PhD Proposal 2017

School: Ecole Centrale de Nantes	
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Collaboration with other partner during this PhD: In France:	In China:

Title: Control-based design of robots
Scientific field: Automation and Robotics
Key words: optimal design, visual servoing, interaction models, link shape optimization

Details for the subject:
Background, Context:
Most of control laws applied on actual robots are laws based on the measures obtained from the internal sensors, i.e. the actuator encoders [1][2]. These measures are then considered as the input of the geometric, kinematic and dynamic models that are used for predicting the pose, velocity and acceleration of the end-effector in order to ensure the robot control. However, these models have inaccuracies and each encoder error is amplified via the use of these models [3]. This is the main reason for which it is preferable, for applications requiring high-accuracy, to use external sensors that will be able to get measures as close as possible from the end-effector. Then new models for the end-effector pose, velocity and acceleration prediction must be computed in order to take into account these new measures. The efficiency of the use of external measures for the modeling, identification and control of certain parallel robots family has already been demonstrated for kinematics [4][5] and dynamics [6][7].

Usually, in the optimal design process, the designer looks for obtaining the best mechanism in terms of given objectives (accuracy, velocity, workspace size, etc.) and constraints (joint limits, actuator maximal speed, encoder accuracy, etc.) [8][9]. The used models are those of classical controllers, i.e. with inputs coming from the actuator encoder measures. As a result, all the performance indices of the optimal design algorithm are extracted from these models [10]. However, if external sensor based control is required, new models are taken into account. It is then necessary to define new performance indices that will be extracted from these models in order to obtain the best robot performances.

Research subject, work plan:
The objectives of the research work are listed below:
1. To optimize the kinematic parameters of robot controlled via external sensors to get the best accuracy performance for the robot
2. To optimize the link shapes of robot controlled via external sensors to get the best quality of observation
3. To achieve the experimental validation of the obtained theoretical results

In order to achieve the three previous goals, this research work will focus on different points. First, discussions will be carried out in order to select the external sensors used for the control (camera, laser tracker, accelerometers, etc.) taking into account that it is required to obtain the best performances possible in terms of accuracy for several types of robots (high-speed robots, robots for milling, etc.). Other discussions will be also carried out in order to define which parts of the robot should be observed and which type information we could get from the sensor.

Once this is achieved, it will be necessary to calculate the geometric, kinematic and dynamic models required for the controller. Several types of sensor-based controllers will be investigated (depending on what is observed by the sensors, i.e. lines representing the projection of cylinders in the image plane [4], the moments of a bodies wrt the sensor space [11], etc.). From these models, performances indices for sensor based control will be extracted. These indices will be used in the optimal design process for obtaining the global robot kinematic parameters [9] and also the link optimal shapes (via link shape optimization methods [13]) in order to get the best robot performance possible taking into account some given specifications (e.g. accuracy, dynamics, but also simplicity of end-effector pose estimation from the measurements).

The last part of the work will be to validate the optimal designs of robots by simulations and then via experimentations. Several types of sensor-based controllers will be first tested on numerical mockups (ADAMS + Simulink) and then applied on the prototypes that will be designed by the student (and created via rapid manufacturing) in order to validate the theoretical results.

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