CS2303 In Class Exercises

Jan 28, 2020

January 13, 2020

Abstract

Today's goal is that you can understand the state machine paradigm as one of your design tools.

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1 State

We can use data, such as measurements, to characterize something, such as a process. The speed and direction of a car, the weather, and aspects of our computation. The collection of the values of these parameters make up the state.

Example:
Some robots include 9 degree of freedom characterizations of state: these are roll, pitch and yaw, and their first and second derivatives.

Note in the example above that only some measurements of interest are included. It is possible to exclude from the state, other measurements that might be of interest to other people or at other times, such as temperature, battery charge, or instantaneous power utilization.

Exercise: (As always, if you have questions, ask. After this occasion, this material becomes background knowledge.)

1. How might you characterize the state of a clothes washer? Don't forget about soap, water and electricity.

   has soap and water if on which means it has electricity
   otherwise if there is no electricity the machine is off and
   does not contain any soad or water but still my contain clothes

2 Finite State Machines

A state machine is an event-driven (reactive) system. In an event-driven system, the system makes a transition from one state or mode to another, if the condition defining the change is true. State machines are described at `https://www.mathworks.com/videos/understanding-state-machines-what-are-they-1-of-4-90488.html`. Note that an unstated assumption is made in this first video. During the idling state of the oven, the heating element is not on, and if the event of turning the oven off were remembered, then as soon as the oven temperature drop caused a transition from the idling state to the heating state, that remembered turning the oven off would be able to take effect. The necessity described in the video, of including an event handler within the idling state, to turn off the oven, implies that no memory of the turn off event is employed. So, we must recognize that the events they are considering are transient.

Compare this notion with what a specific if statement does. That if statement evaluates a condition according to whether that condition prevails at the instant the execution reaches the location of the if statement. Other instants in time are irrelevant for that specific if statement. The execution of the program limits the instants of time that are relevant.

By contrast, a state machine must react to the external events, independent of when they may occur. Some accommodation must be made between the execution of the program limiting the instants of time, vs. the external environment permitting any instant of time to be relevant.

Example:
An elevator has states. The state can be decomposed somewhat. The door is open or closed, the elevator is at rest or moving. If the elevators is moving, it is either moving up or down. If a person stands outside an elevator and presses the affordance for going up, the elevator will behave differently if it is moving up (stops and opens the door) from how it would behave if it were moving down (go by without opening the door).

Exercise: (As always, if you have questions, ask. After this occasion, this material becomes background knowledge.)

1. Describe the behavior of a home furnace, in response to signals from the thermostat.

   if thermostat higher than previously then the furnace will turn on
   the furnace is either on or off 1 or 0

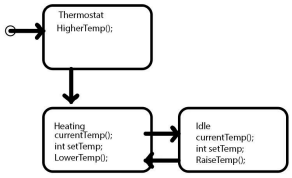
2.1 State Transition Diagram

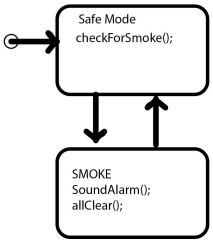
A video introducing state transition diagrams is at `https://www.mathworks.com/videos/understanding-state-machines-why-use-them-2-of-4-90489.html`.

Though the video mentions a tool to convert from these diagrams to code, and that commercial implementations of tool are available, though not necessarily for free, in this class we shall use small examples suitable for you to learn the process automated by the tools.

Exercise: (As always, if you have questions, ask. After this occasion, this material becomes background knowledge.)

1. Draw a diagram to describe the behavior of a home furnace, in response to signals from the thermostat.





2. Draw a diagram to describe the behavior of a smoke alarm. There are two inputs, smoke and an off button.

2.2 Types of Finite State Machines

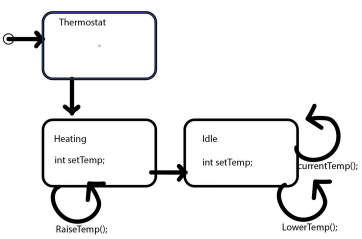
There are two types of finite state machines, a Mealy machine and a Moore machine. You might prefer one to another; ultimately an equivalence between the two can be shown.

A video that describes these two machines is at `https://www.mathworks.com/videos/understanding-state-machines-mealy-and-moore-machines-3-of-4-90490.html`.

Example:
An elevator has states. The state can be decomposed somewhat. The door is open or closed, the elevator is at rest or moving. If the elevators is moving, it is either moving up or down.

Exercise: (As always, if you have questions, ask. After this occasion, this material becomes background knowledge.)

1. Redraw your furnace diagram as a Moore machine and as a Mealy machine.



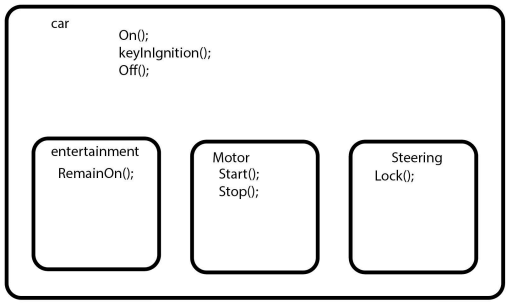
3 Harel State Charts

Harel updated the work of Moore and Mealy. The video at `https://www.mathworks.com/videos/understanding-state-machines-harel-state-machines-4-of-4-90491.html` describes Harel State charts.

Example:
A cell phone has several inputs: The camera, the microphone, the touch screen, the GPS, the buttons. The collection of inputs to the cellphone can be compartmentalized, according to if and how they are relevant to the users' (not forgetting that phone holder's data can be monitored) current activity.

Exercise: (As always, if you have questions, ask. After this occasion, this material becomes background knowledge.)

1. Draw a state diagram, using hierarchy, parallelism, and broadcasting, for a car. It has a motor, steering and brakes, and also an entertainment system. The entertainment system will play for 15 minutes after the motor is turned off, if the keys remain in the ignition. After 15 minutes in that state, the headlights and the entertainment system will turn off.



4 Adoptions of State Charts

State charts are used in Unified Modeling Language (UML) and in Matlab/Simulink. Some development tools will create code (in C++, and possibly other languages).