Business oriented robot Off-Line Programming solution using AutomationML

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Introduction

- Off-Line Programming (OLP) of automated processes in Aerospace

- Off-Line Programming tools are specific to:
  - Robot types
  - Application to automate

- OLP boost robot integration costs (time & money)

- Vision:
  - to be agnostic to
    - The robot type
    - The process specificities
  - to master the E2E data flow
Current situation in Off-Line Programming

- Configuration
- Product definition
- Business to implement
- Post Pro
- Robot type

Many & different input types

Specific programming solutions

Specific commissioning & execution tools

- Commissioning
- Execution

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Automation System Specific Offline-Programming

- Currently there are just a few highly specialised and complex automation systems for automated airframe assembly
  - Example: wing assembly with Low Voltage Electric Riveter (LVER) for A380 wing assembly
    - About 40 controlled NC-axes
    - Many cycles with dozens of parameters each
    - up to 10,000 rivets per panel at A380
  - OLP with generic OLP-Tools not economic (Just virtual teach-in)
    - Tedious single position selection
    - Manual cycle definition is error prone
    - No detailed collision check
  - Current solution CENIT FASTIP with machine specific customisation
    - Process-oriented programming approach
    - dedicated UI for each assembly system (tool and cycle selection)
    - dedicated automated programming strategies
    - dedicated consistency checks
    - dedicated collision check
New trend in automation: Lightweight/collaborative robots

- Increasing number of systems with less complexity
  - Individual customisation of OLP for each system becomes un-economic
  - Hence, process specific and device agnostic approach is necessary
  - However, customised setup for each individual system shall be kept
- Solution:
  - Automated customisation based on machine readable business process description
  - Business process description for automation system necessary
- Usage of PPR Model approach:
  - **Product**
    - Product requirements to be fulfilled by manufacturing process
    - e.g. assembly parts by fastening
  - **Process**
    - Mapping of manufacturing process (install fastener) to product requirements (assembly join)
  - **Resource**
    - Robot, End effector, working cycles, etc.
    - Humans – robots interaction
Requirements

- Software interfaces are important
- File based information transfer
- Technology specificities are described in an AutomationML file
- Programming solution focused on business objects
- Standard output using AutomationML
Semantic description of automated processes

- Data correspond to engineering objects
- Each information is defined once

AutomationML classes and Instance Hierarchies

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Automated customisation of CENIT OLP System with AutomationML

• Definition of device agnostic generic UI structure in OLP System CENIT FASTIP
• Initialise UI with resource and process description based on AutomationML
• Objects to be customised:
  – Manufacturing operations
    – e.g. drilling, fastener installation, measure, etc.
  – Tool-center points
  – End-effectors
  – Cycles (Technical solutions)
  – Auxiliary functions (break, operator message, etc.)
  – Dependencies of valid combinations
• Download of programming result with AutomationML as well
Automated customisation of CENIT OLP System with AutomationML

- Definition of device agnostic generic UI structure in OLP System CENIT FASTIP driven by AutomationML
- Process and machine specific information is directly accessible by the user without additional customisation
- Consistency rules covered by logic relations in AutomationML
Clear end-to-end information flow

Configuration file generator

Off-Line Programming

Process execution

Template file

Configuration file

Process description

Report file

Classes definition

PPR description

Classes definition

PPR description

Classes definition

PPR description

Classes definition

PPR : Product Process Resource

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Use case: MEL-O (Modular Extensible Lightweight Robot - Outside)

Smart and cognitive robotic cell made of standard, “off-the-shelf”, re-usable technology blocks and components

Each hardware component of the cell can be considered an independent module with its own embedded intelligence:

- Robotic arm
- End-Effector
- Vision System
- HMI
- Electrical Cabinet with digital I/Os and pneumatic valves

**Hardware architecture is fully open and scalable**
Retrieving process information from AML

- The AML file is loaded at run-time; **AML Engine** has been used to write a **wrapper** for the robotic cell.
- Starting from the **Process and Product description**, information about **groups of operations** and **product elements** are displayed on the HMI.
- The user can **manage process uncertainties** to exclude part of the task. These **information** is **written** back to AML file.
- The user can **select** the **sub-part of process to start**, or start the whole process.

**Example of robot HMI**

AML Wrapper
Process information is converted to the robotic cell specific language, and a sequence of tasks for the different modules is generated, depending on the selected process part to be executed.

<table>
<thead>
<tr>
<th>Module Name</th>
<th>Task Name</th>
<th>Task Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot Arm</td>
<td>Move</td>
<td>Position, speed, …</td>
</tr>
<tr>
<td>Vision System</td>
<td>Measure</td>
<td>Exp. time, ROI, …</td>
</tr>
<tr>
<td>Tool</td>
<td>Start Cycle</td>
<td>Tool Parameters</td>
</tr>
</tbody>
</table>

AML Wrapper
Log process execution information to AML file

Information about process execution are written to AML report file:

• Execution time info
• Faults
• Sensors measures
• Task executed properly
• Other Critical Parameters
• ...

AML Wrapper → Report File → AML
Integrated tool chains and interfaces

• File based information exchange

• AutomationML based Process-Product-Resource model for automated processes description

• AML based Airbus API for data interaction

• File generation & visualization

File content interaction with Airbus API
Perspectives and current interests

• Implementation of robotic ontology (ISO 8373) in AML

• Robot & machines motions modelling

• Automated processes modelling (PPR structure)

• Import of automation components information into OLP tools

• Digital semantic representation of products, process and resources for future automated process planning by automated resource skill to product requirement mapping
Thank you