Intelligent Motion Control Platform for Smart Mechatronic Systems

Results

Project Information

I-MECH

Grant agreement ID: 737453

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H2020-EU.2.1.1.7.

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€ 17 027 716,68

EU contribution
€ 5 018 274,06

Coordinated by
SIOUX TECHNOLOGIES BV
Netherlands

Start date
1 June 2017

End date
31 May 2020

Closed project

Deliverables

Documents, reports (21)

Overall requirements on I-MECH reference platform

Overall requirements on I-MECH reference platform (Task 2.3, R, M7, Nexperia)
The document specifies overall system requirement on I-MECH reference platform rising from analysing industrial need and latest emerging mechatronic technologies. It serves as a first iteration for platform system design. The document is a base for requirements and specifications for each individual Layer in D3.1, D4.1 and D5.

Training activities report
Training activities report (Task 8.3, R, M35, UNIBS) This document will present an overview of activities performed (and achieved results in terms of participants) for the Training activities of the I-MECH project. It will be reported how the training and awareness will be structured and disseminated to target audiences, as well as the impact and results of the performed trainings. It will also cover all details of the performed trainings (by each partner and by the consortium as a whole).

Motion control requirements and specification (final iteration) (Task 4.1, R, M17, UNIBS) The deliverable is dedicated to description of the final requirements and specification for the motion control layer implementing centralized and decentralized control schemes. The final report will present the results of the generic requirements abstraction for industrial applications and will specify its general architecture in terms of technologies, languages and tools, and provide the guidelines for motion control solution of the I-MECH platform.

System behavior layer integration and connectivity requirements and specification (final iteration) (Task 5.1, R, M17, J&J Vistakon) The deliverable is dedicated to description of the final requirements and specification for the system behavior layer. The final report will present the results of the generic requirements abstraction for industrial applications and will specify its general architecture in terms of technologies, languages and tools, and provide the guidelines for system behavior solution of the I-MECH platform.

Instrumentation Layer requirements and specification (first iteration) (Task 3.1, R, M11, EMCMCC) The deliverable is dedicated to description of the initial requirements for the instrumentation layer. This report will summarize the instrumentation layer requirements specific for the pilots. This report serves for system architecture revision (D2.4)

Instrumentation Layer development final report (Task 3.3-3.7, R, M30, EDI) A summary report will provide comprehensive description of Instrumentation Layer building blocks including implementation aspects on relevant pilot applications, use cases and demonstrators.

Reference tools and interfaces to System Behavior Layer (Task 5.2, R, M30, TECHNOLOGIN) This deliverable reports the design and development of tools for interfacing top layers of production pyramid. It directly elaborates requirements obtained from Task 5.1 into protocols, data packets and high level
drivers for delivering them into commercial MES / predictive maintenance systems.

**Instrumentation Layer requirements and specification (final iteration)**

The deliverable is dedicated to description of the final requirements for the instrumentation layer. The final report will present the results of the generic requirements abstraction.

**Needs for future smart production (manufacturing) in Europe from the mechatronics and robotic point of view**

This deliverable will summarize the main project final requirements. Both the European challenges which have been expressed as a goal for 2020 for manufacturing and the industrial needs coming from the industrial participants in the project will have to be considered. Great attention should be paid to the advanced production automation opportunities (list of gaps). It will provide guidelines for future actions to be implemented in order to overcome the gaps, based on principles of change management theory.

**Updated state of the art and enabling technologies of motion control solutions for smart mechatronics and robotics systems**

A comprehensive report will give a review of the relevant existing technology in advanced and smart production automation – including that which is currently being researched. Recommendations as to which options should be considered by this project and their relative merits and liabilities will have to be presented in this deliverable.

**General specification and design of I-MECH reference platform**

The document specifies the I-MECH reference platform at the system level. It provides the final iteration/revision of system requirements and specifications, combining D2.3 with technological specifications from D3.1, D4.1, D5.1 and D7.1. This will be made of: general design specifications of the I-MECH platform, taking into account the interactions among the Instrumentation Layer, the Control Layer and the interfaces to OKD/MES, review of existing technology and research results which could be exploited through pilot applications.

**Control Layer development final report**

A summary report will provides comprehensive description of Control Layer building
blocks including implementation aspects on relevant pilot applications, use cases and demonstrators.

System Behavior layer final report

System Behavior design and interfaces final report (Task 5.3-5.4, R, M30, BUT)
A summary report will provide comprehensive description of System behavior Layer building blocks including implementation aspects on relevant pilot applications, use cases and demonstrators.

System Behavior Layer integration and connectivity requirements and specification (first iteration)

System behavior layer integration and connectivity requirements and specification (first iteration) (Task 5.1, R, M11, J&J Vistakon) This deliverable provides a summary of initial requirements analysis and specification for system behavior layer. The report will summarize the system behavior layer requirements specific for the pilot plants and will provide the description of general functional blocks, software components, interactions with the motion control layer as well as its interconnection with lower instrumentation level and higher motion planning level. This report serves for system architecture revision (D2.4).

I-MECH best practices guideline

I-MECH best practices guideline (Task 7.1, R, M36, TECHNOLUTION) This deliverable will describe the best practices addressing the implementation and setup and later use of the I-MECH suite. As for the technical reports about the pilots and demonstrators the guideline will be enhanced along the evolutionary approach which is followed for the implementation of the pilots and demonstrators.

Guideline of I-MECH methodology (first iteration)

Guideline of I-MECH methodology (first iteration) (Task 6.1, R, M17, TECHNOLUTION) The deliverable will describe first iteration of methodology supporting the integration and utilization of the I-MECH components from the perspectives of the different industrial stakeholders. It will focus on tentative employment of model based techniques in mechatronics system design.

Motion control requirements and specification (first iteration)

Motion control requirements and specification (first iteration) (Task 4.1, R, M11, UNIBS) This deliverable provides a summary of initial requirements analysis and specification for motion control applications utilizing centralized and decentralized control solutions. The report will summarize the motion control layer requirements specific for the pilot plants and will provide the description of general functional blocks, software components, interactions in the motion control layer as well as its interconnection with lower instrumentation level and higher motion planning level. This report serves for system architecture revision (D2.4).
IPR Management

IPR Management (Task 1.1, R, M36, Sioux CCM) This report will present the current plans for the intellectual property rights (IPR) of the I-MECH project which aims at ensuring the wide accessibility and availability and reusability of all outcomes produced by the project.

Project Management and Quality Assurance Plan

Project Management and Quality Assurance Plan (Task 1.1, R, M2, Sioux CCM) In this document, the quality procedures and processes will be described, including role descriptions, reviewing procedures, communication matrix, etc.

I-MECH center

I-MECH center (Task 8.4, R, M36, Sioux CCM) This deliverable will report establishment of I-MECH center, see Objective SE 1.

Test benchmarking and strategy

Test benchmarking and strategy (Task 6.2/Task 6.3, R, M14, FAGOR) This document covers the strategy to be applied for the evaluation of the different component test and the integration test. The benchmark for performance testing will be specified in this report. The report also summarized benchmarking of subcomponents reused from other linked project (Tab. 7).

Websites, patent fillings, videos etc. (3)

I-MECH eBook

I-MECH eBook (Task 8.1, DEC, M36, ZAPUNI) I-MECH eBook will guide the reader through the selected papers (scientific popular), which are not contained in project deliverables, but are resulting from dissemination activities. It will also summarize the best practices learned from demonstration activities. I-MECH eBook should help the external audience to understand the technical innovation and scientific excellence of I-MECH.

I-MECH center web portal Functional

I-MECH center Website Functional (Task 1.2, DEC, M36, ZAPUNI) A website of I-MECH center will be established in order to promote sustainability of the consortium cooperation and potential for future emerging applications.

Project Website Functional

Project Website Functional (Task 1.2, DEC, M7, ZAPUNI) A website of I-MECH project will be established to inform about I-MECH interests, progress, technical results. It will include all public reports, information about I-MECH consortium. It will also serve as a communication portal for the consortium partners.
Publications

Conference proceedings (18)

Active noise cancellation
Author(s): Mart J. Coenen, Jayanta Deb
Published in: EMC Europe 2018, 2018

On the use of a temperature based friction model for a virtual force sensor in industrial robot manipulators
Author(s): Luca Simoni, Enrico Villagrossi, Manuel Beschi, Alberto Marini, Nicola Pedrocchi, Lorenzo Molinari Tosatti, Giovanni Legnani, Antonio Visioli
Published in: 2017 22nd IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), 2017, Page(s) 1-6
DOI: 10.1109/ETFA.2017.8247655

Model Predictive Control for operator-in-the-loop overhead cranes
Author(s): Marco Giacomelli, Marco Faroni, Domenico Gorni, Alberto Marini, Luca Simoni, Antonio Visioli
Published in: 2018 IEEE 23rd International Conference on Emerging Technologies and Factory Automation (ETFA), 2018, Page(s) 589-596
DOI: 10.1109/etfa.2018.8502591

MPC-PID control of operator-in-the-loop overhead cranes: A practical approach
Author(s): Marco Giacomelli, Marco Faroni, Domenico Gorni, Alberto Marini, Luca Simoni, Antonio Visioli
Published in: 2018 7th International Conference on Systems and Control (ICSC), 2018, Page(s) 321-326
DOI: 10.1109/icosc.2018.8587775

Design and validation of fault-tolerant embedded controllers
Author(s): Saurav Kumar Ghosh, Soumyajit Dey, Dip Goswami, Daniel Mueller-Gritschneider, Samarjit Chakraborty
Published in: 2018 Design, Automation & Test in Europe Conference & Exhibition (DATE), 2018, Page(s) 1283-1288
DOI: 10.23919/date.2018.8342212

Hybrid Automotive In-Vehicle Networks
Feasibility study and benchmarking of embedded MPC for vehicle platoons

**Author(s):** Debayan Roy, Michael Balszun, Dip Goswami, Samarjit Chakraborty
**Published in:** Proceedings of the Eleventh IEEE/ACM International Symposium on Networks-on-Chip - NOCS '17, 2017, Page(s) 1-8
**DOI:** 10.1145/3130218.3130235

An autotuning procedure for motion control of oscillatory mechatronic systems

**Author(s):** Marco Giacomelli, Davide Colombo, Giovanna Finzi, Vlastimil Setka, Luca Simoni, Antonio Visioli
**Published in:** 2019 24th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), 2019, Page(s) 829-835
**DOI:** 10.1109/ETFA.2019.8869039

Evaluation Platform of Platoon Control Algorithms in Complex Communication Scenarios

**Author(s):** Sijie Zhu, Dip Goswami, Hong Li
**Published in:** 2019 IEEE 89th Vehicular Technology Conference (VTC2019-Spring), 2019, Page(s) 1-5
**DOI:** 10.1109/vtcspring.2019.8746477

Delay-based Design of Feedforward Tracking Control for Predictable Embedded Platforms

**Author(s):** Mojtaba Haghi, Feng Wenguang, Dip Goswami, Kees Goossens
**Published in:** 2019 American Control Conference (ACC), 2019, Page(s) 3726-3733
**DOI:** 10.23919/acc.2019.8814430

Feedforward motion control: from batch-to-batch learning to online parameter estimation

**Author(s):** Noud Mooren, Gert Witvoet, Tom Oomen
**Published in:** 2019

Model-Based Processor-in-the-Loop Framework for Composable Multi-core Platforms

**Author(s):** Mojtaba Haghi, Martijn Koedam, Dip Goswami, Kees Goossens
**Published in:** 2019 22nd Euromicro Conference on Digital System Design (DSD), 2019, Page(s) 592-596
**DOI:** 10.1109/dsd.2019.00090

Learning in Machines

**Author(s):** TOM OOMEN
**Published in:** 2018
Application of Impedance Control in Robotic Manipulators for Spacecraft On-orbit Servicing

Author(s): Javier Garcia, Diego Gonzalez, Andres Rodriguez, Bruno Santamaria, Joaquin Estremera, Mikel Armendia
Published in: 2019 24th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), 2019, Page(s) 836-842
DOI: 10.1109/etfa.2019.8869069

Design and performance evaluation of smart vibration sensor for industrial applications with built-in MEMS accelerometers

Author(s): Doseděl Martin, Havránek Zdeněk
Published in: 2018

Prognosis and Health Management in electric drives applications implemented in existing systems with limited data rate

Author(s): B. Klima, L. Buchta, M. Dosedel, Z. Havranek, P. Blaha
Published in: 2019 24th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), 2019, Page(s) 870-876
DOI: 10.1109/etfa.2019.8869520

Iterative learning control in high-performance motion systems: from theory to implementation

Author(s): Martin Goubej, Sven Meeusen, Noud Mooren, Tom Oomen
Published in: 2019 24th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), 2019, Page(s) 851-856
DOI: 10.1109/etfa.2019.8868996

Data-Driven Feedforward Control for Mechatronic Systems: Analysis, New Approach and Application

Author(s): Noud Mooren, Gert Witvoet, Tom Oomen
Published in: 2019

Peer reviewed articles (7)

Modelling the temperature in joint friction of industrial manipulators

Author(s): Luca Simoni, Manuel Beschi, Giovanni Legnani, Antonio Visioli
Published in: Robotica, 2017, Page(s) 1-22, ISSN 0263-5747
DOI: 10.1017/S0263574717000509

On the Inclusion of Temperature in the Friction Model of Industrial Robots

Author(s): Luca Simoni, Manuel Beschi, Giovanni Legnani, Antonio Visioli
Published in: IFAC-PapersOnLine, Issue 50/1, 2017, Page(s) 3482-3487, ISSN
A Fast Autotuning Method for Velocity Control of Mechatronic Systems

Author(s): Marco Giacomelli, Davide Colombo, Luca Simoni, Giovanna Finzi, Antonio Visioli
Published in: IFAC-PapersOnLine, Issue 51/4, 2018, Page(s) 208-213, ISSN 2405-8963
DOI: 10.1016/j.ifacol.2018.06.067

Simplified input-output inversion control of a double pendulum overhead crane for residual oscillations reduction

Author(s): Marco Giacomelli, Fabrizio Padula, Luca Simoni, Antonio Visioli
Published in: Mechatronics, Issue 56, 2018, Page(s) 37-47, ISSN 0957-4158

Comparing Platform-aware Control Design Flows for Composable and Predictable TDM-based Execution Platforms

Author(s): Juan Valencia, Dip Goswami, Kees Goossens
Published in: ACM Transactions on Design Automation of Electronic Systems, Issue 24/3, 2019, Page(s) 1-26, ISSN 1084-4309
DOI: 10.1145/3315572

Analytical Characterization of End-to-End Communication Delays With Logical Execution Time

Author(s): Jorge Martinez, Ignacio Sanudo, Marko Bertogna
Published in: IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, Issue 37/11, 2018, Page(s) 2244-2254, ISSN 0278-0070
DOI: 10.1109/tcad.2018.2857398

Essential challenges in motion control education

Author(s): M. Čech, J. Königsmarková, M. Goubej, T. Oomen, A. Visioli
Published in: IFAC-PapersOnLine, Issue 52/9, 2019, Page(s) 200-205, ISSN 2405-8963
DOI: 10.1016/j.ifacol.2019.08.196

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