Introduction to Robotics

Manipulation and Programming

Unit 4: Motion Control

MOBILE ROBOT PART 3 – FINITE STATE MACHINE

DR. ERIC CHOU

IEEE SENIOR MEMBER

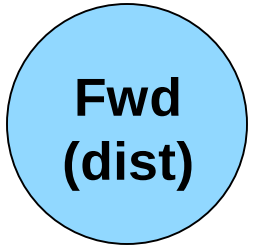
Objectives

- Control Design – Finite State Machine
- Case Study of a Finite State Machine Control

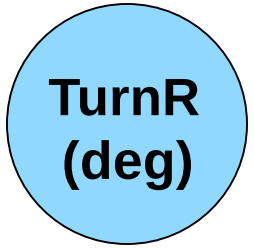
Finite State Machine

SECTION 1

Finite State Machines offer another alternative for combining behaviors



Fwd behavior moves robot straight forward a given distance



TurnR behavior turns robot to the right a given number of degrees

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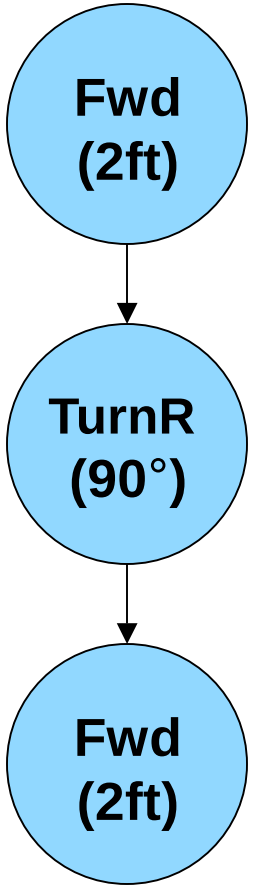

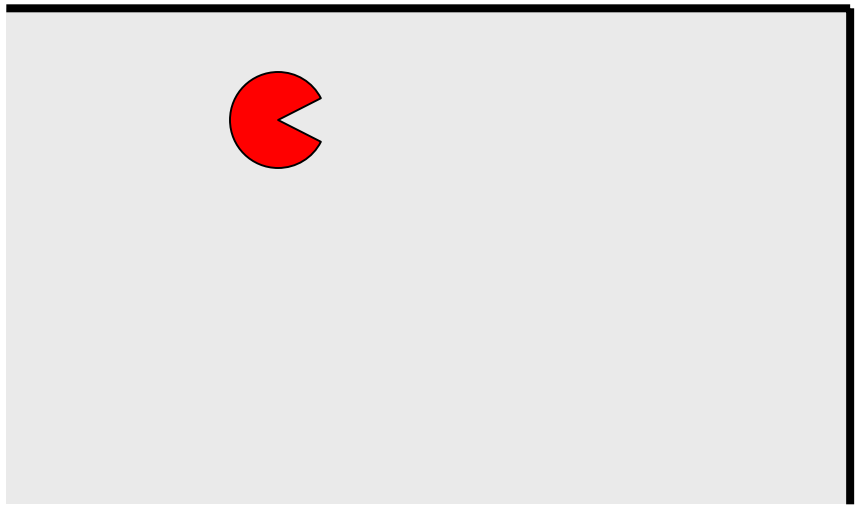

Each state is just a behavior and we can easily link them together to create an open loop control system

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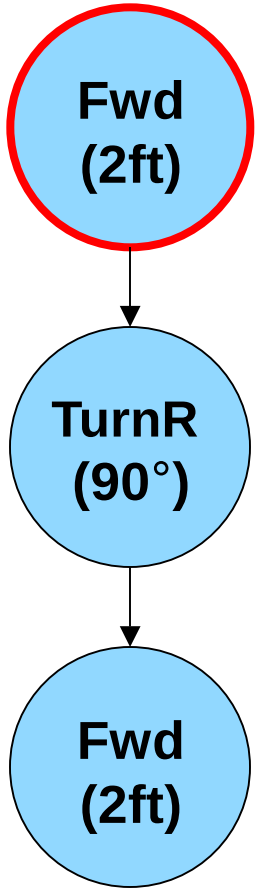

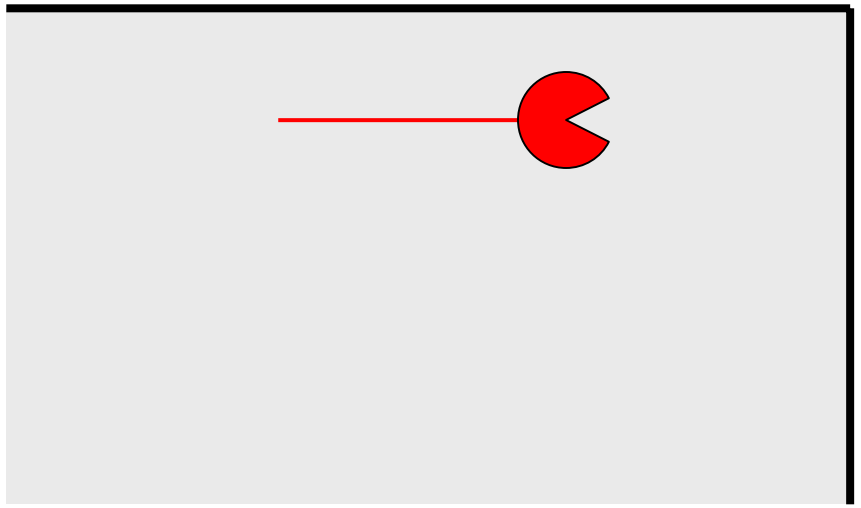

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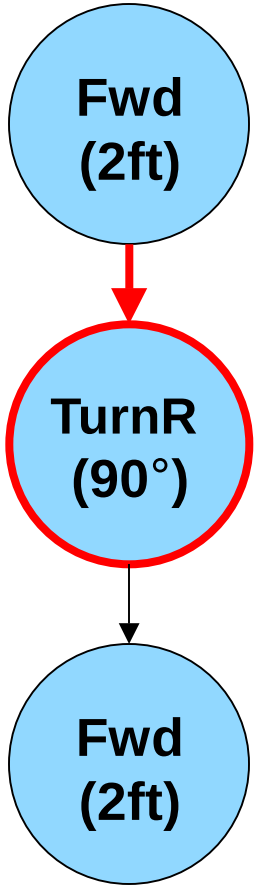

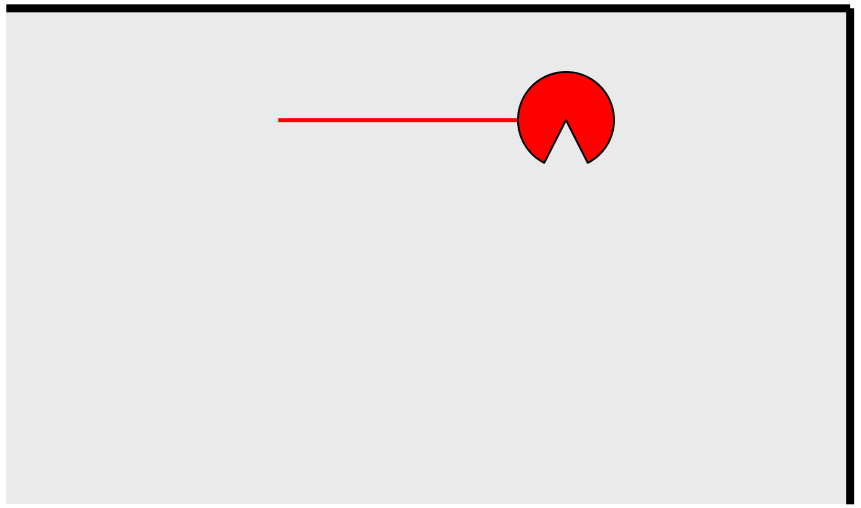

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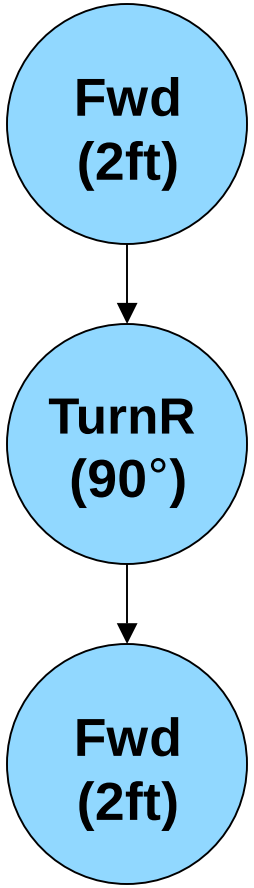

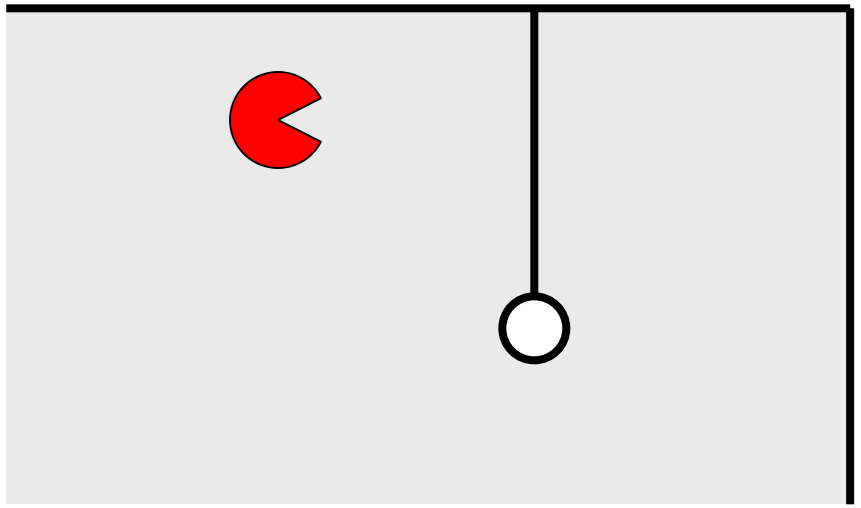

Since the Maslab playing field is unknown, open loop control systems have no hope of success!

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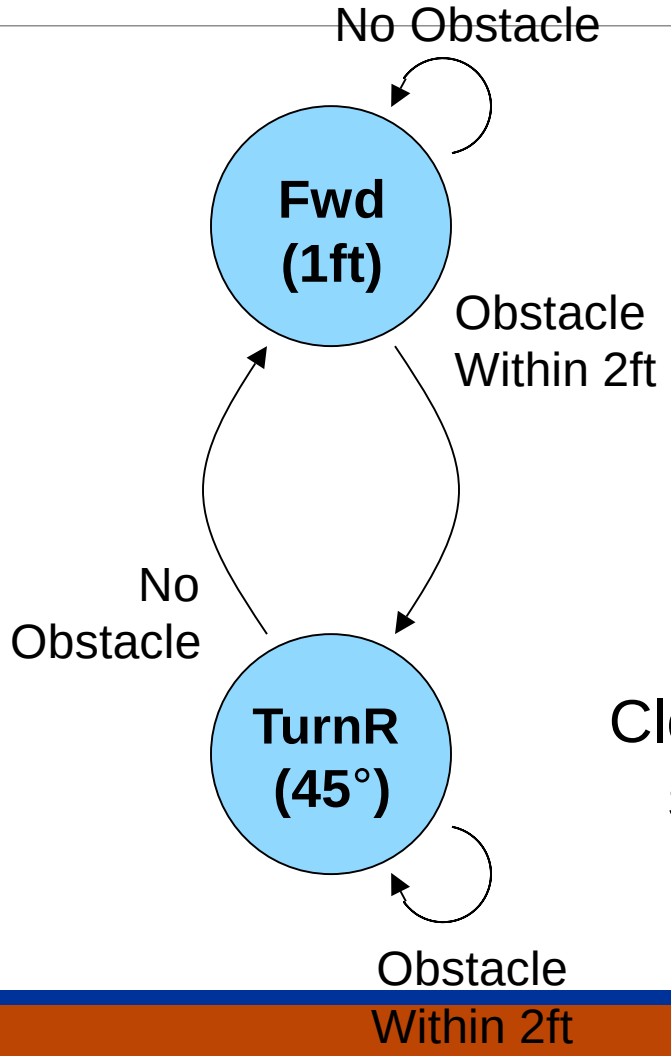

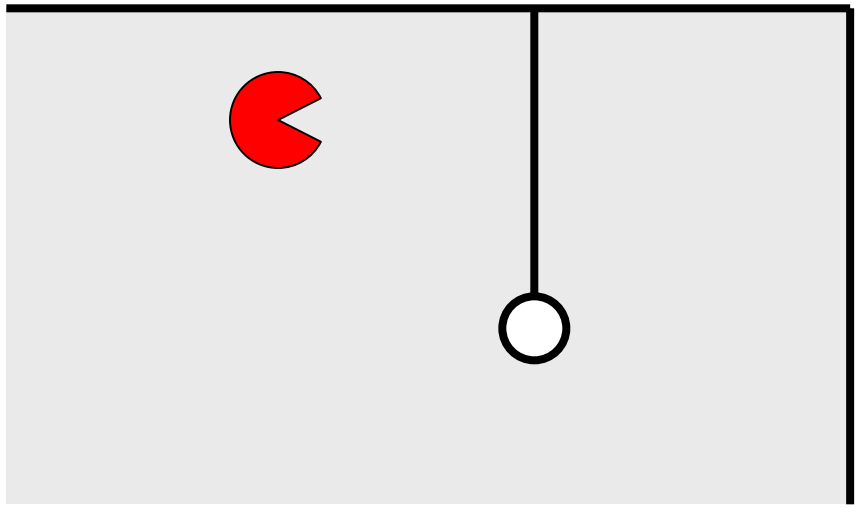

Closed loop finite state machines use sensor data as feedback to make state transitions

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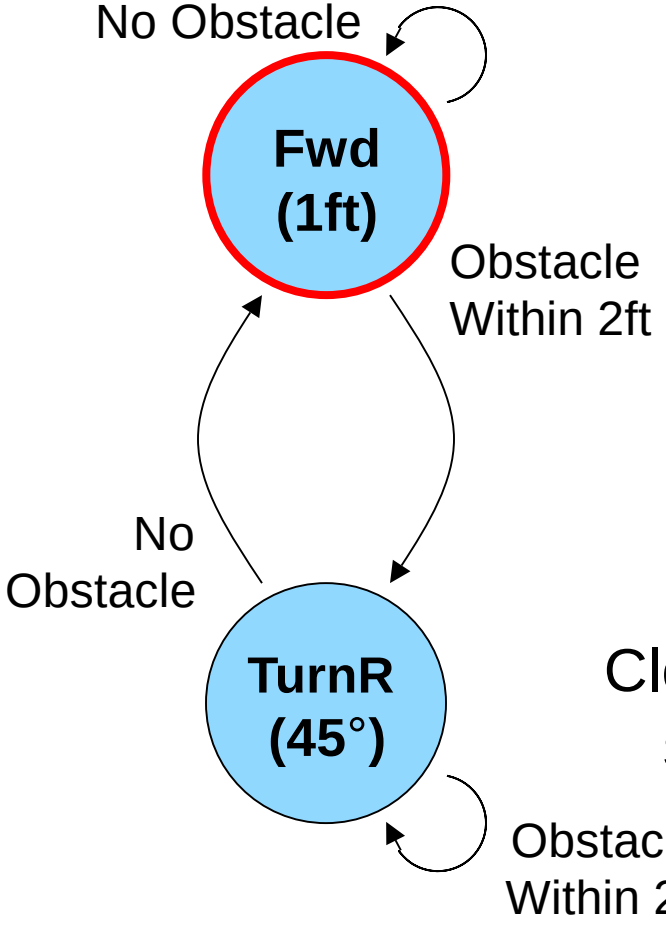

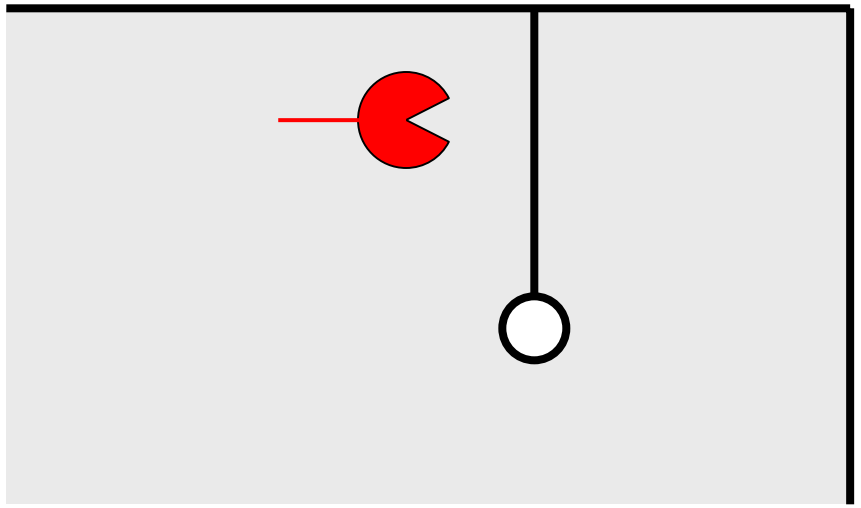

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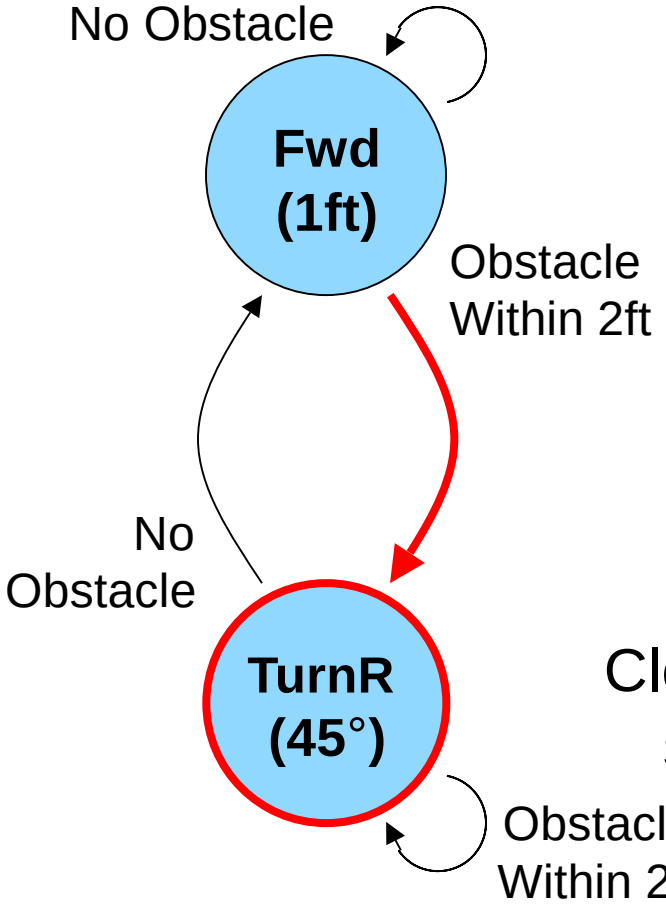

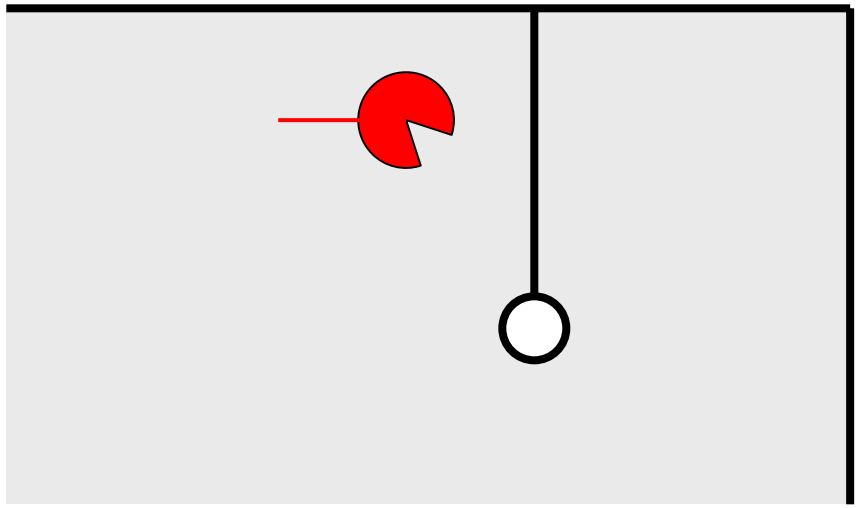

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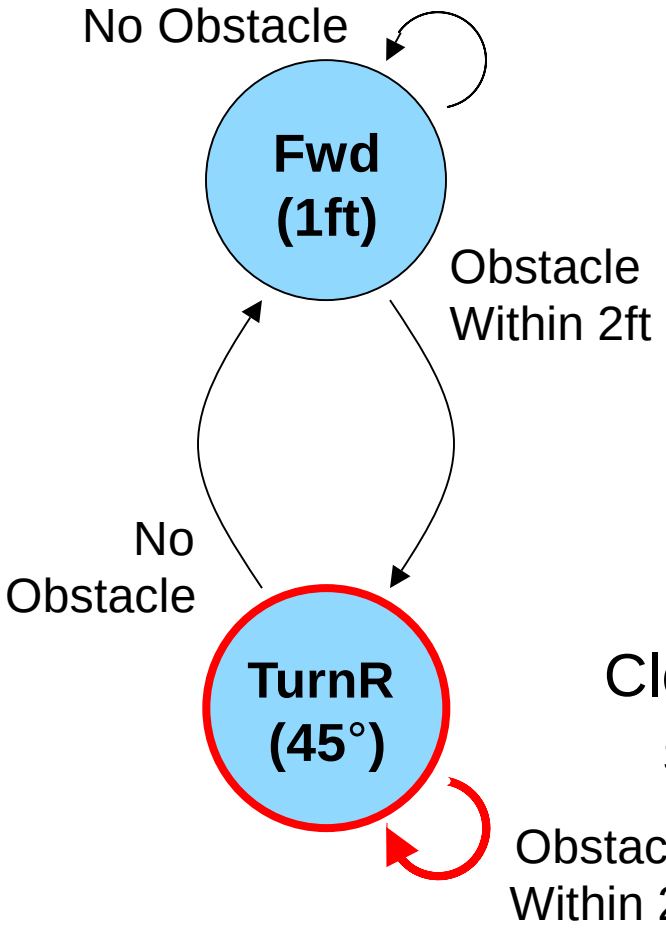

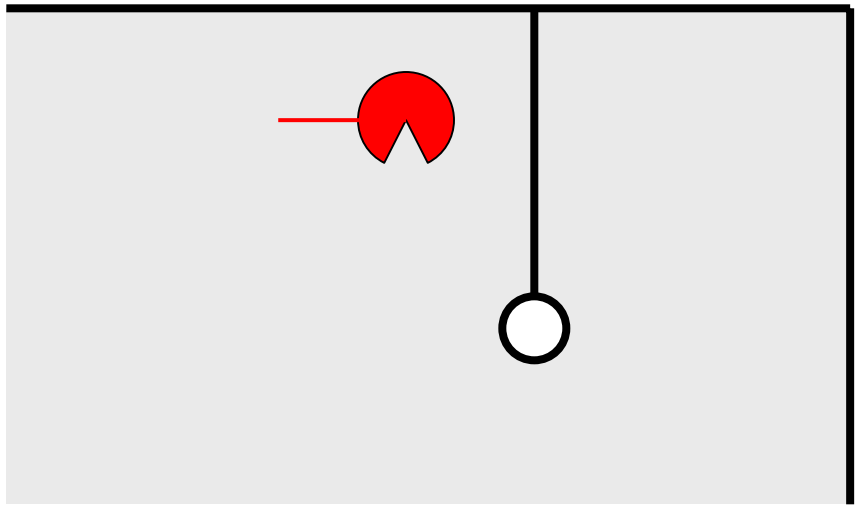

Closed loop finite state machines use sensor data as feedback to make state transitions

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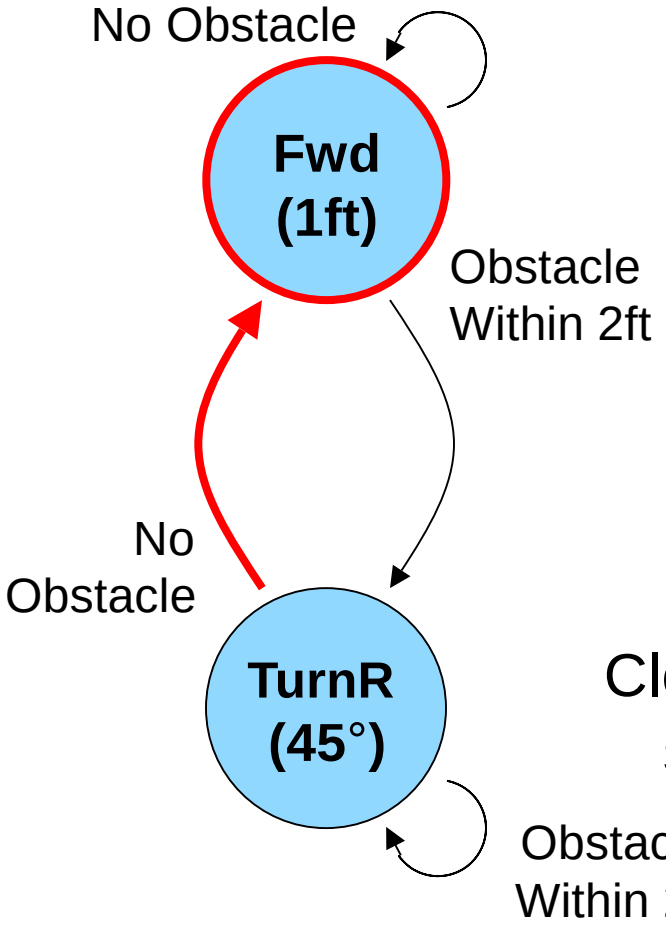
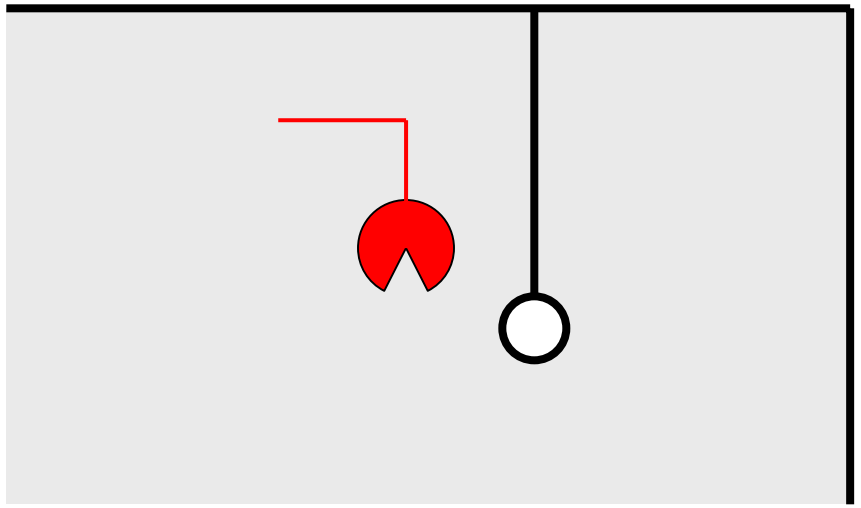
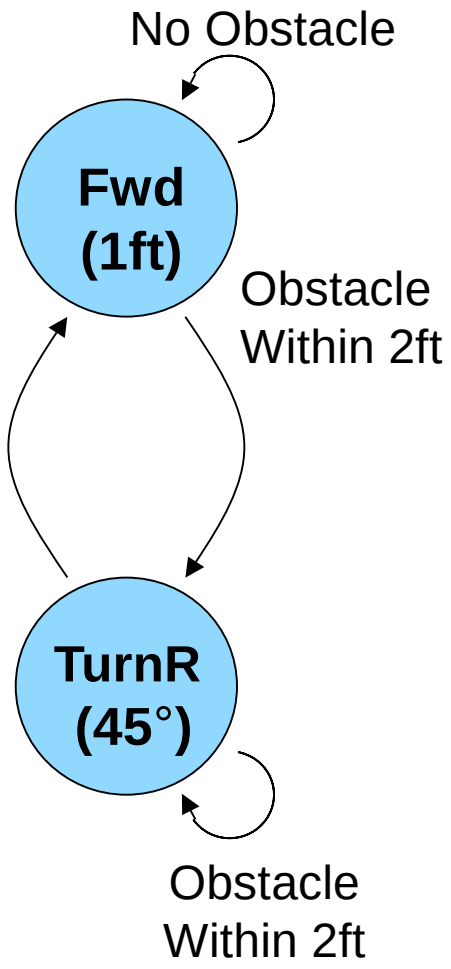




Closed loop finite state machines use sensor data as feedback to make state transitions

Implementing a FSM in Java




```
// State transitions
switch ( state ) {

  case States.Fwd_1 :
    if ( distanceToObstacle() < 2 )
      state = TurnR_45;
    break;

  case States.TurnR_45 :
    if ( distanceToObstacle() >= 2 )
      state = Fwd_1;
    break;

}

// State outputs
switch ( state ) {

  case States.Fwd_1 :
    moveFoward(1); break;

  case States.TurnR_45 :
    turnRight(45); break;

}
```

Implementing a FSM in Java

- Implement behaviors as parameterized functions
- First switch statement handles state transitions
- Second switch statement executes behaviors associated with each state
- Use enums for state variables

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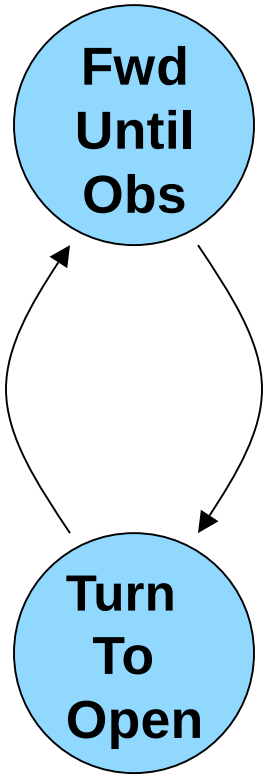
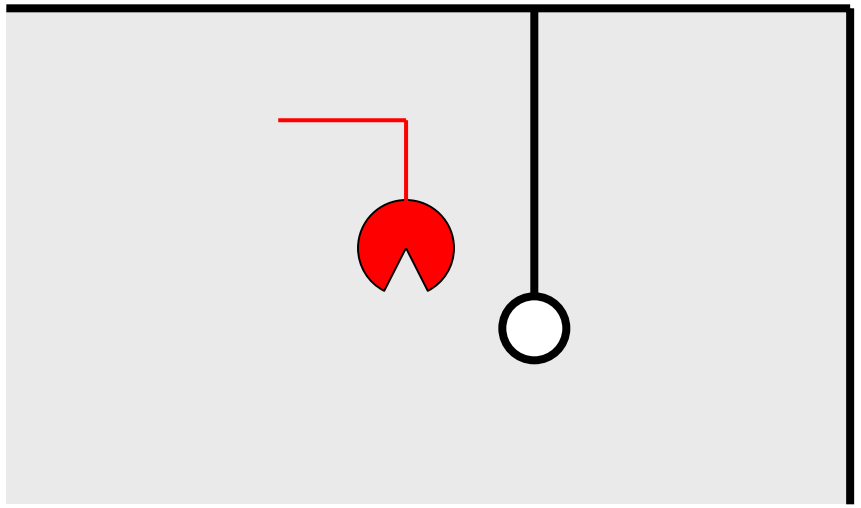


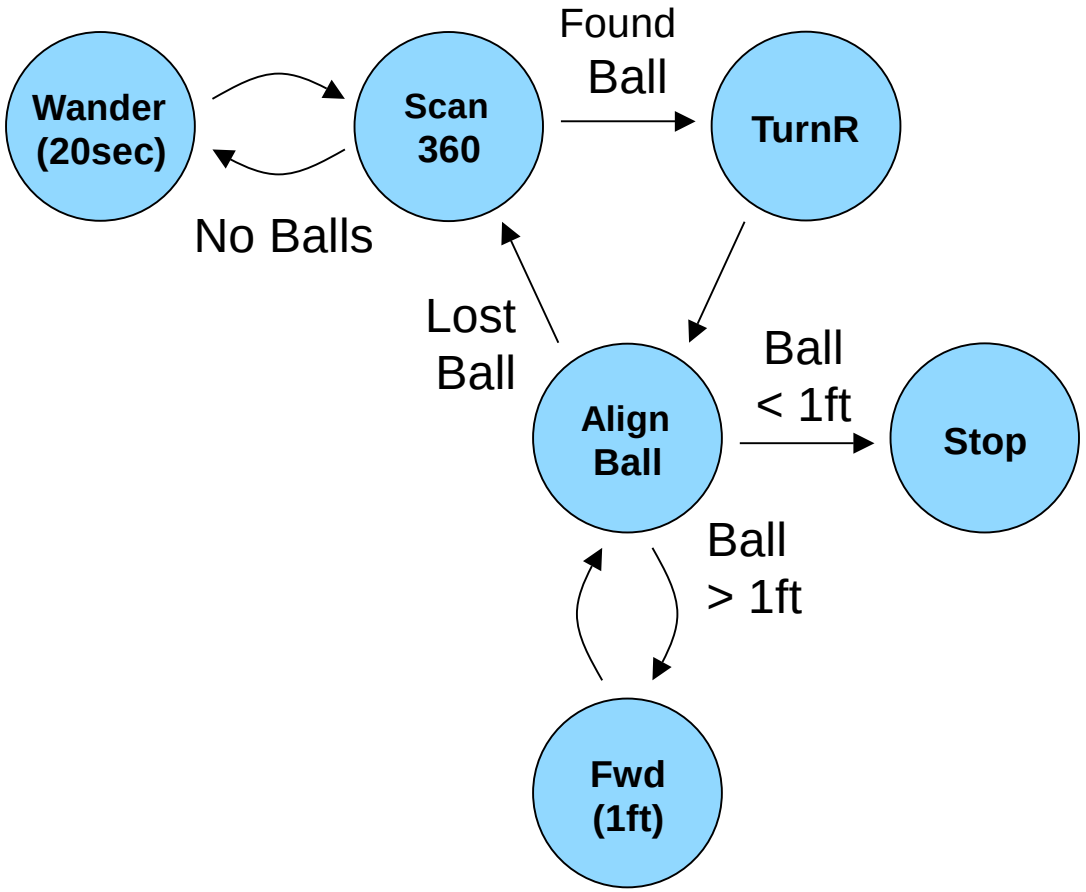


Can also fold closed loop feedback into the behaviors themselves

Case Study

SECTION 1

Simple finite state machine to locate red balls



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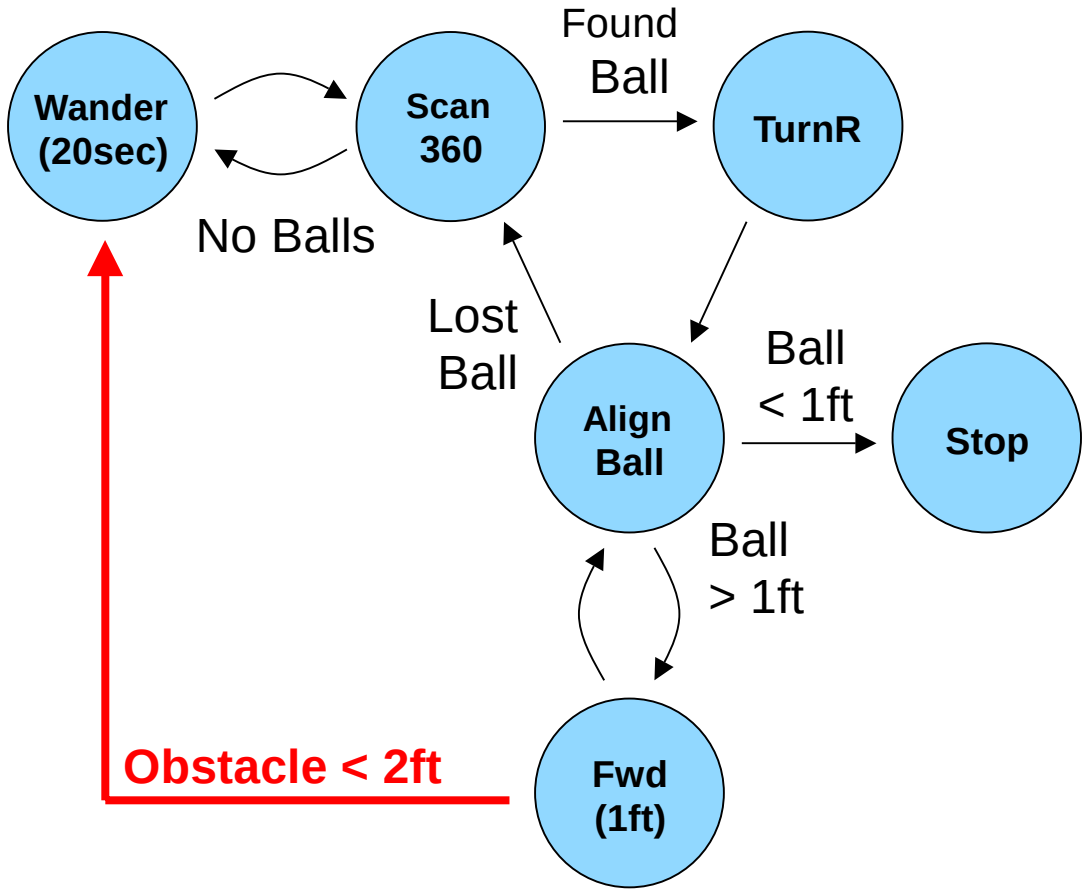
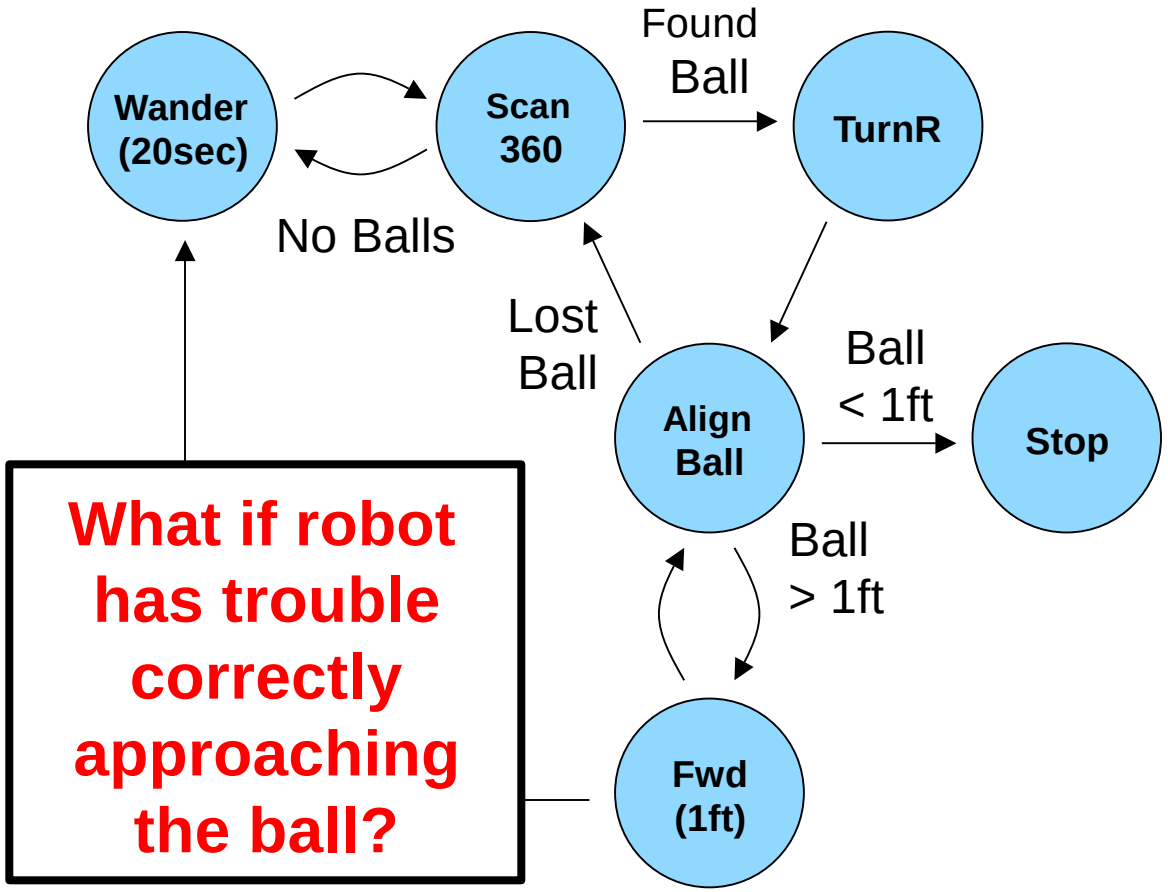


To debug a FSM control system verify behaviors and state transitions



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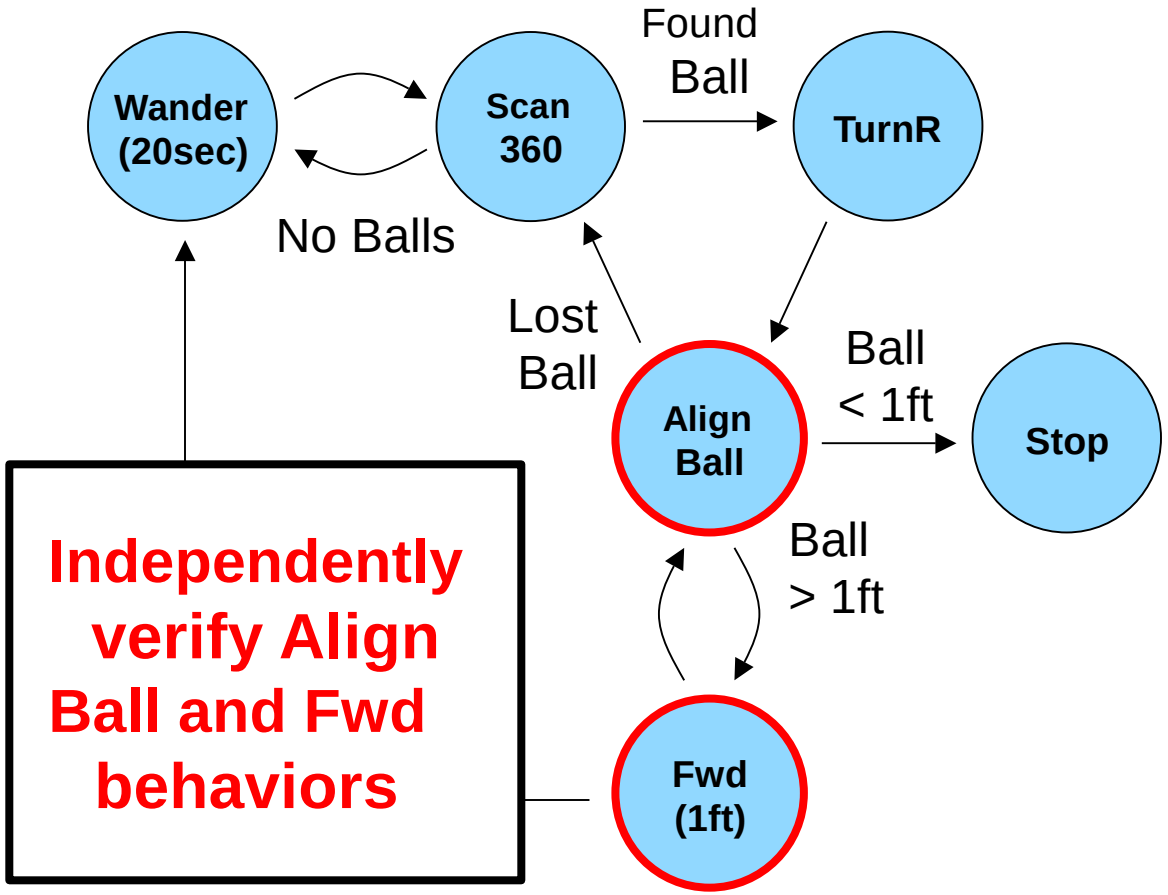
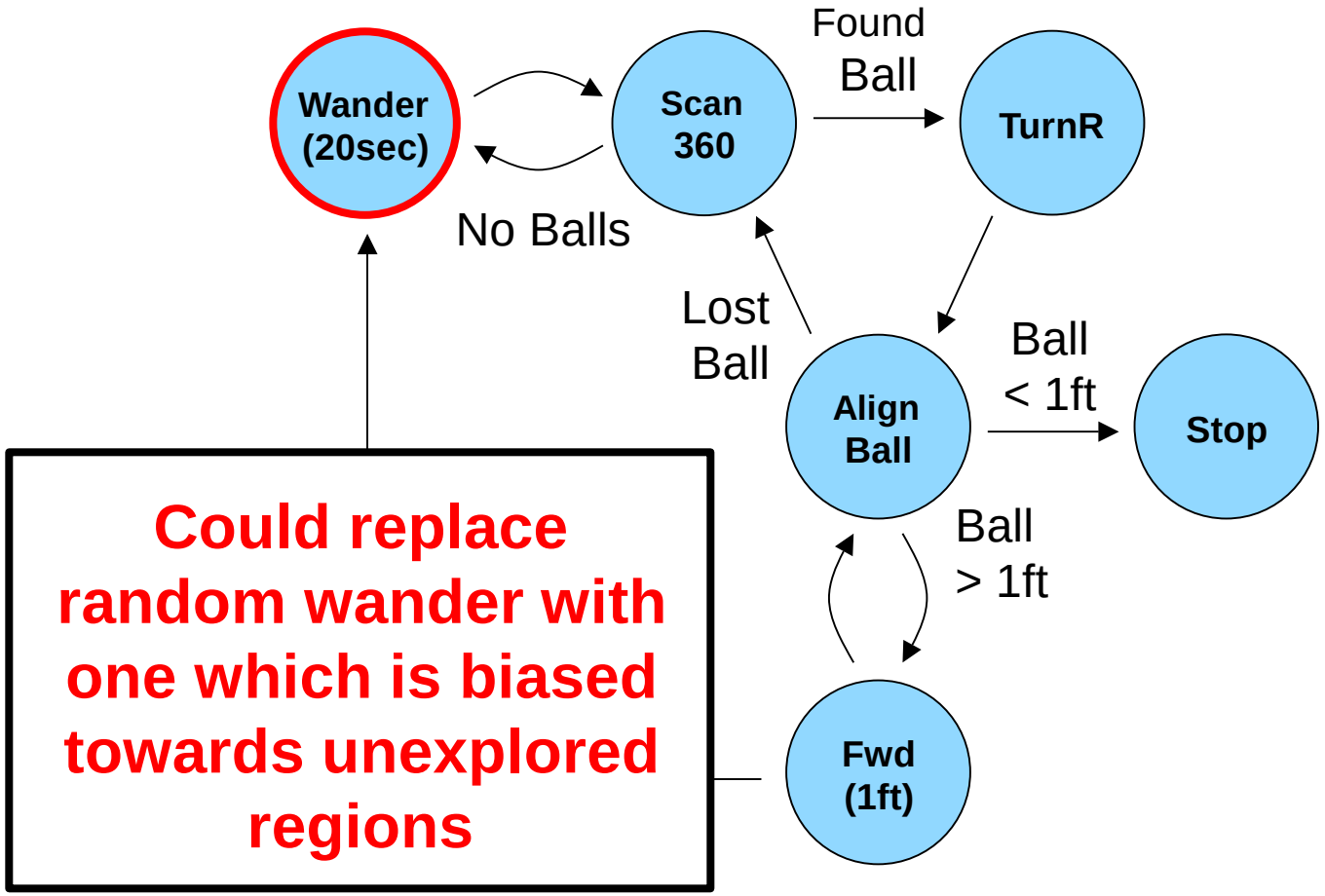


Improve FSM control system by replacing a state with a better implementation



Improve FSM control system by replacing a state with a better implementation

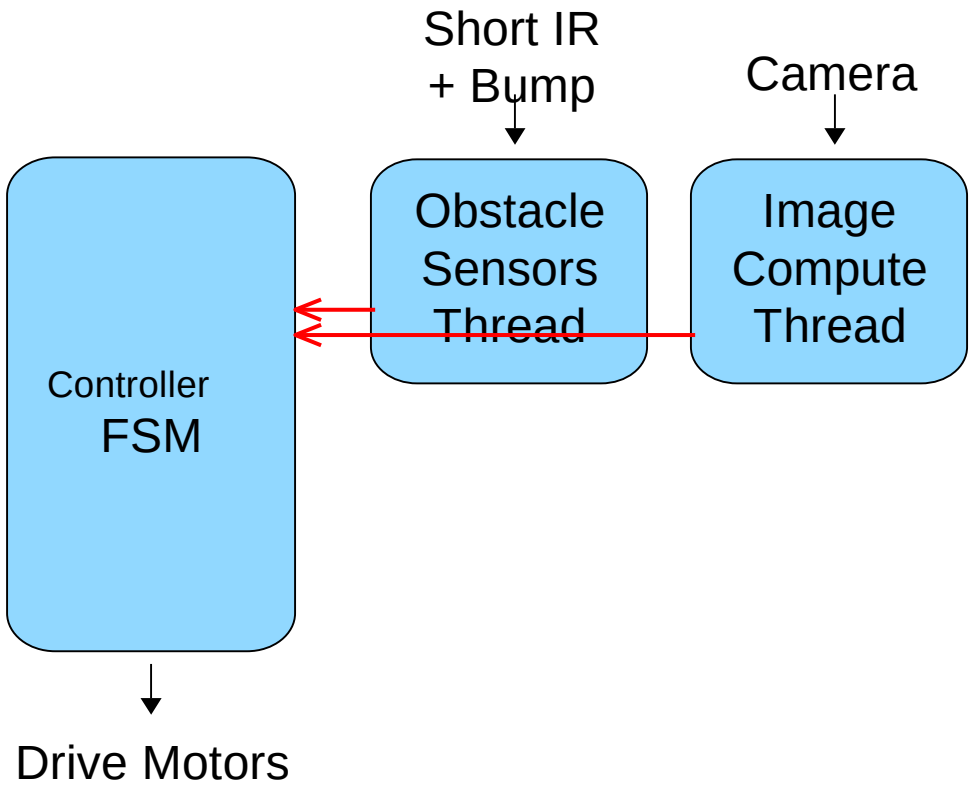
- What about integrating camera code into wander behavior so robot is always looking for red balls?
  - Image processing is time consuming so might not check for obstacles until too late
  - Not checking camera when rotating
  - Wander behavior begins to become monolithic

```
ball = false
turn both motors on
while ( !timeout and !ball )
  capture and process image
  if ( red ball ) ball = true

  read IR sensor
  if ( IR < thresh )
    stop motors
    rotate 90 degrees
    turn both motors on
  endif

endwhile
```

Multi-threaded finite state machine control systems



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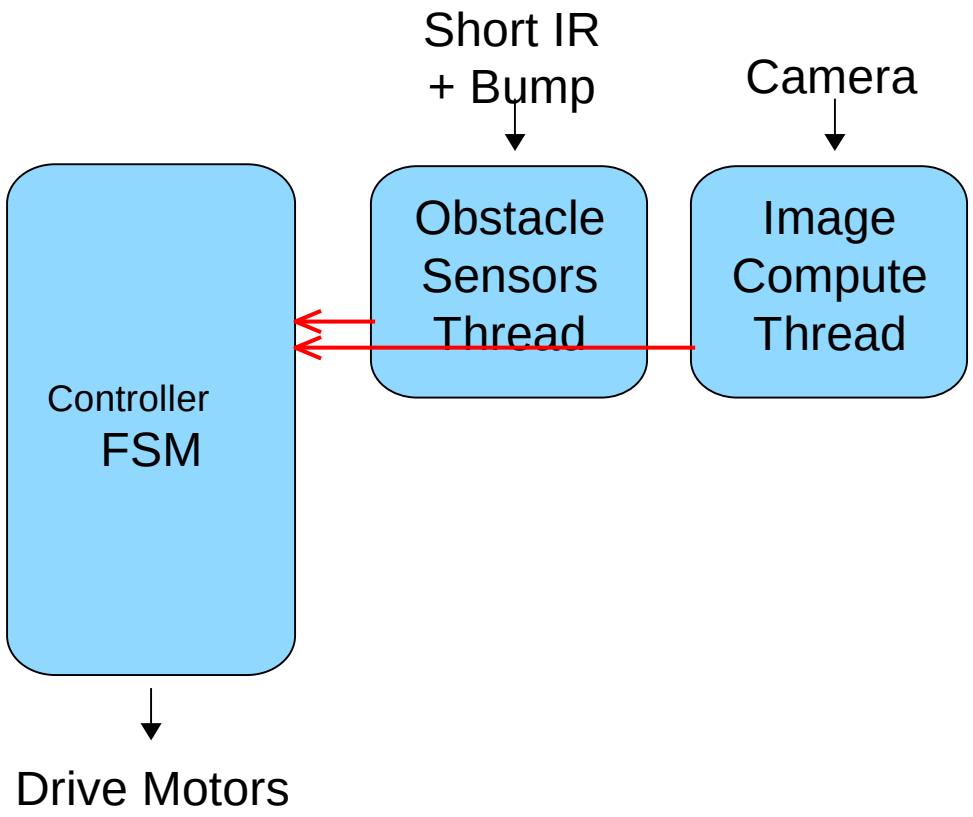

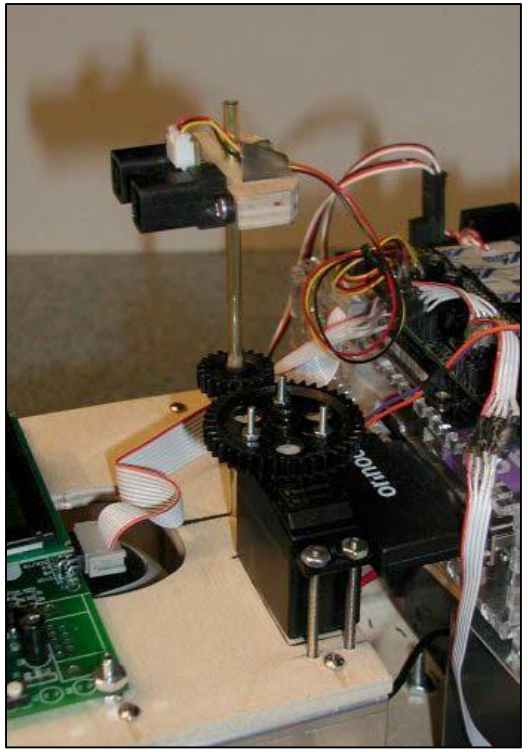

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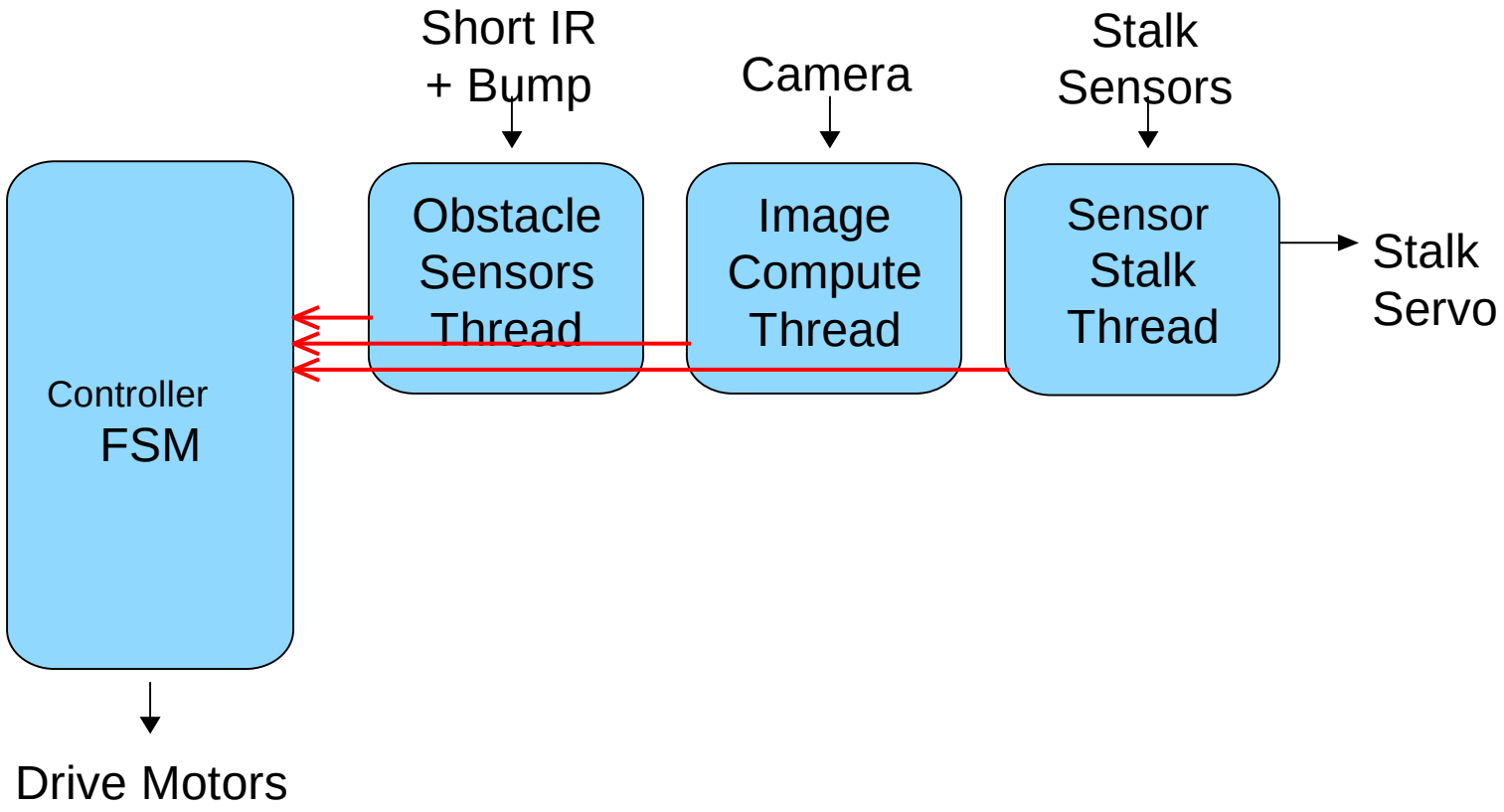

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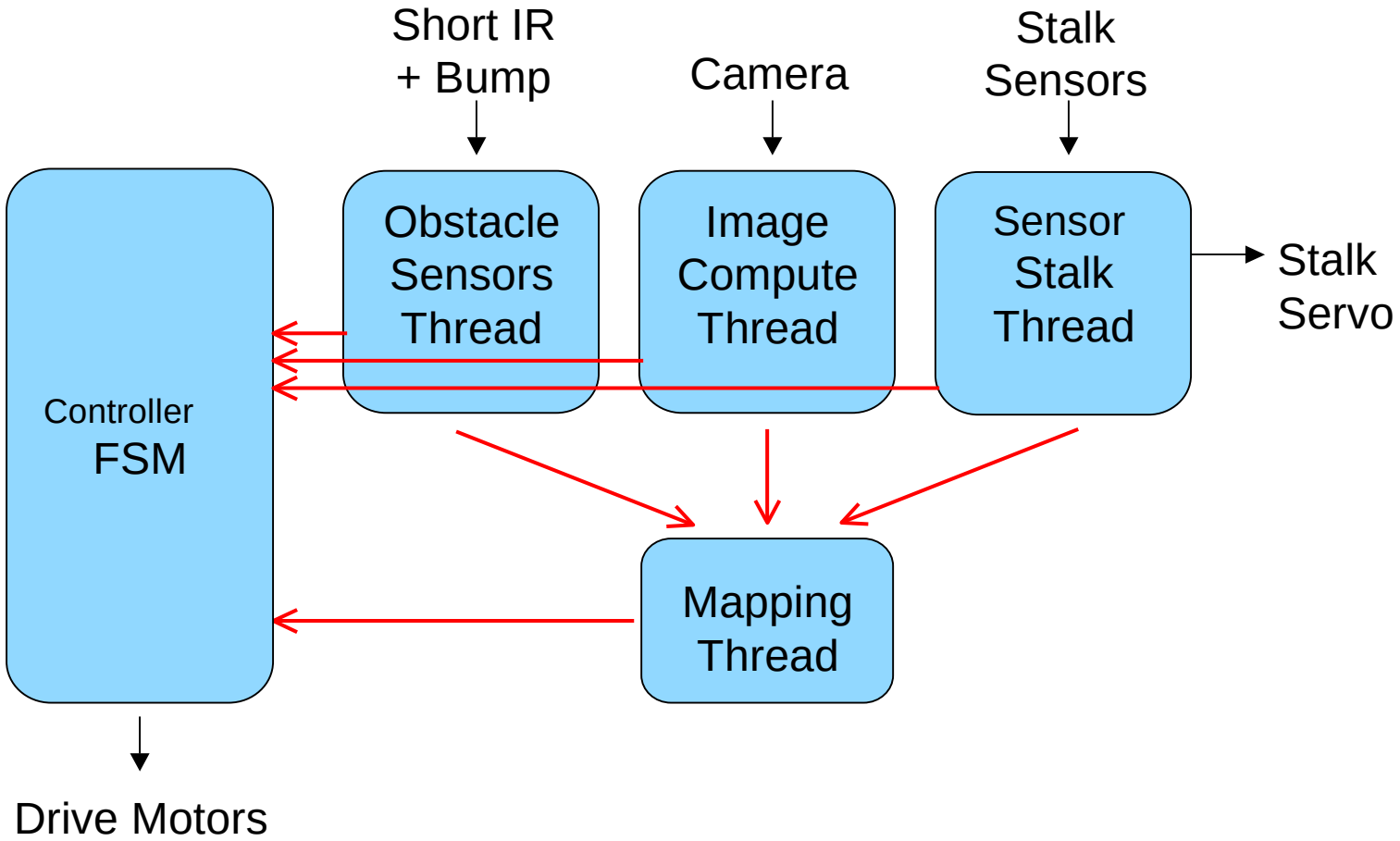

Python Coding

SECTION 1

FSM in Python

- Design of a Finite State Machine model in Python Language.
- Finite state machines can combine the model-plan-act and behavioral approaches and are a good starting point for your robotic control system modeling.