Constraint-Based Motion Description Framework for industrial robots

Sergey Alatartsev
~500 welding seams are needed

6 months required to generate program online

16 hours is needed to perform welding

## Problem

**Online approaches**

- Better to use for SMEs
- Inflexible
- Very simple paths
- Time consuming

**Offline approaches**

- Better to use for large companies
- Flexibility for modification
- Less downtime of production
- Time consuming

The motion planning is still based on the knowledge and experience of the programmer

Software level prevents more widely usage of industrial robots

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Zengxi Pan, Joseph Polden, Nathan Larkin, Stephen Van Duin, John Norrish. Recent Progress on Programming Methods for Industrial Robots. ISR/ROBOTIK 2010
### Summary of used approaches

<table>
<thead>
<tr>
<th>Industrial robot languages:</th>
<th>Algorithmic approaches:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages:</strong></td>
<td><strong>Advantages:</strong></td>
</tr>
<tr>
<td>- limited atomic input set</td>
<td>- easy to use</td>
</tr>
<tr>
<td>(languages have predefined syntax and semantic)</td>
<td>(does not require precise motion description)</td>
</tr>
<tr>
<td>- application independent</td>
<td>- skills independent</td>
</tr>
<tr>
<td>(could be used for major of existing tasks)</td>
<td>(allow to get optimal motions, does not rely on the programmer experience)</td>
</tr>
<tr>
<td><strong>Disadvantages:</strong></td>
<td><strong>Disadvantages:</strong></td>
</tr>
<tr>
<td>- the difficult of use</td>
<td>- the difficult of algorithm set choice</td>
</tr>
<tr>
<td>(require very precise description of the motion: imperative, low-level programming style)</td>
<td>(many parameters are involved: sequence of appliance, current task, etc.)</td>
</tr>
<tr>
<td>- skills dependent</td>
<td>- application dependent</td>
</tr>
<tr>
<td>(Quality of motion depends on skills and experience of programmer)</td>
<td>(algorithms for surface management, collision-free planning, grasping, etc.)</td>
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</tbody>
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All improvements become application dependent

Attempts to improve or generalize algorithms fall into a more application dependence
• What if new approach would combine strengths of both mentioned above approaches?

Limited variety of input parameters => application independent

Algorithmic based => skills independent
General structure

Industrial robot programming approaches

Offline programming

Environments:
- Workplace
- KUKA Sim
- RobotStudio
- COSIMIR
- ...

Instruction Systems:
- Vision, voice, gesture recognition, etc.

Augmented reality approaches

Others

Online programming

Constraint specification

Solver

Facade API

Motion planning algorithms:
- Standalone algorithms:
  - path tracking
  - surface management
  - optimization
  - etc.

Motion planning libraries:
- MPKit (SBL, PRM)
- MSL (RRT, PRM, FDP)
- MPKernel (ACA, RRT, PRM, ATACE, Adapted-RGD, etc.)
- OMPL (RRT, PRM, KPIECCE, EST, etc.)
- OpenRave (RRT, CBIRRT, etc.)
- ROS (SBPL, CHOMP, STOPM, etc.)
Thank you for attention!