30: Hybrid systems
AC model from prelab

on/off button
currTemp
desTemp
mils

1. AC_OFF
2. AC_ON
3. SYS_OFF
Modeling mils

\[
\text{true} \quad / \quad \text{mils} := \text{varMils} \\
\text{varMils} := \text{varMils} + 1
\]
How do we model:

- Current temp
- Desired temp
- Button push
Nondeterminism

Guards out of a state are not mutually exclusive

- Reason about the “possible set of states” a system can be in
- Useful for modeling environment

inputs: $\text{sigR, sigG, sigY : pure}$
outputs: $\text{pedestrian : pure}$

true /

none waiting

crossing

sigG /
sigR /

true / pedestrian

Lee/Seshia fig. 3.11
AC model composed with very simplified, non-deterministic model of current temp and time

2. AC_ON

true*/
currentTemp := currentTemp - 1

true*/ mils := mils + 1

*we would actually have to make sure that these transitions aren't taken if we need to leave state 2, e.g. ¬(sysSwitchToggled ∧ (mils - timeOfSysToggle) ≥ 1000)
AC model composed with *non-deterministic* model of button

1. SYS_OFF

2. AC_ON

\[ \text{sysSwitchToggled} \land \text{(mils - timeOfSysToggle)} \geq 1000 / \text{timeOfSysToggle} := \text{mils} \]

**Pro:**

**Con:**
Composing with model of desired temp: option 1

We lose ability to prove things like:
(desTemp > curTemp → eventually AC_ON)
Composing with model of desired temp: options 2 and 3

2. AC_ON

2. AC_ON

mils - timeOfAcToggle >= 2000
^ currTemp < desTemp

true* / desTemp := ...

desTemp := ...

true* / desTemp := 55

desTemp := 55

desTemp := 56

desTemp < 86* / desTemp := desTemp + 1

desTemp > 54* / desTemp := desTemp - 1

desTemp := ...

desTemp := ...

true* /
What are we missing out on when we tell time by using “mils” as an input?
ODEs

Sometimes it is more desirable to describe a variable in terms of how it changes rather than its explicit form.

Useful for: modeling, reasoning

Define a function in terms of its derivative and possibly initial conditions.

Ordinary Differential Equation, or ODE

Solving general ODEs is beyond the scope of the class, but we will discuss some patterns here.
Example: falling ball
Hybrid systems

Discrete System (FSM)

Continuous System

Hybrid System

jump

flow

EECS 149/249A, UC Berkeley: 8
Timed automata

Distinction between discrete and continuous variables
Continuous behavior defined in “states”

Now called “modes”

Lee/Seshia chapter 4
Example: bouncing ball

Board discussion
Discussion of homework problems