Development of a methodology for the human-robot interaction based on vision systems for collaborative robotics

Abstract

The industrial world is facing an important change that will bring new powerful tools inside the factories. This innovation will be the result of the fourth industrial revolution, also known as “Industry 4.0”. The collaborative robotics is one of the pillars of the Industry 4.0. The goal of the collaborative robotics is to bring the robots outside from the cages in which they are now and make possible the human-robot interaction. This is a radical change in the industrial robotics because it permits to exploit the potentialities offered by the combination of the precision, velocity and repeatability of robots and the extreme adaptability of humans. In these years, several works have faced the topic of the collaborative robotics and several control algorithms have been presented.

This dissertation proposes two algorithms useful to control collaborative robots and permit safe human-robot interactions in an industrial environment. The first algorithm is a collision avoidance algorithm based on the artificial potential fields approach. The proposed algorithm controls the robot in order to avoid collisions with fixed and dynamic obstacles moving along preferred directions. The trajectory conditioning technique proposed in this work gives to the robot the possibility of avoiding collisions with highly dynamic obstacles overcoming the problem of the unknown directions of motion related to the artificial potential fields approach. In this way the operator can predict how the robot will modify the planned trajectory to avoid collisions making the human-robot interaction more natural. A hand-over algorithm is the second novelty proposed in this thesis. This algorithm permits to obtain fluent hand-over between a robot and a human operator. The proposed algorithm makes possible bidirectional, reactive and fast hand-over actions and the pose of the operator’s hand is considered as target that the robot has to reach. Both the algorithms need as input the information related to the position of the human operator working with the robot. The position and the movements of the human worker are acquired by a markerless vision system. In particular, Microsoft Kinect v2 sensors have been used in this work.

A simulation environment has been developed to permit to a human operator to start interacting with a simulated collaborative robot. A virtual collaborative robotics environment has been developed and presents graphical representations of a human body and of a collaborative robot. The simulated worker and robot reproduce the movements of the human operator and of the collaborative robot helping the worker to interact with the robotic manipulator. The movements of the human body and of the robot are calculated by models developed in MathWorks environment. A kinematic model of the human body permits to properly move the simulated human body having as inputs the position vectors of the Kinect joints. A kinematic/dynamic model of collaborative robot controlled by the algorithms here proposed permits to understand the behaviour of the robot. A first phase of tests has

been conducted using this simulation environment. The aim of these tests was to verify the effectiveness of the proposed algorithms.

A second phase of tests has been conducted in an experimental set-up built up to obtain a collaborative robotics workspace where an operator can interact with a real collaborative robot. Two markerless sensors are used to acquire the position of the human worker and three PCs handle the data from the sensors and from/to the controller of the collaborative robot. The results of experimental tests show the performances of the proposed control algorithms. In fact, the collision avoidance algorithm with trajectory conditioning technique permits a human worker to safely share the workspace with a robot. The evasive movements of the collaborative robot occur along directions that had been previously defined by the operator, making the robot movements predictable and acceptable by the worker. The hand-over algorithm drives the robot to adapt the pose of its tool centre point to the pose of the hand of the human operator. In this way the worker and the robot can fluently exchange objects between them. The developed algorithms make possible a natural and seamless human robot interaction.