## PhD offer with scholarship starting 1 September 2015 (3 years)

# Title: Analysis and reduction of vibrations of cable-driven parallel robots

Laboratory: INSA de RENNES, LGCGM, EA-3913, Processes and Systems of Manufacture Team

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***State-of-art:***

Cable-driven parallel robots (CDPRs) are special parallel robots where flexible cables are used instead of rigid links. As cables are light and can provide a large range of motion, CDPRs have significant advantages such as large workspace, high acceleration capability and so on. Therefore, CDPRs have attracted lots of interests over the past few decades. However, as cables present the particularity of not being rigid and are only able to act in tension, the stiffness of CDPRs becomes a vital concern. Stiffness performances have significant effect on the static and dynamic behaviour of CDPRs, such as kinematics, positioning accuracy, force distribution, vibration and control. Deficient static stiffness can decrease the positioning accuracy of CDPRs, and bad dynamic stiffness characteristics can lead to vibrations and long settling time.

The recent research work on the topic showed the relevance of taking into account the effect of cable vibrations on the dynamic behaviour of CDPR. In fact, the effect of cable mass on the cable dynamics has a significant influence towards the dynamic of the whole system. A new dynamic stiffness model has been developed and experimentally validated. This dynamic model of CDPRs considers the vibration of the end-effector, the cable vibration and their coupling. It is a complete model that describes the dynamics of CDPRs. Through this dynamic model, the natural frequencies of CDPRs can be identified and the coupling between cable dynamics and end-effector vibrations can be analyzed.

Vibrations can be induced by initial position and velocity of the end-effector, wind disturbance, friction between cables and pulleys. Vibrations can affect the positioning accuracy (static pose), and lead to tracking errors along a prescribed trajectory. Positioning accuracy of CDPR can be improved by a successful vibration analysis. Practical techniques to reduce vibrations of CDPR are not yet developed.

***Study required:***

The work deals with an extensive study into the analysis and reduction of vibration of the CDPR. The analysis of the dynamic behaviour of the CDPR should be used to derive operational concepts to reduce vibrations in static poses as along a trajectory with time-varying cable lengths. To compensate the positioning errors of the end-effector, it will be either in a passive (CDPR design, additional mechanical damper) or in an active way. Later on, we will seek to use existing actuators to simultaneously control the pose and cancel vibrations in the structure. In this vein, we must act on the performance of the dynamic control, taking into account the variable stiffness and damping in the elasto-dynamic model established. The validity of the concepts proposed will be experimentally validated on a prototype developed in the framework of the IRT Jules Verne CAROCA project.

***Skills and knowledge required:***

- Mechanical Modeling, Analysis, Simulation and Optimization knowledge
- Robotics (Serial and Parallel Manipulators) modelling and kinematic knowledge
- Vibration analysis skills (experimental and numerical modal analysis)
- Programming skills (MATLAB, CAD knowledge)

***Informations:***

- Collaboration with IRCCYN, 1 rue de la Noë, 44321 Nantes CEDEX 3 and IRT Jules Verne
- Financing support : yes

***References:***


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