Inverse kinematics optimization and collision avoidance for KineMedic project

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Organizations:
- German Aerospace Center (DLR), Institute of Robotics and Mechatronics,
- *International Mater on Robotics 2006/07*, University of Genova, ITALY.

Introduction

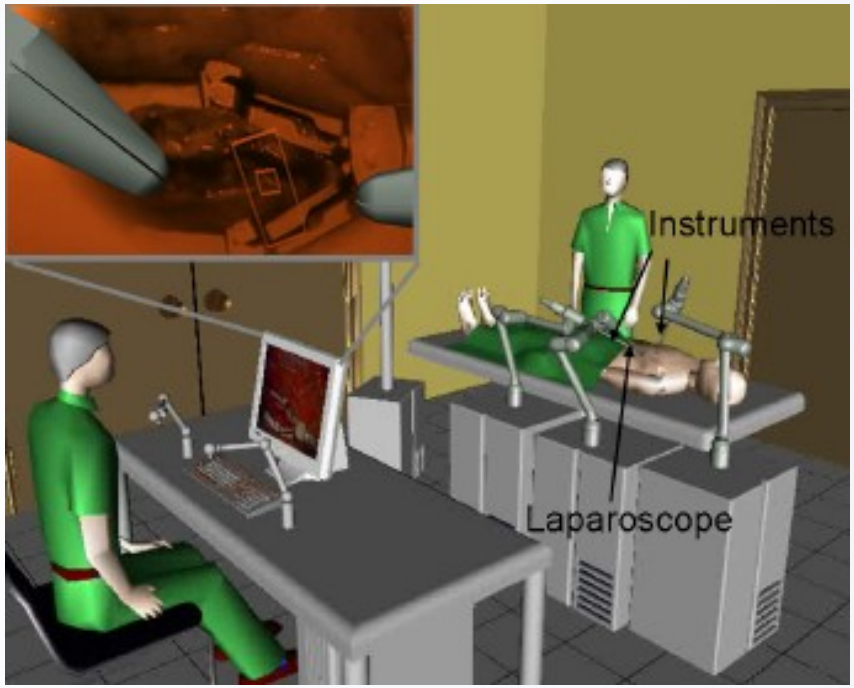
- *Master of Science in Engineering* at Warsaw University of Technology, Warsaw, Poland,
  - Specialization: *Automatic and Robotics*, majoring in *Robotics*.
- *International Master on Robotics 2006/07* postgraduate study of an additional and particular knowledge in Robotics
  - Lectures – 6 months at *University of Genoa*, Department of Mechanics and Machines Design,
  - Internship – 6 months at *German Aerospace Center* (DLR), Germany,
  - End of course: November 2007.

KineMedic Robot

- The KineMedic is a custom-made universal robot for surgical interventions based on the DLR light-weight robot and dexterous hand developments,
- Target application areas reach from minimally invasive surgery over orthopaedic interventions to urology and gynaecology,
- Project is funded by external companies and is in stage of very active development.

KineMedic System

- In target application up to three *KineMedic* robots are to be used,
- Highly integrated system involving:
  - visual feedback,
  - stereo vision,
  - haptics.



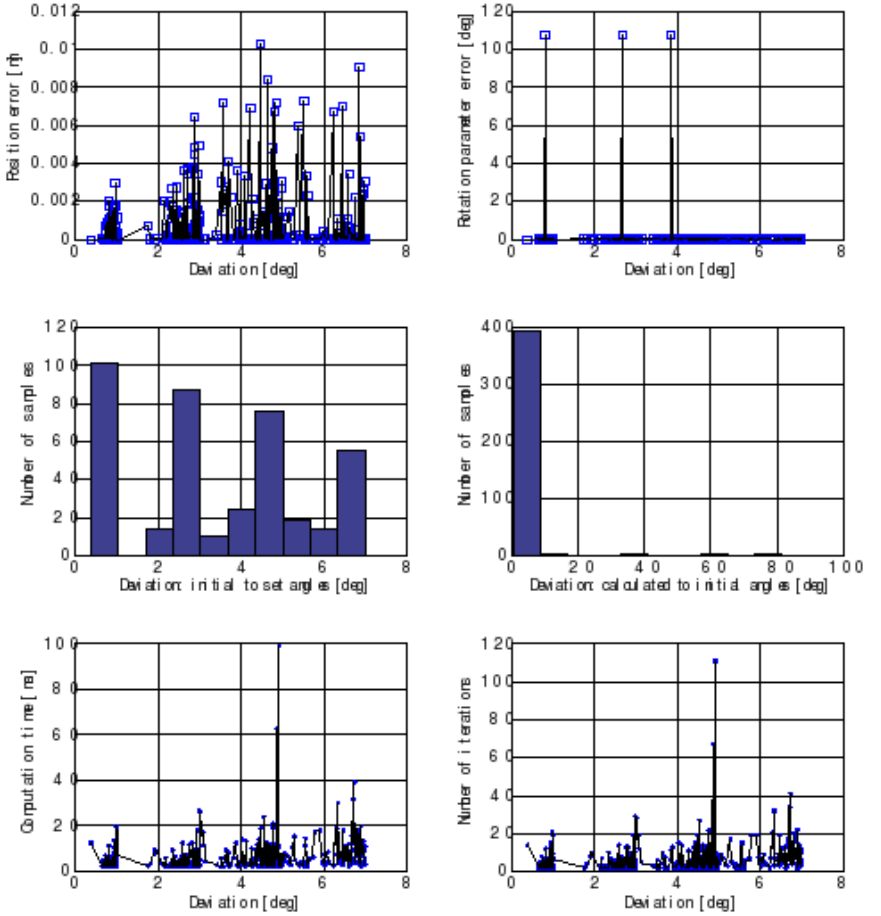
Project: Optimization in solving inverse kinematics problem

- Application of Sequential Quadratic Programming nonlinear solver,
- Improvements:
  - computations speed,
  - accuracy,
  - constraints considerations,
- Open Source and commercial implementations taken into consideration,

$$
\begin{aligned}
f(\mathbf{x}) &= min\{f(\mathbf{x}) : \mathbf{x} \in S\}, \\
S &= \left\{ \mathbf{x} \in \mathbb{R}^n : \begin{array}{ccccc} \mathbf{x}_u & \leq & \mathbf{x} & \leq & \mathbf{x}_o \\ \mathbf{b}_u & \leq & \mathbf{A}\mathbf{x} & \leq & \mathbf{b}_o \\ \mathbf{c}_u & \leq & c(\mathbf{x}) & \leq & \mathbf{c}_o \end{array} \right\}.
\end{aligned}
$$

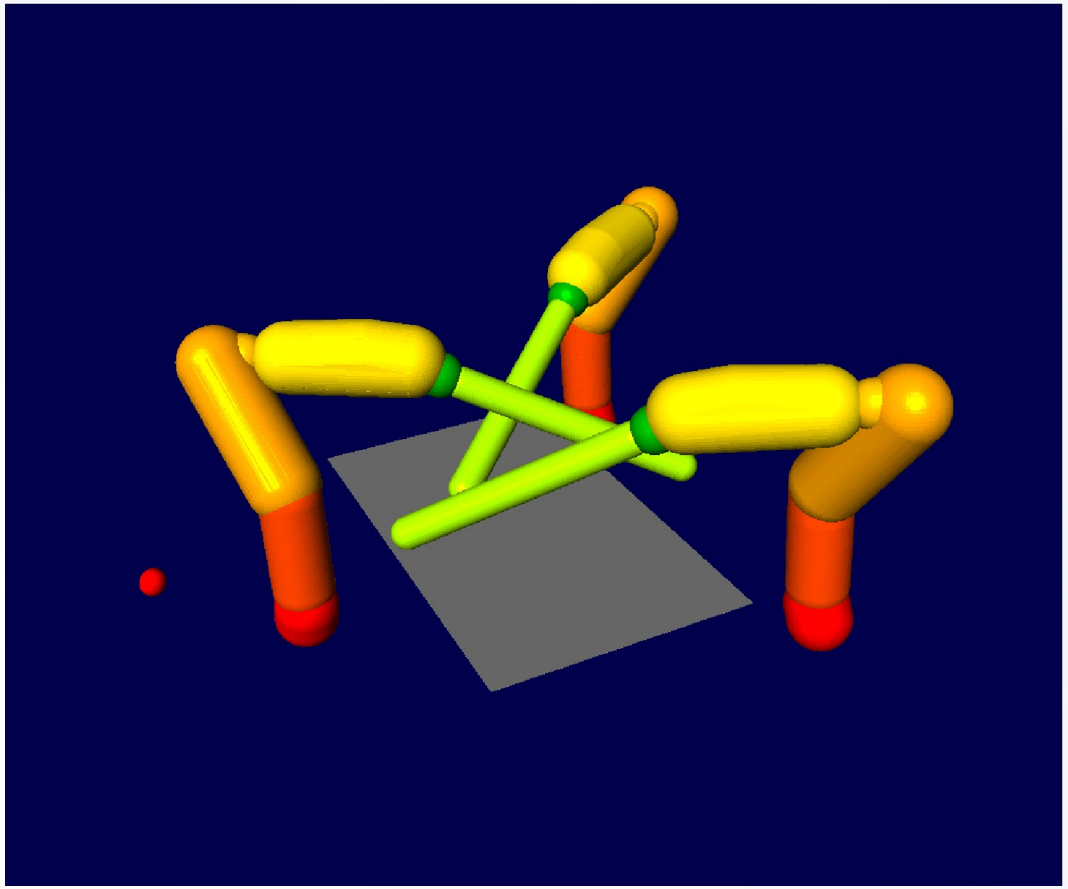
Project: Optimization in solving inverse kinematics problem cont.

- First practical application results are obtained,
- Further development, comparison among different implementations and tuning possibilities are investigated



Project: Collision avoidance

- Collision detection with gradients for collision handling algorithms,
- Models built up from shells covering elements,
- For collision check physics engines and DLR internal solutions can be used.



Conclusion

As a part of *International Master on Robotics 2006/07* the following projects concerning medical applications are performed:

- Practical application of a Sequential Quadratic Programming optimization algorithm in solving inverse kinematics problems
  - Analytical procedures evaluation and comparison,
  - Integration with existing system,
- Collision avoidance for KineMedic scene:
  - Shells generation,
  - Model build-up.

Thank you for your attention