Embedded System Design
Lab 2: Modeling in Ptolemy

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1 Introduction

Lab 2 requires us to design and simulate an automatic windshield wiper with Ptolemy II, an open-source software developed by Berkeley for heterogeneous system design, modeling, and simulation.

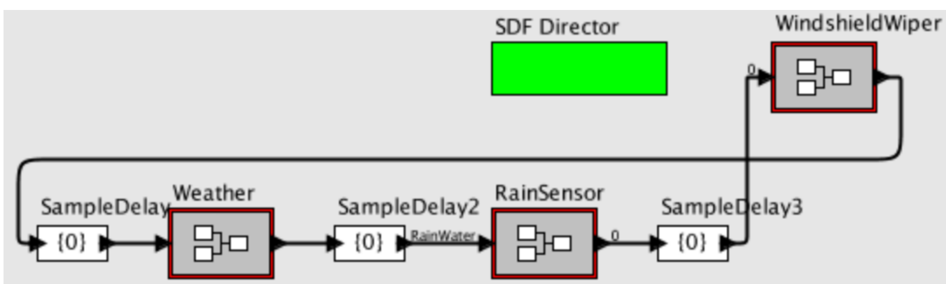

Figure 1. Layout of the Automatic Windshield Wiper Model

As shown in Fig.1, the automatic windshield wiper model is consisted of three parts, the weather model that simulates weather conditions, the rain sensor model that detects raindrops on the surface of the windshield, and the windshield wiper model that receives rain sensor signals and controls the windshield wiper.

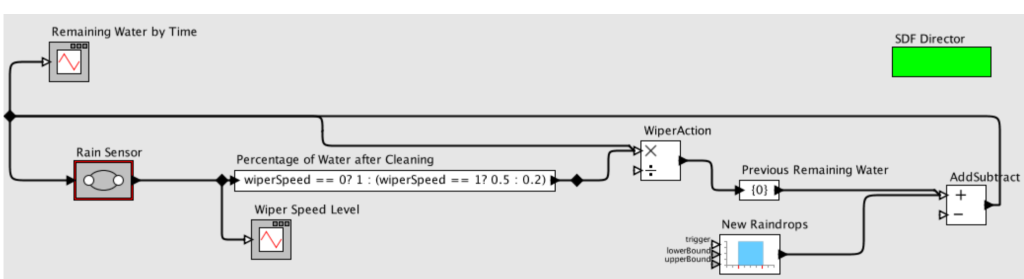

Figure 2. Implementation of the Automatic Windshield Wiper Model

A detailed implementation is shown in Fig.2, where the weather model is realized by a uniform random number generator, an adder, and a delay; the rain sensor model is realized by a finite state machine (FSM); the windshield wiper model is realized by an expression and a multiplier.

2 Visibility Requirements

Raindrop simulation and assumption: To simulate the raindrops on the windshield, we use the actor component of the uniform random number generator. The uniform random number generator outputs a random sequence that follows the uniform distribution. For each iteration, a newly generated number will be used to represent the volume of raindrops at some timestamp. Specifically, we set the uniform distribution range from 1 ml to 8 ml.

Maximum remaining water allowed on the surface of the windshield while the wiper is OFF: We set 10 ml as a threshold, when the volume of remaining water exceeds 10 ml, the wiper works in SLOW mode.

Maximum remaining water allowed on the surface of the windshield while the wiper works in SLOW mode: We set 15 ml as another threshold, when the volume of remaining water exceeds 15 ml, the wiper works in FAST mode.

Wiper speed: The wiper has three states, OFF, SLOW, and FAST. If the status is OFF, the multiplier times the remaining water by 1; if the status is SLOW, the multiplier times the remaining water by 0.5, which means 50% water is wiped out; if the status is FAST, the multiplier times the remaining water by 0.2, which means 80% water is wiped out.

3 Weather Model

As Fig.3 shows, the weather model contains a uniform random number generator, an adder, and a delay. The uniform random number generator is used to simulate raindrops, which generates a sequence of "raindrops" that follows the uniform distribution from 1 ml to 8 ml at each timestamp. The delay stores the volume of remaining water. At each timestamp, the adder adds the newly generated "raindrop" with remaining water and the output is received by the rain sensor model.

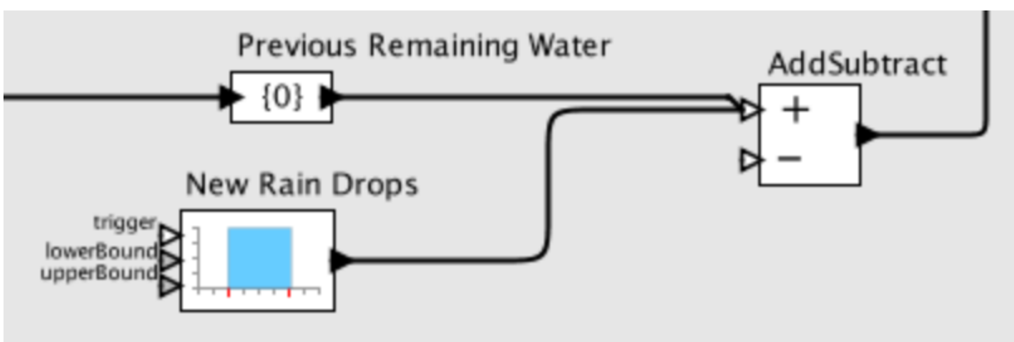

Figure 3. The Weather Model

4 Rain Sensor Model

As Fig.4 shows, the rain sensor model is implemented by a FSM. It receives an input, the volume of remaining water, and outputs a control signal to the windshield wiper model. There are 3 states in this FSM. The first state is OFF, when the volume of remaining water is less than 10 ml, the control signal is 0 and the wiper is OFF. The second state is SLOW, when the volume of remaining water is less than 15 ml but exceeds 10 ml, the control signal is 1 and the wiper is SLOW. The third state is FAST, when the volume of remaining water exceeds 15 ml, the control signal is 2 and the wiper is FAST.

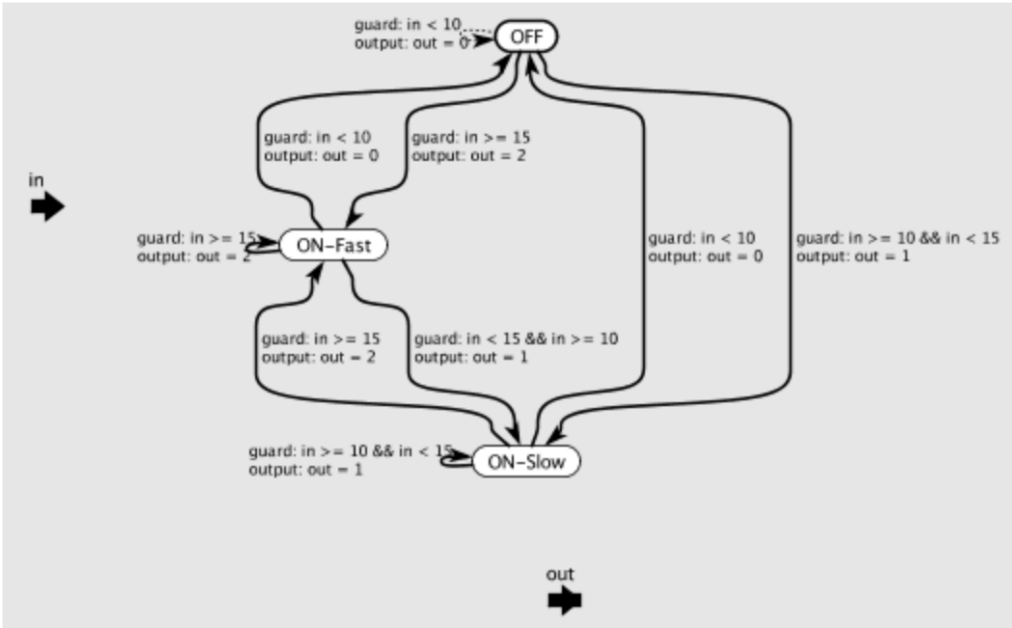

Figure 4. The Rain Sensor Model

5 Windshield Wiper Model

As Fig.5 shows, the windshield wiper model is consisted of an expression and a multiplier. If the wiper is OFF, the expression outputs 1 to the multiplier, which means no water is wiped out; if the wiper works in SLOW mode, the expression outputs 0.5 to the multiplier, which means 50% water is wiped out; if the wiper works in FAST mode, the expression outputs 0.2 to the multiplier, which means 80% water is wiped out.

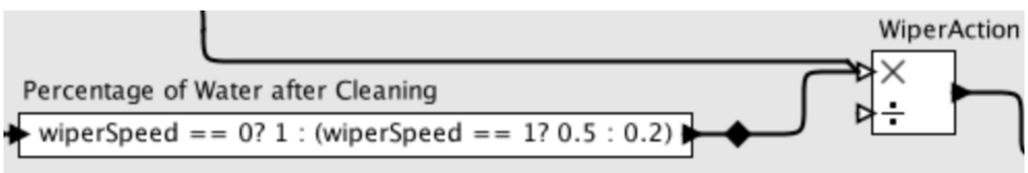

Figure 5. The Windshield Wiper Model

6 Models of Computation

There are three models of computation used in our design,

- **The addition model:** This model is used to compute the water on the surface of the windshield at each timestamp, where the newly generated "raindrop" is added to the volume of remaining water.
- **The FSM model:** This model is used to compute the wiper control signal. If the volume of remaining water is less than 10 ml, the FSM outputs 0 as OFF signal; if the volume of remaining water is less than 15 ml but exceeds 10 ml, the FSM outputs 1 as SLOW signal; if the volume of remaining water exceeds 15 ml, the FSM outputs 2 as FAST signal.
- **The multiplication model:** This model is used to compute the volume of remaining water after each wiper action. The volume of remaining water is multiplied by 1 if the wiper is OFF; the volume of remaining water is multiplied by 0.5 if the wiper works in SLOW mode; the volume of remaining water is multiplied by 0.2 if the wiper works in FAST mode.

7 Parameters

Key parameters include,

- **Raindrop:** Each raindrop is drawn from a uniform distribution from 1 ml to 8 ml.
- **Water Thresholds:** If the volume of remaining water is less than 10 ml, the wiper is OFF; if the volume of remaining water is less than 15 ml but exceeds 10 ml, the wiper works in SLOW mode; if the volume of remaining water exceeds 15 ml, the wiper works in FAST mode.
- **Wiper Speed:** If the wiper works in SLOW mode, 50% remaining water is wiped out; if the wiper works in FAST mode, 80% remaining water is wiped out.

8 Simulation Results

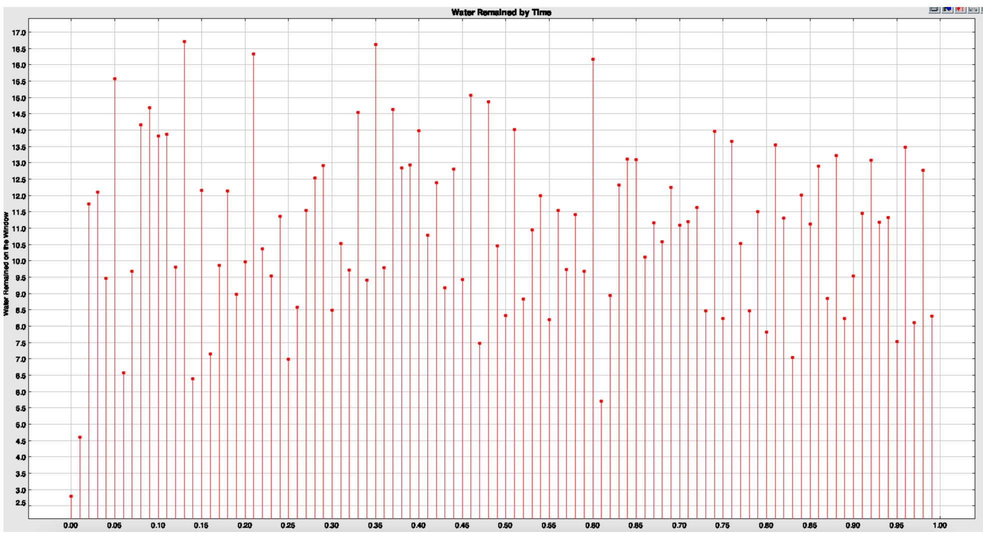

Figure 6. The Volume of Remaining Water by Time

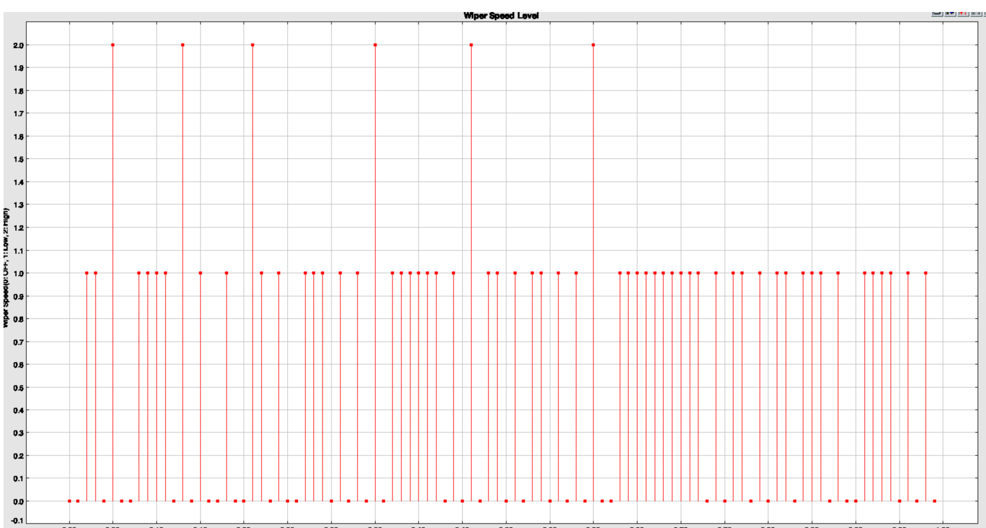

Figure 7. The Wiper Speed by Time