RODYMAN Report Summary

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Mid-Term Report Summary - RODYMAN (Robotic Dynamic Manipulation)

The RObotic DYnamic MANipulation (RoDyMan) project started from the observation that the state of the art of robotic manipulation is still rather far from the human dexterity in the execution of complex motions such as, for example, in dynamic manipulation tasks. Dynamic manipulation is considered as the most complex category of manipulation — in a general meaning of the term— requiring ad-hoc controllers and specialized hardware. In case of deformable objects, the task of dynamic manipulation becomes even more challenging. This reduces the opportunities for wide adoption of robots within human co-habited environments.

Through RoDyMan, the teamwork has got the opportunity to merge all the acquired competencies in an advanced theoretical and technological challenge providing a unified framework for dynamic manipulation control, where the mobile nature of the robotic system and non-prehensile non-rigid objects manipulation will explicitly be taken into account, thus advancing the state of the art in the field. An innovative mobile dual-arm robotic platform with a flexible and high-level task execution capability has been developed and is being tested on an advanced demonstrator, which is currently unfeasible with the prototypes available in the labs. The RoDyMan project will contribute to paving the way towards enhancing autonomy and operational capabilities of service robots, with the ambitious goal of bridging the gap between robotic and human task execution capability.

The teamwork has produced tangible results since the beginning of the project. The original plans have been respected so far. Three milestones were expected in the first half of the project. Namely, the robot prototype is now available and the experiments are underway; the perception modules relative to the tracking of texture-less deformable objects are ready; the control modules about dynamic manipulation of rigid objects have been extensively derived and some of them have been already experimental tested as well. In truth, the teamwork is also in advance with respect to some objectives: the developed robot prototype is indeed able to turn the pizza dough with a real pizza peel.

From a theoretical point of view, the teamwork has produced several significant advances in the mathematical formulation of nonprehensile dynamic manipulation tasks. The port-Hamiltonian framework is the chosen theoretical structure where unify the majority of nonprehensile dynamic manipulation problems. As a backup approach, and in the few cases where the port-Hamiltonian framework is not yet suitable to be applied, a geometric control approach can be adopted. In such a case, the approach is to model the mechanical system in a coordinate-free fashion and study the closed-loop properties within Riemannian manifolds. Regarding perception, the main modules regarding the environmental awareness have been successfully developed. In particular, it is now possible to model and track 3D deformable and texture-less objects subject to both elastic and plastic deformations. The possibility to take care also of possible fractures of the deformable object is considered.

From a technological point of view, the robot prototype is now available. The developed robot is a humanoid with a pan-tilt robotic head (equipped with a stereo camera system, a RGB-D camera and a time-of-flight sensor), a two-dofs torso, two
seven-dofs arms and an extendable omnidirectional mobile platform.

The scientific community, the media and the general public have warmly recognized the developed work. Several collaborations with international research groups have been established. Unforeseen application perspectives have sprung off, like the possibility to track the movements of a real pizza chef with a 3D motion-tracking suit and map them on the developed robotic platform. The RoDyMan project has a good publication record and an ample track record of dissemination to press and general public. In particular, in the Futuro Remoto event from 16 to 19 October 2015, the RoDyMan robot was exhibited for the first time to public in the main square of Napoli. Thousands of visitors, including many kids, had the opportunity to visit the booth, interact with the robot and learn about the projects at PRISMA Lab. Last but not least, the PI has received two prestigious awards in 2015.

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