-REP a dynamic model of a quadrotor UAV equipped with a rigid tool aimed at interacting with the environment. The behavior of the simulated model should be validated through comparison with an automatically generated model of the same UAV. The developed model should be used within a motion planner to generate task-constrained collision-free motions of the quadrotor that move the tool tip along a certain trajectory.

Literature
private notes
general resources on quad rotor dynamics
V-REP documentation

Notes
Good programming skills in C++ are required.

Lab Supervisor
Massimo Cefalo