



Case Study: Cruise Control

Murray Cole

Cruise Control

Cruise Control

Basic idea

- allow driver to set a speed to be maintained without his/her intervention (*e.g.* 70mph down a long straight motorway)
- no need to keep accelerator pressed (less driver fatigue)

Specification

Pin down some requirements

- Driver can request the system to maintain the current speed
- Driver can **always** turn it off
- System should **not operate** after **braking**
- System should allow the driver to **travel faster** than the set speed

Design an FSM

We need to

- specify the inputs
- specify the outputs
- decide on the required states (and a start state)
- specify the transitions

Driver Inputs

- on: on/off button
- set: set the cruise speed to the current speed
- brake: the brake has been pressed
- accP: the accelerator has been pressed
- accR: the accelerator has been released
- resume: resume travelling at the set speed

Sensor Inputs

- correct: indicates the car is travelling at the correct speed.
- slow: indicates the car is going slower than the set speed
- fast: indicates the car is going faster than the set speed

Control Outputs

- store: store the current speed as the cruise speed
- inc: increase the throttle
- dec: decrease the throttle

States

Off: System is not operational.

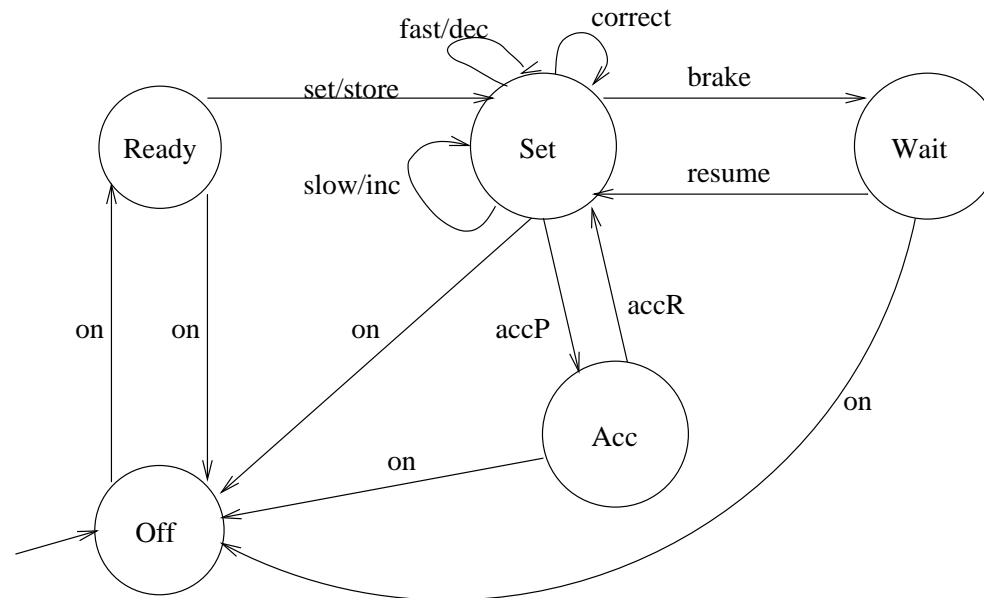
Ready: Switched on but no cruise speed set.

Set: Actively controlling speed.

Wait: Speed set but subsequently overridden by brake. Wait to be told to resume control.

Acc: Accelerator is currently pressed down (so override)

The Controller



All other inputs are loops with no output (ie ignored). Omitted here for clarity!

Java Implementation

Model (real system would interact with car hardware)

- **inputs** with strings from the keyboard
- **outputs** with strings to the monitor
- **state** by a variable holding an integer
- **transitions** by code which changes state and makes outputs in response to inputs

Overview

```
// Initialise Values

// Repeat Forever
while(true) {
    // Display Current State
    // Read input from keyboard
    // Make a transition
    // Display any output
}
```

```
public class CruiseControl {
    // Inputs
    public static final int on = 1;
    public static final int set = 2;
    public static final int brake = 3;
    public static final int accP = 4;
    .....
    // Outputs
    public static final int store = 10;
    public static final int inc = 11;
    public static final int dec = 12;
    // States
    public static final int OFF = 13;
    public static final int READY = 14;
    .....
```

```
int input = 0; int output = 0; int state = OFF;

while(true) {
    String in = keyboard.readLine();
    if (in.equals("on")) input = on;
    else if (in.equals("set")) input = set;
    .....
    else input = 0;

    // Make the appropriate transition (NEXT OVERHEAD)

    switch(output) { // Display any output
        case store: System.out.println(" store "); break;
        .....
    }
}
```

```
switch(state) {  
    .....  
    case SET:  
        switch(input) {  
            case on:    state = OFF; break;  
            case brake: state = WAIT; break;  
            case accP:  state = ACC;  break;  
            case fast:  output = dec; break;  
            case slow:  output = inc; break;  
            case correct: break;  
            default:   break;  
        }  
        break;  
        .....  
}
```

Maintenance

The incident occurred when the driver was on a highway on a rainy night. The traffic was slow, travelling at about 40 mph. The driver engaged cruise control and set it to 40 mph. Later the rain cleared and the traffic got faster so the driver used the accelerator to increase the speed to 60 mph and travelled in this mode for some miles (*the controller still in set mode but overridden by the accelerator*).

Coming to the exit ramp the driver turned off and released the accelerator to coast up the ramp. At that point the cruise control aimed to stabilise the speed at the set level (40 mph). *The driver was taken by surprise and lost control of the car which travelled through a stop sign without braking.* Fortunately no accident occurred.