ME 451 , JAN, 6TH 2014

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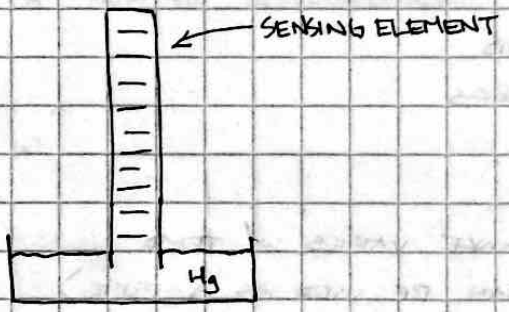
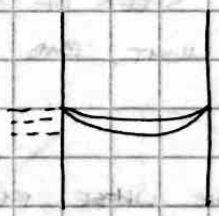
* OFFICE HOURS: TBD

* NOTES:

- SENSORS: THINGS THAT MEASURE THE WORLD
  - → ALLOWS US TO BUILD THINGS THAT RESPOND TO CHANGES
  - → RECORD INFORMATION, TELLING STATUS OF THINGS

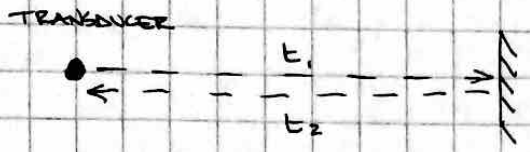
(1.) SENSORS ARE


(2.) GOOGLE EXISTS

1/6/2014

* SONAR SENSOR

"SENSORS DON'T MEASURE WHAT YOU WANT TO MEASURE - DIRECTLY"





QUANTIZATION ERROR

NOISY:
- HOW FLAT IS THE WALL?
- (SURFACE CHARACTERISTICS)
- AUDIO INTERFERENCE
- DISCRETIZATION ERROR

WRONG:
- SPEED OF SOUND
- AIR TEMP
- BAD MATH

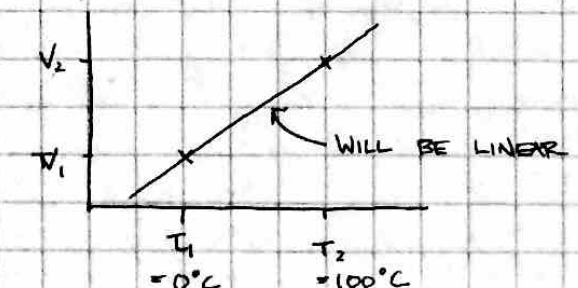
LATE:
- ARE THINGS MOVING? $t_1 \neq t_2$

1/8/2014

SENSORS ARE:
- NOISY : DATA POINTS
- WRONG : BAD MATH, SPEED OF SOUND
- LATE : SPEED OF LIGHT, BAD SENSORS

NOTES:
- THERMISTOR: RESISTOR WHOSE RESISTANCE VARIES W/ TEMP.
  - PTC : POSITIVE TEMP. COEFF. (CAN BE USED AS A FUSE)
  - NTC : NEGATIVE TEMP. COEFF.

- THERMOCOUPLE
  - SEEBACK EFFECT; CONDUCTORS GENERATE A CURRENT WHEN SUBJECTED TO A TEMP. GRAD



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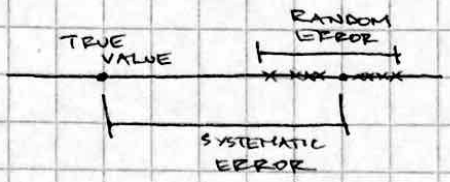
*VALIDTY OF MEASUREMENT:

- ERROR = (MEASURED VALUE) - (TRUE VALUE)

• SOURCES OF ERROR:
  - CALIBRATION
  - NONLINEAR
  - LOADING ERRORS
  - INTRUSIVE SENSOR
  - OTHER VARIABLES

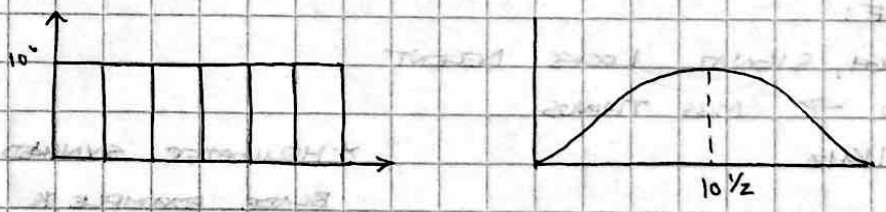



• ACCURACY: SYSTEMATIC ERROR
• PRECISION: RANDOM ERROR

*WHY NORMAL DISTRIBUTIONS?:
- USED A LOT IN MODELING

SYSTEMATIC ERROR $\approx \mu$
RANDOM ERROR $\approx \sigma$
} WANT BOTH TO BE CLOSE TO ZERO

• CENTRAL LIMIT THEOREM:
- DISTRIBUTION OF SUM OF N ARBITRARY DISTRIBUTIONS TENDS TOWARDS A NORMAL DISTRIBUTIONS




- POPULATION: ENTIRE COLLECTION OF MEASUREMENTS
- SAMPLE: REPRESENTATIVE SUBSET POPULATION

MODE = HIGHEST POINT ON CURVE
MEAN = AVERAGE
MEDIAN = # OF MOST FREQUENTLY READ

1/13/2014

ANALOGUE TO DIGITAL CONVERSION

DIGITAL: A SYSTEM THAT USES DISCRETE VALUES (OPPOSITE OF ANALOGUE)

BINARY:

1
10
11
100
101
110
111

LEAST SIGNIFICANT BIT

MOST SIGNIFICANT BIT

* ANALOG TO DIGITAL CONVERTOR

- TRADE OFF: RESOLUTION VS. SAMPLING SIZE

• RESOLUTION:
  - 10 BIT OUTPUT HAS 1024 ($2^{10}$) UNIQUE MEASUREMENT POSITIONS

  → LOOK @ SLIDES w/ WATER TANK EXAMPLE

• SAMPLING RATE:
  - FAST ENOUGH, SIGNAL LOOKS DECENT
  - TOO SLOW → MISS THINGS
  - CD = 44.1 KHz

* HELICOPTER SYNCHED ROTOR BLADE EXAMPLE *

* ALIASING:
• FALSE FREQ. THAT IS AN ARTIFACT OF THE SAMPLING PROCESS
  - UNDERSAMPLE: LOSE INFORMATION
  - ~~OVERSCIENCE~~ :
  - OVERSAMPLE: FILE TOO LARGE

* NYQUIST FREQUENCY:
  - HALF THE SAMPLING RATE OF AD
  - $f_s > 2f_m$

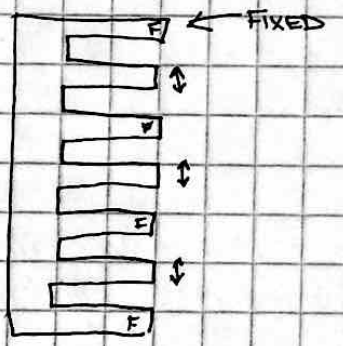
IT IS THE HIGHEST FREQUENLY THAT CAN BE MEASURED W/ A GIVEN SAMPLING RATE

* FORIER TRANSFORM:

* MEMS, ACCELORIETERS

MEMS → MICRO-ELECTRIC-MECHANICAL SYSTEMS

- ACCELEROMETERS
  - MEASURE FORCES, NOT ACCELERATIONS




← FIXED

CAPACITANCE BETWEEN FINS CHANGES W/ DISTANCE, WHICH CHANGES W/ ACCELERATIONS

WHAT DID YOU DO @ LTG?

- WORKED IN NPD, GROUP RESPONSIBLE FOR DEVELOP. OF TOOL FROM SELECTION → IMPLIMENTATION, ALSO CI ENGR.

- INVOLVED IN THE ENTIRE [redacted] DESIGN PROCESS

- BIG PROJECTS

  ① TROUBLESHOOTING JAW PROCESSING
  - GRINDING LOGO AWAY / NOT TOUCHING IT
  - SUPPLIER REDESIGN FOR MANUFACTURABILITY

  } 2 PART

  → LTG HAVING TROUBLES W/ EXCESS JAW SCRAP, TO THE POINT OF SHUTTING THE LINE DOWN
  - LOGOS GETTING GROUND OFF / NOT TOUCHED

  → REMEDIED BY COMING UP W/ A DESIGN ~~THAT INCORPORATED~~ WORKED FOR BOTH PARTIES

WHAT ARE YOU LOOKING FOR IN 2ND INTERNSHIP?

- PLANNING ON GOING TO GRAD SCHOOL, [redacted] LIKELY IN THERMAL-FLUIDS
  - AT LTG, I HAD A LOT OF VERY OPEN-ENDED PROJECTS, AND I ENJOYED THAT.
  - ALSO, SOMETHING IN THERMAL-FLUIDS
  - BUT, I SEE THESE INTERNSHIPS AS...

*RESEARCH

- FIXED PLAY IN AIRFOIL EXTENSION
- HELPED W/ DEFLECTION ANGLE PLOT
- WORKING ON FFT / FILTER CIRCUIT ALGORITHM

*NOTES:

- ADJUSTABILITY OF PRELOAD
- PRE-LOAD OF SOFT SPRING

*LAB:

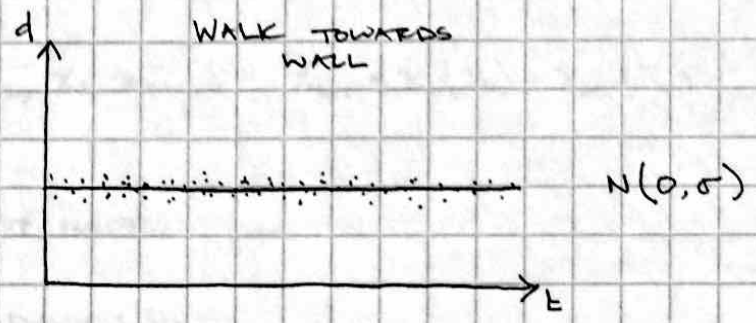
- RE-DO DATA FOR $R_c = 0$
- ADD ELECTRICAL TAPE COVER
- PRE-LOAD SPRING MEASUREMENT

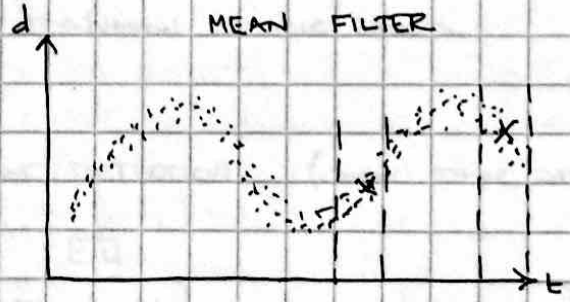
ME 451 1/22/2014

NOISE: UNWANTED RANDOM ADDITION TO A WANTED SIGNAL

- NOISE SOURCES:
  - PERMANENT MAGNET MOTORS
  - COSMIC RADIATION
  - THERMAL NOISE
  - VIBRATIONS (OPTICAL TABLE)
  - RADIATION (HARDENED IC)

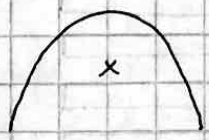
- HOW TO DEAL W/ NOISE
  - REDUCE SOURCES
  - FILTER
  - REPRESENT THE NOISE AS UNCERTAINTY.




MEDIAN FILTER IS BETTER FOR SIGNALS W/ LARGE OUTLIERS

1/27/2014


DIFFERENT METHODS CAN CHANGE DATA

-DEPENDING ON SIGNAL TYPE, YOU HAVE TO ADJUST SAMPLING WINDOW.

*DIGITAL FILTERS:

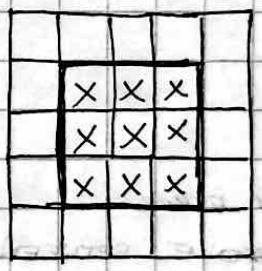
-KALMAN FILTER → BEST, BUT EXTREMELY COMP. INTENSIVE
- KEEP AN ESTIMATE, THEN MODIFY WHEN NEW DATA COMES IN

$x_1, x_2, x_3 \ldots$ $\hat{x}_{k+1} = x_k(9/10) + x_{k+1}(1/10)$ RECURSIVE STATE ESTIMATE

* FILTER ISSUES:

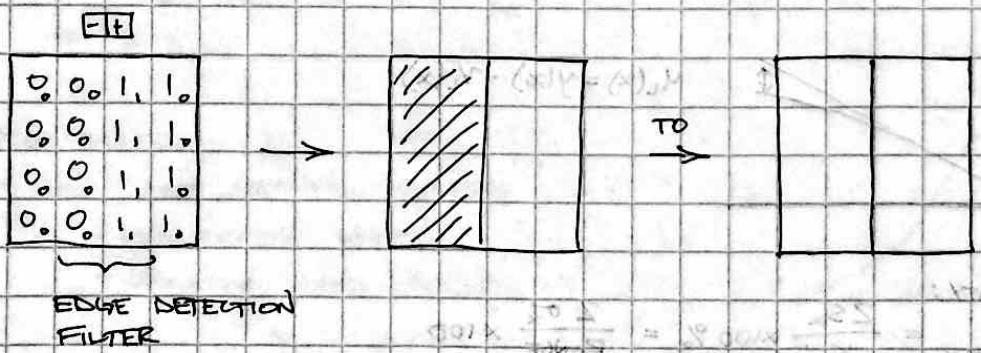
- PHASE LAG
- FILTERING PARTS OF SIGNAL
- ATTENUATION OF YOUR SIGNAL

IMAGE BLUR = MEAN FILTER




TAKE MEAN VALUE, DIVIDE BY 9 ; REPLACE

-EDGE DETECTION: (CANNY EDGE DETION)




EDGE DETECTION FILTER

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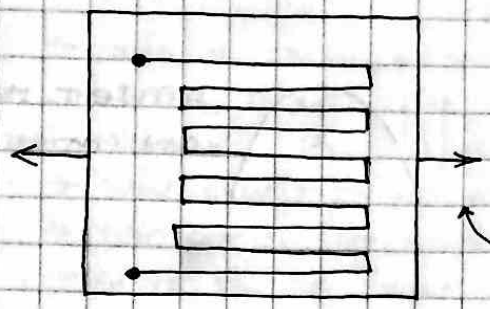
* STRAIN GAGES



STRAIN GAGE = VARIABLE RESISTOR

CALIBRATED FOR 1-DIRECTION

-MEASURE WITH VOLTAGE DIVIDER
→ WHEATSTONE BRIDGE
-PROBLEMS: THERMAL EXPANSION, WIRE RESISTANCE

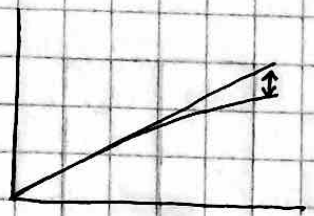
GET RID OF THERMAL EFFECTS BY ADDING CLOSE PROXIMITY STRAIN GAGE @ $R_2$

HOW THICK IS THE BEAM?
IS THE MATERIAL INSULATING?

2/3/2014

* MIDTERM

- LINEARITY ERROR
  - DIFFERENCE BETWEEN LINEAR MODEL & WHAT YOU GET



$$y_L(x) = y(x) - Y_L(x)$$

- REPEATABILITY:

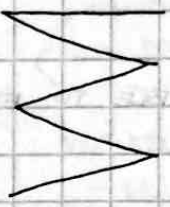
$$\%\, y_{R_{MAX}} = \frac{2S_x}{Y_0} \times 100\,\% = \frac{2\sigma_x}{RANGE} \times 100$$

2/3/2014

- OVERALL ERROR:

$$u_L = \{u_1^2 + u_2^2 \dots u_n^2\}^{1/2}$$

- ALIAS FREQUENCY:



$$\text{NYQUIST} = f_n = \frac{f_s}{2} \leftarrow \text{SAMPLE FREQ.}$$

- BINARY ⇔ DECIMAL

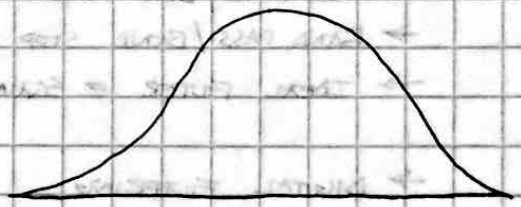
0 - 1
1 - 2
10 - 3
11 - 4
100 - 5
101 - 6

MOST SIG. BIT ⟷ LEAST SIG. BIT

- ANALOGUE → DIGITAL CONVERSION
  - TAKE VOLTAGE
  - BINARY REPRESENTATION (INTEGER)
  - RESOLUTION, IN BITS: $2^{\text{Bits}}$ DISCRETIZATION
  - DISCRETIZATION SIZE =

- FOURIER TRANSFORMS
  - THEY EXIST
  - REPRESENTS ARBITRARY PERIODIC SIGNAL AS SUM OF SINES & COSINES
  - FFT:
    - → ALG. USED IN PRACTICE
    - → DFT

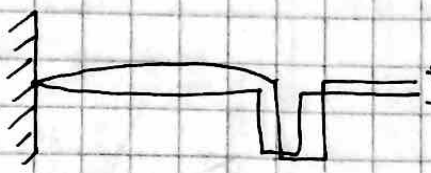
- PROBABILITIES
  - MOST ARE NORMAL DISTRIBUTIONS
    - MEASUREMENT ERROR
    - VARIATION ACROSS POPULATION



2/3/2014

* SENSORS

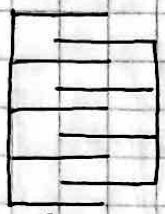
- THERMOCOUPLES: BE ABLE TO DRAW.




PICTURE IN BOOK!

- BE ABLE TO ENUMERATE VARIOUS SOURCES OF ERROR!

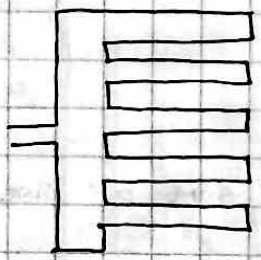
- ACCELEROMETERS:




- WANT ACCELERATION
- ACTUALLY MEASURE CAPACITANCE
- CALLED "MEMS DEVICE" → MICRO-ELECTRO MECHANICAL

BE ABLE TO DRAW THESE PICTURES

- STRAIN GAGE:

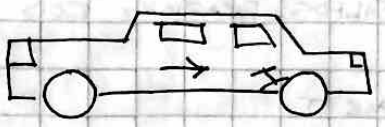


- WANT STRAIN/STRESS
- GET RESISTANCE
- MEASURE VOLTAGE
- USE WHEATSTONE BRIDGE
- KNOW ISSUES BETWEEN DIFFERENT TYPES OF WHEATSTONE BRIDGES

- NOISE & FILTERING:
  - → HIGH PASS / LOW PASS
  - → BAND PASS / BAND STOP
  - → IDEAL FILTER = SQUARE
  - → DIGITAL FILTERING:
    - KNOW HOW TO WRITE A MEAN/MEDIAN FILTER CODE
    - SIGNAL ATTENUATION
    - SIGNAL LAG
    - SIGNAL ATTENUATION
    - REAL TIME VS. AFTER THE EXPERIMENT

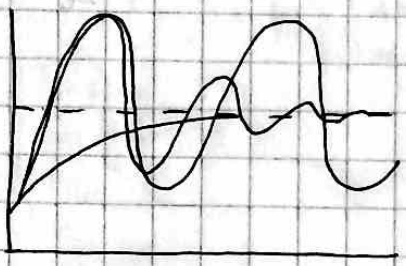
2/12/2014

* MOTOR CONTROL
  - FEEDBACK CONTROL
    → FEEDBACK NEEDS SENSORS



  - CLOSED-LOOP: LOOK @ SPEED
    - TOO SLOW → DEPRESS THE PEDAL
    - TOO FAST, DON'T PRESS GAS

VOLTAGE → MOTOR → ENCODER → A/D → COMPUTER



ERROR IN POSITION: $e(t)$

1.) PROPORTIONAL, $P_{out} = K_p e(t)$

2.) DERIVATIVE, $P_{out} = K_D = \frac{de(t)}{dt}$

3.) INTEGRAL, $P_{out} = K_I \int e(t)\,dt$

MOTOR AMPLIFIERS → H-BRIDGE

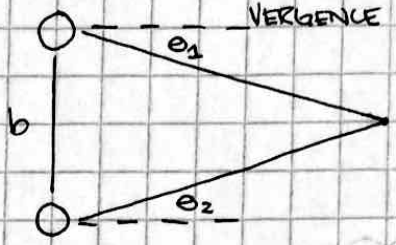
2/17/2014

ANALOG DATA TRANSMISSION

- CONTINUOUS SIGNAL
  - -AC VOLTAGE / CURRENT
  - - VOLTAGE FROM ACCELEROMETER
  - - ANALOG INPUT TO AMP

2/24/2014

* STEREO VISION:




RGB-D → [IMAGE] + [DEPTH IMAGE]

2/25/2014

Q: 1

#1: THERMISTOR ....

#2:

$$\frac{\text{SENSOR TEMP RANGE}}{\text{SENSOR VOLTAGE RANGE}} \cdot \frac{\text{A-TO-D VOLTAGE RANGE}}{\text{A-TO-D}} = \frac{100 - 0\,C}{}$$

#3:

$\pm 1$ OR $\pm 2$

#4:

SYS. ERROR: 0.1 V

RAND. ERROR: $1\% \cdot (2) = 0.02V$

A → D ERROR: TUE $= \frac{2.46}{2^8 \text{ LSB}} = 0.0096V$

$$u_T = \left\{ c_s^2 + e_r^2 + e_a^2 \right\}^{1/2} \rightarrow \boxed{u_T = 0.1024V}$$

#5:

$$\sqrt{e_r^2 + e_a^2} = \boxed{0.0222V}$$