Digital Beam Attenuator

Group Members

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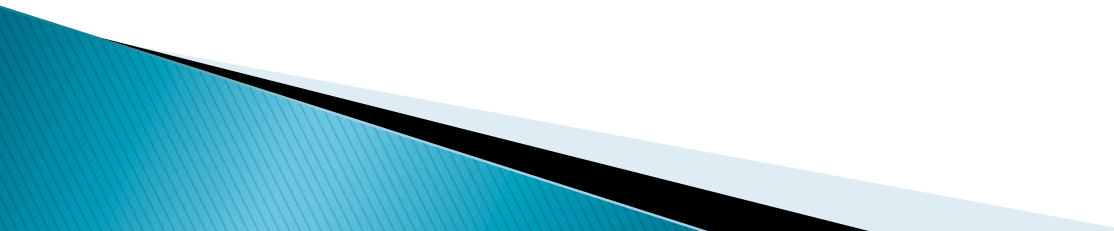
Advisor

Professor Chris Brace

Client

Dr. Charles Mistretta

Tim Szczykutowicz

Overview

- Client Description
- X-Ray CT Background
- Problem Definition
- Product Design Specifications
- Design Alternatives
- Design Matrix
- Future Work
- Acknowledgements

Client Description

http://www.med.wisc.edu/quarterly/news/chuck-mistretta-honored-by-radiological-society-of-north-america/31011

Dr. Charles Mistretta

Credit: Tim Szczykutowicz

Tim Szczykutowicz
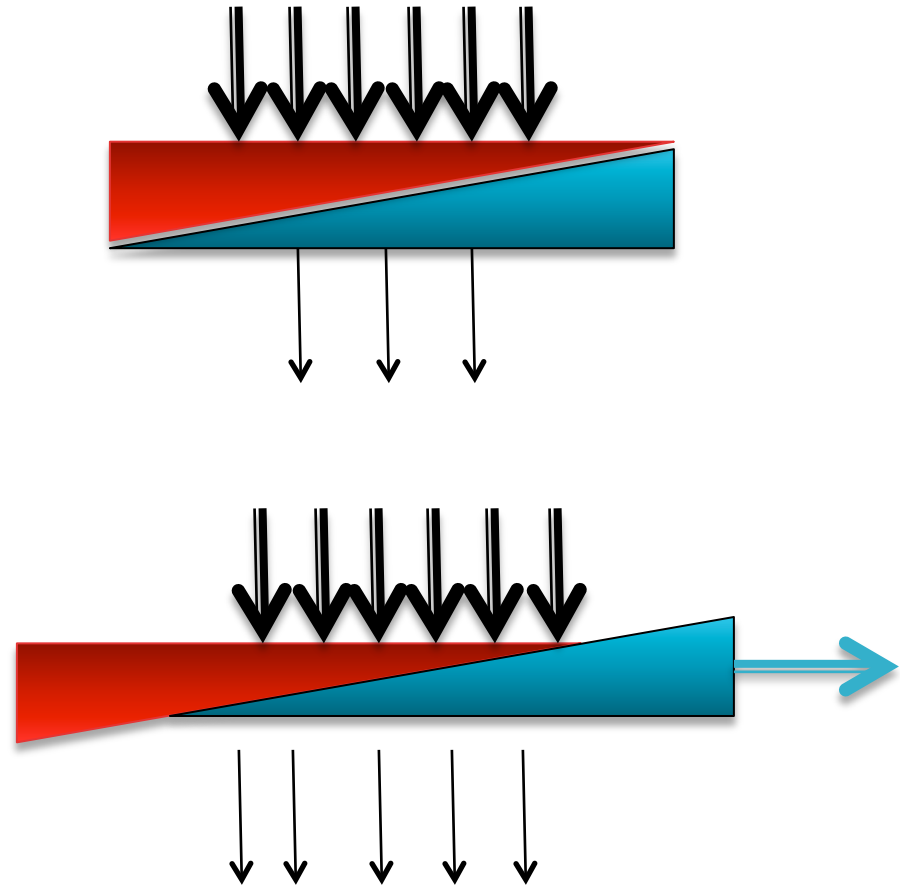
Background of X-Ray CT

- X-Ray Computed Tomography (CT)
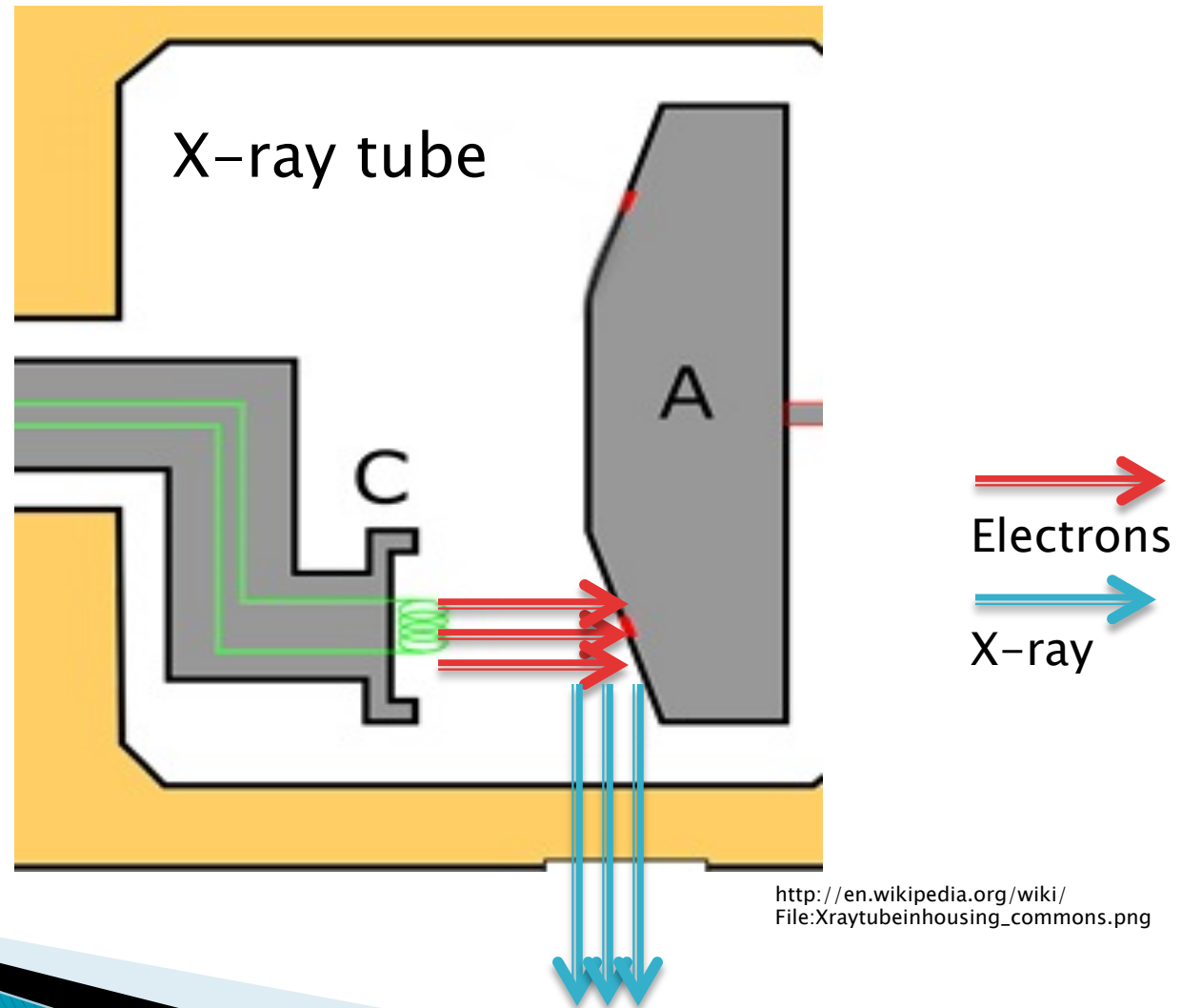- Diagnostic imaging
- CT-Guided Procedures
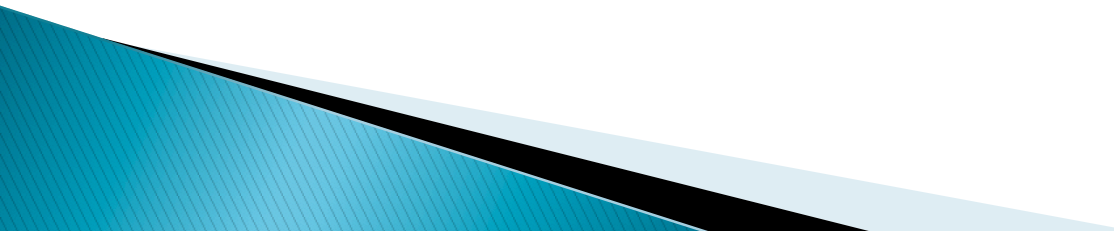

gifbin.com

Cranial CT

Problem Definition

- Current CT scans lack dose modulation
  - Lowest dosage used
  - Low quality images

- Client Proposal: Attenuate X-Ray dosages
  - Wedge thickness
  - Changes over time

- Goal:
  - Determine actuation mechanism
  - Simple prototype

Beam Modulation Background

X-ray tube

A

C

Electrons

X-ray

Product Design Specifications

- Wedges
  - Independent motion
  - Pre-programmed positions dependent on time
- Post-scan report of individual wedge positions
- Minimum 1mm movement increments
- Stroke length > 4cm
- Minimum speed: 15mm/s

Current Prototype

Credit: Tim Szczykutowicz

- ▸ 10 Wedges
  - ◦ Hand-actuated
  - ◦ 17.5mm in width
  - ◦ 275g/wedge
  - ◦ Steel
  - ◦ Mounted on plexiglass

System Alternatives

Electrical Control

▸ Pros:
  ◦ Precise positioning
  ◦ Less complex
    • Fewer components
    • Compatibility with CT

▸ Cons:
  ◦ Larger
  ◦ Expensive

Hydraulic Control

▸ Pros:
  ◦ Smaller
  ◦ Scalable
  ◦ More responsive velocity control

▸ Cons:
  ◦ More complex
  ◦ Potentiometer-based position feedback

Design Alternative 1:

Brushless DC Motor

▸ Low wear cost

us

Motor: http://electronics.howstuffworks.com/brushless-motor.htm
Screw and Pinions: http://www.havdonkerk.com/LinearActuatorProducts/
LeadScrewsAndNuts/LeadScrews

Lead-Screw

Gear and Track

Design Alternative 2:

Stepper Motor

- High precision

- Scalable

- Fixed step rotation

- Rotational motion

http://wintechprecision.com/StepMotors.aspx

Design Alternative 3:

Linear Servo-Motor

http://www.firgelli.com

- ▸ Precise position control
- ▸ Different controlling mechanisms
- ▸ Linear actuation
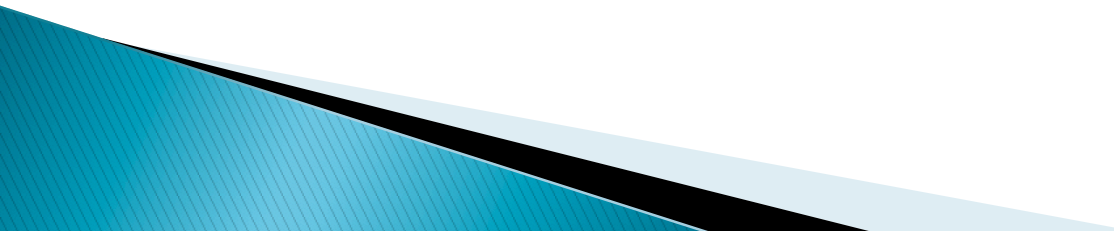
Design Matrix

Criteria	Brushless DC Motors	Stepper Motors	Linear Servomotors
Accuracy and Precision (20)	10	14	18
Size (20)	17	17	15
Scalability (20)	15	15	12
Speed (15)	13	13	12
Cost (10)	7	6	9
Control Mechanism (10)	4	5	8
Extent of Fabrication (5)	2	3	5
Total (100)	68	73	79

Future Work

- This semester:
  - Research hydraulics
  - Select method of actuation
  - Fabricate one-wedge prototype

- Next semester:
  - Actuate all wedges
  - Improve prototype

- Beyond:
  - Integrate DBA into X-Ray C-Arm

Acknowledgements

- Professor Chuck Mistretta
- Professor Chris Brace
- Tim Szczykutowicz
- Erick Oberstar
- Kevin

References

Kak, A.C. and Malcom Slaney. <u>Principles of Computed Tomographic Imaging</u>. IEEE Press, 1988.

McCollough, Cynthia H., Michael R. Bruesewitz and Jr,James M. Kofler. "CT Dose Reduction and Dose Management Tools: Overview of Available Options." <u>RadioGraphics</u> (2004).

Ketcham, Richard. <u>X-Ray Computed Tomography (CT)</u>. 1 February 2011. 29 September 2011 <<u>http://serc.carleton.edu/research_education/geochemsheets/techniques/CT.html</u>>.