Ubiquitous Tracking in the Medical Environment

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Introduction

Computer-Integrated Surgery (CIS) and **intra-operative navigation** opened a new era in interventional medicine.

- possibility to track tools
- visualize patient's preoperative records in real-time
- access the desired anatomical region
- overlay patient information and critical data
- surgical simulation and training of medical students

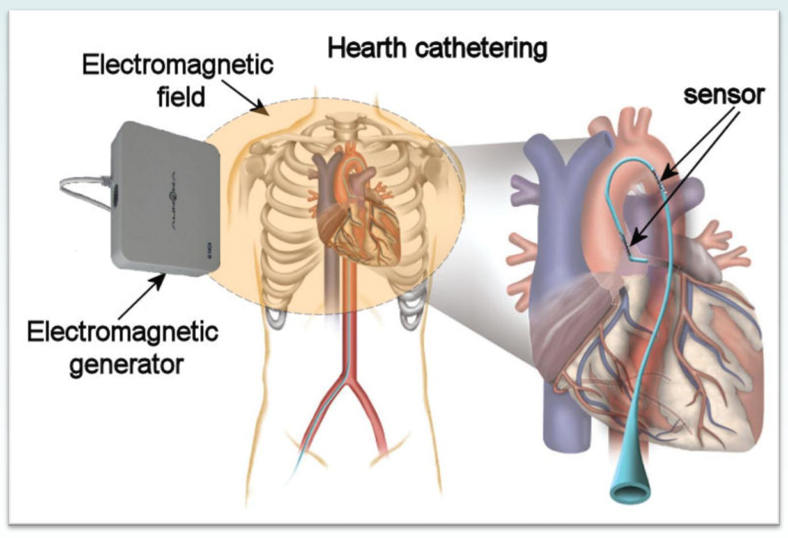
Electromagnetic Tracking (EMT)

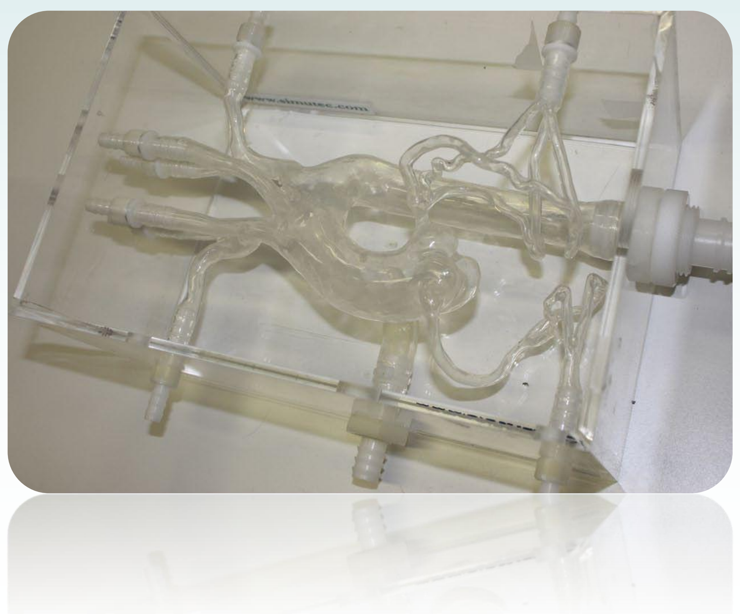
Main advantages:

- no need of *line-of-sight* between marker and the receiver
- possible to assist complex interventions (bronchoscopy, radiosurgery, heart ablation and beyond)
- works even with certain metals (e.g., titanium)

Main disadvantages:

- highly susceptibility to other electronic devices and metals
- especially ferromagnetic items
  surgical tool and instruments: laparoscopic forceps, cutlery, trays, etc.
- lower accuracy compared to optical modality
- working volume significantly limited
- no generic solution for metallic sensitivity



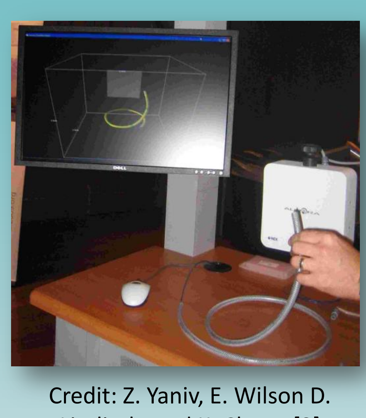


Credit: Hugo Correia Duarte Furtado [1]

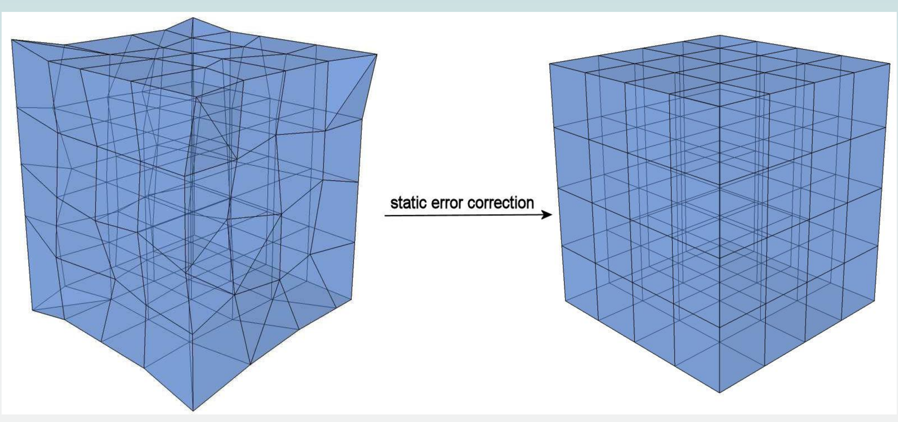
Possible advancement in the near future

Primary technical difficulties to be solved:

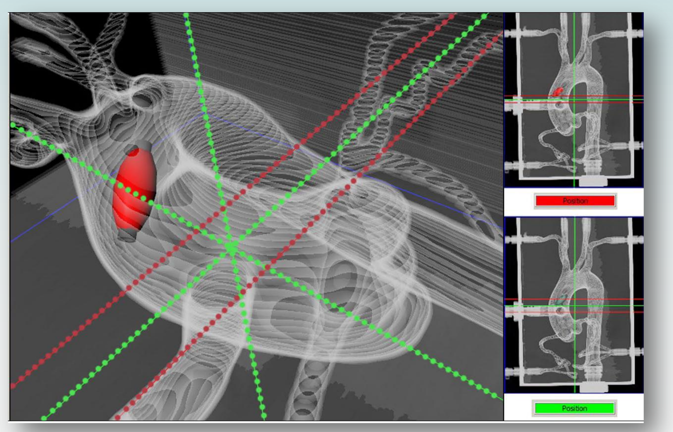
- dynamic EM distortion calibration (with quick protocols)
- static error correction and susceptibility reduction
- distortion modeling and simulation
- enabling device specific tracking in the medical environment
- support of multi-sensor applications (swarms)
- significant extension of the work space
- innovative types of sensors



Credit: Z. Yaniv, E. Wilson D. Lindisch, and K. Cleary [3]



Credit: J. Much [2]



Credit: Hugo Correia Duarte Furtado [1]

Conclusion

In the future, we expect the rise of the concept of "ubiquitous tracking", where all major parts of the medical working environment is tracked and modeled real-time in a virtual environment according to their physical state and position. This will lead to a complete understanding of the procedures.

Acknowledgment

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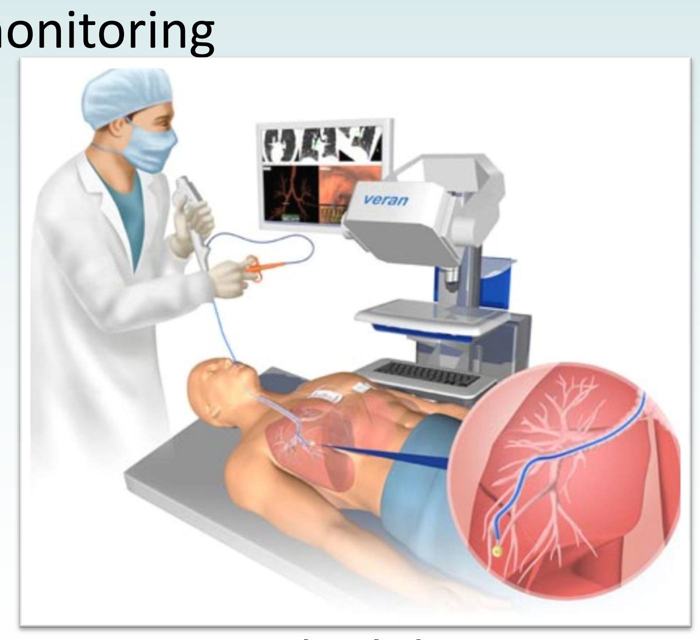
Development within a few decades

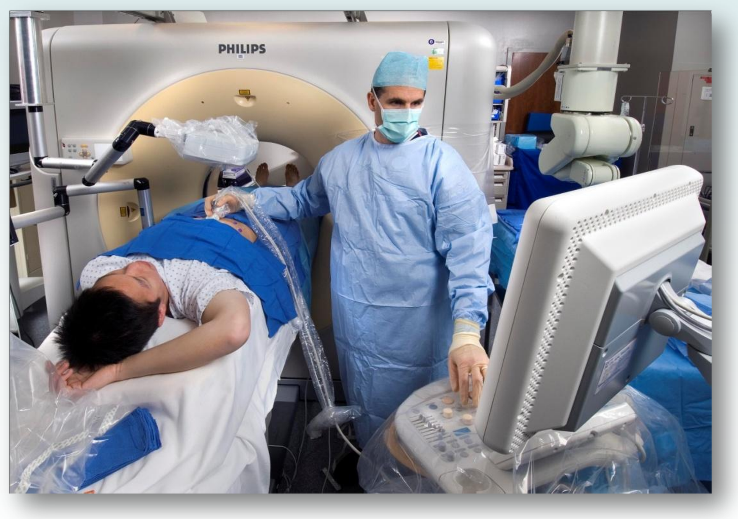
- realistic simulation programs
  modeling the field and the distortion caused by individual instruments
- all active and passive devices in the OR will be modeled and tracked leading to the concept of **ubiquitous tracking**
- CT breeds and MR fiducials will be incorporated
  providing a gold standard for CAD model calibration

Accurate soft tissue/soft environment models

- ○ continuous patient motion compensation (physiological & external)
- ○ immediately determine how the magnetic field was affected by other devices or surgical tools
- ○ EM compensation in real time
- ○ highly trusted position measurements
- ○ all environmental variables fully tracked and recorded for monitoring



Credit: medGadget

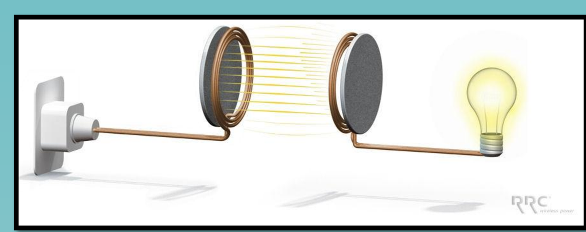


Credit: NIH, Clinical Center

FET: Fully sensorized operating room

Ubiquitous tracking & wireless power transmission technologies [4]

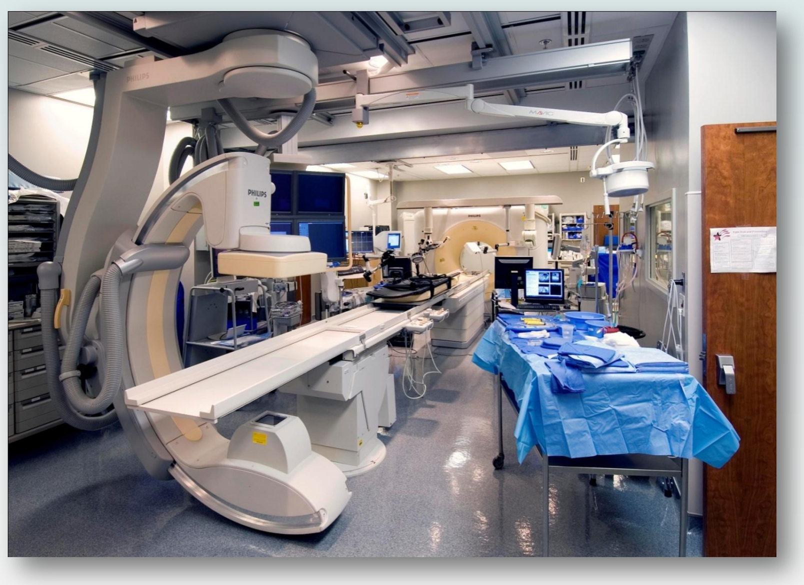
- ○ sensors will transmit and receive power
- ○ effective compensation of the EM field
- ○ freeing the operating room from cables



Credit: RRC power solutions

- tracking technology will be embedded throughout the operating room
- tracking sensors and RF IDs will complement each other
- motion of the tools, devices and the patient will be tracked

- enormous improvement in surgical simulation and workflow analysis
  dramatic improvement of assistive surgical technologies
- error assessment and rapid calibration for the entire workspace
  in any environment (including MR rooms)
- emergence of fully controlled operating room,
  unprecedented accuracy through tracking
- compensating the EM fields distortions in real-time,
  tracking to improve minimally invasive procedures



Credit: NIH, Clinical Center

Courtesy of Richard M. Satava

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[1] H. Furtado, "Augmented Reality and wireless sensor networks applications to support minimally invasive cardiac surgery"; Doctoral Dissertation; 2010
[2] J. Much, "Error Classification and Propagation for Electromagnetic Tracking", MSc thesis in Computer Science, Technische Universitat Munchen; 2008
[3] Z. Yaniv, E. Wilson D. Lindisch, and K. Cleary, "Electromagnetic tracking in the clinical environment", *Medical Physics*; Vol.36:3, p.876–892; 2009
[4] J. Payne, K. Song, S. Yang,J. Kim, Y. Park,S. Choi , "Wireless power transmission for medical applications", *Proceedings of the SPIE*, Vol.7291, 2009

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