Session Overview
Mechanisms and Design

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Robot mechanisms science must be understood as acquiring an in-depth understanding of the mechanical behavior of a robot and involve domains such as kinematics, dynamics and singularity analysis. Two issues must be addressed:

- *analysis*: determine all the mechanical properties of a given robot that are necessary to control it and to verify that its behavior will satisfy a given set of requirements
- *synthesis*: being given a set of requirements determine what should be the mechanical arrangement and the dimensioning of the robot. Synthesis is in general a much more complex issue than analysis

The study of robot mechanisms and of their design is a fundamental and exciting part of robotic science as the mechanical part of the robot will, at the end, condition what the robot can performed in term of tasks and will drastically influence control issues.

It may be believed that this part of robotics is well mastered now, especially for serial industrial robots. Even in that case they are still many open issues. For example for the analysis part, a consequence of manufacturing tolerances is that a real robot will always differ from its theoretical model: managing these uncertainties to certify some robot properties is a complex problem that is far from being solved and involves sophisticated mathematics. It may then be understood that the synthesis of serial industrial arm is also an open problem, especially if manufacturing tolerances are taken into account.

Robotics is also a rapidly evolving field in which new application fields and materials renew and enlarge the mechanisms that must be studied. For example recent moves in robotics toward closed-chain mechanism and nano-robots must be emphasized. In the first case the closed structure allows to reach very good performance level for load, accuracy and stiffness, that open loop mechanisms cannot rival. As for micro-robot the change of scale implies that some mechanical effects, that are usually neglected at the macro scale, become preponderant: it is hence necessary to completely revisit the analysis

and synthesis of such mechanism. Furthermore new materials with astounding properties (e.g. Ghz motion) may be used, although their use and integration in a robotic system is still an open problem.

The papers presented in this session illustrates perfectly such evolution:

1. the paper presented by M. Uchiyama and co-authors describes the use of a closed-loop mechanism for a 6-dof haptic device. Here the stiffness and force/torque capacities of such type of mechanism is a key advantage for the application but requires a careful analysis of the dimensioning
2. B.J. Nelson and co-authors address the building of nanoelectromechanical systems (NEMS). They combine the top-down (direct fabrication) and bottom-up (assembly) approaches to design actuators and sensors with carbon nanotubes and Si nanocoils and present experimental, theoretical and design perspectives
3. in the last paper of the session J-P. Merlet investigates performance indices based on the Jacobian matrix that are used for design purposes and shows that they are not appropriate for closed-loop chains.