tourings

training for collaborative robotics integration

TOURINGS

Joint Curriculum Overview

Final Version

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The Project

1 About TOURINGS

TOURINGS is based on a transdisciplinary strategic partnership composed by a national standardisation body, higher education institutions, vocational education and training institutions and research centres on smart manufacturing, high-performance production and innovation in engineering. Each of the partners will provide their knowledge and expertise related to collaborative robotics, manufacturing, project management, ergonomics assessment, assembly line balance and digital simulations, aligned to the ISO-TS 15066 and considering problems such as work-related musculoskeletal disorders.

2 Context

The use of robotics in european industry continues to grow. According to the latest report from the International Federation of Robotics, the supply of industrial robots has increased 7% in Europe from 67.000 to 71.000 units in the last years. By 2020, more than 1.7 million new robots will be installed worldwide [1]. A collaborative robot is designed for direct human interaction in a defined collaborative space. Their integration in the industry allows to automate non-ergonomic or repetitive tasks. It improves assembly times, to make automation flexible for changing environments and automates work in restricted areas, a set of advantages which makes it very useful for manufacturing sectors. Only ISO-TS 15066 regulates cobots [2], complementing two existing type C standards on industrial robots (UNE 10218-A and 10218-2). This standard is key in terms of risk assessment and design of safety features considering contact situations and different collaborative methods like safety-rated monitored stop, hand guiding, speed and separation monitoring or power and force limiting.
European workforce is ageing, and repetitive and non-ergonomic tasks are one of the main concerns of european healthcare due to WMSDs. Cobots enhance workers well-being and improves employment conditions and the efficiency of some tasks. This is a key point considering the competition that european manufacturing sector has to face with more automatized countries like China or Japan and other emerging countries with a younger and cheaper workforce Under this context, different training topics are targeted: Cobots installation and workstation design, hardware, software and cells

design, functionalities design, assembly line balance and ergonomics assessment of human-robot interaction.

3 Main Goal

The desire of TOURINGS is to develop innovative training tools addressed to manufacturing sectors in the fields of collaborative robotics and thus facilitate its installation and improve the skills and knowledge on this key technology for the upcoming years.

TOURINGS will deliver a training course addressing key aspects for European manufacturing sectors:

a) safety requirements for human-robot interaction,
b) ergonomic measurementin human-robot interaction,
c) cobots integration in the assembly line balance and
d) design of different robot modules and behaviours to address production needs.

TOURINGS aims to foster the installation of cobots aligned with ISO-TS 15066 across EU to improve workers' wellness by avoiding work-related musculoskeletal disorders (WMSDs), improve the design of cobots behaviours by its modularity and improve the knowledge on the assembly line principles.

The training course should consist of the following modules:

1. **Collaborative Robotics Basics**: it will include all the pertinent aspects related to mechanics, electronics, computer science, artificial intelligence, control engineering and physics among others.
2. **Collaborative Robotics Modular Design and Behaviour**: it will show the possibilities of modularity and re-programmability of collaborative robotics' functionalities and different robotic cells
3. **Collaborative Robotics Safety Requirements**: it will cover all the relative aspects related to a safe physical human-robot interaction aligned to the requirements of ISO 15066
4. **Collaborative Robotics Installation on the Assembly Line**: it will introduce the learners in some assembly line and manufacturing principles to take into account before installing collaborative robotics to the make the most of it
5. **Collaborative Robotics Interactions. Digital Human Model, Digital Human Simulation and the RULA Method**: this module will show how a digital human model can be created to measure physical human-robot interaction using different methods.

The course will be addressed to manufacturing companies along EU with special attention to those sectors where workers have more repetitive tasks, with heavy loads

in nonergonomic positions. It is also addressed to human resources managers, policy makers, VET providers, training organisations and trainers and Higher Education Institution specialized in robotics, consultancies offering specialized support for robotics installations and assembly lines balance and students and unemployed interested in collaborative robotics.

JOINT CURRICULUM

1

Basic of collaborative robotics

The aim is to know what a collaborative robot is, what opportunities and risks a cobot offers, what it can and cannot be used for and what distinguishes it from conventional industrial robots.

Lesson 1 History	1.1. Industrial Revolutions 1.2 Robotics from the beginning to present 1.3 Impact of Robotics in the production process
Lesson 2 Structure of Collaborative Robots	2.1 Axes 2.2 Coordinate Systems 2.3 Digital inputs and outputs 2.4 Analog inputs and outputs 2.5 Control Systems
Lesson 3 Characteristics of Collaborative Robots	3.1 Weight and Payload 3.2 Reach 3.3 Precision 3.4 Repeteability 3.5 Spped and acceleration 3.6 Singularities and limits
Lesson 4 Initial Cobot Configuration	4.1 Installation files 4.2 TCP (Total Center Point) 4.3 Center of mass 4.4 Limits
Lesson 5 Basic Programming Techniques	5.1 Program structure 5.2 I/O Instructions 5.3 Movement instructions 5.4 Control instructions 5.5 Advanced examples

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Collaborative Robotics Modular Design and Behaviour

The learner has understanding, knowledge and skills about cobots' modular design and behaviour and how Cobots work; knows basics of programming cobots and can demonstrate the basic skills and knowledge to program cobots; knows possibilities of modularity and re-programmability of cobots' functionalities and different robotic cells; has knowledge and skills about sensors, actors and machines an application needs, and gripping technologies.

Lesson 1 **Hardware Cobot**	1.1 Robot frame 1.2 Links and joints 1.3 Drive system 1.4 Technical capabilities 1.5 Robot optimal selection
Lesson 2 **Software / Programming, technical drawings**	2.1 Robot programming methods 2.2 On-line programming 2.3 Off-line programming 2.4 Robot programming languages 2.5 Robot control systems
Lesson 3 **Gripping Technologies**	3.1 End Of Arm Tooling (EOAT) main principles 3.2 EOAT classification 3.3 EOAT selection 3.4 EOAT systems at the workplace
Lesson 4 **Sensor and AI**	4.1 Sensor classification and applications 4.2 Needs for using sensors 4.3 Integration of sensor information in the cobot working cycle 4.4 Digital twins based on AI technologies for process improvement
Lesson 5 **Typical cobot applications**	5.1 Assembly 5.2 Quality inspection 5.3 CNC machine tending 5.4 Polishing and grinding (machining) 5.5 Inbound logistics
Lesson 6 **Risk assessment and cost-benefit analysis**	6.1 Risk definition according to ISO 31000 6.2 Risks in project management 6.3 Risks in cobot implementation process 6.4 Risk assessment methodology according to ISO 31000 6.5 Principles of cost-benefit analysis and payback time calculations

3

CR safety requirements

Know the standards, know the risk assessment process, know how to design a safe application.

Lesson 1 **Standards**	1.1 DIN EN ISO 12100 standards 1.2 ISO/TS 15066 standards 1.3 Their limits in their application 1.4 Points of attention while implementing cobots in production lines
Lesson 2 **Biomechanical Limits**	2.1 definition of biomechanical limits 2.2 Types of measures of the biomechanical limits
Lesson 3 **CE-Conformity & Risk Assessment**	3.1 Definition of the risk assessment 3.2 Ways of the risk assessment
Lesson 4 **Planning a safe cell**	4.1 Principles of a safe cell 4.2 Bases of design 4.3 Bases of project management 4.4 CAD models 4.5 Needs to implement a safe cell 4.6 Design of safe gripping fingers
Lesson 5 **Safety Technologies**	5.1 Types of safety sensors and their way of working 5.1.1 Light barriers 5.1.2 Light grids 5.1.3 Optical systems 5.1.4 Others

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Collaborative Robotics Installation in the Assembly Line

The learner has understanding and is able to demonstrate how to install cobots on assembly line and balance assembly line

Lesson 1 Basics of integration project	4.1 Basics for deciding for starting implementation project of a cobot 4.2 Project management principles 4.3 Main mistakes 4.4 Main benefits of robot integration
Lesson 2 Implementation principles and Workplace layout	2.1 General principles of robot integration 2.2 Main stages of the implementation project 2.3 The impact of work task on workplace design
Lesson 3 Integration of cobot to assembly line and assembly line balancing	3.1 Main steps for successful cobot integration 3.2 Assembly system 3.3 Cobot integration to assembly line 3.4 Integration tools 3.5 Principles of assembly line balancing
Lesson 4 Configuration and recon-figuration of assembly line	4.1 Human-robot collaboration (HRC) 4.2 Configuration principles of assembly line
Lesson 5 Specific Work- or Production processes	5.1 Specific work- or production processes 5.2 Workplace and cobot performance

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Collaborative Robotics Interactions. Digital Human Model, Digital Human Simulation and RULA Method

This module aims at: - provide a helpful base for the companies to work on performance and WMSDs risks decrease.

Lesson 1 Collaborative robotics interactions	1.1 Definition of collaborative robotics interactions 1.2 Risks of WMDs 1.3 Risks of psychological disorders by using collaborative robotics
Lesson 2 Digital Human simulation and RULA method	2.1 Definitions of digital human model, digital human simulation and RULA method 2.2 Reasons to use those methods 2.2.1 more productivity 2.2.2 Better well being of the employees 2.2.3 Better employer brand 2.3 Ways to mesure those methods
Lesson 3 Analysis of the results of digital human simulation and RULA method	3.1 Evaluation of the risk 3.2 Calculate the most effective way to apply solutions 3.3 Measurement of the advantages led by use of collaborative robotics 3.4 Ways to improve current situations

4 References

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