DEVELOPMENT OF AN UPPER EXTREMITY FRACTURE MODEL

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Client: Dr. Matthew Halanski

PROBLEM STATEMENT

- Teach proper and safe techniques of fracture reduction and immobilization throughout the process of cast application and removal using a forearm fracture simulator
- Forearm fracture simulator must provide immediate feedback to the user to monitor fracture reduction:
  - Bone alignment
  - Applied force (three-point molding, cast saw)
  - Temperature at skin surface

CLIENT DESCRIPTION

- Dr. Matthew Halanski
  - Pediatric orthopedic surgeon at UW Hospital & Clinics
  - Research interest in safe fracture reduction

DESIGN CONSTRAINTS

Forearm fracture simulator must:

- Mimic the size of pediatric forearm (18 cm long, 5 cm wide)
- Protect sensors for damage by the saw
- Measure & display temperature, pressure & alignment in real time
- Clearly indicate successful fracture reduction
  - <15° angulation
  - <2 mm displacement

MOTIVATION

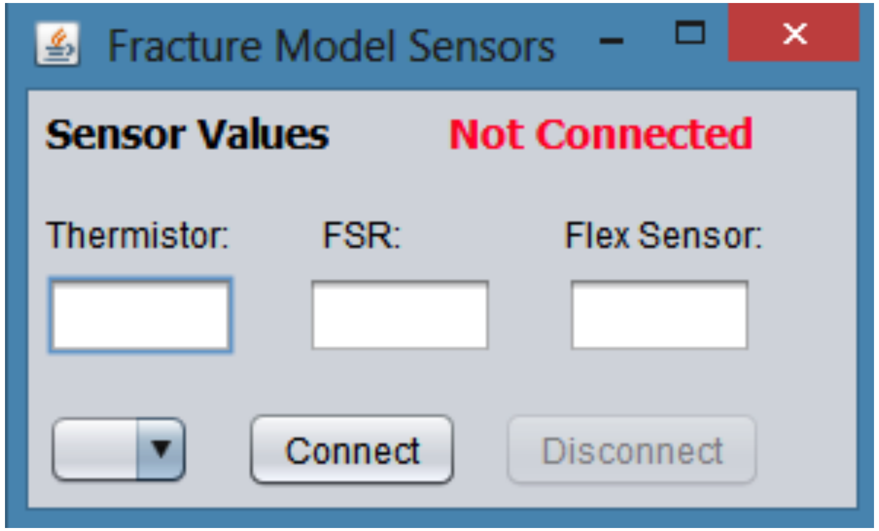
- 1/3 of children will suffer a fracture, forearms most common (Hedström. *Acta Orthopaedica* 2010; 81(1):148–153)
- Casting is not always safe!
  - Cast accidents are #1 cause of litigation, each can cost up to $120,000 (Killian, J of Ped Ortho. 1999. 19(5): 683-7)
  - Little formal, hands on training for residents

Figure 1: Cast saw burns (courtesy of Dr. Halanski).

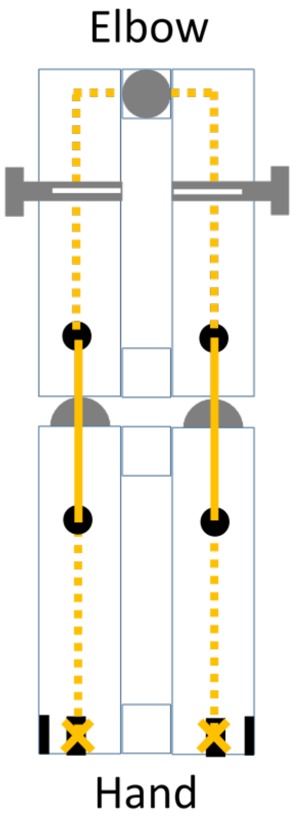
CURRENT DEVICES

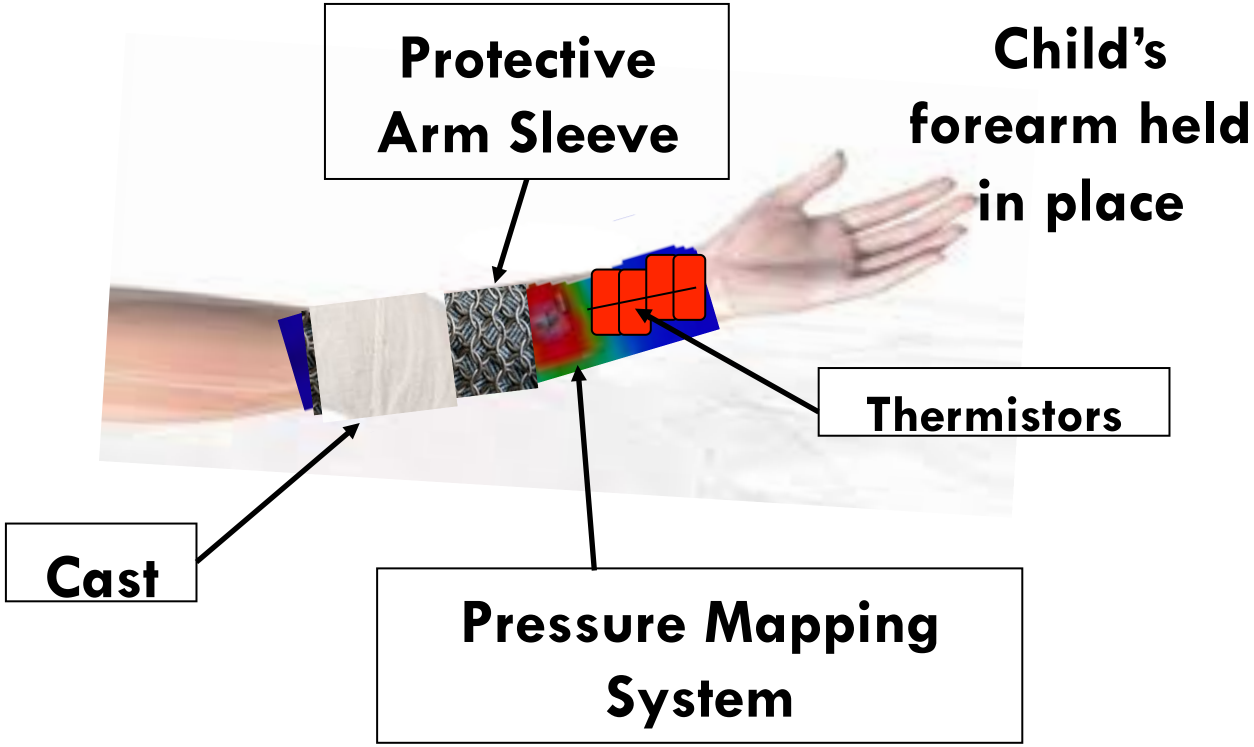
Figure 2: Client's prototype (courtesy of Dr. Halanski).

PRELIMINARY PROTOTYPE



CURRENT PROTOTYPE





EVALUATION AND TESTING

- Latex Tubing - Modulation of Resistance - MTS Testing
  - To failure
  - Static testing
  - Tension: cycles of stretching bands 0%-30%
- Temperature sensors
- Alignment and Pressure Sensors: Cast Index and X-Ray Verification
  - Accuracy
  - Precision
- Effectiveness of the device as a learning tool
  - Each person is own control
  - Test, practice, retest
  - Evaluate improvement over time

TIMELINE

Construction

- 3/01 Modular mechanical components & flex sensor integration
- 3/15 Soft tissue incorporation
- 3/22 Pressure mapping system integration,
- 4/01 Update user interface

Evaluation

- 4/12 Validate sensitivity with expert users
- 4/26 New user testing, teaching model

DESIGN IMPROVEMENTS

- Accessible internal components
  - Modulate resistance in multiple plains
- User manual including maintenance instructions & safety warnings
  - Additional surgical tubes with instructions about fatigue
  - Replacement skin layers after damage
- All components easily removable from board & able to rotate
  - Components easily transported in a small box plus board

FUTURE COST ANALYSIS

Additional Materials	Quantity	Cost Estimate
Thermistors	12	$13.00
PlatSil Gel-10	4 lbs	$50.00
Flex Sensors	6	$75.00
Pressure Mapping system	1	$10,225
Miscelaneous Mechanical and electrical Components	-	$30
TOTAL:		$10,393.00

CURRENT COST ANALYSIS

Material	Quantity	Cost
Plywood Base	1	$5
PVC Pipes	1	$1.25
Thermistor	3	$3.24
Force Sensing Resistor	1	$20
Arduino Mega Microcontroller	1	$47.99
Arduino Starter kit	1	$22.50
Protective Sleeve material	48”x 84”	$7.85
PDMS	500 grams	$60
PlatSil Gel-10	6 lbs	$100
USB A-B Cable	1	$4.00
1/4” ID Latex Surgical Tubing	17’	$36.00
Prewrap material	1 roll	$5
Flex Sensor	2	$24.90
Miscelaneous Mech. Components	-	$0
	TOTAL:	$330.50

QUESTIONS?