



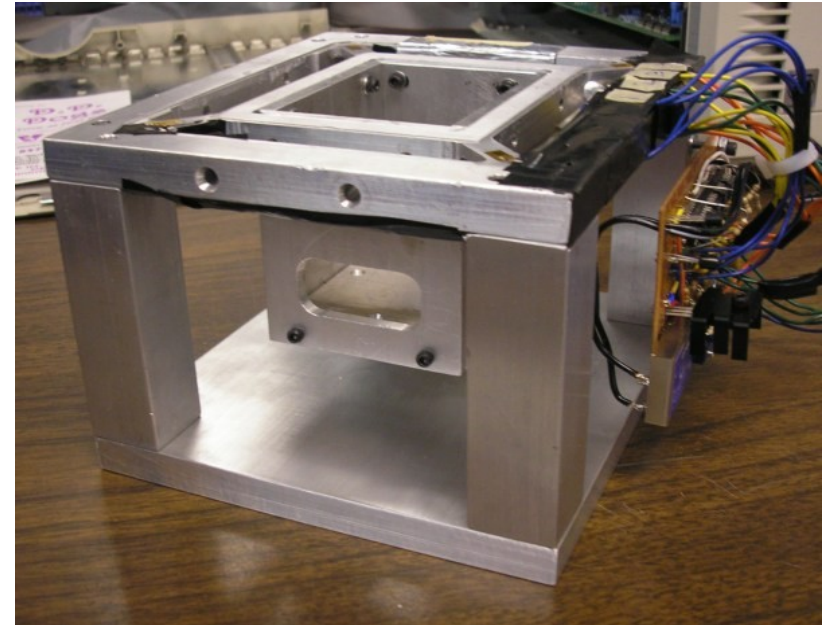
Bachelor Work

Fingertip Position Sensor

Stefan Bracher

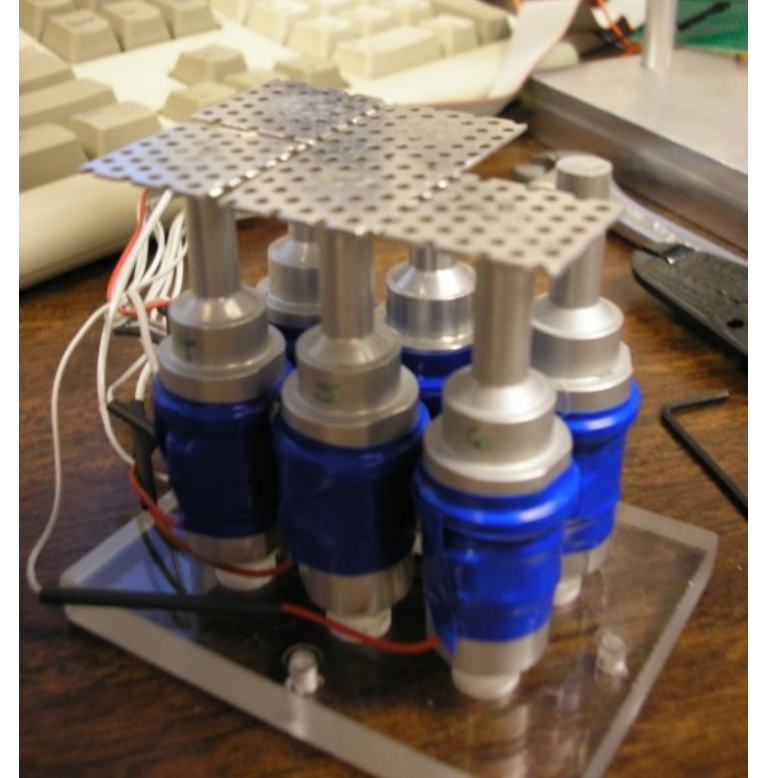
Northwestern University/ ETH Zürich

- Content
 - Introduction
 - Mathematical model
 - Implementation
 - Testing
 - Conclusion/ Discussion



Fingertip position sensor

- Introduction
 - The tactile display
 - developed at Northwestern University by John Glasmire
 - surface friction can be changed



The tactile display



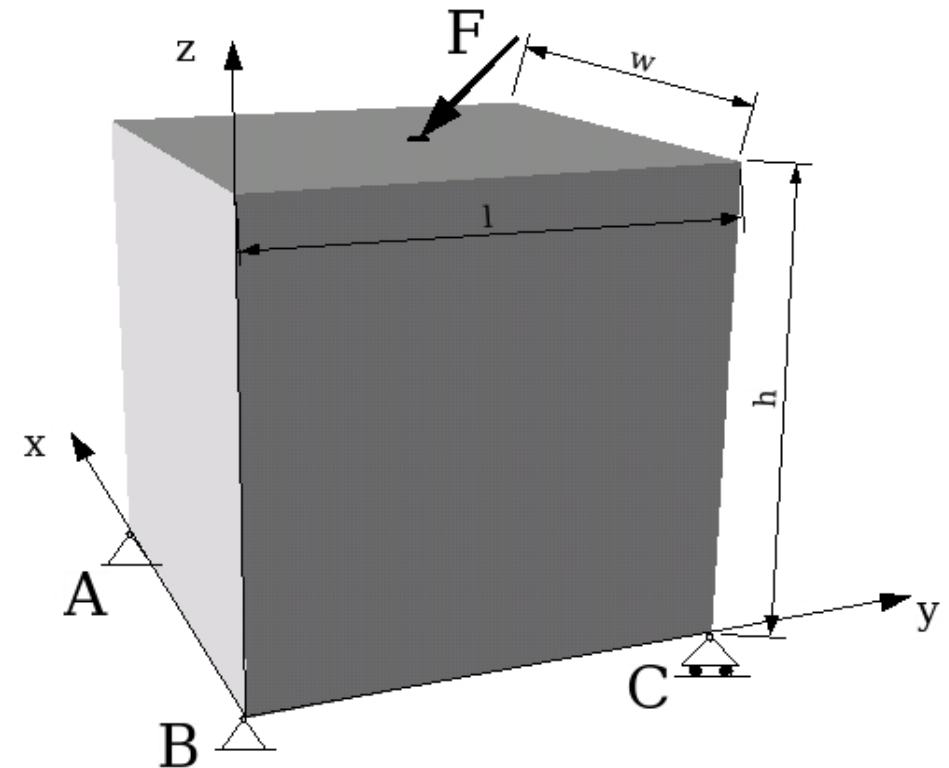
Fingertip Position Sensor

- Introduction
 - Task description
 - Development of a fingertip position sensor for the tactile display, based on reaction forces
 - Mathematical model
 - Design and fabrication of the sensor
 - Real-time computer code under QNX
 - Interface to tactile display

- Mathematical Model

- Constraints

- Point A: y, z
 - Point B: x, y, z
 - Point C: z

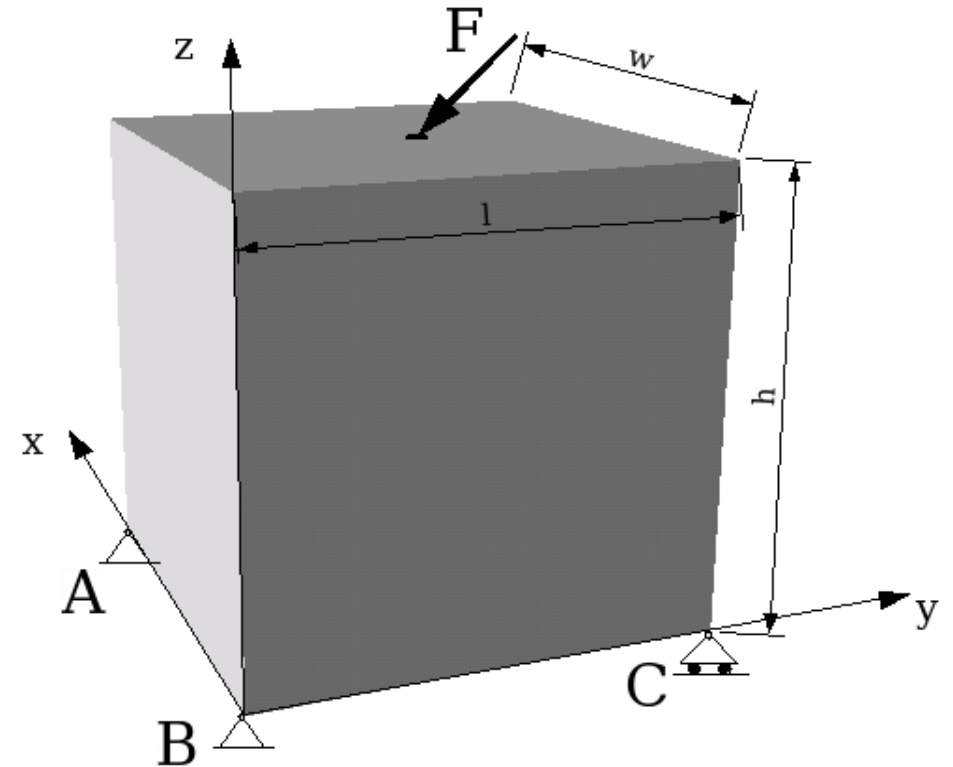


Idealisation of the tactile display as a box

- Mathematical model
 - Solution

$$y = \frac{F_y * h - C_z * l}{F_z}, \quad x = \frac{F_x * h - A_z * w}{F_z}$$

$$F_x = -B_x, \quad F_y = -A_y - B_y, \quad F_z = -A_z$$

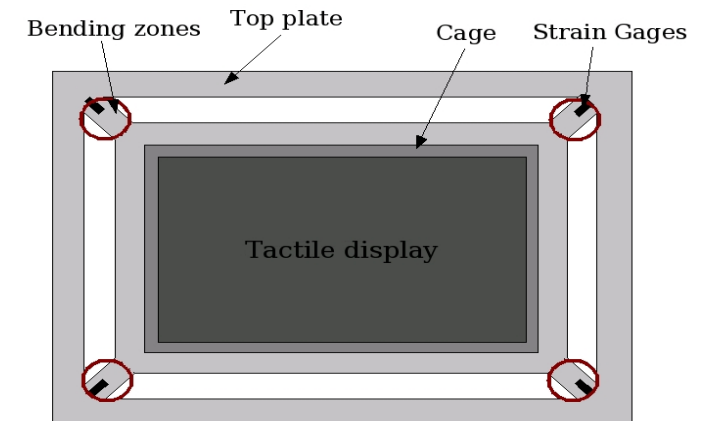
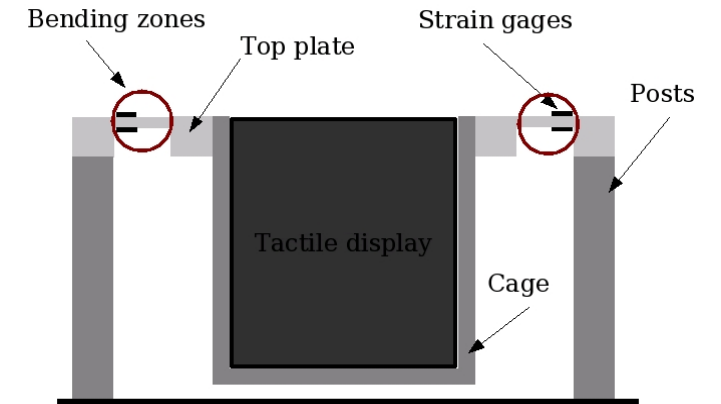


Idealisation of the tactile display as a box

Fingertip Position Sensor

- Implementation
 - Simplifications
 - Force measurement in top plane
 - 4 supporting points
 - Forces in x and y direction neglected
 - Modified formula

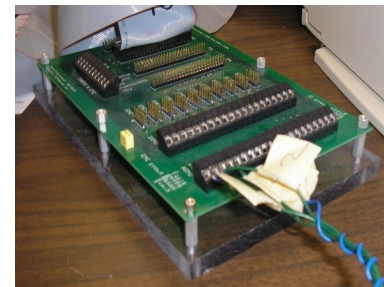
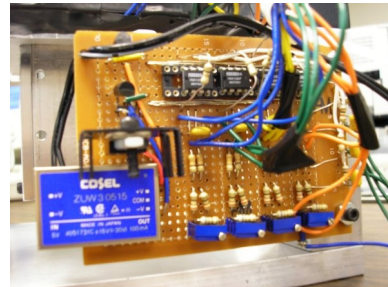
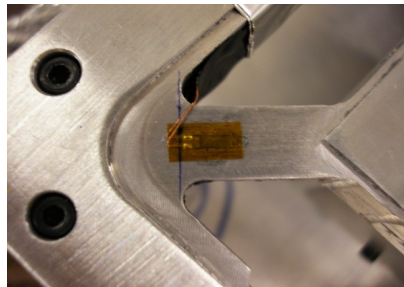
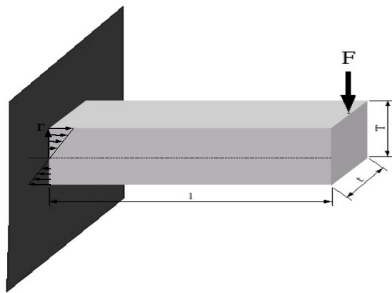
$$y = \frac{-(C_z + D_z) * l}{F_z}, \quad x = \frac{-(A_z + D_z) * w}{F_z}$$



Cross section and top view of the device

Fingertip Position Sensor

- Implementation
 - Working principle



```

Sensor1: -2.3535
Sensor2: 0.6836
Sensor3: -0.9448
Sensor4: 2.0801

Sensor1-filtered: 0.0854
Sensor2-filtered: -0.3340
Sensor3-filtered: 0.0414
Sensor4-filtered: -0.0473

x: 3.0000
y: 0.0000
    
```

QNX Platform



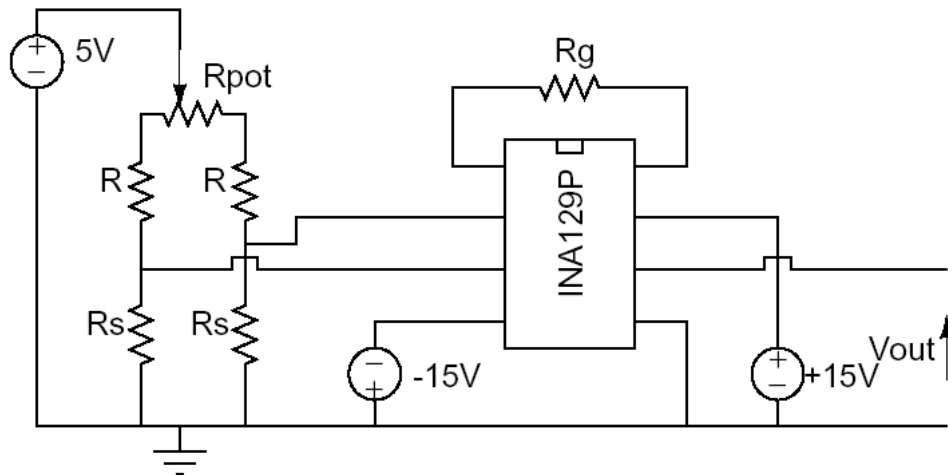
Fingertip Position Sensor

- Implementation

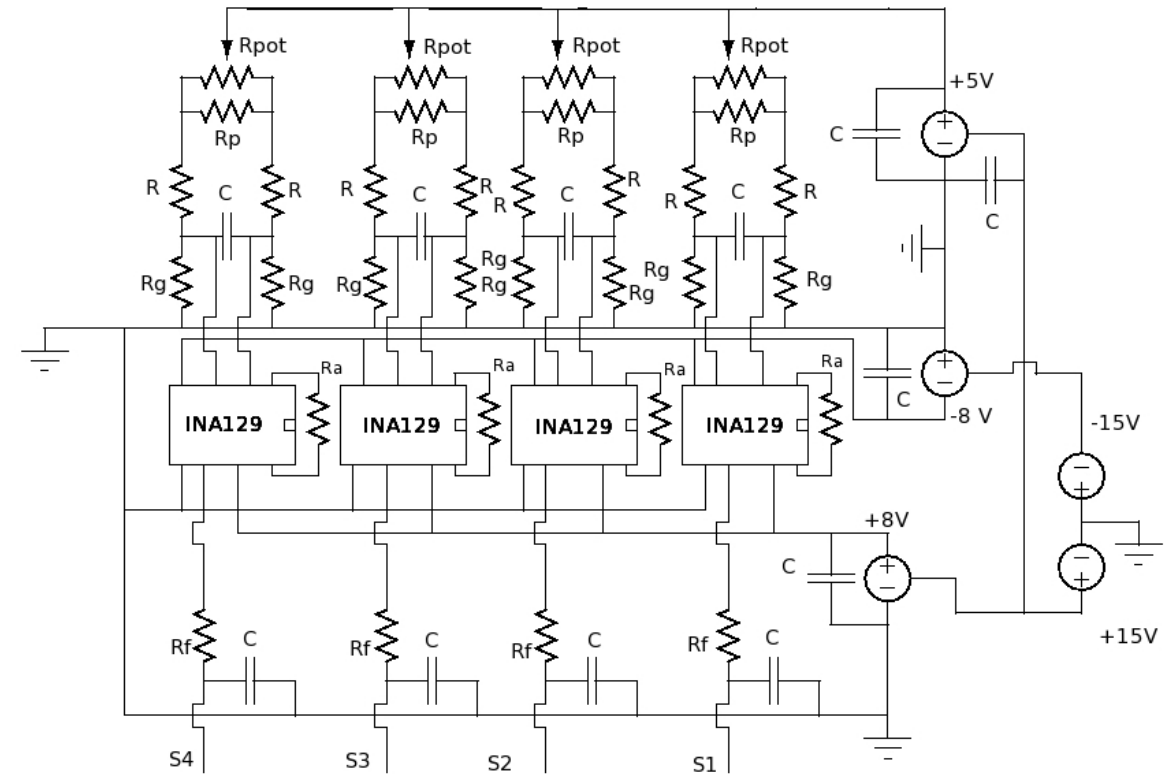
- Dimensioning

- “Cage” dimensions given by the tactile display (3*2.25*4 inch)
- Cantilever dimensions (0.6*0.4*0.15 inch)
 - a finger touch (25g) gives 1.9V (after amplification with 2500)
 - maximal push (200g) gives 9.5V (after amplification with 2500)

- Implementation
 - Signal Conditioning and Amplification



Wheatstone half-bridge and Op-Amp



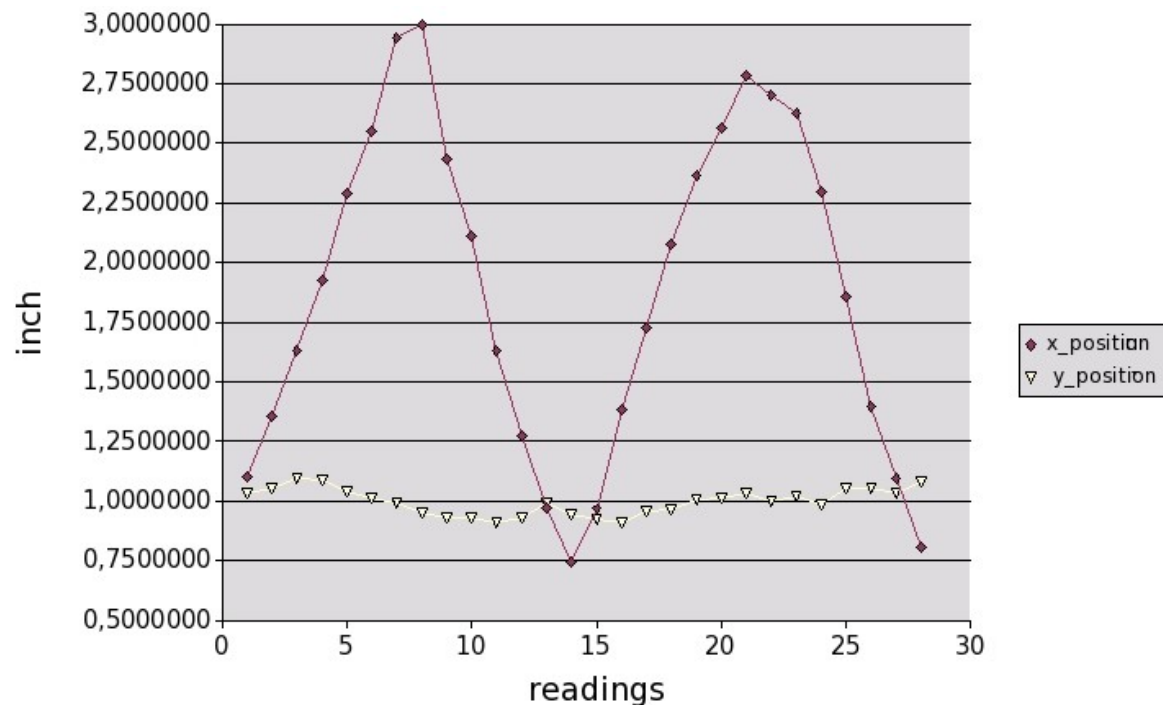
Complete circuitry



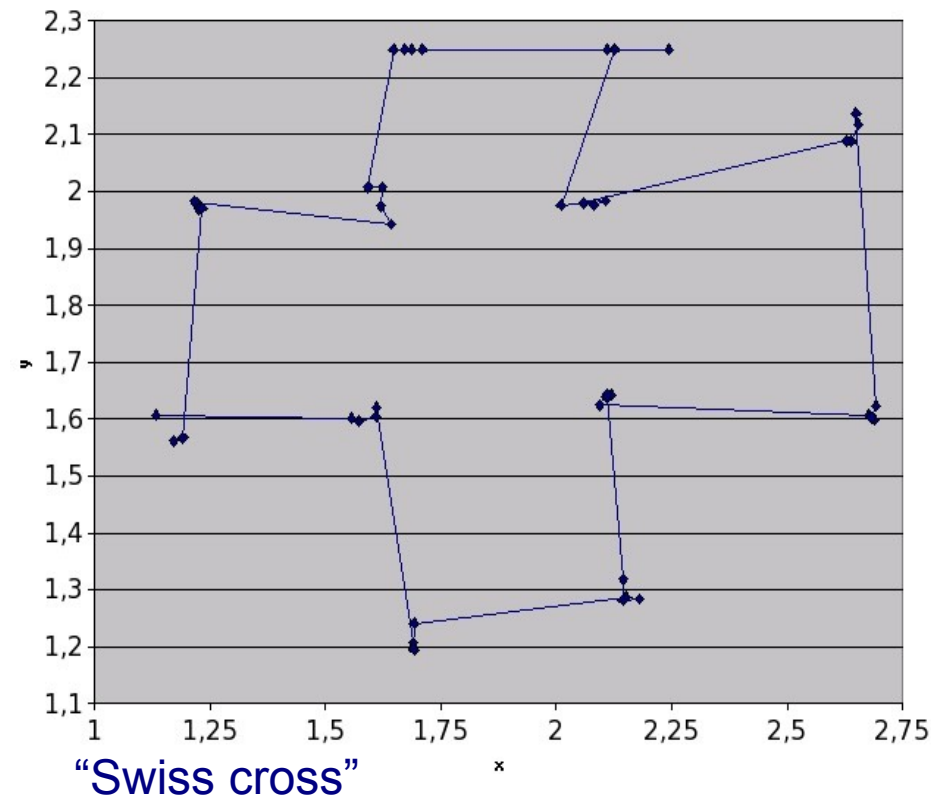
Fingertip Position Sensor

- Implementation
 - Software
 - Real time QNX Platform
 - Additional functions included in program of tactile display
 - Moving average filter
 - Sensor Calibration
 - Fingertip Position Calculation
 - Coordinate system mapping
 - Data Recording

- Tests

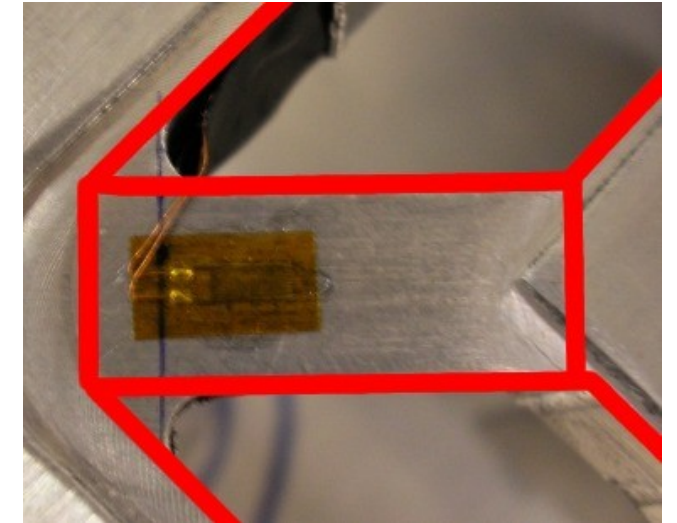


Finger moved along x-axis



"Swiss cross"

- Problems
 - Signal 20 times smaller than expected
 - Noise
 - Drift
- Inaccuracy of about 0.5 inch
- reduced sensitivity: Only a “Push” can be detected



Ideal vs. real cantilever shape



Fingertip Position Sensor

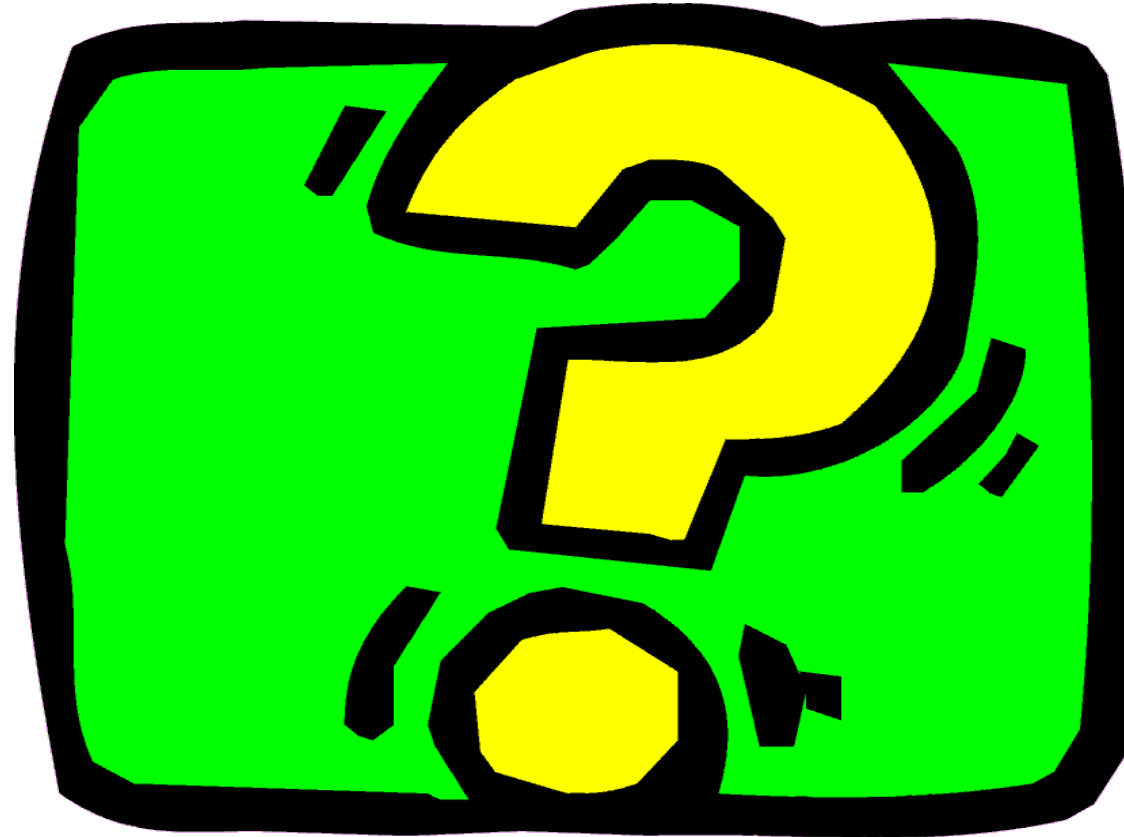
- Conclusion/ Discussion
 - It is possible to make a “Touchpanel” based on the reaction forces
 - Improvements can and have to be done
 - More signal
 - Avoid drifting
 - Noise reduction



Fingertip Position Sensor

- Conclusion/ Discussion
 - Proposed improvements
 - Thinner cantilever beams
 - Full Wheatstone Bridges (4 instead of 2 strain gages per cantilever)
 - Separating the heat producing part of the electronics (DC/DC Converter and Voltage controllers)
- Details see report

- Questions



<http://bcn.boulder.co.us>