Caroline Chow– CE 291 F Final Project Presentation 12/04/07

EXTREMUM SEEKING USING A UNICYCLE MODEL

EXTREMUM SEEKING

- Miroslav Krstic

EXTREMUM SEEKING

- Control technique

- Goal:
  - Force an output to its maximum

- Also referred as SOURCE SEEKING

- Applications:
  - Track an object emitting a signal
  - Find a contaminant…

SIGNAL MODEL

- The signal model is NOT known.

- Non-linear distribution on the (x,y) plane:

$$T = f(x,y)$$

- Signal strength decays away from a source
  - e.g. diffusion phenomenon

HEAT EQUATION

- 1D HEAT EQUATION

$$\frac{\partial T}{\partial t} = D\frac{\partial^2 T}{\partial x^2}$$

or

$$\frac{\partial T}{\partial t} = \Delta T$$

HEAT EQUATION

- Deriving:
  - Plugging Fourier's law

$$q = -K\frac{\partial T}{\partial x}$$

  - Into the continuity equation

$$c_p\frac{\partial T}{\partial t} = -\frac{\partial q}{\partial x}$$

HEAT EQUATION

- Solving:
  - Using the self-similar variable:

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  - Get the 2nd order ODE:

$$f''(\eta) + \eta f'(\eta) = 0$$

HEAT EQUATION

- MATLAB solving: using pdepe.m

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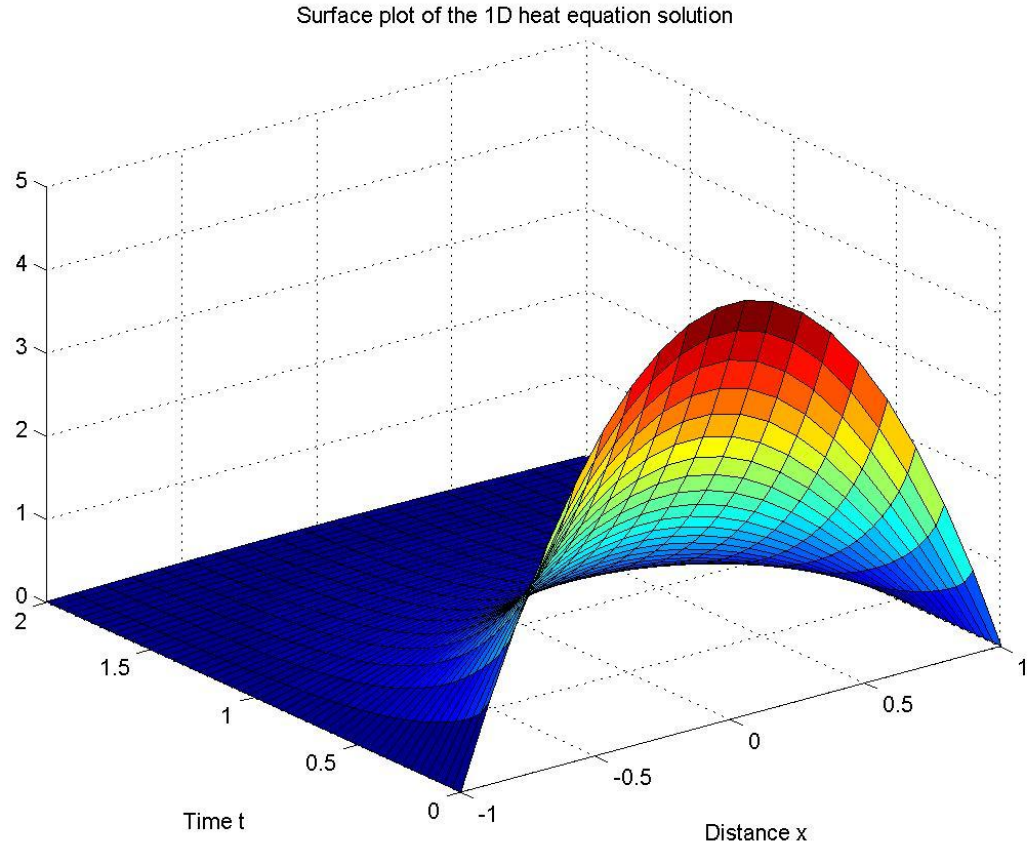

2-D DIFFUSION EQUATION

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- No MATLAB solver in the lab
- STEADY STATE SOLUTION

$$0 = \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}$$

2-D DIFFUSION EQUATION

- STEADY STATE SOLUTION

$$T(x,y) = T^{*} - a(x - x^{*})^{2} - b(y - y)^{2}$$

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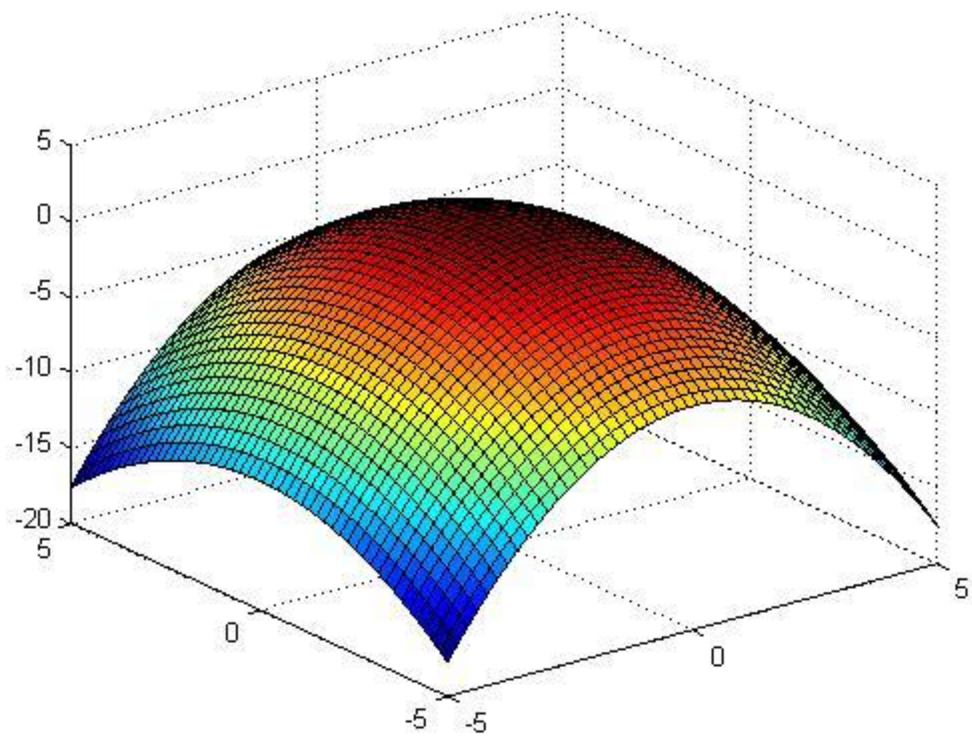

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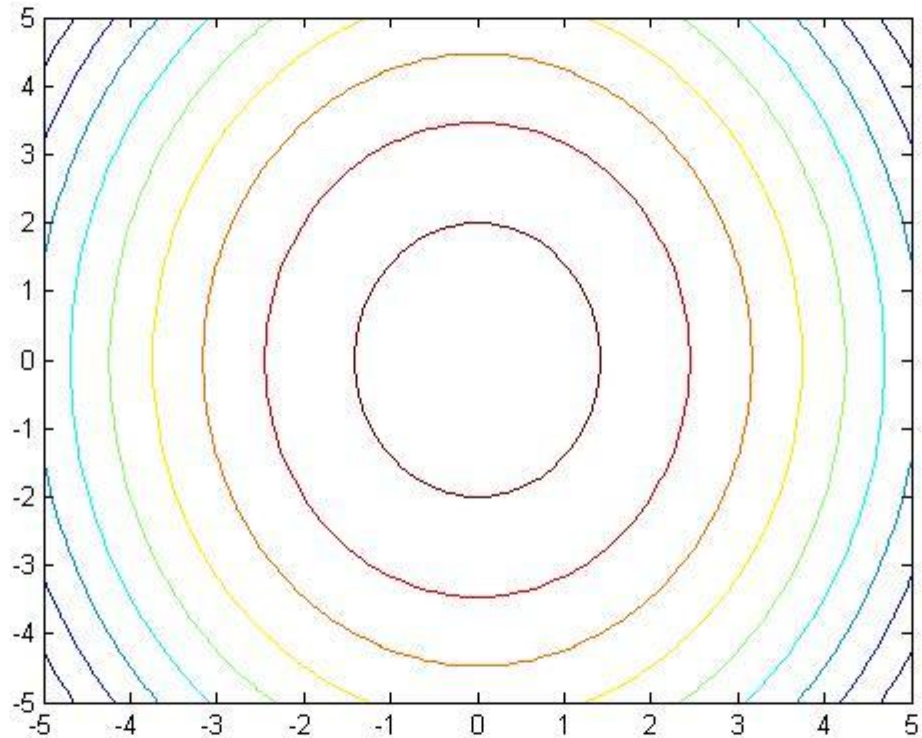

VEHICLE MODEL

- UNICYLE

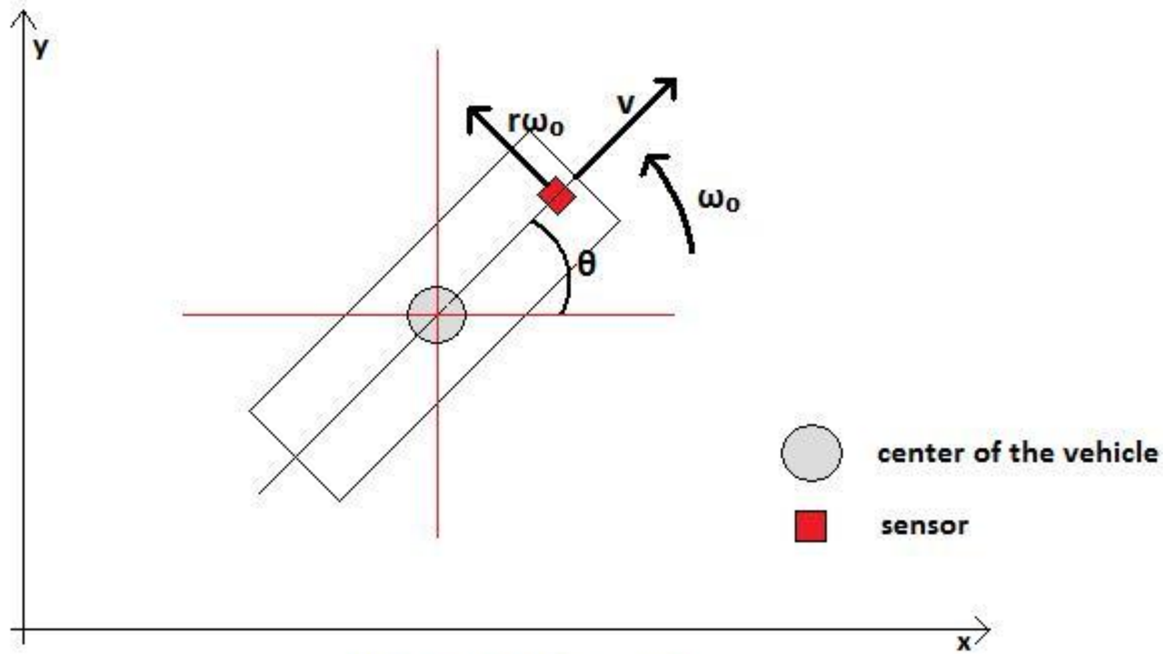

Figure 2 - Vehicle model

VEHICLE MODEL

- MOTION EQUATIONS
  - center of the vehicle:

$$x'_C = v\cos\theta$$
$$y'_C = v\sin\theta$$
$$\theta' = \omega_0$$

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- MOTION EQUATIONS
  - center of the vehicle:

$$x_C' = v\cos\theta$$
$$y_C' = v\sin\theta$$
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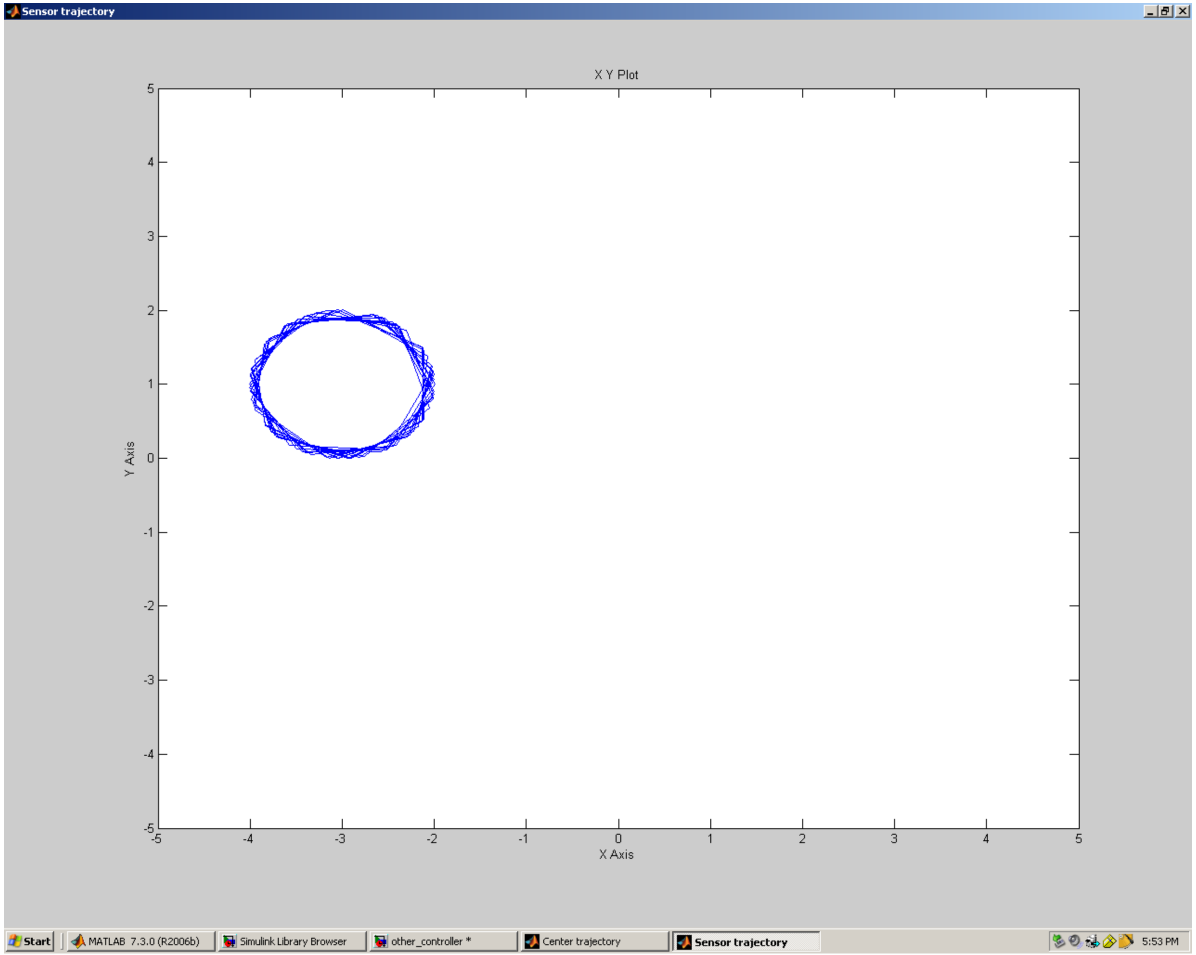
  - sensor:

$$x_s = x_0 + r\,cos\,\theta$$
$$y_s = y_0 + r\,sin\,\theta$$

VEHICLE MOTION



EXTREMUM SEEKING ALGORITHM

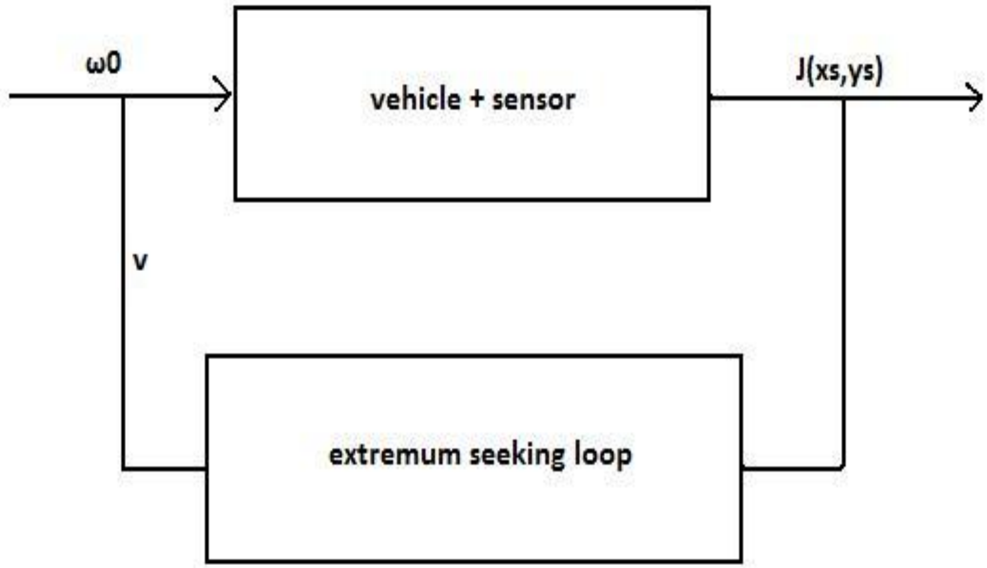


Figure 3. Very basic feedback controller

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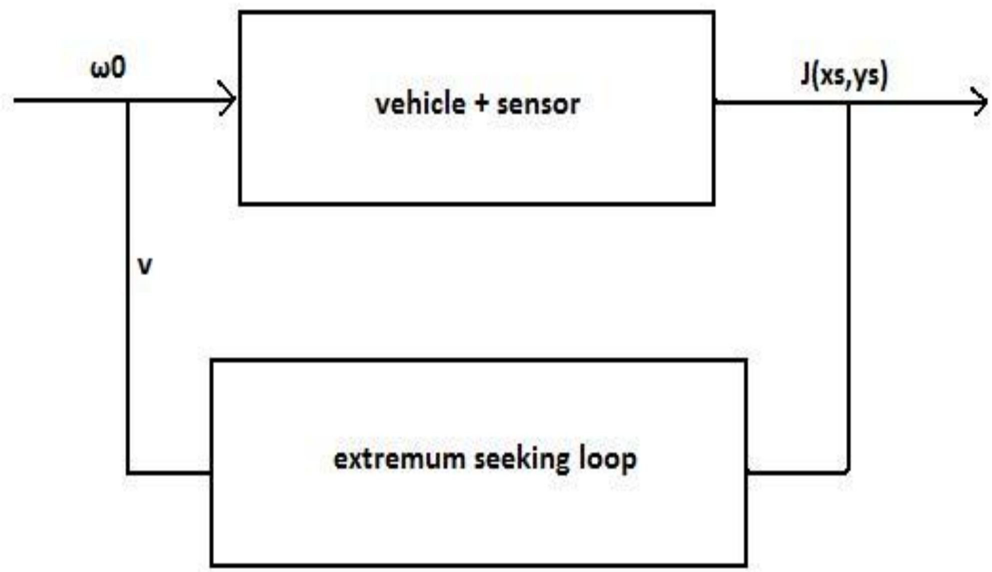

Figure 3. Very basic feedback controller

- Fixed angular velocity/ turn rate

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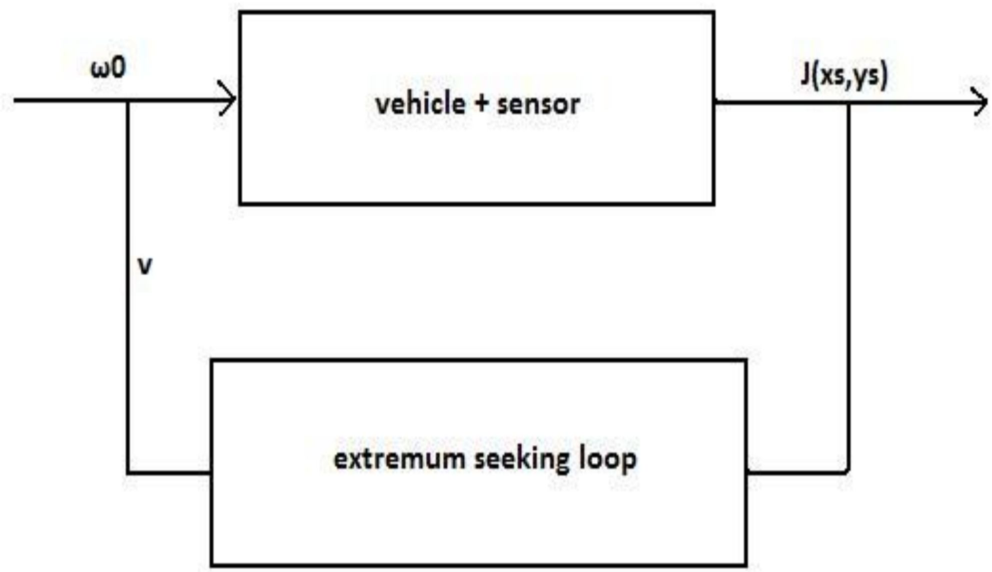

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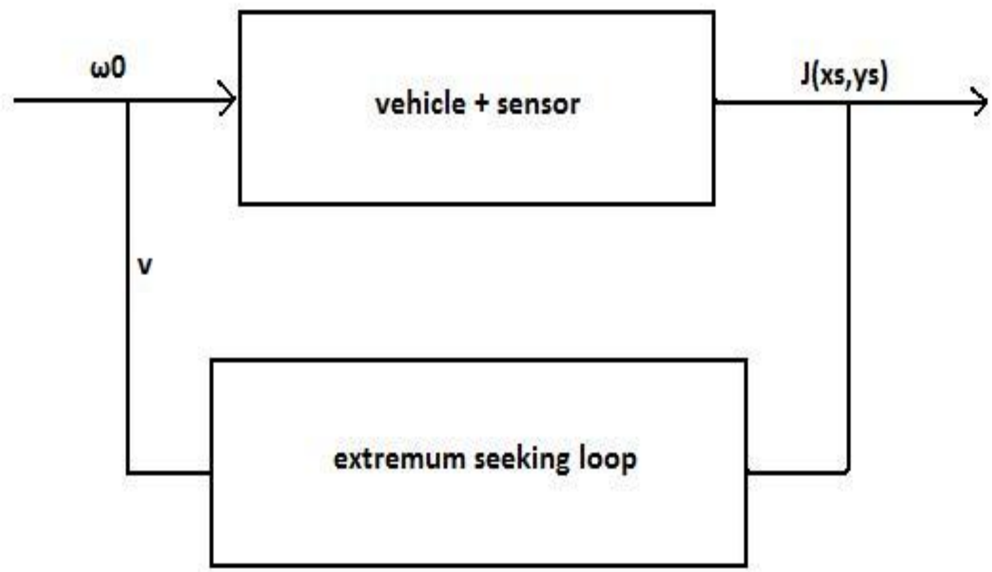
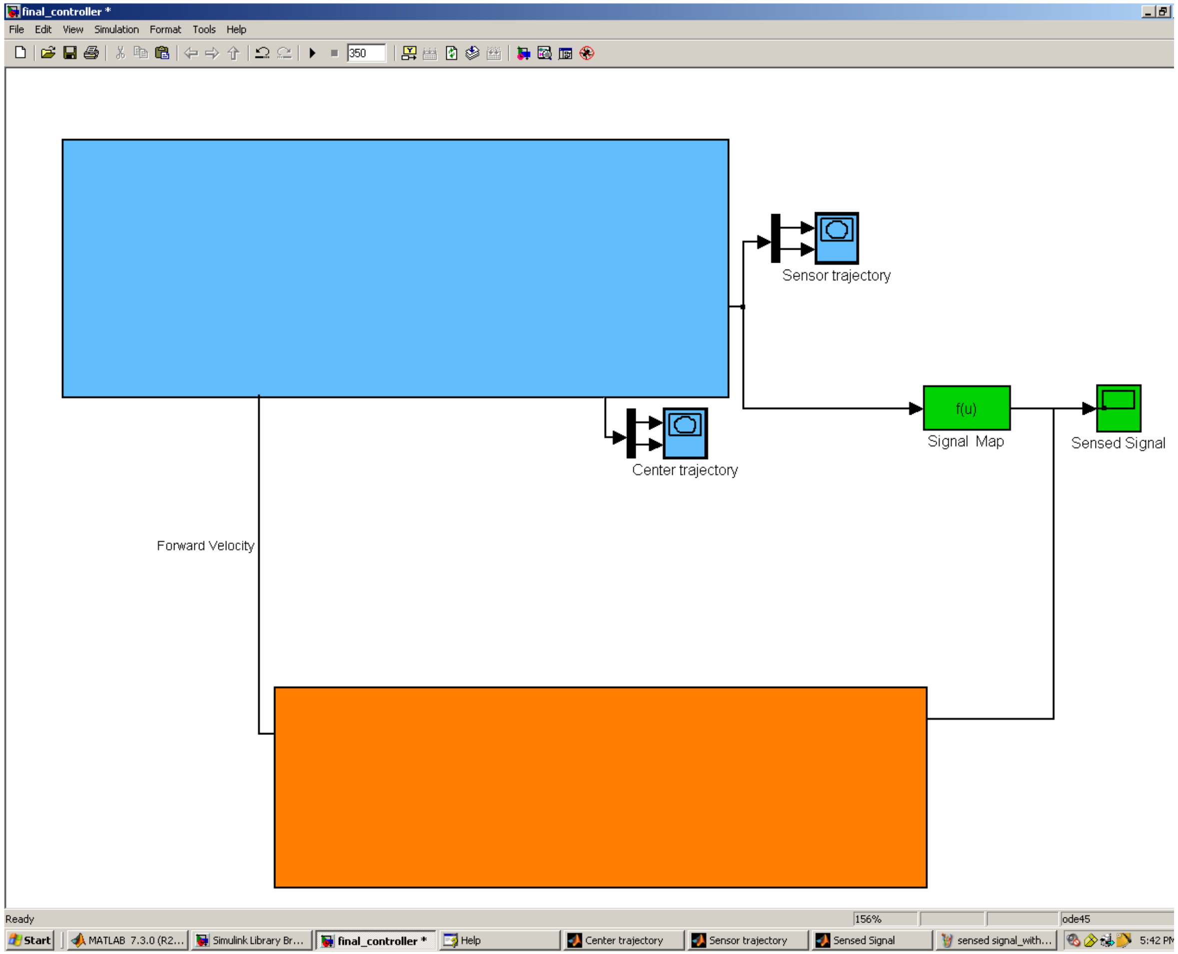


Figure 3. Very basic feedback controller

- Fixed angular velocity/ turn rate
- OUPUT: VALUE OF SIGNAL
- CONTROL/INPUT: FORWARD VELOCITY

EXTREMUM SEEKING ALGORITHM



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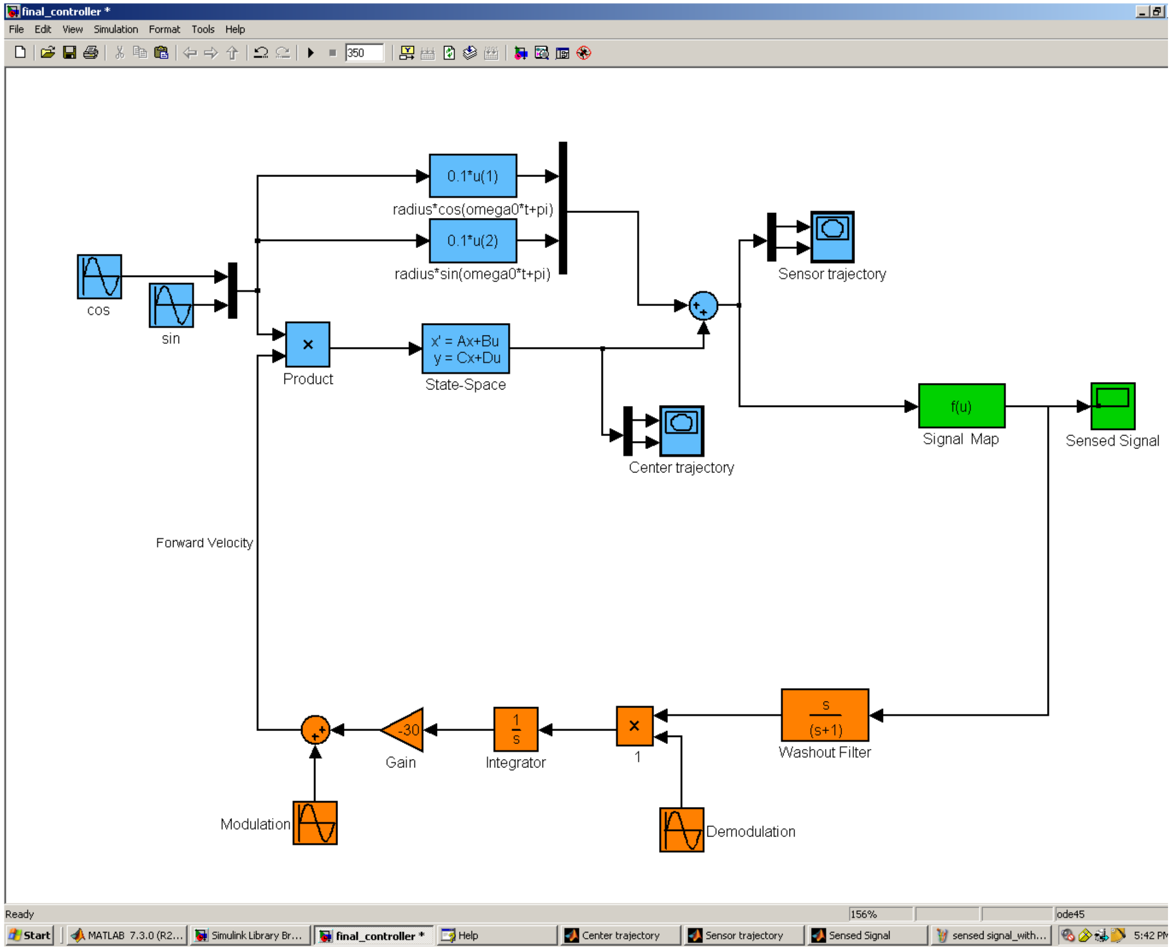

EXTREMUM SEEKING PARAMETERS

- SIMULINK IMPLEMENTATION with:
  - Signal & domain
  - Initial coordinates and heading
  - Angular velocity and radius
  - Perturbation frequency

EXTREMUM SEEKING CONVERGENCE

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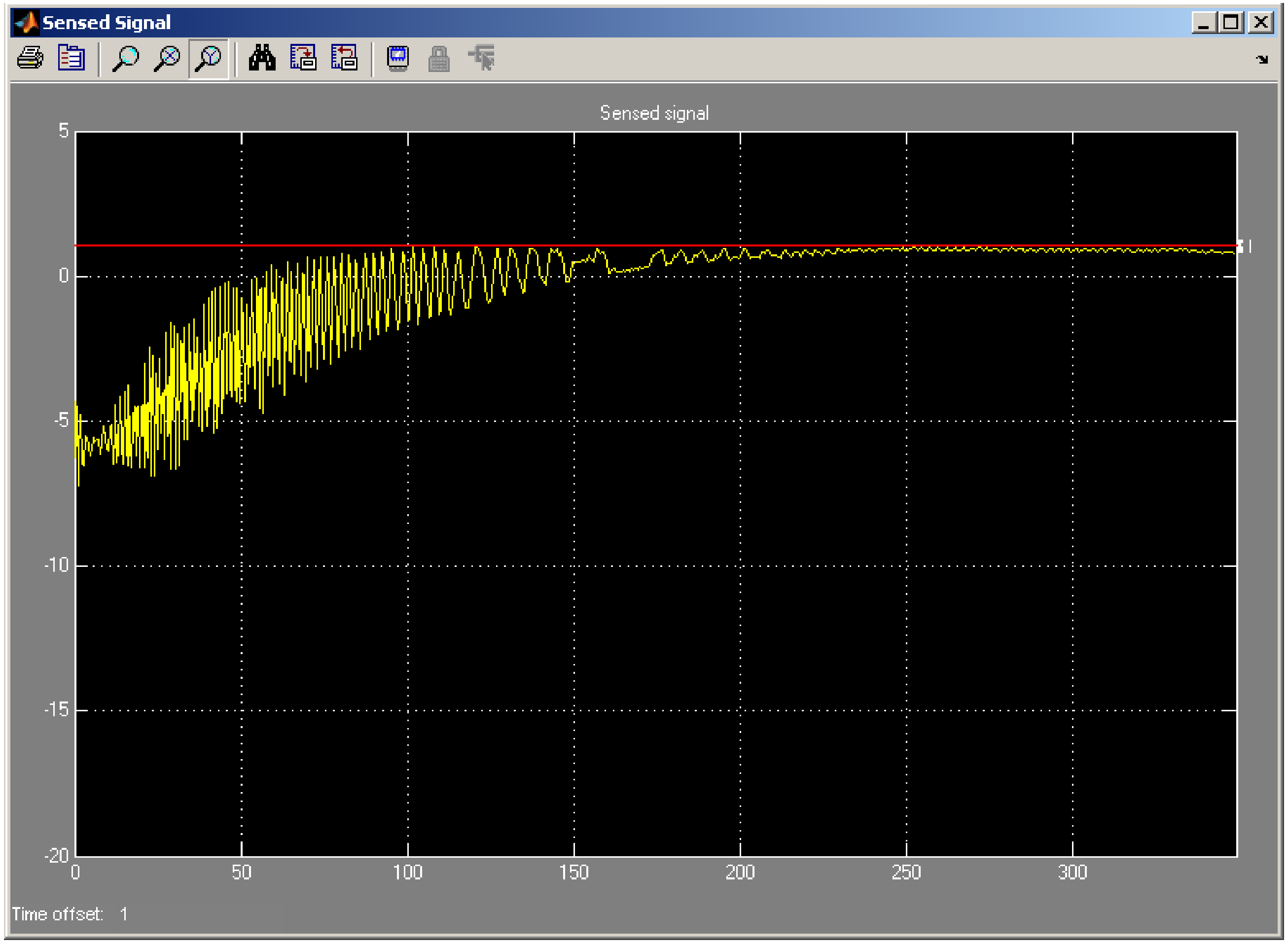

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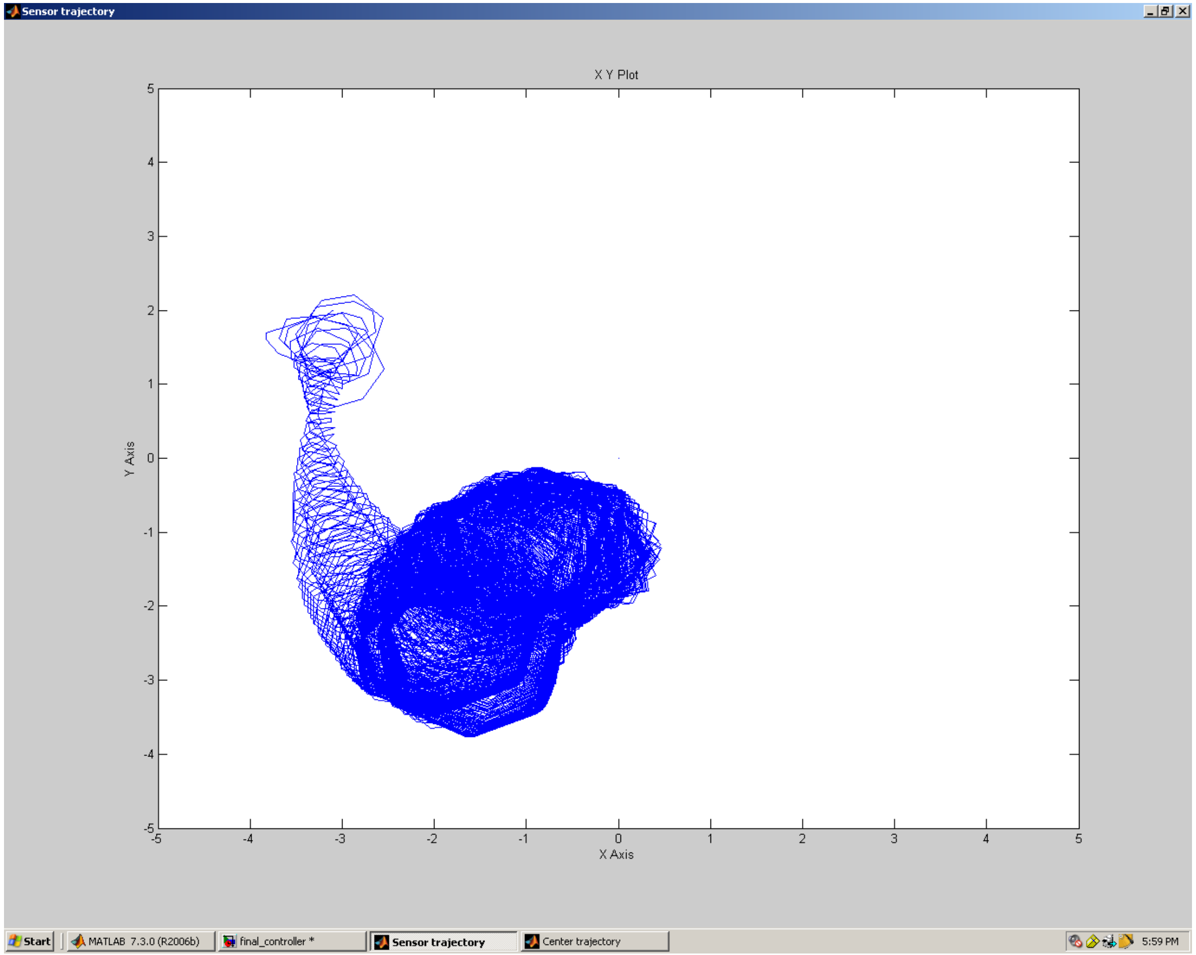

NEXT STEPS

- Get a pro version of MATLAB
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