Sustainable and reliable robotics for part handling in manufacturing automation.

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OVERVIEW

• WHY? Motivation of the Proposal
• WHAT? Objectives of the Proposal
• HOW? Activities
• WHO? Partners
• Conclusions
WHY?

Motivation of the Proposal
• **STAMINA**: building the Factory of the Future with the help of new robotics technologies
  
  • Find profitable solutions to increase the competitiveness of EU
  
  • Increase the flexibility of production facilities to face:
    • Ever increasing customisation of products
    • Production volumes variations
  
  • Address ageing workforce issues and occupational diseases
  
  • Allow the deployment of workers to tasks of greater interest and value added for the customer

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**Diagram:**

- Synchronization of referenced parts
- Transfer parts to the production line
- Kitting operations
Transfer parts to the production

The challenge
• Unload heavy parts from a bulk-storage or palette
• Feed the isolated part in the proper position and orientation
• 7 seconds / part

The benefits
• Ergonomics: 4000 parts / shift (up to 20 tons)
• Cost-effective: 75% of the price of installations on feeders
• Deployment: 215 applications with bulk-stored parts identified
Synchronization of referenced parts

The challenge
• Reorder parts according to production request
• Fragile parts (7kg) can only be grasped by specific zones
• 9 different parts in different storage conditions
• 3 min to prepare 20 parts

The benefits
• Ergonomics: 12 tons / shift
• Quality (conformity, traceability)
• Deployment: every plant
Kitting operations

Definition: Process in which individually separate but related items are grouped, packaged, and supplied together to the production line

The challenge
• Gather a selection of parts and place it on a carrier
• Diversity of parts (shape, flexibility, colour)
• Different storage conditions in a wide area
• 60 sec to prepare a full kit

The benefits
• Flexibility to production changes
• Quality (traceability)
• Deployment: 99% of vehicle parts are delivered in kits (goal)
TECHNOLOGICAL CHALLENGES

- Bin picking, de-palletising, kitting and part feeding
  - Object recognition and Grasping capabilities
- Safe navigation among humans
- Cooperation with fleet of mobile robots and/or manual forklifts
  - Control through the ERP System
- Easy programmable by humans
- Compliance with safety regulations
TECHNOLOGICAL CHALLENGES

• Sustainability:
  • easy adaptability to new tasks and missions
  • able to automatically compensate for limited variability
  • programmable even by shop-floor workers
  • Complies with safety requirements as far as possible
WHAT?

Objectives of the Proposal
Solve the above three use-cases with a mobile robot such that
the robot has the following set of skills

1. able to navigate safely
2. able to bin-pick within the given use-cases
3. able to place parts + inspect part
4. able to communicate with other robots
5. do all this in a safe way
The Solutions are Reliable and Sustainable

1. works in all three use-cases
2. only minor re-programming efforts
3. with parameters provided by human / MES system
Advanced Human Robot Interface

1. normal shop-floor workers
2. MES system of the company can interface with the robot
3. safety requirements are assured by the HRI
The System Complies as much as Possible with the Safety Requirements

1. Proactive work on safety measures by choosing right HW, sensors
2. Provide input to revision of industrial requirements for use of mobile, cooperative robots
3. Risk analysis across all test-sprints
HOW?
1. AVAILABLE ROBOT TYPES

- Robm@rket, based on Artemis AGV, BA-Systémes
- ROBY, BA-Systémes
- Little Helper Robot, AAU --> Skill concept, HRI
2. LEAN DEVELOPMENT

- Regular test-sprints will assure constant:
  - focus,
  - fast identification of safety issues and fast accommodation of user feedback
- Tests under realistic conditions
- Direct technical feedback

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University/Lab
- UBO - Bin Picking
- ALU-FR - Navigation
- INESC - Fleet-control
- UEDIN - Planning
- AAU - Skills, HRI, part-feeding, inspection

Provide code that
  - is state-of-art
  - runs under lab conditions
  - works on the use-case objects

Integration&Development
- BAS - Integration
  Provide
  - prepare code to run under use-case conditions
  - prepare the hardware for use-case conditions
  - documentation, quality control
  - safety
  - testing

Shop Floor
- PSA - Experiments
  Provide
  - use-case scenario
  - optimize code under use-case conditions
  - optimize hardware for use-case conditions
  - documentation, quality control
  - safety
  - testing
  - user-testing
WP1: Integration, testing, Use case-definition, validation and evaluation

T1.1  T1.2  T1.3  T1.4

T2.1  T2.2  T2.3  T2.4  T2.5

WP2: Robot Control

Skill Concept, & Architecture

Feedback from the experiments

Direct implementation only for the M10 experiments

WP3: Skills for differentiated robot fleets

T3.1  T3.2  T3.3  T3.4

WP4: Mission tasks and vertical enterprise integration

T4.1  T4.2  T3.3  T4.4

Implementation input:
- Code works in lab space on parts
- Embedded in skills
INTEGRATION, TESTING, USE CASE-DEFINITION, VALIDATION AND EVALUATION

- definition of the targeted use-cases
- hardware requirements
- define user requirements and performance and usability criteria
- allow incremental integration of hardware and software designed in WP2-4
- conduct iterative test cycles for evaluation and feedback to R&D partners
- assure safety proactively where possible, and derive new solutions where necessary, together with WP2-4
- carry out a safety risk assessment with associated risk reduction measures
WP2: ROBOT CONTROL

Provides the “low-level” capabilities of the STAMINA-Robot

- Localization and Mapping
- Robot Navigation
- Picking
- Single Part Feeding and Inspection
- Inter-robot coordination and communication
- Safety criteria are provided by WP1 and are considered within each sub-task.

Success-criteria: Provided code runs under lab-simulated use-cases settings while taking into account the requirements provided by WP1.
WP3: SKILLS FOR DIFFERENTIATED ROBOT FLEETS

On the robot:

- defines “skill API” to supports integration of robot controls from WP2
- identify the set of necessary skills required to complete the common missions
- actually integrate the different robot controls from WP2 into the skill structure
- implement task-planner that controls skills
- define HRI based on touch pad and possibly other modalities
WP4: MISSION PLANNER AND VERTICAL ENTERPRISE INTEGRATION

Not on the robot:
• specify API between MES system and mission-planning subsystem
  • integration mechanisms with MES systems
• provide the software level integration to support communication between MES and mission planner
• define and implement the mission planning subsystem
WP5: KNOWLEDGE TRANSFER, DISSEMINATION AND EXPLOITATION

• **Academic Partner:**
  • public dissemination
  • conferences, workshops
  • fairs
  • journal publications

• **Industrial Partners:**
  • exhibitions, fairs (Automatica, Hannover industrial fair, etc)
  • shop-floor of PSA show-case to partners (e.g. EADS) and suppliers (manufacturing and product parts)
  • use of the stamina robot at the PSA plants
  • BAS: building and selling advanced AGVs
WHO?

Partners and Roles
Aalborg University, Denmark (Coordinator)
coordinator, project administration, research
• part-feeding and inspection
• robot skills concept

PSA Peugeot Citröen, France:
system integrator, end-user
• application development
• testing and validation
• use-case definition, definition of benchmarks,
• safety

BA Systémes, France:
technology provider, system integrator
• robot and application development, safety;
• testing and validation
• safety
University of Freiburg, Germany
• mapping
• localization
• robust navigation in dynamic environments

University of Bonn, Germany
• Bin-picking

INESC-Porto, Portugal
• multi robot coordination and cooperative mapping,
• ERP integration, Network interfaces

University of Edinburgh, UK
• task planning, execution monitoring of robot task plans,
• fleet-level/mission planning
CONCLUSIONS

• **Key objective**
  • build a robot system that is equipped with capabilities to handle a set of logistic tasks while assuring that the system is sustainable:
    • it is NOT overspecialised
    • it is easily adaptable to new scenarios

• **3 use-cases are used to achieve that:**
  • kitting
  • bin-picking
  • de-palletizing