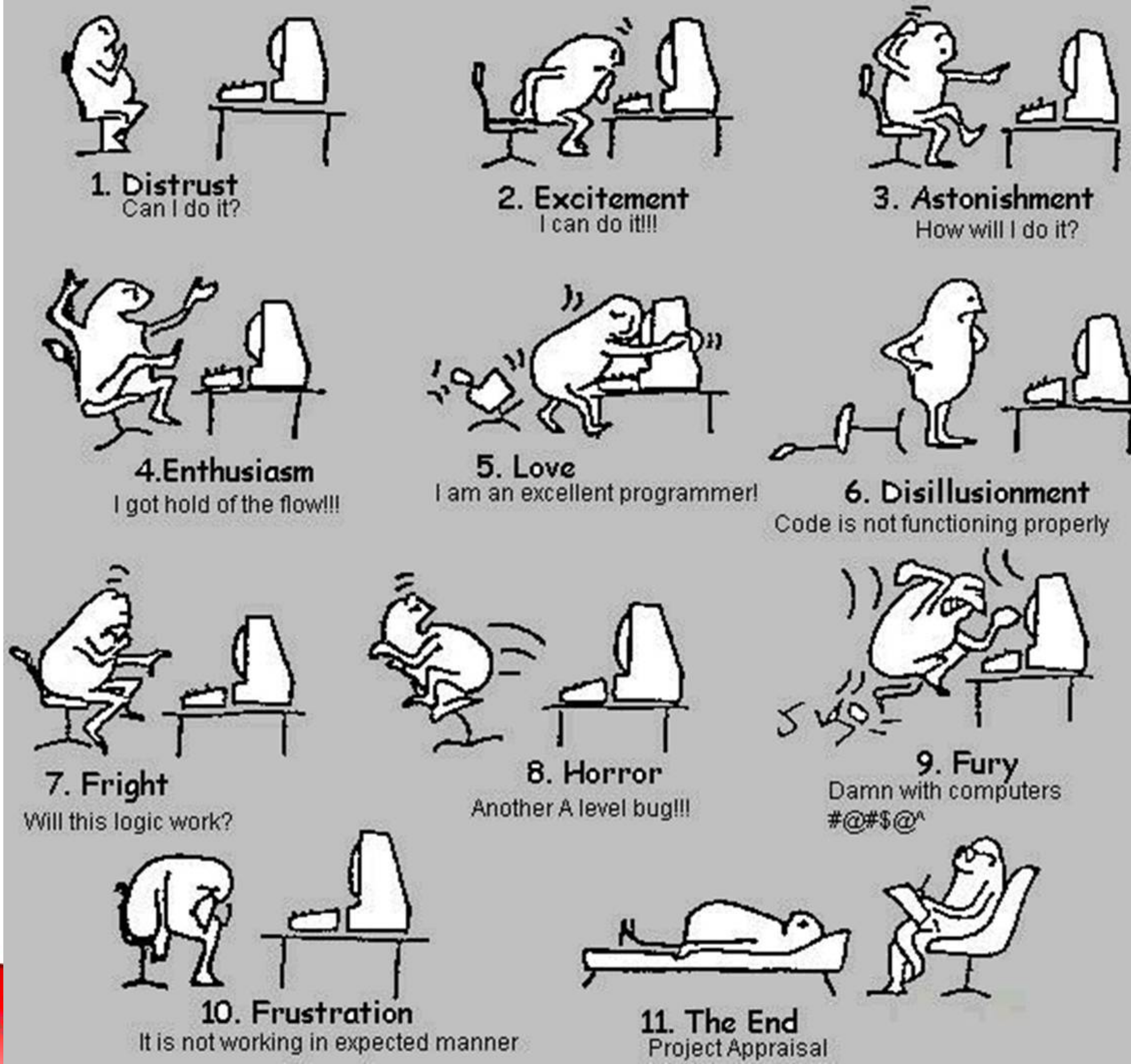
https://ajaywhiz.wordpress.com/2010/02/23/software-development-life-cycle-emotions/

IPS Debugging and Evaluation

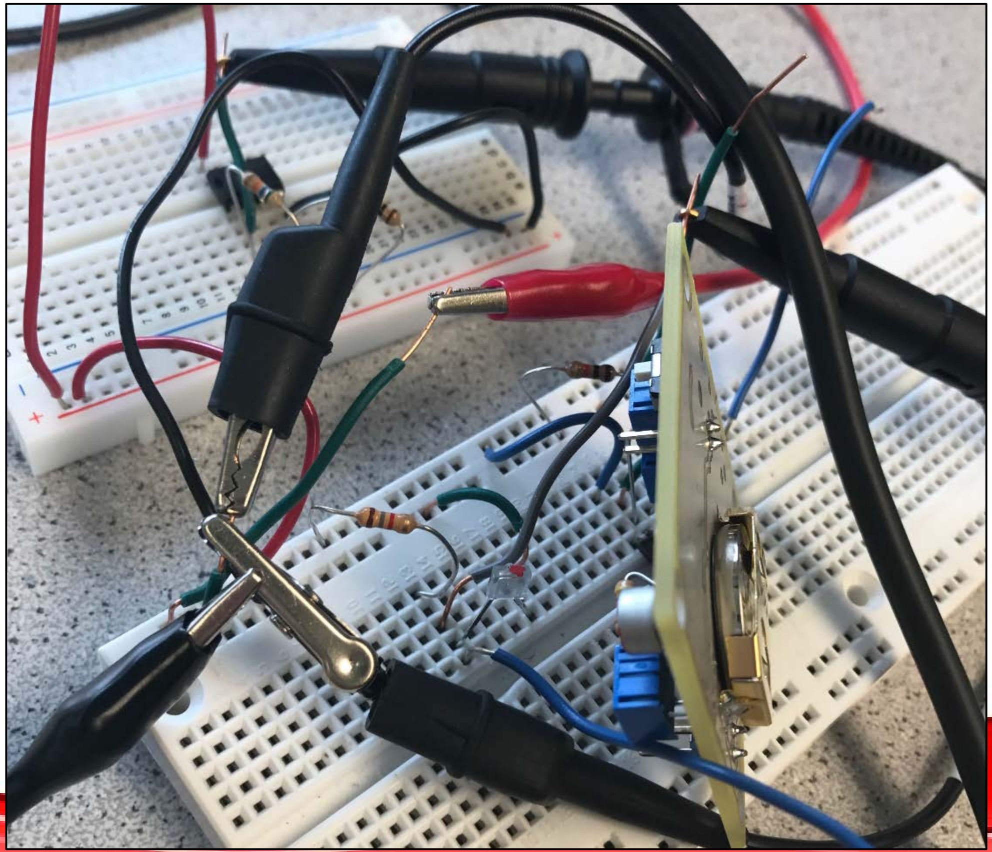


Specification and Evaluation

Electronics

- Sensitivity of IR sensors
  - Output vs. distance
  - SNR
  - Resistance to ambient light
- Sensitivity of microphone
  - Output vs. distance
- Bandwidth of communication
- Battery life time
  - (Under specific circumstance)
- Computation speed/memory
- Filters…
- Encoders…
- etc.

The One-ders, 2017



Specification and Evaluation

Software

- FFT
  - What is the Q of your filter?
- Search
  - How long does it take to find a path?
    - Worst case and best case scenarios
  - How does your implementation scale in time and memory with the size of the maze?

Mechanics

- Speed/power of your servos
- Payload capability

Evaluation

Intelligent Physical System

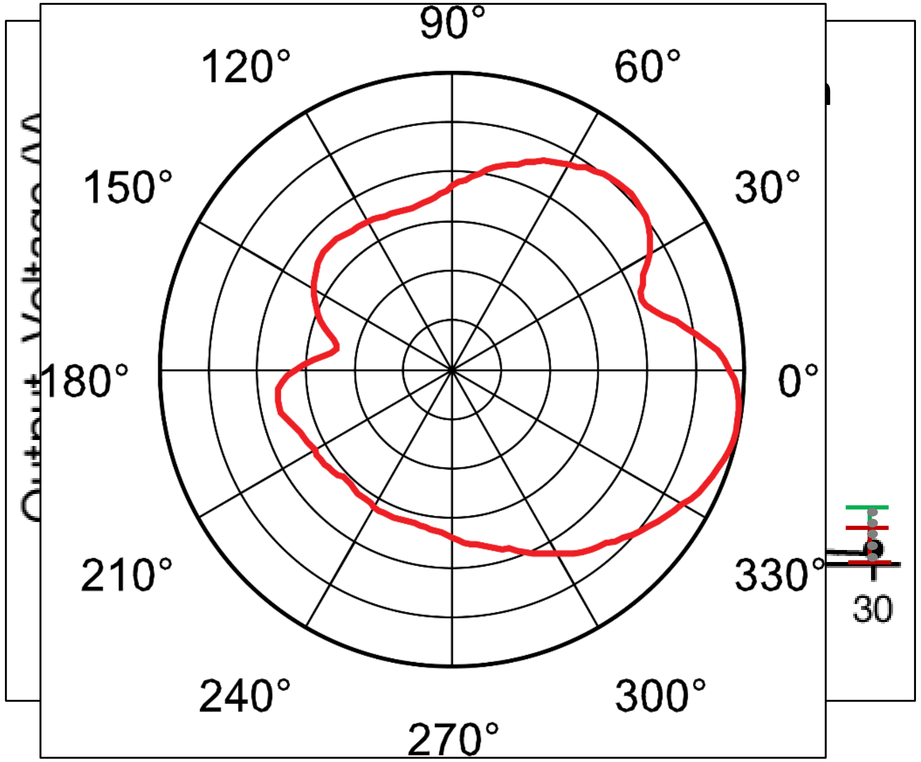
- Straight line velocity
- Turn speed, turn radius
- Reliability of grid traversal (straight/turn)
- Battery life time
  - Straight line test

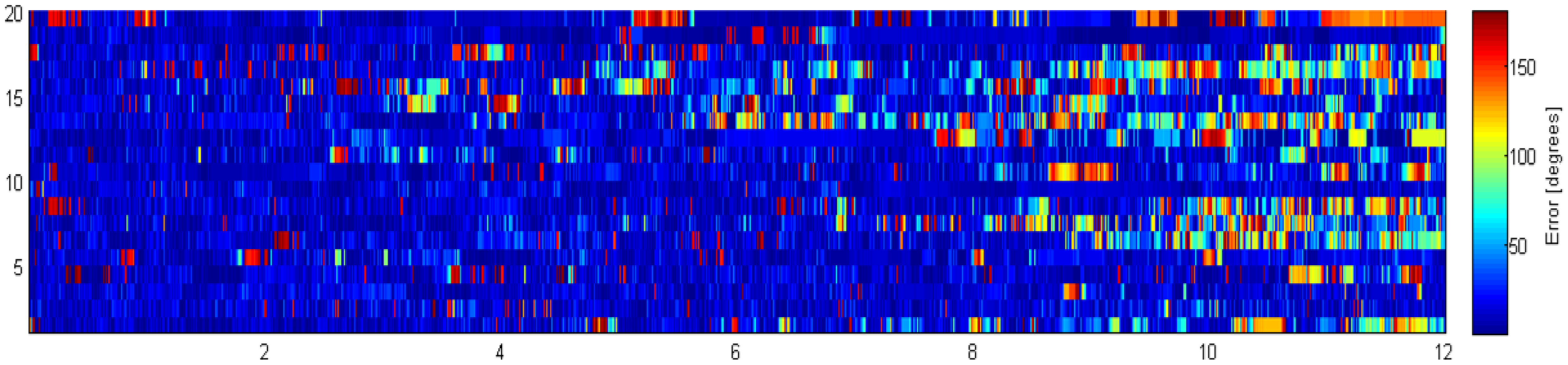
Standards

- Help you compare different systems
- …not that common in robotics
  - To help; be thorough in your evaluation, report negative results and reliability tests

How to convey the information?

- Tables (max/min values)
- Graphs
  - with error bars
- Color maps
  - NB: BW printers/color blind people





Debugging Intelligent Physical Systems

Debugging is more complex than ever!

- Electronics
- Software
- Mechanics
- Multiple connected devices
- Simulation

Worst bugs are intermittent

→ Apply a methodical and documented search

Debugging Intelligent Physical Systems

MARK I Computer, Harvard, by Howard Aiken in 1944

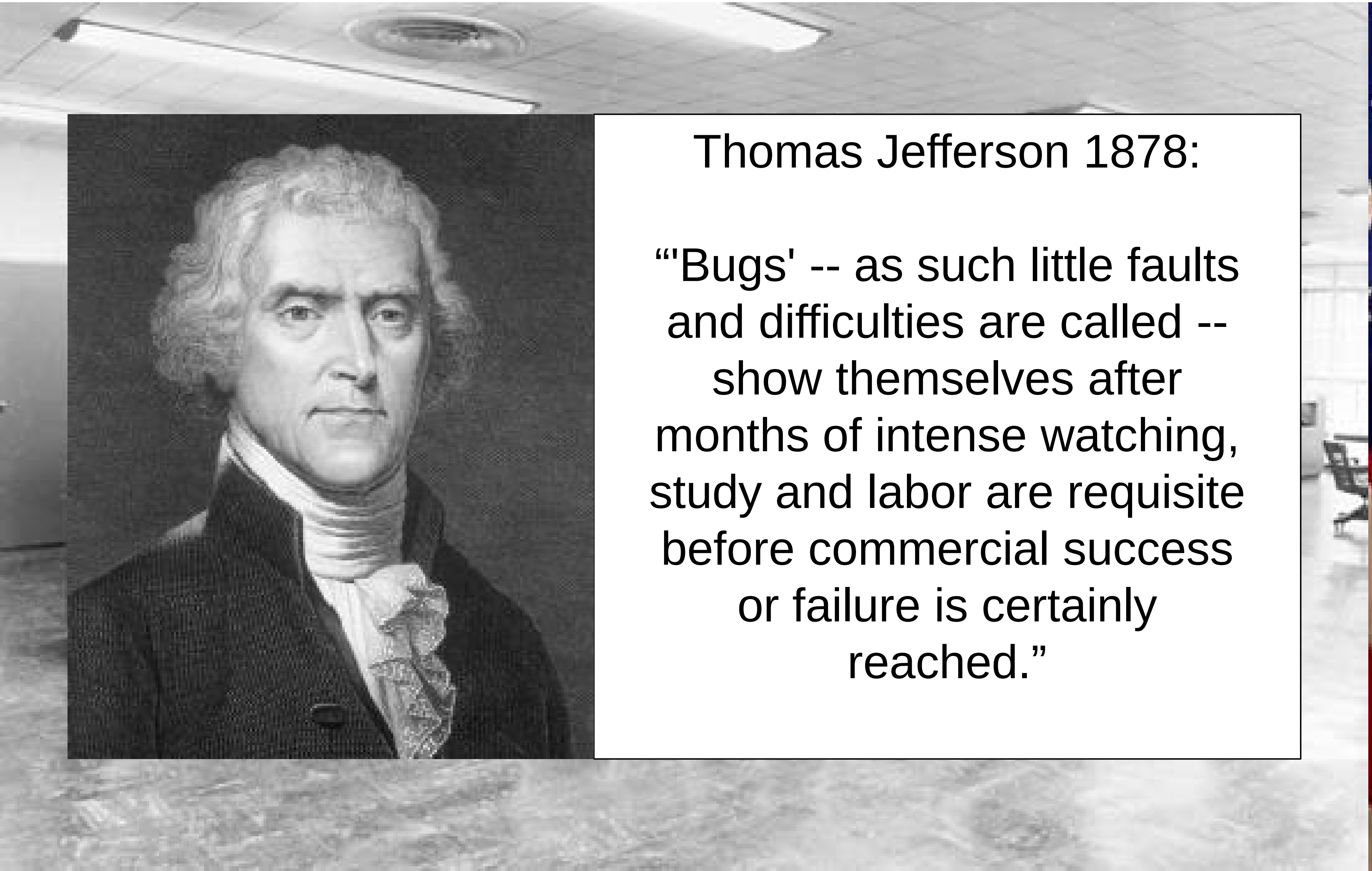
Debugging Intelligent Physical Systems

MARK I Computer, Harvard, by Howard Aiken in 1944

Admiral Grace Hopper, 1906-1992

Debugging Intelligent Physical Systems

MARK I Computer, Harvard, by Howard Aiken in 1944



Admiral Grace Hopper, 1906-1992

Thomas Jefferson 1878:

“'Bugs' -- as such little faults and difficulties are called -- show themselves after months of intense watching, study and labor are requisite before commercial success or failure is certainly reached.”

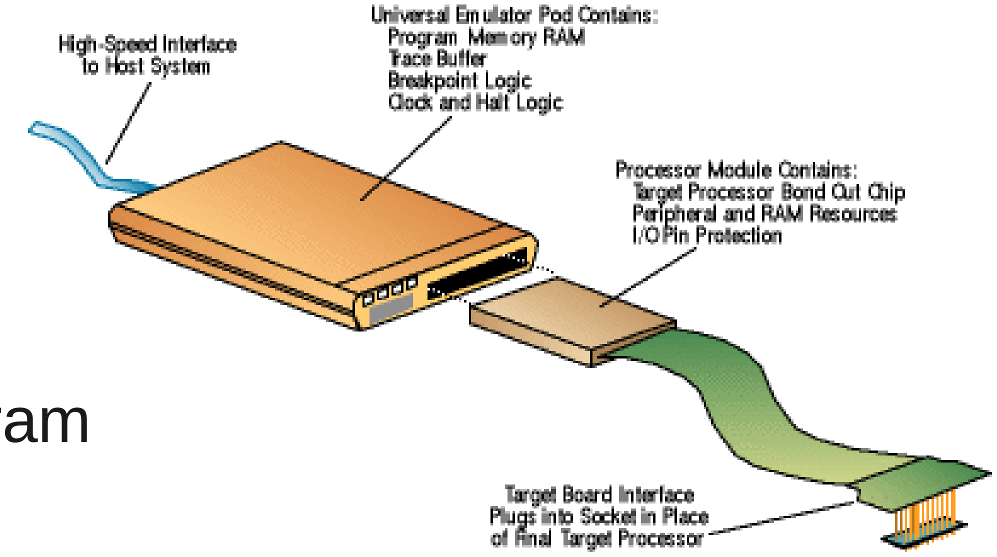
Developing Your System

- Bottom-up development
  - Unit testing
  - Faster initial progress
- Top-down development
  - Implement every thing to begin with
  - Add dummy functions as placeholders
  - Leads to more modular products

Software Debugging

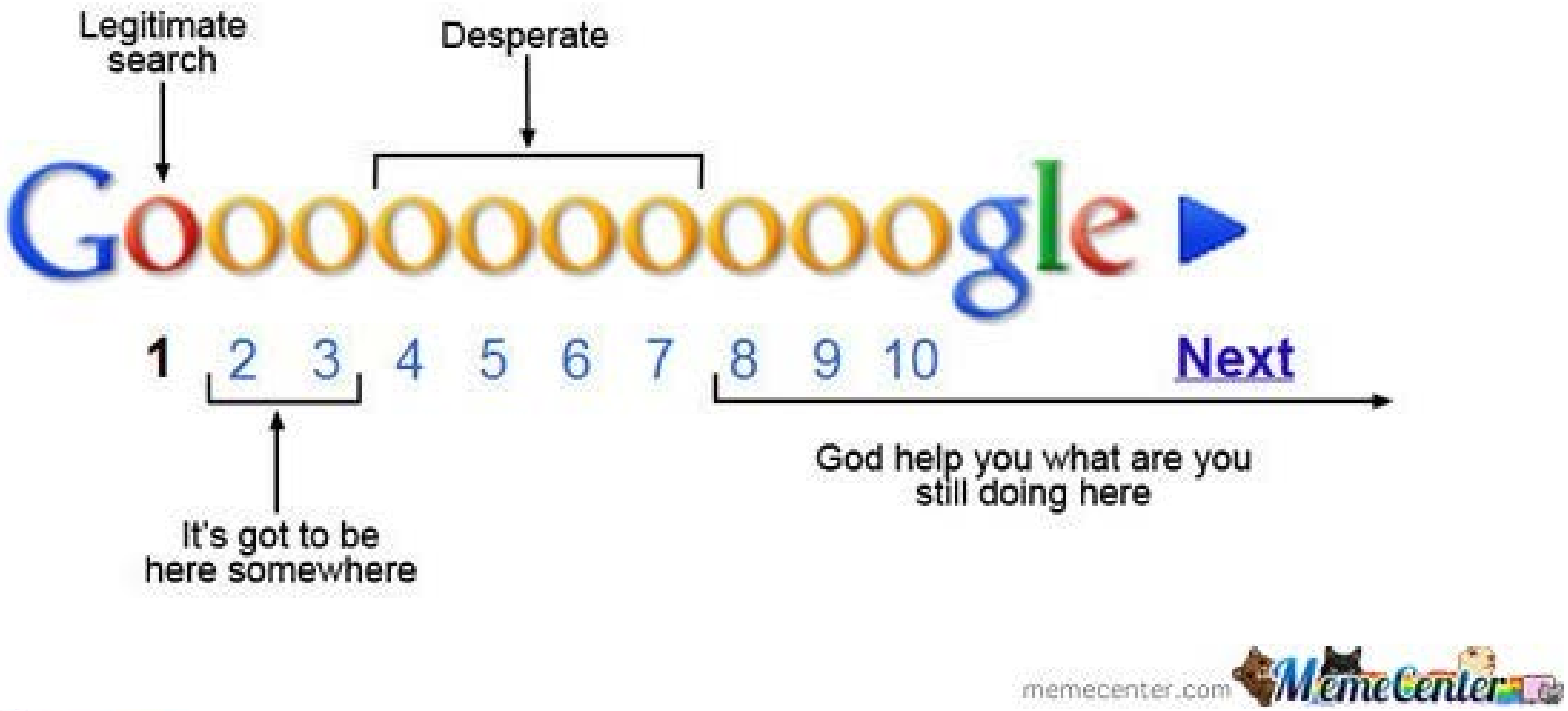
- Compilers
  - Checks for low level errors such as
  - Syntax or type errors
  - Exception handling
- Software debuggers
  - Allows you to monitor the execution of a program
  - Stop it
  - Restart it
  - Set break points
  - Change values in memory
  - AVR Studio / Visual Micro debugger for the Atmel processers

Alternatively, use in-circuit emulators



Cheap, but slow…

Browsing for help online

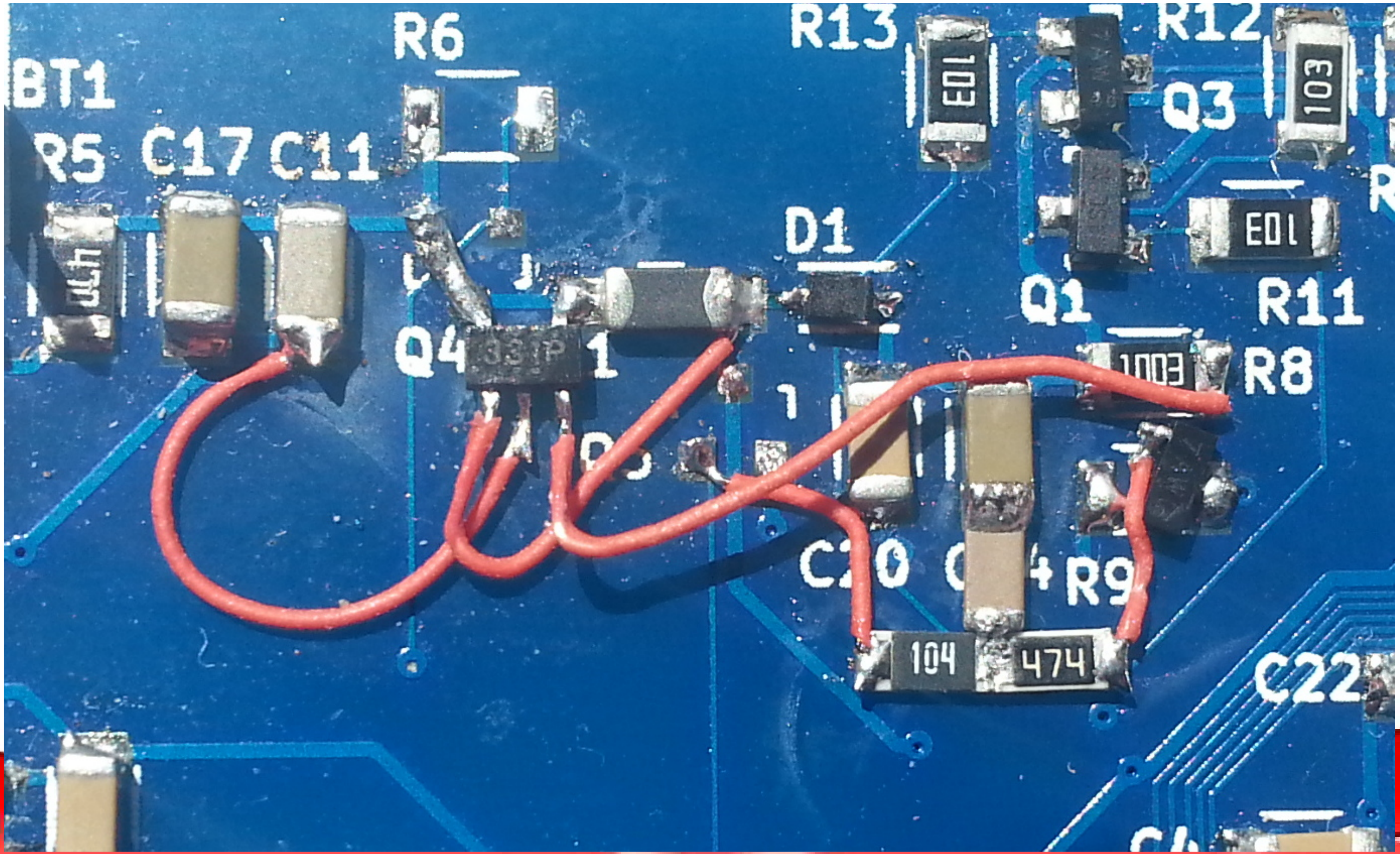


PCB Debugging

- Always test circuit beforehand!
- Add test points
- Make circuit dividers

- Visual inspection
- Go/Nogo
- Test jig
- Automated Test Equipment

time, price, thoroughness



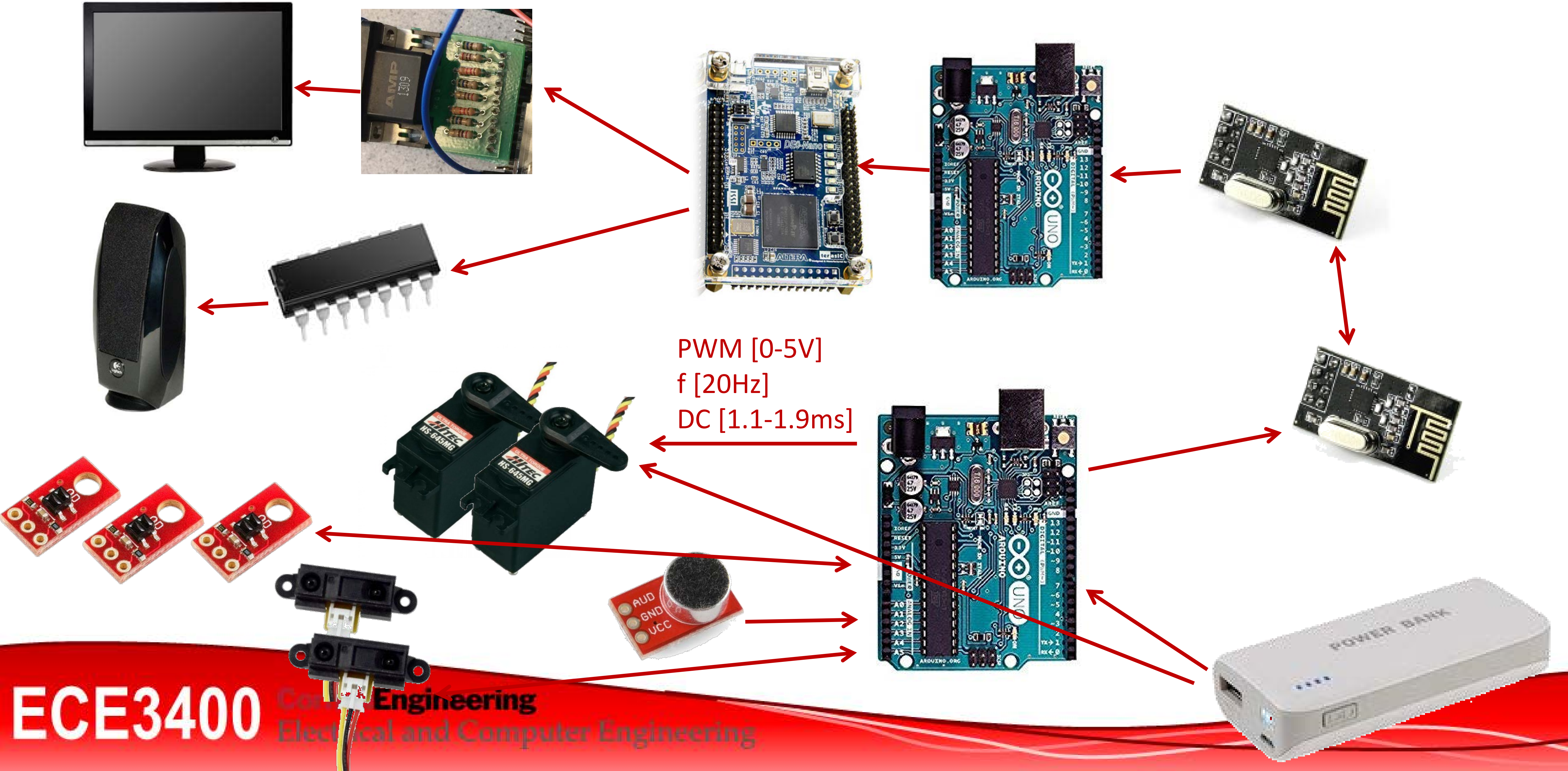
Mechanical Bugs?

- Typically related to friction or jamming
- Broken teeth/dirt in gears
- Broken axels
- Fallen/obscured sensors
- Broken wires

Errors leads to symptoms:

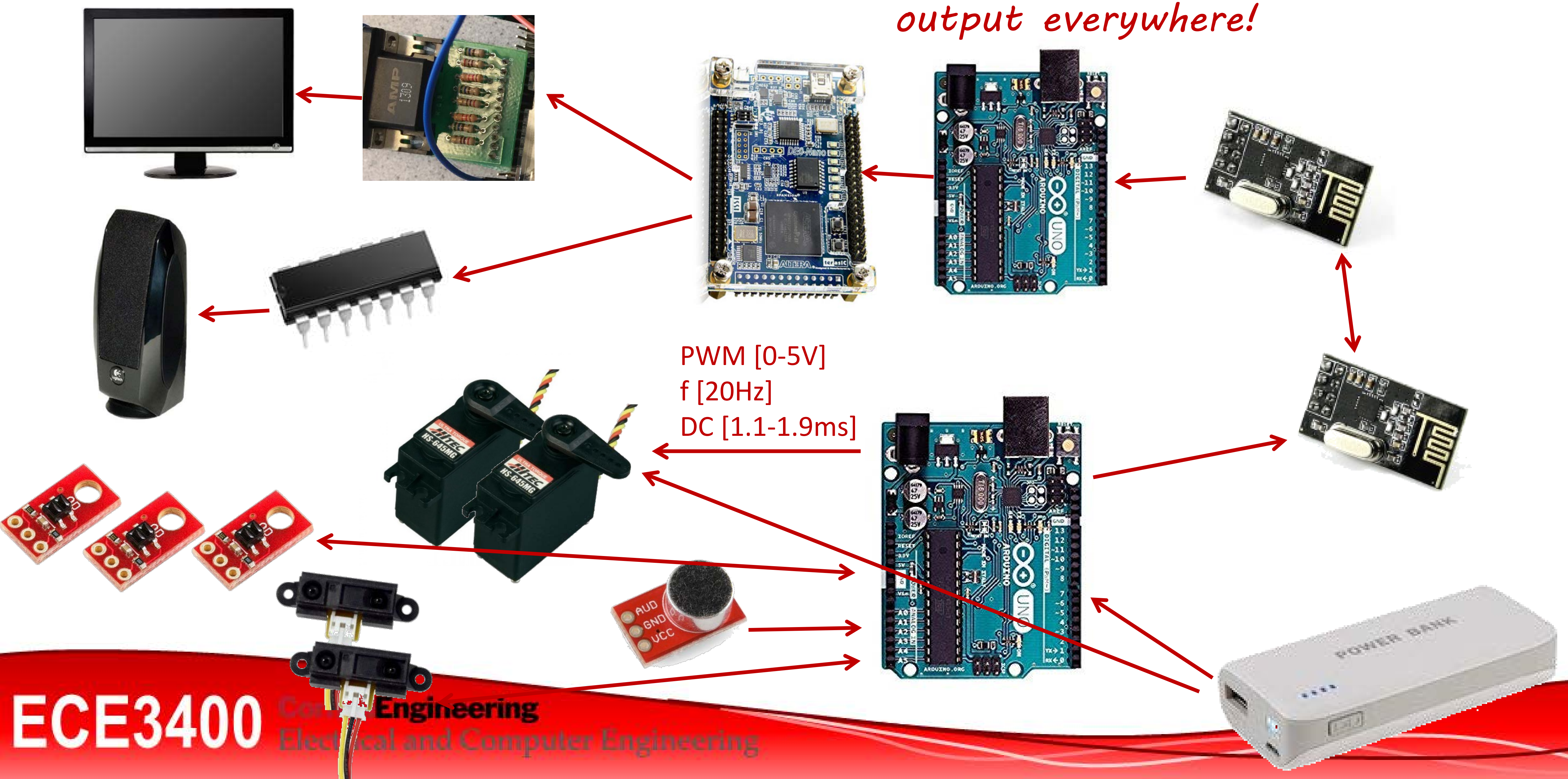
- Bad sensor values
- Slow/biased movement
- Jamming may cause power surges and reset conditions
- Make a test jig for the robot

Map Your System , *then describe your interfaces!*



Make a System Test

Make a setup (code, environment) that generates a predictable output everywhere!



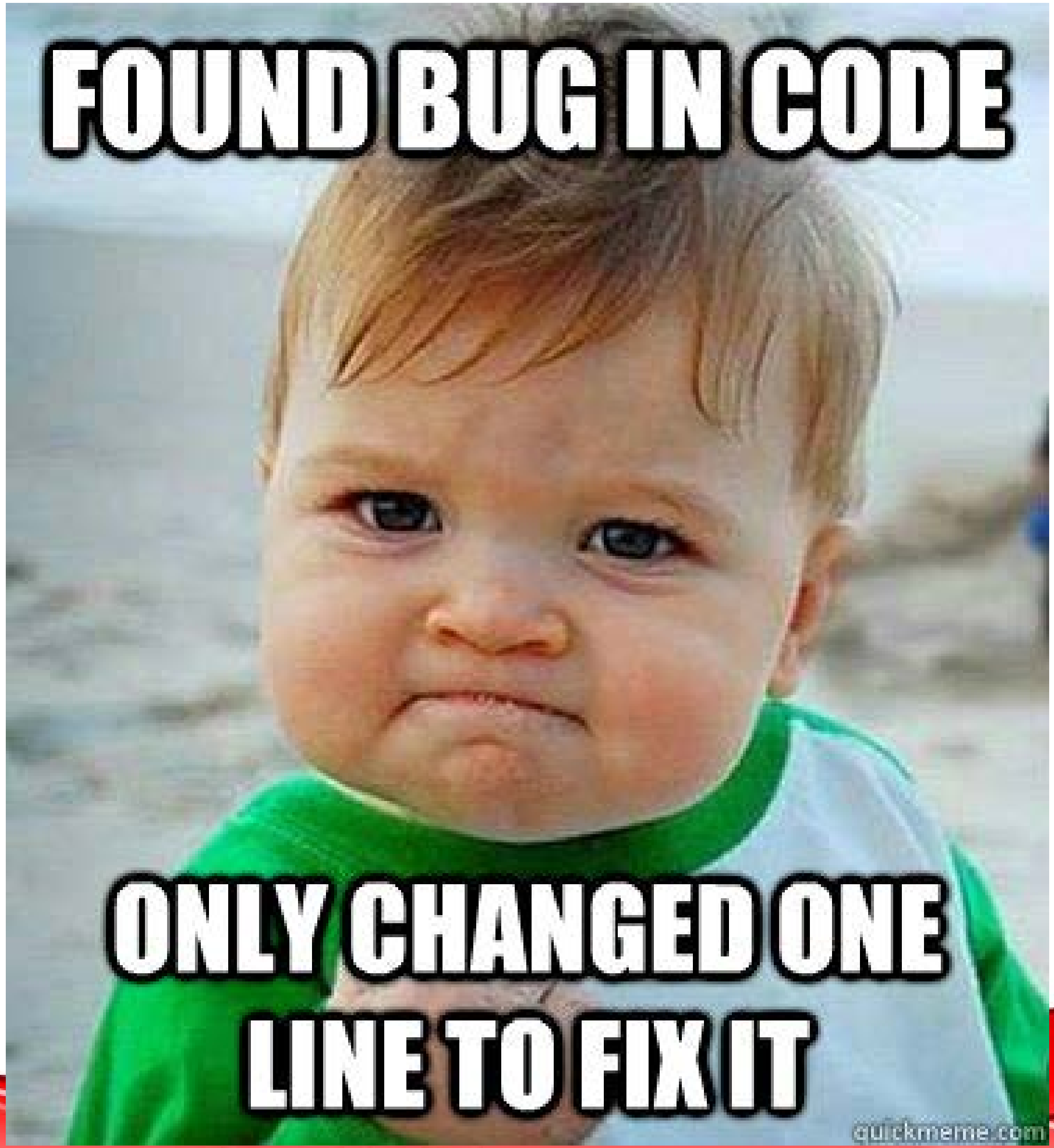
Debugging IPS

- STEP 1: Reproduce the symptom!
- STEP 2: Hunt down the bug
  - Brute force debugging
  - Problem simplification
  - Backtracking (start from problem)
  - Tracing or print debugging
  - Binary Search
  - Scientific Method: Form hypothesis and test it
  - Bug clustering

Debugging IPS

Then solve the problem

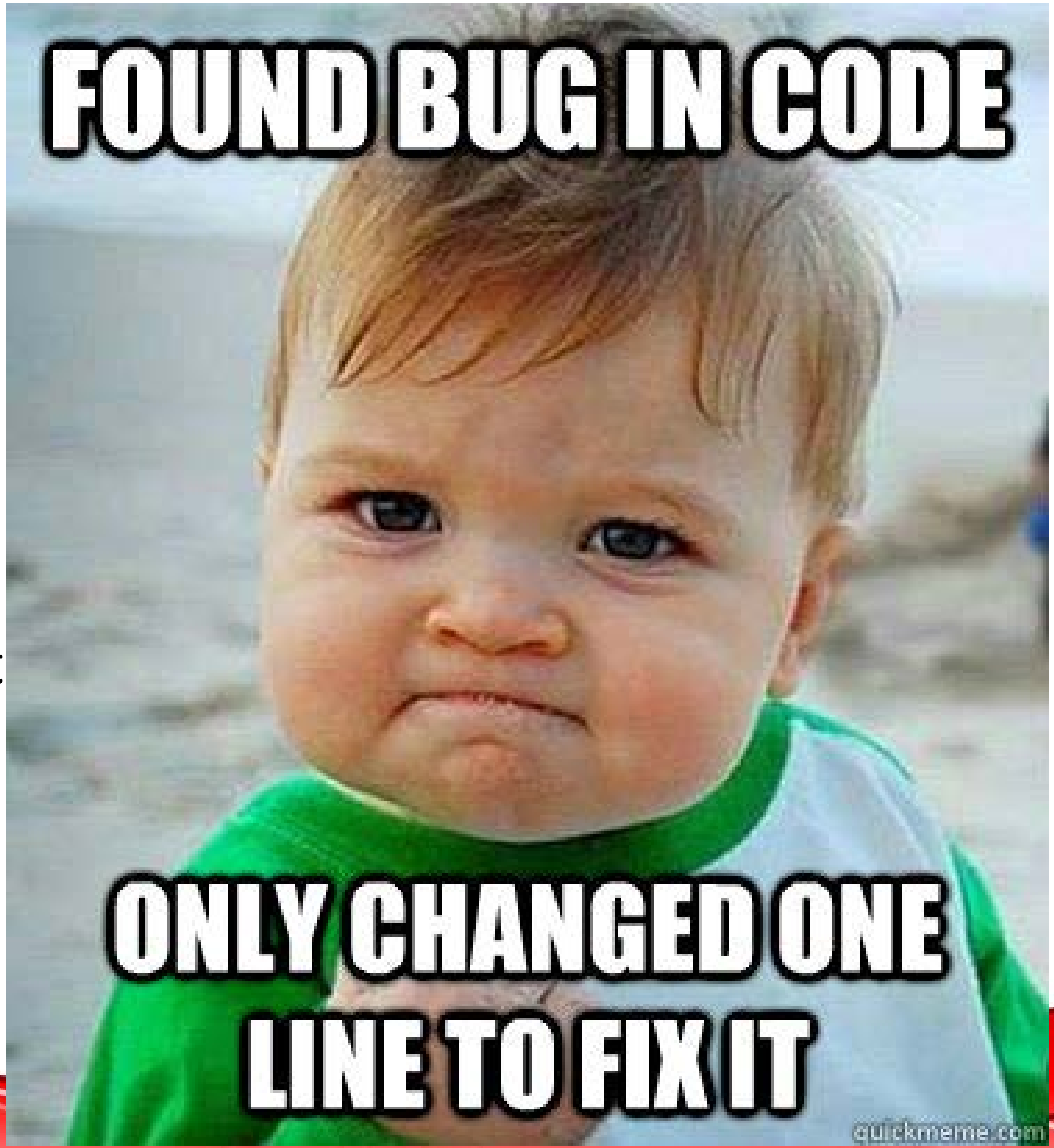
- In most cases the fix is simple
- Some times it is hard!
  - The error may be remote in space or time
  - Many errors may be present and correlated
  - Patch solutions?
    - Fixing one error may introduce new errors



Debugging IPS

Or try to prevent the bug in the first place

- Clean code, electronics, wiring, mechanics
- Incremental development: Compile/test often!
- Instrument program to log information
- Instrument program with assertions
  - Always add else-statements
  - Always add default to switch case statement
  - Add value checkers
  - Add visible feedback (LEDs?)



Mindset

- It appears hopeless, but there is a logical structure in there. The evidence may be obscure, but consistent in pointing to the guilty element.
- Don't panic -- be methodical. Often the TA is able to do this, and they don't know more about your code than you do.
- Discuss it with a team mate
- Sleep on it!

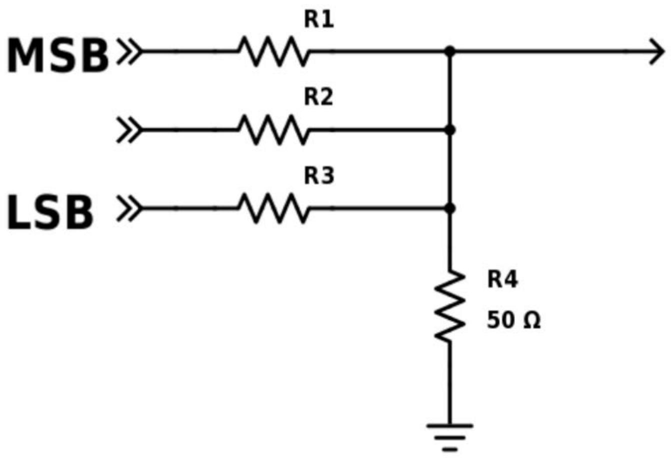
Mindset

- Intuition and hunches are great— you just have to test them out. When a hunch and a fact collide, the fact wins.
- Don't look for complex explanations. Even the simplest omission or typo can lead to very weird behavior.
- The clue to what is wrong is in the values of your variables.
- Be systematic and persistent. The bug is not moving around in your system, trying to trick or evade you. It is just sitting in one place, doing the wrong thing in the same way every time.
- If your code was working a minute ago, but now it doe changed?
- Do not change your code haphazardly trying to track d
- Fix bugs immediately (even if they're not the original b may be correlated).

Calculating the Resistor Values of the DAC

*Courtesy of Team 9-10

3-bit Signal	Voltage value
000	0V
001	1/7 V
010	2/7 V
011	3/7 V
100	4/7 V
101	5/7 V
110	6/7 V
111	1 V



$$\frac{3.3V - 1V}{R_{eq}} = \frac{1V - 0V}{50\Omega}$$

$$R_{eq} = \frac{(3.3V - 1.0V) \cdot 50\Omega}{1V} = 115\Omega$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R3} = \frac{1}{R_1} + \frac{1}{2 \cdot R_1} + \frac{1}{4 \cdot R_1} = \frac{4+2+1}{4 \cdot R_1} = \frac{7}{4 \cdot R_1}$$

$$R_1 = \frac{7}{4} \cdot R_{eq} = \frac{7 \cdot 115\Omega}{4} = 201.25\Omega \Rightarrow R_2 = 2 \cdot R_1 = 402.50\Omega \Rightarrow R_3 = 2 \cdot R_2 = 805\Omega$$

E Series Resistor Values

R1 = 270Ω
R2 = 561Ω
R3 = 1200Ω

E3
- 3 values in each decade: 1Ω, 2.2Ω, 4.7Ω
- Tolerance: ±40%

E6
- 6 values in each decade: 1Ω, 1.5Ω, 2.2Ω, 3.3Ω, 4.7Ω, 6.8Ω
- Tolerance: ±20%

E12
- 12 values in each decade:

1Ω, 1.2Ω, 1.5Ω, 1.8Ω, 2.2Ω, 2.7Ω, 3.3Ω, 3.9Ω, 4.7Ω, 5.6Ω, 6.8Ω, 8.2Ω
- Tolerance: ±10%

etc…

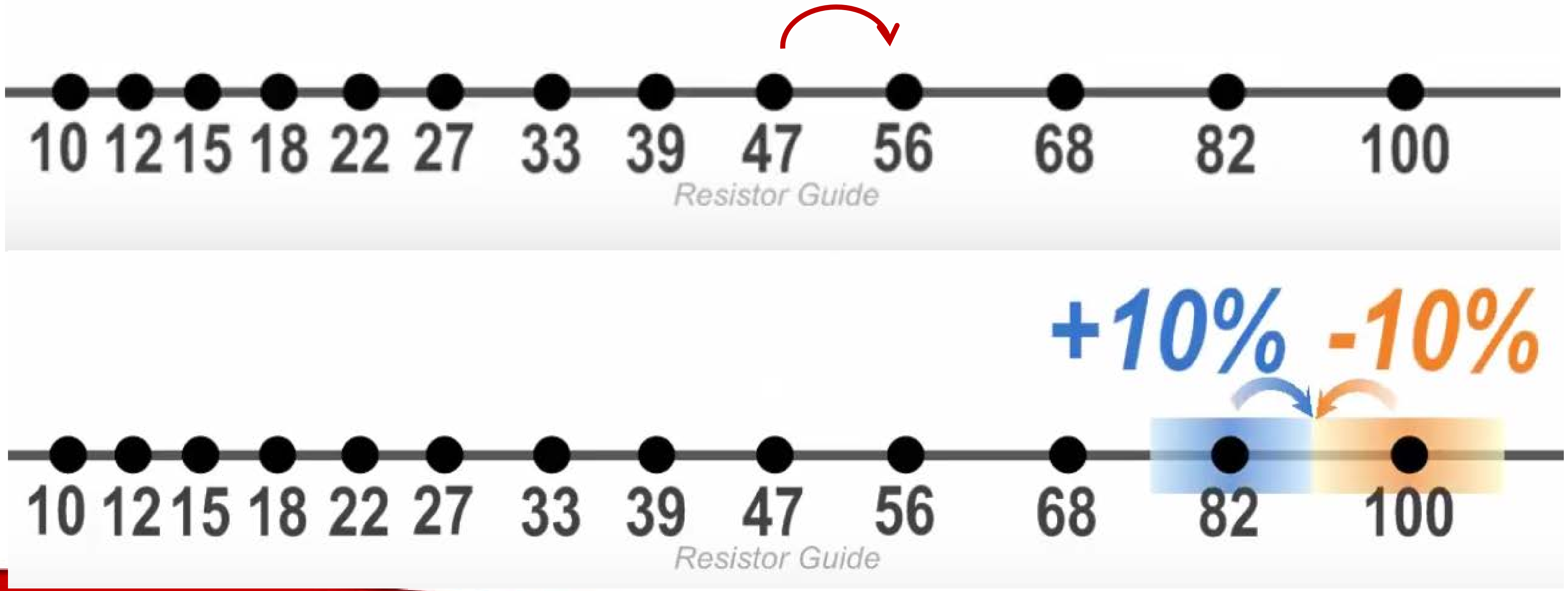
E Series Resistor Values

- Equally spaced out on a logarithmic scale
- Current tolerances are typically 5%, 1-2%

R1 = 270Ω
R2 = 561Ω
R3 = 1200Ω

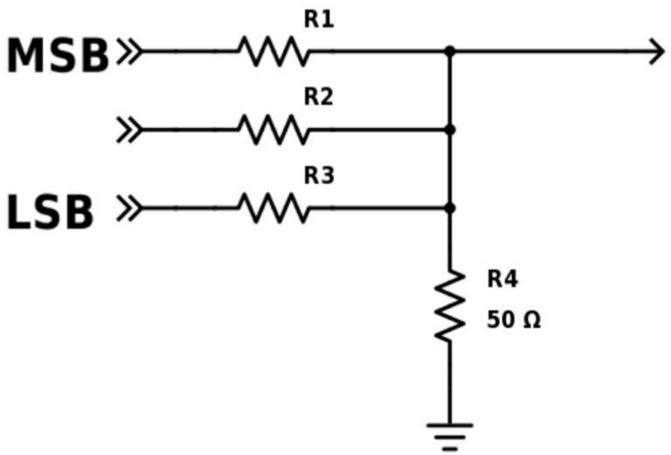
E-12 Series

$10^{1/12} = 1.2$



Calculating the Resistor Values of the DAC

3-bit Signal	Voltage value
000	0V
001	0.1428 V
010	0.2857 V
011	0.4285 V
100	0.5714 V
101	0.7142 V
110	0.8571 V
111	1 V



R1 = 270Ω
R2 = 561Ω
R3 = 1200Ω

0X1 → 3.3V · [50Ω||R1] / [R3 + (50Ω||R1)]
= 3.3V · 42.2Ω /(1200Ω+42.2Ω) = 0.11V

X01 → 3.3V · [50Ω||R2] / [R3 + (50Ω||R2)]
= 3.3V · 46.0Ω /(1200Ω+46.0Ω) = 0.12V

XX1 → 3.3V · 50Ω / [R3 + 50Ω]
= 3.3V · 50Ω /(1200Ω+50Ω) = 0.132V

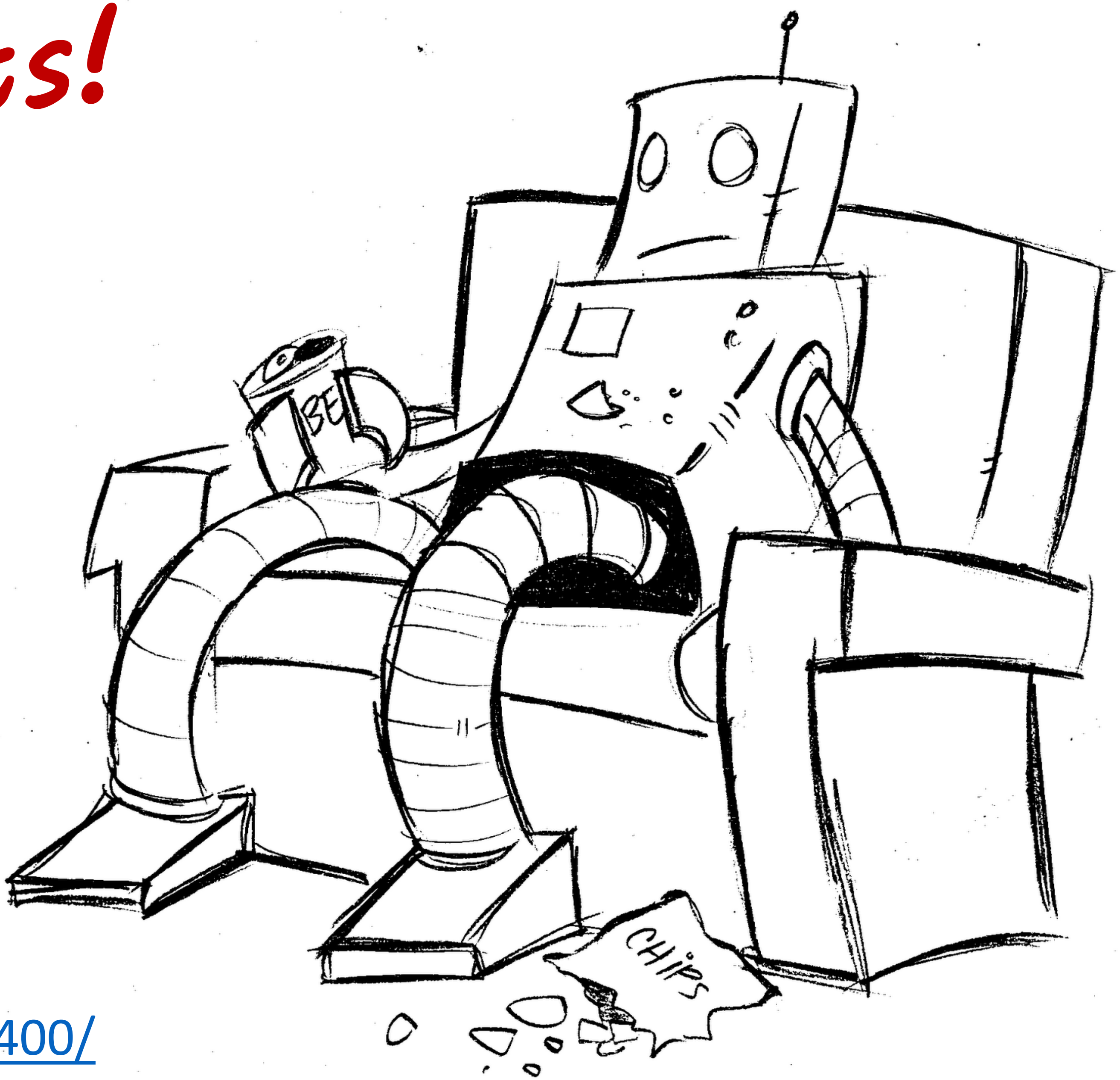
Tristate pins:

- `Set pins to inputs!`

Logistics:

- **Next week**
- **Ethics!**
  - **Lectures and Homework**

Go Build Robots!



Class website: https://cei-lab.github.io/ece3400/

Piazza: https://piazza.com/cornell/fall2017/ece3400/home