# Surgsim in everyday use

# Figuring out what to build and how to built it

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# An evolving approach to surgical education

| | | |
|---|---|---|
| Patient | → | Surrogate Patient |
| Completion | → | Competence |
| Subjective | → | Objective |
| Opportunity | → | Curriculum |

Competence Assessment defining competence

Metrics to assessment

Simulation to metrics

Participation & accumulation

Decisions through discernment

Instructional discernment

Didactic presentation Information

# Proprioception & cognition

Therapeutic result

Skill

Action

Decision

Cognition

Skill

Cognition

Sensory requirements

Proprioception

Sensory input

# Unanticipated events & errors

Immediate
personalized
contextual
feedback

Doing/interpreting wrong

Why

Avoid/adapt

Iatrogenic event

Teachable moment

M&M instead

# How to design a simulator

Competence brokers

Learning management

Curriculum

Why → How

Focus/Facilitator

Cognitive/Proprioceptive

Training goals/metrics

# Simulation is

Synthetic reality

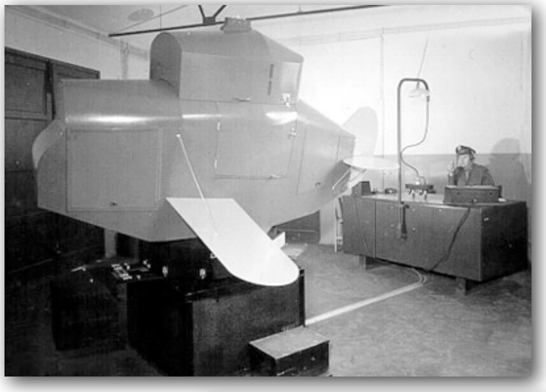
Suspension of disbelief

Widely used in flight training & high value/danger applications

Fulfilling expectations

Sensory consistency

Response to interaction

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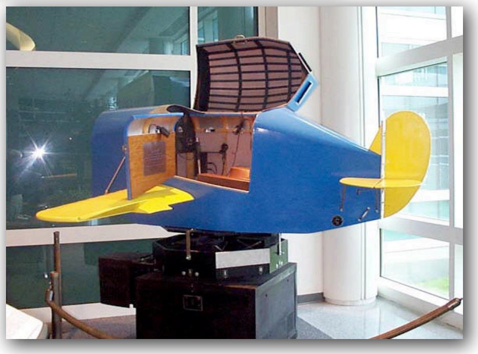
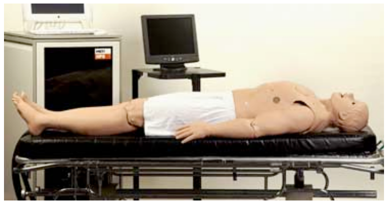
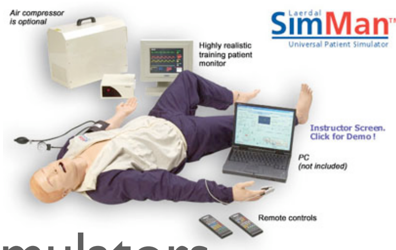


# Medical simulation evolves






1970-90s
Human patient simulators

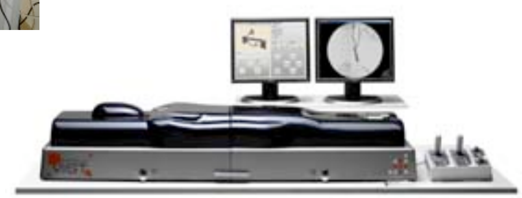
Anesthesia
certification

1987
Fibrendoscope

First simulator
Ethicon/Ixion
Preceptor

1995
MIST

Part task
OR to VR



2000 VIST

Full procedure
FDA carotid stent

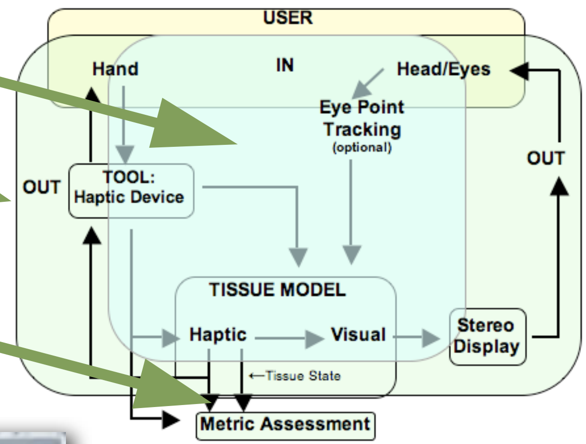
# Simulator infrastructure

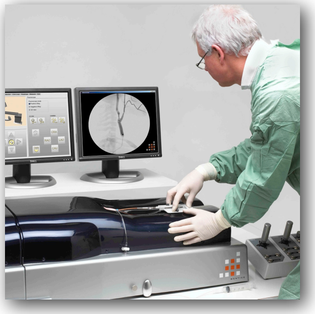
Simulation core

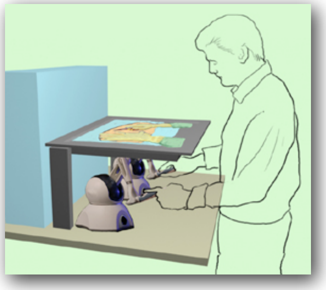
Interface/interaction

Learning infrastructure

Content creation

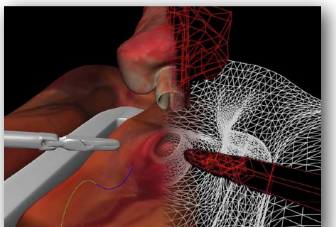


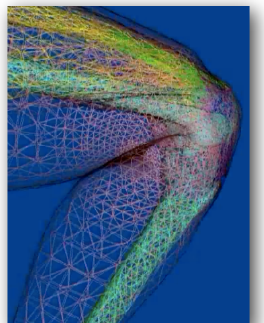





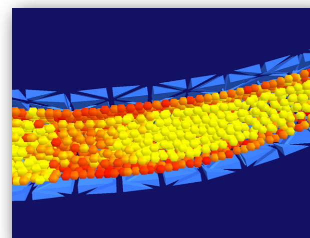
# Replicate physical world

Mechanical
Interaction response

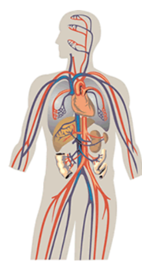


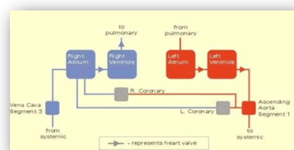


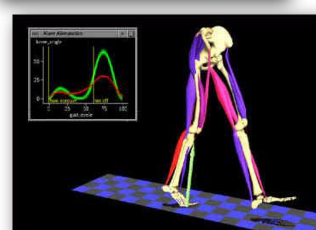
Fluid
Blood & others
Gaseous

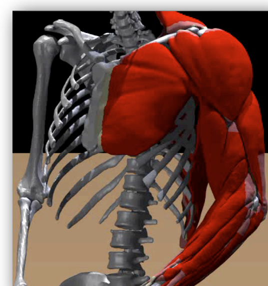


Systemic
Cardiovascular
Musculoskeletal
Linkage of systems









# Physics

# The big picture

Generalizable

External result

Engineering validation

Metric from values

Interaction optimizations

Engineering mechanics

Biomechanics

Underlying phenomena

Bottom up

Top down

External result

Game physics

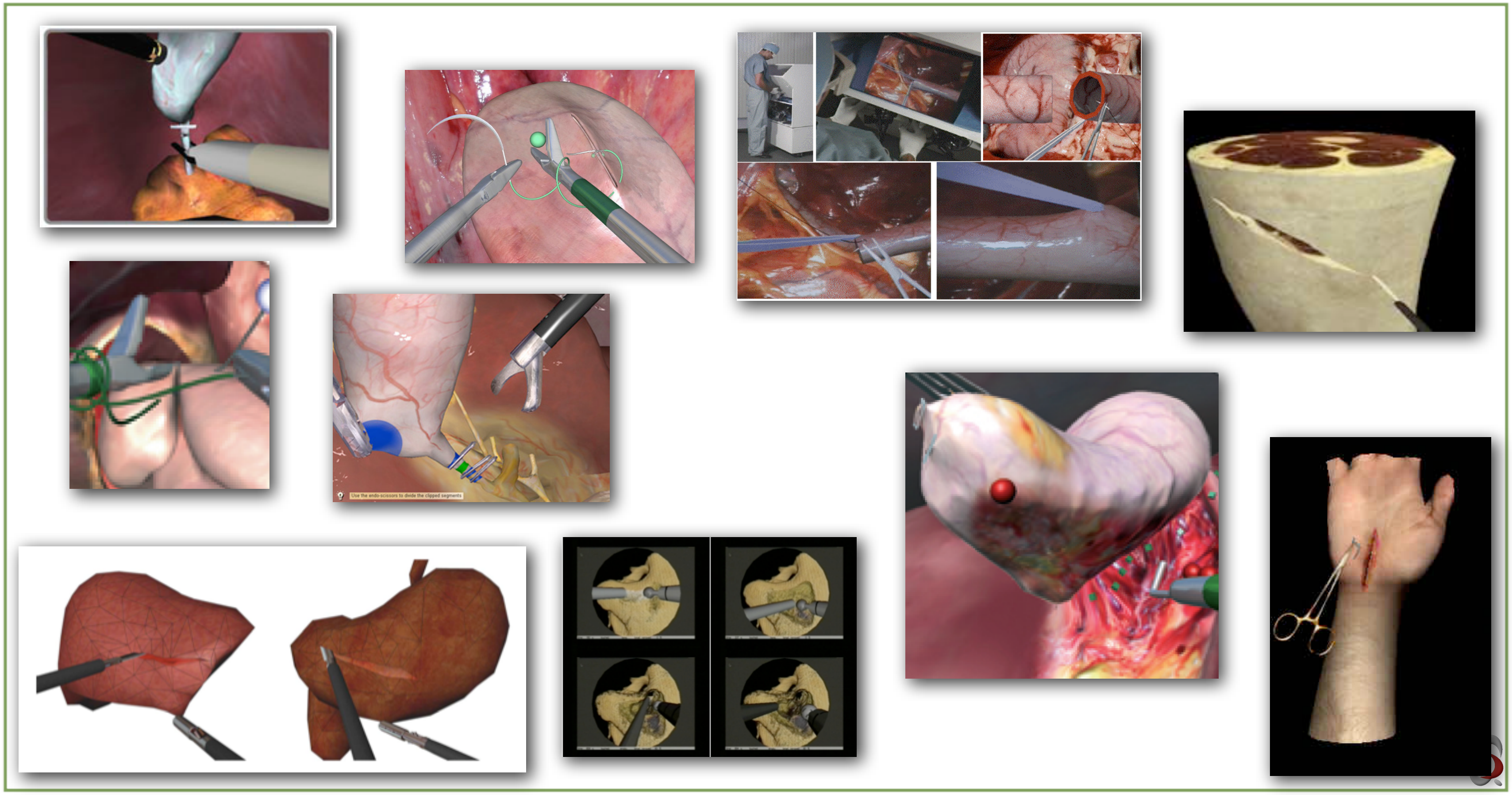
Tune perceived result

Scale for metric

Task specific

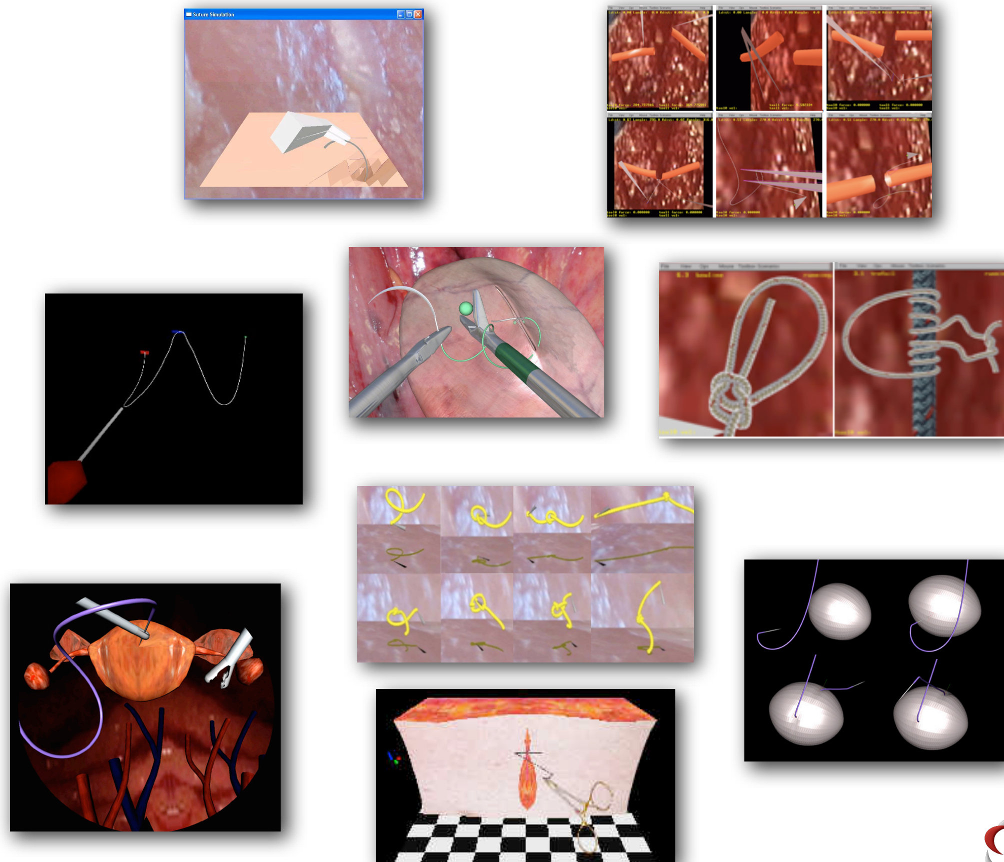
Situational validation

# Tool tissue interaction



# Suture

- Needle puncture
- Knot formation
- Tissue tearing
- Thread dynamics
  - Active splines
  - Coupled particles
  - Cossart frame



# Physics implementation

- Open source vs. commercial solutions
  - Commercial physics packages better than current open source efforts
  - Driven by games
  - Nothing contains all the needed functionality
  - Need to extend existing work
  - No accepted open file format standards for surgsim (yet)
- Integration of metrics instrumentation
  - Need to access whatever physical variable is computed that is reflective of an objective measure of the task being simulated and observed/recorded

# Hardware vs software

CPU centric approaches to date

GPU approaches emerging

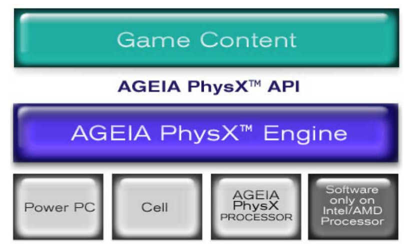
Dedicated physics processor

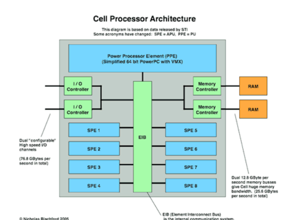
Sony PS3 cell processor

Intel massively multi-core CPU

Ultimate winner unclear

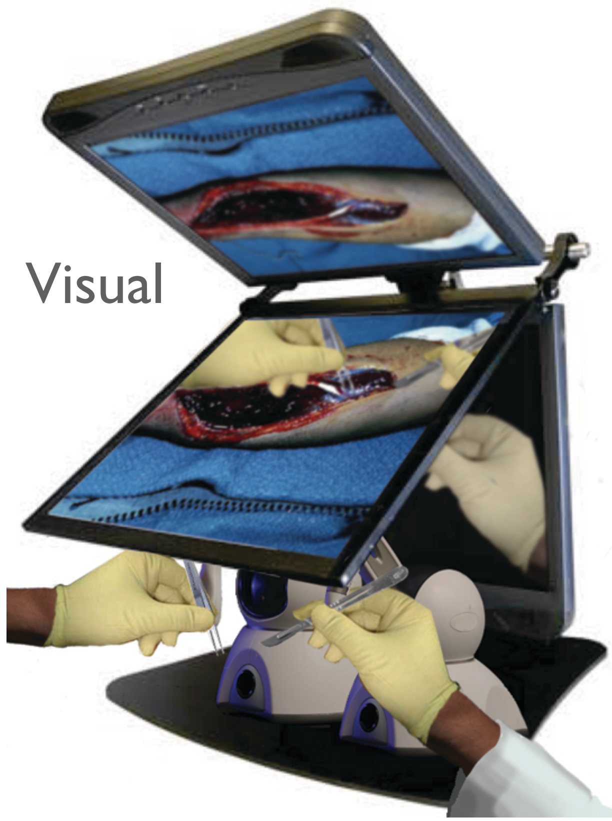
Open physics interface OpenGL



# Interaction/interface

Visual



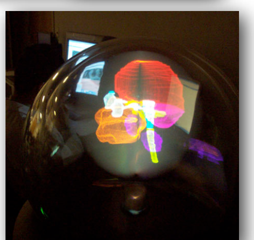
Haptic

# Visual display










# Interaction

Tool manipulation → Proprioception → Haptics

Finger contact → Tactile → Surrogate anatomy

Haptics → Devices

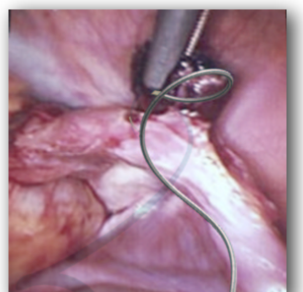
~~Tactile~~

# Haptics fidelity

Perception not replication

Sight + Feel + sound + smell

Psychophysics



Visuo-haptics

# Haptics devices

| | | | | |
|---|---|---|---|---|
| Position<br>Force | → | 3 DOF | → | $2,000 |
| Position + orientation<br>Force + moment | → | 6 DOF | → | $50,000 |

# Haptic interface

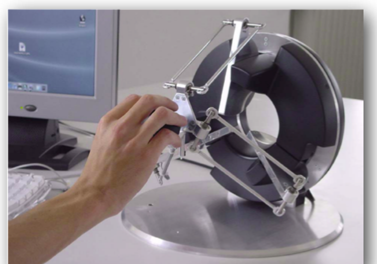
Immersion

MPB

SensAble

Novint

Haption



Force Dimension

# Location-based entertainment

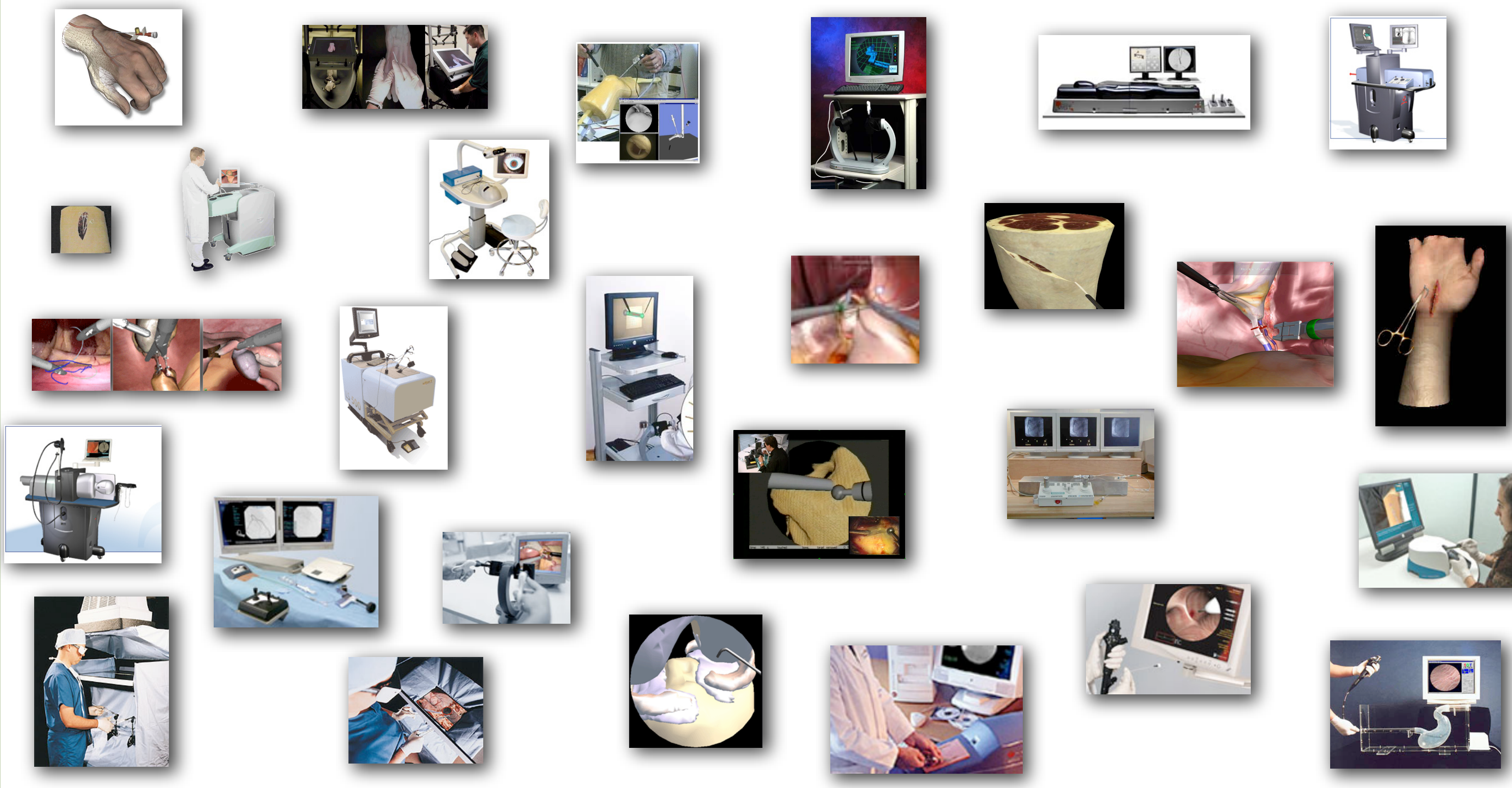
## Multisensory feedback in practice







# Surgical simulation now

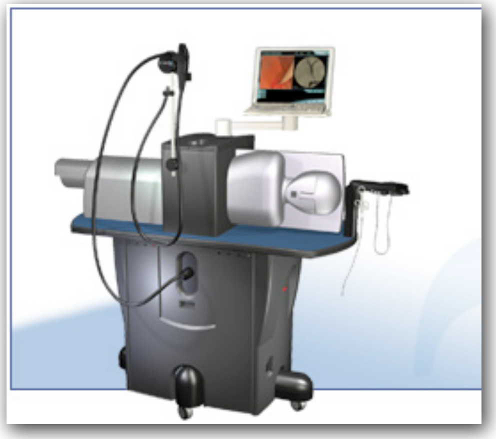


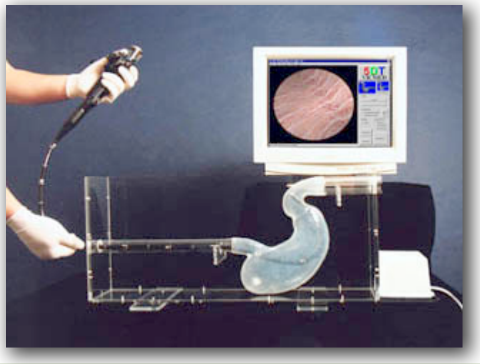
# Commercial Product Areas

- Rigid endoscopy
- Flexible endoscopy
- Endovascular
- Needle insertion
- Ophthalmic
- Dental
- Ultrasound
- Human patient simulators

- Advanced Simulation Corp.
- Anesoft
- Brown & Herbranson
- Delltatech
- DenX
- Garmaud
- IDEA
- Laerdal
- METI
- Haptica
- Immersion
- Medic Vision
- Medical Simulation Corp.
- MedSim
- Melerit
- Mentice
- Mimic
- Research Triangle Int.
- Select Vest Systems
- Simbionix
- Simedge
- SimQuest
- SimSurgery
- SimuLife
- Simulution
- Surgical Sciences
- Touch of Life
- Verefi
- VirtaMed
- VRMagic
- Yantric

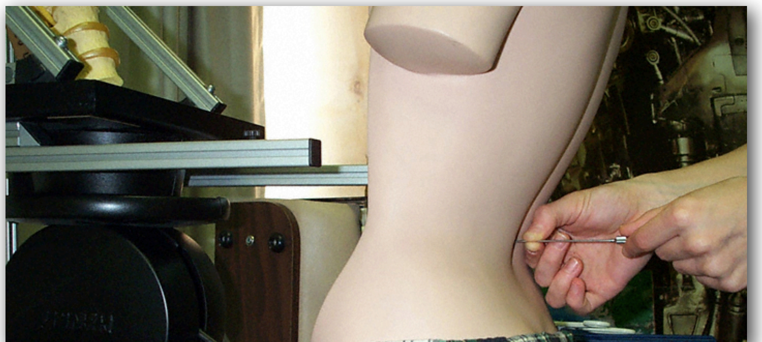
# Flexible endoscopy examples

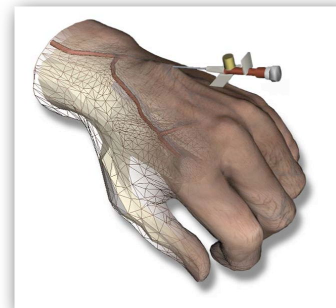


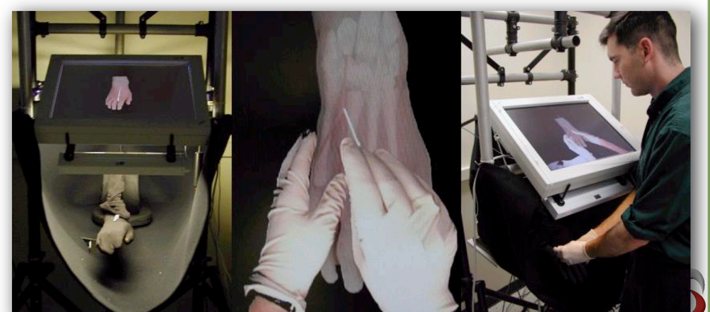


# Rigid endoscopy examples

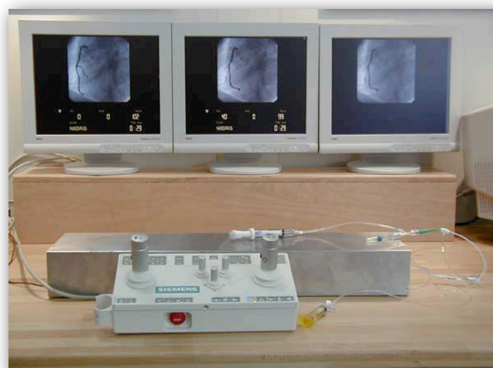
# Needle insertion examples







# Endovascular examples



# Building your own

# Design Philosophy

- Build it only if you have to
- Work from your strengths
- Compartmentalize
- Increment & Iterate
- Use standard tools
- Use standard data formats & interfaces
- Make scalable
- Web accessible as much as reasonable
- Establish a cost budget to constrain design

Continual application of design constraints

All that can be left is the product

# Infrastructure

- Multiple processes, processors or machines
- State accessible
- Support high level design
- Well documented interfaces
- Debugged, stable codebase
- Integration of time sampled continuous and discrete event processes
- Support detailed runtime debugging

# Infrastructure

- Remote debugging
- Scriptable
- Variables exposed for recording/modifying
- Debug variable & condition bounding

# Multiple Physical Parameters

- Multiple data structures for same entity
- Optimal data structures for optimal algorithms
- Mapping between representations
  - Pre-computation as much as possible
  - Intelligent, localized, asynchronous remapping when changed
  - Multi-thread, multi-process capable
- Data created from single source
  - Automated conversion to optimal data structure