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SAFE HUMAN-ROBOT COOPERATION BASED ON AN ADAPTIVE TIME-INDEPENDENT IMAGE PATH TRACKER

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Abstract. *This paper describes a multi-sensorial manufacturing system for performing complex disassembly tasks which require human-robot cooperation. This system is composed by two coordinated subsystems: a robotic image-based visual servoing path tracker and a safety system for human-robot interaction. The path tracker based on visual servoing solves the problems of previous computer vision systems proposed to guide robots in situations where the robot interacts with the workspace. On the one hand, this path tracker always completes the planned trajectory due to its time-independent behaviour. On the other hand, this path tracker is adaptive because the camera is calibrated on-line by using virtual visual servoing during the visual servoing task. The stability of this path tracker has been analyzed with the Lyapunov theory. Furthermore, in order to guarantee the human safety during the cooperation, a new collision avoidance system is presented. This safety system implements a multi-sensorial fusion approach to precisely determine the distance between all the links of the robot and all the limbs of the human operator during the task. Both subsystems have been evaluated in a real task which involves the change of a blown light bulb of a streetlamp.*

Keywords: Human-robot collaboration, Tracking trajectories, Visual servoing, Manufacturing, Robot guidance

1. **Introduction.** Automatic disassembly systems based on robots are becoming more and more widespread in the last years [1] because they increase the productivity of the production process and reduce the production time. In these systems, industrial robots usually have to follow a path in order to perform the disassembly task. These robots need an extensive use of sensor technology [2,3] to modify their trajectories depending on the presence of unexpected changes in the robotic work-cell. Vision sensors are commonly used to provide this flexibility to the disassembly systems and visual servoing techniques [4] are applied to guide the robots according to the visual information obtained from these sensors. This paper presents a new adaptive visual servoing technique which not only makes the robot track a predefined path but also is able to stop this tracking process while there are unexpected obstacles in the environment. Two are the main contributions of this technique over previous similar systems [5-7]: its time-independent behaviour and its adaptation to changes in the intrinsic camera parameters based on on-line calibration. Because of its time-independent behaviour, the system is able to continue and complete the initial predefined path regardless of the time interval while the tracking process has been stopped. During the visual servoing task, the system performs an on-line calibration of the intrinsic camera parameters based on virtual visual servoing. The precise knowledge of the camera intrinsic parameters not only solves one of the main problems found in the