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Human-centered control of robots in hybrid manufacturing cells

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Biography

Behzad Sadrfaridpour received his BSc and MSc degree in mechanical engineering from Tabriz university, Tabriz, Iran, and, University of Tarbiat Modares, Tehran, Iran, in 2008 and 2011, respectively. He joined the Interdisciplinary & Intelligence Research (I^2R) lab as a Ph.D. student in 2013. His research interests include human-robot interaction, manufacturing automation, dynamic systems and control, and manipulation and motion planning.

Overview:

The recent emergence of safe, lightweight, human-friendly, and flexible robots has opened a new realm for human-robot collaboration (HRC) in manufacturing. For such robots with the new human-robot interaction (HRI) functionalities to interact closely and effectively with a human coworker, new HRI-based control criteria are demanded. The aim of this research is to integrate HRI factors (both physical and social interactions) into the robot motion controller for human-robot collaborative assembly tasks in a manufacturing hybrid cell.

Motivation

Conventionally, industrial robots are used to perform repetitive tasks in human-free cages with minimal human-robot interaction (HRI) for safety concerns. Thanks to the safety and flexibility functions embedded in human-friendly manufacturing robots, humans and robots can collaborate closely with each other accomplishing the tasks that were previously done by human workers solely. Consequently, existing criteria for designing robot controllers need to be modified by considering the human workers' demands since the performance of a human worker would vary due to factors such as individual strength, working pattern, and the interaction with the robot.

State of the Art

One of the most challenges of the new generation of robots is physical HRI (pHRI), in which humans and robots interact while sharing some workspace [1]. The state of the art of pHRI deals with developing safe and effective collaborative robots [1]. Social HRI (sHRI) is another research trend in robotics. sHRI focuses on a natural and interpersonal manner interaction in various applications such as education, health, entertainment, communication, and collaboration [2]. In particular, human trust in robot and robot anthropomorphic features may have high impacts on sHRI.

Intellectual Merit

This study proposes novel trust-based control architectures and frameworks for human-aware, smooth and effective HRI in manufacturing environments.

Broader Impact

The result of this study contributes to the transition from current conventional robots into the more capable partner robots.

Research Approach

(i) Dynamics of human's trust in robot during the interaction is modelled first. This model is evaluated and verified through a series of IRB-approved human-in-the-loop experiments. (ii) An HRI-based framework is developed for controlling the speed of a collaborative robot performing pick and place tasks alongside a human in a hybrid manufacturing cell. (iii) A framework that considers both pHRI and sHRI is developed for planning and controlling the motion of the robot performing hand-over tasks to the human in a hybrid manufacturing cell. (iv) A series of IRB-approved human-in-the-loop experimental studies is conducted to evaluate the impact of implementation of the frameworks on overall efficiency and HRI criteria such human workload and trust and robot usability.

Findings to Date

(i) The model for the human's trust to robot in manufacturing settings is found. The human trust in robot depends on previous trust, robot and human performance and fault. The preliminary results are presented in 2014 AAAI Spring Symposium Series [3]. The final results of human-in-the-loop experiments are published in a Springer book chapter [4]. (ii) An HRI-based framework is developed for controlling the speed of a collaborative robot in a hybrid manufacturing cell. The preliminary result of is presented and won the best student conference paper award in 2016 IEEE Conference on Automation Science and Engineering (CASE) [5]. The final results of the thorough statistical analysis are submitted to IEEE Transaction of Automation Science and Engineering (T-ASE).

Conclusions

To this end, human trust's in robot is modelled. Moreover, a trust-based framework is developed for controlling the speed of the robot. The next step is to design a trust-based framework and motion planner for hand over tasks. Finally, these two frameworks are combined to construct a comprehensive trust-based motion planner and controller for a collaborative robot.

References

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