Inline

EICS

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Inline Visualization and Manipulation of Real-Time Hardware Log for Supporting Debugging of Embedded Programs

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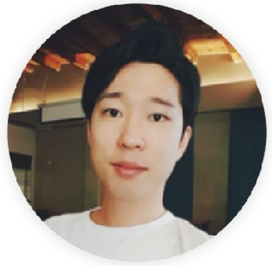
Austin Z. Henley

Microsoft



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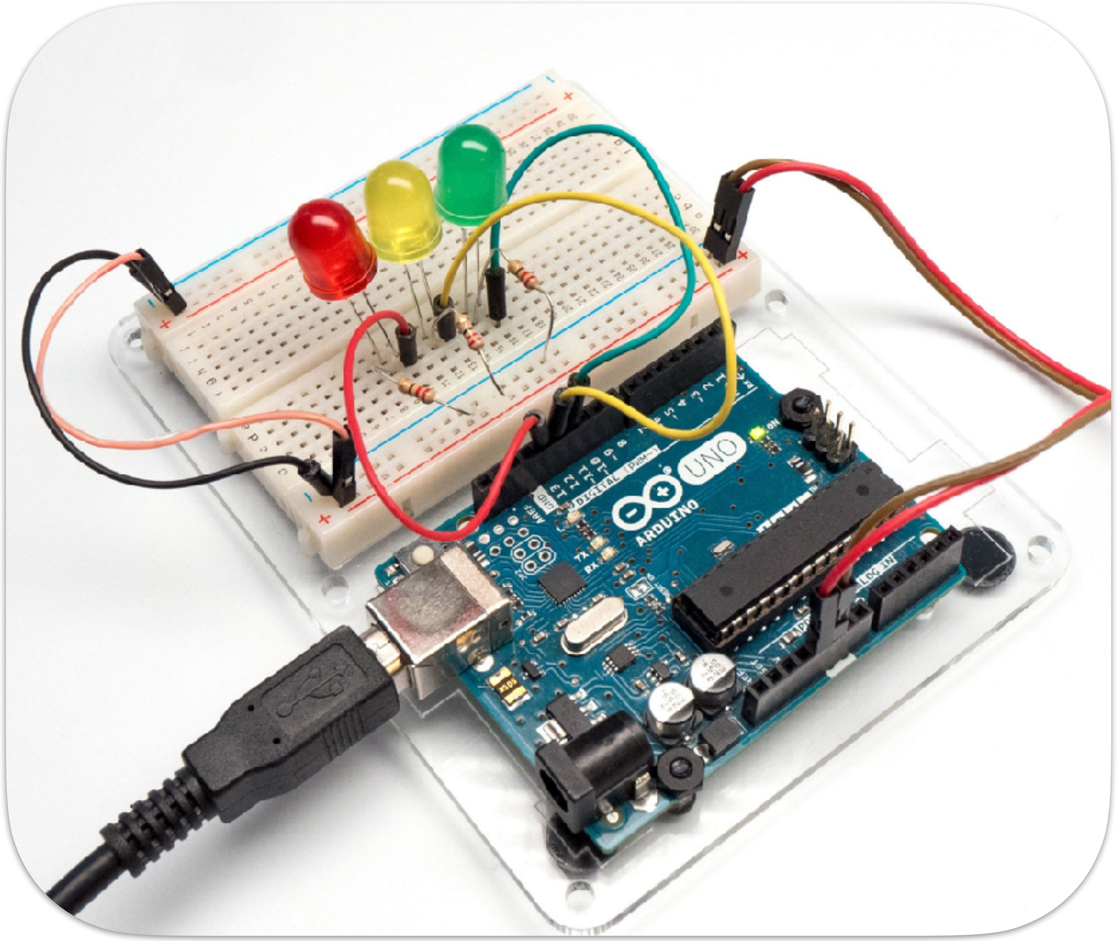
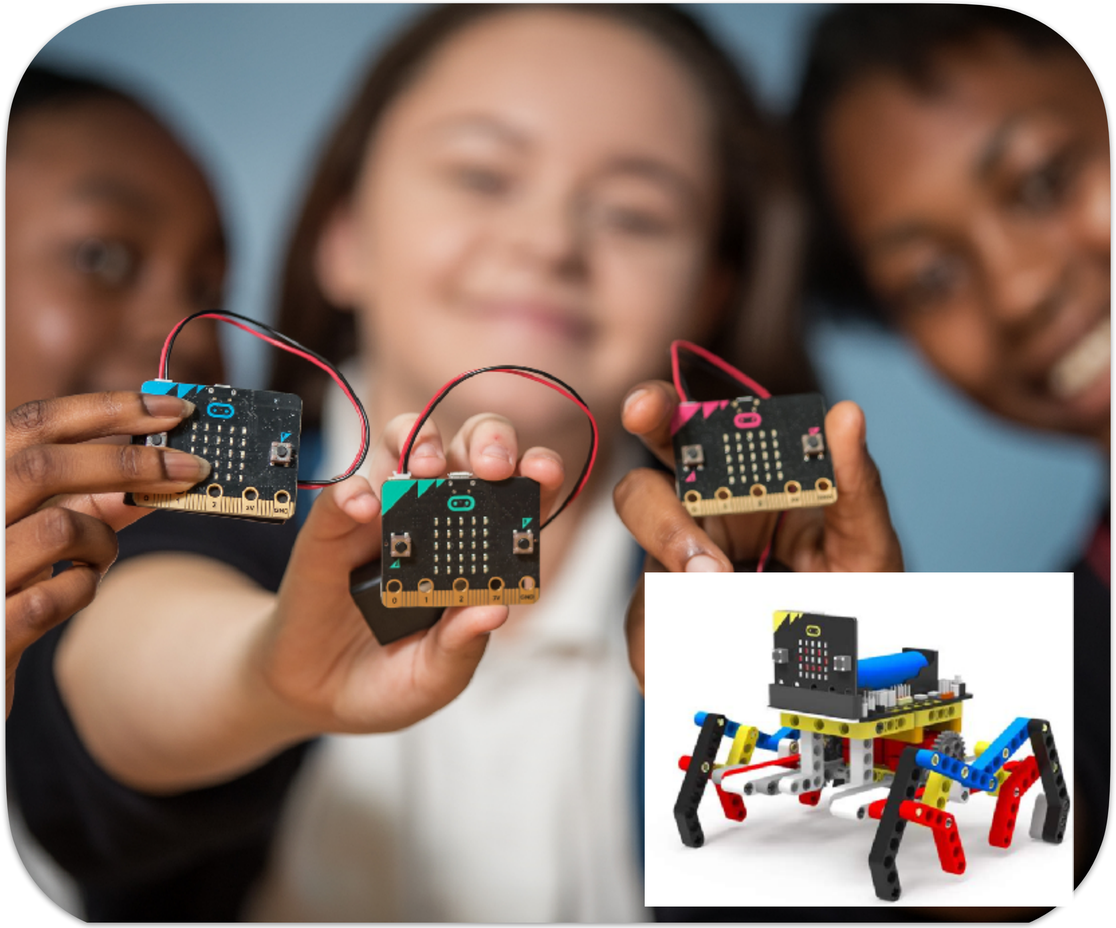
CAU 중앙대학교

Microsoft

Physical Computing and STEM education

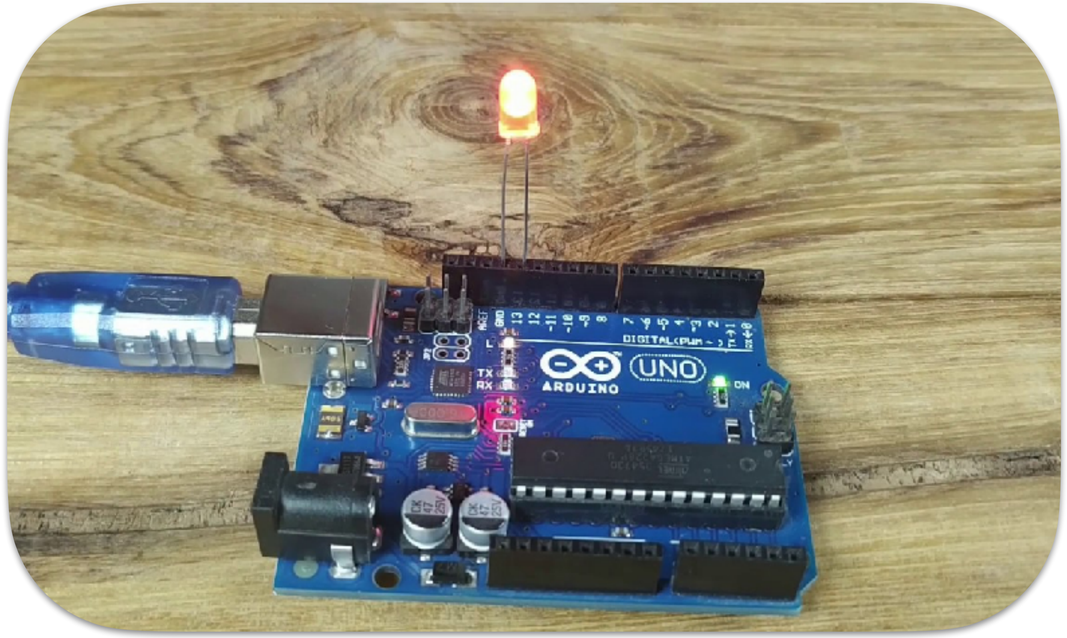




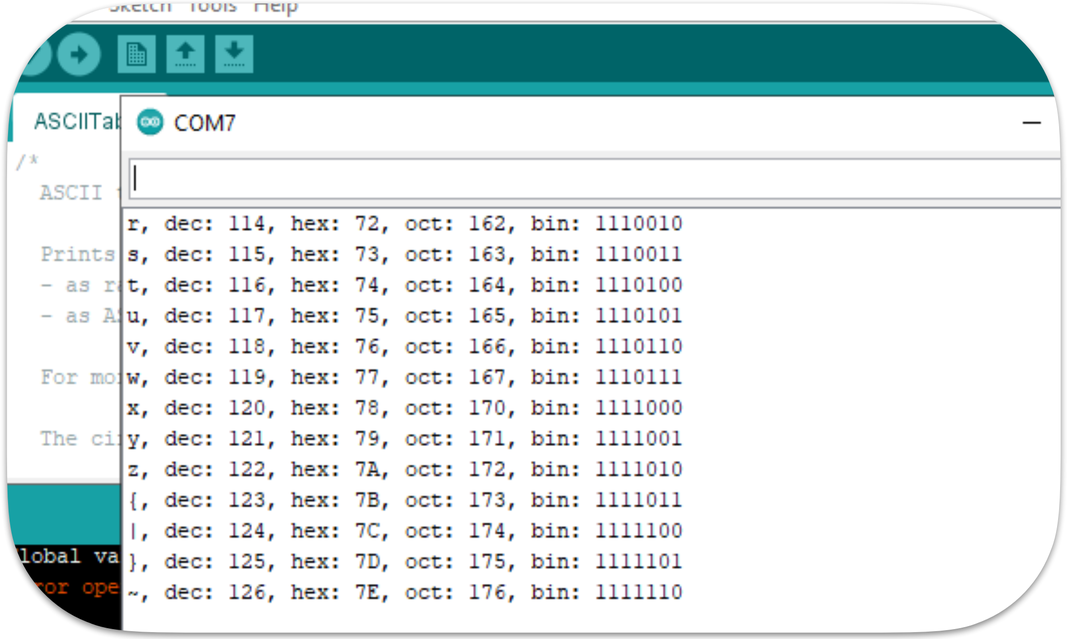
- Widespread popularization of user-friendly platforms like Arduino & co.
- Computational thinking with STEM though embedded programming

Challenges with Physical Computing

- Mistakenly perceived as a *simple* activity
- Previous study [Booth 2016] report 54% of unsolved problems at the interplay between software and hardware
- Information barriers [Ko 2004]: interpreting the program internal state from *externally observable information* (**debugging**)



Blinking LED as ***physical proxy***



Printing statements for ***console logs***

How to make sense of hardware debug logs?

What are debugging logs anyway?

```
void setup(){
    Serial.begin(115200);
}

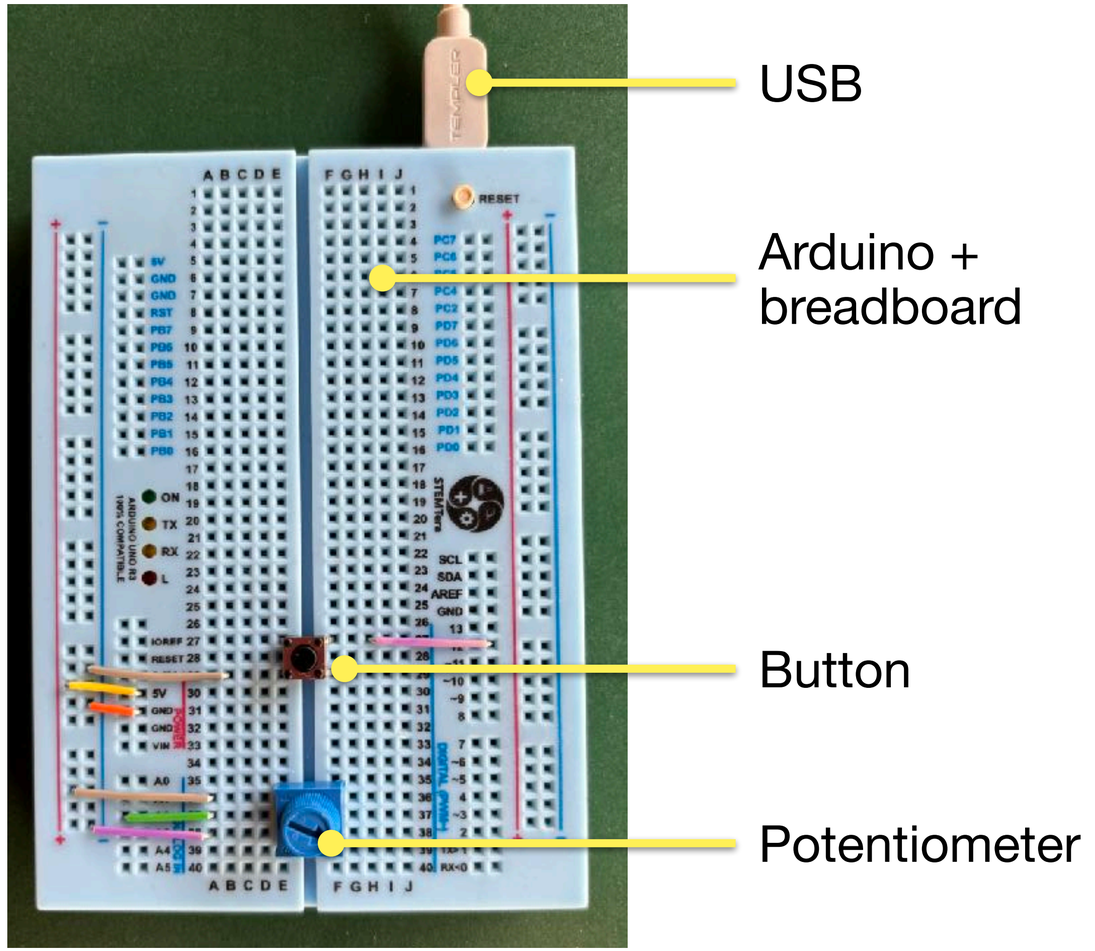
void loop(){

    // Reading an analog value
    int val = analogRead(A2);
    Serial.println(val);

    // Mapping the value to a suitable
    // duty-cycle for PWM
    int mapped = map(val, 0, 1024, 0, 255);
    Serial.println(mapped);

    analogWrite(3, mapped);

    delay(100);
}
```



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    analogWrite(3, mapped);

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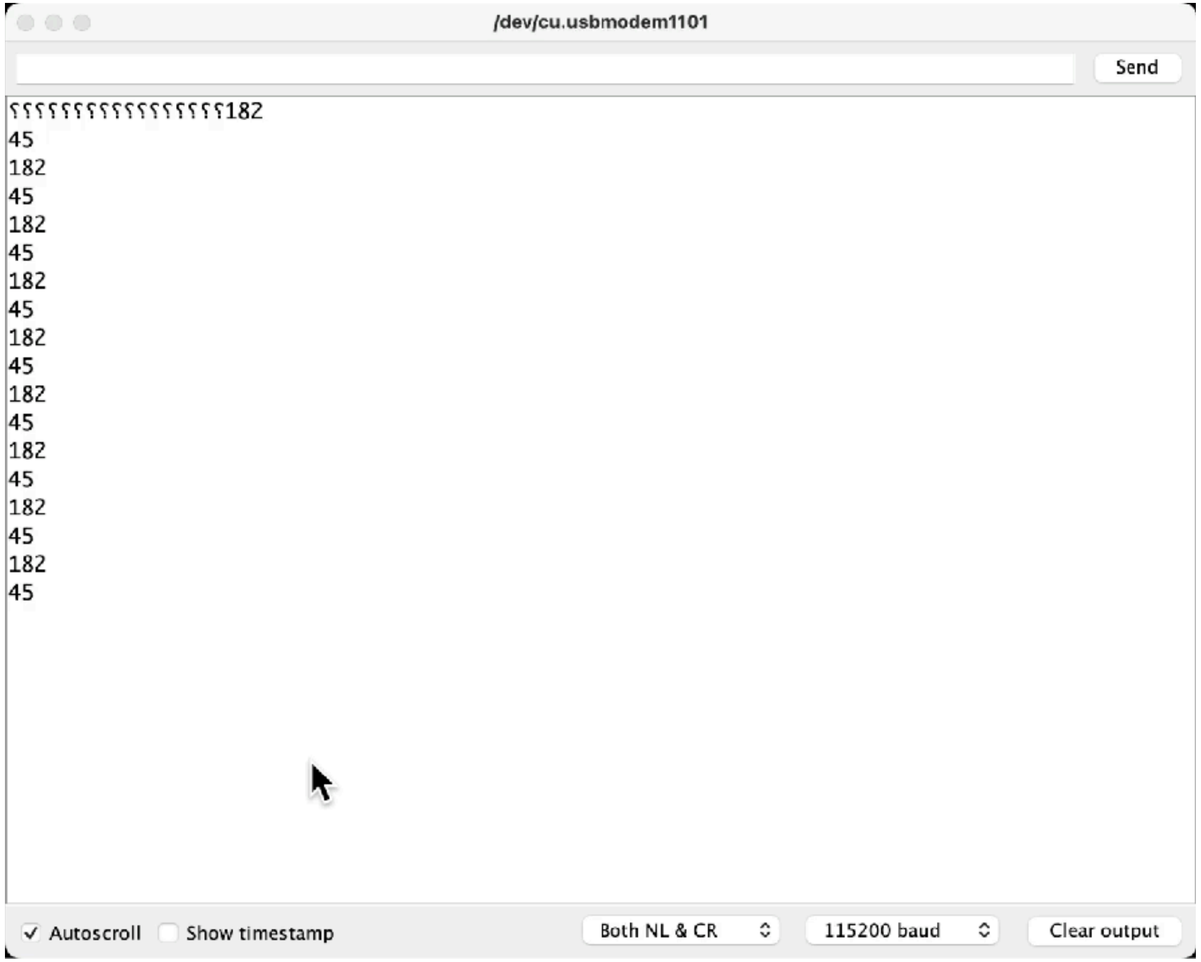

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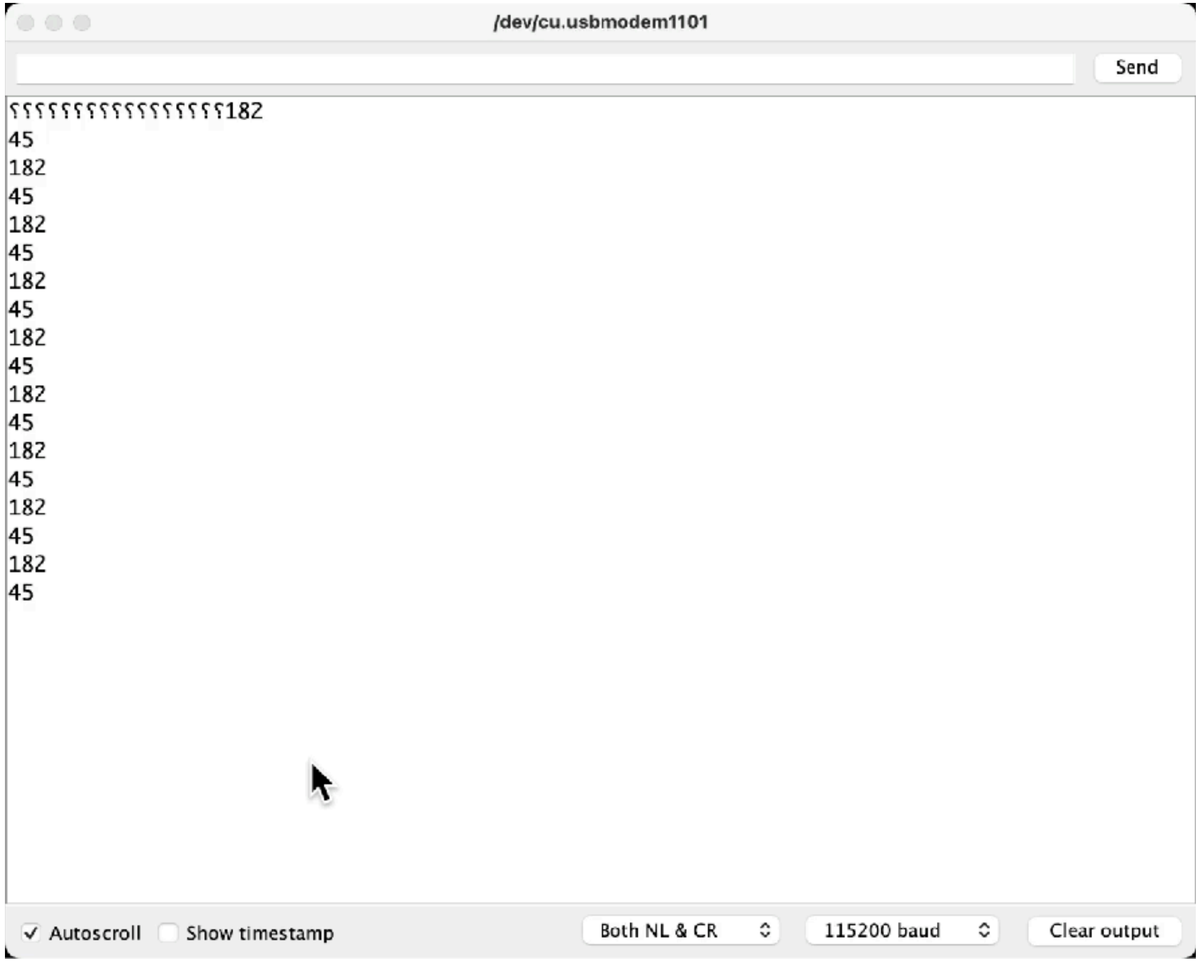
    Serial.println(mapped);

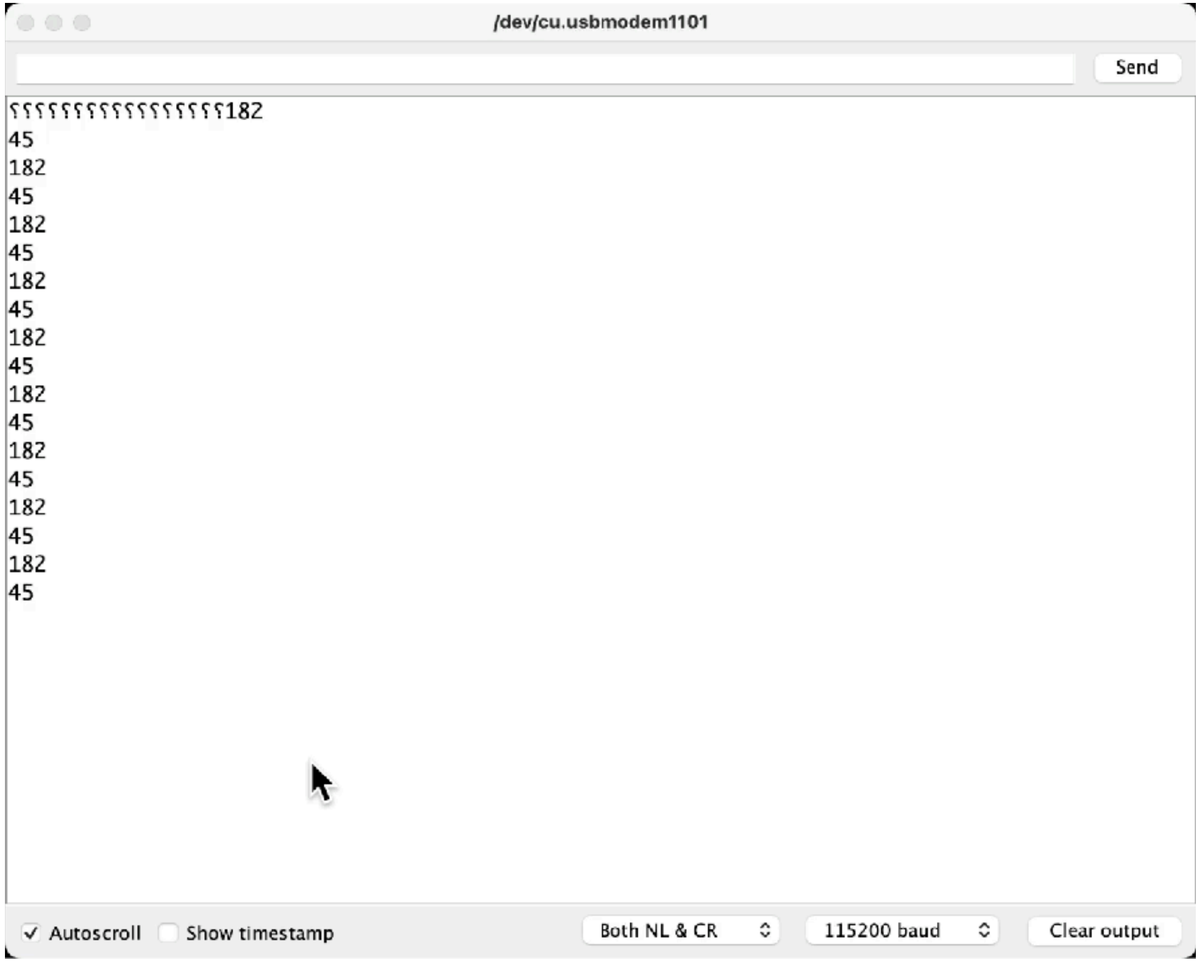
    analogWrite(3, mapped);

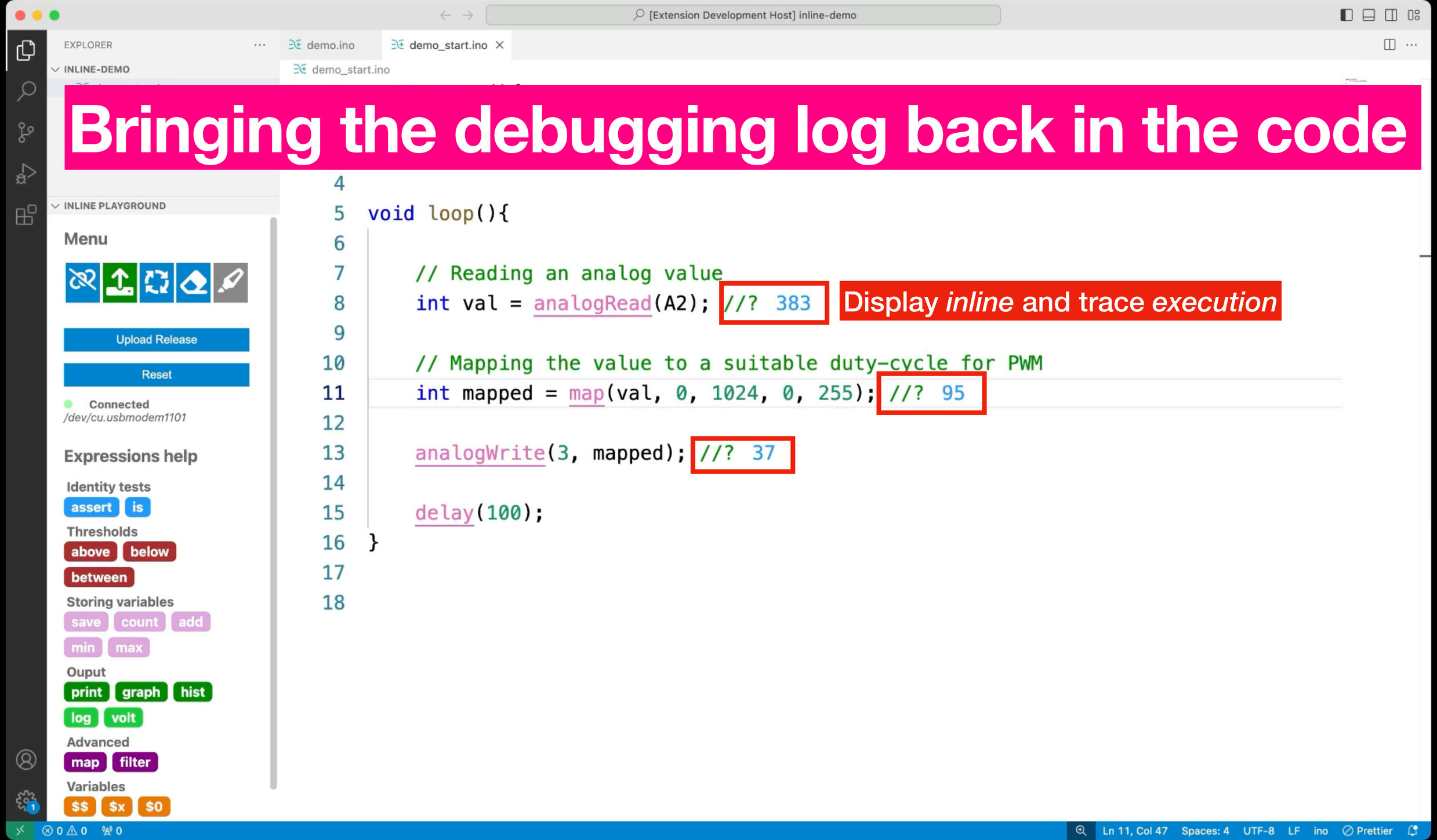
    delay(100);
}
```

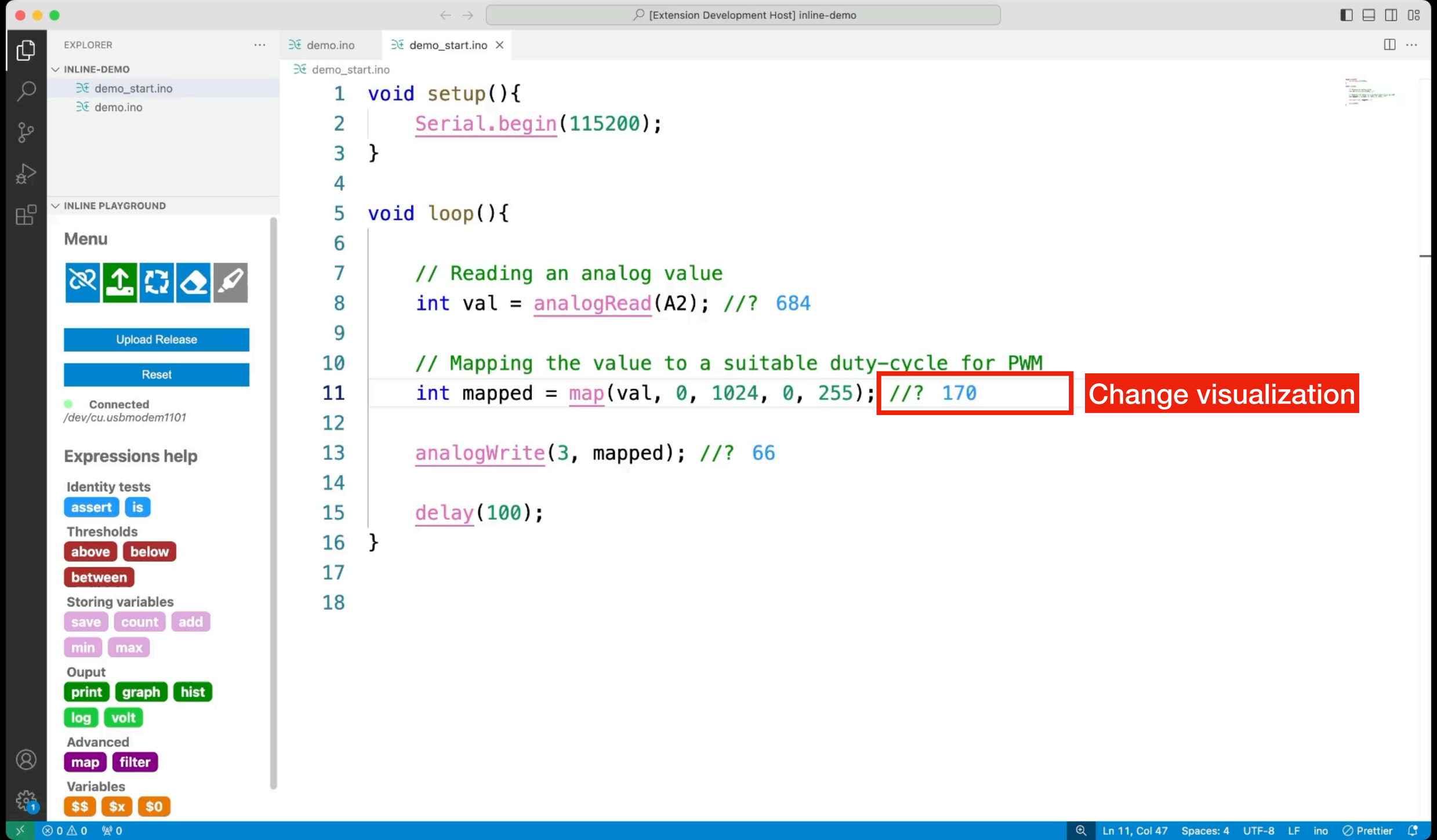


What are debugging logs anyway?

- Where/When/How are **logs** generated?
- Logs are disjointed from the code
- How to store or manipulate them in a simple way?




[Extension Development Host] inline-demo
EXPLORER
INLINE-DEMO
demo.ino
demo_start.ino
demo_start.ino
Bringing the debugging log back in the code
INLINE PLAYGROUND
Menu
Upload Release
Reset
Connected
/dev/cu.usbmodem1101
Expressions help
Identity tests
assert
is
Thresholds
above
below
between
Storing variables
save
count
add
min
max
Ouput
print
graph
hist
log
volt
Advanced
map
filter
Variables
$$
$x
$0
4
5 void loop(){
6
7 // Reading an analog value
8 int val = analogRead(A2); //? 383
9
10 // Mapping the value to a suitable duty-cycle for PWM
11 int mapped = map(val, 0, 1024, 0, 255); //? 95
12
13 analogWrite(3, mapped); //? 37
14
15 delay(100);
16 }
17
18
Display inline and trace execution
Ln 11, Col 47
Spaces: 4
UTF-8
LF
ino
Prettier


[Extension Development Host] inline-demo
EXPLORER
INLINE-DEMO
demo_start.ino
demo.ino
INLINE PLAYGROUND
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Expressions help
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Advanced
map
filter
Variables
$$
$x
$0
demo.ino
demo_start.ino
demo_start.ino
1 void setup(){
2 Serial.begin(115200);
3 }
4
5 void loop(){
6
7 // Reading an analog value
8 int val = analogRead(A2); //? 684
9
10 // Mapping the value to a suitable duty-cycle for PWM
11 int mapped = map(val, 0, 1024, 0, 255); //? 170
12
13 analogWrite(3, mapped); //? 66
14
15 delay(100);
16 }
17
18
Change visualization
Ln 11, Col 47
Spaces: 4
UTF-8
LF
ino
Prettier

[Extension Development Host] inline-demo

EXPLORER

INLINE-DEMO

demo_start.ino

demo.ino

INLINE PLAYGROUND

Menu

Upload Release

Reset

Connected
/dev/cu.usbmodem1101

Expressions help

Identity tests
assert is

Thresholds
above below
between

Storing variables
save count add
min max

Ouput
print graph hist
log volt

Advanced
map filter

Variables
$$ $x $0

demo.ino | demo_start.ino

demo_start.ino

```
1  void setup(){
2      Serial.begin(115200);
3  }
4
5  void loop(){
6
7      // Reading an analog value
8      int val = analogRead(A2); //?  383
9
10     // Mapping the value to a suitable duty-cycle for PWM
11     int mapped = map(val, 0, 1024, 0, 255); // graph?  95
12
13     analogWrite(3, mapped); //?  37
14
15     delay(100);
16 }
17
18
```

Manipulate values

Ln 11, Col 53 (5 selected) Spaces: 4 UTF-8 LF ino Prettier

[Extension Development Host] inline-demo

EXPLORER

INLINE-DEMO
- demo_start.ino
- demo.ino

INLINE PLAYGROUND

Menu

Upload Release

Reset

Connected
/dev/cu.usbmodem1101

Expressions help

Identity tests
assert is

Thresholds
above below
between

Storing variables
save count add
min max

Ouput
print graph hist
log volt

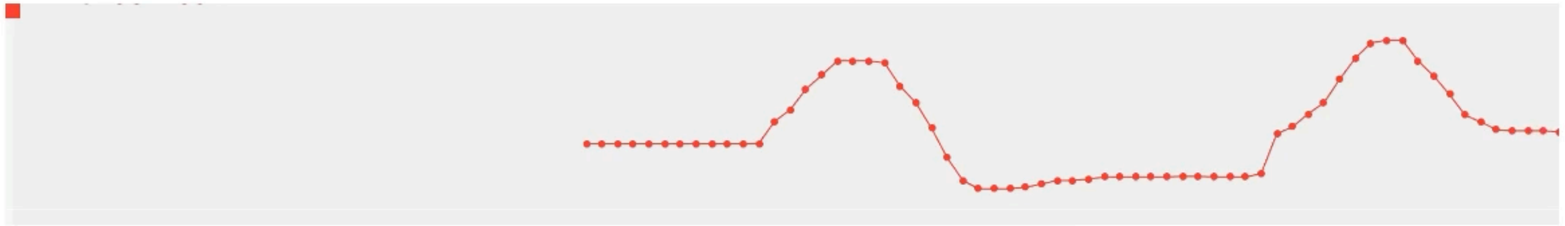
Advanced
map filter

Variables
$$ $x $0

demo.ino | demo_start.ino

demo_start.ino

```
1  void setup(){
2      Serial.begin(115200);
3  }
4
5  void loop(){
6
7      // Reading an analog value
8      int val = analogRead(A2); // min x | max y ?
9
10     // Mapping the value to a suitable duty-cycle for PWM
11     int mapped = map(val, 0, 1024, 0, 255); // graph?  113
```



Plot multiple values

```
12
13     analogWrite(3, mapped); //?  44
14
15     delay(100);
16 }
17
18
```

Ln 8, Col 33 (15 selected) Spaces: 4 UTF-8 LF ino Prettier

What has been done?
Our Contribution

Inspirations: Tools for debugging software

- Lab studies [Ko 2006, Piorkowski 2013] show that 35-50% of programmers' time is spent navigating code and program output (**debugging**).

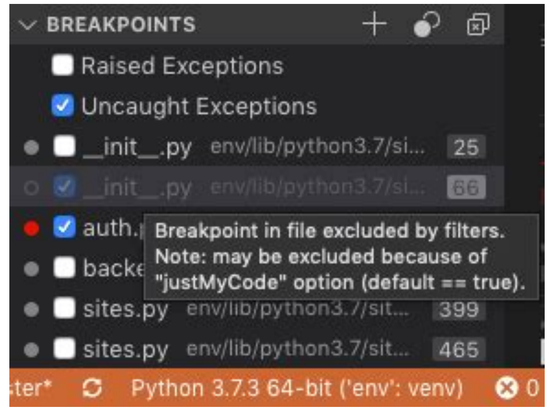
- **Bret Victor**'s notion of *representations of dynamic behavior*

- **Tools** for end user programmer

  A) **Symbolic debugger** and **breakpoints**

  B) **QuokkaJS** / Console Ninja

  C) **Copilot** / ChatGPT and **LLM**-powered tools



GitHub Copilot

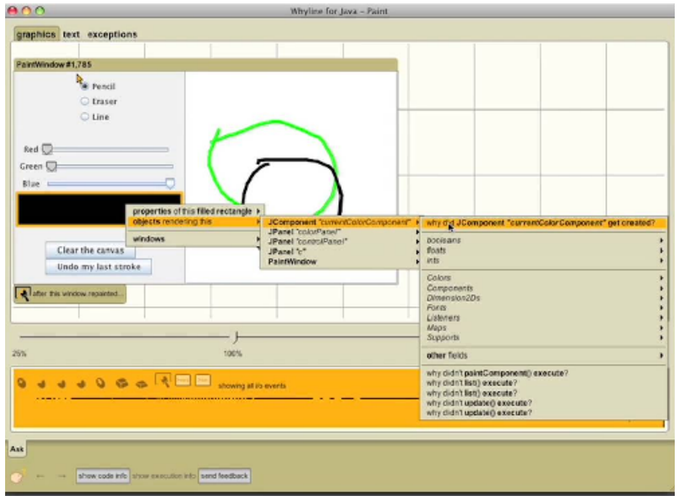
Cursor

Inspirations: Research Tools for debugging software

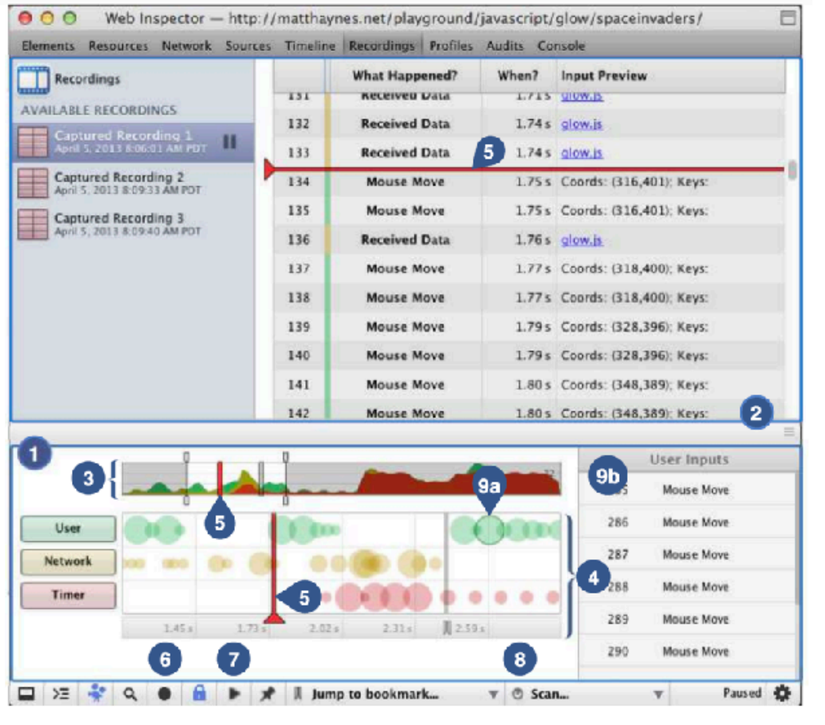
- **Log-it**: instrument logs for better visualization
- **TimeLapse**: replay program execution
- **WhyLine**: ask why and why not

We focus on hardware instead

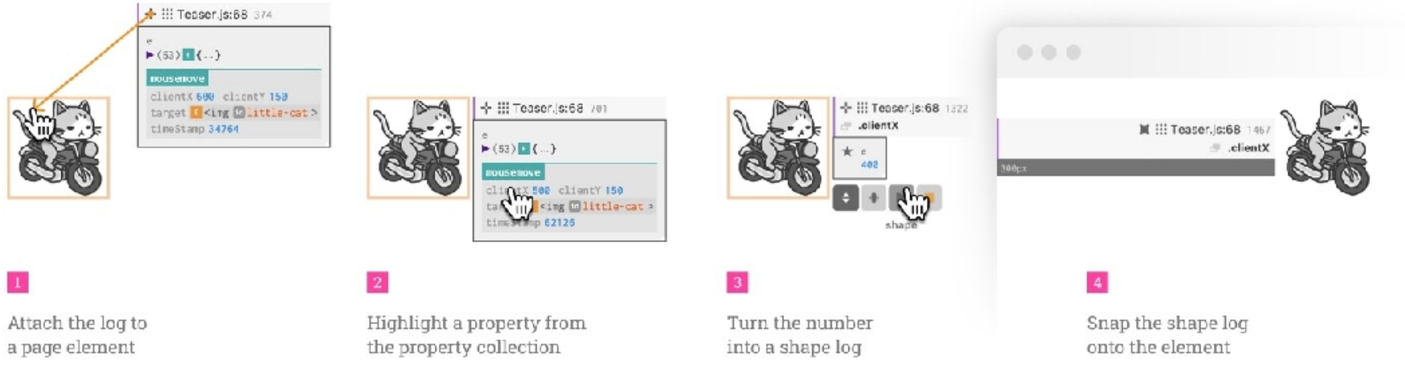
Whyline [CHI 2004]



TimeLapse [UIST 2013]



Log-it [CHI 2023]



1 Attach the log to a page element

2 Highlight a property from the property collection

3 Turn the number into a shape log

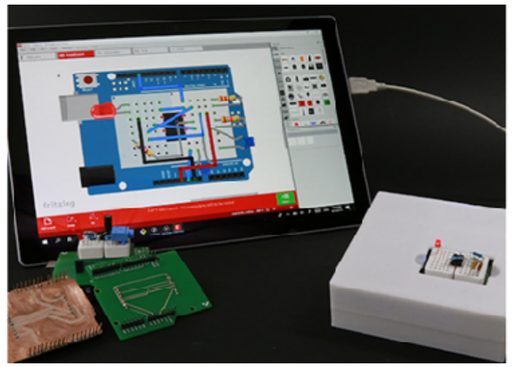
4 Snap the shape log onto the element

Related work: Tools for hardware construction

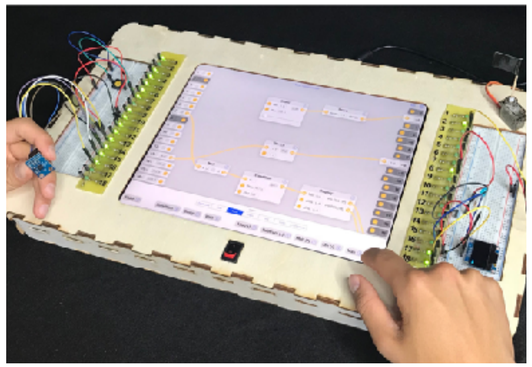
- Hardware tools focused on **facilitating construction** of circuits

A) **Simplifying wiring**:, VirutalWire, FlowBoard, Jacdac

B)**Virtualizing components**: Proxino,VirtualComponent

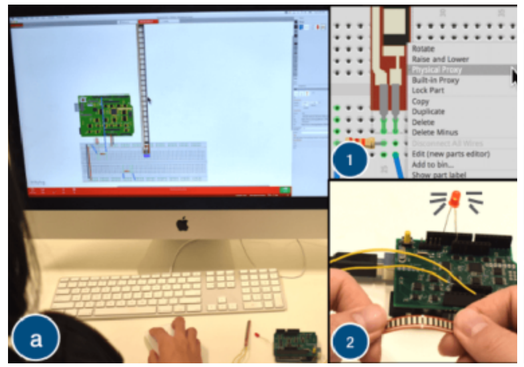


VirtualWire
[TEI 2021]

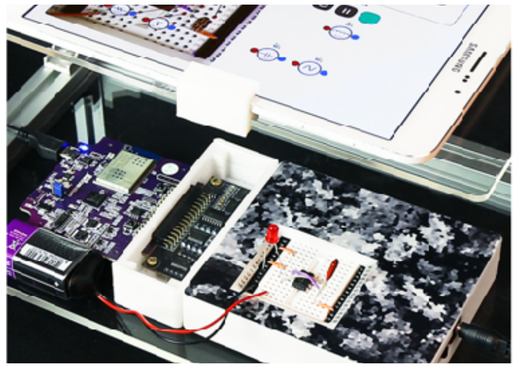


FlowBoard
[TOCHI 2023]

JacDac
[IMWUT 2022]



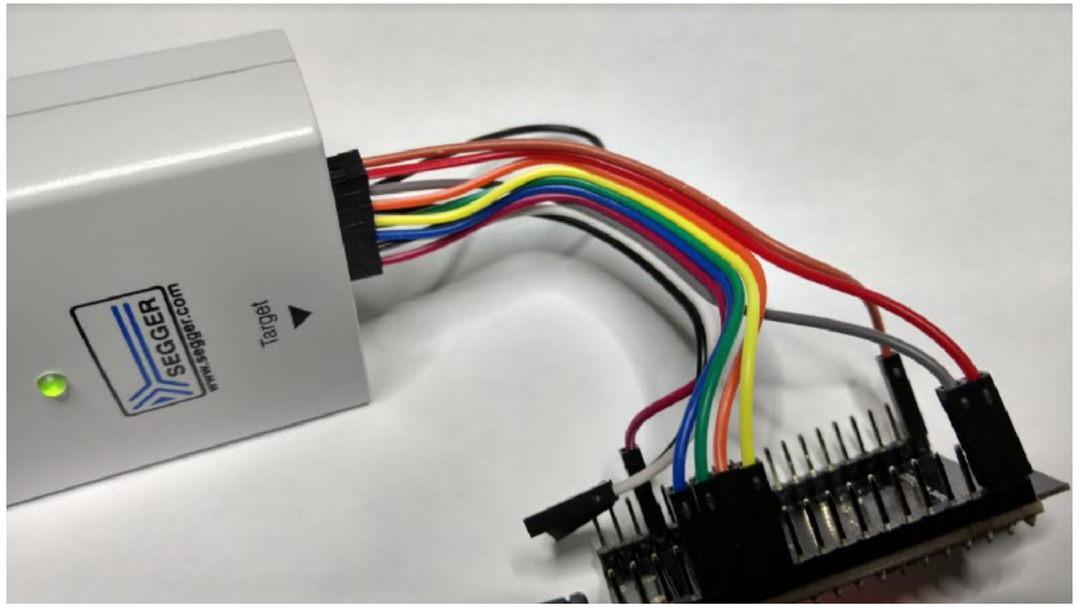
Proxino
[UIST 2019]



VirtualComponent
[CHI 2019]

Related work: Tools for debugging hardware

- **JTAG** and boundary scanners: the hard way
- SchemaBoard & ARDW: debugging **schematic**
- CircuitSense & ToastBoard: **current** and **voltage** inspector
- PinPoint & HeyTeddy: **test driven programming** and **simulation**
- Bifröst: non real-time hardware/code inspector



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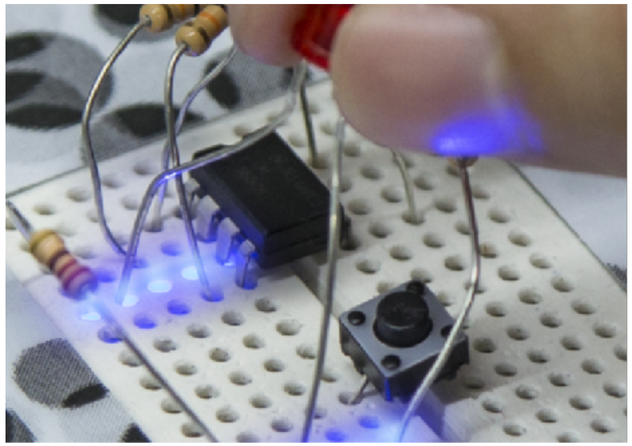
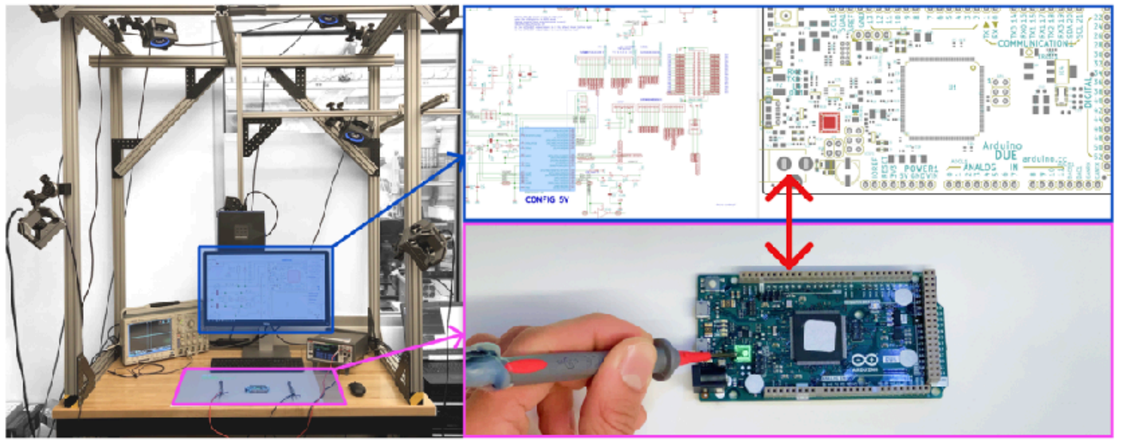


SchemaBoard
[UIST 2021]



ARDW
[UIST 2022]

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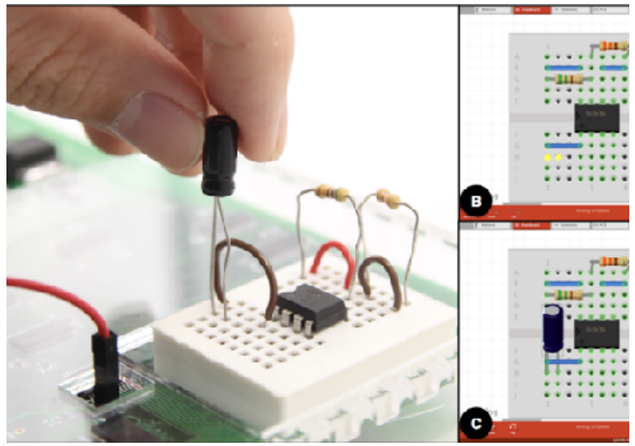
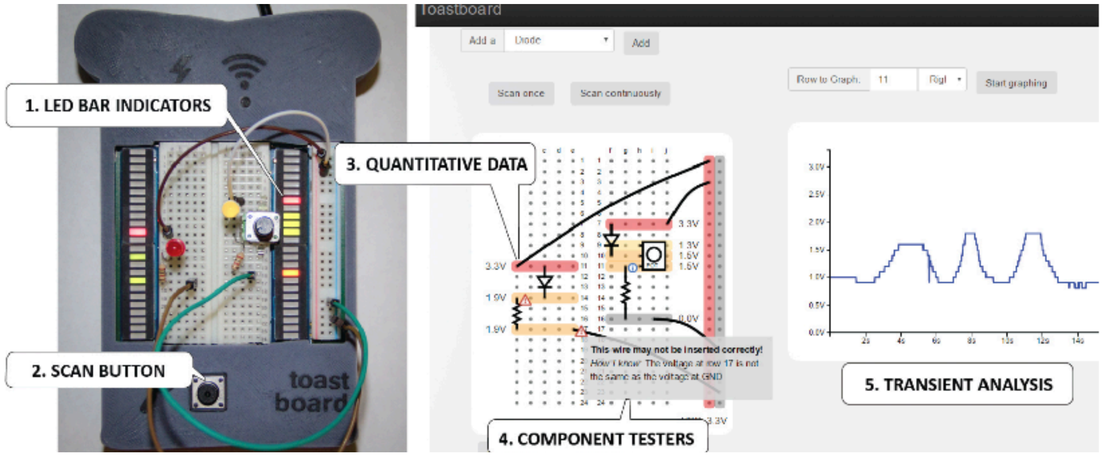


CircuitSense
[UIST 2017]



ToastBoard
[UIST 2016]

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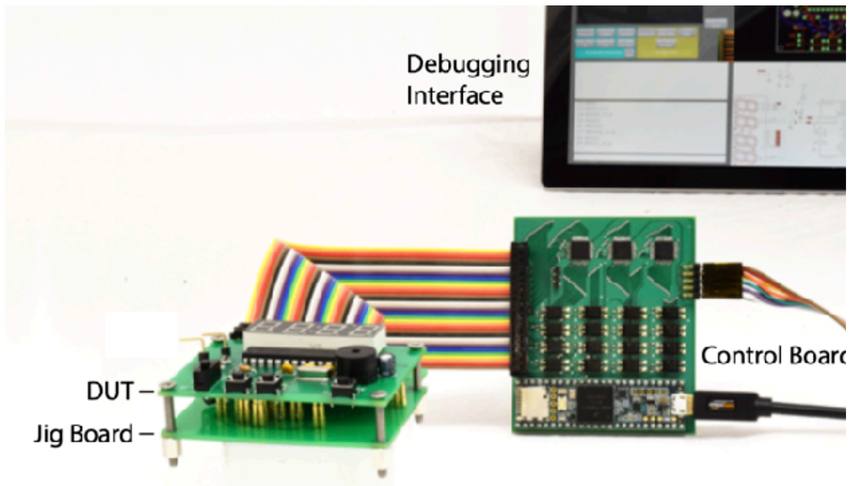

PinPoint
[CHI 2019]

HeyTeddy
[IMWUT 2020]

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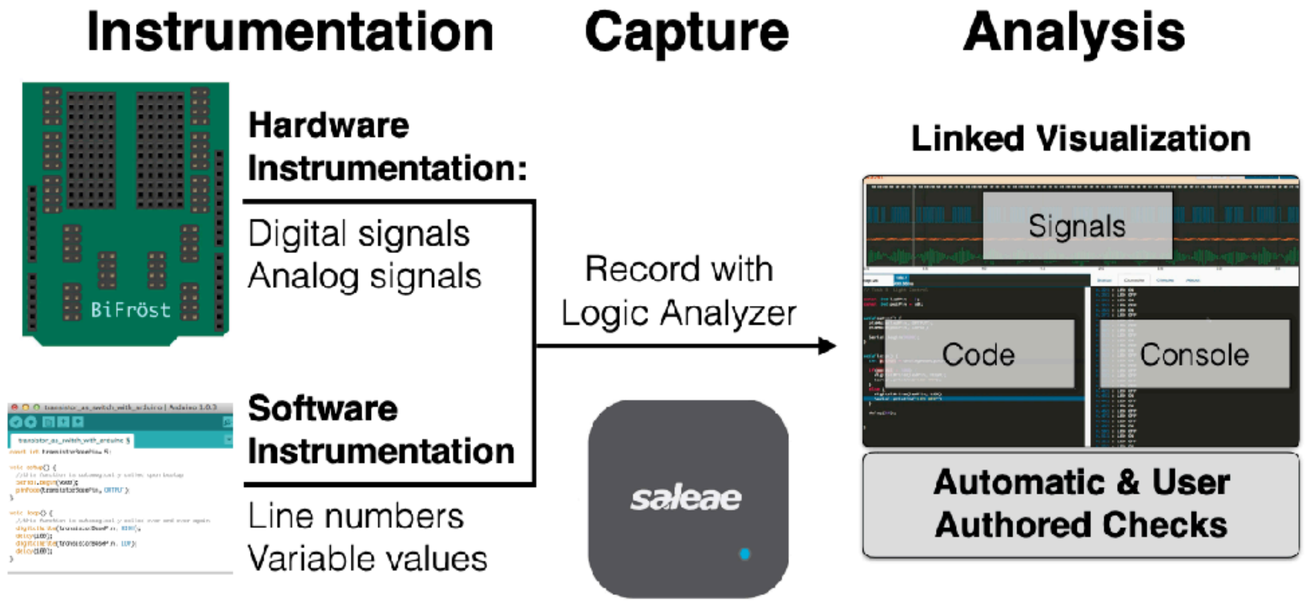

Bifröst
[UIST 2017]

Our contributions

1. Hardware debugging via **inline** visulization

```
A0);//?   867
```

```
Serial.print("one");//?  ...
delay(1000);
Serial.print("two");//?  ...
delay(1000);
Serial.print("three");//?  ...
delay(1000);
```

```
//assert?  ✅
//is 1?  true
//above 0?  1
//below 5?  1
//between 0, 5?  1
//save x?  1
//count y?  18
//add z?  18
//print $x?  1, 1
//log?  1
//volt?  0
//map x=>x/2?  0.5
//filter x=>x<2?  1
```

Our contributions

2. Real-time visitation and directly within the editor

```
A0);//?  176
```

```
Serial.print("one");//?  one
delay(1000);
Serial.print("two");//?  two
delay(1000);
Serial.print("three");//?  three
delay(1000);
```

```
//assert?  ✅
//is 1?  true
//above 0?  1
//below 5?  1
//between 0, 5?  1
//save x?  1
//count y?  20
//add z?  20
//print $x?  1, 1
//log?  1
//volt?  0
//map x=>x/2?  0.5
//filter x=>x<2?  1
```

Our contributions

3. Manipulation of logs for exploring the data

```
A0);//?   0
```

```
Serial.print("one");//?  one
delay(1000);
Serial.print("two");//?  two
delay(1000);
Serial.print("three");//?  three
delay(1000);
```

```
//assert?  ✅
//is 1?  true
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//below 5?  1
//between 0, 5?  1
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//add z?  21
//print $x?  1, 1
//log?  1
//volt?  0
//map x=>x/2?  0.5
//filter x=>x<2?  1
```

Collecting requirements via formative study

Formative Study

- **10 participants** (7 male, 1 female) aged 26-31 + **2 university professors** (2-15 years teaching experience)

Participants	Occupation	Department	Age	Physical Computing Experience (years)	Software Development Experience (years)	Physical Computing Self-Rank (scale:1-7)
P1	maker	Design (M.S)	26	9	6	6
P2	maker	Design (Ph.D)	28	7	7	5
P3	maker	Design (M.S)	26	6	6	6
P4	maker	CS (Ph.D)	26	2	8	3
P5	maker	Design (Ph.D)	29	10	7	6
P6	maker	CS (Ph.D)	31	7	7	6
P7	maker	CS (Ph.D)	32	6	14	4
P8	maker	Design (Ph.D)	28	8	6	6
P9	instructor	Electronics	50	15 (physical computing) + 15 (teaching)	-	-
P10	instructor	Design	35	12 (physical computing) + 2 (teaching)	-	-
Avg (SD)	-	-	28.3 (2.3)	9.9 (7.7)	7.6 (2.7)	5.3 (1.2)

- Semi-structure interviews (50 minutes)
- Translation + open-axial coding
- Three main findings

Challenge 1: Printing and managing logs

Students **use** the serial monitor and are ***formally taught*** to use it in class.

Problem arise when there are **multiple print statements**

> "it was almost impossible to follow all different data in the text logs. [...] Even when I wanted to trace them, the scroll bar kept moving on, and I lost them."

Solution 1 is to log in data files and exploring the patterns later (**not real time**)

Solution 2 is to print statements a few at a time, but this requires continuously changing the code, and recompile/upload (possibly **introducing new bugs**)

> "it would be really nice if I could simply **toggle the output of the logs** I want to see in real-time, on and off."

Challenge 2: Tracking code execution in real time

Tracking code behavior: e.g. how the value from sensors change over time.

Require spending time tracking for errors.

> "I needed to **scroll back and forth** in both windows to locate the code that needed fixing and keep track of the logs, which confused me."

One way is to use known events and **physical proxies**, like LED and actuators.

This is fast reaction time but limited to simple binary checks (e.g., over threshold or condition happens) with limited bandwidth.

> "For instance, if you expected it to be off but unexpectedly turned on, you could recognize that something was wrong."

Challenge 3: Making sense of logs

Filtering and making sense of the data is also complex

"They might look at this data, but *it's not helpful for them*." (instructor)

> "students try to print and read text logs to debug their prototypes, but they **cannot explain the meaning of those texts** even though they wrote the code."

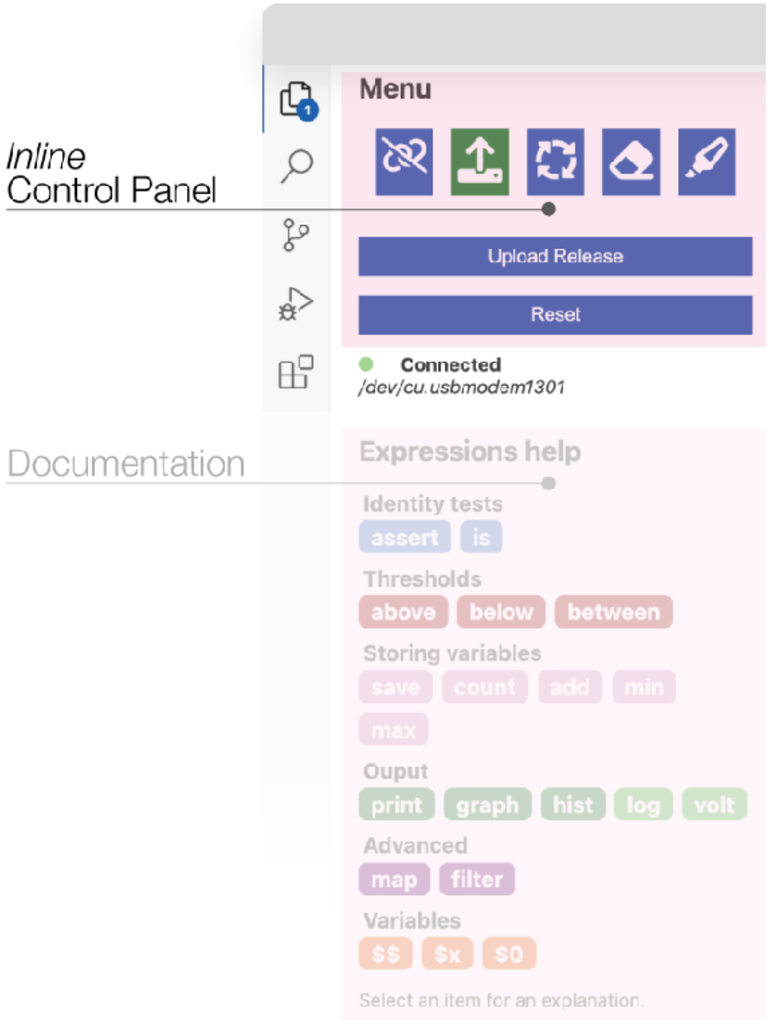
Introducing condition or code to **manipulate the code** might introduce new bugs

> "I adjusted the cutoff value to make the data smoother, then it started to be too slow and did not match the real-time movement."

The system: overview and demo

The VSCode Extension

The Menu Panel



Menu

Connect
Disconnect

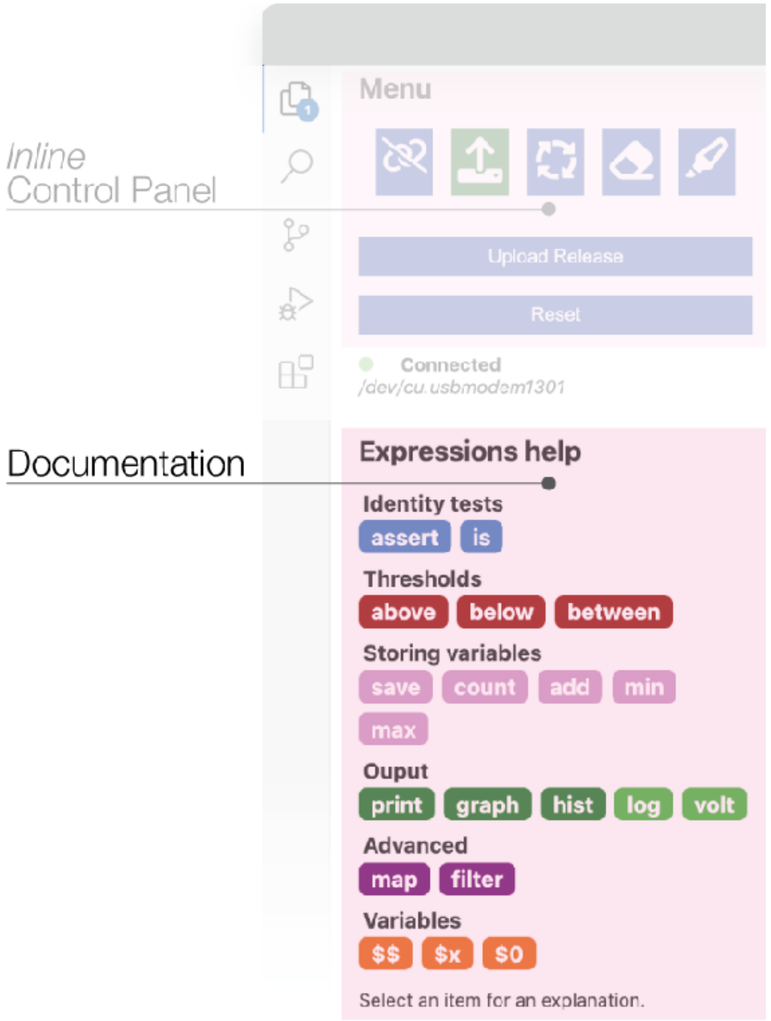
Upload
Is dirty?

Refresh

Delete
annotations

Highlight

Documentation



Expressions help

Identity tests

assert | is

Thresholds

above | below | between

Storing variables

save | count | add | min | max

Ouput

print | graph | hist | log | volt

Advanced

map | filter

Variables

$$ | $x | $0

```
// input | assert ? ✅ or ❌
```

`assert` returns ✅ if the **input** expression evaluates to **true**, otherwise ❌.

Examples

```
// 2 == 2 | assert ? ✅
```
copy

```
// 0 | assert ? ❌
```
copy

```
// 15 | above 10 | assert ? ✅
```
copy

Feature 1

1. Trace and view the execution flow of the program

[Extension Development Host] inline-demo

EXPLORER

INLINE-DEMO
- 2_trace.ino
- demo_start.ino
- demo.ino

INLINE PLAYGROUND

Menu

Upload Release

Reset

Connected
/dev/cu.usbmodem21101

Expressions help

Identity tests
assert is

Thresholds
above below between

Storing variables
save count add min max

Ouput
print graph hist log volt

Advanced
map filter

Variables
$$ $x $0

Select an item for an explanation.

demo.ino | 2_trace.ino | demo_start.ino

2_trace.ino

```ino
void setup(){
    Serial.begin(115200);
    pinMode(12, INPUT_PULLUP);
}

void loop(){

    if (digitalRead(12) == LOW){
        int val = analogRead(A2); //? ...
        int mapped = map(val, 0,1024,0,255);//? ...
        analogWrite(5, val);//? ...
    }else{
        Serial.println("Do other"); //? Do other
    }
    delay(1000);
}
```

Ln 15, Col 17 Spaces: 4 UTF-8 LF ino Prettier

Feature 2

2. Display logs inline with the code

//?

```
int value = analogRead(potentiometer); //?  555

int randomValue = random(5); //?  4

sqrt(4); //?  2
```

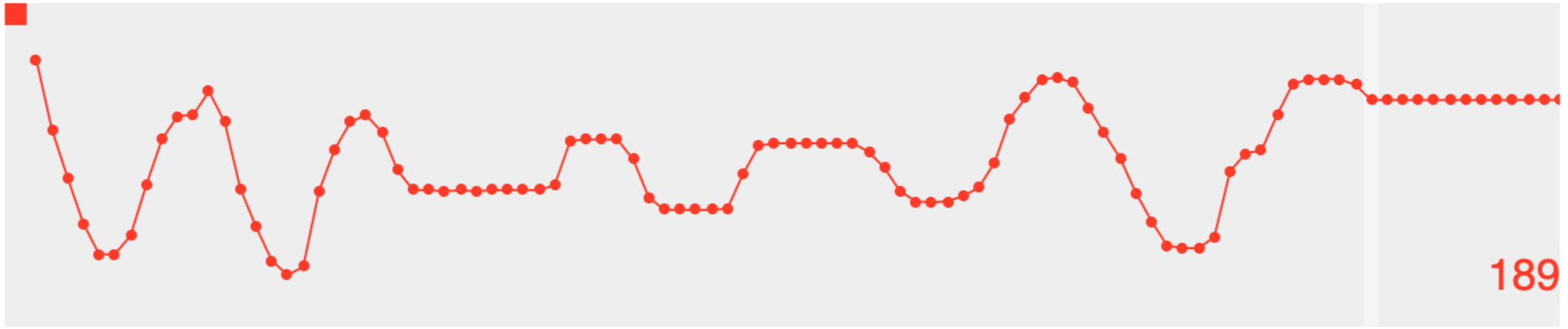
Works with any Arduino function

```
int randomValue = random(5); analogRead(potentiometer); //$1?  556
```

Chaining with pipe

```
value = analogRead(potentiometer); //below 100 | assert?   ❌
analogWrite(PWM_PIN, value/4); //below 100 | assert?  ✅
```

```
int value = analogRead(pot1); //above 0 | below 255 | graph?  189
```



Feature 3

3. Multiple visualizations along the code

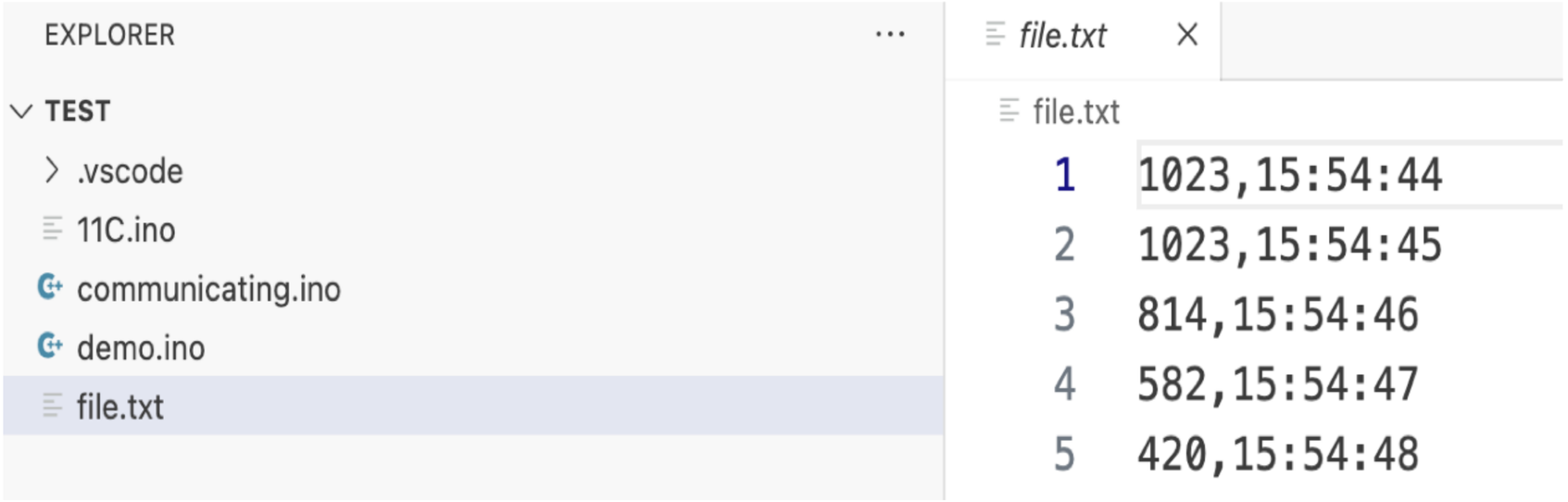
Text, Graphs or Histograms

Textual view

```
value = analogRead(potentiometer); // volt?   2.71
value = analogRead(potentiometer); // volt 3?   1.63
```

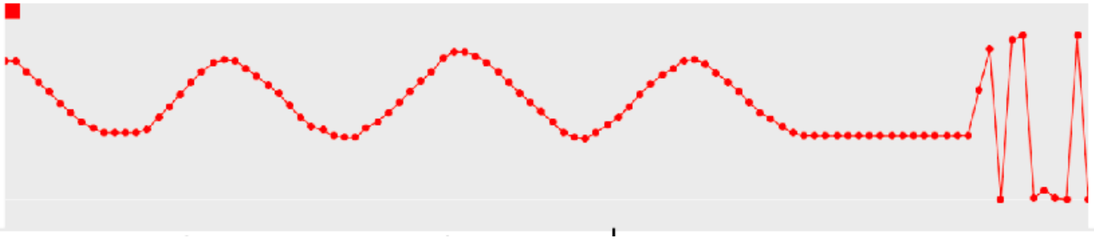
```
value = analogRead(potentiometer); // log file.txt?   556
```

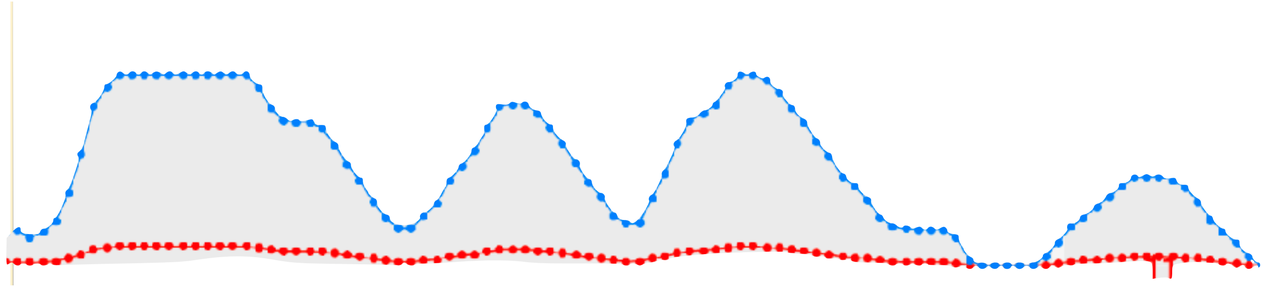
File logs



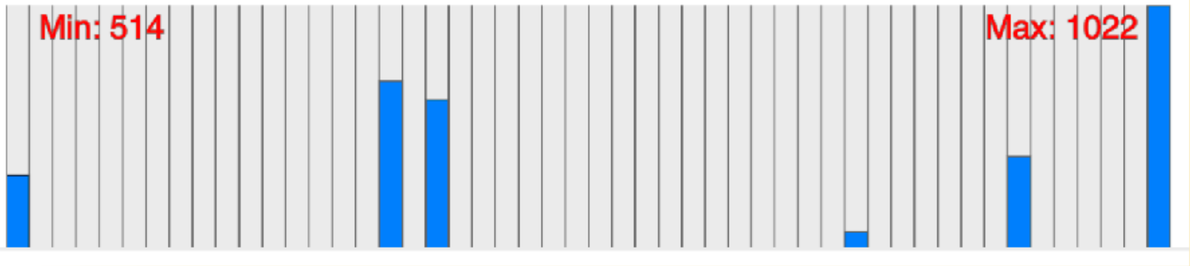
Text, Graphs or Histograms

```
int value = analogRead(pot1); //graph?
```





```
int value = analogRead(pot1); //hist?   703
```




```
int value = analogRead(pot1); //save x ?  1023
analogWrite(PWM_PIN, value/4); //hist $x?  100, 1023
```

One variable

Multiple variables

Feature 4

4. Use runtime expressions to explore and manipulate logs

Identity / Assertion

assert returns ✅ if the **input** expression evaluates to **true**, otherwise ❌.

```
// 2 == 2 | assert? ✅
// 0 | assert? ❌
// 15 | above 10 | assert? ✅
```

is checks whether **input** is equal or not to a specified value.

```
// 1 | is 1 ? true
// 0 | is 1 ? false
// "string" | is "string"? "string"
```

Visual Output

print takes an **input** and maps it with a function to an output.

graph takes an **input** and return is the filter function returns true, otherwise *None*

```
// 12 | filter x ⇒ x%2==0? 12
// 5 | filter x ⇒ x > 10? None
```

hist takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

log takes an **input** and return is the filter function returns true, otherwise *None*

```
// 12 | filter x ⇒ x%2==0? 12
// 5 | filter x ⇒ x > 10? None
```

volt takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

Using Variables

$$ / $0 takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

$name takes an **input** and return is the filter function returns

```
// 12 | filter x ⇒ x%2==0? 12
// 5 | filter x ⇒ x > 10? None
```

Thresholds

above takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

below takes an **input** and return is the filter function returns true, otherwise *None*

```
// 12 | filter x ⇒ x%2==0? 12
// 5 | filter x ⇒ x > 10? None
```

between takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

Storing Variables

save takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

count takes an **input** and return is the filter function returns true, otherwise *None*

```
// 12 | filter x ⇒ x%2==0? 12
// 5 | filter x ⇒ x > 10? None
```

add takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

min takes an **input** and return is the filter function returns true, otherwise *None*

```
// 12 | filter x ⇒ x%2==0? 12
// 5 | filter x ⇒ x > 10? None
```

max takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

Advanced

map takes an **input** and maps it with a function to an output.

```
// 10 | map x ⇒ x*2 ? 20
```

filter takes an **input** and return is the filter function returns true, otherwise *None*

```
// 12 | filter x ⇒ x%2==0? 12
// 5 | filter x ⇒ x > 10? None
```

Thresholds

```
int randomValue = random(5); //between 0,5?  1
int randomValue = random(5); //above 5?  None
int randomValue = random(5); //below 0?  None
```

Variables

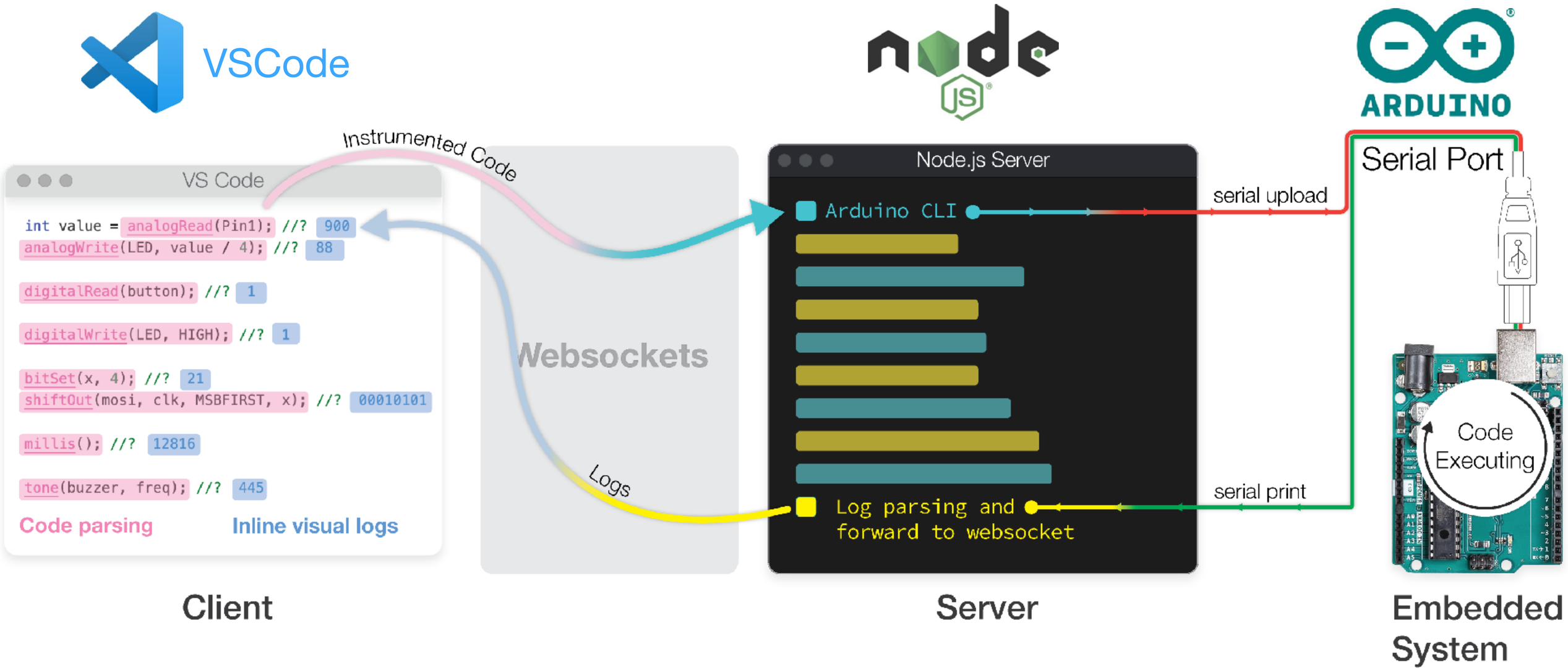
```
int randomValue = random(5); //save x?  3
analogRead(potentiometer); //$x?  3
```

map and filter

```
int value = analogRead(pot1); //map x => x/4?  189.75
int value = analogRead(pot1); //filter x => (x>=0) && (x<= 255) ?  None
int value = analogRead(pot1); //filter x => (x>=0) && (x<= 255) ?  129
```

Implementation details

System Architecture



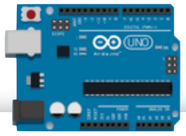
Implementation details

1. User code

```
1 void loop(){
2     shiftOut(dataPin, clockPin, MSBFIRST, 10);
3 }
```

Upload

2. Instrumented code



position
line
logs on line
identifier

```
void loop(){
    _shiftOut(dataPin, clockPin, MSBFIRST, 10, "a8a4ac", 2, 1, 1);
}

void _shiftOut(uint8_t dataPin,  // user's argument
               uint8_t clockPin, // user's argument
               uint8_t bitOrder, // user's argument
               uint8_t val,      // user's argument
               PARAMS){          // Inline METADATA via MACRO

  shiftOut(dataPin, clockPin, bitOrder, val);

  printValueFormatted(SerialWrapper(int2bin(val, bitOrder)),
                      id, line, index, items);
}
```

Serial output

```
$a8a4ac\t2\t"00001010"
```

Start tag — identifier — line — payload

Serializer

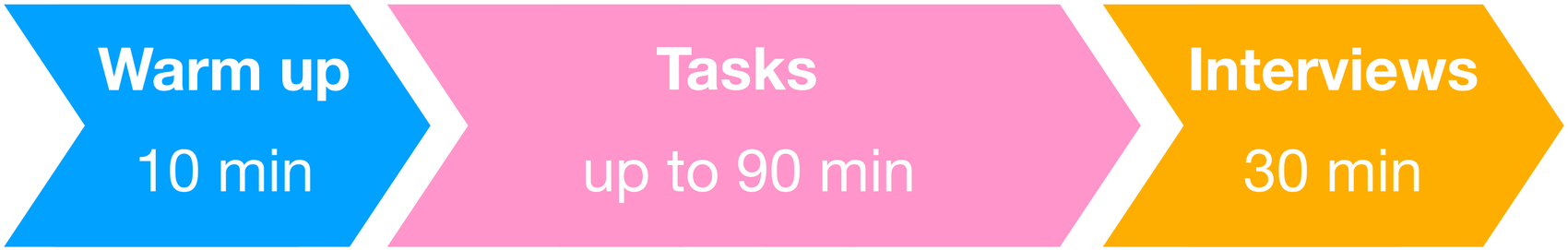
3. *Inline* Log Decorators

```
1 void loop(){
2     shiftOut(dataPin, clockPin, MSBFIRST, 10);//? 00001010
3 }
```

Evaluation with users

User Study

- **12 makers** (8 male, 4 female) aged 20-34 (avg=25.7, sd=4) from our institution
- Writing code and **findings software/hardware bugs** in 5 debugging exercises

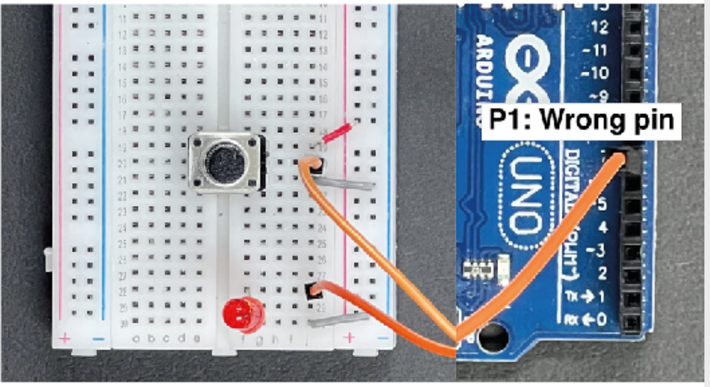


- Data **analyzed by three researchers** (axial coding)
- **Ecological validity**: open ended solutions

The tasks

Tasks	Goal	Problems and Solutions
1	Adjust LED brightness using a potentiometer	(HW/SW) Reconnect the LED to a PWM pin, not a digital one
		(HW/SW) Replace digitalRead with analogRead
		(HW/SW) Map analogRead values to a 0-255 range
2	Toggle the LED with a button	(HW/SW) Set button pinMode as "INPUT_PULLUP"
		(SW) Use "==" for equality, not "="
		(HW/SW) Replace analogRead with digitalRead
3	Alternate two LEDs using random values	(HW/SW) Set pinMode for LEDs as "OUTPUT"
		(SW) Adjust if-else condition values to 0 and 1, not 1 and 2
4	Play a tune and silence the buzzer using a bend sensor	(HW) Ground the buzzer
		(SW) Correct the minimum and maximum value ranges
5	Update LED brightness using a button and a photoresistor	(HW/SW) Modify the upper bound of the value's current range to 9 in the map function

T1: Adjusting brightness of LED with a potentiometer



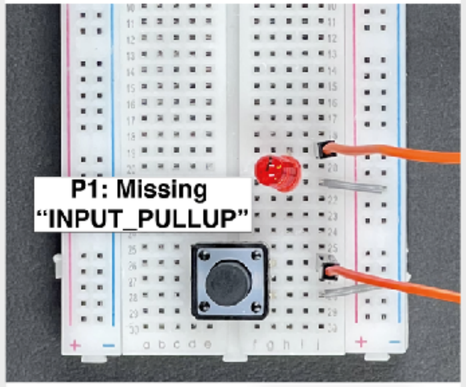

```
int value = digitalRead(potentiometer);
```

P2: Incorrect read function

P3: Incorrect mapping

```
analogWrite(PWM_PIN, value);
```

T2: Turn LED on/off with a button

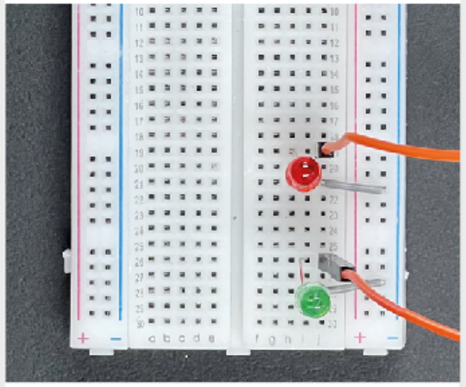



```
if (but = HIGH)
{
    analogWrite(LED_PIN, HIGH);
}
else
{
    analogWrite(LED_PIN, LOW);
}
```

P2: Wrong comparison operator

P3: Incorrect read function

T3: LEDs randomly light up in turns.

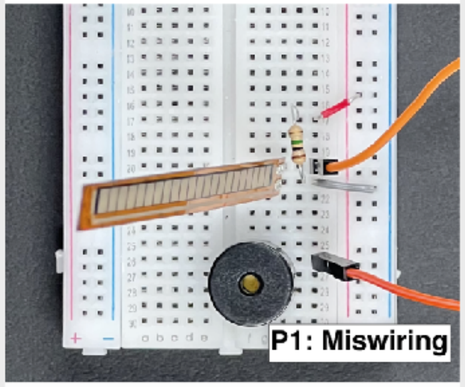


```
pinMode(LED_GREEN, INPUT);
pinMode(LED_RED, INPUT);
int randomValue = random(2);
if (randomValue == 1)
{
  digitalWrite(LED_RED, HIGH);
}
else if (randomValue == 2)
{
  digitalWrite(LED_GREEN, HIGH);
}
```

P1: Wrong pin setup

P2: Unreachable code

T4: Tune the buzzer with a bend sensor



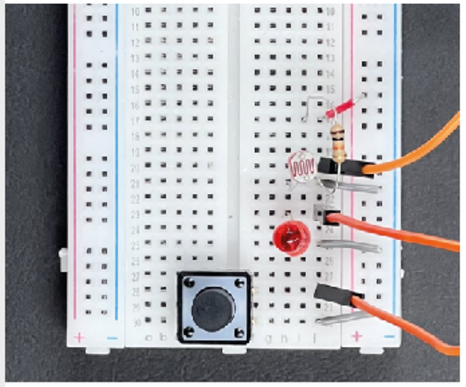

```
int val = analogRead(bendSensor);

int minV = 0;
int maxV = 1023;

val = map(val, minV, maxV, 0, 1000);
```

P2: Incorrect mapping

T5: Adjust LED brightness with a photoresistor

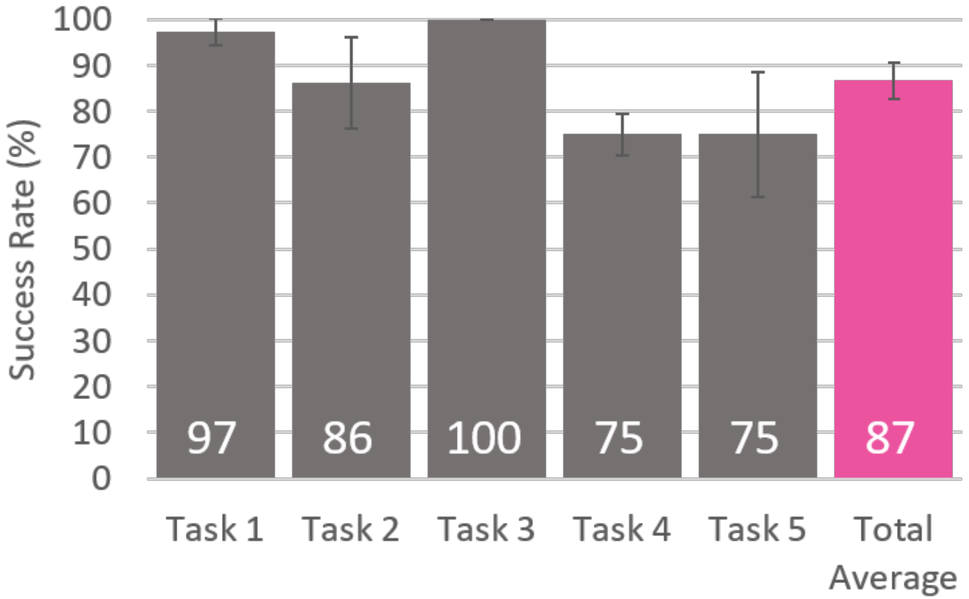


```
val = map(val, 0, 1023, 0, 255);
```

P1: Incorrect mapping

Overall sentiment

- Ten participants did well. 8 participants identified all bugs and 2 made a single mistake.
- Two users unable to identify 3-4 bugs



- **Features used**: `//?` 35% (n=51), output expressions 29% (42), identity tests 16% (24), variables 11% (16), and thresholds 9% (13).

- Overall **appreciation** of conveniency ("don't have to change the code every time"). **Histograms** used for identifying operational ranges, line **graphs** to see sensors.

Patterns of usage

- Start with `//?` and then more specific intent (e.g. `volt`) and then `graph / hist`.
- `assert` used to check whether lines were **executed**
- `above 0` to check for **nullish** value
- inline markings **left there** as annotations (can help other understand"
- Typically users were able to **identify the source of a problem**, but not necessarily how to fix it

In conclusions

1

Print value *Inline*

printing functions value next to the line of code

input from hardware *output Inline*

```
analogWrite(LED, value / 4); //?  88
```

```
int value = analogRead(Pin1); //?  900
analogWrite(LED, value / 4); //?  88

digitalRead(button); //?  1

digitalWrite(LED, HIGH); //?  1

bitSet(x, 4); //?  21
shiftOut(mosi, clk, MSBFIRST, x); //?  00010101

millis(); //?  12816

tone(buzzer, freq); //?  445
```

2

Highlight

Tracking code's execution flow

```
if (A && B) {
    quadrature = 0;
    digitalWrite(LED1, HIGH); //?  1
} else if (!A && B) {
    quadrature = 1;
    digitalWrite(LED2, HIGH); //?  1
} else if (!A && !B) {
    quadrature = 2;
    digitalWrite(LED3, HIGH); //?  1
} else if (A && !B) {
    quadrature = 3;
    digitalWrite(LED4, HIGH); //?
}
```

3

Analyze / Visualize data *Inline*

```
// assert?  ✅
// is 1?  true
```

Identity Test

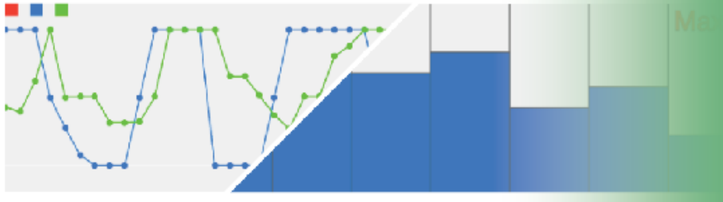
```
// above 100?  960
// below 100?  None
// between 100, 200?  None
```

Threshold

```
// save x?  1023
// count y?  831
// add z?  465522
// min a?  0
// max b?  1023
```

Storing Variables

```
// print $x, $y?   , 1023, 831
// graph $$, $x?  960, 960, 1023
// hist?  826
```



```
// log myLog.txt ?  960
// volt?  4.69
```

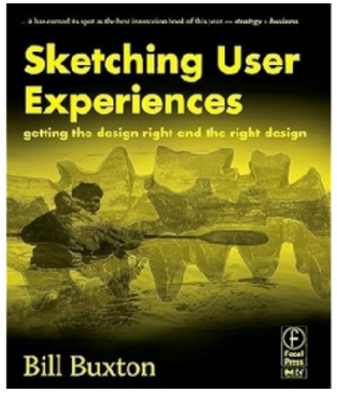
Output

```
// map x => x / 2?  480
// filter x=> x%2 == 0?  960
```

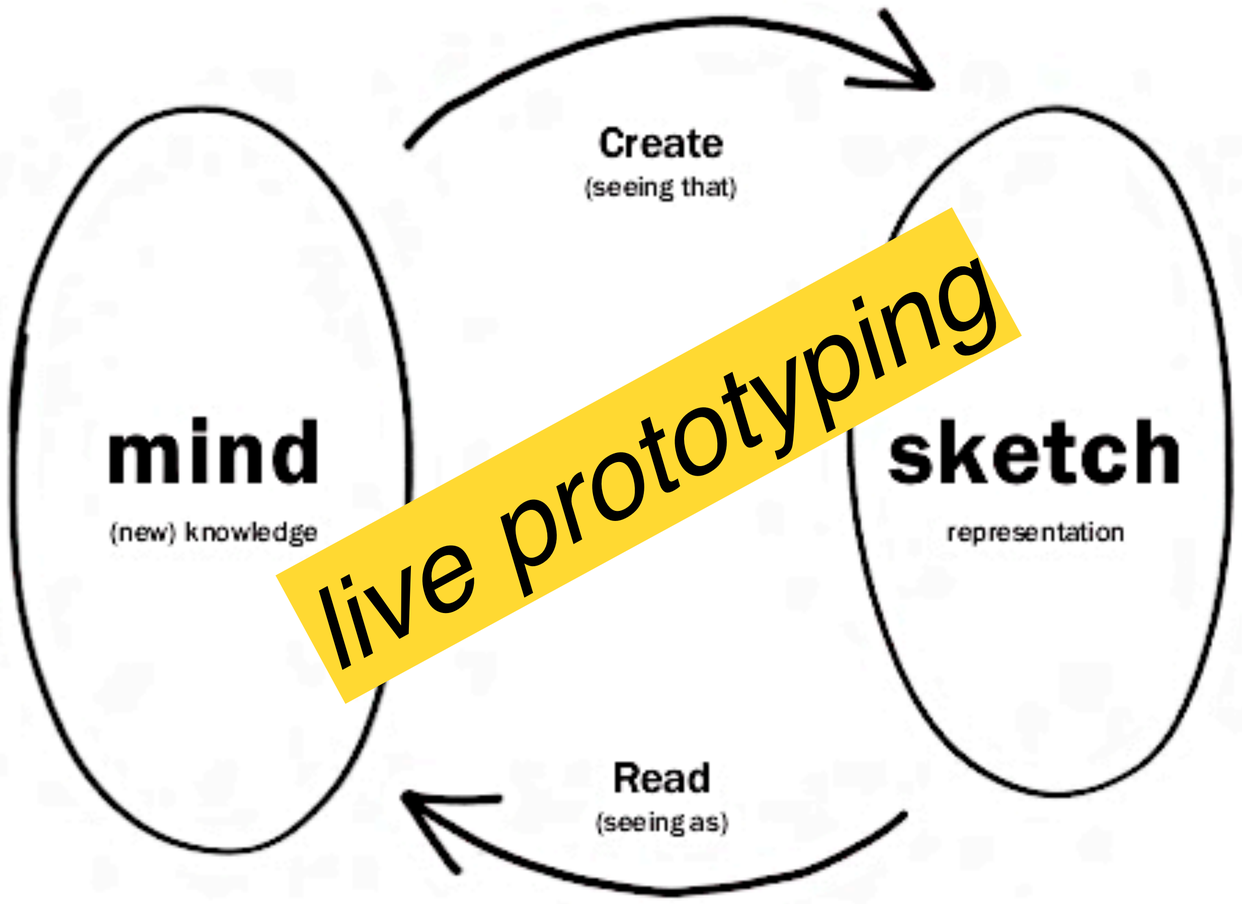
Advanced

“Sketching is about the activity not the result”

Bill Buxton



Microsoft Research



Inline

EICS

EICS 2024

Inline Visualization and Manipulation of Real-Time Hardware Log for Supporting Debugging of Embedded Programs

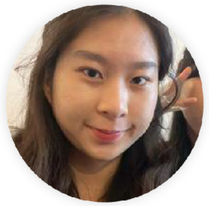
Andrea Bianchi

Department of Industrial Design
& School of Computing,
KAIST

A tool for

- **Inline visualization** of debugging logs for hardware
- **Real-time** tracing
- **Manipulation** of logs

Another step toward *live prototyping* with hardware



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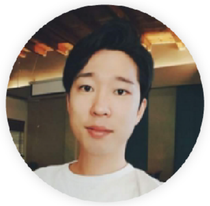

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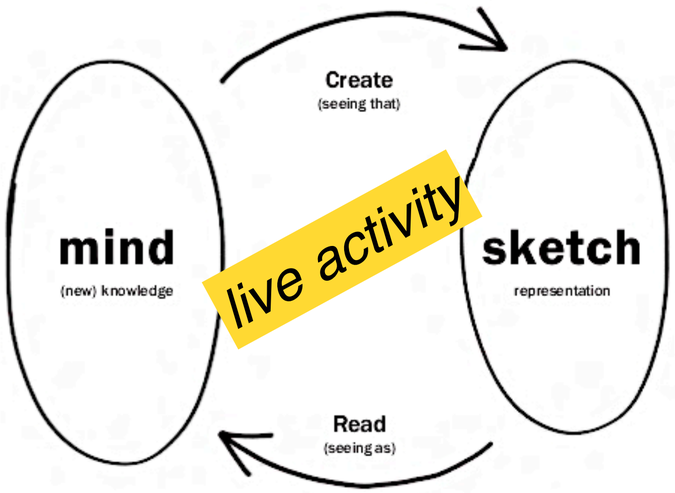
KAIST

CAU 중앙대학교

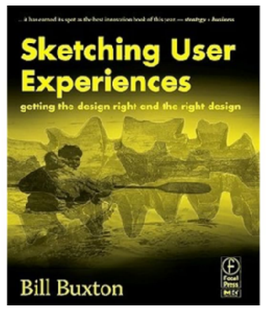
Microsoft

Appendix



"Sketching is about the activity not the result"

Bill Buxton



Microsoft Research

```
152
153 void loop(){
154   potVal = analogRead(potPin); //? 0
155   int length = map(potVal, 0, 1023, 0, 11); //? 0
156   int brightness = map(potVal, 0, 1023, 10, 50); //? 10
157
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Video