MECH 464 / 563 / EECE 589
Introduction to Robotics

- **Instructor:** Prof. Tim Salcudean *tims@ece.ubc.ca.*

- **Teaching Assistant:** Alaa Eldin Abdelaal aabdelaal@ece.ubc.ca
- **Lectures:** MWF 11:00-12:00 by Zoom. Will record pre-lecture videos and tape the actual lectures – mainly Q&A. There will be pre-lecture slides and reading material.
- **Tutorial:** M 17:00-18:00 – only if needed, please keep open if possible.

- **UBC Canvas Web Page:**
  https://canvas.ubc.ca/courses/70761

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Your Instructor: *www.ece.ubc.ca/~tims*

- B.Eng, M.Eng McGill (adaptive control)
- PhD UC Berkeley (optimization-based CAD of control systems)
- 1986-1990 IBM TJ Watson Research Centre (robotics)
  - Maglev devices, optical fiber alignment, scanning tunneling microscopy
- UBC – C.A. Laszlo Professor, Canada Research Chair
- Sabbaticals:
  - 1996-1997 – ONERA (French Aerospace) Toulouse – helicopter-ship landing system simulation, excavator simulation, shuttle flight STS-85 support
  - 2005 – CNRS – soft tissue simulation, needle insertion simulation
- Research:
  - Medical robotics and image guidance for medical procedures
  - Tissue deformation and elasticity measurement ("elastography")
  - Correlation of elastography with cancer/disease (prostate, breast, kidney, liver)
  - Medical image segmentation, registration
  - Medical simulation
- Experienced in robot system design and control, will provide examples from own work.

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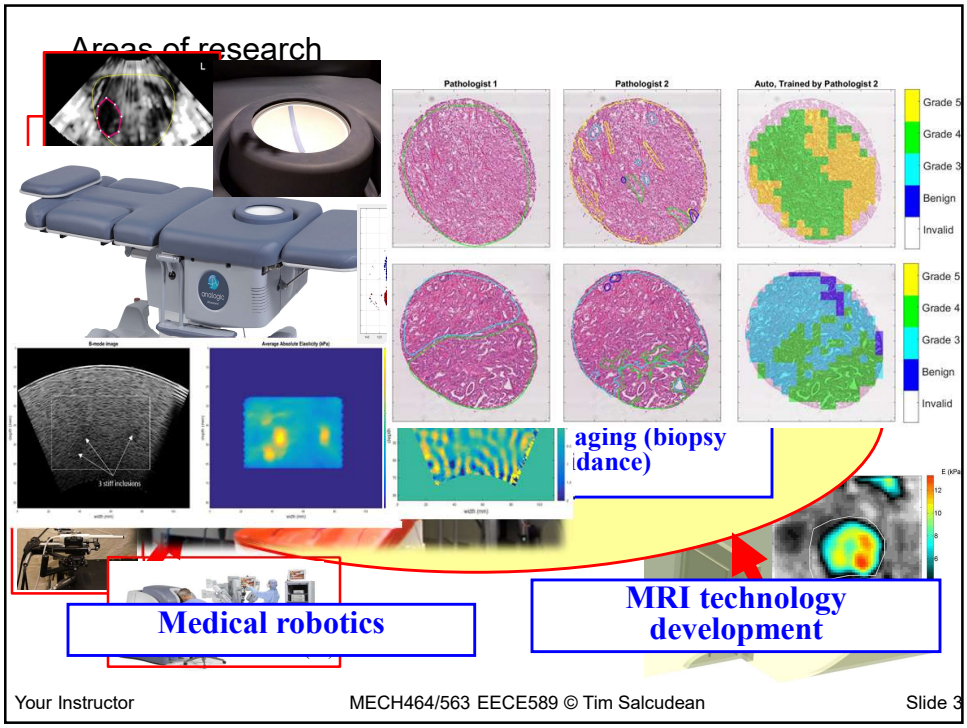

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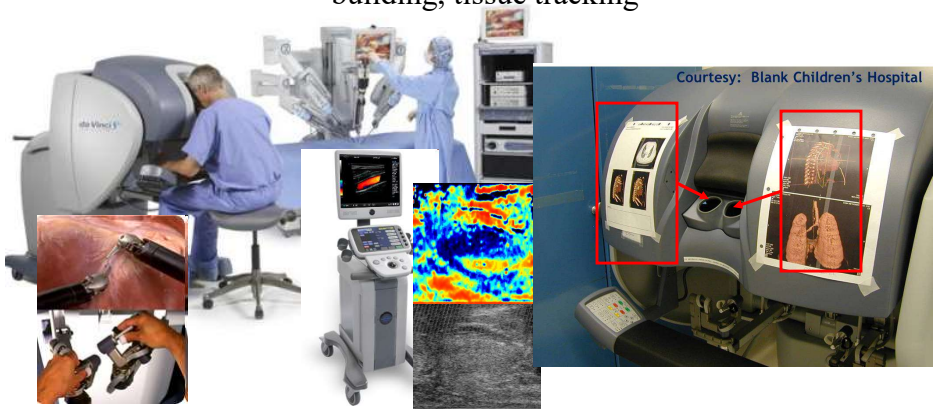
da Vinci – related projects

- ultrasound and 'ultrasound mediated' image guidance for medical interventions
- Videos: "Pick-up" ultrasound, TRUS robot, vessel model building, tissue tracking



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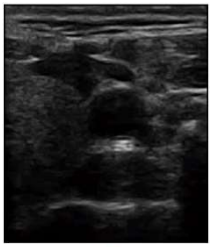
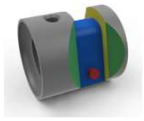
Intra-operative “Pick-up” Ultrasound

- Linear Array
- 10 MHz center freq
- 128 elements
- 28 mm footprint
- 44.5 mm total length
- 15 mm diameter
- Embedded EM sensor





- Controlled by operating surgeon
- Available throughout the surgery (no tool changes)
- Repeatable grasp; Tracked by EM sensors or stereo camera

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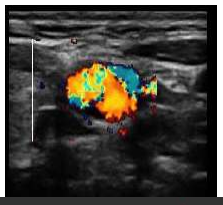
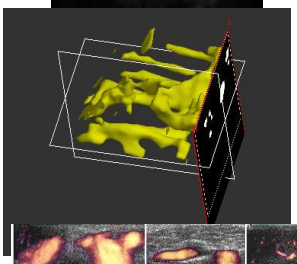
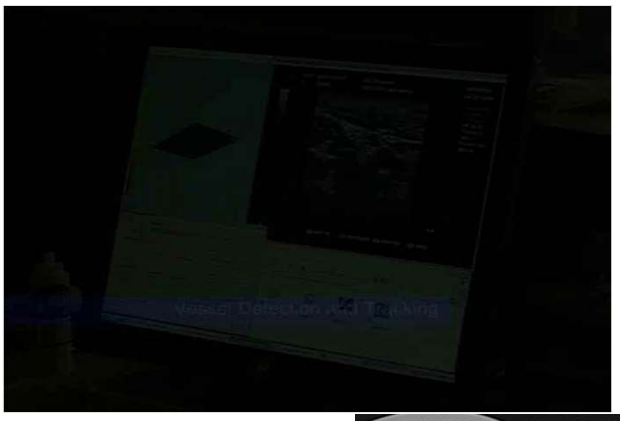
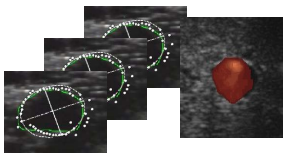
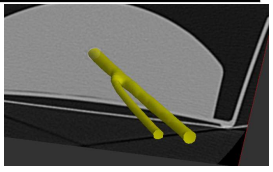
Example of model building from ultrasound











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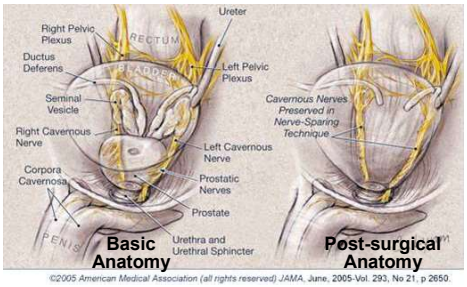
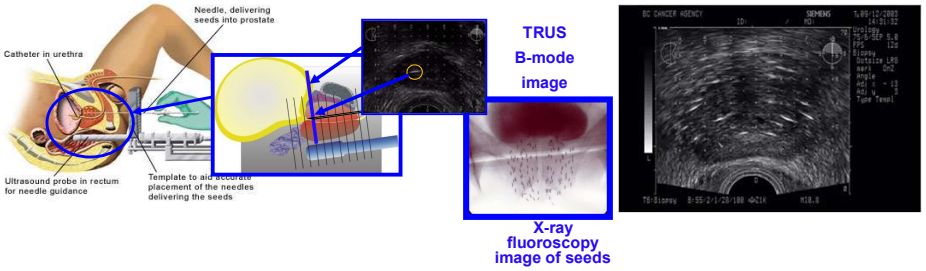
Radical Prostatectomy

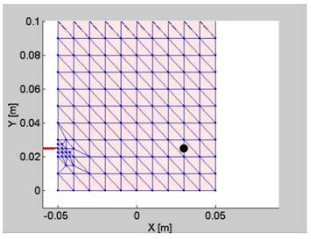
- To identify:
  - boundary between the prostate and the bladder neck
  - boundary of the prostate apex
  - neurovascular bundles
  - cancer

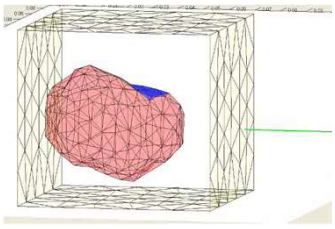


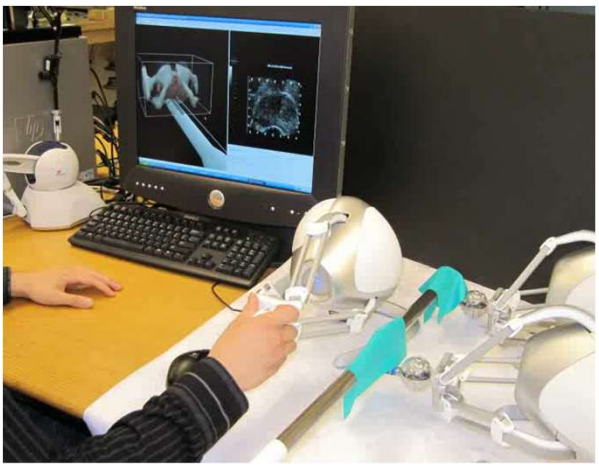
Prostate Brachytherapy



Brachytherapy Simulator

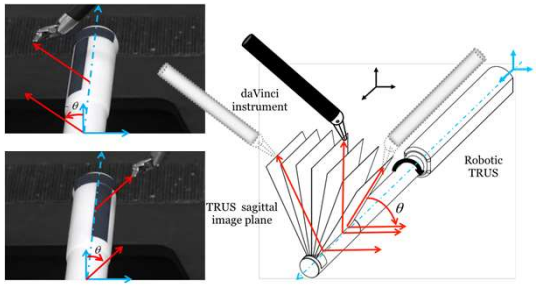




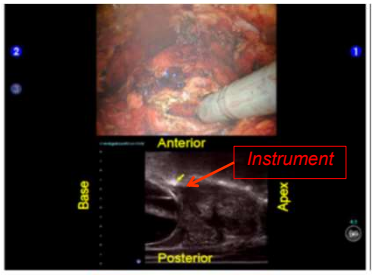


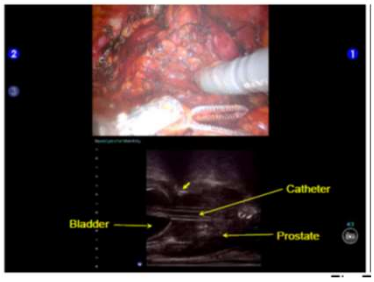
Integration of TRUS with da Vinci prostatectomy

- Brachytherapy transducer
- Remote control
- Calibrated
- Controlled manually or by using tool as pointer



Anterior bladder neck dissection





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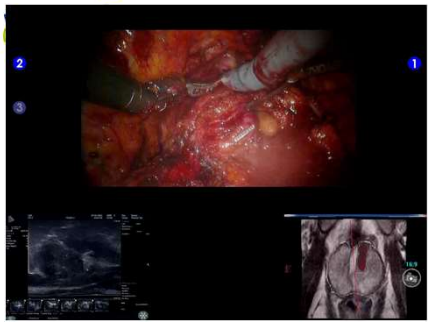

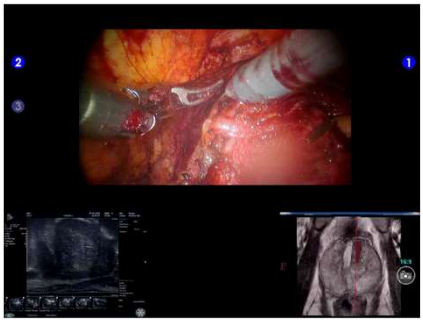

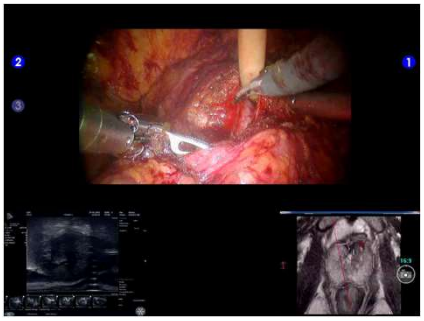

Example use cases during surgery

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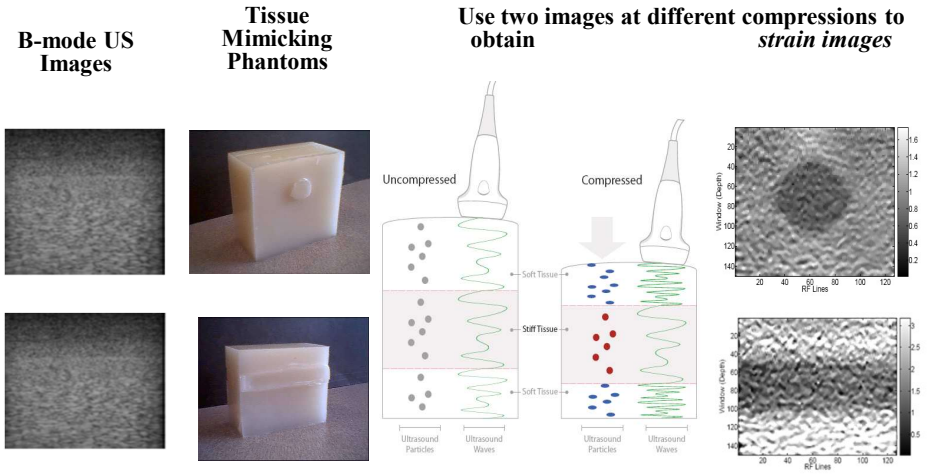
Elastography - introduction



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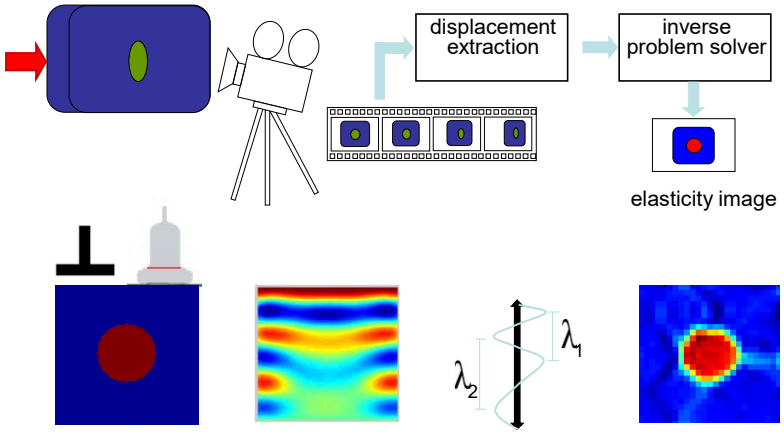
Elastography – basic components



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Homer and Dr. Hibbert

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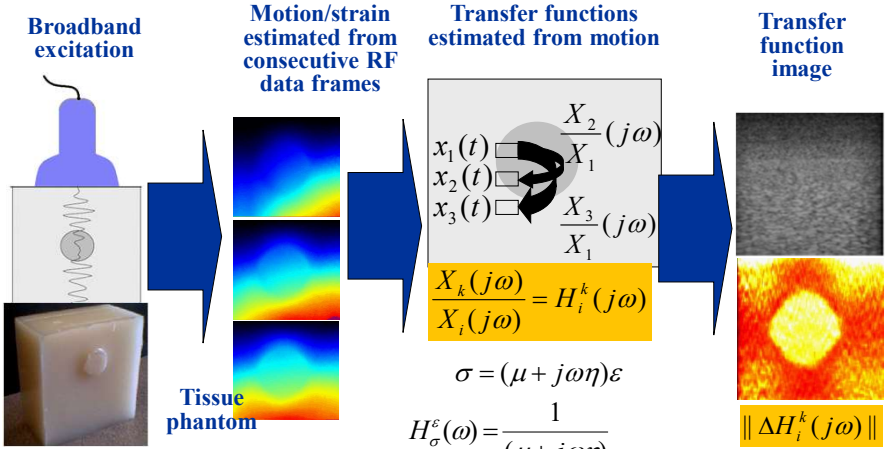
Vibro-elastography (VE)



$$\sigma = (\mu + j\omega\eta)\varepsilon$$

$$H_\sigma^\varepsilon(\omega) = \frac{1}{(\mu + j\omega\eta)}$$

$$\tau = \frac{\eta}{\mu} \qquad \tau = -\frac{1}{\omega}\angle H_\sigma^\varepsilon(\omega)$$

= relaxation time

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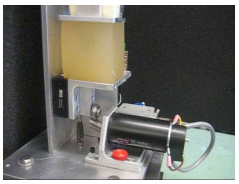
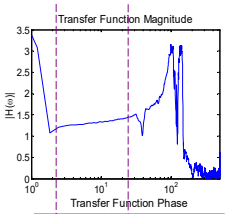
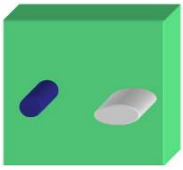
Shear Wave Vibroelastography - SWAVE

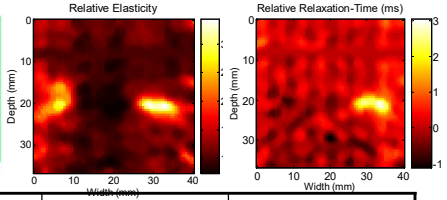


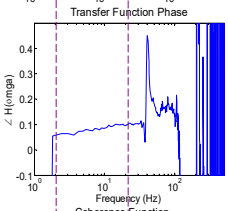
$$C_y^x(\omega) = \left|P_{xy}(\omega)\right|^2 / \left(P_{xx}(\omega).P_{yy}(\omega)\right)$$

$$H_y^x(\omega) = P_{xy}(\omega) / P_{yy}(\omega)$$

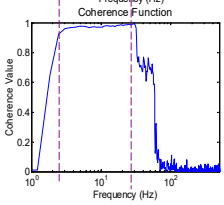








Material	Elastic Modulus (At 0.1Hz)	Relaxation-time (At 5Hz)
12% Gelatin	7 kPa	1.9 ms
18% Gelatin	17.1 kPa	1.7 ms
PVA Sponge	20 kPa	8.4 ms



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