Balancing Safety and Cost in Robotically Assisted Surgery

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SimQuest

Thank yous

- ChIR & XirTek
- INRIA
- Intuitive Surgical
  France & USA
- HEGP **& A. Carpentier**
- The RNTS, RNRT
- SimQuest

Outline

- Motivation
- Quick Outline of XirTek
- Safety vs. Cost: XirTek step-by-step
- Safety vs. Cost: Further examples from Immersion Medical and SimQuest
- Conclusion

Motivation

- Example 1: Who knows CPR?
  - $90 - 5 hrs
  - Available everywhere

American Red Cross

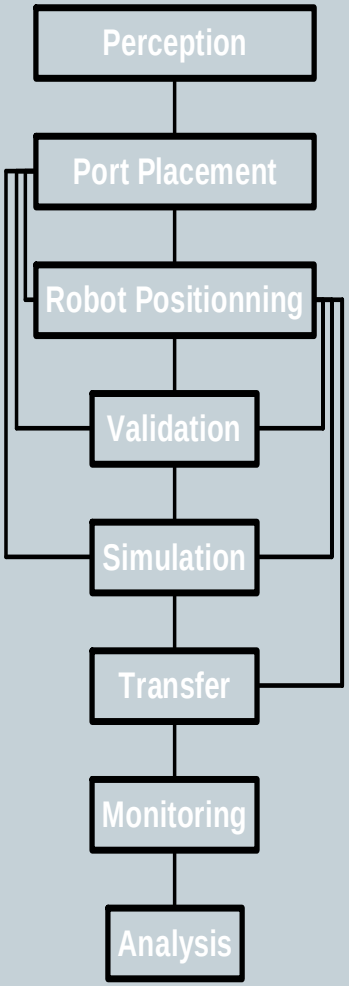
- Example 2: The dilemma:

"Humans as absolute value"

vs.

"What it takes to save/help someone"

Chir/XirTek – What is was



Xirtek: How does it increase safety?

- Prepare through Planning
  - Port placement
  - Pose planning
- Prevent through V & V
  - Formal verification
  - Result validation
- Practice through Simulation
- Pre-empt during Monitoring

Xirtek – What it became

- Project Chir went in a one year evaluation to assess Xirtek's feasibility
- The conclusion was that is was "too soon" for Xirtek
- Why too soon?
  - All the technology was available
  - Enough customers were identified
- Why; really?

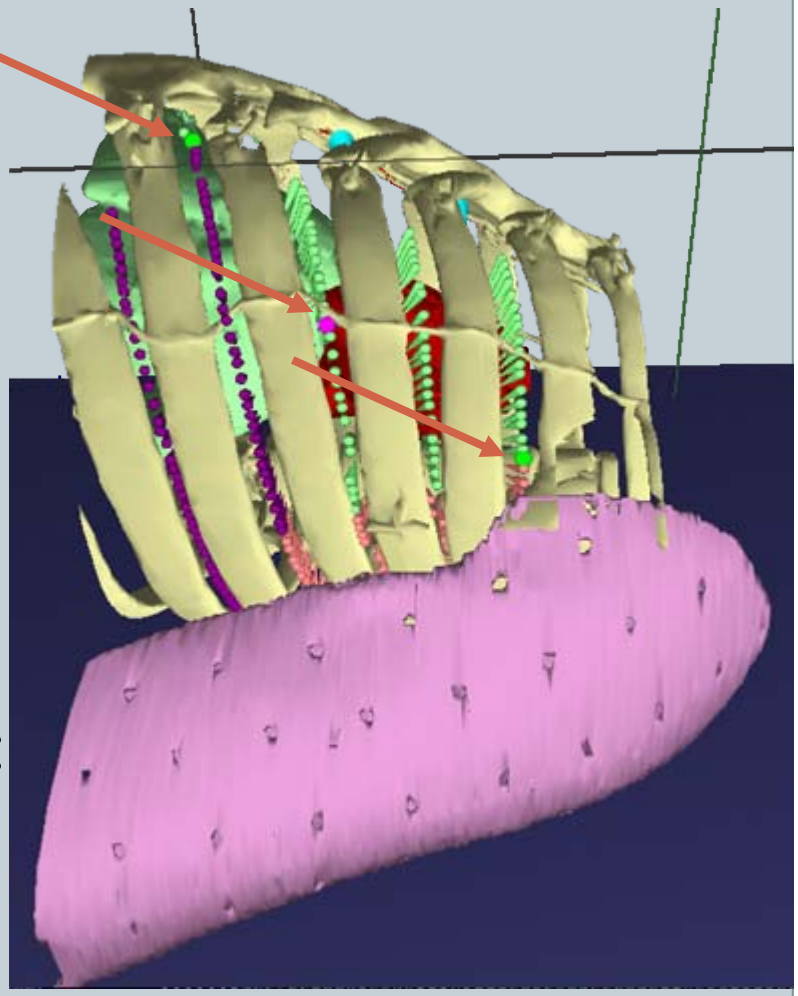
Final bottom line after the whole chain was negative (at least at the time)

Chir: Port Placement

Problem Statement:

Compute optimal *incision sites* based on *surgeon requirements* and *robot specs*

- All ports must be *admissible*
  - No internal collisions
- Triplet optimization based on:
  - Surgeon's requirements
  - Robot limit (max dexterity)



Chir: Port Placement Cost

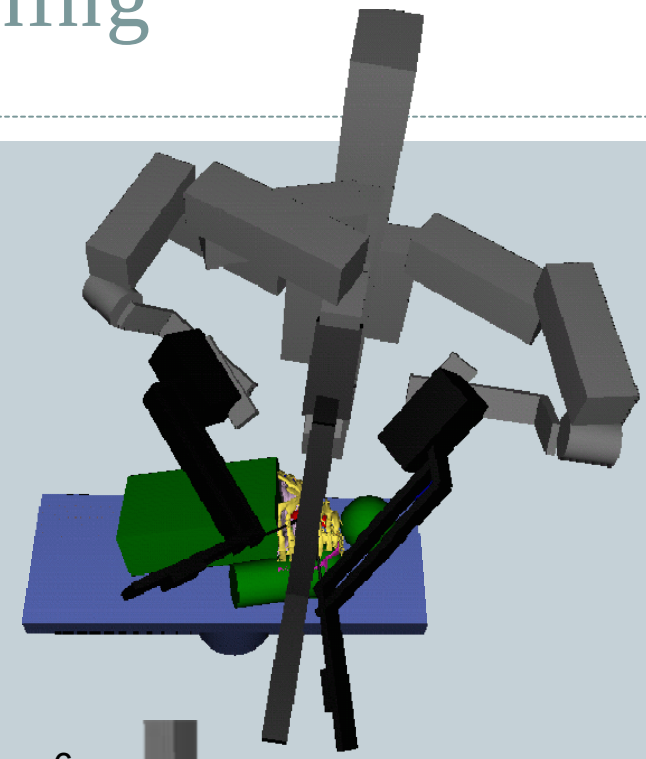
- CT scans
  - Complete torso
  - Injected and synchronized heart image
- Coronarography (optional)
- Segmentation
  - Automatic
  - Manual
- UI
  - Selecting the targets
  - Choosing solution

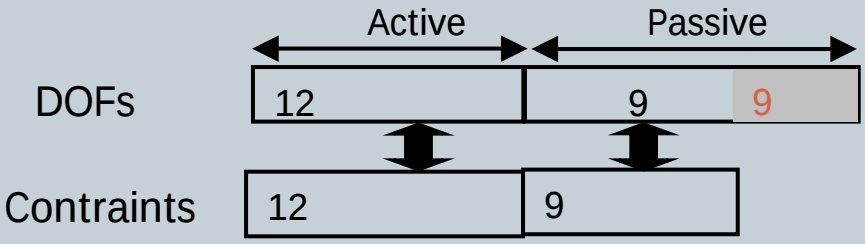
Chir: Pose Planning

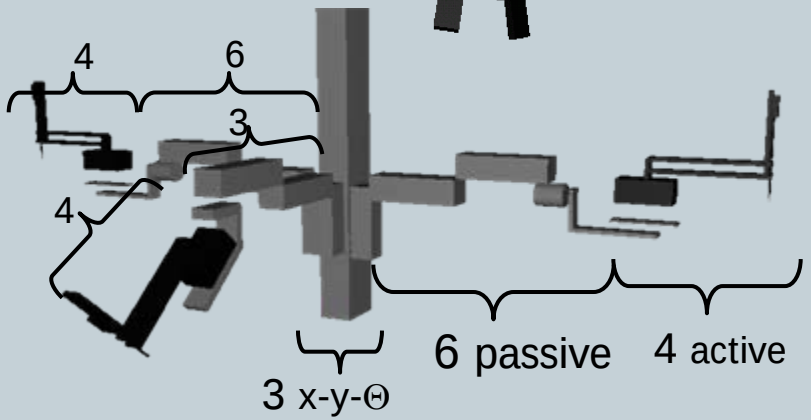
Problem statement

Position a robot in a way to achieve a collision free path *g(t)* such that:

- Incision points @ remote centers
- Maximize a clearance measure *F*

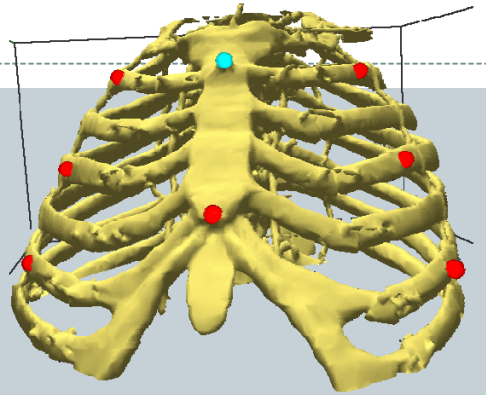


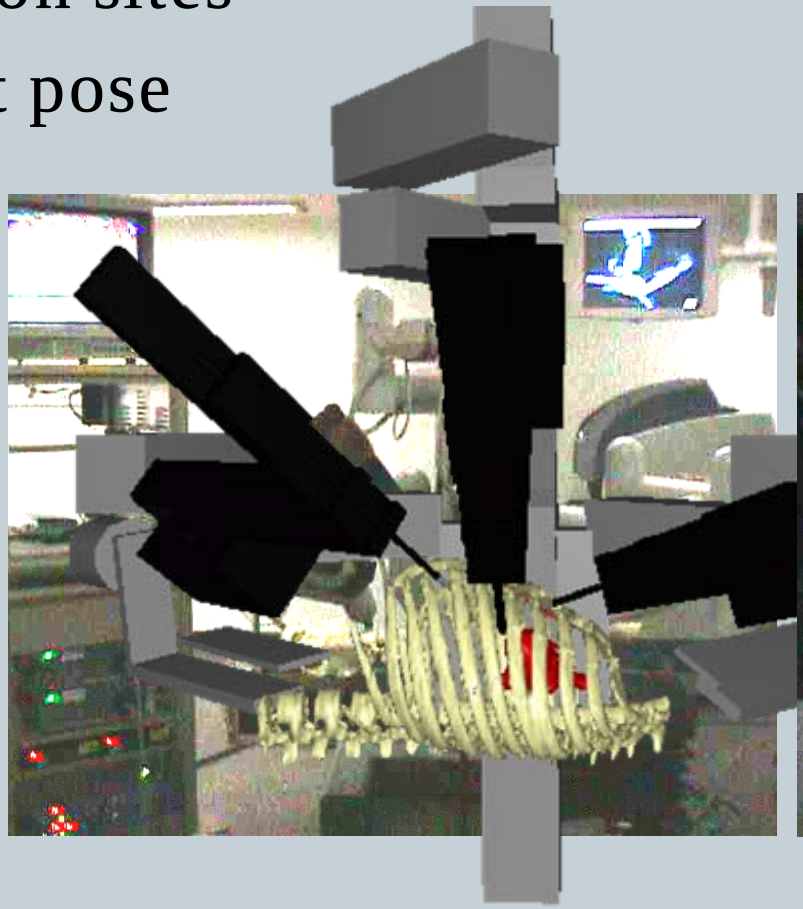


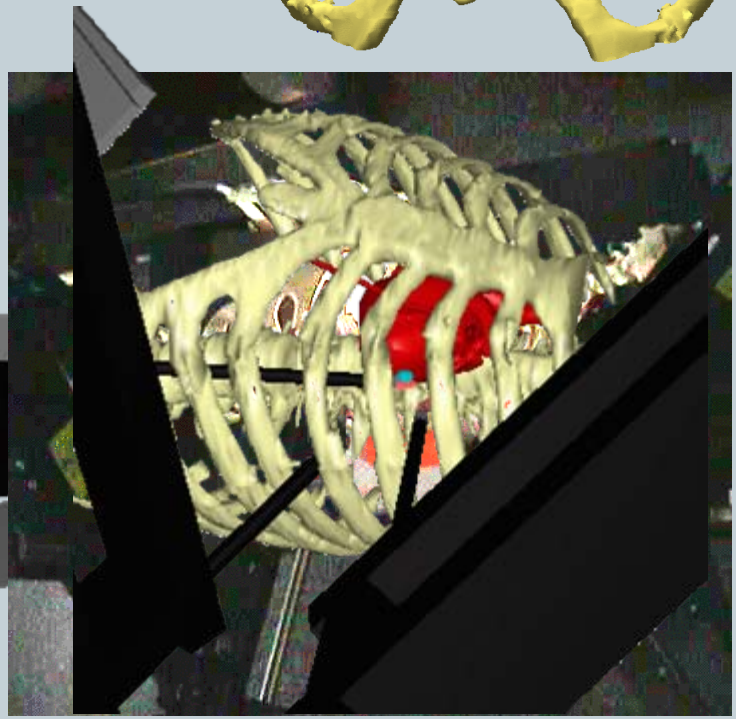


Chir: Transfer

- Incision sites
- Robot pose





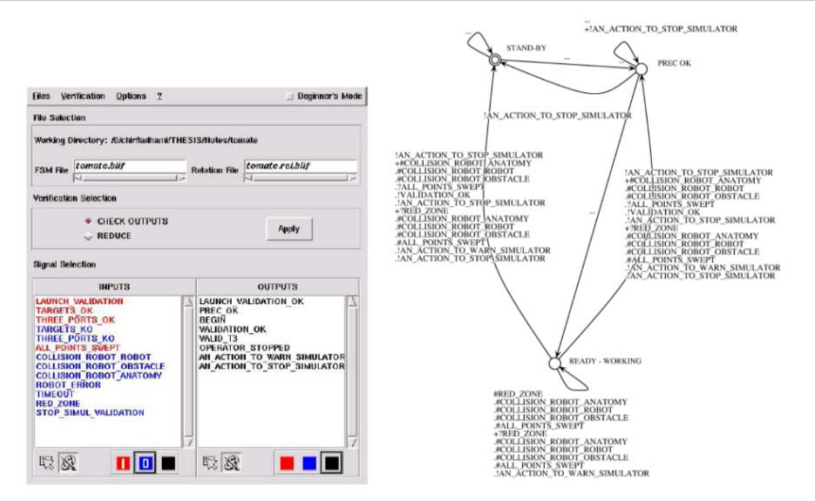


Chir: Transfer & Monitoring Cost

- Registration of pre / intra operative models
  - 3d reconstruction
- Port placement
  - Robot as pointing device
- Robot pose matching
  - GUI
- Required setup
  - Robot API
  - 1-2 laptops
  - Stereo system

Chir: Verification Cost

- Algorithmic Verification
  - Took 1 post-doc 3 months to formally verify 1 collision detection function (using Coq)
- Formal Verification
  - Intra-operative steps were validated using XEVE



Further Examples: IMMR LapVR Handles

- Handle electrocuted a client
  - Redesigned the wiring
  - Cost = Law suit $$$
- Handles were burning the clients
  - Changed the enclosing to plastic
  - Cost = Loosing clients $$
- Handles were burning out
  - Removed the haptics *despite their recognized benefits*
  - Cost = COGS + less repairs $

Further Examples: SimQuest's BurrHole

- Requirements
  - Deliver very high forces (20N)
  - Low cost without compromising Reliability or Safety
- Solution
  - Used custom made version of commercially available Novint devices (2 Falcons)
  - Close coordination with Novint was needed

Conclusion

- Should not idealize safety – yet should not lower our standards
- Work with a given or reasonable cost mind to achieve an explicit level of safety

- *Neglecting the cost could kill your project/product – this doesn't mean it's an excuse to neglect safety*

Publications

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