Modélisation des interactions physiques entre un humain et un robot avec élasticité adaptative

Modeling of Physical Interactions Between a Human and a Robot with Adaptive Compliance

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Mots clés en français: **Robot intelligent, collaboration homme-robot, interaction physique, manipulateur avec élasticité adaptative**

Mots clés en anglais : **Intelligent robot, human-robot collaboration, physical interaction, manipulator with Adaptive Compliance**

Contexte

The thesis focuses at development of human/robot physical interaction models taking into account particularities of the manipulators with adaptive compliance. To solve this problem, it is required to estimate the impact of the interaction forces on the robot using direct and indirect measurements of its configuration and classification of force origin. Current approaches are limited in their capabilities and can be used only if the external force application point is known in advance. The most common way to determine the force applied to the end-effector is the use of a force sensor fixed between the robot end-point and the tool. However, this approach cannot provide high accuracy of estimation of the acting force, introduces additional undesirable compliance in the robotic system and cannot be used to evaluate the impact of the force applied to any other point except to the manipulator end-effector. At the same time, in the case when robot interacts with human the contact point may differ from the end-effector, and often is not defined in advance. It should be mentioned that in some cases vision systems may have a problem with contact detection and its localization.

Objectifs

In the frame of this work it is planned to solve the following problems:

- Develop techniques allowing to estimate the robot deflections caused by multiple external forces applied to different components of the manipulator (both end-effector and manipulator internal links/joints)
- Develop methods and algorithms allowing to identify physical interactions (forces/torques and their application points) using measurement data from redundant internal sensors of the robotic manipulator
- Develop human-robot physical interaction scenarios and relevant control algorithms allowing to improve robot positioning accuracy in the contact operations, ensure human safety and prevent physical damage to the environment and the mechanical components of the robot.

The project will address three research tasks whose solutions will be presented in the form of algorithms and integrated into a high-level control algorithm of a robotic manipulator.

1. Estimation of the position and orientation errors of the robotic manipulator under the influence of external force with the following error compensation, using a manipulator elasto-dynamic model and redundant information on its posture.
2. Identification of the interaction force/torque vector and localization its application point using the redundant information on the robot configuration
3. Identification of the interaction force/torque nature using machine learning and selection an appropriate physical human-robot interaction scenario.

In thus thesis, it is planned to develop mathematical models, identification methods and robot control algorithms for different manipulator/operator interaction scenarios:

- Robot interaction with a physical object involved in a technological task where the external loading applied to the manipulator end-effector (contact operation with expected interaction force).
- Robot interaction with static and dynamic obstacles (where interaction is unexpected).
- Interaction of two robots sharing the same workspace (cases of expected and unexpected contacts).
- Human-robot physical interaction while performing a common technological task (contact is expected).
- Robot-human interaction while robot working next to the human (contact is unexpected).

At present, the above-mentioned problems are in the focus of a number of research laboratories and robot manufacturers, but at the moment none one of the tasks have been solved completely. In the frame of this work, some novel techniques will be developed that are based on the supervisors' previous fundamental results in the stiffness modeling of robotic manipulators

Compétences requises

Robotics, Mechatronics, Mechanical engineering, Control theory, Software development, Intelligent computing