Robot A. MiR 500 in a warehouse

MiR500 is designed to automate the transportation of pallets and heavy loads across industries. With a total payload of 500 kg, and a footprint of 1350x910 mm, MiR500 is a large, powerful, and robust collaborative, autonomous mobile robot.

Figure A.1. The real MIR500 AGV

In your study, 5 MiR 500 robots are used in a warehouse for transporting the goods from the receiving area to the storage area. The goods are manually loaded onto the pallet racks. Then by using the MiR 500s' laser scanning technology, the work environment is analyzed along the way, so the obstacles can be avoided. The transportation route between the receiving area to the storage area has a distance of 100 meters with 3 to 4 twists and turns. Also, the path has to go through some crowded areas inside the plant. When the MiR500 robots arrive in the storage area, they wait in an orderly fashion to transport their pallets of packaging materials to a series of high bay racks. Once they have unloaded the pallets, a specialized high bay fork truck then lifts and places the pallets into the high bay racks for storage.

The warehouse is a dynamic environment, so obstacles such as people, pallets and other robots may appear in the MIR 500 AGVs' paths and cause congestion. The MiR Fleet management system can be used to control the robots and allow them to navigate multiple paths in a safe and orderly manner. Technicians can also use the software system to monitor daily data task management, and automatically give instructions to the robots, such as sending a robot back to its charging position to recharge. The case study can refer to the use case in Novo Nordisk China.

https://mobile-industrial-robots.com/cases/novo-nordisk-china

Robot B. An agriculture robot in wine yards (wine yard tractor)

The agriculture robot is intended to be working in wine yards with the following possible tasks:

- Soil maintenance
- Sustainable use of pesticides
- Pruning
- Tying-up

The robot can be operated in two modes: manual mode and autonomous mode.

Figure B.1. Front side of the agriculture robot.

Figure B.2. The backside of the agriculture robot.

The preliminary design of the agriculture robot is shown in Figure B.1 and Figure B.2. The specified technical data of the agriculture robot can be found following the links below:

https://www.fort-it.com/eng/agriculture-division/multifunctional-machine/rd25/
https://www.youtube.com/watch?v=qdM00rNm5x0

The navigation system of the agriculture robot is based on Lidar system and radar system.

Specification and work conditions:

- The agriculture robot is used in wine yards(for outdoor use)
- The agriculture robot is started up in manual mode (one driver) and changed into autonomous mode.
- Obstacles and position of the tractors should be detected by navigation systems.

- The speed of agriculture robot can be adjustable.
- The maximum speed is 7.5km/h.

Robot C. REHAROB Therapeutic System-Reharob 3.0

REHAROB provides personalised, three-dimensional motion therapy for patients with neuro-motor impairments. REHAROB = robotic rehabilitation system for upper limb motion therapy for the disabled. The therapy will be driven by industrial robots utilising intelligent identification of the required physiotherapy motions.

The robot, Reharob 3.0, is composed of Universal Robots: UR5e and UR10e. The UR 10e via a two robotic finger hand module will move the hand while the UR5e will move the elbow. REHAROB 3.0 Physiotherapy Equipment is used for the clinical physiotherapy of the upper limb of hemiparetic patients. The physiotherapist teaches the equipment by exercising the patient. The physiotherapist therefore uses the same physiotherapy exercises to teach the system as they use in their daily work. During training, the system remembers the physiotherapy, for example, the series of movements of the upper arm and forearm, based on the signals from the built-in sensors. The sample program and the associated safety data, which only allows the safe repetition of the given physiotherapy, are generated automatically by the system. The physiotherapist can determine and change the parameters of the taught exercises, e.g., the speed, the number of repetitions, the order of the exercises. The therapeutic program thus completed can be repeated by the REHAROB Physiotherapy Equipment in an unlimited number, without the supervision of additional nursing staff.

The schematic drawing of the dual cobot arm therapeutic system in Figure C.1.

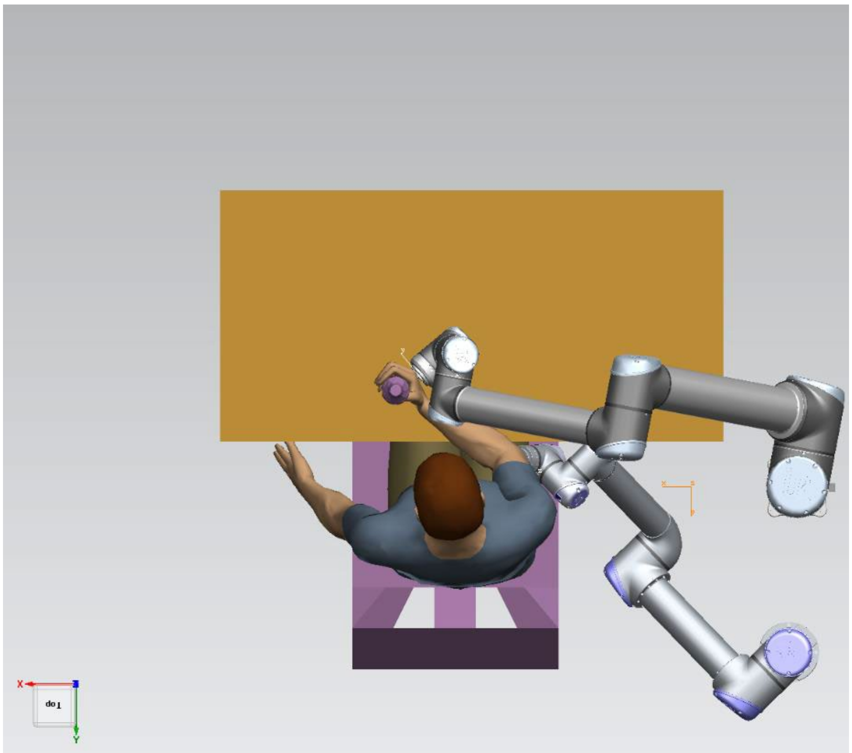

Figure C.1. Schematic drawing of the dual cobot arm therapeutic system.

Specification and work conditions:

- The robot is used for exercising patients in door at room temperature, without the supervision of additional nursing staff.
- The kinetic energy is delivered to the patient in a controlled way.
- The cleaning of the orthoses has to be done by the therapist.
- The robot may be influenced by temperature, humidity, vibration.
- The robot can be used repeatedly.
- The cable connector is only compatible with the EU mains connector and with the corresponding voltage and frequency (230 VAC, 50 Hz). The voltage from the transformer of Universal Robots robot is 48 V, and the voltage from DarpaMotion Robot Finger ("DMRF") is 24 V.
- The robot is connected to a PC.

Robot D. The robot arm application for pick and place in a slaughterhouse

A pick and place task, which is a common task in a slaughterhouse is shown in Figure D.1. The robot arm application idea is that a robot manipulator will replace the human worker working on picking and placing meat cuts. The object for manipulating in this task is the meat cut which is transferred by a conveyor belt. The task here is to grab the meat cut from the conveyor belt and hang it onto a Christmas tree. The meat cuts will be in various shapes and dimensions. There are four subtasks involved in the pick-place: tracking, grasping, lifting, and hanging. Tracking is mainly realized through a stationary visual sensor, where computer vision algorithms are used to detect meat and predict its position in 3D. Grasping executes after the robot receives the pose information. The arm will go toward the meat along the planned path and grasp the meat with the gripper. Then, the meat will be lifted and hung on a specific Christmas tree branch.

Figure D.1.(a) Human involved in meat pick and place process. (b) Autonomous meat pick and place experiment setup.

As in the traditional working process, a human operator will work alongside the robot manipulator to supervise the condition of the meat and the hardware status, including the robot, and to adjust the operation during the pick-place process. When the human's working area overlaps with the robot's working area, we believe the collaboration happens between human and robot (HRC).

The specifications for the application platform can be found in the publication[1].

[1] Wu, H., Andersen, T. T., Andersen, N. A., & Ravn, O. (2016). Visual Servoing for Object Manipulation: A Case Study in Slaughterhouse. In Proceedings of the International Conference on Robotics and Automation IEEE. https://doi.org/10.1109/ICARCV.2016.7838841