

INTERACT WITH THE PHYSICAL WORLD

- SENSORS TO GATHER DATA
- ACTUATORS TO SEND FEEDBACK
- PROJECT BUILD A NIGHTLIGHT

INTRODUCTION 2 IMPORTANT CONCEPTS

SENSORS

- WHAT ARE SENSORS?
- USE A SENSOR
- SENSOR TYPES

ACTUATORS

- WHAT ARE ACTUATORS?
- USE AN ACTUATOR
- ACTUATOR TYPES

WHAT ARE SENSORS?

HARDWARE DEVICES THAT SENSE THE PHYSICAL WORLD

THEY MEASURE PHYSICAL PROPERTIES AND SEND THAT INFORMATION TO AN IOT DEVICE

COMMON SENSORS

- TEMPERATURE
- HUMIDITY
- BUTTONS (INTERACTION)
- LIGHT SENSOR (LEVELS, COLORS...)
- CAMERAS
- ACCELERATORS
- MICROPHONES

DO YOUR RESEARCH

WHAT SENSORS DOES YOUR PHONE HAVE?

ALL SENSORS CONVERT THE SENSED INPUT INTO ELECTRICAL SIGNALS THAT IOT DEVICES CAN INTERPRET MEANINGFULLY

USE A SENSOR

PICK YOUR HARDWARE PATH ADD YOUR FIRST SENSOR

- W/D TERMINAL: BUILT-IN LIGHT SENSOR (photodiode) CONVERTS ANALOG SIGNAL INTO INTEGER VALUE (0-1023)
- SINGLE BOARD COMPUTER (R-Pi): EXTERNAL SUNLIGHT SENSOR (GROVE)
- SINGLE BOARD COMPUTER (VIRTUAL DEVICE): CREATE SENSOR, USE A VIRTUAL LIGHT SENSOR WITH THE COUNTER FIT APP

SENSOR TYPES 2 PRIMARY TYPES

ANALOG SENSORS

PRODUCES A CONTINUOUS ANALOG SIGNAL PROPORTIONAL TO THE SENSED INPUT

EXAMPLE: TEMP SENSOR

DIGITAL SENSORS

PRODUCES DISCRETE VALUES (0,1 - BINARY STATES)

EXAMPLE: LIGHT SWITCH

ANALOG SENSORS

HOW IT WORKS: IOT DEVICE (5V) -> SENSOR (3.8V)

WHAT IS VOLTAGE? IT'S A MEASURE OF EFFORT NEEDED TO PUSH ELECTRICITY FROM ONE POINT TO ANOTHER

THE IOT DEVICE CAN 'READ' THE VOLTAGE COMING OUT OF THE SENSOR AND REACT TO ITS VALUE OR CHANGE

SENSOR RECEIVES VOLTAGE FROM IOT DEVICE, ADJUSTS AND RETURNS IT TO REFLECT DATA

POTENTIOMETER

IS ONE EXAMPLE OF AN ANALOG SENSOR DEVICE

ROTATE THE DIAL BETWEEN TWO FIXED ENDS (mapped to 0V, 5V)

SENSOR MEASURES ROTATION BY SENDING REDUCED VOLTAGE (OR NUMERIC MAPPING) CORRESPONDING TO SHIFT

DO YOUR RESEARCH

WHAT IS A THERMISTOR? WHAT TYPE OF SENSOR IS IT - AND HOW DOES IT WORK?

WHAT DO YOU THINK HAPPENS IF SENSOR SENDS OUT HIGHER VOLTAGE THAN IT RECEIVES?

ANALOG-TO-DIGITAL

IOT DEVICES ARE DIGITAL!

ANALOG SENSORS NEED TO 'DIGITIZE' THEIR VALUES BEFORE IOT DEVICE CAN USE THEM

MANY IOT DEVICES HAVE BUILT-IN ADC AND MANY SENSORS CAN WORK WITH ADCs VIA A CONNECTOR BOARD!

SOFTWARE LIBRARIES FOR SENSORS/DEVICES HANDLE MUCH OF THIS FOR YOU TRANSPARENTLY

WE HAVE OPTIONS

ABC = ANALOG-TO-DIGITAL CONVERTER

ANALOG INPUT -> ABC -> DIGITAL VALUE

DIGITAL SENSORS

ALSO DETECT WORLD BY MEASURING ELECTRICAL CHANGES BUT THEY OUTPUT DIGITAL SIGNALS (EITHER BY USING BINARY STATE OR BY USING AN ADC)

SIMPLEST EXAMPLE ON/OFF SWITCH

ADVANCED DIGITAL SENSORS

- READ ANALOG SIGNALS
- CONVERT USING ON-BOARD ADC
- OUTPUT PURELY DIGITAL SIGNALS

DIGITAL INPUTS ARE MORE RELIABLE TO READ IN.

DIGITAL TEMP SENSOR: ANALOG TEMP -> ADC -> DIGITAL TEMP

ADVANCED DIGITAL SENSORS

DIGITAL DATA HAS ADDED BENEFITS

- SENSORS CAN BE MORE COMPLEX, SEND DETAILED DATA
- EASIER TO ENCRYPT DATA FOR SECURE TRANSMISSION
- MORE IMMUNE TO ENVIRONMENTAL AND ELECTRONIC 'NOISE'
- MORE FLEXIBILITY IN SIGNAL PROCESSING SYSTEMS

EXAMPLE: CAMERA AS DIGITAL SENSOR

DIGITAL CAMERAS USE SENSORS LIKE THIS TO CAPTURE LIGHT FROM THE LENS AS PIXELS IN A FRAME/IMAGE

IMAGE PIXELS

JPG compressed for transmission

WHAT ARE ACTUATORS?

OPPOSITE OF SENSORS CONVERT ELECTRICAL SIGNAL FROM IOT DEVICE INTO ACTION IN REAL WORLD

REAL WORLD -> Gather real world data -> SENSOR -> send electrical signal to IOT device -> ACTUATOR -> send electrical signal to the actuator with request -> REAL WORLD

takes action in real world

EXAMPLES: LED, SPEAKER, RELAY, SCREENS, STEPPER MOTORS

USE AN ACTUATOR

PICK YOUR HARDWARE PATH ADD AN ACTUATOR (USE GUIDE)

BUILD A NIGHTLIGHT

ARDUINO - W/D TERMINAL

SINGLE BOARD COMPUTER RASPBERRY PI

SINGLE BOARD - VIRTUAL DEVICE

READ SENSOR VALUE -> CHECK THE SENSOR VALUE -> CONTROL THE LED STATE

ACTUATOR TYPES

JUST LIKE SENSORS, THERE ARE 2 TYPES OF ACTUATORS: ANALOG & DIGITAL

ACTUATORS HAVE A CONTROL SIGNAL AND A SOURCE OF ENERGY

BASED ON SIGNAL, THEY CONVERT ENERGY INTO SOME MOTION OR INTERACTION

EXAMPLE: CONTROL SIGNAL TRIGGERS ROTARY SWITCH TO MOVE, TURNS LIGHT ON IN ROOM

DO YOUR RESEARCH

ACTUATORS CAN BE CATEGORIZED BY THE FUNCTION THEY SERVE AND HOW THEY CONVERT ENERGY

Learn About:

- PNEUMATIC
- HYDRAULIC
- ELECTRIC
- THERMAL
- MAGNETIC

How do the actuators change?

ANALOG ACTUATORS

ANALOG ACTUATOR CONVERTS ANALOG SIGNAL INTO SOME INTERACTION THAT IS PROPORTIONATE TO VOLTAGE SUPPLIED

EX: DIMMABLE LIGHTS

25V -> DIMMER -> LIGHT BULB

5V -> DIMMER -> LIGHT BULB

DAC = DIGITAL TO ANALOG CONVERTER

REQUIRED TO CONVERT IOT DEVICE DIGITAL OUTPUT (0,1) TO ANALOG VOLTAGE (RANGE)

PULSE WIDTH MODULATION

= SWITCH DIGITAL SIGNAL FROM IOT DEVICE BETWEEN TWO STATES CREATING PULSES

VARYING THE DUTY CYCLE (ON/OFF DURATION) MODULATES PULSE WIDTH - CREATING AN OUTPUT SIGNAL THAT ACTS ANALOG

CONTROL A MOTOR'S SPEED WITH A 5V DIGITAL SUPPLY

Pulse modulation varies avg rpm based on duty cycle

0.2s ON / 0.2s OFF -> 50% DUTY CYCLE -> 150 rpm

0.1s ON / 0.3s OFF -> 25% DUTY CYCLE -> 75 rpm

DO YOUR RESEARCH

THE DUTY CYCLE OF MODULATED PULSE -> INFLUENCES THE SPEED OF ROTATION OF MOTOR

CONTROL SIGNAL -> ACTUATOR MOTION

HOW WOULD YOU KEEP MOTOR ROTATION SMOOTH?

DIGITAL ACTUATORS

- HAVE 2 STATES (CONTROLLED BY HIGH AND LOW VOLTAGE) LIKE DIGITAL SENSORS
- HAVE BUILT-IN DAC THAT CONVERTS DIGITAL INPUT INTO ANALOG SIGNAL THEY CAN USE!

EXAMPLE: SIMPLE LED

2 STATES (ON/OFF)

HIGH VOLTAGE = ON

LOW VOLTAGE = OFF

DO YOUR RESEARCH

WHAT ARE SOME OTHER EXAMPLES OF 2-STATE ACTUATORS?

HOW ABOUT A SOLENOID? WHERE IS IT USED?

CHALLENGE

- LOOK AT YOUR PREVIOUS LISTS OF IOT DEVICES
- FOR EACH DEVICE - WHAT SENSORS/ACTUATORS ARE THEY CONNECTED TO?
- WHAT IS THEIR PURPOSE?

WHAT'S NEXT?

CONNECT YOUR DEVICES TO THE INTERNET

LEARN TO:

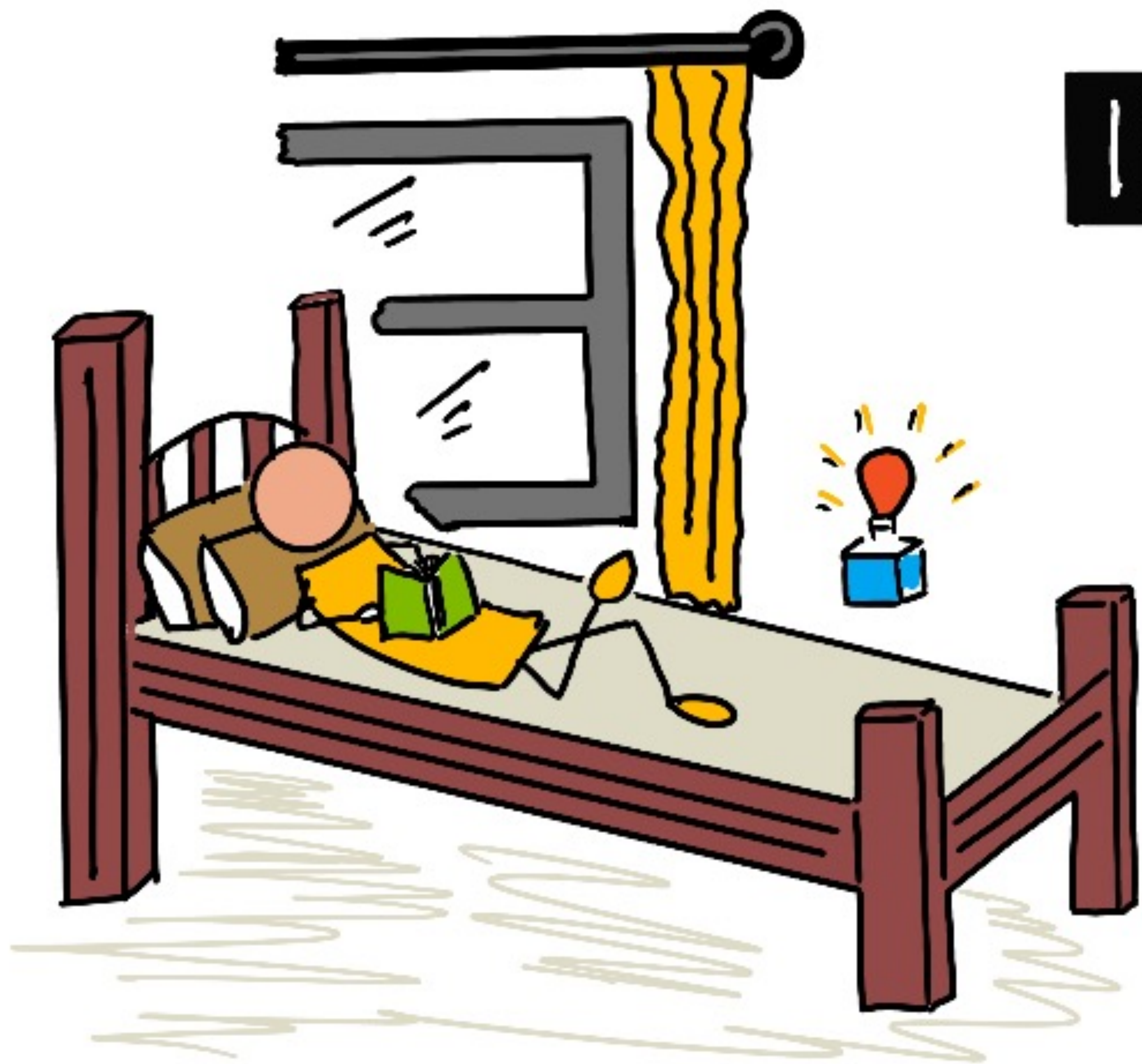
- SEND & RECEIVE MESSAGES
- CONNECT LIGHT TO MQTT BROKER
- CONNECT DEVICE TO INTERNET

CONGRATULATIONS

YOU MADE YOUR FIRST IOT NIGHTLIGHT!

CREATED BY @SKETCH THE DOCS

INTERACT WITH THE PHYSICAL WORLD



SENSORS
TO GATHER DATA



ACTUATORS
TO SEND FEEDBACK



PROJECT
BUILD A NIGHTLIGHT

INTRODUCTION

2 IMPORTANT CONCEPTS



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- USE A SENSOR
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WHAT ARE SENSORS?



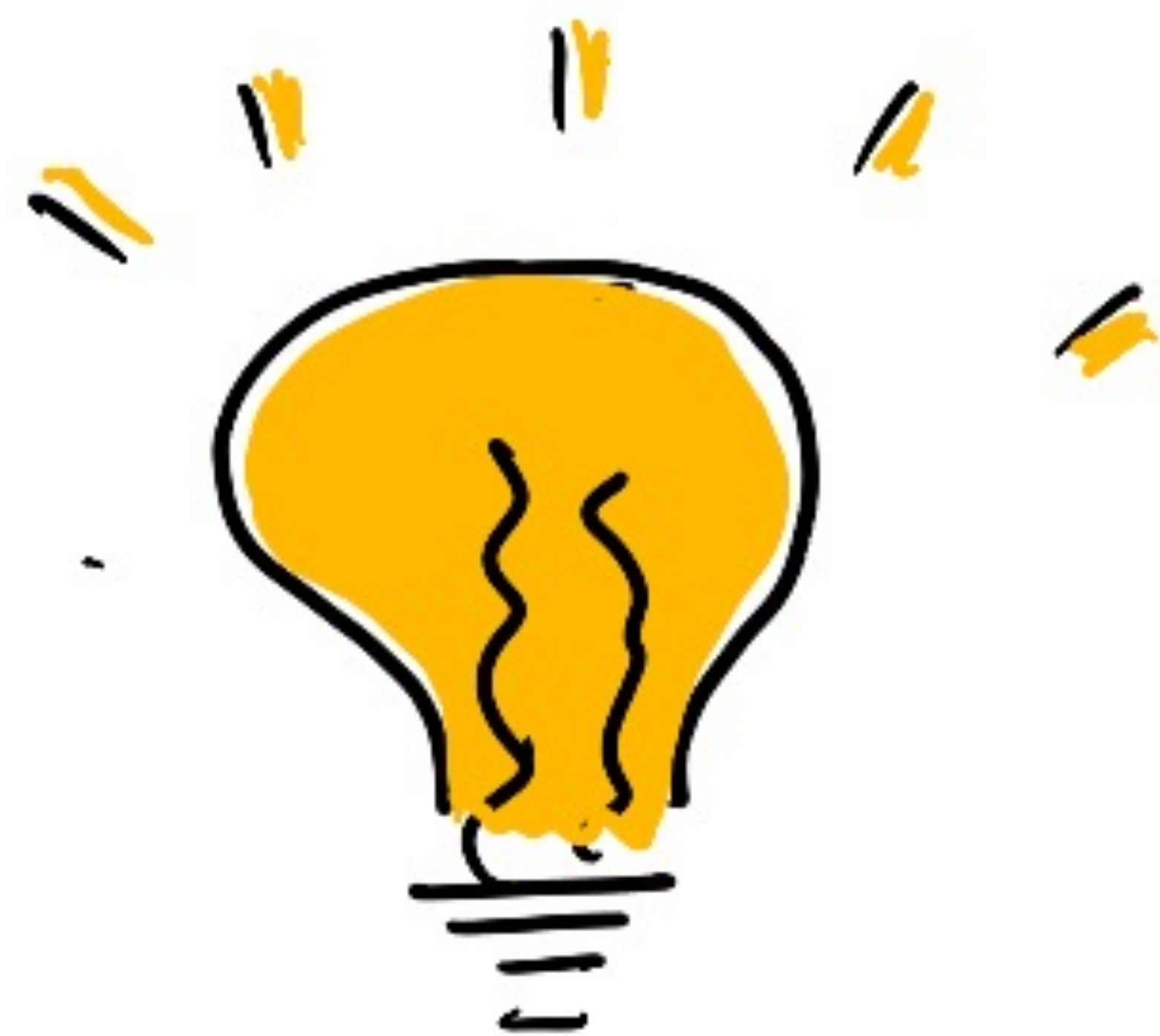
HARDWARE DEVICES
THAT SENSE THE
PHYSICAL WORLD

THEY MEASURE PHYSICAL
PROPERTIES AND SEND
THAT INFORMATION TO AN
IoT DEVICE



COMMON SENSORS

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HUMIDITY
- BUTTONS
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USE A SENSOR

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SETUP
GUIDES

① WID TERMINAL



BUILT-IN LIGHT
SENSOR (photodiode)
CONVERTS ANALOG
SIGNAL INTO INTEGER
VALUE (0 - 1023)

② SINGLE BOARD COMPUTER

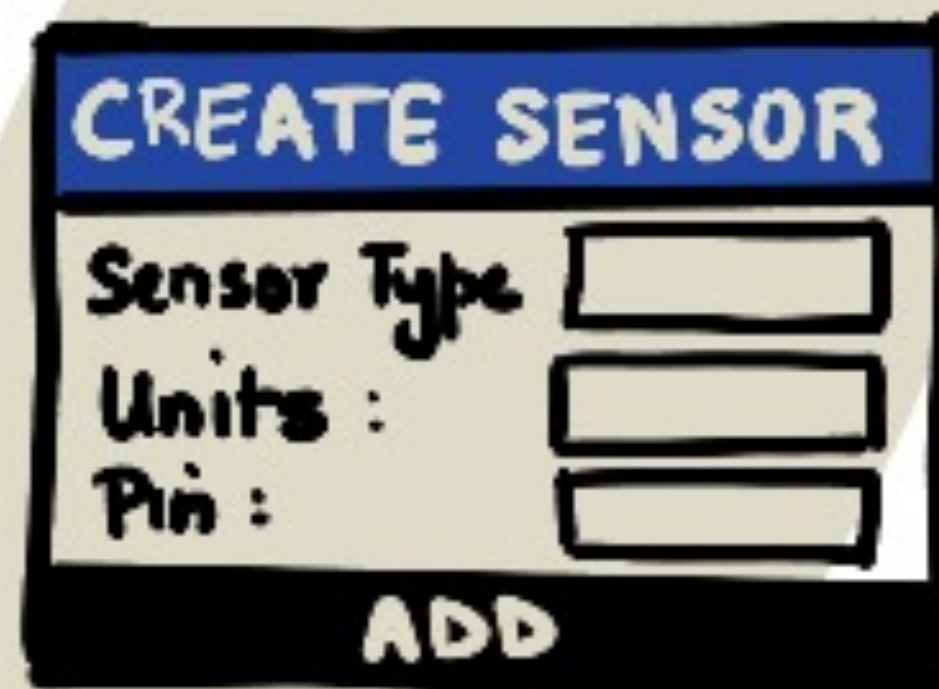
(R-Pi)



EXTERNAL SUNLIGHT
SENSOR (GROVE)

③ SINGLE BOARD COMPUTER

(VIRTUAL DEVICE)



USE A VIRTUAL LIGHT
SENSOR WITH THE
COUNTER FIT APP

SENSOR TYPES

ANALOG SENSORS


PRODUCES A CONTINUOUS
ANALOG SIGNAL PROPORTIONAL
TO THE SENSED INPUT

▶ EXAMPLE:

TEMP SENSOR



2 PRIMARY TYPES

✓  ANALOG

✓  DIGITAL

DIGITAL SENSORS

PRODUCES DISCRETE VALUES
(0,1 - BINARY STATES)

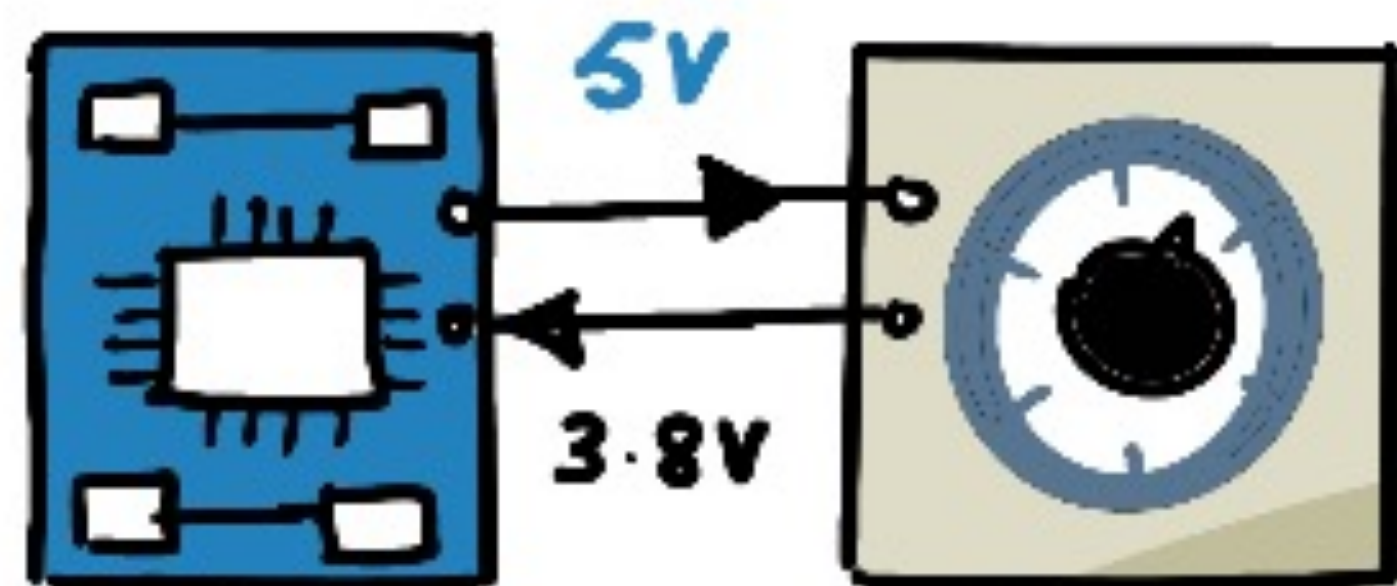
EXAMPLE:

LIGHT SWITCH



ANALOG SENSORS

HOW IT WORKS



IOT
DEVICE

SENSOR

SENSOR RECEIVES VOLTAGE
FROM IOT DEVICE, ADJUSTS
AND RETURNS IT TO REFLECT DATA

WHAT IS VOLTAGE?



IT'S A MEASURE
OF EFFORT NEEDED
TO PUSH ELECTRICITY
FROM ONE POINT
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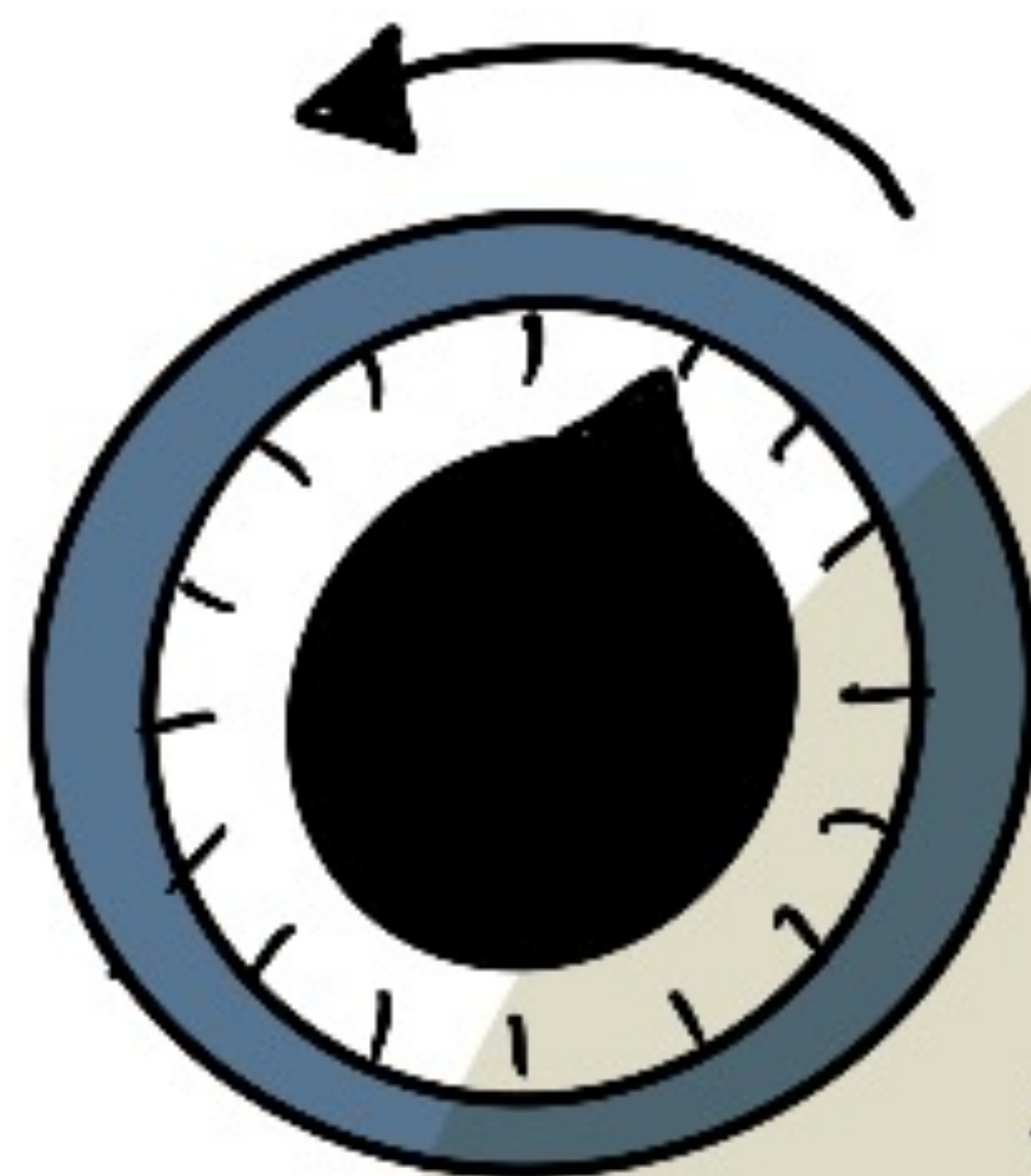
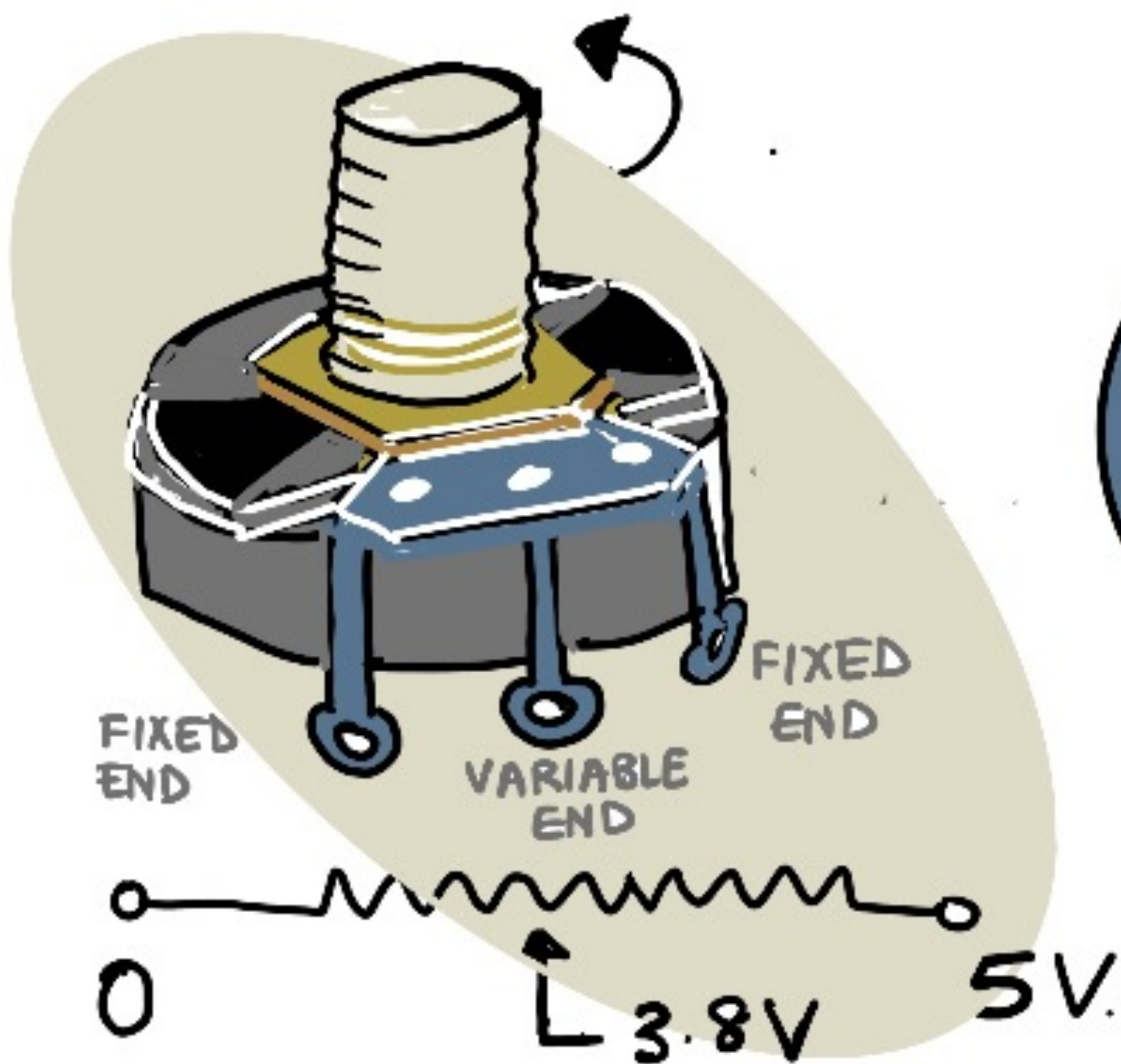
THE IOT DEVICE CAN
'READ' THE VOLTAGE
COMING OUT OF THE
SENSOR AND REACT TO
ITS VALUE OR CHANGE

VALUE
IS DRIPPING
... TIME TO
ACT ON IT!



POTENTIOMETER

IS ONE EXAMPLE OF AN
ANALOG SENSOR DEVICE



ROTATE THE
DIAL BETWEEN
TWO FIXED ENDS
(mapped to 0V, 5V)

SENSOR MEASURES
ROTATION BY SENDING
REDUCED VOLTAGE
(OR NUMERIC MAPPING)
CORRESPONDING TO SHIFT



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IT — AND HOW DOES IT WORK?



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ANALOG-TO-DIGITAL

IOT DEVICES
ARE DIGITAL!

ANALOG SENSORS
NEED TO 'DIGITIZE'
THEIR VALUES BEFORE
IOT DEVICE CAN USE THEM



GIVE ME 0'S
AND 1'S!!



WE HAVE
OPTIONS

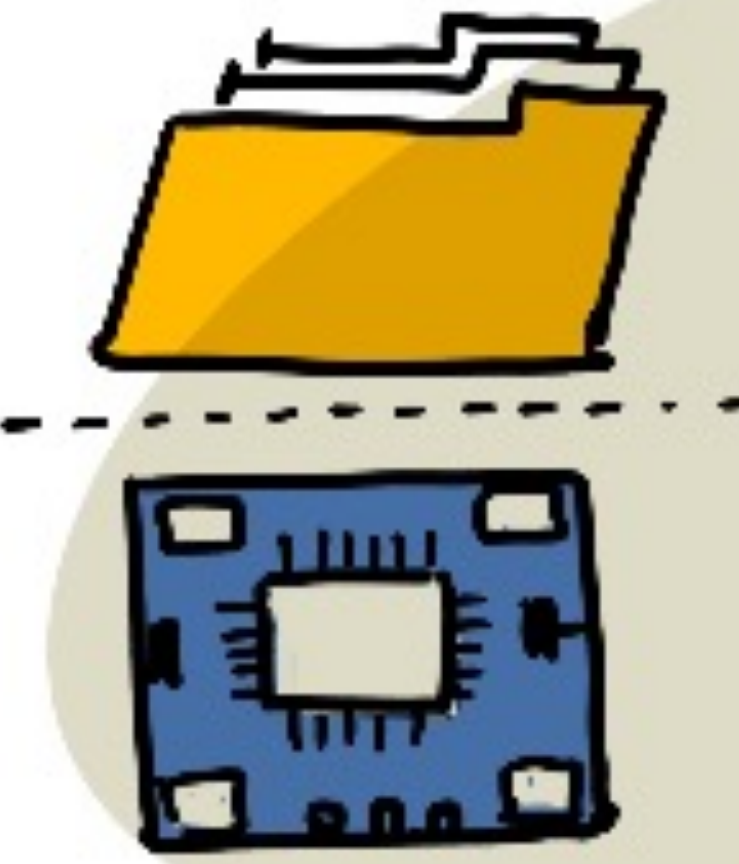
MANY IOT DEVICES
HAVE BUILT-IN ADC

AND

MANY SENSORS CAN
WORK WITH ADCs VIA
A CONNECTOR BOARD!



ADC
= ANALOG-TO-
DIGITAL
CONVERTER

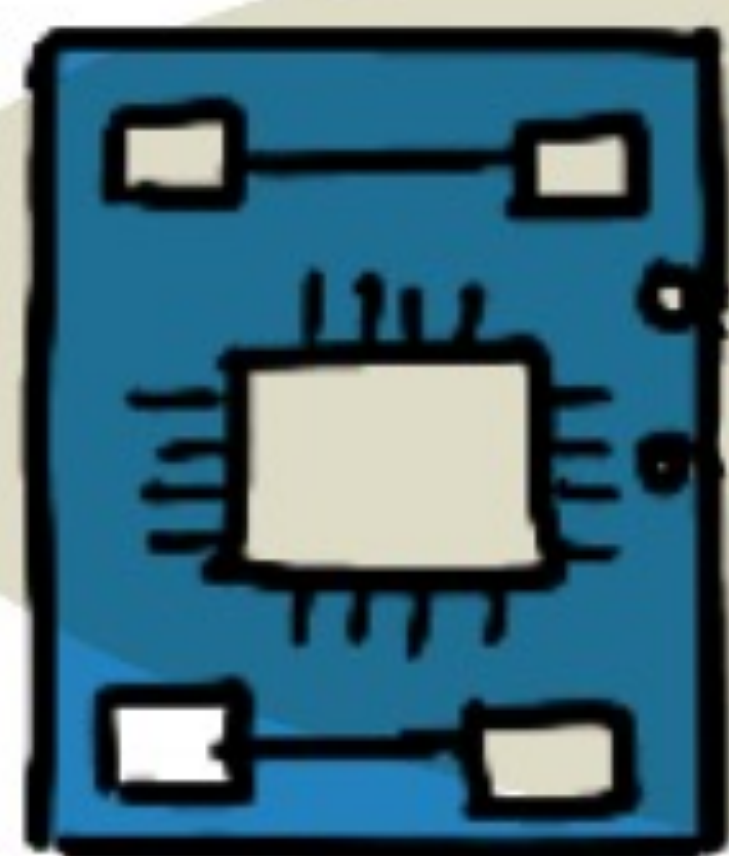


SOFTWARE
LIBRARIES FOR
SENSORS/DEVICES
HANDLE MUCH OF
THIS FOR YOU
TRANSPARENTLY

DIGITAL SENSORS

ALSO DETECT WORLD
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CHANGES BUT

THEY OUTPUT DIGITAL
SIGNALS (EITHER BY
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OR BY USING AN ADC)

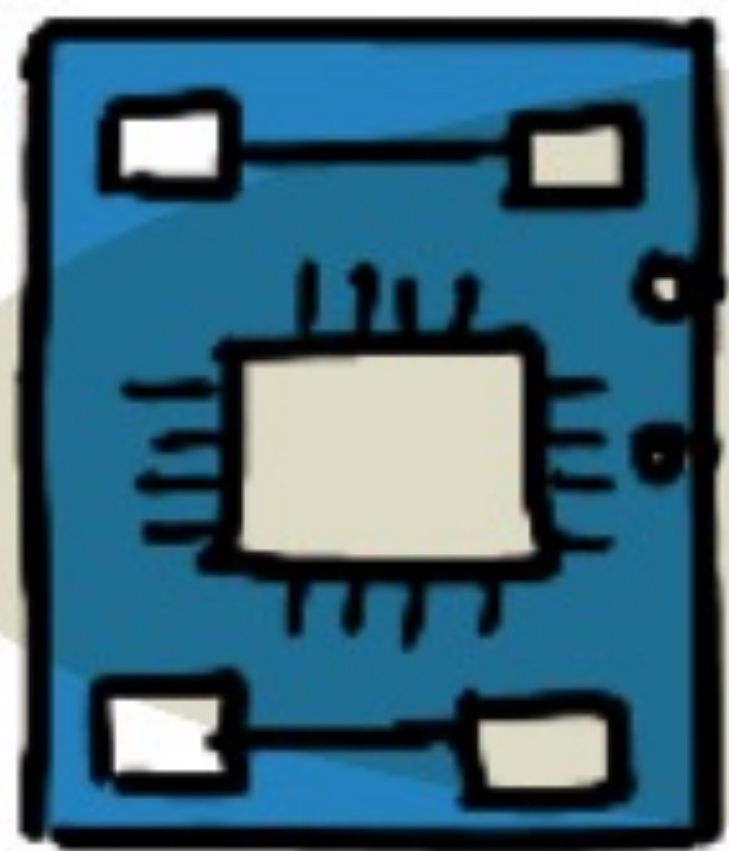


5V
→
←
0V

SWITCH



OFF



5V
→
←
5V



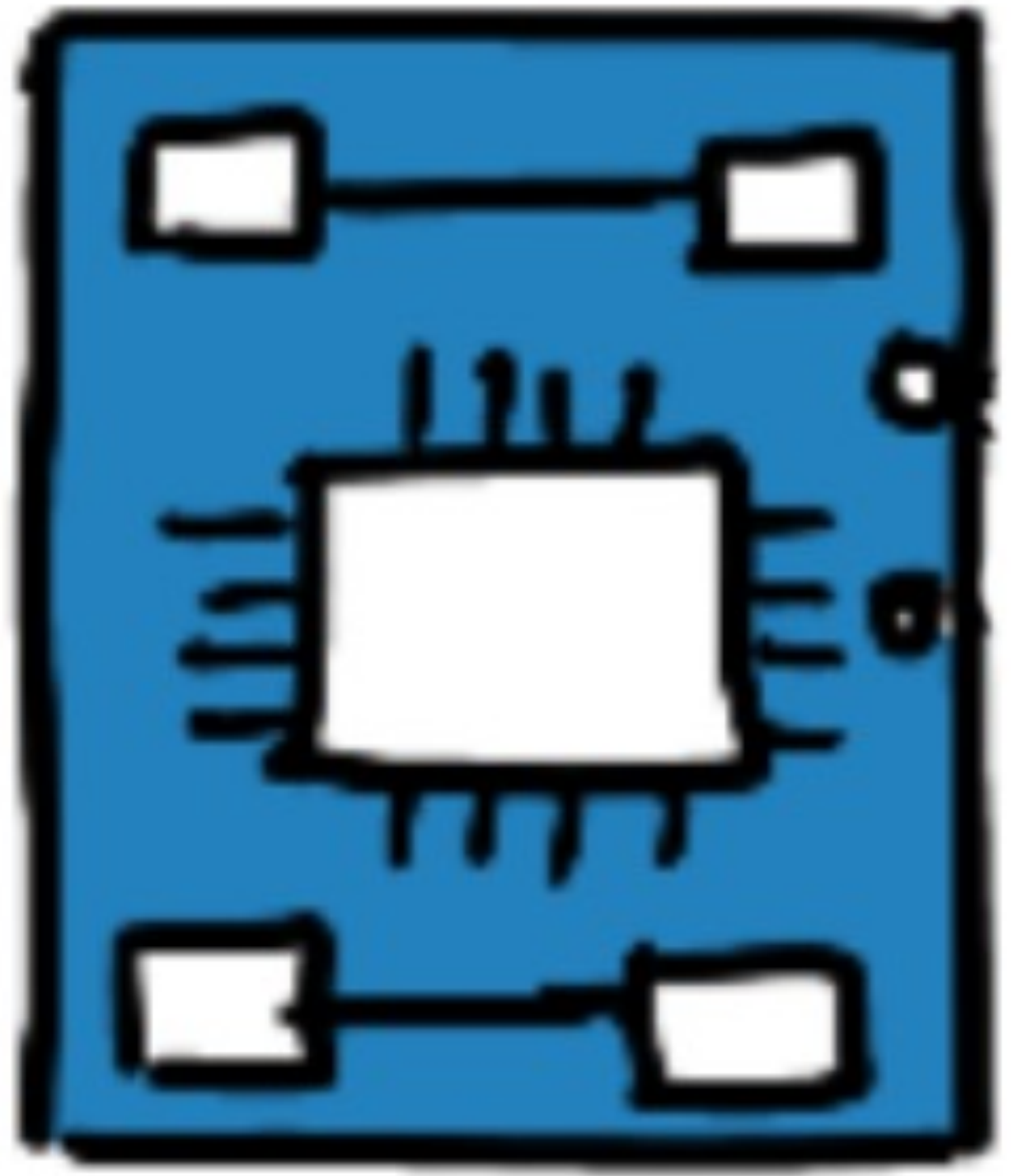
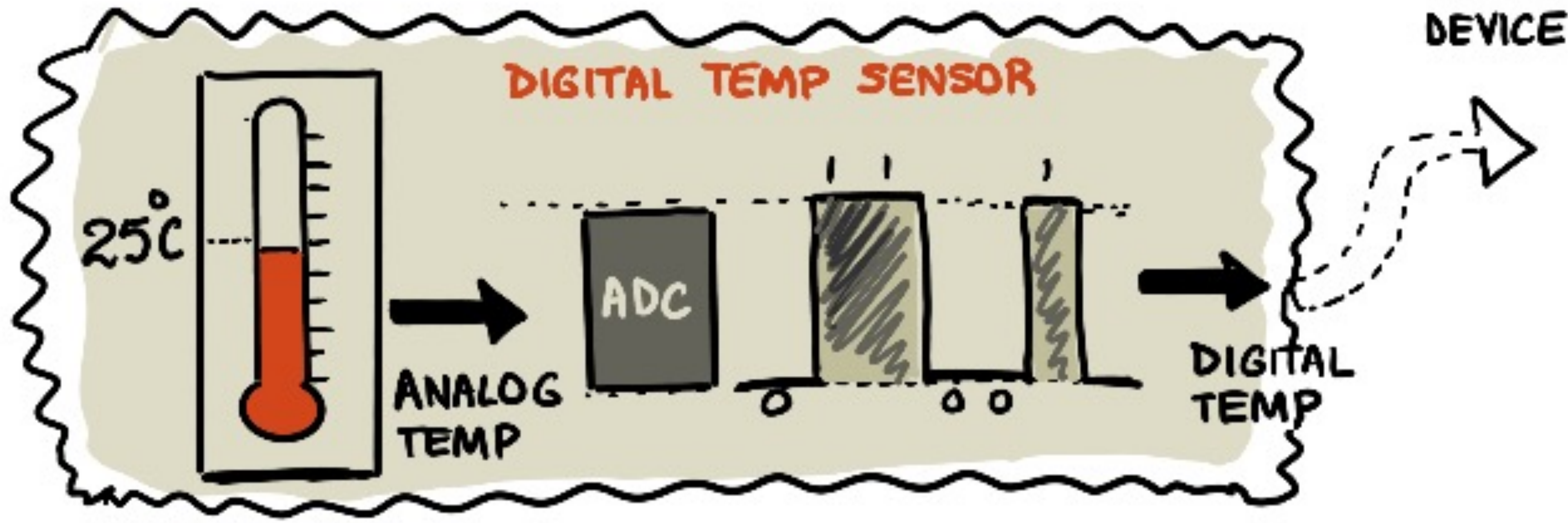
ON

SIMPLEST EXAMPLE
ON/OFF SWITCH

ADVANCED DIGITAL SENSORS

- READ ANALOG SIGNALS
- CONVERT USING ON-BOARD ADC
- OUTPUT PURELY DIGITAL SIGNALS

DIGITAL INPUTS
ARE MORE RELIABLE
TO READ IN.

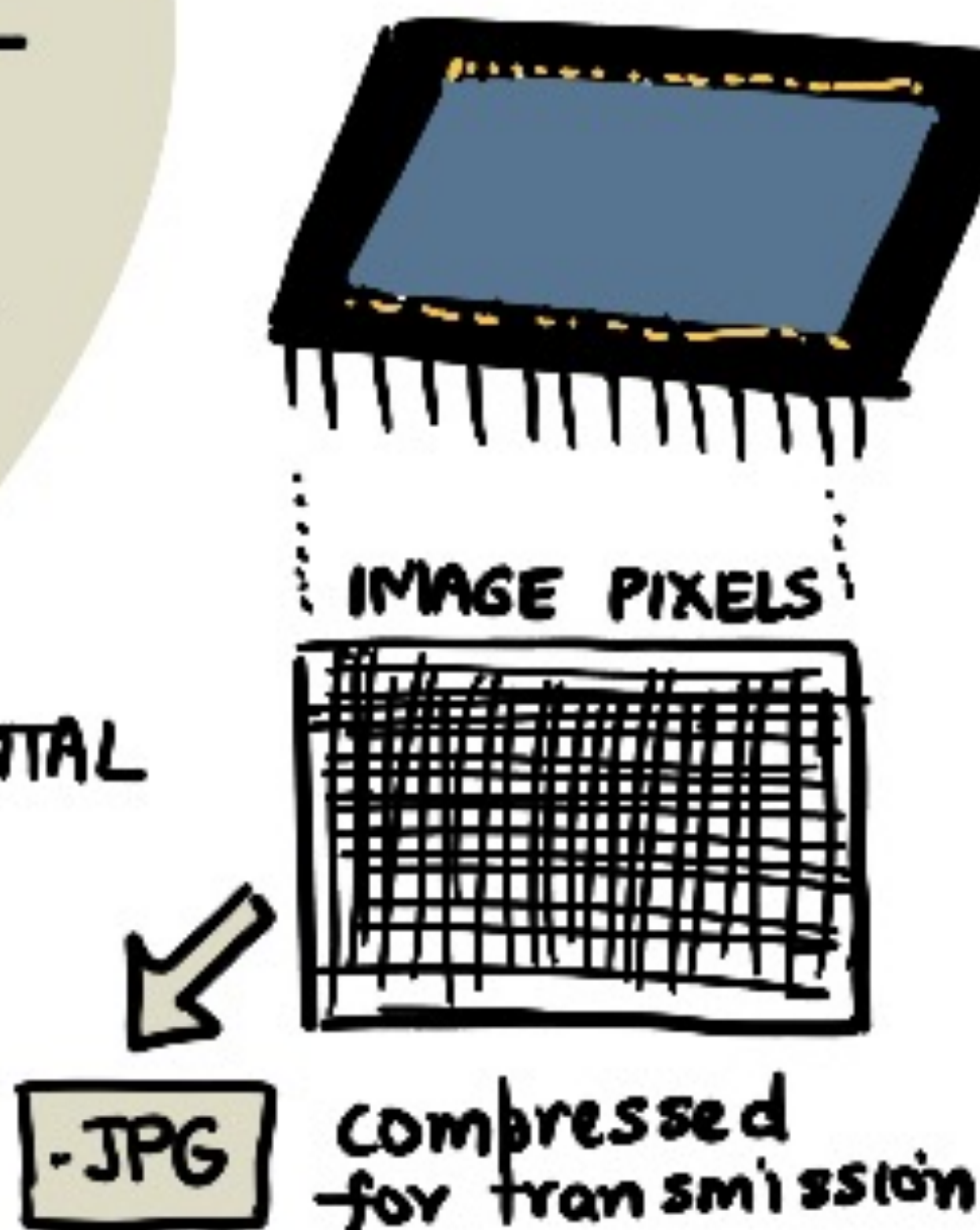


ADVANCED DIGITAL SENSORS

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EXAMPLE : CAMERA AS DIGITAL SENSOR

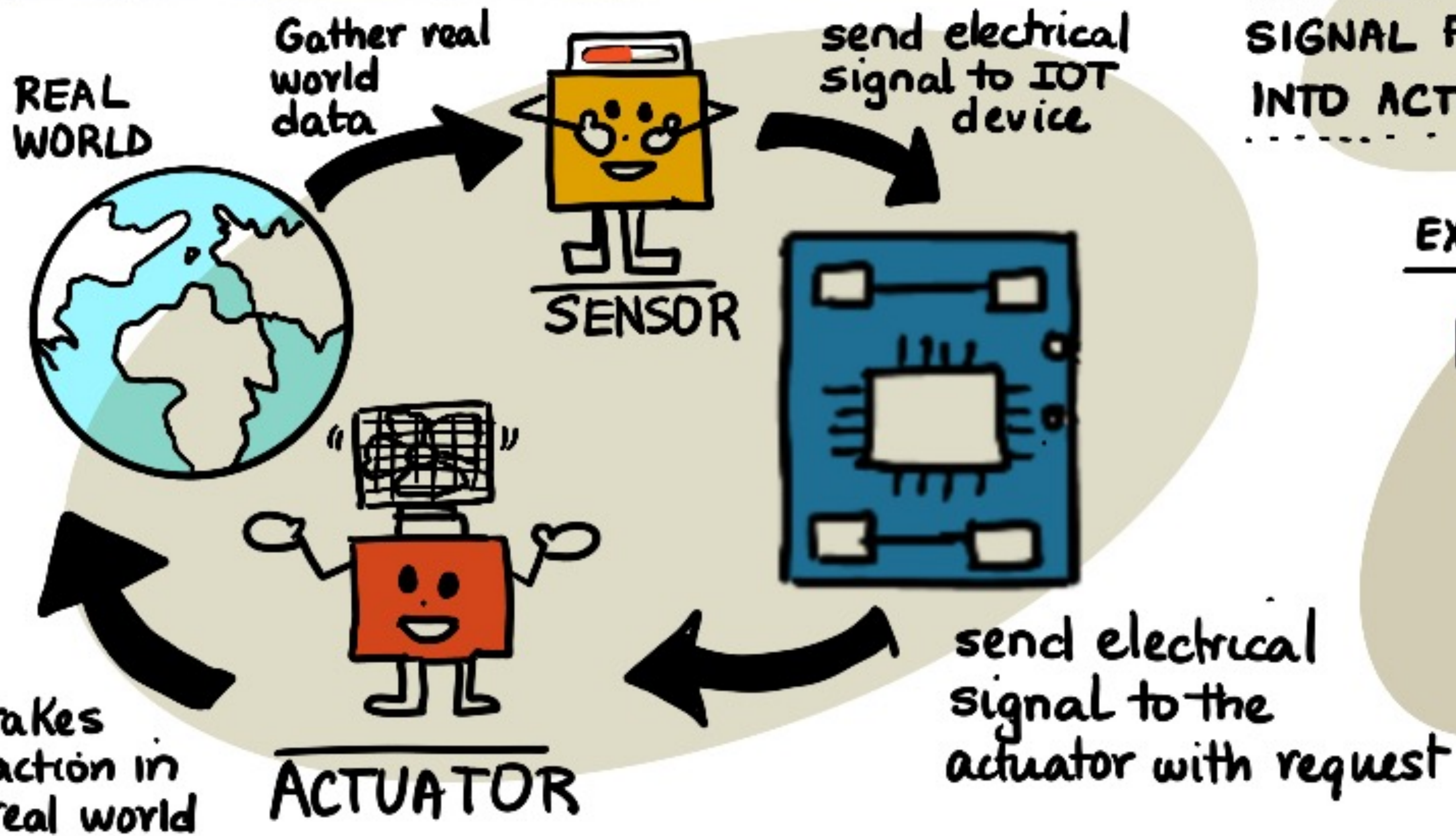


DIGITAL CAMERAS USE SENSORS LIKE THIS TO CAPTURE LIGHT FROM THE LENS AS PIXELS IN A FRAME/IMAGE

WHAT ARE ACTUATORS?



OPPOSITE OF SENSORS
.....
CONVERT ELECTRICAL
SIGNAL FROM IOT DEVICE
INTO ACTION IN REAL WORLD
.....

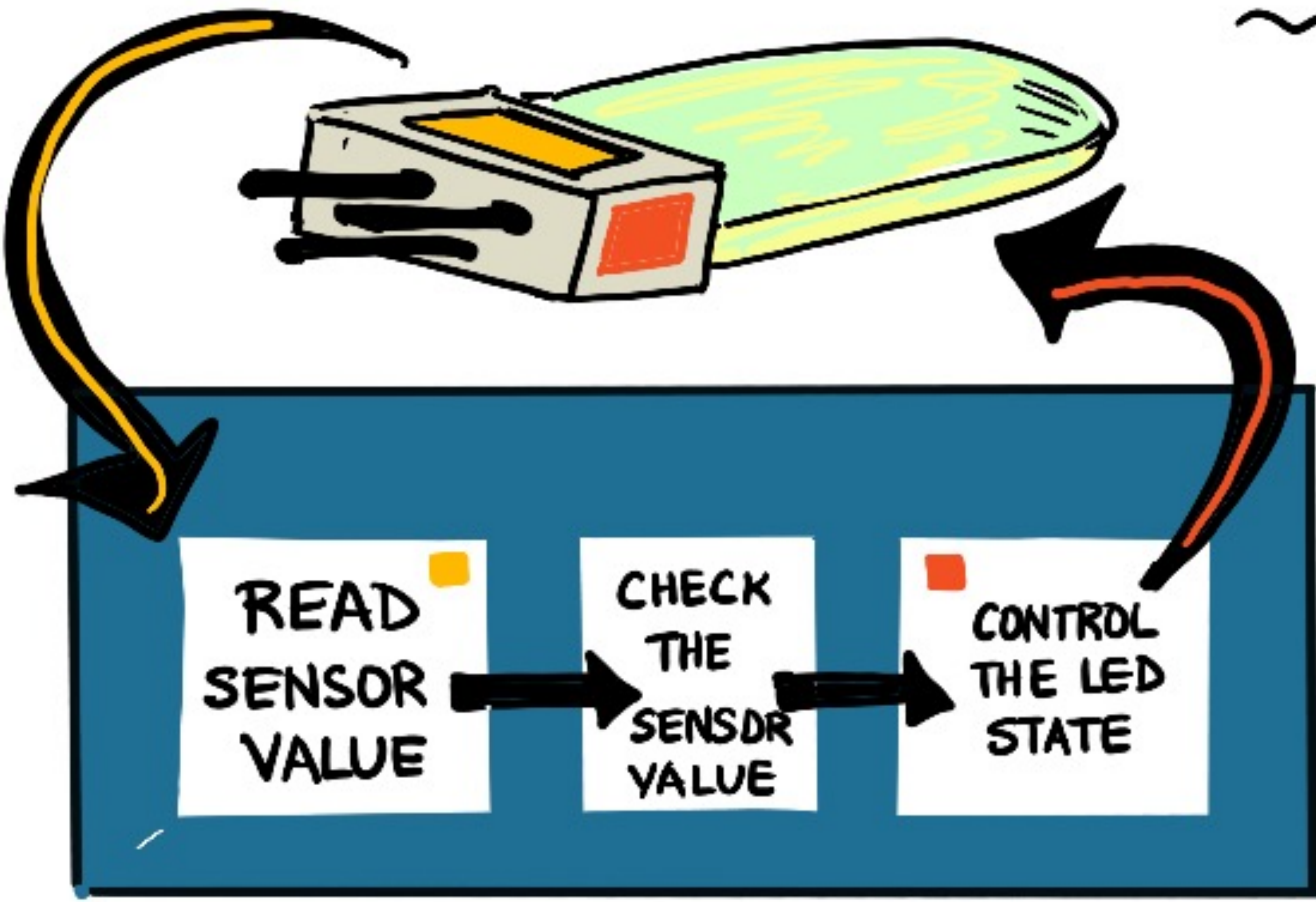


EXAMPLES




- LED
- SPEAKER
- RELAY
- SCREENS
- STEPPER MOTORS

USE AN ACTUATOR

PICK YOUR HARDWARE PATH
ADD AN ACTUATOR (USE GUIDE)



BUILD A NIGHTLIGHT

-  ARDUINO - W/D TERMINAL
-  SINGLE BOARD COMPUTER - RASPBERRY PI
-  SINGLE BOARD COMPUTER - VIRTUAL DEVICE

ACTUATOR TYPES

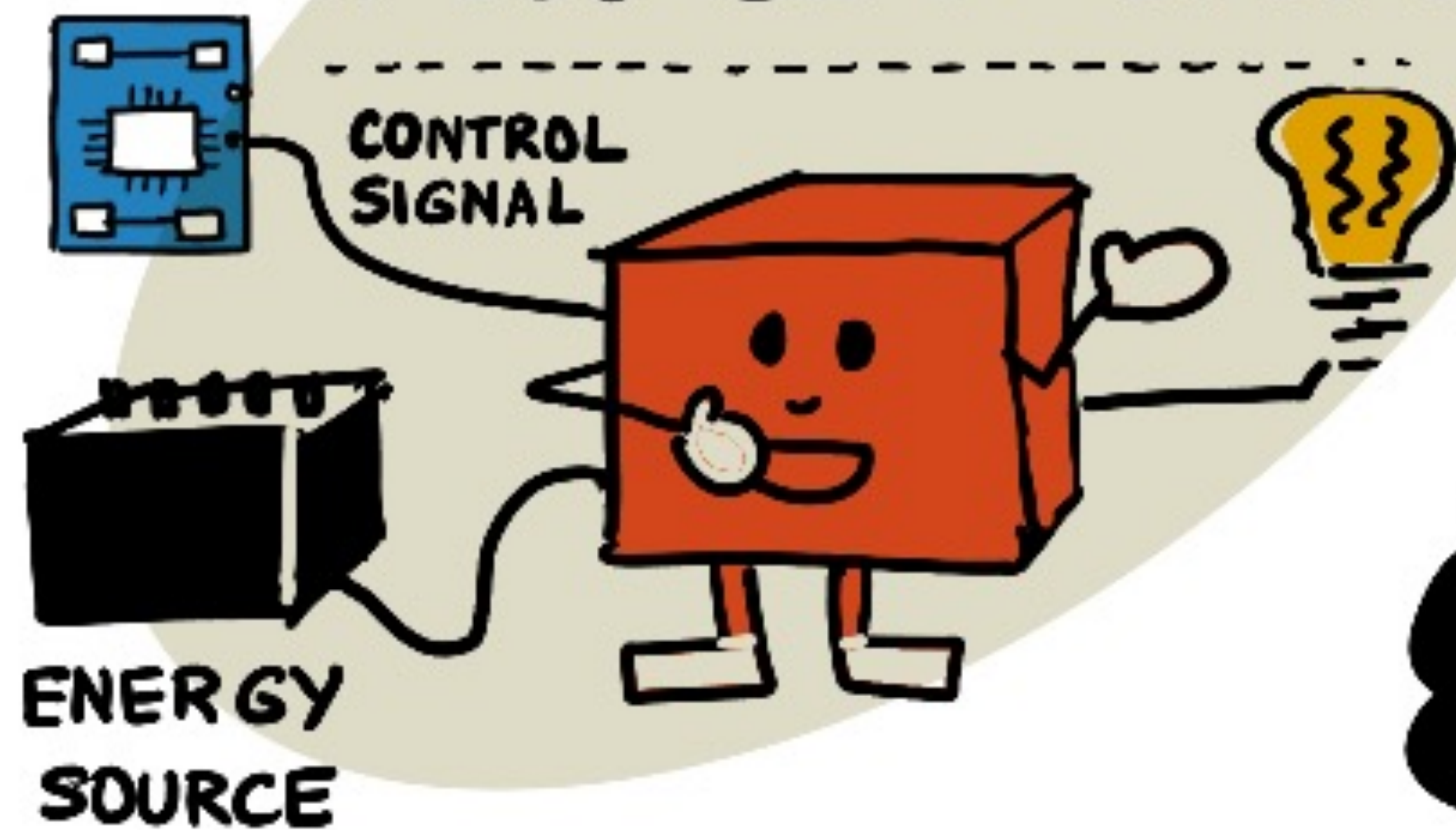
JUST LIKE SENSORS,
THERE ARE **2** TYPES
OF ACTUATORS

ANALOG & DIGITAL

BASED ON SIGNAL, THEY
CONVERT ENERGY INTO SOME
MOTION OR INTERACTION

EXAMPLE: CONTROL SIGNAL TRIGGERS
ROTARY SWITCH TO MOVE, TURNS LIGHT
ON IN ROOM

ACTUATORS HAVE A
CONTROL SIGNAL AND
A SOURCE OF ENERGY





DO YOUR
RESEARCH

ACTUATORS CAN BE CATEGORIZED
BY THE FUNCTION THEY SERVE
AND HOW THEY CONVERT ENERGY

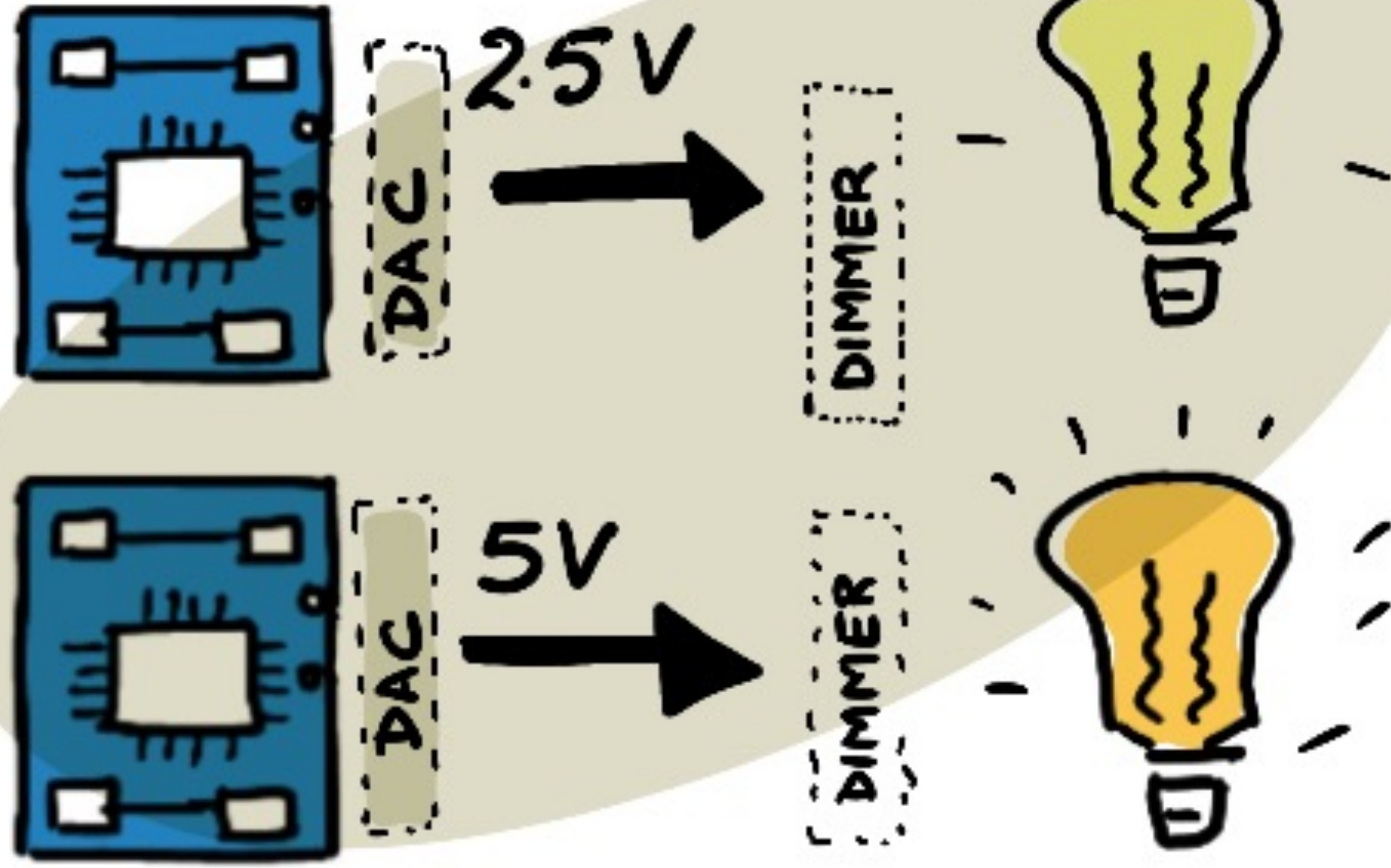
Learn
About

- PNEUMATIC
- HYDRAULIC
- ELECTRIC
- THERMAL
- MAGNETIC

How do these
actuators effect
change?

ANALOG ACTUATORS

Ex: DIMMABLE LIGHTS

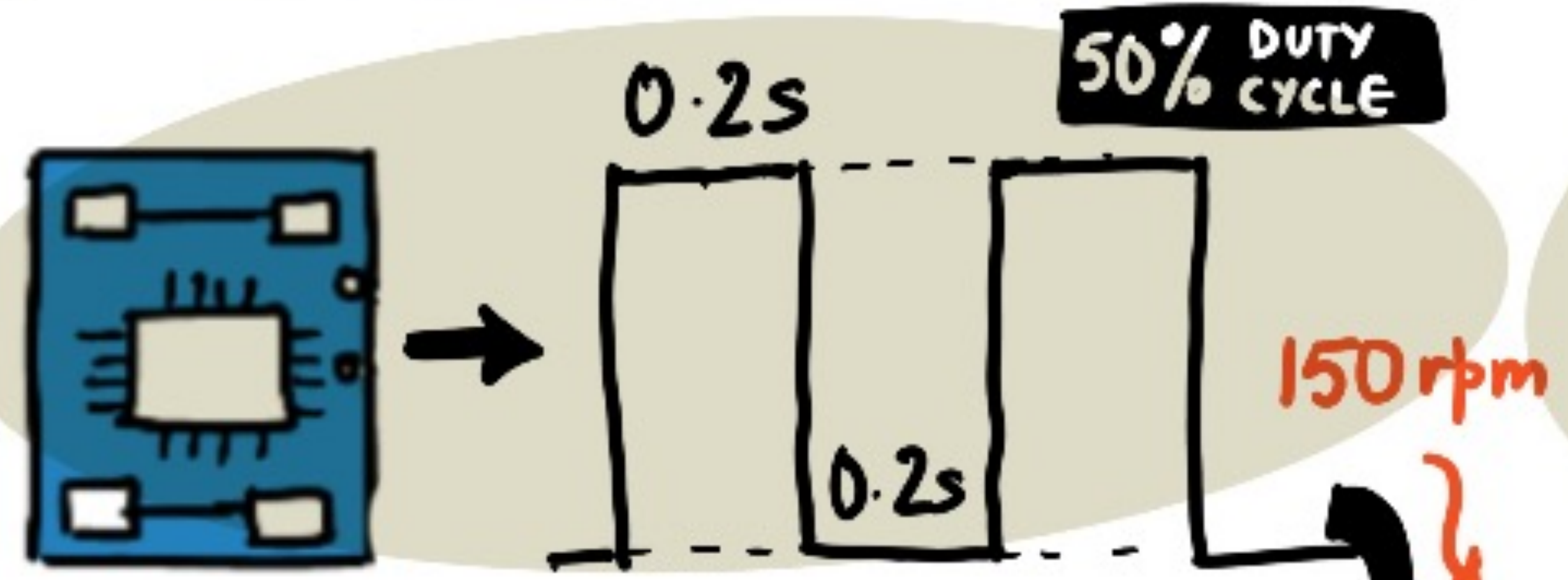


ANALOG ACTUATOR
CONVERTS ANALOG
SIGNAL INTO SOME
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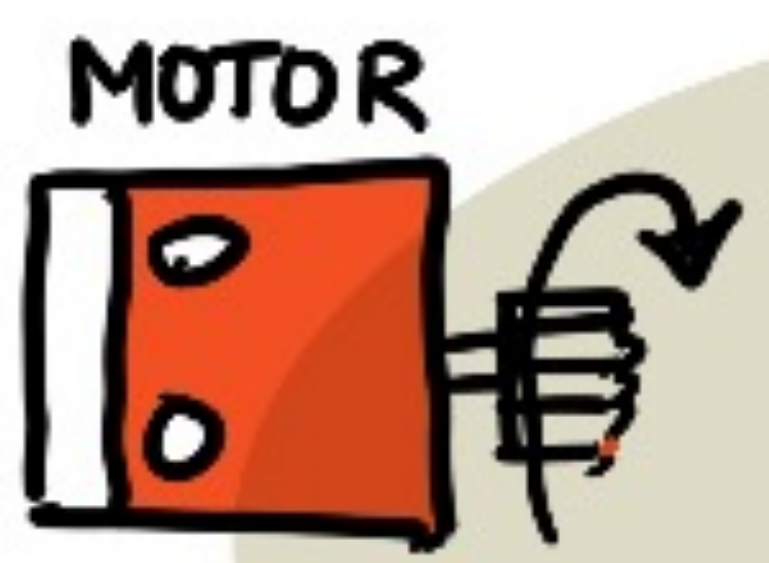
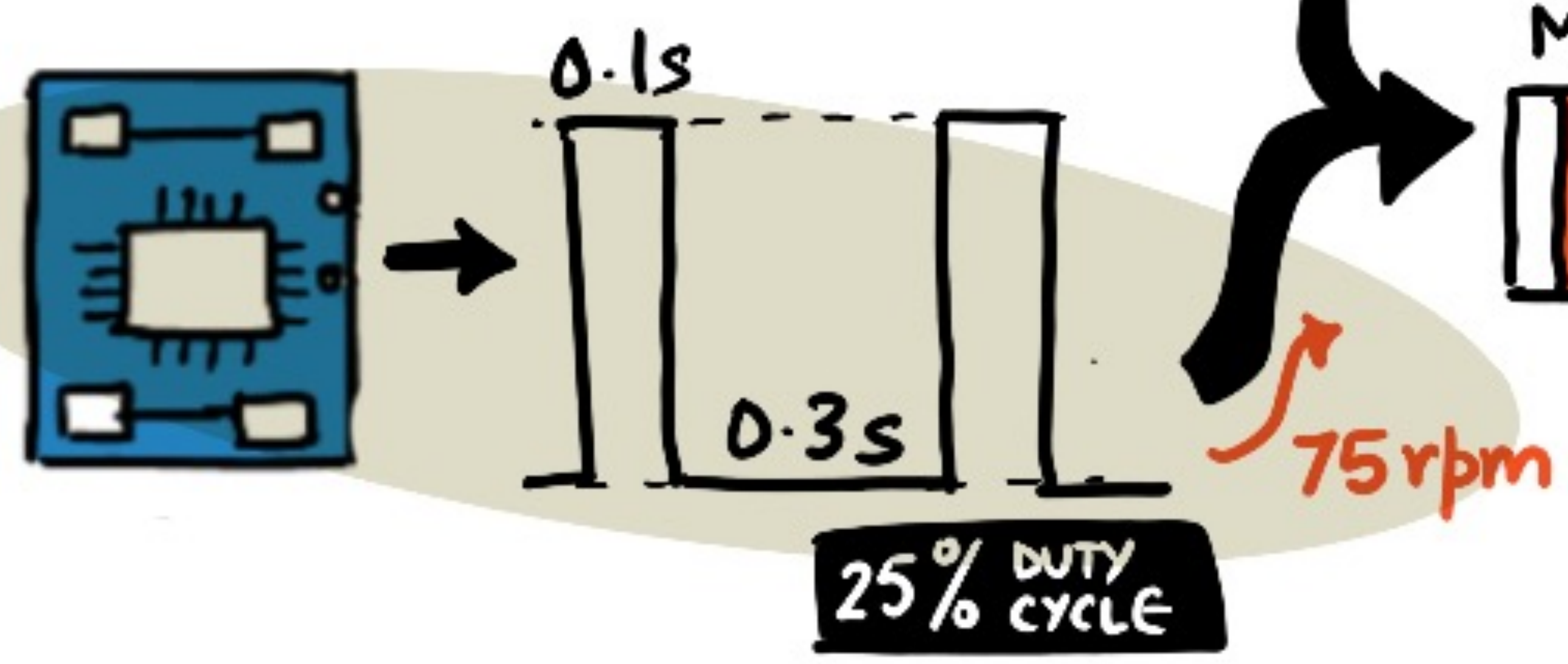
DAC = DIGITAL TO ANALOG
CONVERTER
REQUIRED TO CONVERT IOT
DEVICE, DIGITAL OUTPUT (0,1)
TO ANALOG VOLTAGE (RANGE)

PULSE WIDTH MODULATION

= SWITCH DIGITAL SIGNAL FROM IOT DEVICE BETWEEN TWO STATES CREATING PULSES.



VARYING THE DUTY CYCLE (ON/OFF DURATION) MODULATES PULSE WIDTH - CREATING AN OUTPUT SIGNAL THAT ACTS ANALOG



Control a motor's speed with a 5V digital supply
Pulse modulation varies avg rpm based on duty cycle



DO YOUR
RESEARCH

THE DUTY CYCLE
OF MODULATED
PULSE

CONTROL
SIGNAL



INFLUENCES
THE SPEED OF
ROTATION OF
MOTOR

ACTUATOR
MOTION

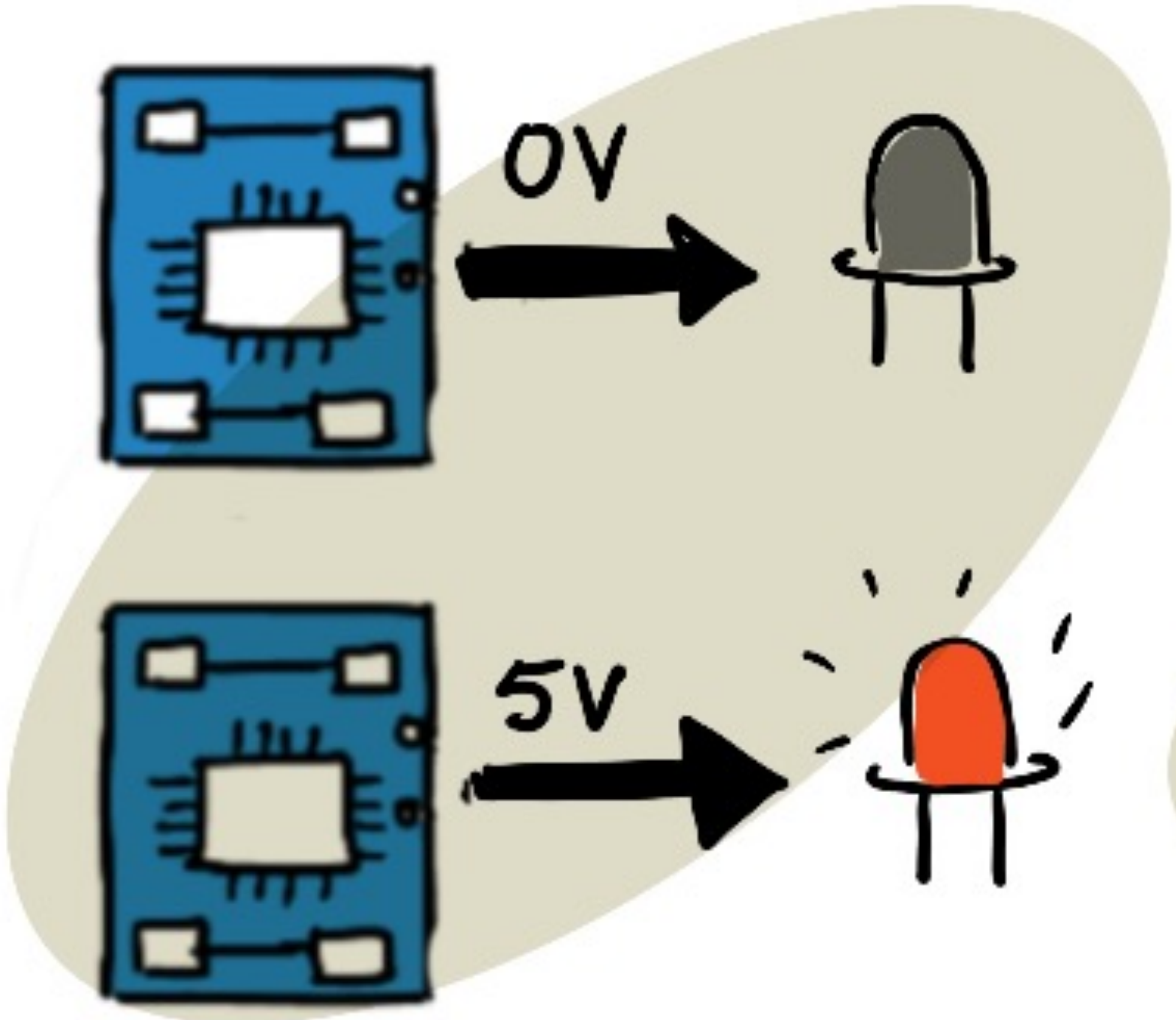
HOW WOULD YOU KEEP
MOTOR ROTATION SMOOTH?

DIGITAL ACTUATORS

① HAVE 2 STATES (CONTROLLED BY HIGH AND LOW VOLTAGE) LIKE DIGITAL SENSORS

OR

② HAVE BUILT-IN DAC THAT CONVERTS DIGITAL INPUT INTO ANALOG SIGNAL THEY CAN USE!

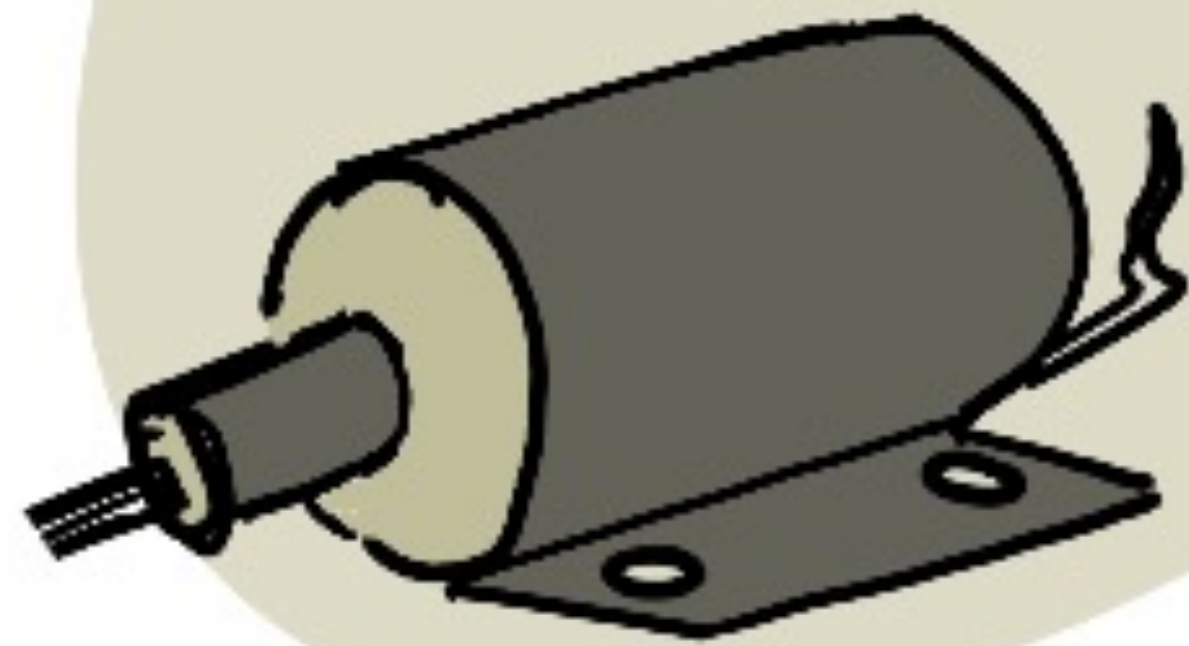


EXAMPLE
SIMPLE LED] 2 STATES (ON/OFF)
HIGH VOLTAGE = ON
LOW VOLTAGE = OFF

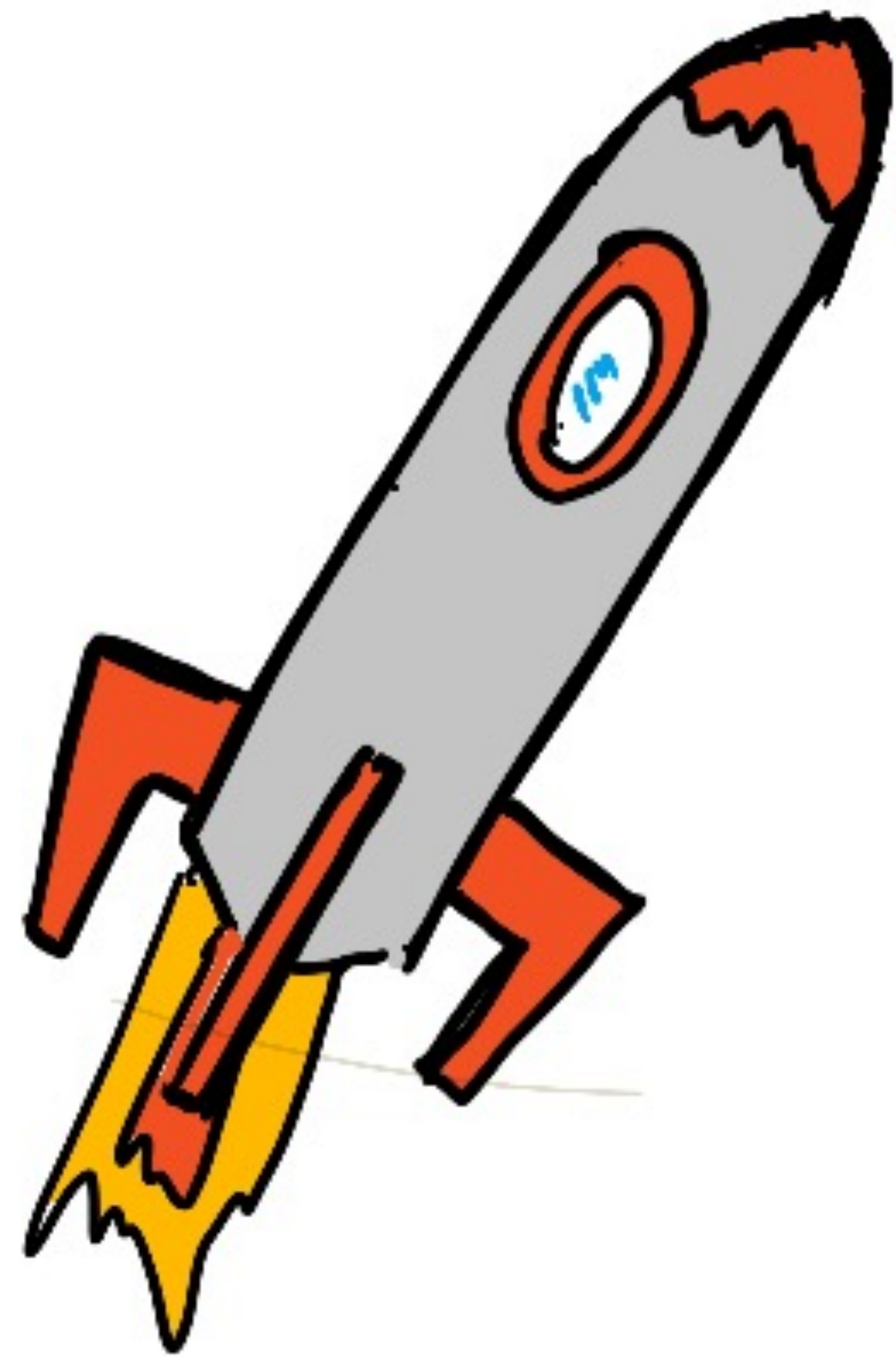


DO YOUR
RESEARCH

WHAT ARE SOME OTHER
EXAMPLES OF
2-STATE
ACTUATORS ?



HOW ABOUT A
SOLENOID?
.....
WHERE IS IT USED?



CHALLENGE

- LOOK AT YOUR PREVIOUS LISTS OF IOT DEVICES
- FOR EACH DEVICE - WHAT SENSORS / ACTUATORS ARE THEY CONNECTED TO?
- WHAT IS THEIR PURPOSE?

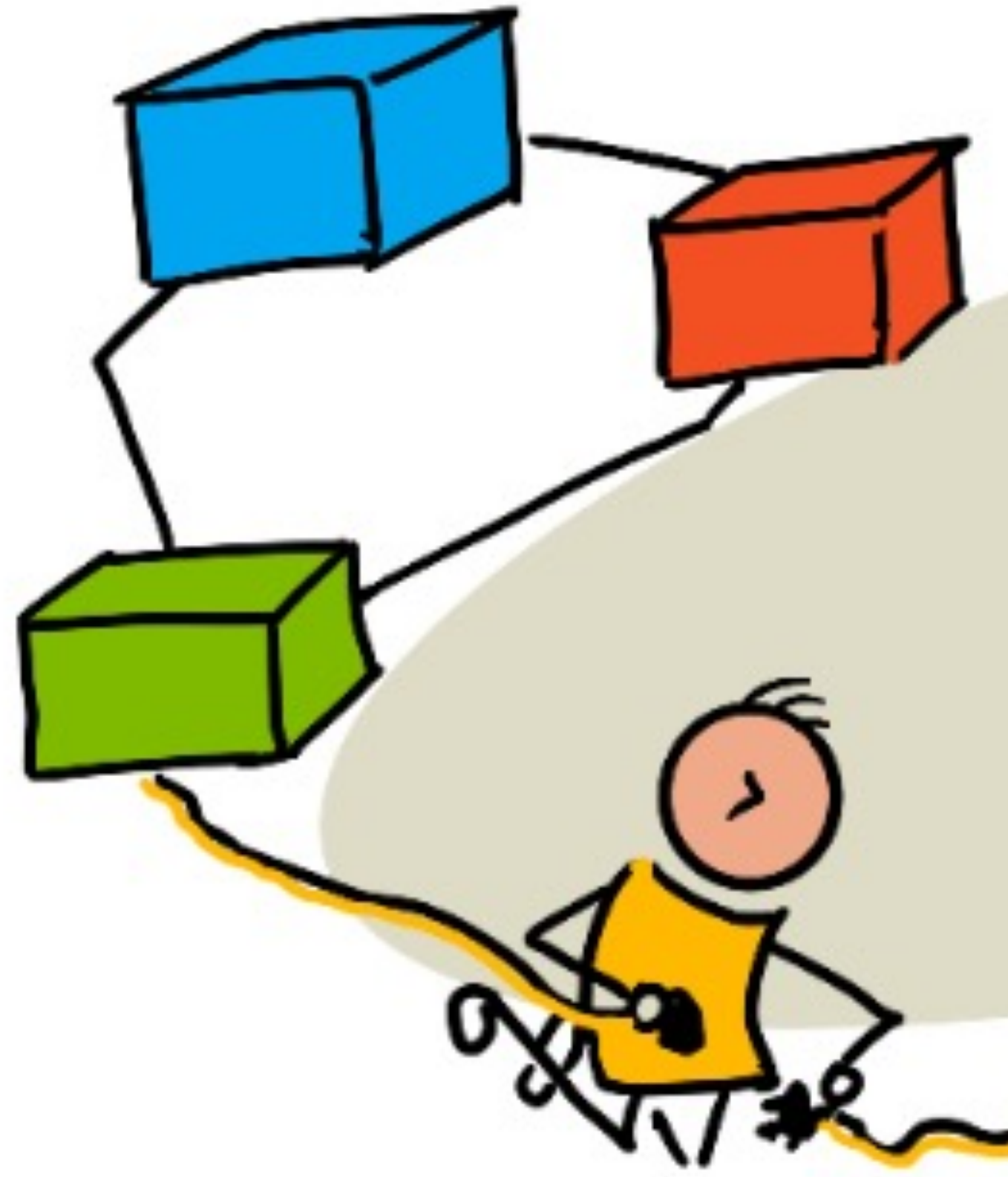
WHAT'S NEXT?

CONNECT

YOUR DEVICES
TO THE INTERNET



LEARN TO



- SEND & RECEIVE MESSAGES
- CONNECT LIGHT TO MQTT BROKER
- CONNECT DEVICE TO INTERNET



CREATED BY
@ SKETCHTHE DOCS