force dimension

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making more sense of touch

Systèmes haptiques et dispositifs médicaux,
l'expérience Force Dimension – EPFL

Charles Baur, PhD

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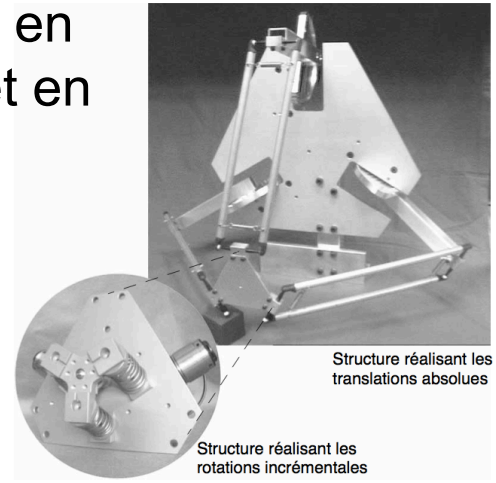
Un peu d'histoire ….

Thèse EPFL Lorenzo Flueckiger (1998):
Interface pour le pilotage et l'analyse des robots basée sur un générateur de cinématiques

Proposition d'un *Syntaxeur* basé sur cinématique *Delta*

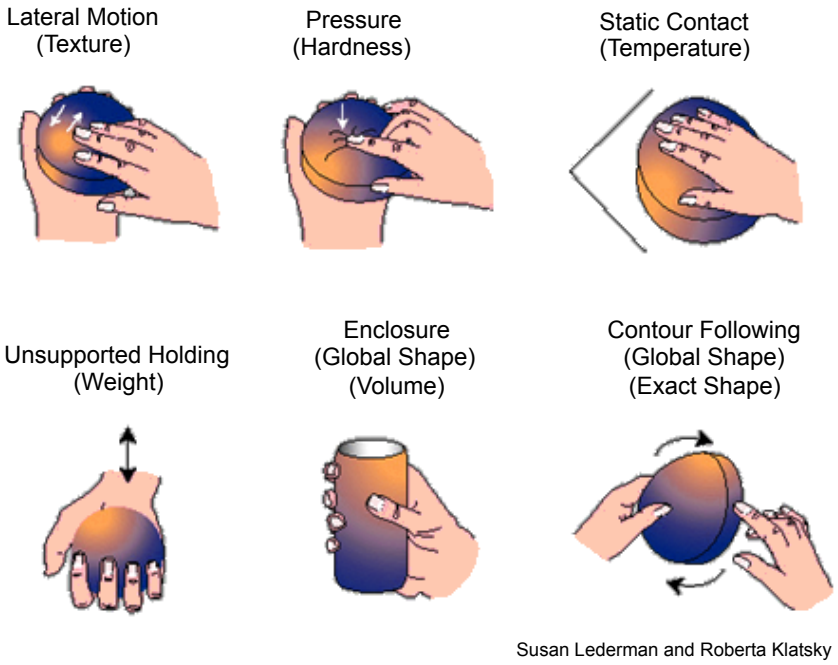
Début systèmes haptiques **Force Dimension** (fondé en 2001, siège à Nyon, bureaux en Amérique du Nord et en Asie, production en Suisse)



Expertise multidisciplinaire: mécanique, électronique, contrôle, modélisation et logiciel

human perception

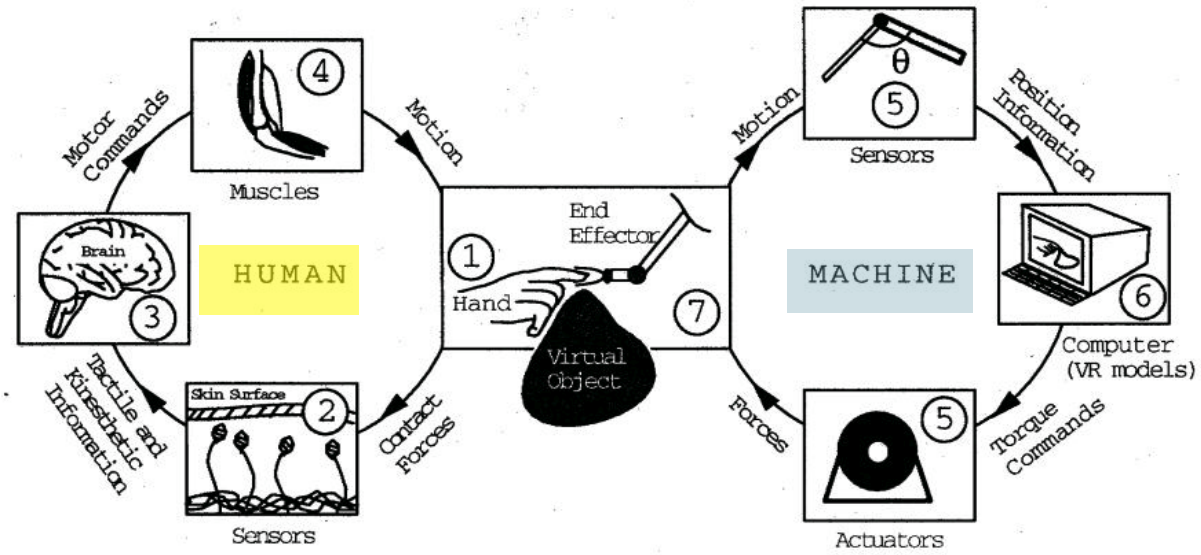
Qu'est ce que le haptique?
Interaction physique via le sens du touché
(du grec haptesthai – saisir)



Susan Lederman and Roberta Klatsky

human perception

haptic interaction control loop



Mandayam Srinivasan, MIT

impedance model

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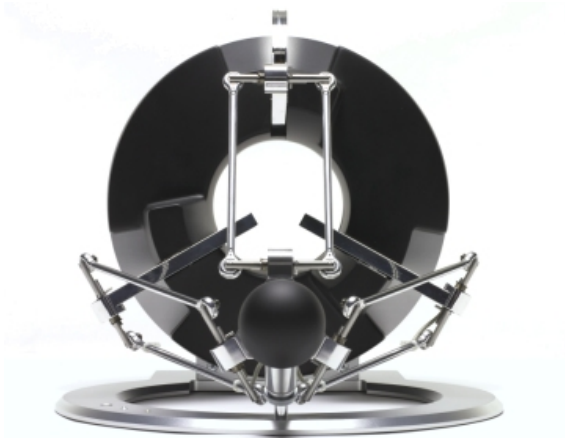
human perception

creating the illusion of continuity

graphics rendering

25 Hz



haptics feedback

1000 Hz

technology

why use haptics?

to allow real-time co-operation between man and machine

mouse/joystick →

keyboard/buttons →

voice/gesture →

← visual

← audio

tactile ↔

human in the loop !

haptic interfaces

omega.3

3 translations
based on the delta kinematics

High forces
12 N continuous

desktop workspace
cylinder ⌀160 x 110 mm

software API
Windows, Linux, Apple, QNX

USB 2.0
runs on a laptop

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haptic interfaces

omega.6 extension

3 rotations
- passive structure
- natural range of motion

optimal wrist design
- decoupled from translations
- hand-centered

force dimension

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haptic interfaces

omega.7 extension

3 rotations
passive structure
natural range of motion

optimal wrist design
decoupled from translations
hand-centered

active grasping

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haptic interfaces

delta.3

3 translations
based on the delta kinematics

High forces
25 N

Large workspace
Cylinder ⌀400 x 260 mm

USB 2.0

haptic interfaces

delta.6

3 tanslations
- based on the delta kinematics

3 rotations
- proprietary wrist structure
- easy clip-on technology
- center of rotation inside the hand

High forces, high torques
- 25 N, 200 mNm continuous

Large workspace
- cylinder ⌀400 x 260 mm

USB 2.0

force dimension

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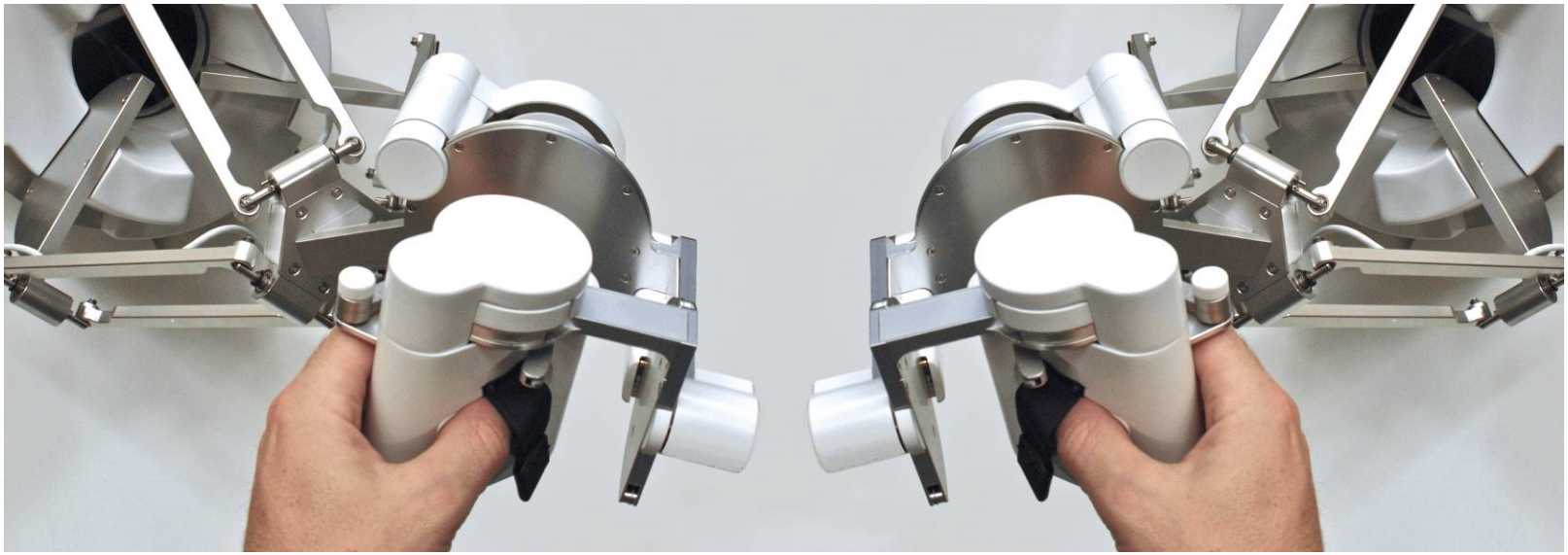
haptic interfaces

sigma.7



fully active on 7 degrees of freedom

3 translations

3 rotations

1 grasping

force dimension

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haptic interfaces

sigma.7

fully active on 7 degrees of freedom
- 3 translations
- 3 rotations
- 1 grasping

high forces, high torques
- 20 N, 400 mNm continuous

intermediate sized workspace
- cylinder ⌀190 x 130 mm

large angular motion ranges
- 235° / 140° / 200°

software API
- Windows, Linux, Apple, QNX

USB 2.0

force dimension

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haptic interfaces

dual sigma.7 console

haptic interfaces

Novint Falcon

Force dimension technology
licensed to Novint Technologies

Designed for entertainment
robust enough to resist excitement
performance suitable for video games
cost effective
manufactured in China

USB 1.0

Force dimension SDK
Windows, Linux, Apple
QNX, INtime

software

chai3D.org

Simulation framework

- C++ libraries
- open source
- multi-platform

Capabilties

- 3D graphic rendering (openGL)
- haptic force simulation
- modeling of dynamic bodies
- real-time deformable structures
- volumetric models
- force control systems

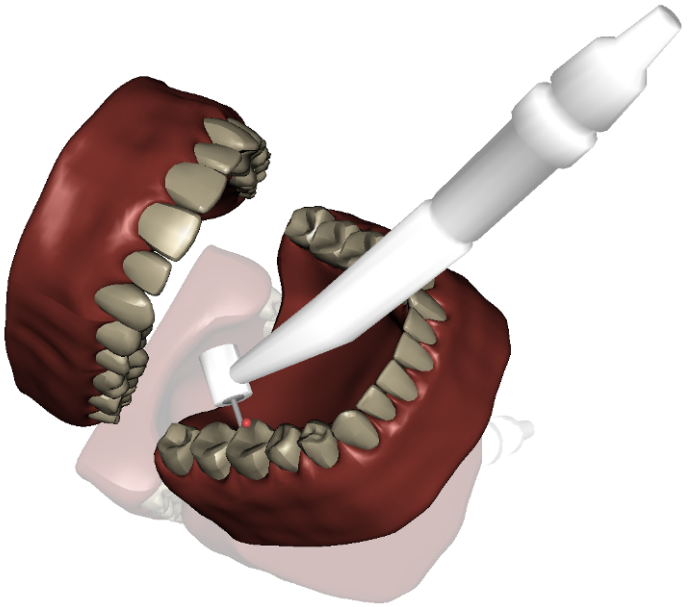
Industry and academic partners

- Stanford University
- EPFL
- Hansen Medical
- Force Dimension

software

advanced collision engine

- based on 3D meshed objects (from CAD)
  same model for graphics and haptics rendering
  allows for high ratio between local detail and overall size
  well-suited for rendering shells and thin curved sheets
  inherent distance calculation between objects
  collision intrusion avoidance
- unique performance
  high refresh rates
  high resolution
  high haptics rendering quality
  compatible with under-actuated interfaces



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software

dynamics simulation engine

Dynamics

- multi-body dynamics
- articulated systems
- contact detection and resolution
- modeling of complex robotic systems

Haptics

- haptic force simulation
- multi-device control
- multi-point contact interaction
- friction and texture rendering

Graphics

- stereo displays supported
- OpenGL version 4.2

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applications

3 types

Simulation

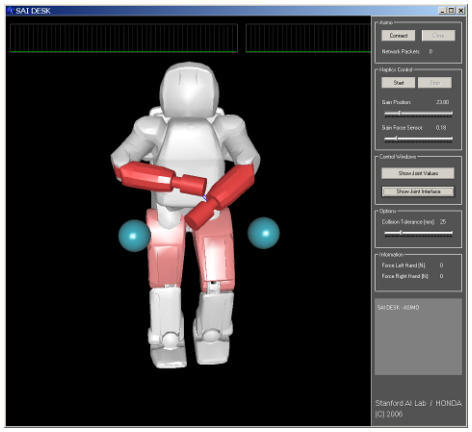
learning, training
assessment, certification
psychophysics
experimentation
planning
design
virtual realities
virtual environments

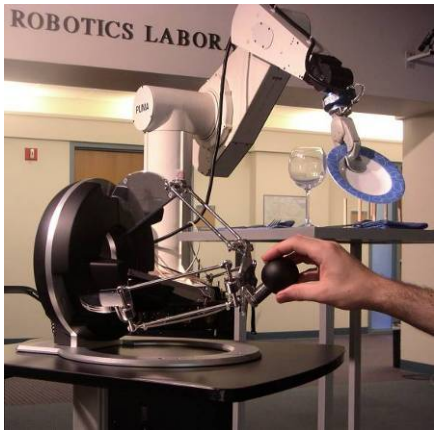
Tele-operation

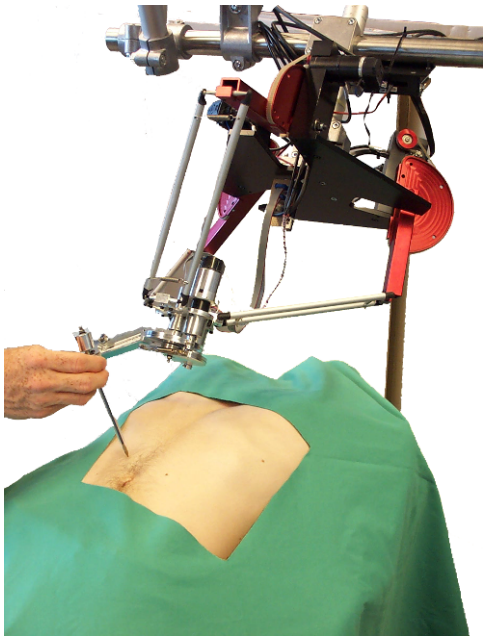
remotely control a slave robot or camera
tele-presence
augmented reality
force feedback from any sensor or model

Gesture guidance

collaborative haptic fixture
smart tool-holder
haptically augmented reality







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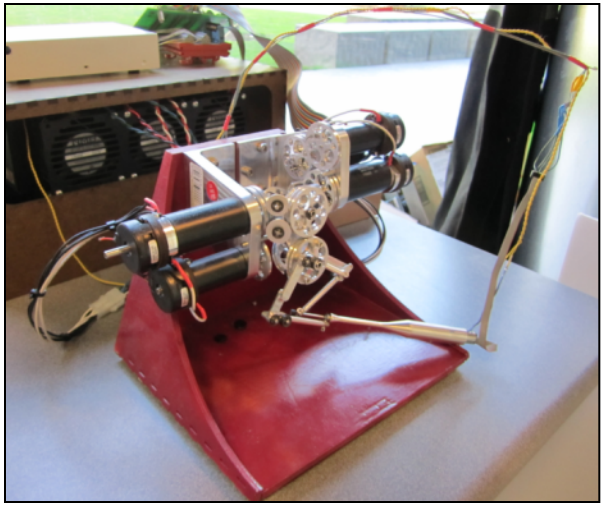
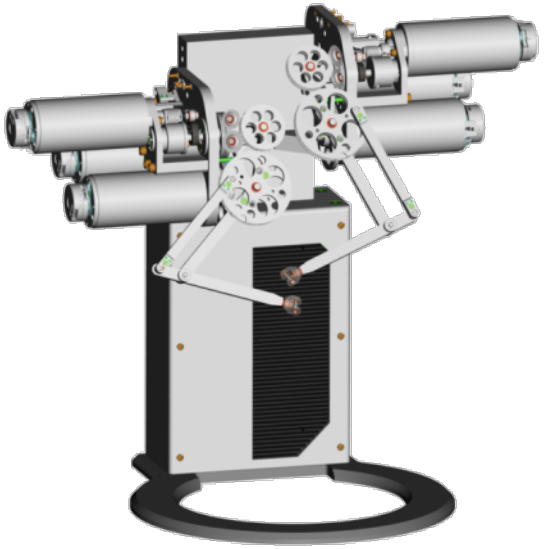
Stanford Micro Haptic Device



μ-HD1

μ-HD2



μ-HD3

force dimension

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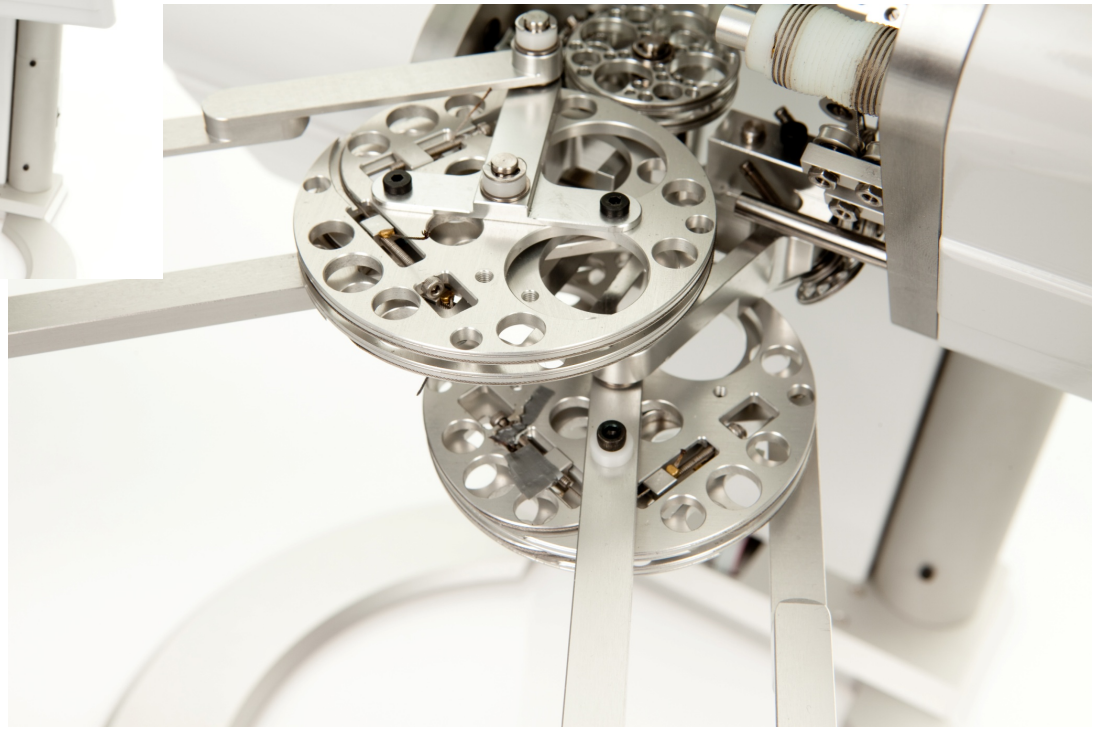
VRAI

Instant-Lab



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VRAI

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Etat de l'art

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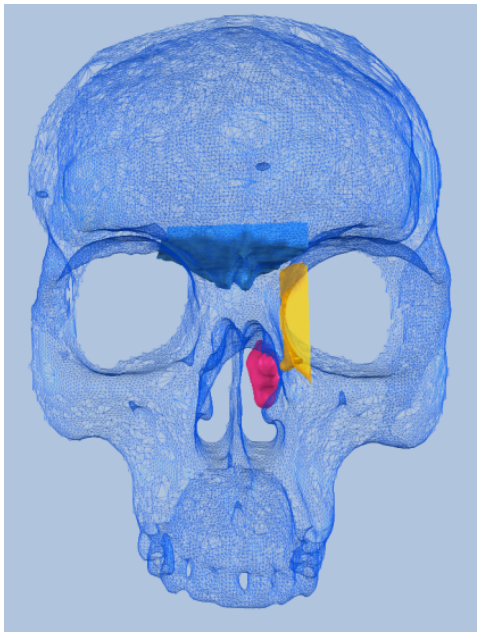
Intelligent tool holder for neurosurgery (tool, actuator and proximal & distal sensor design)

3D model for planning and navigation (HMI)



- Expertise in tooling design (hardware & software) as well as HMI modules (hardware & software)

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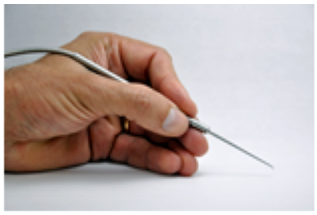
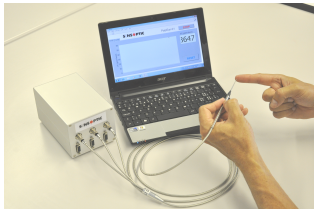
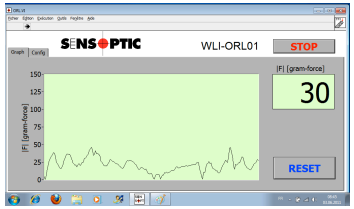
Miniature force sensor integrated in the Pick 45°, 16 mm 2,5 mm hook from the surgical tool's company Karl Storz used today by surgeons
Tri-axal sensor technology using optical fibers and micromechanical flexible structures for accurate force measurement at the tip of the instrument
Optical measurement: no electrical signals, no EM-interference, no heating
Measuring range between 0 and 1.5 N (0 to 150 gram-force)
3 % accuracy, 1 gram resolution and 22 Hz measuring bandwidth
Continuous recording and visualization of force in a computer display
Three adjustable force ranges in three colors for security alarm purpose
Force indication also by audio signal of the three adjustable ranges
Sterilisable instrument for use in operation room



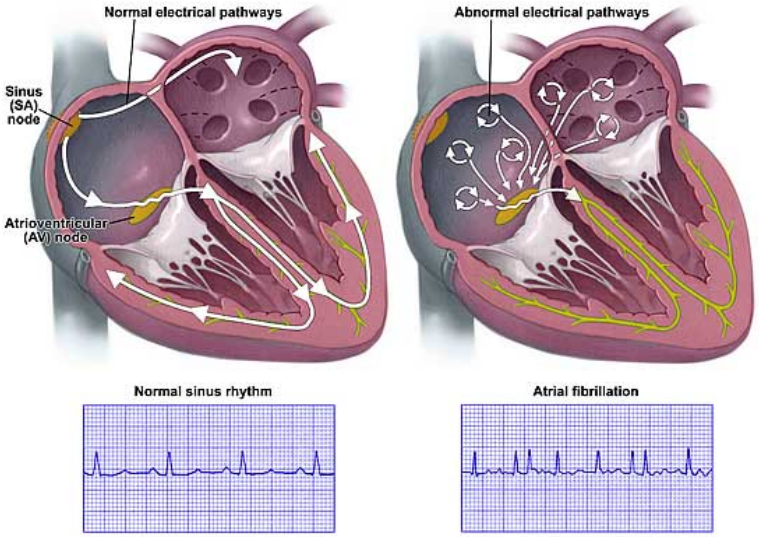




medical (Hansen Medical)

Atrial Fibrillation

- electrical activity of the heart's atria is irregular
- may lead to congestive heart failure, stroke, and more



why would a robot help?

Low level control of tools

- increase stability due to continuous servoing

User interface

- more intuitive control of DOFs (e.g. Cartesian space)
- automated control of n>3 DOFs allows for more capable tools
- kinesthetic feedback can be reproduced
- tele-operation allows for reduced x-Ray exposure

Visualization

- visual and tool reference frames can match
- pre-operative simulation and intra-operative planning

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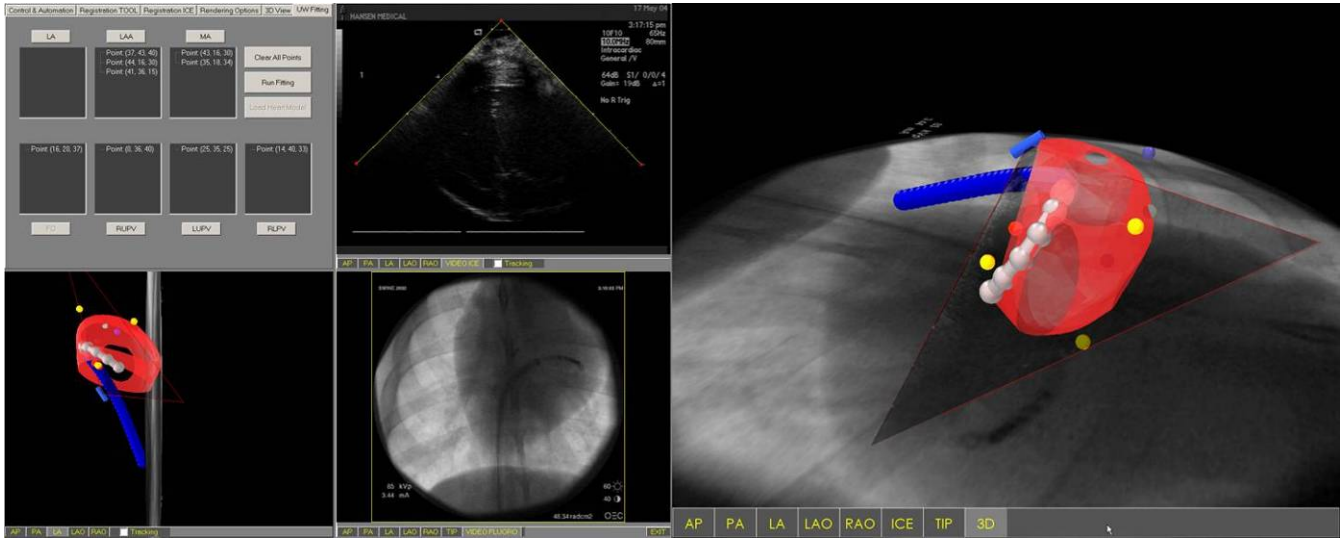
software

chai3D.org - application development

Application user interface development
GUI, HUI
simulation of hardware components

Rapid development of proof-of-concept



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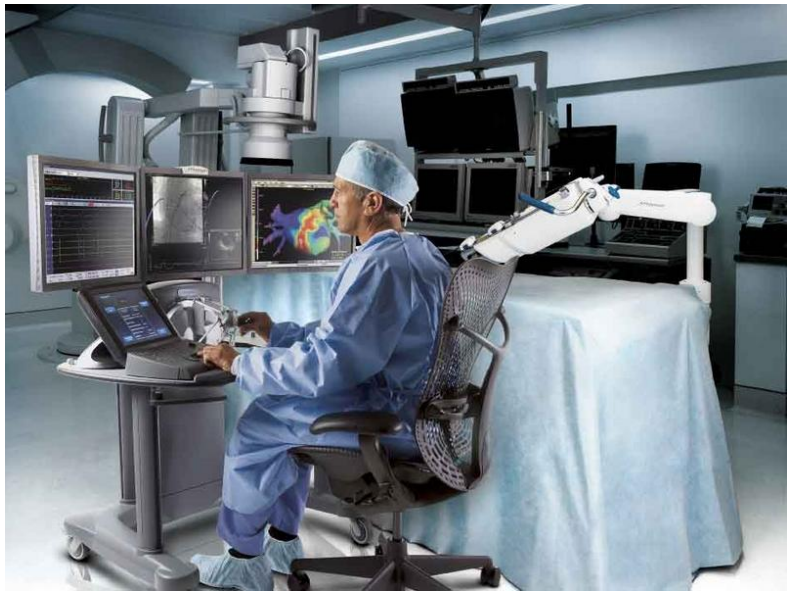
medical (Hansen Medical)

radiofrequency catheter ablation



hansen MEDICAL

The Global Leader in Flexible Robotics

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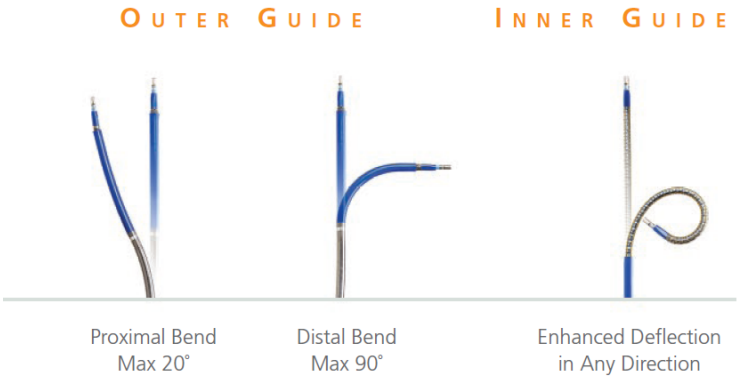
medical (Hansen Medical)

precise navigation & haptics feedback



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stability

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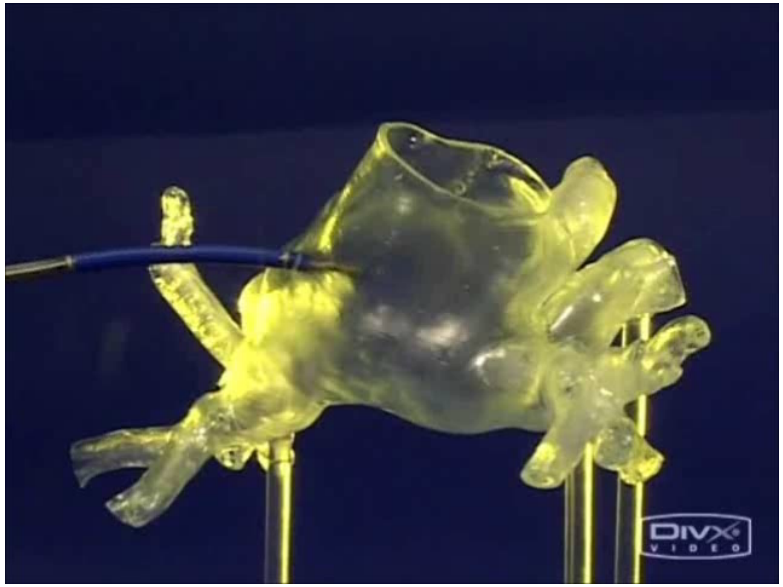
instinctive cartesian control



force dimension

simulation

MedaPhor ScanTrainer

force dimension

simulation

MedaPhor ScanTrainer

force dimension

simulation

MedaPhor ScanTrainer

Software application
describes the environment and task

force dimension

simulation

MedaPhor ScanTrainer

Custom haptic device
workspace size and force matches real application

Custom end-effector
replicate the simulated tool