Abstract

The FINROP project advocates the use of a motion control stack based upon constraint-based task specifications, such that the robot program application is invariant with respect to small task variations and uncertainties. Concretely:

- These task specifications allow to describe a sensor-based robot task as a set of (geometric and force-based) constraints to be satisfied.
- These constraints can be chosen to refer to specific robot object features.
- Such constraint-based specifications have the advantage to describe only the necessities for the task at hand, thus giving opportunities for online reaction to external disturbances and task optimization.
- The “low layer” control input (e.g., position, velocities, torques) is generated online as a solution of an iterative optimization problem that minimizes one or more objective functions.
- This methodology is hardware independent.
- It has the advantage of composability, since the same task specification can be adapted to a different work environment as well as to a product having customized features with respect to the last processed item.

The project proposes a three layer framework that lets human operator specify tasks for the robots in an intuitive way that are in turn translated into skills by the robot executed in a constraint based approach.

Methodology

The FINROP project introduces the Fast and Intuitive Robot Programming (FINROP) project:

- The aim is to promote a novel and efficient way of developing robotic applications.
- The project will implement a constraint-based programming approach.
- The constraint based programming shall be invoked by intuitive means making it easier for humans to program robots.
- This enables the flexibility typically needed for small, highly customised batch size productions.
- The effectiveness of the solution is evaluated by applying this approach in real industrial scenarios proposed by the project’s industrial partners.

In its implementation, the FINROP project envisages to develop a three-layered framework as depicted in Figure 2. The proposed three-layer framework to be built as part of the FINROP project will enable intuitive robot programming.

Framework

Control layer: eTaSL

- The FINROP project adopts the expressiongraph-based Task Specification Language (eTaSL) as its control layer core.
- At its current status, eTaSL is an internal domain specific language based on Lua that allows us to specify constraints by means of expressiongraphs.
- Automatic differentiation techniques are implemented for these expressiongraphs, facilitating the computation of Jacobians, inverse kinematics and feedforward control terms.
- An eTaSL specification can include an arbitrary number of feature variables, which are variables that aid the definition of complex constraints.
- Executing an eTaSL specification corresponds to solving a constrained optimisation problem; the specification is then translated into a numerical form and resolved by a dedicated solver.
- Currently, eTaSL integrates the qpOASES solver, but it can easily be adapted to other existing solvers as well.

Industrial Case Studies

The FINROP project will be driven by real industrial case studies identified by our industrial partners.

Automation of quality control tasks

- Proposed framework will be implemented for industrial processes, such as gluing and spot welding.
- These scenarios can be solved by means of an automated contour following skill realized with our proposed framework.

Partial automation of assembly tasks

- The manufacturing of complex products such as compressors, gearboxes, etc. requires manual assembly and processing on parts with highly parametrized surfaces.
- Few of these processes are cumbersome for human operators to perform.
- This set of demonstrators is centered around sharing the workspace between the robot and human.

Acknowledgements

This work is supported by the Flanders Make and Hermes funds as part of Flanders Innovation & Entrepreneurship.

Contact Information

- KU Leuven, Department of Mechanical Engineering, Division PMA, Robotics Research Group Celestijnenlaan 300b - box 2420, 3001 Heverlee, Belgium. The Robotics Research Group is an associated research lab of Flanders Make (email: enea.scioni@kuleuven.be).
- Flanders Make, Oude Diestersbaan 133, Lommel, B-3920, Belgium (email: asad.tirmizi@flandersmake.be).

Research Partners

KU Leuven, Department of Mechanical Engineering, Robotics Research Group, Heverlee, Belgium. The Robotics Research Group is an associated research lab of Flanders Make.

Industrial Partners

Flanders Make, Oude Diestersbaan 133, Lommel, Belgium.

Figure: The consortium consists of Flanders Make and KU Leuven as research partners along with leading names from industry.

Goals

The following are the goals of this research:

- Shun conventional programming of robots in favour of developing and deploying a constrained based task specification approach to program in an industrial context.
- Lower the barrier for employing robotic technology in workshop scenarios by using intuitive interfaces between the robot and the operator.
- Complex robotic tasks should become accessible to operators having low (or no) expertise in robot programming.