Modeling and Control of a Radiation Therapy Couch (Counteract Breathing Induced Tumor Motion)

in honor of
Tom Edgar's 65th Birthday

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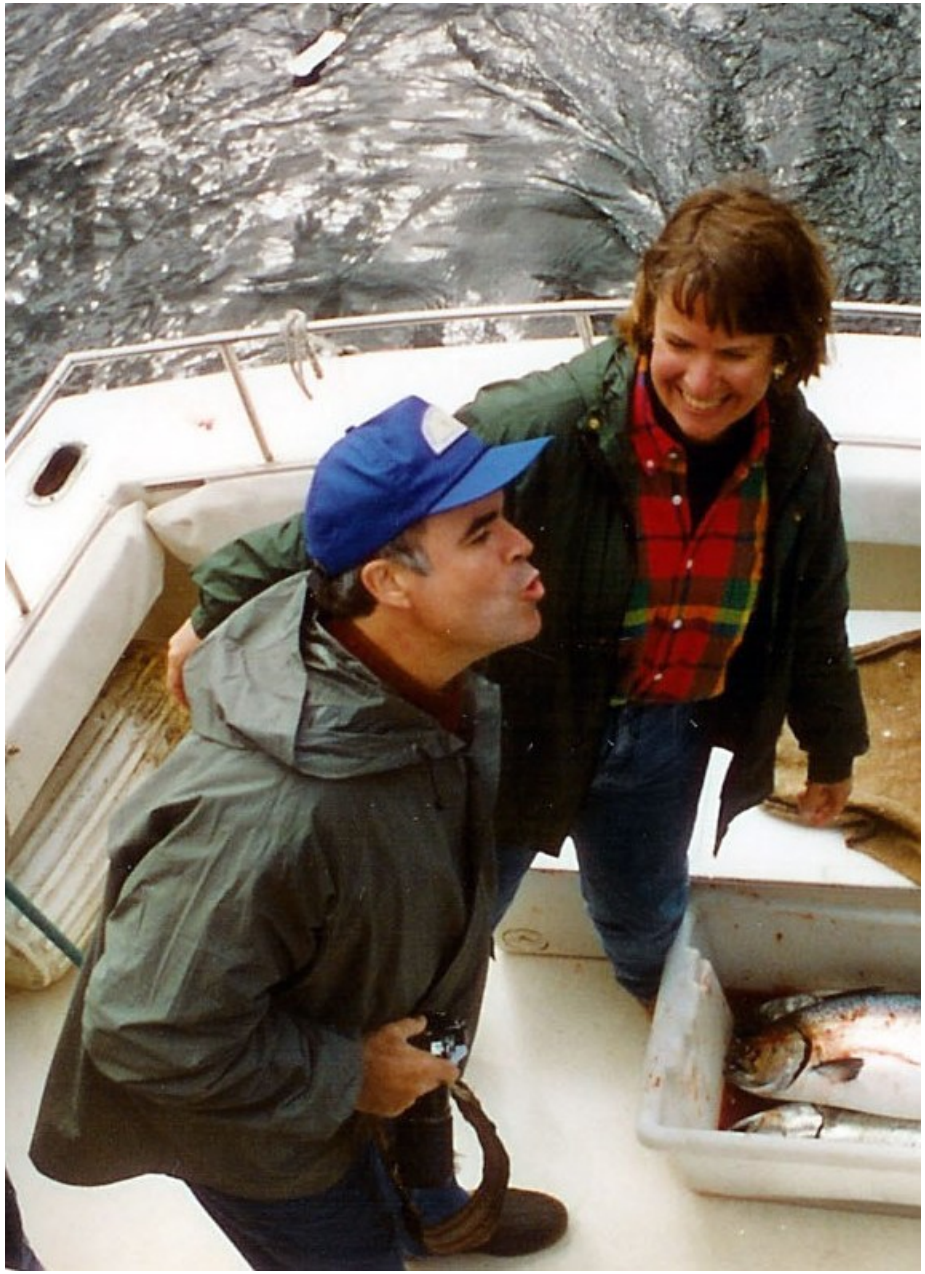
1993
Alaksa
Trip

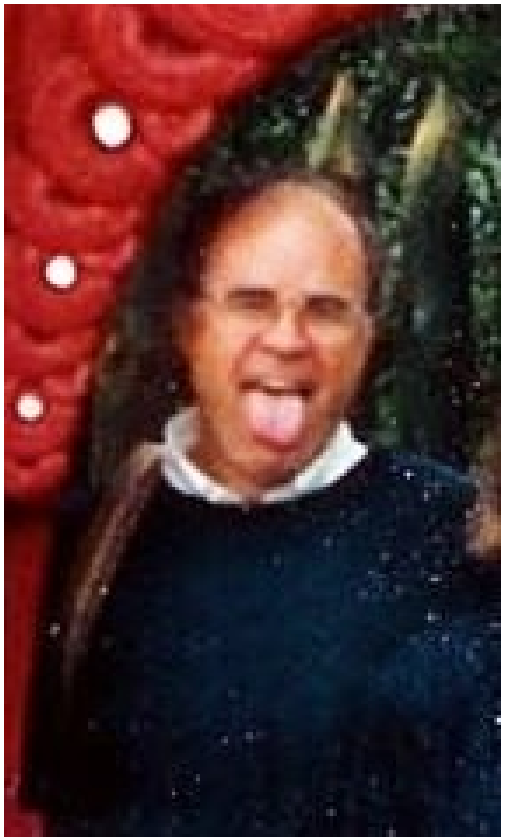
Tom Edgar's Record of Accomplishments

- Supervised 45 MS and 80 PhD's
- Over 250 Research Papers
- Numerous Professional Awards (Allan P. Colburn, Warren K. Lewis , Eckman Education , …)
- President of AIChE and AACC
- UT Austin Department Chair, Associate Dean , Vice President for Computing

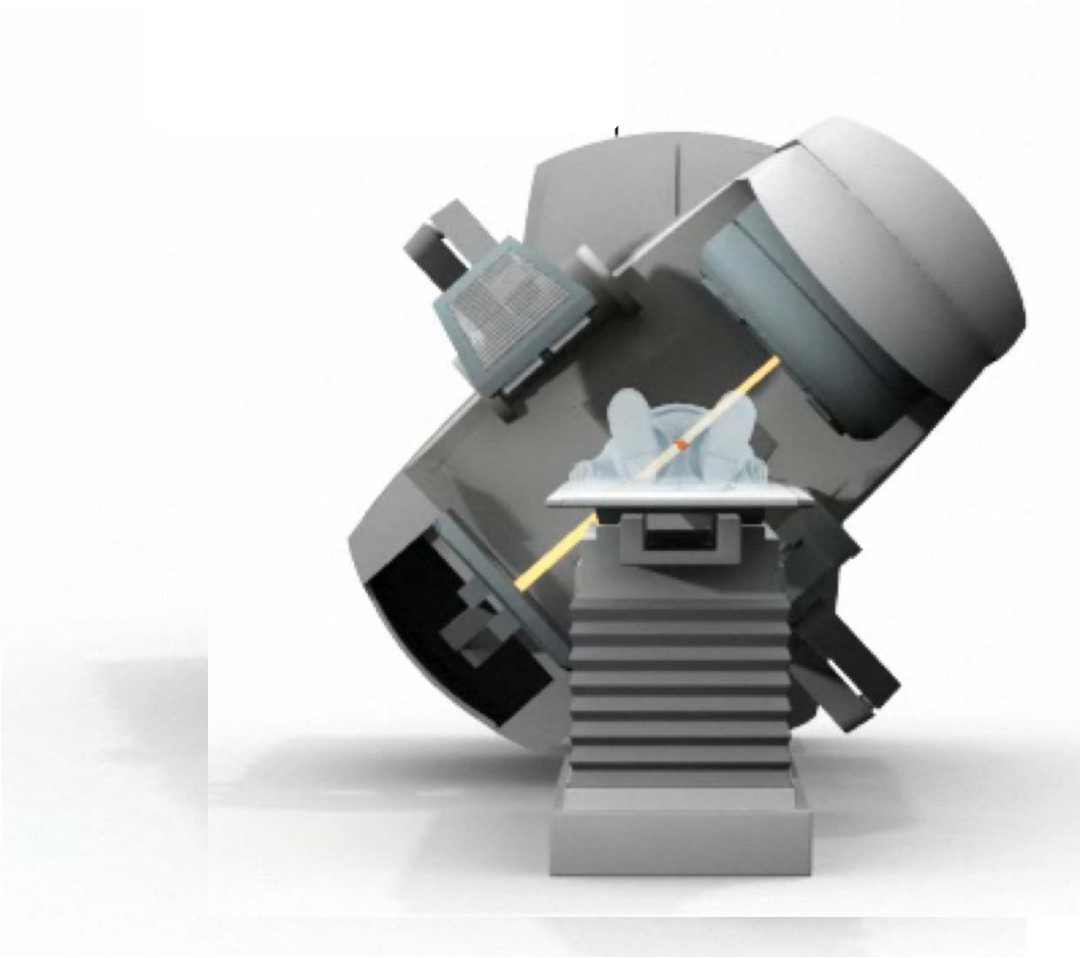
Serious Obstacles Tom Overcame

I WANT YOU
FOR U.S. ARMY
NEAREST RECRUITING STATION
JACK DANIEL'S
OLD TIME
Old
No.7
BRAND
QUALITY
HISKEY





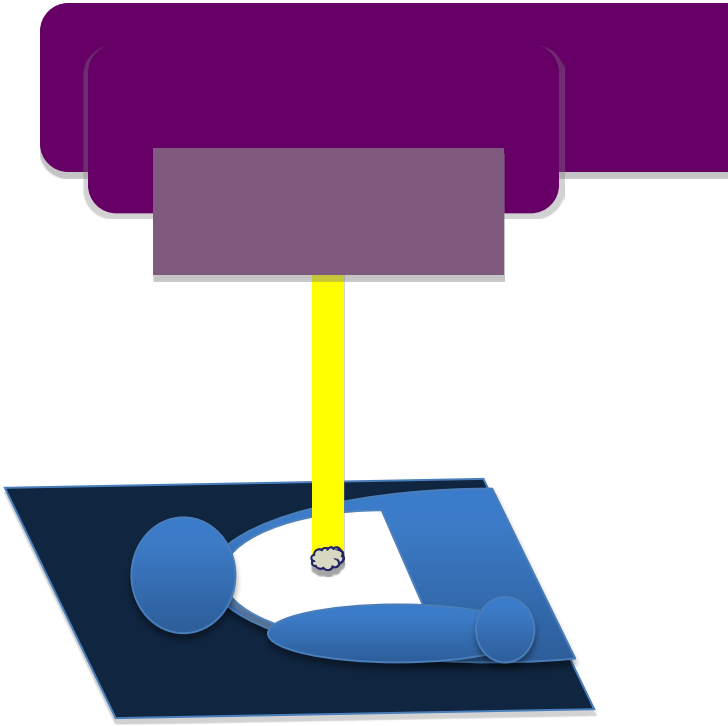
Cancer & Radiation Therapy



Breathing Induced Tumor Motion

Examples:

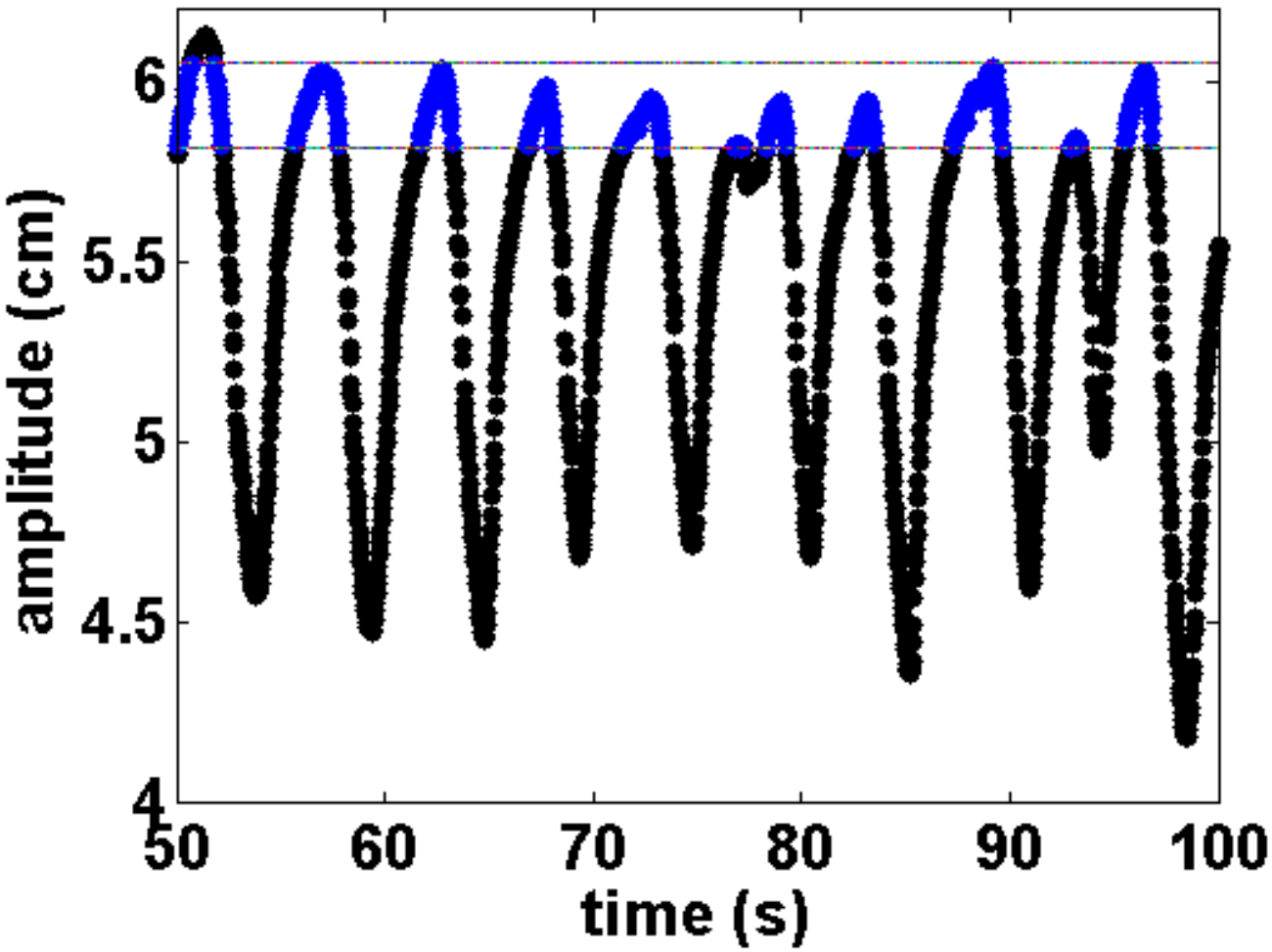
- Lung Tumors (Leading cause of cancer death)
- Tumors Close to Diagphragm



Existing Tumor Motion Correction Methods

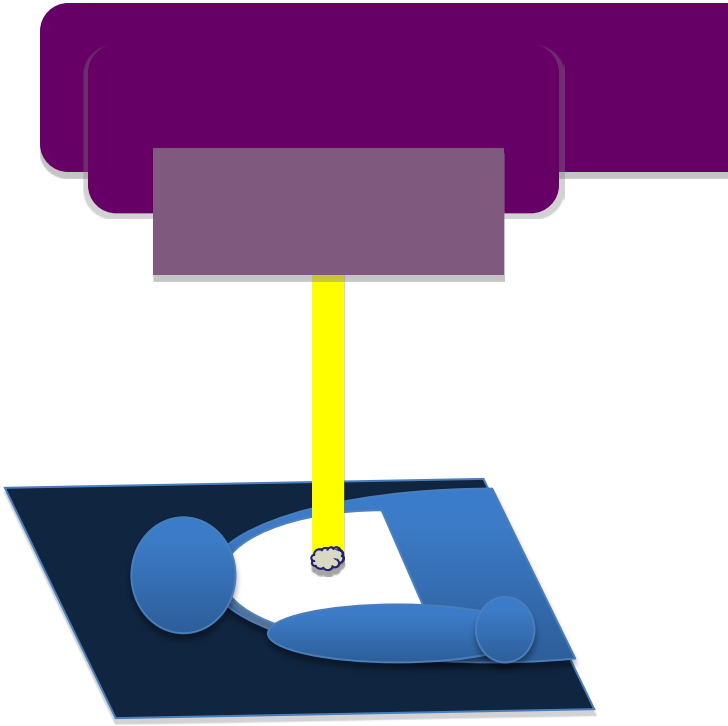
- Planning Margin to avoid geometrical misses
  - Results in increased volume of normal tissue irradiated
- Breath-holds (voluntary and forced)
  - Not tolerated well by lung tumor patients
  - Increased treatment time
- Gating
  - Requires patients to breathe reproducibly
  - Increased treatment time

Gating Window

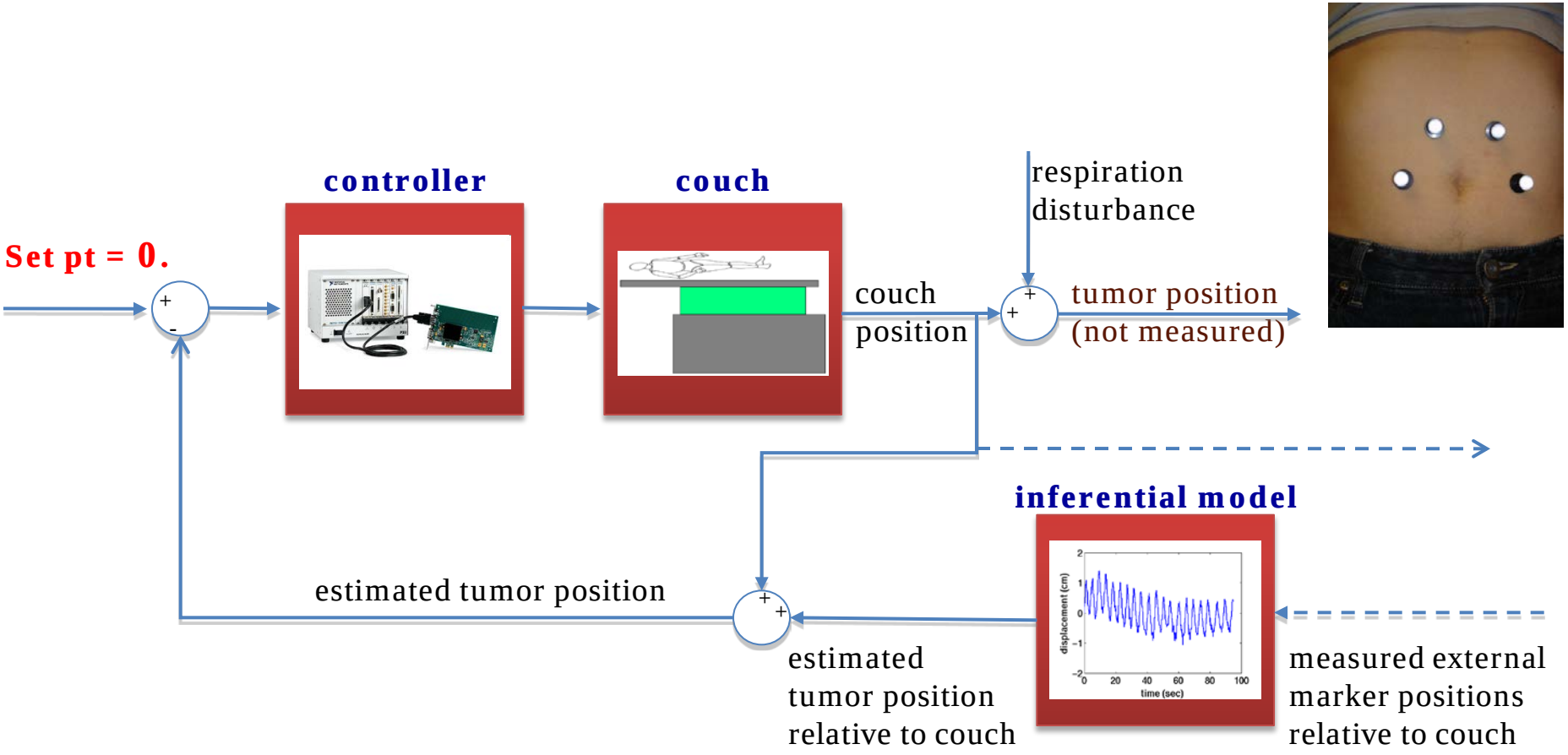


Breathing Induced Tumor Motion

- University of Maryland solution:
  - Reposition the treatment couch (and the patient) in real time to compensate for tumor motion



Inferential Model and Treatment Couch Control System



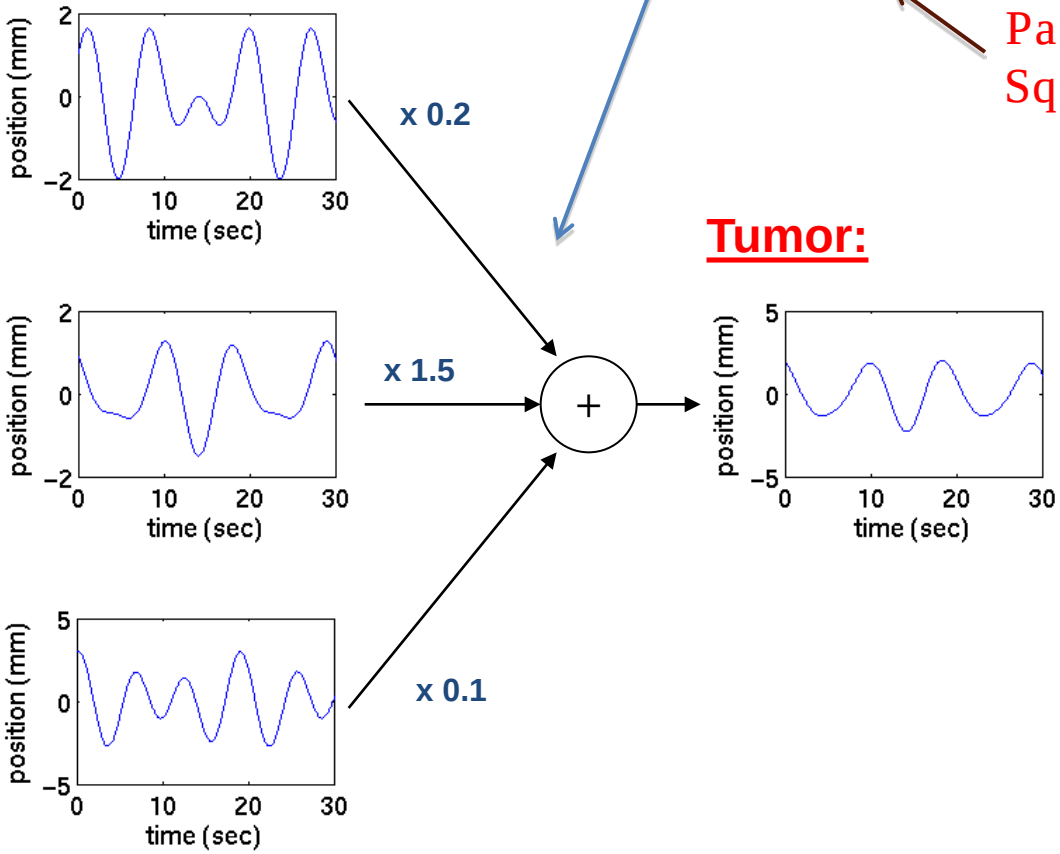
PLS Inferential Model

$$\hat{y} = b_1 \cdot x_1 + b_2 \cdot x_2 + \mathrm{K} + b_j \cdot x_j$$

$$\hat{Y} = X \cdot B$$

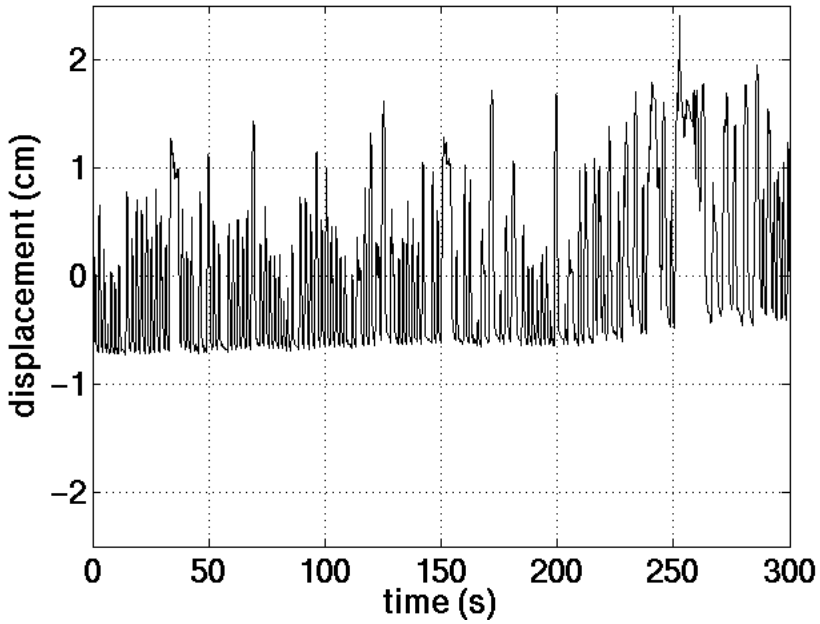
Partial Least Squares Regression

External Markers:

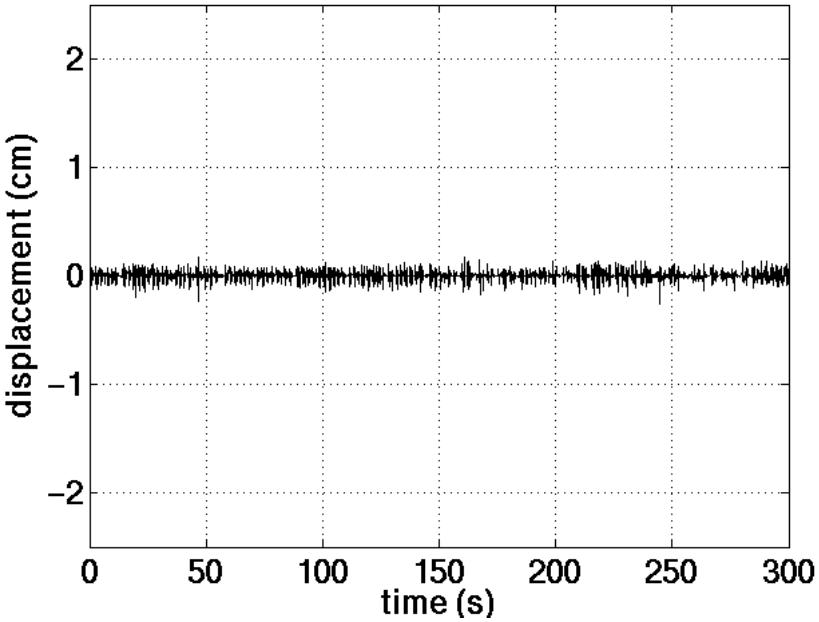


Feedback Control System Performance with Simulated Couch Dynamics

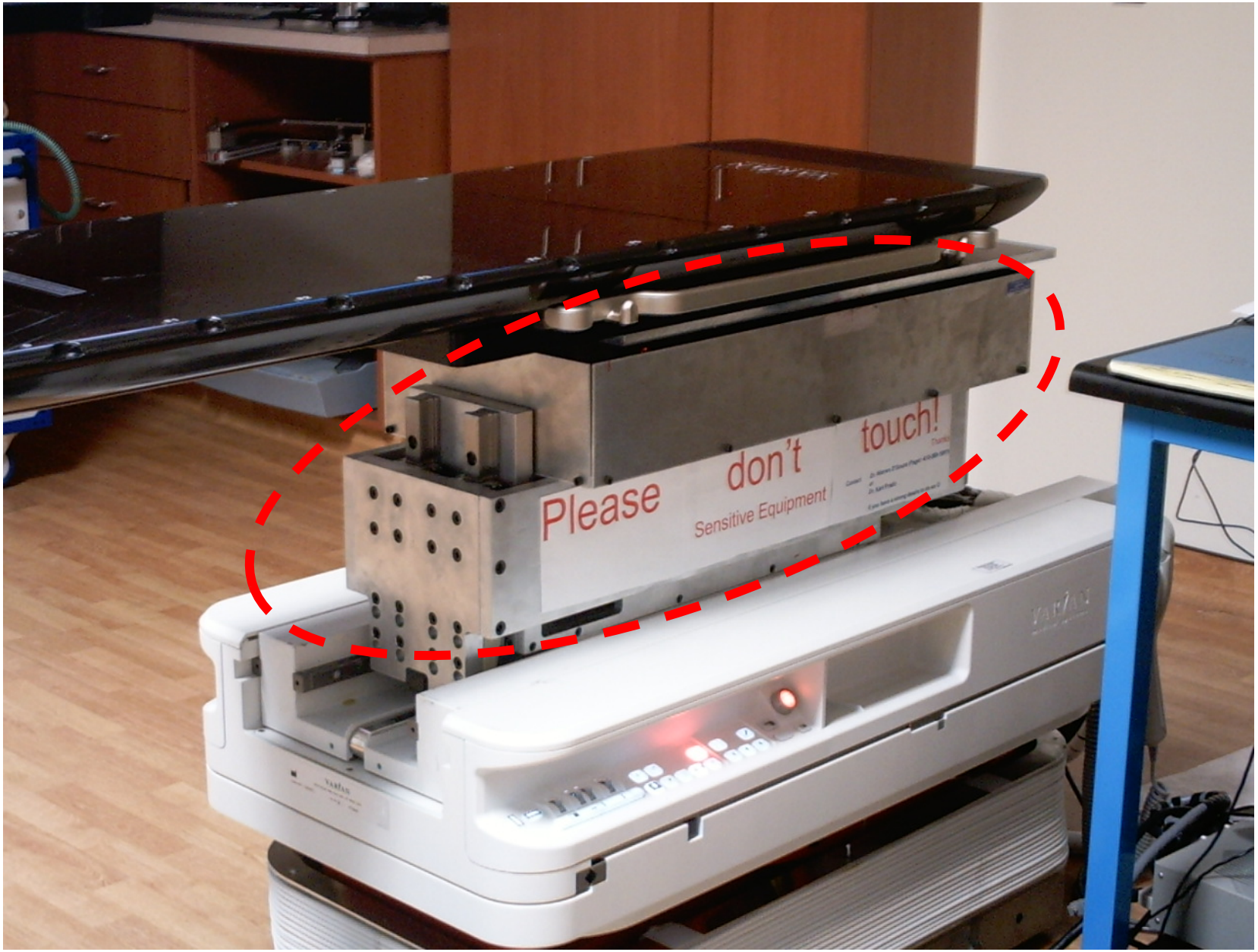
Raw tumor motion



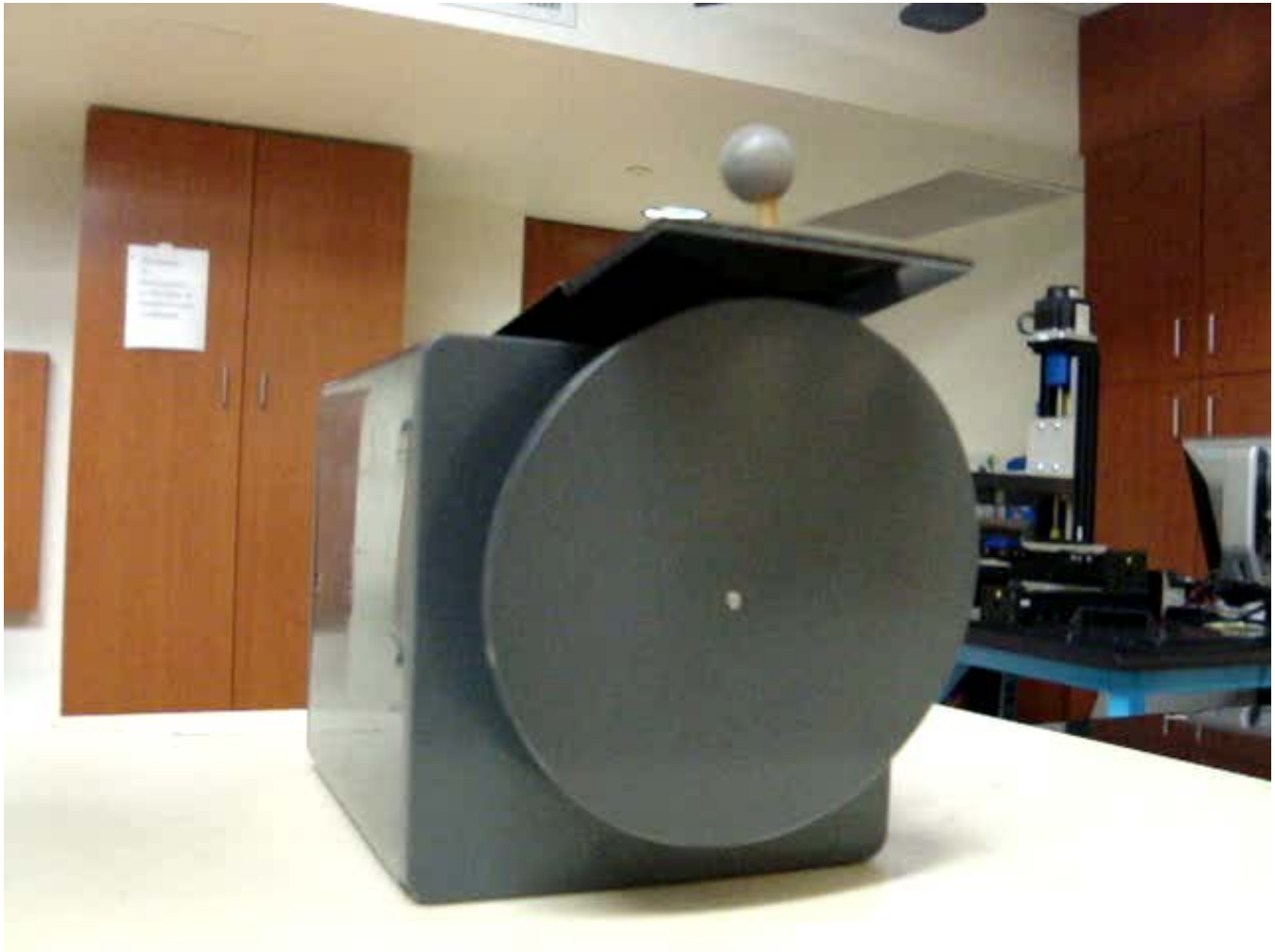
Residual motion



τ_t=0.068 *s*, τ_c=0.10 *s*,
θ_t = 0.067 *s*


Please don't touch!
Sensitive Equipment

Recent Progress: Hardware System



Real-Time Motion Synchronized Treatment Couch
(Interesting Process Control Problem)

- **Received Funding From NIH**
- **Prototype Couch Has Been Constructed**
- **Inferential Data Base Being Developed**
- **Dynamic Modeling/Control Being Studied**