State Transition Diagrams

- How to organize code for an reactive controller?
Crossing at an Intersection

• If light is red, wait for light to turn green
• If light is yellow, wait for light to turn green
• If light is green but there is not enough time, wait for light to turn red and then green
• If light is green and there is enough time,
  – Proceed on crosswalk
  – If a car is speeding at you, get out of the way
• Stop crossing when other side is reached

Formulating such a rule-based system as a state transition diagram
State

• A *state* is a **unique** set of conditions that hold at a given time

• Conditions include:
  – Measured or sensed properties of the environment
    • E.g., light is green and there is 20 seconds to cross
  – Current behaviour
    • E.g., Crossing the street
  – Current expectations
    • E.g., Will reach the other side without being run over

• Key Idea: A robot can be in one state at a time

• Robots can transition from one state to another state
State Transitions

• A state transition occurs when
  – An event occurs
  – One of the conditions describing the state changes
  – The state of the robot changes

• Transitions are typically caused by
  – External events
    • E.g. The stoplight changing colour
  – Internal event (Completion of a step in a task)
    • E.g. Completion of crossing the street
State Transition Diagrams

• Idea: We use a state transition diagram to model a task
• States are represented by circles
• Arrows represent transitions between states

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  - Proceed on crosswalk
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- Stop crossing when other side is reached
Creating State Transition Diagrams

• Identify the states (steps) of a task
  – Determine what **actions** must be performed
  – Determine groups of **unique** (relevant) conditions
  – Label each group with a **unique** name

• Identify state to state transitions
  – What is being sensed?
  – What external events will be sensed?
  – What internal events will occur?
  – What conditions will these events change?
  – Determine which conditions change?
  – Determine the corresponding states in the transition
  – Label each transition with a unique label

• Create diagram
  – Combine states and transitions
  – Refine the diagram by repeating the process

• **This diagram is a blueprint for your program!**
Determine if Number of People is Even

• **Idea**
  – Don’t want to count people
  – Just keep track if # of people is odd or even

• **States:** (2)
  – Even
  – Odd

• **Transitions:**
  – Each additional person causes a transition to the other state
Avoid the Boundary

• Idea
  – Two actions
    • Move forward
    • Back off
  – Two events
    • Black line sensed
    • Finish back-off

• States: (2)
  – Forward
  – Back-off

• Transitions:
  – Line sensed (prox event)
  – Back-off done (timer event)
Move in a Square

• Idea
  – Two actions
    • Move forward
    • Turn right
  – Two events
    • Finish straight move (timer expired)
    • Finish right turn (timer expired)

• States: (2)
  – Forward
  – Turn

• Transitions:
  – On timer events
    • (timers expire)

```plaintext
onevent timer0
  motor.left.target = -motor.left.target
  if motor.left.target < 0 then
    timer.period[0] = TURN_PERIOD
  else
    timer.period[0] = FWD_PERIOD
  end
```
Make One Square

• Idea
  – Two actions
    • Move forward
    • Turn right
    • Repeated 4 times
  – Two events
    • Finish straight move (timer)
    • Finish right turn (timer)

• States: (?)
  – Forward?
  – Turn?
  – ...

• Transitions:
  – When timers expire
  – ...
Follow the Line

• Setup
  – Actions?
  – Events?
• States: (?)
• Transitions: ?
Determine if Number of People is Divisible by 3

• **Idea**
  – Don’t want to count people
  – Just keep track if # of people is divisible by 3

• **States:** (?)

• **Transitions:**
  – Each additional person causes a transition