Control Systems: How Clean is the Pond?

Pseudocode - Calibration Function “calibrateWater()”

```
show “S” on the micro:bit
SUM = 0
COUNT = 10

while COUNT >= 0
     VALUE = analog value of the light sensor
     SUM = SUM + VALUE
     COUNT = COUNT - 1

CLEANTHRESHOLD = SUM / 10
show “F” on the micro:bit
return CLEAN THRESHOLD
```

Pseudocode - Inital Calibration

```
turn LED on
CLEANTHRESHOLD = calibrateWater()
```

Pseudocode - Re-Calibration

```
if Button A on the micro:bit is pressed
     turn LED on
     CLEANTHRESHOLD = calibrateWater()
```

Pseudocode - Main Code

```
while TRUE
     WATER = analog value of the light sensor
     if WATER <= CLEANTHRESHOLD // if the water is clean
          show “C” on the micro:bit
          turn off the red LED
     else
          show “D” on the micro:bit
          turn on the red LED
```

Code

```
function calibrateWater() {
   basic.showString("S")
   let sum = 0
```

```
    let count = 10
    while (count >= 0) {
        let value = pins.analogReadPin(AnalogPin.P1)
        sum = sum + value
        count = count - 1
    }
    let cleanThreshhold = sum / 10
    basic.showString("F")
    return cleanThreshhold
}

pins.digitalWritePin(DigitalPin.P0, 1)
let cleanThreshhold = calibrateWater()

input.onButtonPressed(Button.A, function () {
    pins.digitalWritePin(DigitalPin.P0, 1)
    cleanThreshhold = calibrateWater()
})

basic.forever(function () {
    let water = pins.analogReadPin(AnalogPin.P1)
    if (water <= cleanThreshhold) { // if the water is clean
        basic.showString("C")
        pins.digitalWritePin(DigitalPin.P2, 0)
    }
    else {
        basic.showString("D")
        pins.digitalWritePin(DigitalPin.P2, 1)
    }
})
```

[Functioning Micro:bit Configuration]

Questions

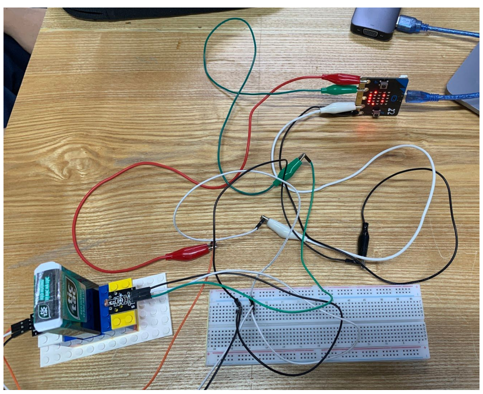
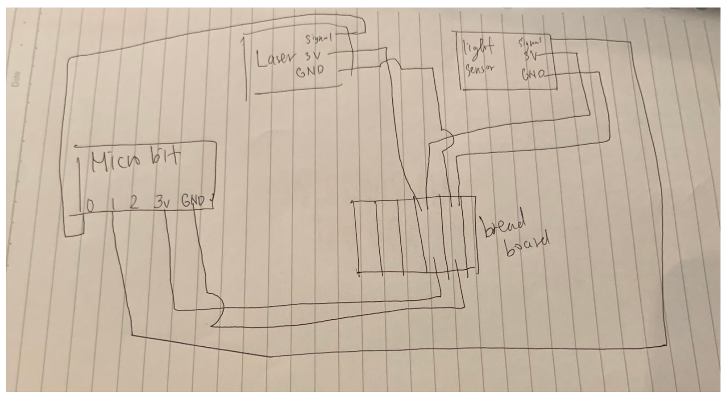
1. How will this give an indication of the amount of algae in the water sample?

If there is a relationship between how clean the water source is and how much light is passed through when a laser is shined, then we can measure the amount of light passed through with a sensor and figure out how much algae is in the water. The more light that is passed through, the less algae there is, and the less light that is passed through, the more light there is.

2. Why is calibration needed? How often is calibration needed?

Calibration is needed because the light sensor value for clean water would probably be different for every system, and if the values do not match, we have a chance of reporting the water is clean when it is dirty and vice versa. Calibration is needed probably every time you introduce the machine into a new environment and even if it is the same environment, regular new calibrations so that we can ensure the values are appropriate.

3. Document your apparatus setup (video and/or photo). Explain why you made specific connections

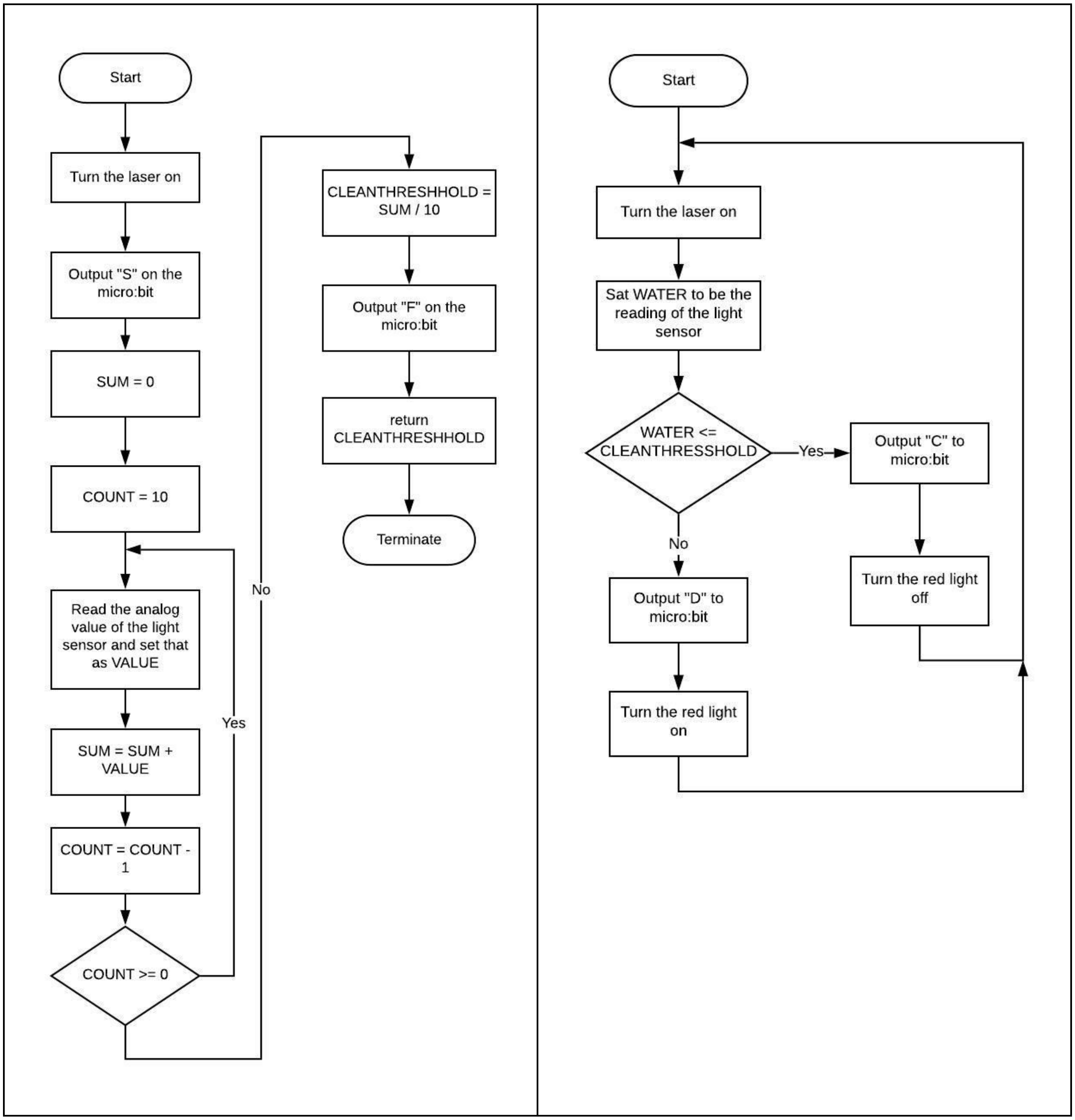
Since the micro:bit only had so many ports available, we connected the ground of the laser and the light sensor together in the breadboard and from there connected it to the micro:bit using alligator clips. We did the same with the 3V. It wouldn't matter to the final product if these were connected to the same port on the micro:bit as they were there to supply energy to the laser and the sensor. As for the signal ports, we connected the signal of the laser to pin 0 and the signal of the light sensor to pin 1. The laser outputs values while the light sensor inputs values, so it would have been disastrous if we connected them together in the breadboard as we did with ground and 3V.

4. What event(s) will you use to trigger the calibration? The reading?

When the micro:bit is turned on, the laser is turned on and a calibration happens. The calibration also happens when Button A of the micro:bit is pressed. Afterward, the program continues to take readings of the light until the micro:bit is turned off.

5. Document your pseudocode/flowchart for what will happen when these events are triggered.

Calibration	Reading



6. How would you edit the program script if you wanted the filter to keep the pond water even cleaner in the future?

We could use an even cleaner sample of water or have the code lower the value for the clean water threshold.

7. What is the difference between an analog sensor and a digital sensor? What type of sensor are you using and how will it impact your code?

An analog sensor reads values from 0 to a finite number (our sensor reads to 0 to 1023), while a digital sensor reads discrete values of 0 or 1. Our light sensor is set to be an analog sensor because how much light passes through the water is a spectrum from 100% light to no light at all. If we set the senor to be a digital value, it would only be correct when there is absolutely no algae and when there is so much algae no light can pass through. This isn't the case for our system since the user defines how much algae in the water is considered clean, so we need to use the analog sensor.

8. Provide a screenshot of your working code and explain the programming techniques you utilized in the code.

This is our code:

```
function calibrateWater() {
    basic.showString("S")
    let sum = 0
    let count = 10
    while (count >= 0) {
        let value = pins.analogReadPin(AnalogPin.P1)
        sum = sum + value
        count = count - 1
    }
    let cleanThreshhold = sum / 10
    basic.showString("F")
    return cleanThreshhold
}

pins.digitalWritePin(DigitalPin.P0, 1)
let cleanThreshhold = calibrateWater()

input.onButtonPressed(Button.A, function () {
    pins.digitalWritePin(DigitalPin.P0, 1)
    cleanThreshhold = calibrateWater()
})

basic.forever(function () {
    let water = pins.analogReadPin(AnalogPin.P1)
    if (water <= cleanThreshhold) { // if the water is clean
        basic.showString("C")
        pins.digitalWritePin(DigitalPin.P2, 0)
    }
    else {
        basic.showString("D")
        pins.digitalWritePin(DigitalPin.P2, 1)
    }
})
```

For our code, we made the calibration for the threshold of clean water as a function since we would need to calibrate multiple times. In this function, we used a while loop to take multiple readings of the clean water so we could take the average of these readings and possibly get a more accurate threshold value.

In the `basic.forever` function, we used an if statement to separate the water readings as "clean" or "dirty". The water is classified as clean when the value for light is lower than the calibrated threshold and dirty for every other value.

9. Explain what a control system is and why this pond filtration system is a control system.

A control system is something that regulates what process is done based on an input. The pond filtration system is a control system because it takes an input, if the water is clean or dirty, and switches on the filtration system based on this input. If the water is dirty, it switches the filter on, and if it is clean, it switches it off.

10. Define "sensor". What sensor(s) did you use in this control system? Explain how additional sensor(s) could be used in this control system.

A sensor is a device that records a physical quality. In our pond filtration system uses a light sensor that records the amount of light from the laser through the algae. A temperature sensor could be used because the temperature of the water could affect the future amount of algae in the pond. A viscosity sensor (if there is such a thing) could be used because generally pond owners want their ponds to be less viscous.

11. Define “actuator”. Explain how actuator(s) could be used in this control system.

An actuator is a mechanical component of the system that uses movement (like a motor). An actuator could be used in the pond filtration system to mechanically turn the filtration system on by flipping a physical switch.

12. Explain the relationship between the sensors, microprocessors, and actuators/indicators in this control system.

The sensors record the amount of light passing through clean water so that it could be stored as calibrated value. Then the sensors read the value of how much light passed through the water and the microprocessor determines if the water is dirty or clean. The indicator shines the red light if the water is determined to be dirty. If the water is clean, no light shines. All the commands of the system are essentially controlled by the microprocessor.

13. Would this control system be considered an “open-loop” control system, or a “closed-loop” control system? Explain the difference between these types of control systems in your answer.

The pond filtration system is a closed-loop because it measures if the water is clean and switches on the filtration if the water isn’t clean. An open-loop doesn’t change the process based on the external feedback, like how a ceiling light will continue to be on no matter how much external light is in the room, but a closed-loop would change the input based on feedback, like how an airconditioner would change how much air it puts out depending on the temperature of the room, so our system is a closed-loop since it takes the feedback of how clean the water is and applies that to turn the filtration on or off.

14. Discuss the social impacts and ethical considerations associated with the use of this control system.

In our control system, we first had it calibrate the “dirty water” threshold and the “clean water” threshold. If we separated the readings of the water at the dirty water threshold, we would have a danger of passing water as clean when it was really dirty. In contrast, if we separated the readings of the water at the clean water threshold, we would have the danger of passing the water as dirty when it is really clean. We thought that passing the water as dirty when it was clean was better than passing the water as clean when it is dirty was better since we wouldn’t risk poisoning the user.

15. What were the sensors and actuators used in the automatic watering control systems video?

It uses the moisture sensor and a water pump actuator. The sensor measures the moisture of the soil, and if it has too little water, the micro:bit pumps the water into the system for 2 seconds using the actuator.

Team Member Contribution

Person 1: San Kwon

- Found out that blue containers couldn’t work with the light sensor

- Brainstorming how we should represent the data so the UI would be more user-friendly (the addition of the red LED)
- Planning the algorithm
- Writing the code
- Debugging the code
- Answering half the questions

Person 2: Hina Sekine

- Wiring the micro:bit
- Planning the algorithm
- Writing the code
- Debugging the code
- Answering half the Questions
- Writing the pseudocode
- Making the flow charts