Central European Seminar on Computer Graphics for students, 2011

AUTHOR: **Petr Kadleček** SUPERVISOR: **Petr Kmoch**

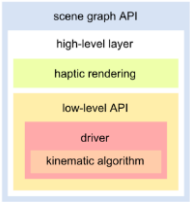
CHARLES UNIVERSITY PRAGUE

faculty of mathematics and physics

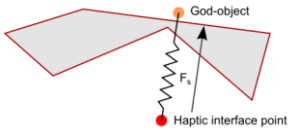
Overview of current developments in haptic APIs

Presentation

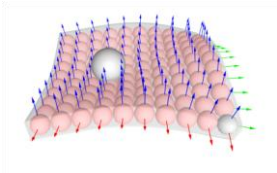
Haptics



Haptic programming



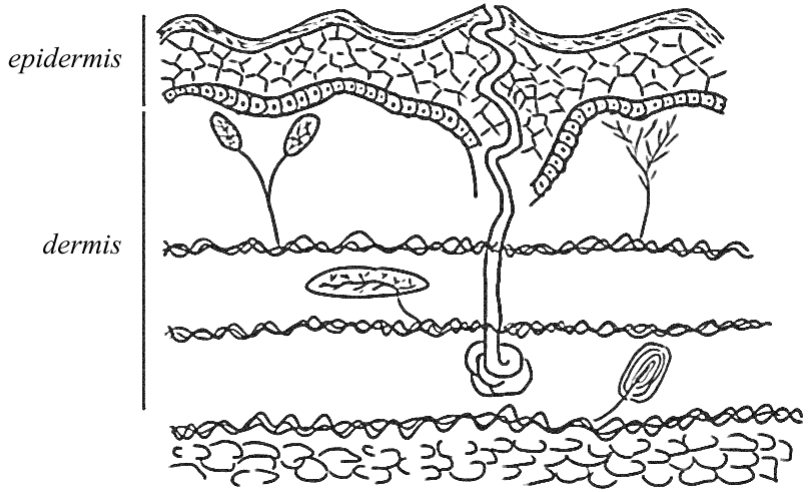
Haptic rendering



Haptic APIs

Haptics

"hapt esthai"

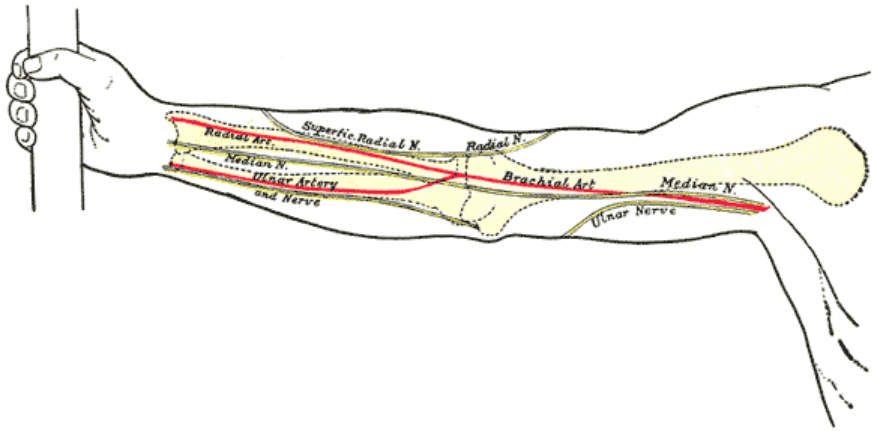


Sense of touch

- cutaneous organs
- Tactile/touch devices

Kinesthetic sense

- muscles & joints
- Haptic devices



Haptic devices

- **Degrees of freedom**
  - 3-DOF, 6-DOF, 6/3-DOF, …

Novint Falcon
3-DOF

Haptic devices

- Workspace *[inches]*
- Position resolution *[DPI]*
- Maximal force *[N]*
- Stiffness *[N/m]*

PHANTOM Desktop
6/3-DOF

Application of haptics

- **assistive technology**
  - ease of cognitive load
  - for visually impaired or blind people
- **medicine**
  - teleoperation
  - **virtual palpation**
  - simulations of surgical operations
- military, painting, CAD and gaming

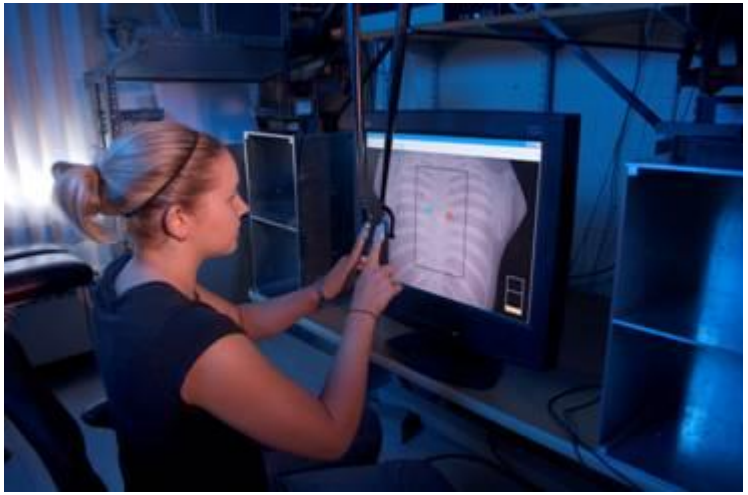
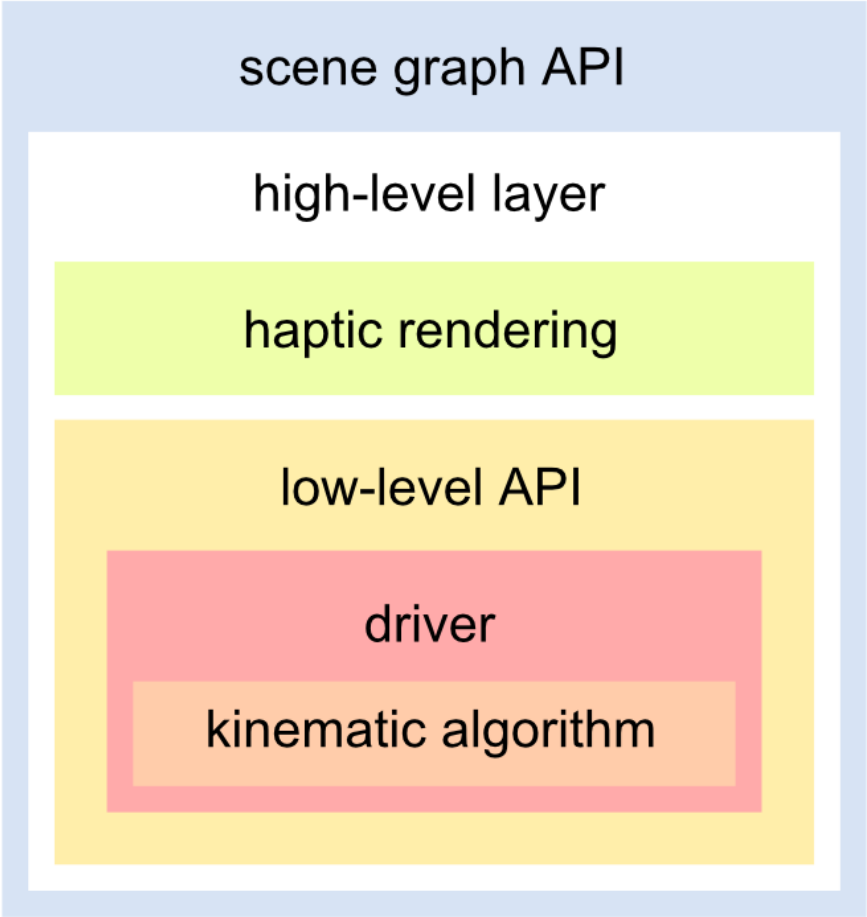


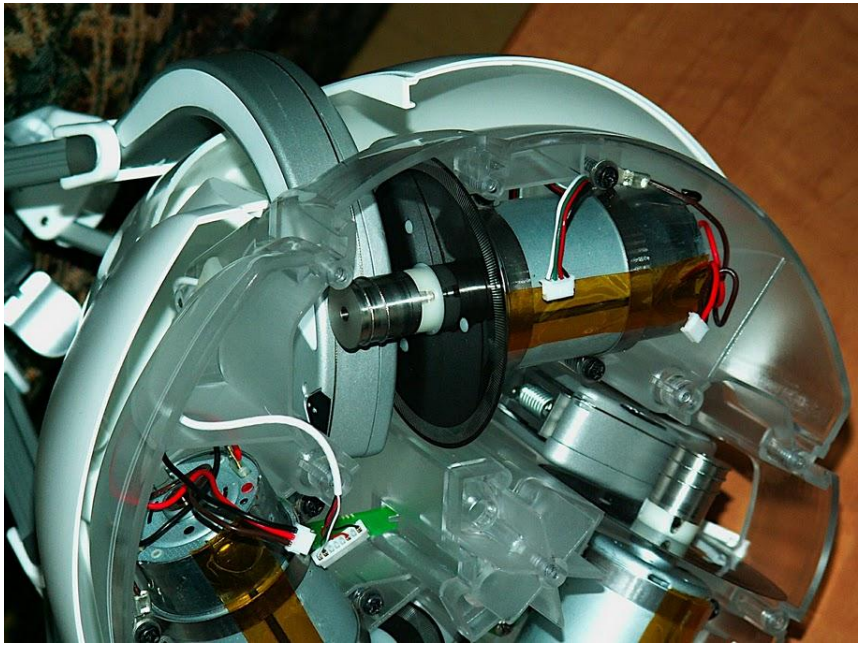
Image source: http://oak.cats.ohiou.edu/~williar4/html/VHB/VHB.html

Abstraction layers of haptic APIs



Abstraction layers of haptic APIs

- **driver**
  - serial bus communication (USB, IEEE 1394)



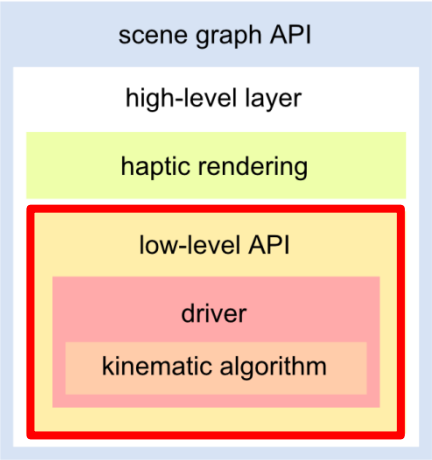
- **kinematic algorithm**
  - encoders

    e.g. warped tri-hemispherical regions workspace
  - Cartesian coordinates

Image courtesy: Kevin Ouellet

Abstraction layers of haptic APIs

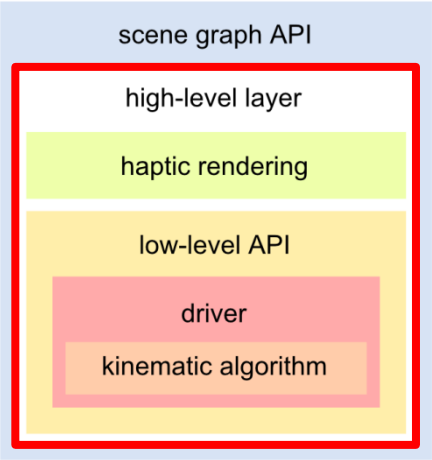
- **Low-level API**
  - hides kinematic algorithm
    - **position**, rotation *vector*
    - **force** *vector*



  - device handler *(hides driver layer)*
    - different devices with same interface
  - servo loop *(thread handling)*
    - blocking / non-blocking

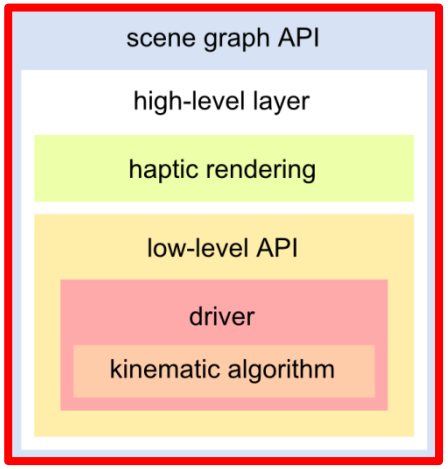
Abstraction layers of haptic APIs

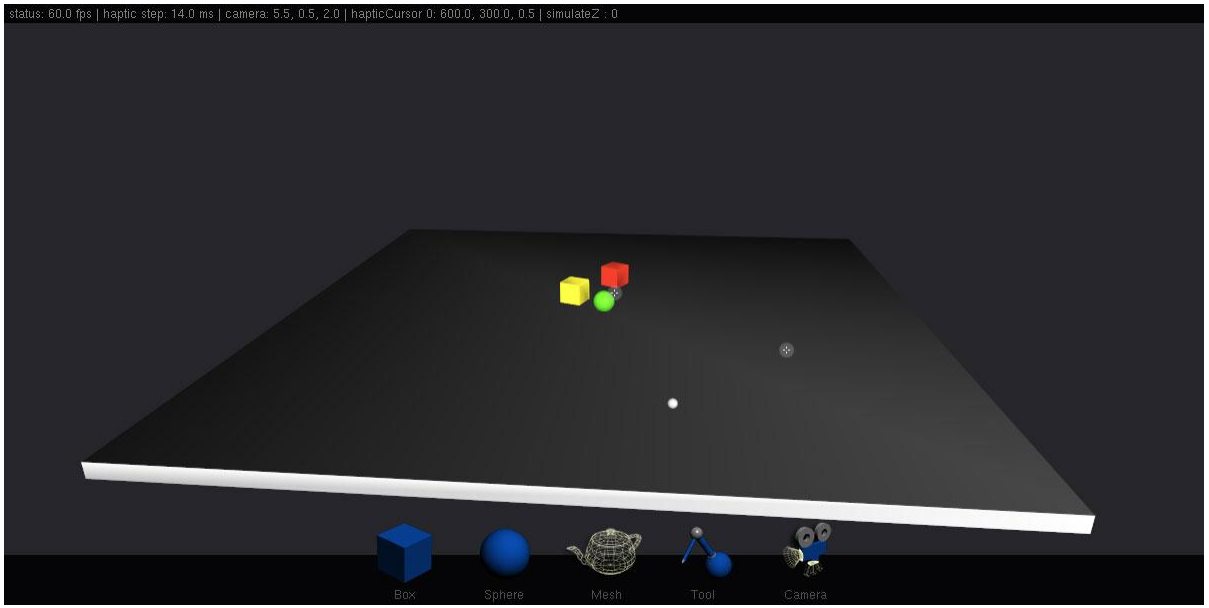
- **High-level layer**
  - Model **data** representation
    - **graphical = haptical**
    - *primitives, polygon soup*
  - OpenGL support
    - FeedbackBufferCollector
  - Haptic rendering



Abstraction layers of haptic APIs

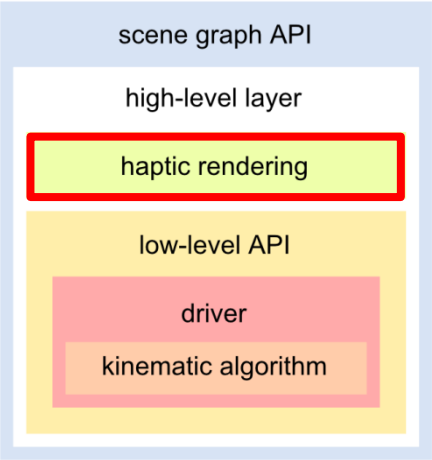
- **Scene graph API**
  - Graphics + haptics + audio…
  - Tree structure of objects
    - *Properties, effects, …*





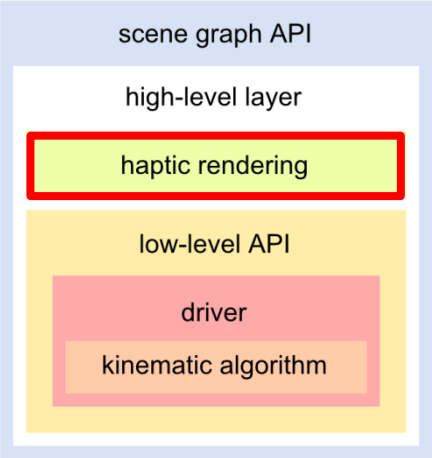
Haptic rendering

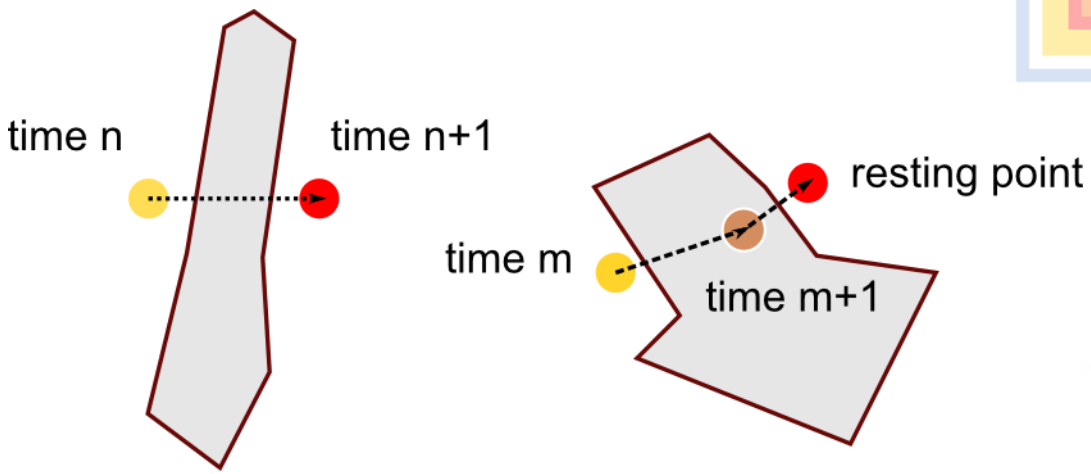
- **Haptic force generation algorithm**
  - Realistic/non-realistic kinesthetic feel
  - **1000 Hz ~= 30x faster than real-time graphics**
- **Haptic tool** $\xleftrightarrow{\text{force}}$ **object**
  - 3-DOF rigid body
  - Stiffness limitation problem
- Ideal mass-less spring
  - Hooke's law: $F_s = -k\Delta x$



Haptic rendering

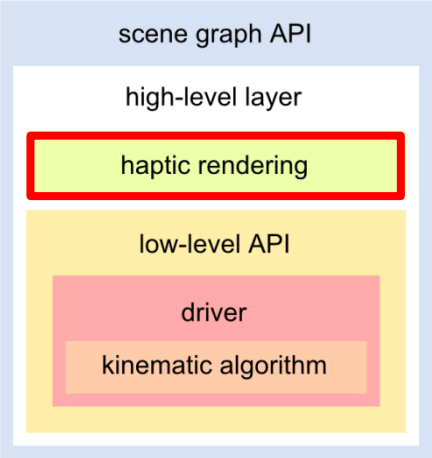
- **Penalty based methods**
  - force field
  - pop-through problems

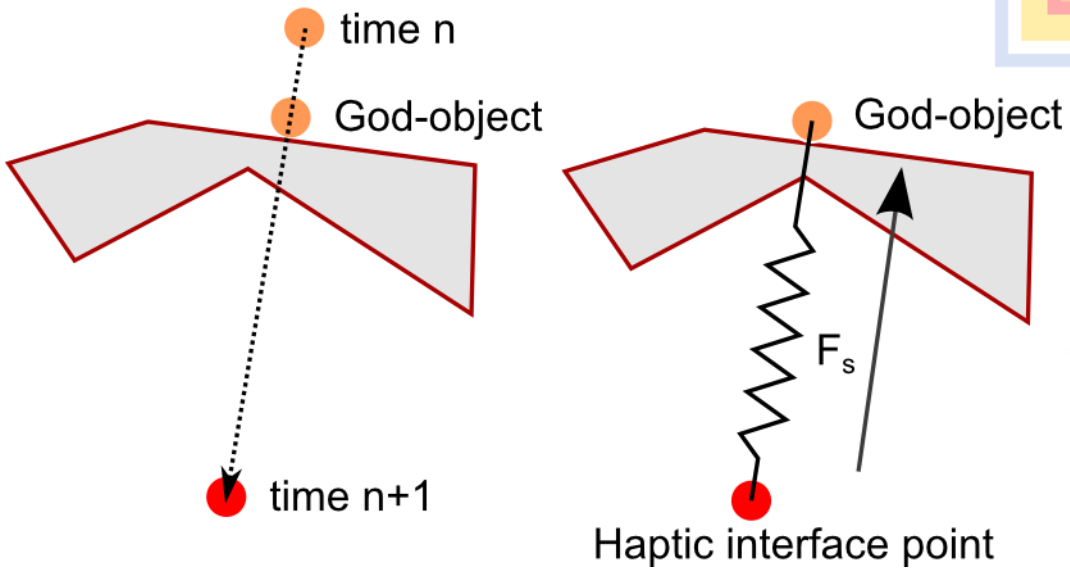




Haptic rendering

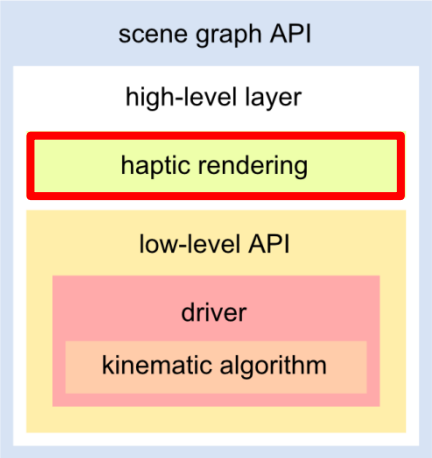
- **God-object method** (Zilles et al.)
  - Constraint planes
  - Haptic textures
  - Force shading

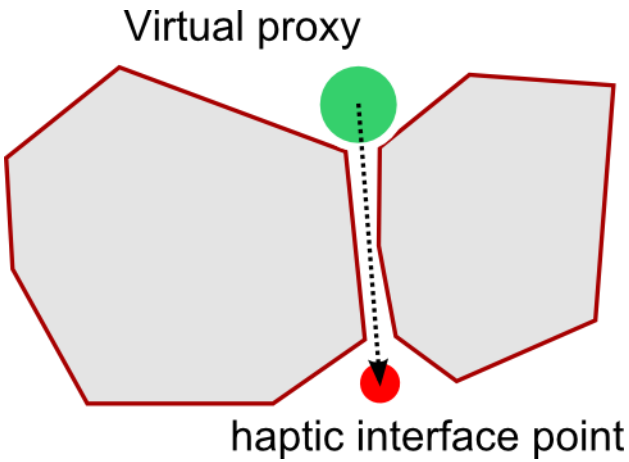




Haptic rendering

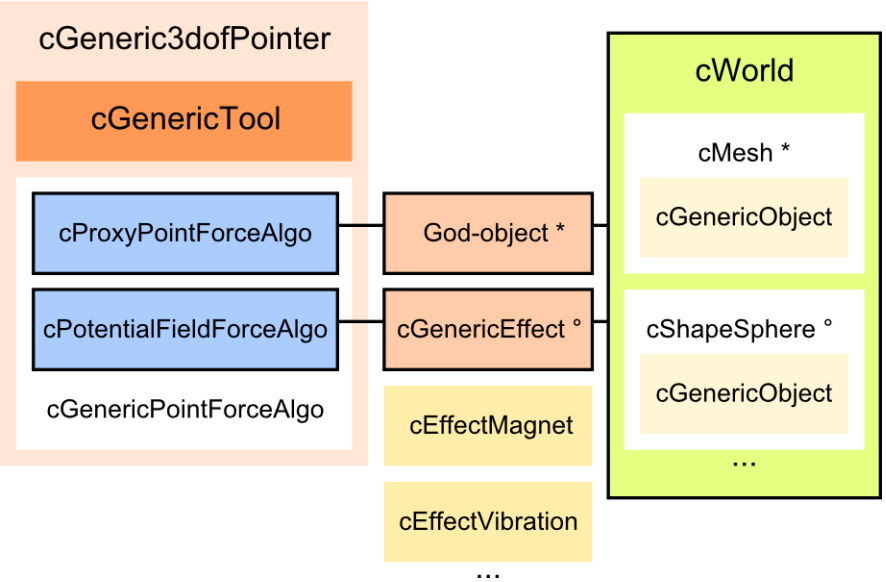
- **Virtual proxy method** (Ruspini et al.)
  - resolves small surface gaps
    - low-quality digitization
    - non-precise modeling

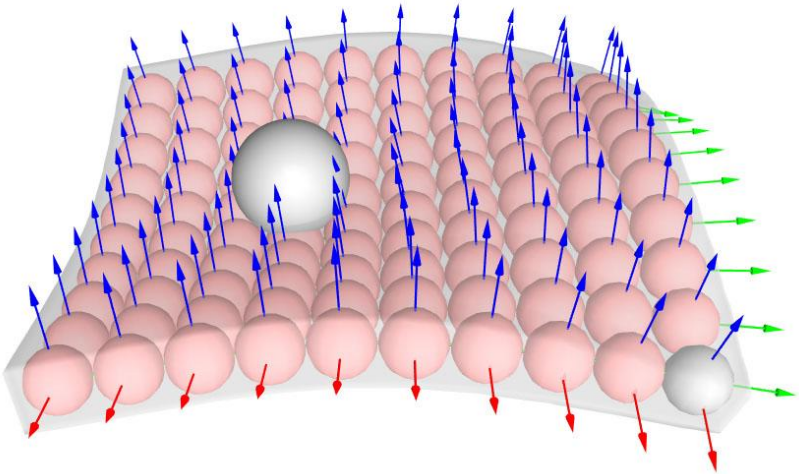




Haptic APIs

- **CHAI 3D**
  - Scene graph API
    - OpenGL
    - Low-level use
  - God-object
  - Modules
    - **ODE** module
    - **GEL** module
    - **BASS** module





Haptic APIs

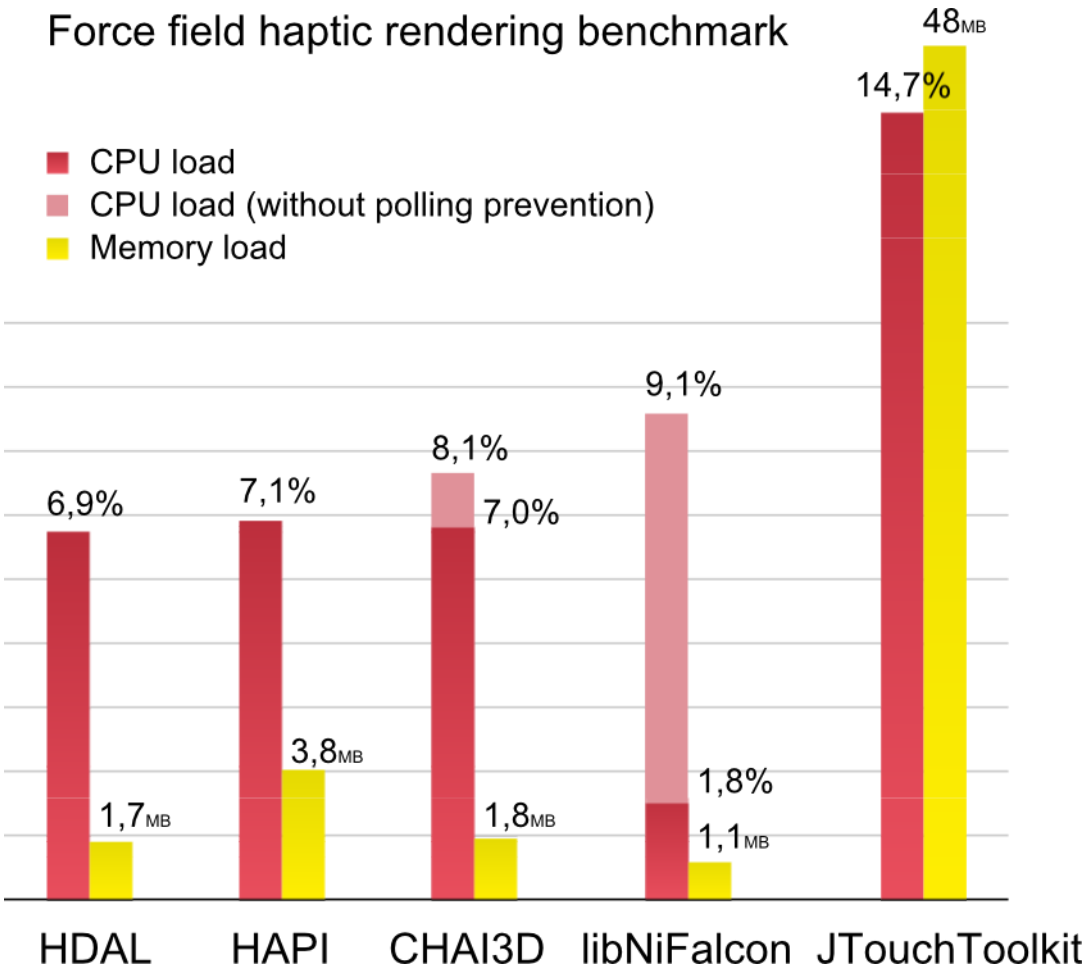
- **H3D API**
  - HAPI - haptic rendering
    - FeedbackBufferCollector, …
    - God-object / Virtual proxy
  - OpenGL - graphic rendering
  - **X3D** - scene definition
  - C++, **Python** interface
  - Fast prototyping
  - **good support**

Haptic APIs

- **Other haptic APIs**
  - OpenHaptics
    - Academic edition
  - HDAL SDK
    - Novint Falcon low-level API
  - libNiFalcon
    - Novint Falcon open-source driver
  - JTouchToolkit
    - Java wrapper for HDAL/HDAPI/HLAPI

Haptic APIs

- **Benchmark**



Testing hardware: Intel Atom 330 1.6 GHz dual core CPU

Haptic APIs

- **Future work**
  - **6/3-DOF haptic rendering algorithm**
    - implementation to CHAI 3D / HAPI
    - fast *(continuous)* collision detection
      - **GPU** acceleration on CUDA
      - closed loop algorithm
  - **Haptic interaction in Autodesk Maya**
    - Haptic tool: 3D locator (Maya API)
    - Forces: constraint-based aid

End

Thank you

Questions ?