Simulated Needle Insertion With KUKA

Project Medical Robotics

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Outline

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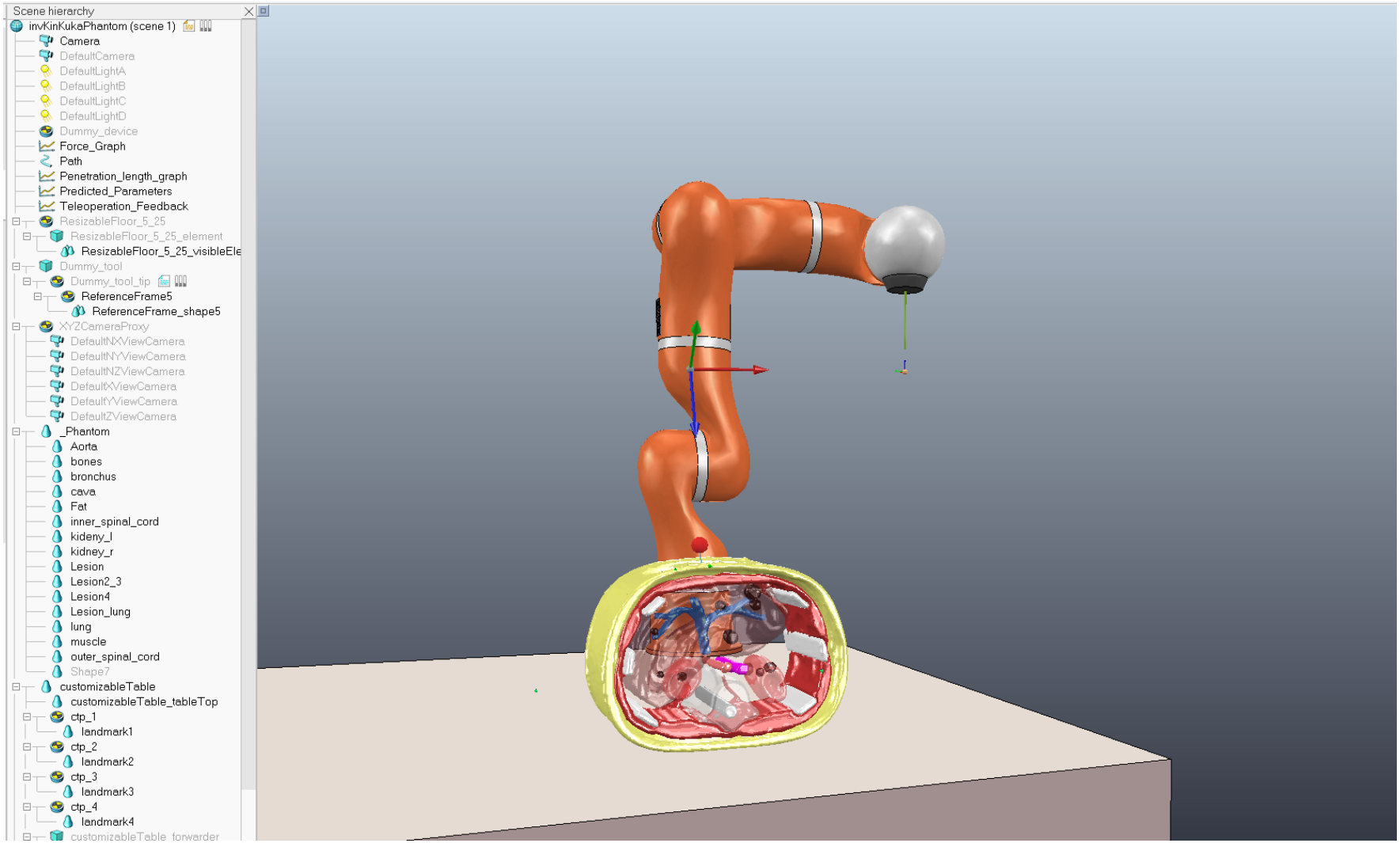
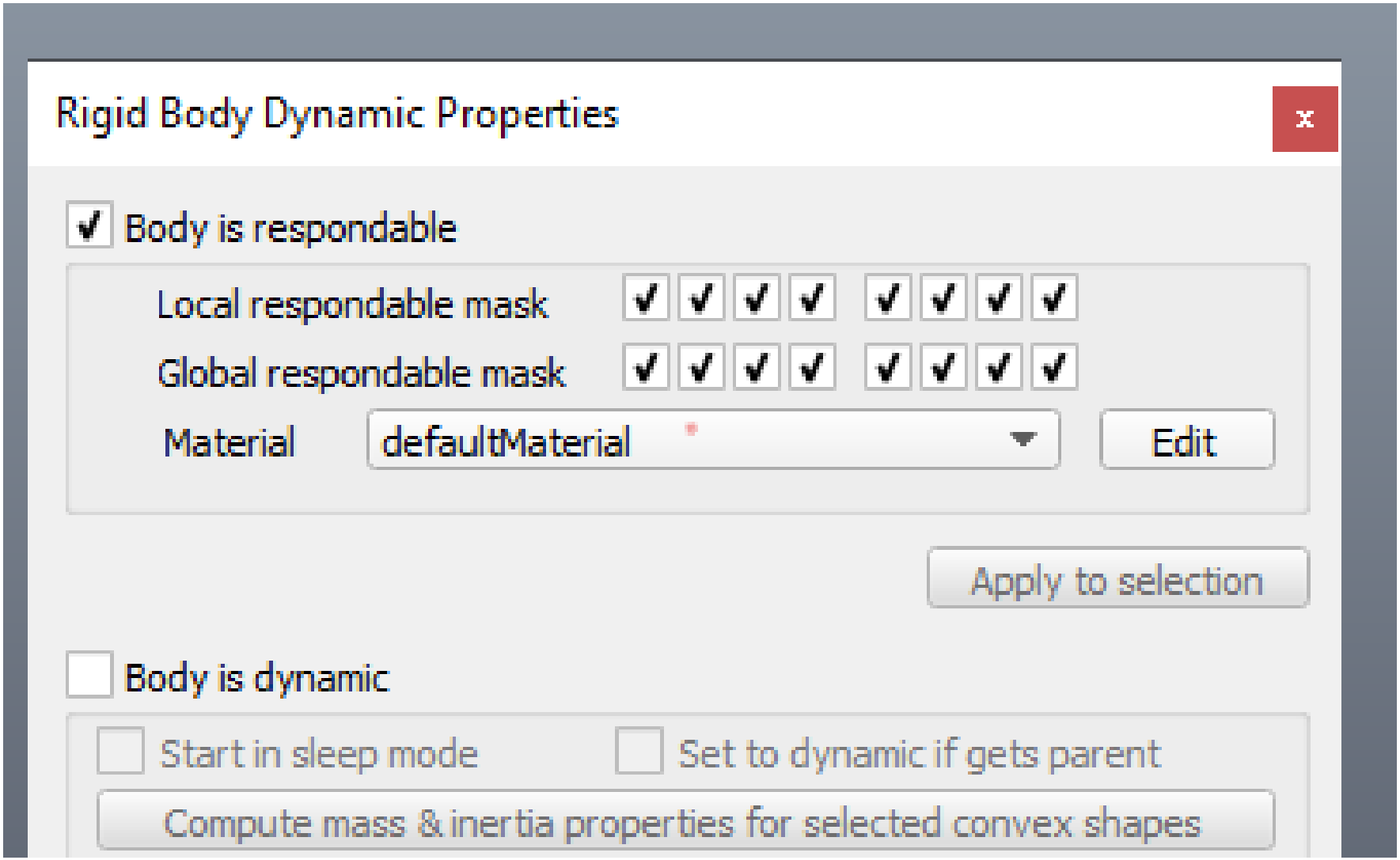
Simulate the force-feedback during a simulation of a needle insertion in V-REP.

Outline

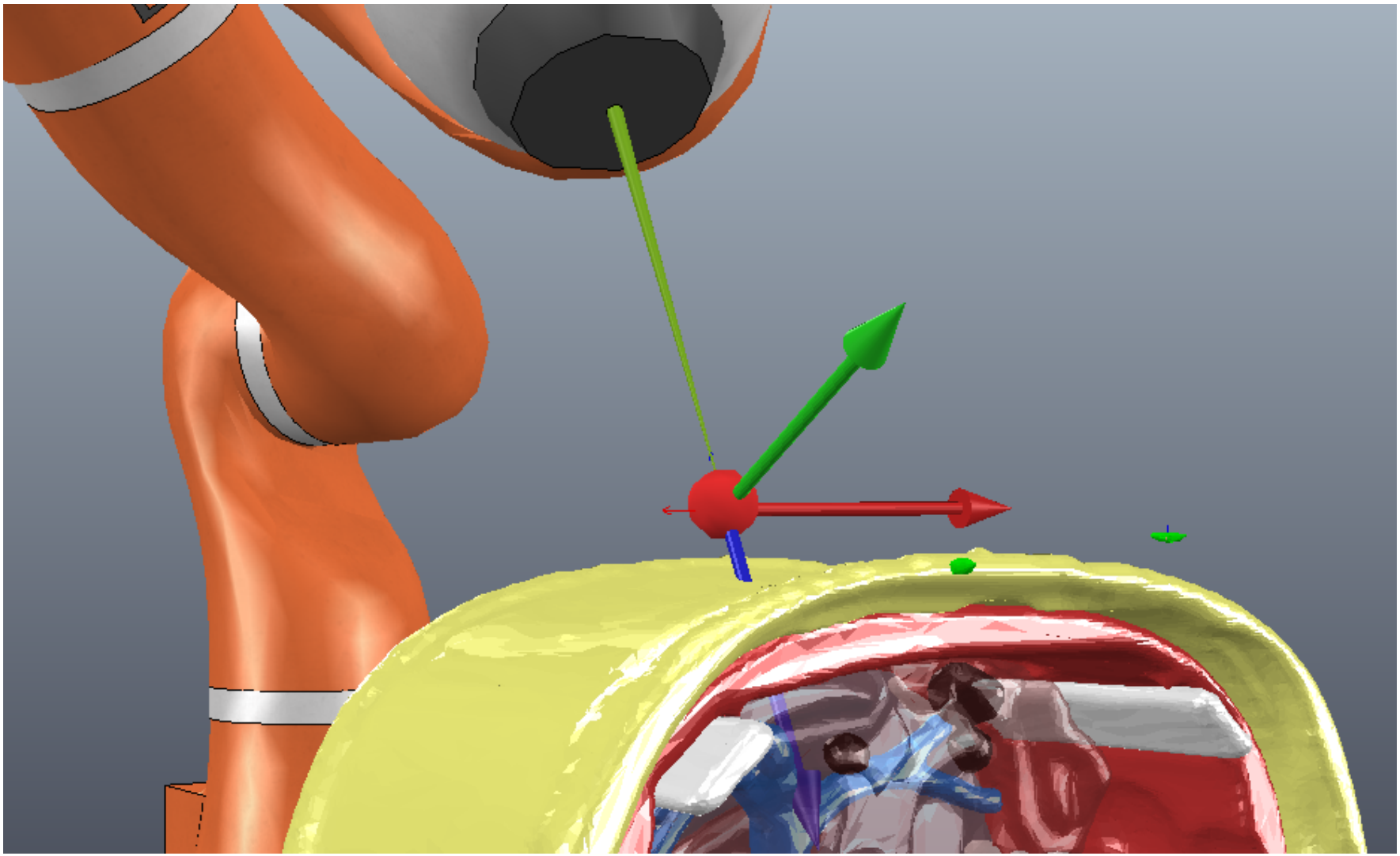
Scene Objects



Scene Properties



Moving the KUKA robot

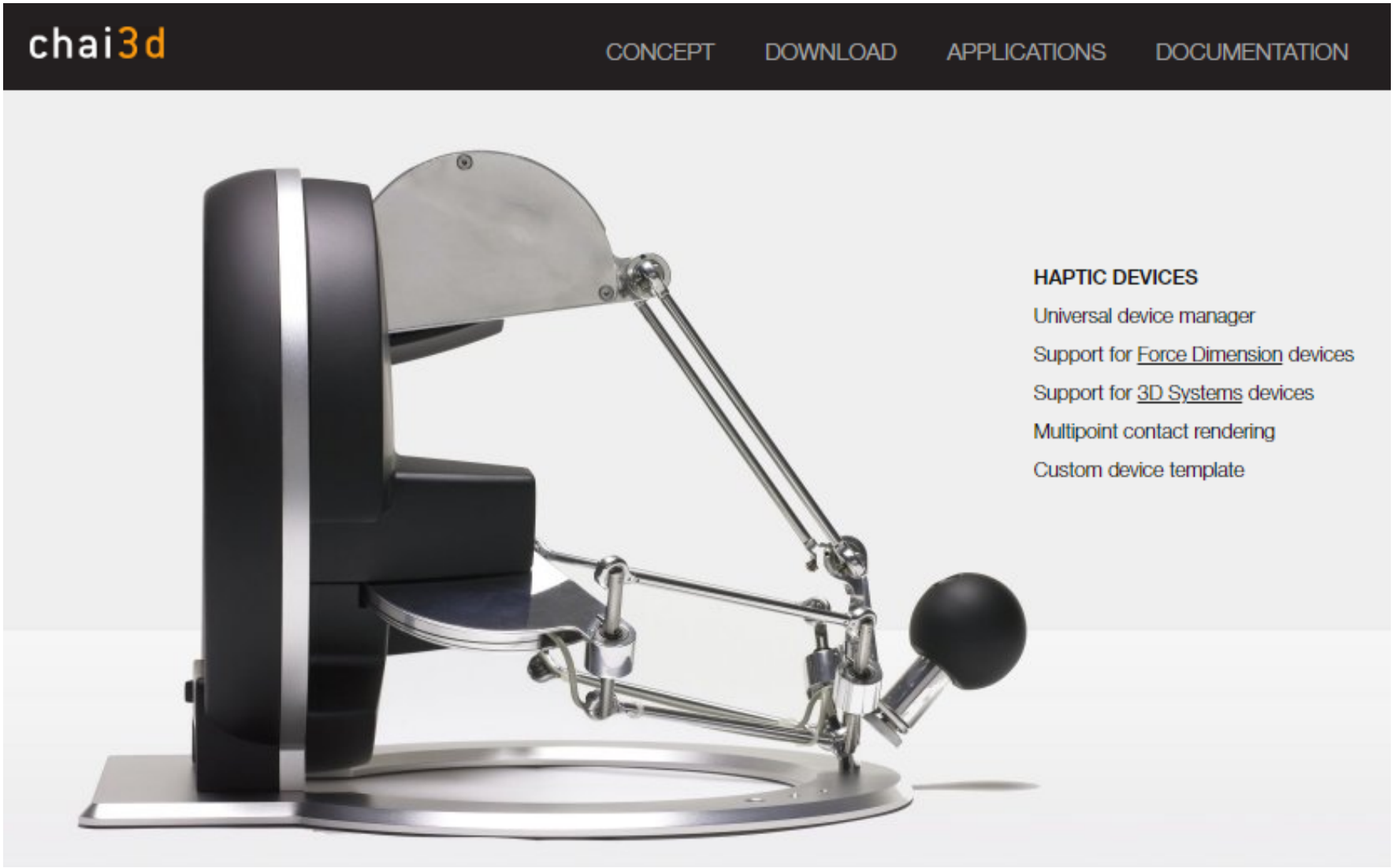


Outline

V-REP Plugins

- C++
- Lua functions
- v_repMessage
- sim_message_eventcallback_modulehandle

Chai3D


chai3d
CONCEPT
DOWNLOAD
APPLICATIONS
DOCUMENTATION
HAPTIC DEVICES
Universal device manager
Support for Force Dimension devices
Support for 3D Systems devices
Multipoint contact rendering
Custom device template

Codebase former projects

- KUKA control
- More related to the other part of the project
- Several issues

Outline

Pre-rupture modelling

- Complex shapes
- Physics engine V-REP
- Deactivation threshold

After-rupture modelling

Method 1

- CGAL
- Convex hull
- More precise
- Real-time

Method 2

- Distance from puncture
- Less precise
- More efficient

Force interaction model

Karnopp

- Modified Karnopp model
- Bi-directional
- Only implemented friction

$$F_{\text{friction}}(z, F_a) = \begin{cases} C_n \text{sgn}(z) + b_n z, & z \leq -\Delta v/2 \\ \max(D_n, F_a), & -\Delta v/2 < z \leq 0 \\ \min(D_p, F_a), & 0 < z < \Delta v/2 \\ C_p \text{sgn}(z) + b_p z, & z \geq \Delta v/2 \end{cases}$$

Kelvin-Voigt

- Viscoelastic
- Adapted to needle insertion
- $$\sum_{t \in T} \mu_t VA(x_t)$$
- $A(x) = \pi r x$

References

[1] H. Freeman and R. Shapira. Determining the minimum-area encasing rectangle for an arbitrary closed curve. *Commun. ACM*, 18(7):409–413, July 1975.

[2] David. Computing oriented minimum bounding boxes in 2d, 2014.

[3] Convex hull algorithms, 2019.

[4] A. M. Okamura, C. Simone, and M. D. O'Leary. Force modeling for needle insertion into soft tissue. *IEEE Transactions on Biomedical Engineering*, 51(10):1707–1716, Oct 2004.

[5] Mohsen Mahvash and Pierre Dupont. Mechanics of dynamic needle insertion into a biological material. *IEEE transactions on bio-medical engineering*, 57:934–43, 11 2009.

[6] P N Brett, T J Parker, A J Harrison, T A Thomas, and A Carr. Simulation of resistance forces acting on surgical needles. *Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine*, 211(4):335–347, 1997. PMID: 9330545.