EE16A Lab: Locationing
Wed 8-11

GSI: Angela

Lab Assistants: Gary, Loren, Seiya

Semester Outline

~~Imaging Module~~

~~Touchscreen Module~~

Locationing Module

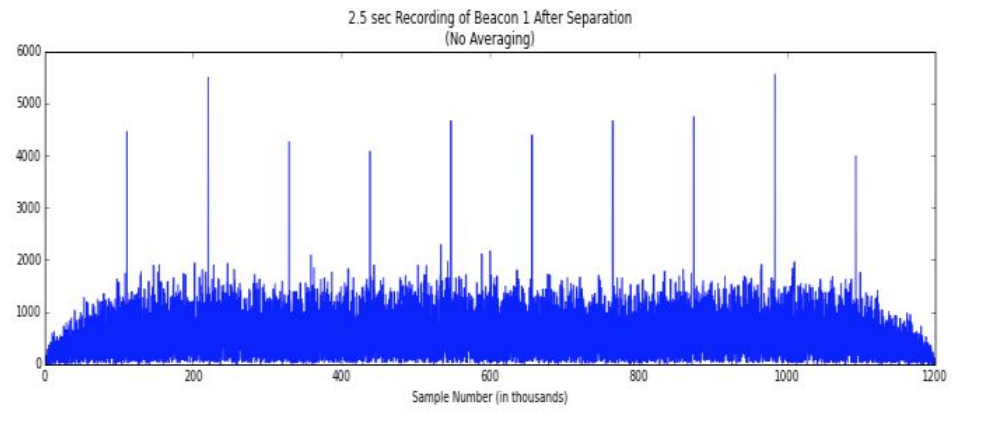
Announcements!

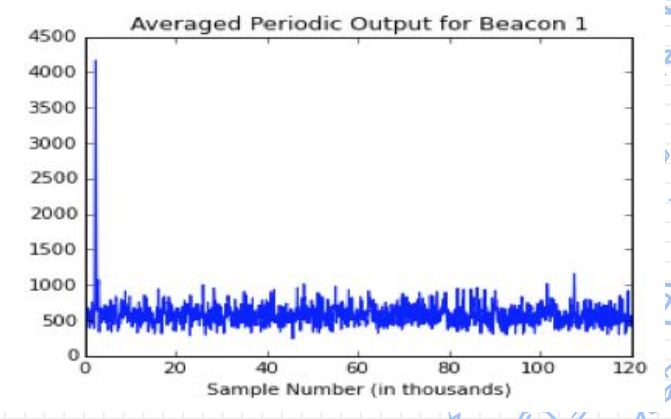
- This is the **last lab!!!**
- Check your lab grades with me if you want
- **GOOD LUCK ON YOUR EXAMS** & thanks for being so **amazing** at 8AM every week

motivational penguin

Last lab

- Averaging Function
  - Reduced noise, higher accuracy in determining peaks



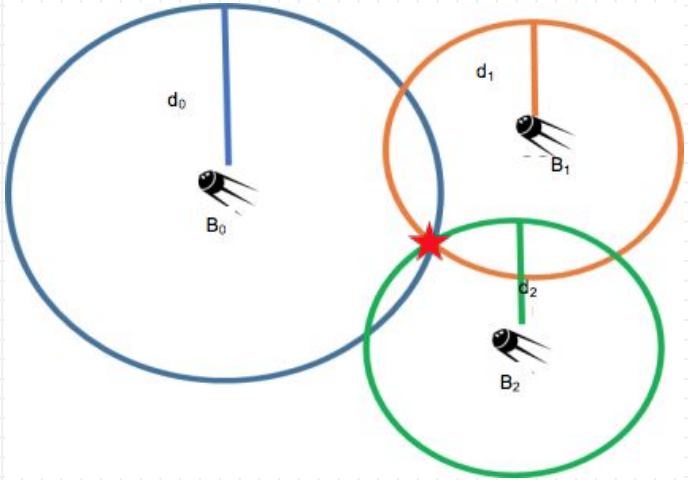


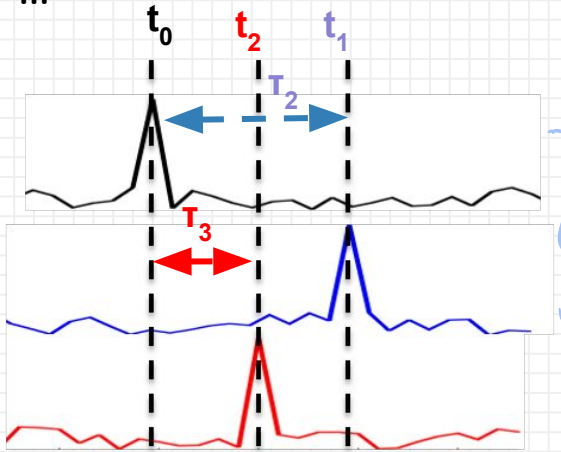
- Signal_to_distances(raw_signal, t0)
  - We don't usually have t0 known

3 Beacons

- Let beacon centers be: (x_0, y_0), (x_1, y_1) and (x_2, y_2)
- Time of arrivals: t_0, t_1, t_2
- Distance of beacon m (m = 0, 1, 2) is $d_m = vt_m = R_m$ (circle radii)

Circle equations: $(x - x_m)^2 + (y - y_m)^2 = d^2_m$

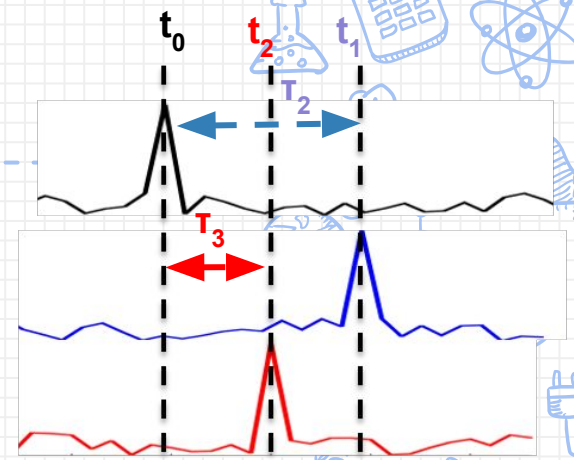




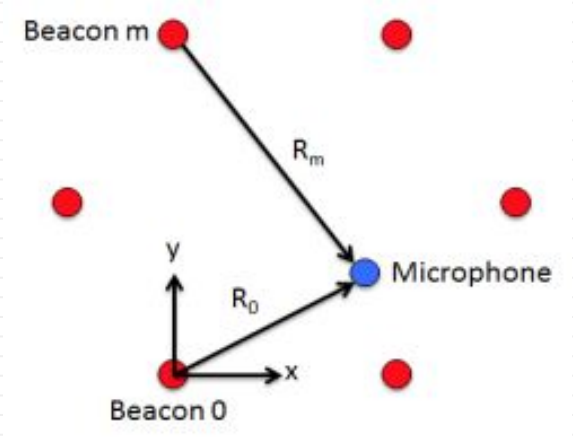
CC of received signal and beacons

Problem: We do not know t_0

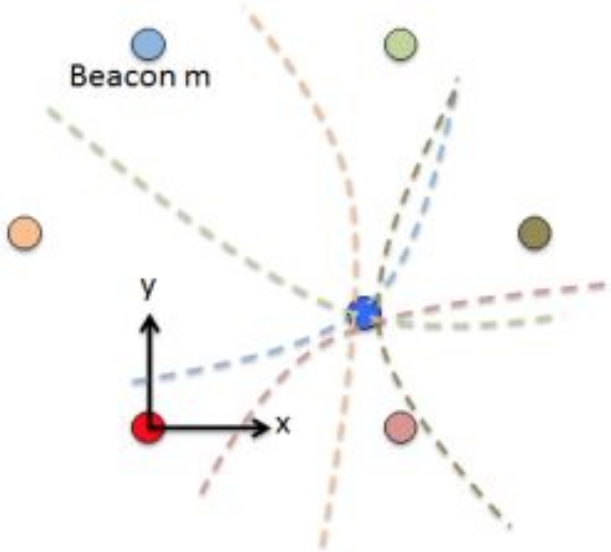
- Only know time offsets: $\tau_m = t_m - t_0$
- $R_m = \sqrt{(x - x_m)^2 + (y - y_m)^2} = v_s t_m$
- $R_0 = \sqrt{(x)^2 + (y)^2} = v_s t_0$ (Beacon 0 is at origin)
- $R_m - R_0 = v_s (t_m - t_0) = v_s \tau_m$



CC of received signal and beacons



Setting up n-1 hyperbolic equations



Beacon 0 is not used for locationing since it acts as the reference signal.

$$R_m - R_0 = v_s \tau_m$$

simplify!

$$v_s \tau_m = \frac{-2x_m x + x_m{}^2 - 2y_m y + y_m{}^2}{v_s \tau_m} - 2\sqrt{x^2 + y^2}$$

- ✘ $m \neq 0$ (as $\tau_0 = 0$)
- ✘ This is the equation for a hyperbola
- ✘ :(This is hard to solve tho

Making it linear:

- Same trick: subtract first equation from others

$$v_s\tau_m = \frac{-2x_m x + x_m{}^2 - 2y_m y + y_m{}^2}{v_s\tau_m} - 2\sqrt{x^2+y^2}$$

$$v_s\tau_m - v_s\tau_1 = [\frac{-2x_m x + x_m{}^2 - 2y_m y + y_m{}^2}{v_s\tau_m} - 2\sqrt{x^2+y^2}] - [\frac{-2x_1 x + x_1{}^2 - 2y_1 y + y_1{}^2}{v_s\tau_1} - 2\sqrt{x^2+y^2}]$$

simplify! $m \neq 0, m \neq 1$

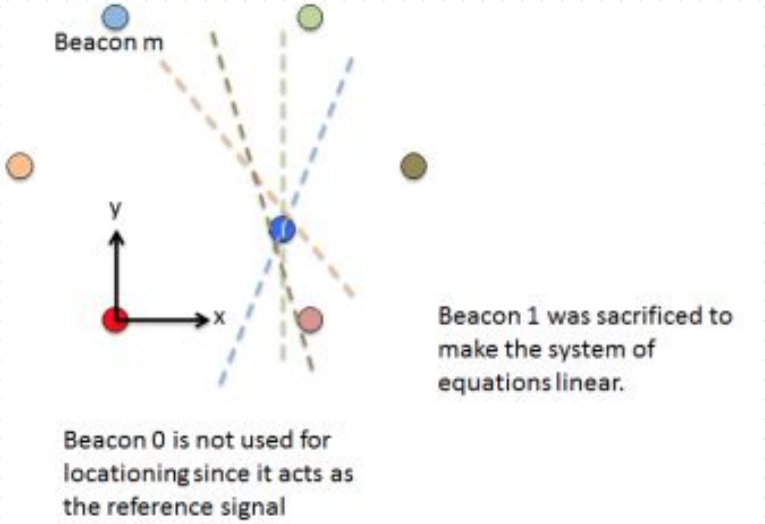
$$(\frac{2x_m}{v_s\tau_m} - \frac{2x_1}{v_s\tau_1})x + (\frac{2y_m}{v_s\tau_m} - \frac{2y_1}{v_s\tau_1})y = (\frac{x_m{}^2 + y_m{}^2}{v_s\tau_m} - \frac{x_1{}^2 + y_1{}^2}{v_s\tau_1}) - (v_s\tau_m - v_s\tau_1)$$

$$m \neq 0,\ m \neq 1$$

Making it linear:

$$\left(\frac{2x_m}{v_s\tau_m} - \frac{2x_1}{v_s\tau_1}\right)x + \left(\frac{2y_m}{v_s\tau_m} - \frac{2y_1}{v_s\tau_1}\right)y = \left(\frac{{x_m}^2 + {y_m}^2}{v_s\tau_m} - \frac{{x_1}^2 + {y_1}^2}{v_s\tau_1}\right) - (v_s\tau_m - v_s\tau_1)$$

- After simplifying, we have n-2 linear equations
- Can do least-squares!
  - Regardless of number of beacons
  - Best estimate of location if measurements are inconsistent



Notes

- Plug the microphone in before starting your iPython notebook to avoid having to restart the kernel later on.
- When you are done:
  - Put yourself in checkoff queue as usual
  - Come over to station 6 after you get checked off and we'll run the full locationing system

Question Form:

http://tinyurl.com/lab114-form

Question Queue:

http://tinyurl.com/lab114-queue