Final Report Summary - RODYMAN (Robotic Dynamic Manipulation)

The RObotic DYnamic MANipulation (RoDyMan) project started from the observation that nonprehensile dynamic manipulation can be reasonably considered as the most complex manipulation task. It might be
argued that such a task is still rather far from being fully solved and applied in robotics, reducing the opportunities for broad adoption of robots within human co-habited environments.

As a final demonstrator, it was thought to realize a pizza-maker robot. This is a tribute to Naples, the hosting city of the project, an avant-garde city in robotic technology, automation, gastronomy, and art culture. The pizza maker robot is a perfect example to understand the robot challenge, considering the difficulties that every inexperienced person encounters in preparing a pizza having to manipulate a mixture of water and flour, of every varying shape and consistency.

Through RoDyMan, the teamwork got the opportunity to merge all the acquired competencies in an advanced theoretical and technological challenge, providing a unified framework for dynamic manipulation control. The RoDyMan project contributed to paving the way towards enhancing autonomy and operational capabilities of service robots.

The teamwork produced tangible results throughout all the project. The developed platform is a humanoid-like robot with a pan-tilt sensorized robotic head, a two-dof torso, two seven-dof arms, and an omnidirectional mobile platform. The pizza maker demonstrator was realized in all its aspects in simulation, and at 90% in the experimental phase.

From a theoretical point of view, the teamwork produced several significant advances in the mathematical formulation of nonprehensile manipulation tasks. The port-Hamiltonian framework was chosen as the theoretical structure to unify the majority of nonprehensile manipulation problems. In the few cases where the port-Hamiltonian framework was not suitable to be applied, a geometric control approach was adopted. In such a case, the approach was to model the mechanical system in a coordinate-free fashion and study the closed-loop properties within Riemannian manifolds.

As concerns with perception, the main modules regarding environmental awareness were 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 was considered. The viscosity of the pizza dough was taken into account by modelling a deformable object through a smoothed particle hydrodynamic approach.

Finally, the scientific community, the media, and the general public warmly recognized the developed work. Several collaborations with international research groups were established. The RoDyMan project has a wide track record of dissemination to press and general public. The project was covered by media like Scientific American, The Times, The Telegraph, and Mashable. The RoDyMan robot was also exhibited at the Maker Faire European Edition 2017, in Rome, where it was awarded the Maker of Merit recognition. Unforeseen applications were found in the industrial scenario to glue the sole on the shoe upper.

Furthermore, the connection between nonprehensile manipulation and walking gaits of a legged robot is currently carried on in forthcoming projects after the successful experience of the RoDyMan project. Last but not least, several of the developed control techniques can be applied within the robotic surgery field. Since the RoDyMan robot can manipulate flexible and deformable objects, it is foreseeable to think applying similar methodologies to soft tissues, muscles, organs, and the skin. The Principal Investigator of the RoDyman project is currently the Director of the Interdepartmental Center for Advances in Robotic Surgery (ICAROS) Center of the University of Naples Federico II.

**Last update:** 4 May 2016

**Permalink:** https://cordis.europa.eu/project/id/320992/reporting