Human-Robot Collaboration in Industry 4.0

E4 “Research” project

General Context and Challenges

Human-Robot collaboration aims at combining the advantages of robots, like high speed and good repeatability, with the flexibility and adaptability of human workers. Robots can support humans when performing physically challenging tasks and at the same time allow automation in scenarios where this was previously considered unfeasible without the capabilities of collaborative robots. As a result, complex manufacturing processes can be carried out even though shortage of skilled labor continues to rise. The use of collaborative robots could consequently contribute to social and economic sustainability of industry.

Project description

Recently, the European Commission started a complementary approach to Industry 4.0, called Industry 5.0. It is a transformative vision of the European industry, moving toward more sustainable, human-centric, and resilient systems [1]. In this new paradigm, human-robot collaboration refers to environments, where humans and robots work in close proximity, sharing their workspaces, resources, or even their tasks [2]. In such working setup new challenges arise that are related to the productivity, but also to the safety of human workers. Safety aspects are of utmost importance for the acceptance of this technology [3] and for the commissioning of such systems, various normative requirements must be met [4] [5].

Machine vision in human-robot collaboration

Although machine learning and artificial intelligence have allowed considerable advances in computer science, its industrial adoption in the domain of robotics is still in its early stages. A review of recent achievements is available in [6]. A number of elementary tasks still remain open: distinguishing backgrounds and objects, identifying moving objects, identifying partially covered objects, recognizing changing shapes or articulation or understanding the position and orientation of objects. All these tasks are required to enable the following paradigms :

- safety – collision avoidance (with humans and obstacles)
- coexistence – the robot capability of sharing the workspace with other workers
- collaboration – capability of performing robot tasks with direct human interaction and coordination

The presence of humans in the workspace or the random presence of objects to be manipulated introduces uncertainty that requires sensor inputs for robot control. Three sensory modalities have become dominant: vision, touch and distance, see e.g. [7] Sensors can be mounted on the robot or fixed in the workspace (referred to as “eye-in-hand” and “eye-to-hand” visual servoing, respectively). The sensing can be used for actuation, servoing, trajectory planning, and security [8]. The sensor inputs are translated to servoing commands via the classic inverse kinematic problem [9] or recently, using reinforcement learning.

Objectives of the internship

Safety – The robot must not perform a move that would cause injury to the co-worker. To that objective, several tasks have to be performed in real time : 1) detection of presence of one or more co-workers, 2) determination of the position of all parts of the co-worker's body in the space (in 3D).

Collaboration – the recognition and understanding of the co-workers needs and commands. These commands can be hand gestures, as e.g. outstretched hand palm up, fingers apart to have the robot hand an object to the worker.

Partial and intermediate steps

1) Make a literature survey on the state of the art to identify the existing solutions and identify current technological barriers for ensuring the safety and enabling the collaboration, as described above.

2) 3D space perception can be provided to the robot using low-cost sensors using either : i) lidars, ii) depth cameras, or iii) visible+depth cameras. Find existing, available datasets using convenient modalities with humans presents, e.g. [10].

3) Develop methodology to detect presence of humans and determination of position of all human body parts in the space [11]. Segment principal parts of the body – head, arms, hands, legs and feet and provide 3D position in space for all.

3) Develop methodology to detect and understand co-worker's gesture to command the robot. Figure out and implement 5 to 6 possible gestures to issues various commands.

4) Create a demonstrator using a chosen sensor and a real-time, data-processing application illustrating the concept.

Note : No robot servoying will be treated in the project.

Application condition

the following skills are necessary : image analysis skills, real-time coding, AI coding skills (tensorflow, pytorch)

Literature:

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