ESMERA MANUFACTURING CHALLENGES

Industrial robots play an indispensable role in the manufacturing process and perform a huge number of tasks in all stages: from material handling and processing (transferring material from the storage area or manipulating tools to perform a process such as spot welding, painting, cutting, pick and place operations, etc.) towards to the assembly and the inspection (fitting together manufactured parts into a complete product, machine, structure, or unit of a machine and checking the components if they are in the standards). The roles of robots play increasingly important role in processing and assembly automation through their evolution in the recent decades, becoming able to perceive their environment and perform a various number of tasks. Networking, sensing and actuation technologies are being developed to allow these robots to work in higher autonomy and in collaboration with human operators. However, there are still great leaps to be undertaken in order to advance from the traditional use of robots that excel in highly repeatable and part dedicated operations.

ESMERA has identified several industrial challenges and classified the needs for further technical advances in 5 main challenges. Under each Manufacturing challenge ESMERA propose two options of industrial challenges that can be solved, option a) ESMERA proposed challenge and option b) Open challenge

Manufacturing Challenge 1: Robotic Perception Systems

Perception as described by Robotics 2020 Multi-Annual Roadmap is a key part of the ability of any robot system to perceive its environment. Perception technology provides a robot with the means to measure and interpret its environment. In order to enable intelligent behavior, perception technologies process raw sensor measurements to infer additional information and represent sensor data in a useful way. Under this scope the ESMERA challenge on robotic perception encompasses the following topics:

- **Perception for product identification and localization.** Novel technologies for fast and reliable object detection, identification and localization are needed for robots to become more efficient in handling different assembly tasks. Vision, depth, sound, thermal or any other technology able to provide faster and more accurate results than existing approaches are sought.
- **3D - Mapping of unstructured environments in real time.** In order for robots to operate in unstructured or dynamic environments, new approaches for 3D mapping of their surroundings are required. Both hardware sensors and algorithms for fast data collection and processing are required in this direction.
- **Perception for safety.** Under this topic perception system that can enhance the safety of operation of robotic systems are required. Perception may be implemented not only through visual detection but also through haptic, pressure actuated or any other system not available in conventional robot systems. Performance has to be up to existing safety standards in the EU.

It is expecting from the system to fulfill the following metrics:

- **Cost**: The solution has to be affordable and it should have a cost advantage over its competitors.
- **Flexibility**: The solution has to be flexible and adaptable to product and environment changes.
- **Efficiency:** The solution has to recognize and detect objects/humans not only from as the farthest possible distance, but also has to recognize and detect objects as the quickest possible time.
- **Reliability:** The solution has to be able to correctly identify the objects and not to damage them during the process.

Under the above challenge ESMERA project proposes two options. The proposer must address at least one of these challenges although addressing more than one or highlighting where elements of the proposed system could be used for the benefit of more than one system would be beneficial.

A) ESMERA proposed challenge: This challenge is extracted from five industrial ESMERA use cases which are

MANUFACTURING CHALLENGE 1. A1 (M1. A1)

TV Speaker Assembly: In TV set production, it is needed to assemble 2 speakers on each product. There are 20 different TV models which involve 3 different speaker options. TV sets are assembled on running conveyors without stopping on manual assembly station. Left and right speakers are mechanically different. The microphones are fed on different boxes. In this challenge we are looking for a perception system which can identify the correct TV speaker for the model of TV that is to be assembled and also use perception technologies for performing the complete assembly.

This challenge is provided by the company Arçelik A.Ş..

Figure 1: Supplement of speakers

MANUFACTURING CHALLENGE 1. A2 (M1. A2)

Oven insulation installation: In this challenge ESMERA is looking for perception systems that can enhance the safety of operation of robotic system in the assembly line of ovens body production. The robot should be able to work on one side of the conveyor while the operator is free to work on the other side. The challenge will focus on developing perception technologies that allow the safe coexistence of the human and the robot in the same workspace.

The current process can be seen from here.

This challenge is provided by BSH Hausgeräte GmbH.

Figure 2: Oven insulation installation

MANUFACTURING CHALLENGE 1. A3 (M1. A3)

Wire-harness assembly for TV units: In the production of TVs, it is needed to assemble cable harnesses on each product on the running conveyors. This challenge not only requires a perception system to identify the related wire harness for the TV model in the storage box (4 different cables with different lengths (from 302 mm to 475 mm) and different colors) and to detect the location of the connectors to plug the cable harnesses, but also requires the dexterous

Figure 3: TV assembly unit

handling of the flexible material. The current process can be seen from here.
This challenge is provided by the company Arçelik A.Ş..

MANUFACTURING CHALLENGE 1. A4 (M1. A4)

Labeling and sorting laser-cut garment: In the garment industry one of the struggles/bottle necks are on specific activities in the production line. Especially on labelling and sorting laser cut garment parts. A robotic system required to take over human operator in production line doing labelling and sorting of pieces of laser-cut garment for the next step.
In this challenge we're looking for robotic perception systems that labels and sorts pieces of laser-cut garment and moves group of textile pieces to different sections on production line unit.

Figure 4: Garment production environment

B) Open challenge (MANUFACTURING CHALLENGE 1.B (M1.B)

Any other proposal for similar technologies is eligible for funding, provided that a thorough explanation of the industrial needs is presented. The proposals will also have to clearly identify the state of the art in commercially available solutions and highlight the differences/advances over it. More specific each proposal in order to be in line with the ESMERA requirements has to provide:

- Clear indication of the company, institution or other that are in need of the proposed solution (no funding is allocated to challenge providers)
- Description of the problem that the company or companies need to be solved.
- Proof that currently there is no comparable solution (concept or approach, performance, cost…) in the market.

Manufacturing Challenge 2: Enhancing the capability of robots to handle flexible materials.

Motion in flexible materials as described in Robotics 2020 Multi-Annual Roadmap is the development of systems able to operate within flexible objects and soft objects and react appropriately to textural changes and object density. This challenge focuses on technologies and systems that allow robots to handle arbitrary objects of varying geometry and weight while requiring only few to no user input. This capability is brought forth by a combination of grasp planning, cognitive abilities and sophisticated sensing means. Three identified topics on enhancing the capability of robot s to handle flexible material are listed below:

- **Real time handling of deformable material**. Development and evaluation of various gripping technologies and control strategies for handling deformable materials are requested. Integration of sensors and perception for real time manipulation of soft materials with different shapes and sizes are also required.

- **Algorithms and simulation models to predict material deformation and adapt the robot control strategy**. Novel methods and models to simulate the behaviour of flexible materials are expected to allow smoother control of such objects by robots (material tension during the handling process for reliable pick-up, maintaining geometric definiteness during the handling process etc). Such systems are expected to complement robot control strategies which are based on position, force and compliance control.
- **Multi arm coordination for flexible material manipulation.** Flexible materials, especially of large dimensions, may require more than one robotic arm to operate at the same time. Coordination and control mechanisms able to orchestrate the motion of the arms in real time and achieve part manipulation without impacting on product quality or process cycle are sought.

It is expecting from the system to fulfill the following metrics:

- **Cost**: The solution has to be affordable and it should have a cost advantage over its competitors.
- **Collaborative and safe**: The solution has to include a collaborative robot which is able to work with a human or another robot without any safety risks. The developed solution should consider requirements of international standards for each problem.
- **User friendliness:** The robot should be easily calibrated/operated with intuitive user interfaces.
- **Flexibility**: The system should be able to handle different kinds of materials.

Under the above challenge ESMERA project proposes two options. The proposer must address at least one of these challenges although addressing more than one or highlighting where elements of the proposed system could be used for the benefit of more than one system would be beneficial.

A) ESMERA proposed challenge: This challenge is extracted from five industrial ESMERA use cases which are.

MANUFACTURING CHALLENGE 2. A1 (M2. A1)

Assembly of the balloon protector. Currently this operation performed manually since technical limitations does not allow the easy automation of the process.

The operator inserts the balloon protector and uses tapes to secure it on the refrigerator. Variability is very high, including 49 different models (range of 85-120 cm in width and 175-205 cm height). The operator applies the tapes from the panels of the refrigerator to cover the whole doors of the refrigerator horizontally and vertically with the balloon protector. This is a critical and hard operation for the robots. In this challenge we are looking for a system to automate this process.

This challenge is provided by the company Arçelik A.Ş..

Figure 5: Applying the protector to the refrigerator

Figure 6: Tape, table for balloon protector

MANUFACTURING CHALLENGE 2. A2 (M2. A2)

Isolation Cover Automation: In the production of oven, covering it with an isolation cover which made by a soft material is one of the process which might be dangerous for the people's health is an important process. At this challenge, ESMERA is looking for a collaborative robotic system that covers the oven with an isolation cover (soft material) and tight it with a wire. The list of the task for this challenge is:

- An operator takes the isolation material from the storage area and puts it on the oven,
- The both ends of the material are put together by another operator in the next stage in the production line.
- The third operator takes a wire from in the storage area and tight the isolation covers with it in the same stage,
- Then, the oven is rotated 90º by the third operator.

The current process can be seen from here.
This challenge is provided by the company Arçelik A.Ş..


Figure 7: Isolation cover assembly process

B) Open challenge (MANUFACTURING CHALLENGE 2.B (M2.B)

Any other proposal for similar technologies is eligible for funding, provided that a thorough explanation of the industrial needs is presented. The proposals will also have to clearly identify the state of the art in commercially available solutions and highlight the differences/advances over it. More specific each proposal in order to be in line with the ESMERA requirements has to provide:

- Clear indication of the company, institution or other that are in need of the proposed solution (no funding is allocated to challenge providers)
- Description of the problem that the company or companies need to be solved.
- Proof that currently there is no comparable solution (concept or approach, performance, cost…) in the market.

Manufacturing Challenge 3: Mechatronic devices for dexterous assembly

Mechatronics, as close coupling of mechanism, sensors, actuation and control, have always been a cornerstone of robotics. This group of technologies is critical and fundamental to the functioning of every robot. Mechatronics include some of the most mature technologies associated with robots. The importance of these technologies means that any significant developments or improvements in capability will have a wide impact across all sectors of the community. Mechatronics actually subsumes a large range of individual technologies, each of which will be addressed within dedicated sub-topic groups. The main contributions are expected in Mechanical System Design, Sensors, Actuators, Power Supply and Management, Communications, Materials and control.

This challenge fosters the design and development of mechatronics systems for the execution of highly dexterous assembly operations by robots. The proposed technologies should address but may not be limited to topics such as:

- Smart grippers and tooling able to adapt their structure and reconfigure their operation in real time
- Novel actuation technologies using lightweight materials and high performance to size ratio
- Completely new robotic equipment that can outperform conventional robotic solutions in assembly tasks

It is expecting from the system to fulfill the following metrics:

- **Cost**: The solution has to be affordable and it should have a cost advantage over its competitors.
- **Efficiency:** The solution should be easily set and can be easily reprogrammed for task reallocation. In addition, it is expected from the solution to enable the maximum efficiency during the operation in terms of each problem's efficiency measurements.
- **Flexibility**: The system should be able to handle objects with different shapes. Moreover, it is expected from the solution to achieve it at the same time or shorter cycle time than a human.
- **Collaborative and safe**: The solution has to include a collaborative robot which is able to work with a human or another robot without any safety risks. The developed solution should consider requirements of international standards for each problem.

Under the above challenge ESMERA project proposes two options. The proposer must address at least one of these challenges although addressing more than one or highlighting where elements of the proposed system could be used for the benefit of more than one system would be beneficial.

A) ESMERA proposed challenge: This challenge is extracted from five industrial ESMERA use cases which are.

MANUFACTURING CHALLENGE 3. A1 (M3. A1)

Assembly of the adjustable feet of the refrigerator. Operator takes the adjustable feet to a table in where these feet can be reached easily. When the refrigerator arrives in the station the operator:

- takes one adjustable foot to his/her one hand
- a nutrunner in other hand,
- places the adjustable foot to the refrigerator and uses nutrunner to tighten the foot.

In this challenge we are looking for a mechatronic device for automated execution of the picking and assembly of the adjustable foot.

This challenge is provided by the company Arçelik A.Ş..

Figure 8: Refrigerator's cabinet on the production line, adjustable feet, Nutrunner

MANUFACTURING CHALLENGE 3. A2 (M3. A2)

Refrigerator Styrofoam assembly: At this challenge ESMERA is looking for a robotic application for placing styrofoam to the one side of the refrigerator. Currently, this process is realized by an operator and consists of the following steps:

He takes the Styrofoams and the tape from the keeping area and places to a table in where this equipment's can be reached easily. The he performs the following steps:

– Operator cuts 1 tape which is10 cm long
– applies the tapes to the Styrofoam
– applies the taped Styrofoam to the refrigerator

Figure 9: Styrofoam Placed Refrigerator

– Repeats until all styrofoams of the refrigerators are placed.

This challenge is provided by the company Arçelik A.Ş..

MANUFACTURING CHALLENGE 3. A3 (M3. A3)

Protective film removal: The provided challenge requires dexterous handling to remove a protective film from an INOX sheet metal.

In this process, a piece of sheet copper is used as a tool to cut the protective film without damaging the INOX sheet metal under this film. The protective film should be cut through otherwise removing it will not be easy.

Currently this work is done manually, therefore work-time depends on human operators' skill.

In this challenge we're looking for robotic systems that could do following;

- A system that could determine on how to remove protective film from INOX sheet metal, without damaging the good with predictable worktime.

It is important to note that products can be damaged during the workflow and the product is discarded in case of any damage.

This challenge is provided by the company SILVERLINE.

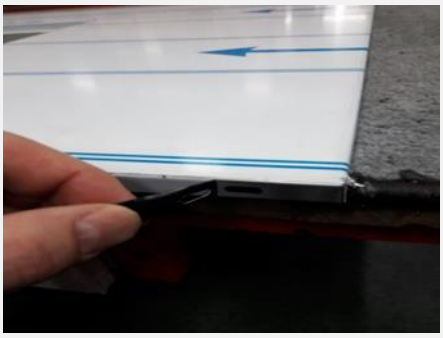

Figure 10: Protective film removal from metal sheet.

MANUFACTURING CHALLENGE 3. A4 (M3. A4)

Assembly of the led bar for the TV: Assembly of a led bar to the TV requires dexterous handling of the flexible material. The current process is done manually, and an operator does the following tasks in a row:

- takes the corresponding led bar from the trolley
- places it on the sockets on rear panel,
- takes outs the film and throw it to the bin, and
- stick it to the rear panel applying pressure.

In each panel, this process is repeated three times: led bars are assembled on the left, right and middle of the panel. The length of bars varies between 600 mm to 950 mm and their width varies 10 mm to 12 mm based on the TV model.

In this challenge, we are looking for a robotic system to automate the current process which can be seen from here.

This challenge is provided by the company Arçelik A.Ş..

Figure 11: Led bar assembly

MANUFACTURING CHALLENGE 3. A5 (M3. A5)

Assembly of sticky and flexible material to evaporator pipes: For the sound isolation of refrigerator, bitumen mastic material which is sticky and flexible is used. In this challenge, ESMERA is looking for a dexterous system that can handle the bitumen material from the storage area, take its film out, assemble it to the evaporator pipeline while wrapping it and stick it to the panel applying a pressure. The working area (rear panel of the refrigerator) varies between 600 mm and 840 mm and the whole tasks are done manually by an operator in 16 secs in the current process. The current process can be seen from here. This challenge is provided by the company Arçelik A.Ş..

Figure 12: Assembly of bitumen in the refrigerator

B) Open challenge (MANUFACTURING CHALLENGE 3.B (M3.B)

Any other proposal for similar technologies is eligible for funding, provided that a thorough explanation of the industrial needs is presented. The proposals will also have to clearly identify the state of the art in commercially available solutions and highlight the differences/advances over it. More specific each proposal in order to be in line with the ESMERA requirements has to provide:

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- Proof that currently there is no comparable solution (concept or approach, performance, cost…) in the market.

Manufacturing Challenge 4: Increasing efficiency of Human Robot Collaborative applications

Human robot collaborative applications include the ability of a system to interact physically, cognitively and socially either with users, operators or other systems around it and other robots. The ability to interact may be as simple as the use of a communication protocol, or as advanced as holding an interactive conversation in a social context. The ability to interact is critical to many areas of application. Interaction depends on both the medium of interaction and on the context and flow of the interaction. The ability to interact takes place in three distinct ways physical interaction, cognitive interaction and social interaction. The description of the levels of Interaction Ability include these three types of interaction

This challenge refers to any generic supporting tool, either robotic or other automation system, that is not included in the above categories and aims at supporting the interaction and collaboration between robots and operators. The proposed technologies have to address topics such as:

- Novel means of seamless interaction between humans and assembly robots (robot to human / human to robot)
- Control strategies and AI for adapting robot behaviour to operator's needs and requirements
- Tools for designing/planning/optimizing/deploying human robot collaborative assembly cell.
- Operator support systems focused on HRC using multi modal interaction modules
- Improvement of safety conditions for operators when performing HRC activities

It is expecting from the system to fulfill the following metrics:

- **Cost**: The solution has to be affordable and it should have a cost advantage over its competitors.
- **Ergonomy:** It is expected from the system to put less strain on workers
- **Collaborative and safe**: The solution has to include a collaborative robot which is able to work with a human or another robot without any safety risks. The developed solution should consider requirements of international standards of each problem.
- **Efficiency:** The robotic solution has to adapt its behaviour at operator's needs and requirements.

Under the above challenge ESMERA project proposes two options. The proposer must address at least one of these challenges although addressing more than one or highlighting where elements of the proposed system could be used for the benefit of more than one system would be beneficial.

A) ESMERA proposed challenge: This challenge is extracted from five industrial ESMERA use cases which are.

MANUFACTURING CHALLENGE 4. A1 (M4. A1)

Electric motor: This challenge consists of the installation and screwing of the inverter on the unit rotor/stator. The inverter is equipped with a cable provided with a connector which must pass through the casing of the electric machinery before posing the inverter on the engine. In an HRC scenario the operator could assist the robot in picking parts and during the invertor positioning. Positioning the invertor, it is necessary to orient the cable through the electric motor casting. The robot could handle the inverter and approach it to the rotor/stator block and the operator could perform the insertion of the cable. Solutions to allow smooth HRC are sought by this challenge.

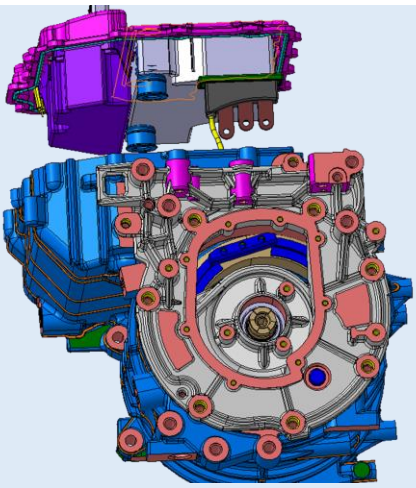

Figure 13: Electric Motor

MANUFACTURING CHALLENGE 4. A2 (M4. A2)

Assembly of front window: At this challenge ESMERA project is looking for a HRC solution in a manufacturing continues assembly line for front and rear window to the vehicle in right position and measure the quality of its assembly operation. There are two types of production line: continuous type and stop-and-go type.

Figure 14: Current Process in the continuous type

- For the continuous belt type lines, the position of the car is not accurate which requires from the robot to detect the car's position. In addition to this difficulty, the continuous belt line movement is not reliable due to the chain gaps in the conveyor belt system.
- For the stop-and-go stations, the position of the car might be affected by the velocity of the line and the vibrations in the line.

It should be noted that, the position of the car body not only vary on the direction of the conveyor movement but also it may vary in the right or left direction. Moreover, the position of the car body may differ ±20mm front or the rear stations.

Figure 15: Current process in the stop-and-go type

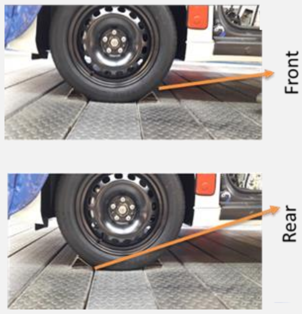

Figure 16: The position of the car body in the station

B) Open challenge (MANUFACTURING CHALLENGE 4.B (M4.B)

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Manufacturing Challenge 5: Decisional Autonomy

Decisional autonomy as described in Robotics 2020 Multi-Annual Roadmap is the development of a system in which the self-reaction ability is increased in the control process. In industrial robotics, failure prediction and fault tolerance are helpful in reduction of a system downtime in the following manner: by tolerating failures robot's lifespan is increased, and by identifying faulty components or subsystems to speed up the repair process. In this challenge, we expect proposers to predict the robot's failures/ breakdowns using the continuously received data.

This challenge requires

1. **Data interpretation.** Assigning a meaning to the received information and determining its importance and implications.
2. **Decisional Autonomy in real-time operations.** Based on the received data it is expected from the system to decide for the further steps. It is expected from the system to analyze the data and to decide the next steps in real time.

It is expecting from the system to fulfill the following metrics:

- **Cost**: The solution has to be affordable and it should have a cost advantage over its competitors.

- **Efficiency**: The system is able to identify the type of the predefined task, choose between them and can alter its strategy as it gathers new knowledge about the environment. The system has to make real-time decisions about the environment and so controls interaction with the environment in order to achieve a predefined task. The system has to be re-configurable depending on the tasks or changed environmental conditions. Moreover, it is expected form the system to decide for the next step in a possible minimum time.
- **Reliability:** The system has to be reliable in terms of its overall decisions (detection of the problems/failures, etc.).
- **User friendliness:** The robot should be easily calibrated/operated with intuitive user interfaces.

Under the above challenge ESMERA project proposes two options. The proposer must address at least one of these challenges although addressing more than one or highlighting where elements of the proposed system could be used for the benefit of more than one system would be beneficial.

A) ESMERA proposed challenge: This challenge is extracted from five industrial ESMERA use cases which are.

MANUFACTURING CHALLENGE 5. A1 (M5. A1)
Prediction of robot failures. In automotive manufacturing, many robots are used in body shops, especially on spot welding process. During the operation of robots, two data are continuously taken from them: i) robot's error log, and ii) real-time component data (torque, current, temperature etc). In this challenge we're looking for systems that can detect the problem/failures based on the collected real-time data from robots and inform the user about the possible problems before it happens.

This challenge is provided by the company Ford Otosan.

B) Open challenge (MANUFACTURING CHALLENGE 5.B (M5.B)

Any other proposal for similar technologies is eligible for funding, provided that a thorough explanation of the industrial needs is presented. The proposals will also have to clearly identify the state of the art in commercially available solutions and highlight the differences/advances over it. More specific each proposal in order to be in line with the ESMERA requirements has to provide:

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