# 27: Modeling



### **FSM-based design for software**

- Incorporates reasoning about state into design
- Translates pretty easily to code
- Guides unit testing





3. mov

6. wait for but

7. game over

4. wait after mov

### FSMs as models

FSM describes behavior of the system

Abstracts away some aspects of the system





What do you think when you hear "all models are wrong, some models are useful"

?

## **Formalizing FSMs**

We handwaved some aspects of FSMs Role and behavior of inputs and outputs Presence/absence of self-loops

Distinction between FSMs and extended SMs

### **Back to the formal definition**

(Lee/Seshia 3.3.3)

An FSM is a 5-tuple: (States, Inputs, Outputs, update, initialState)

- States is a finite set of states
- Inputs is a set of input valuations
- Outputs is a set out output valuations
- update: States x Inputs  $\rightarrow$  States x Outputs is an update function
- initialState is the initial state

Valuation: a set of values that a signal can take on or the assertion that the value is absent

Numerical signals: R U {absent} or N U {absent} Pure signals: {present, absent} Categorical signals: examples {1, 2, 3, ... 8, absent} or {true, false, absent}

### Present vs. Absent

For a *discrete* system, events for an input:

- Are discrete (separate, individual events)
- Happen in sequence

absent means "absence of an event," while a value means "we received this value"

Lightswitch

VS.

Push button

### **Time/event triggered design**

#### **Purely time-triggered**

#### **Event-triggered**

(Our implementations are time-triggered)

We call update\_fsm with all inputs periodically

All inputs are present for every update

(Would get complicated to implement using our template)

Transition the FSM based on a change in input (e.g. interrupt)

Not all inputs may be present for every update

## **Keeping track of data**

An FSM is a 5-tuple: (States, Inputs, Outputs, update, initialState)

How do we keep track of internal data?

Example: system with yes/no vote buttons, keep track of difference in votes





Figure 3.3: Visual notation for a finite state machine.



Figure 3.9: Notation for extended state machines.

Lee/Seshia chapter 3



What are we missing out on when we tell time by using "mils" as an input?