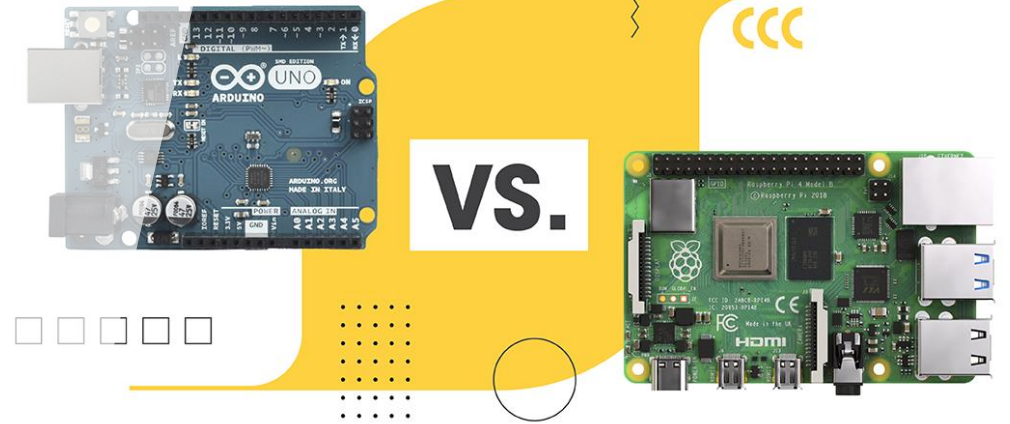




National Taiwan University
Biomechatronics Engineering



NTU X COA

認識微控制器

Yan-Fu Kuo | 19, June 2023



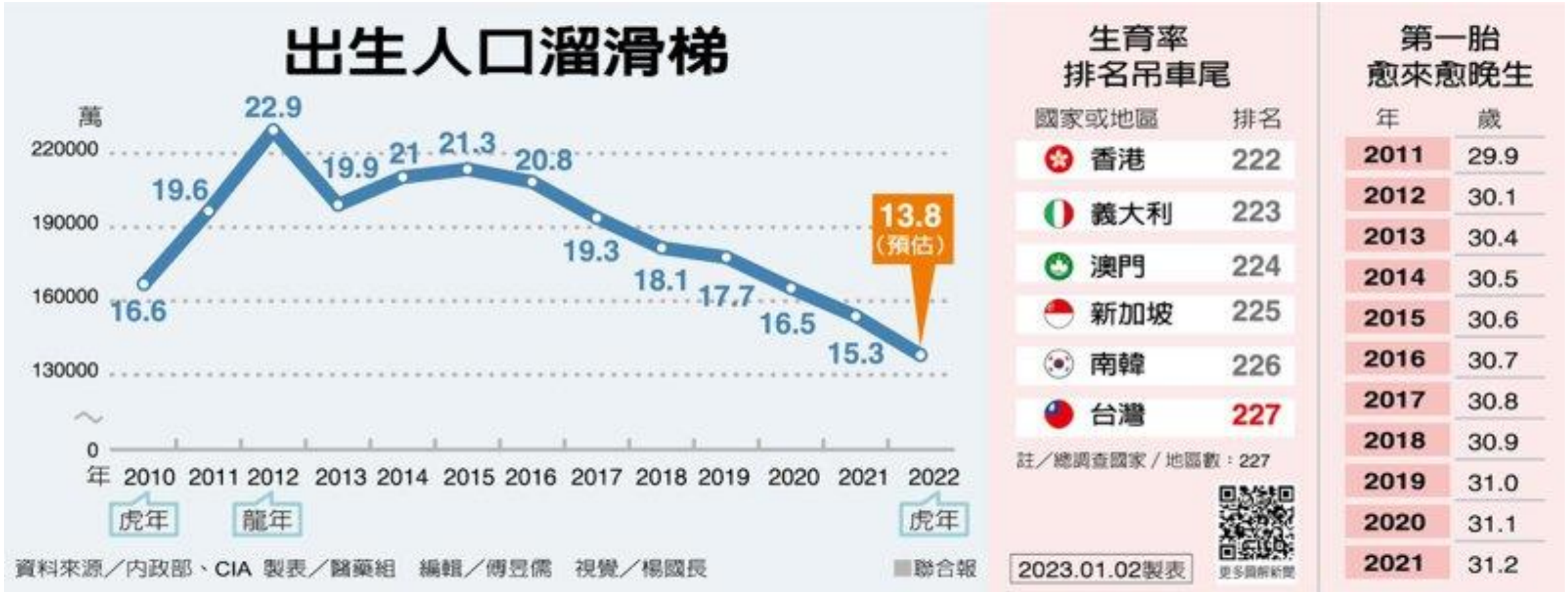
Food Security



Traditional Farming




Labor Shortage and Farmer Aging

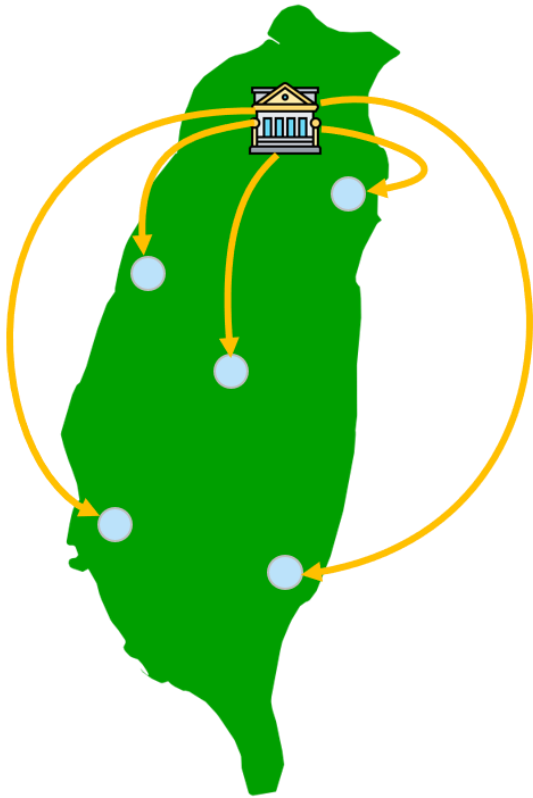


Source: 聯合報

Smart Agriculture

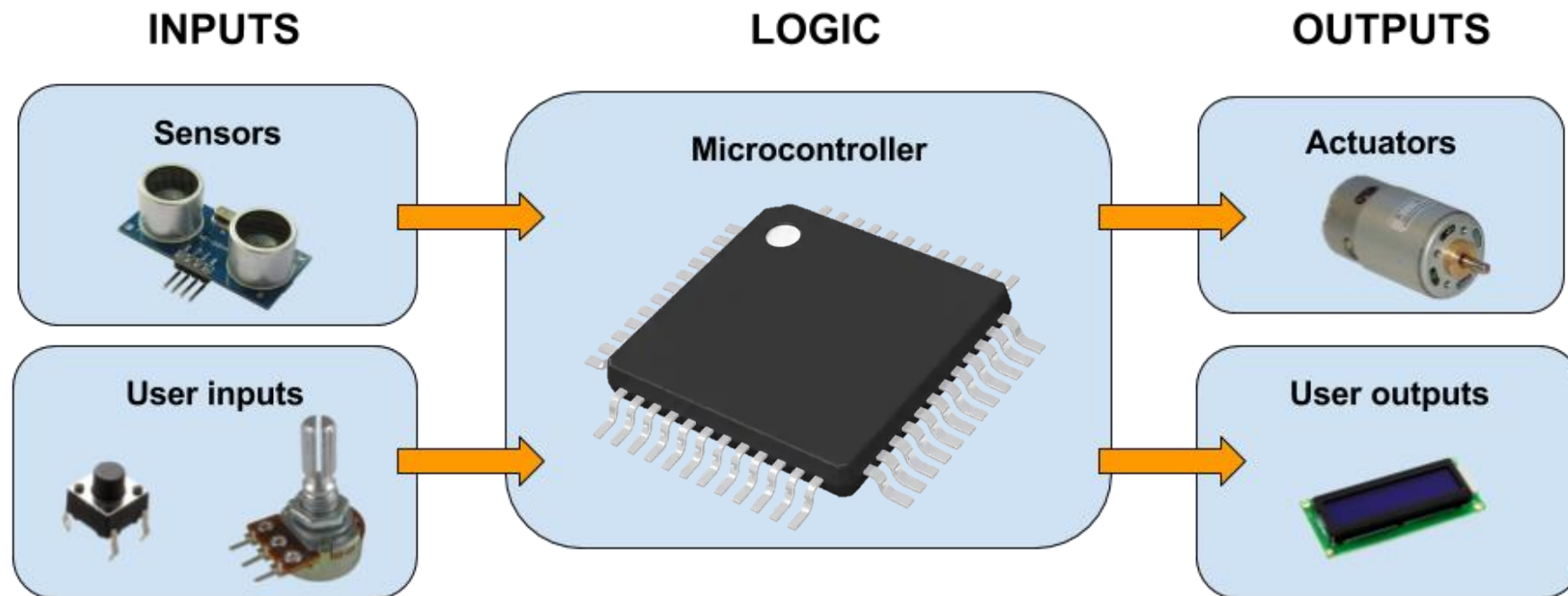
Information and communication technology, IoT, big data, smart machine

 COUNCIL OF AGRICULTURE
EXECUTIVE YUAN, R.O.C.



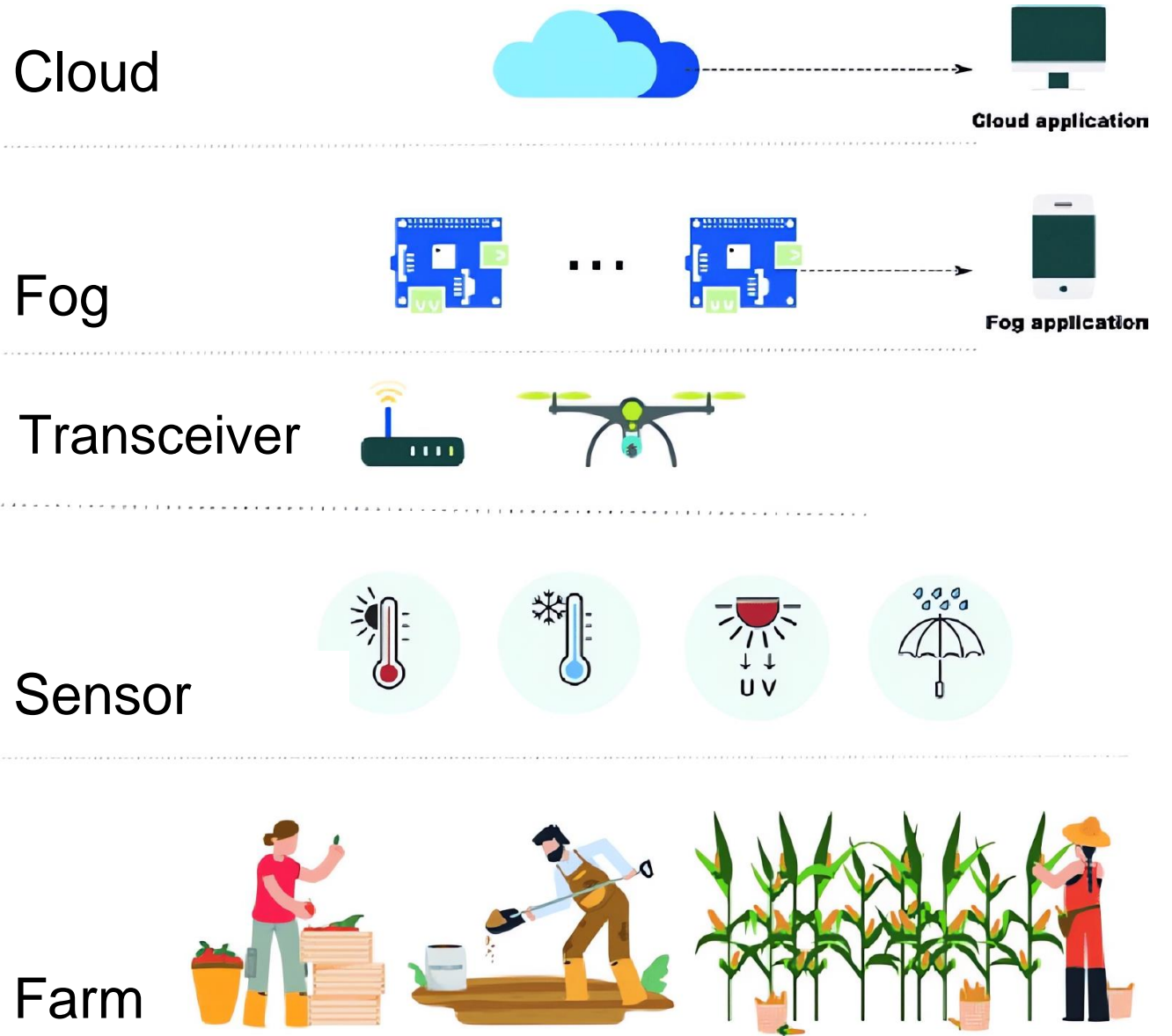
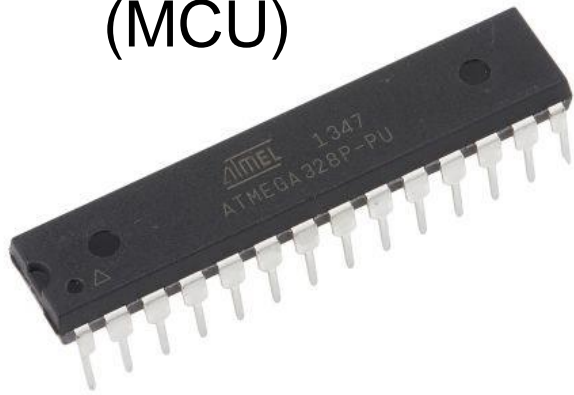
What is a Microcontroller (MCU)?

- Programmable small computer
- In the form of an integrated circuit (IC)



MCU in IoT of Smart Agriculture

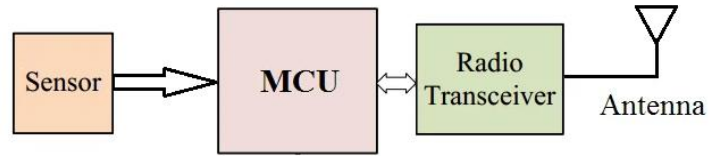
Microcontroller (MCU)



Source: https://link.springer.com/chapter/10.1007/978-3-030-41110-7_3



Microcontroller in IoT

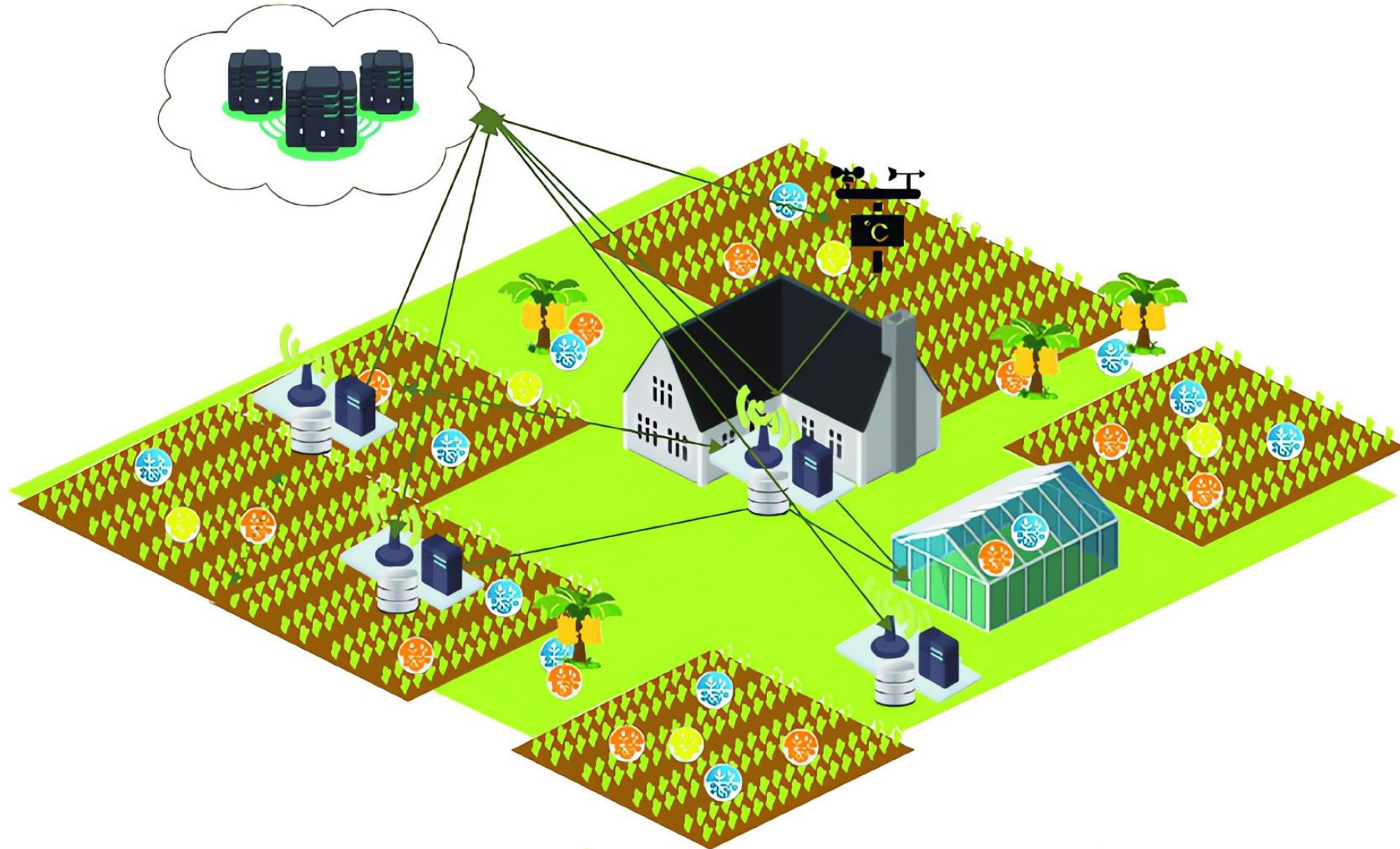


Source: <https://www.theengineeringprojects.com/2021/11/components-of-internet-of-things.html>

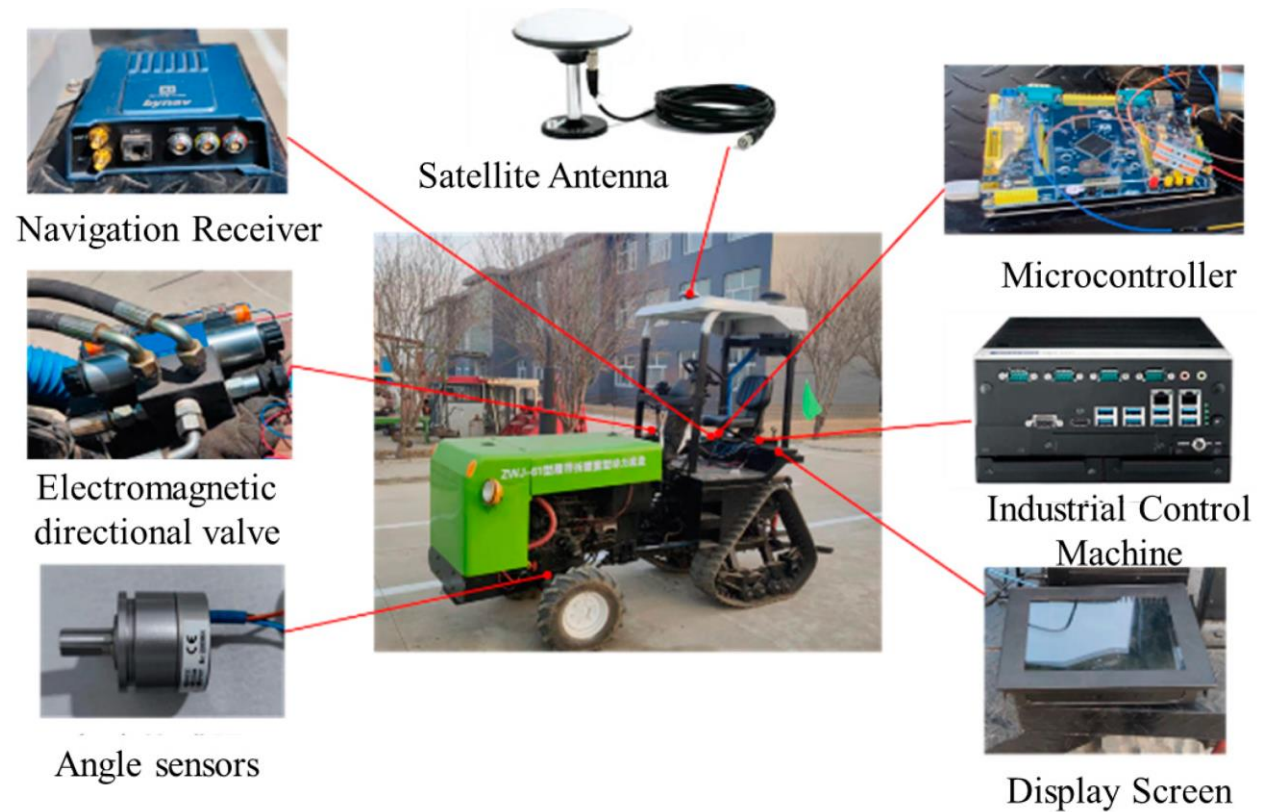
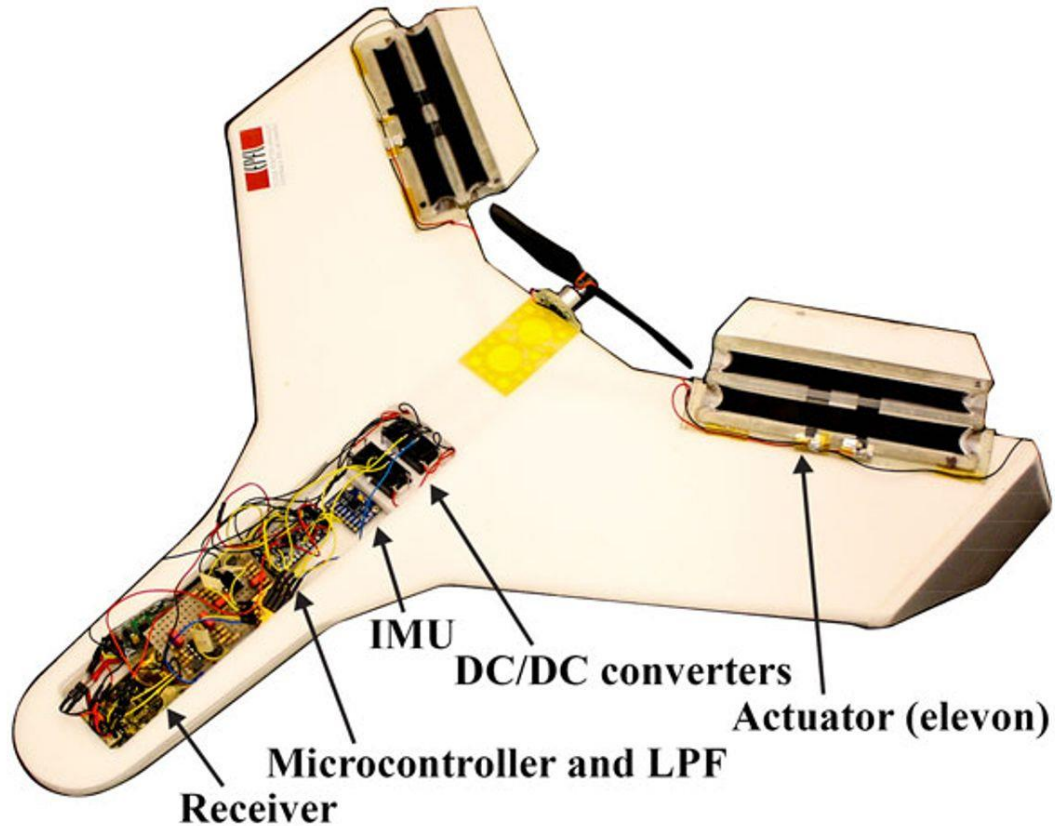
<https://www.allaboutcircuits.com/news/st-packs-power-connectivity-strengths-stm32-into-wireless-mcu-module/>



Smart Agriculture

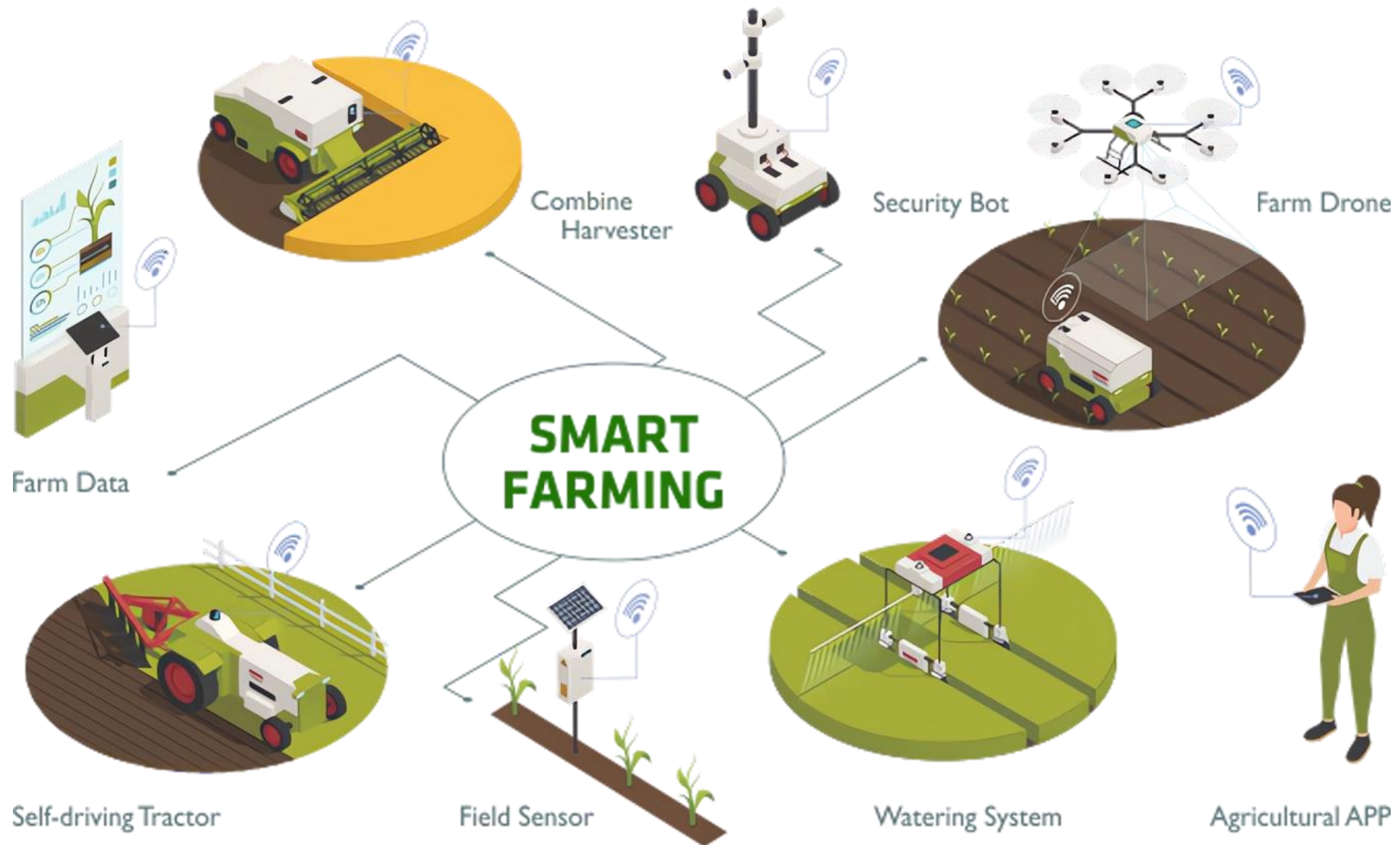


Microcontroller in Local Control



Source: <https://spectrum.ieee.org/uavs-flex-their-artificial-muscles>
<https://www.mdpi.com/2077-0472/13/4/871>

Future Agriculture



MCU Producers and Markets

6
key markets



Mobile
& Consumer



Automotive
& Mobility



Telecom &
Infrastructure



Medical



Defense
& Aerospace



Industrial

Integrators,
end-users and
software developers

DENSO
Crafting the Core



SONY



Panasonic



Canon



TOSHIBA
Leading Innovation >>>

Device
manufacturers



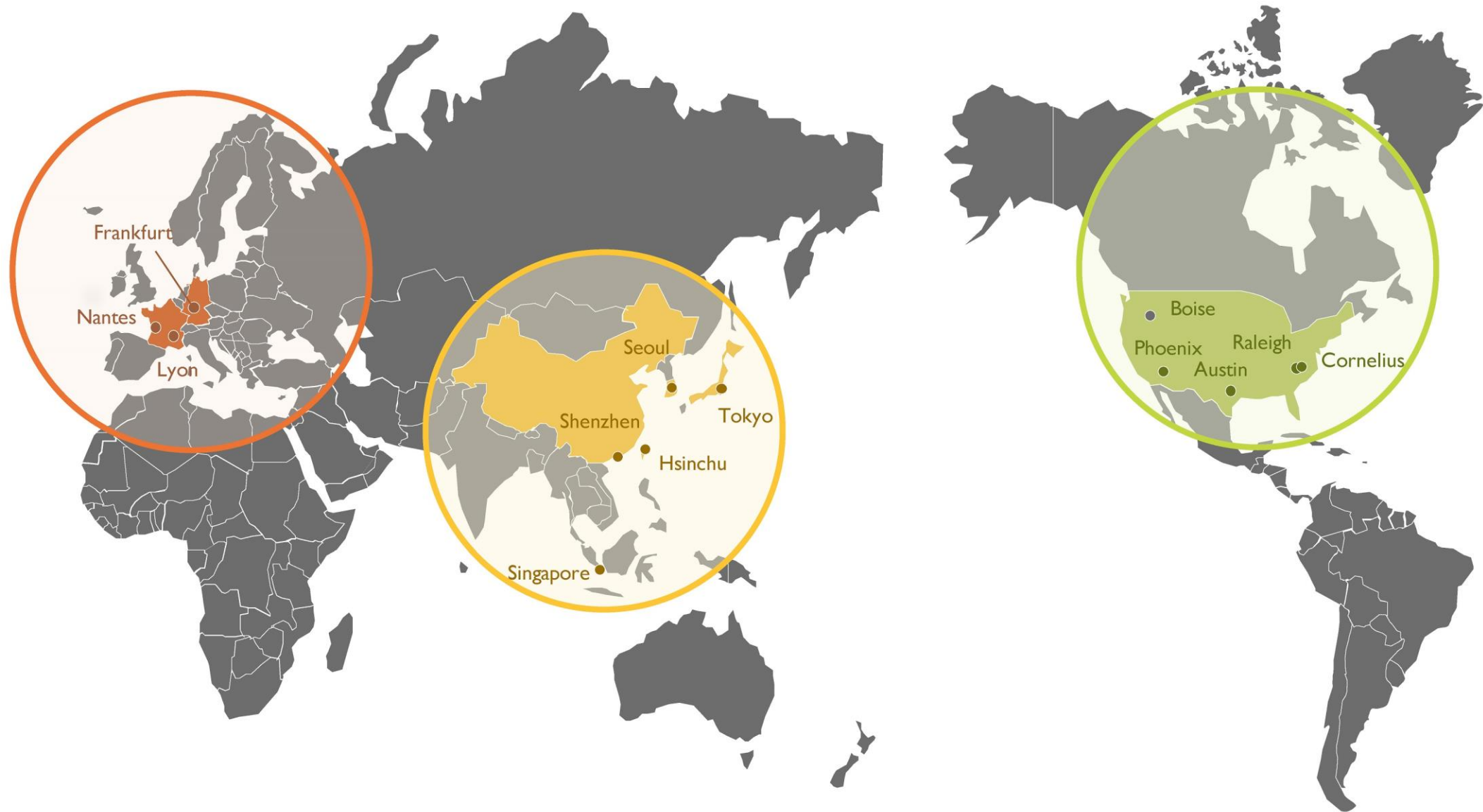
Suppliers: material,
equipment, OSAT, foundries...



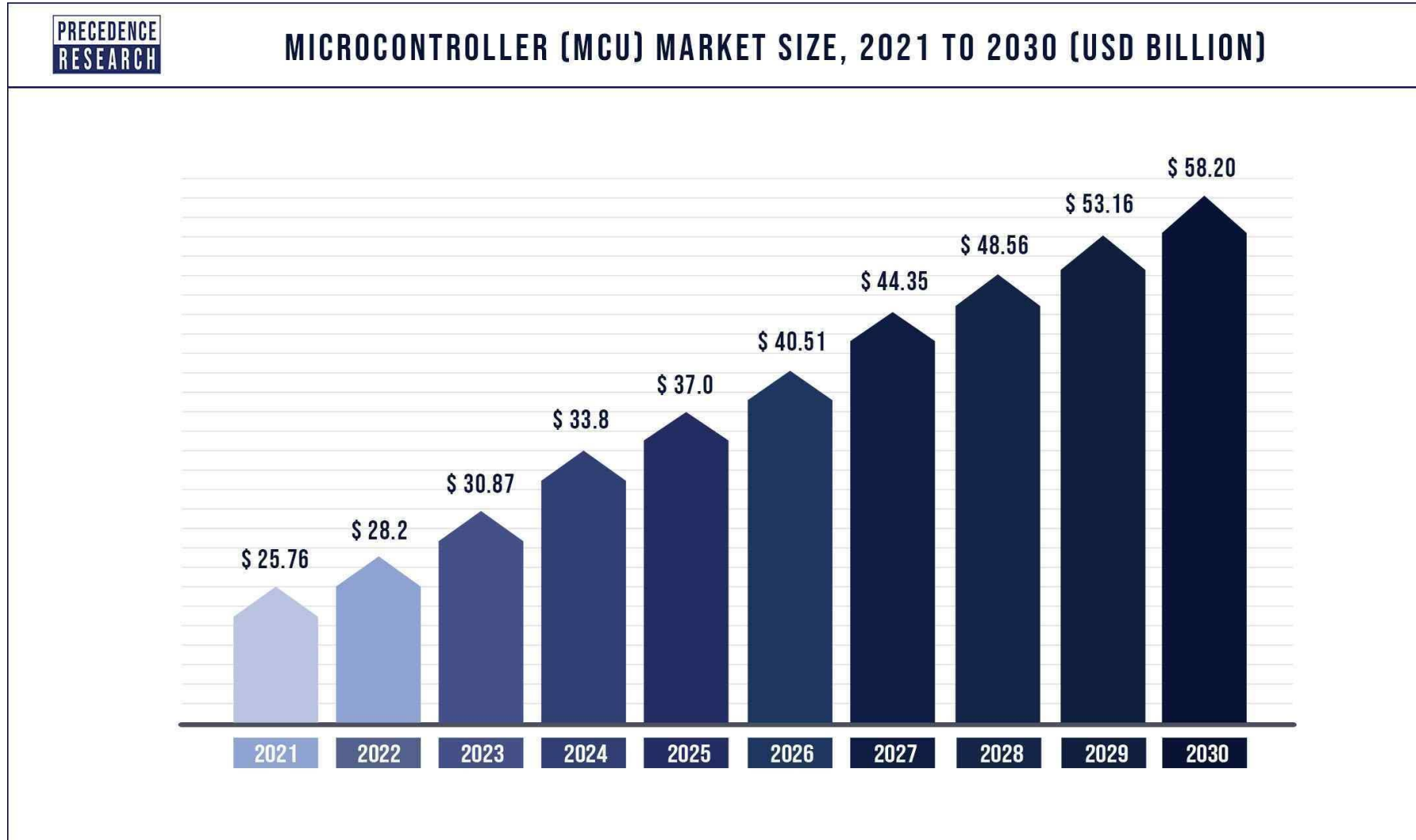
Financial investors, R&D centers



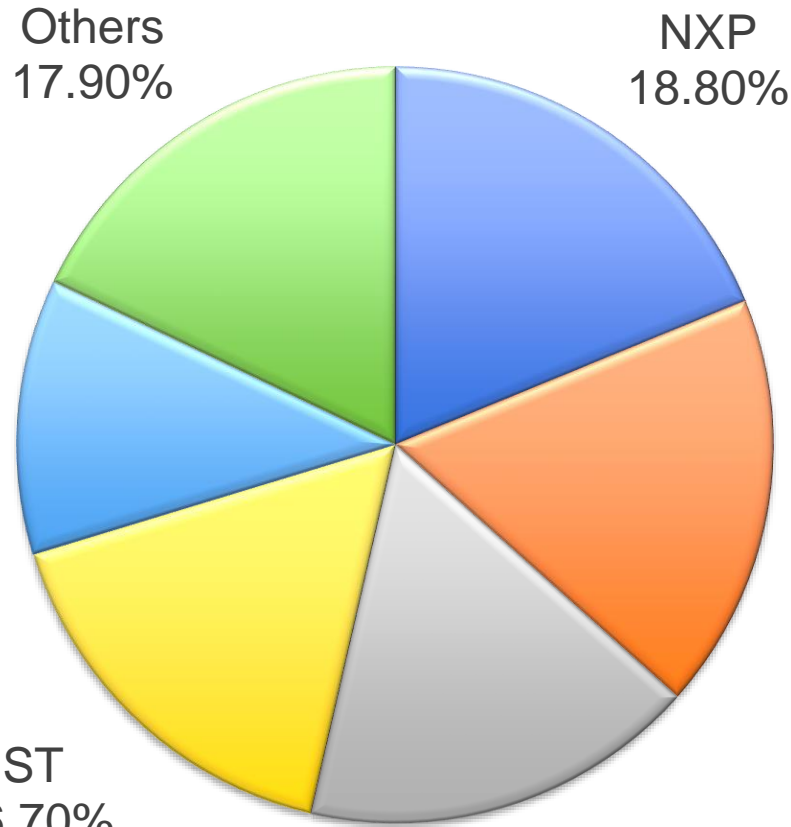
Global Participants of MCU Manufacture



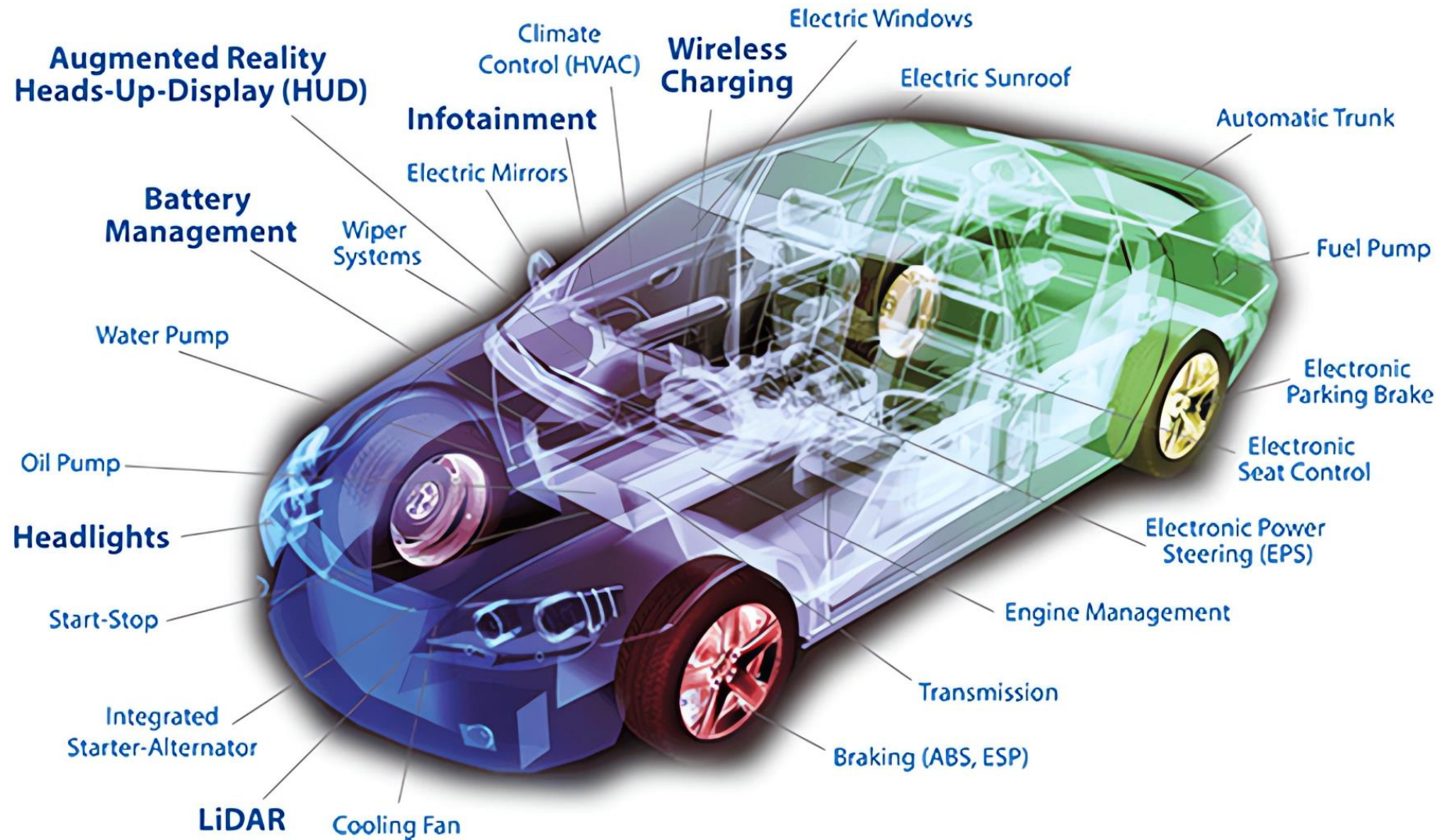
MCU Market Size



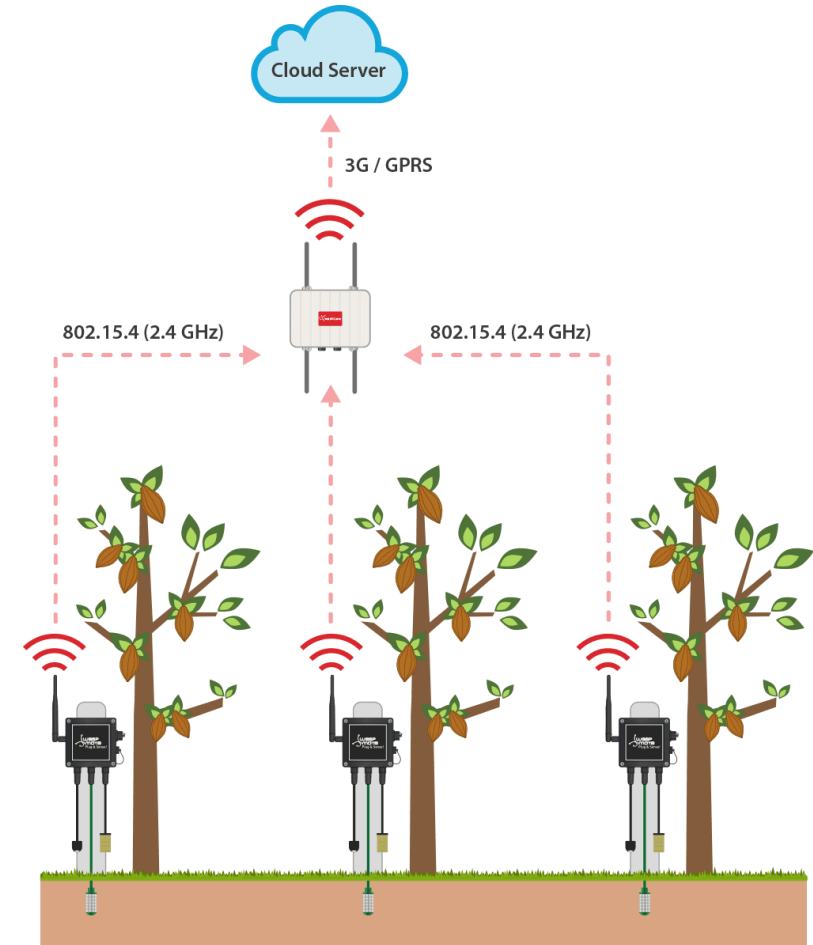
Major MCU Suppliers



MCU on Cars



MCU Used in Agriculture

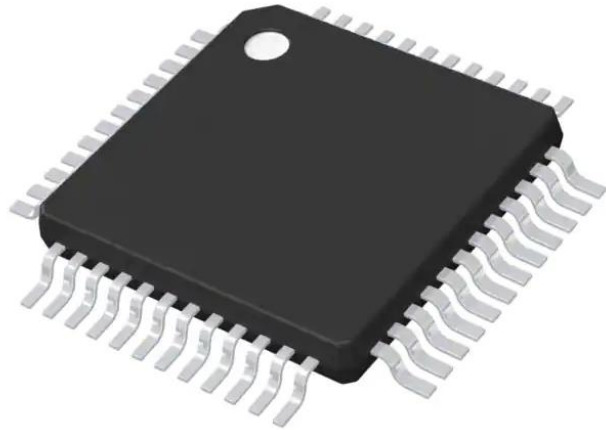


Source: <https://www.hars.com.tr/en/what-are-the-main-parts-and-functions-of-the-tractor>
https://www.assemblymag.com/ext/resources/White_Papers/Sep16/Introduction-to-Machine-Vision.pdf
<https://medium.com/vsinghbisen/application-of-computer-vision-in-precision-agriculture-farming-79b0600d5a5d>

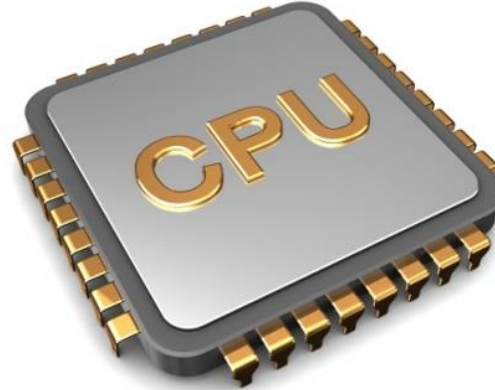


Difference between MCU, MPU, and PLC

Microcontroller
(MCU)



Microprocessor
(MPU)

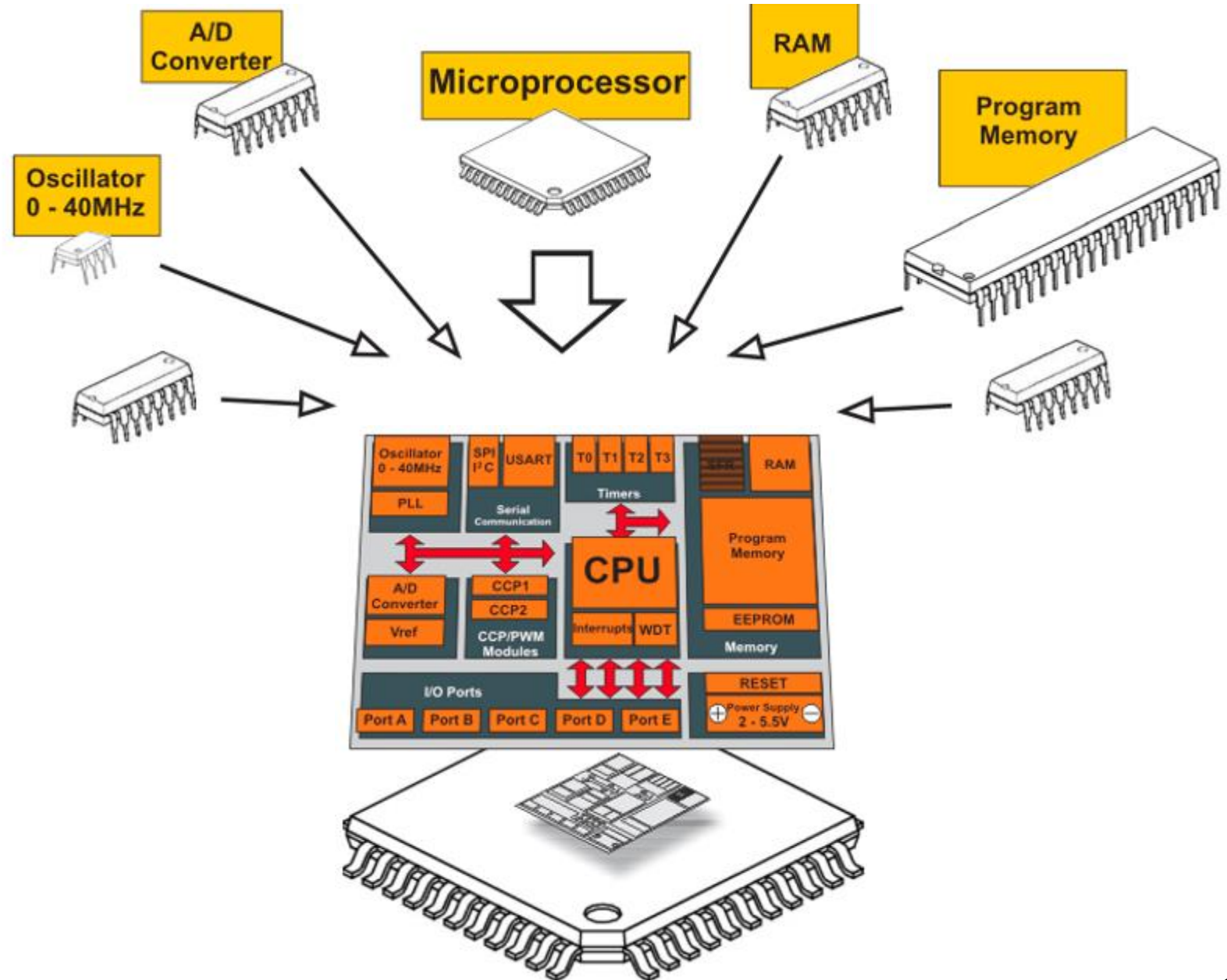


Programmable
logic controller
(PLC)

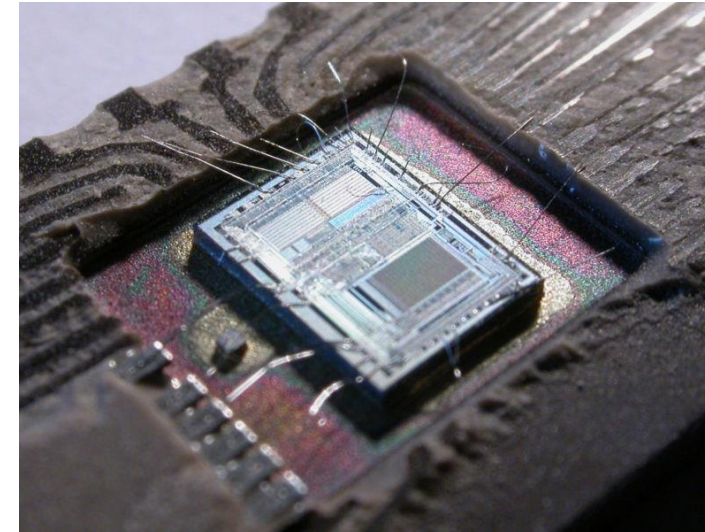
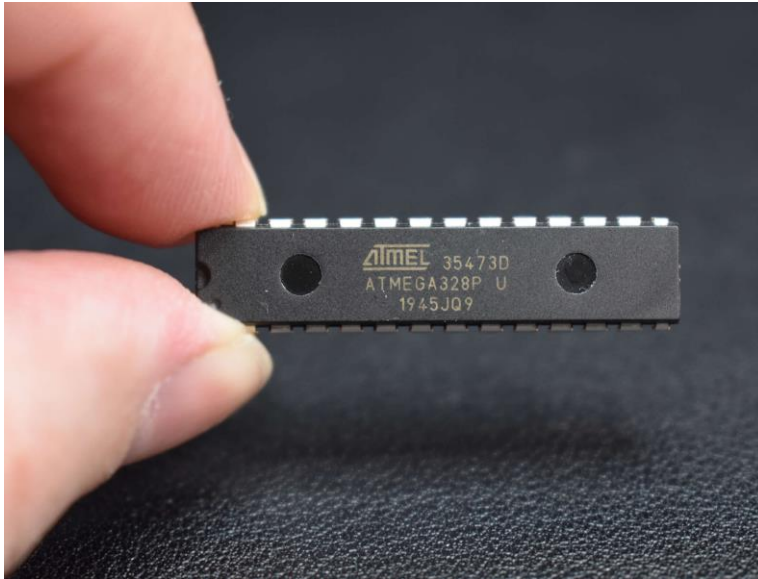


Source: <https://www.amsmart.com.tw/products/fx3u-32mres>

MCU vs. MPU



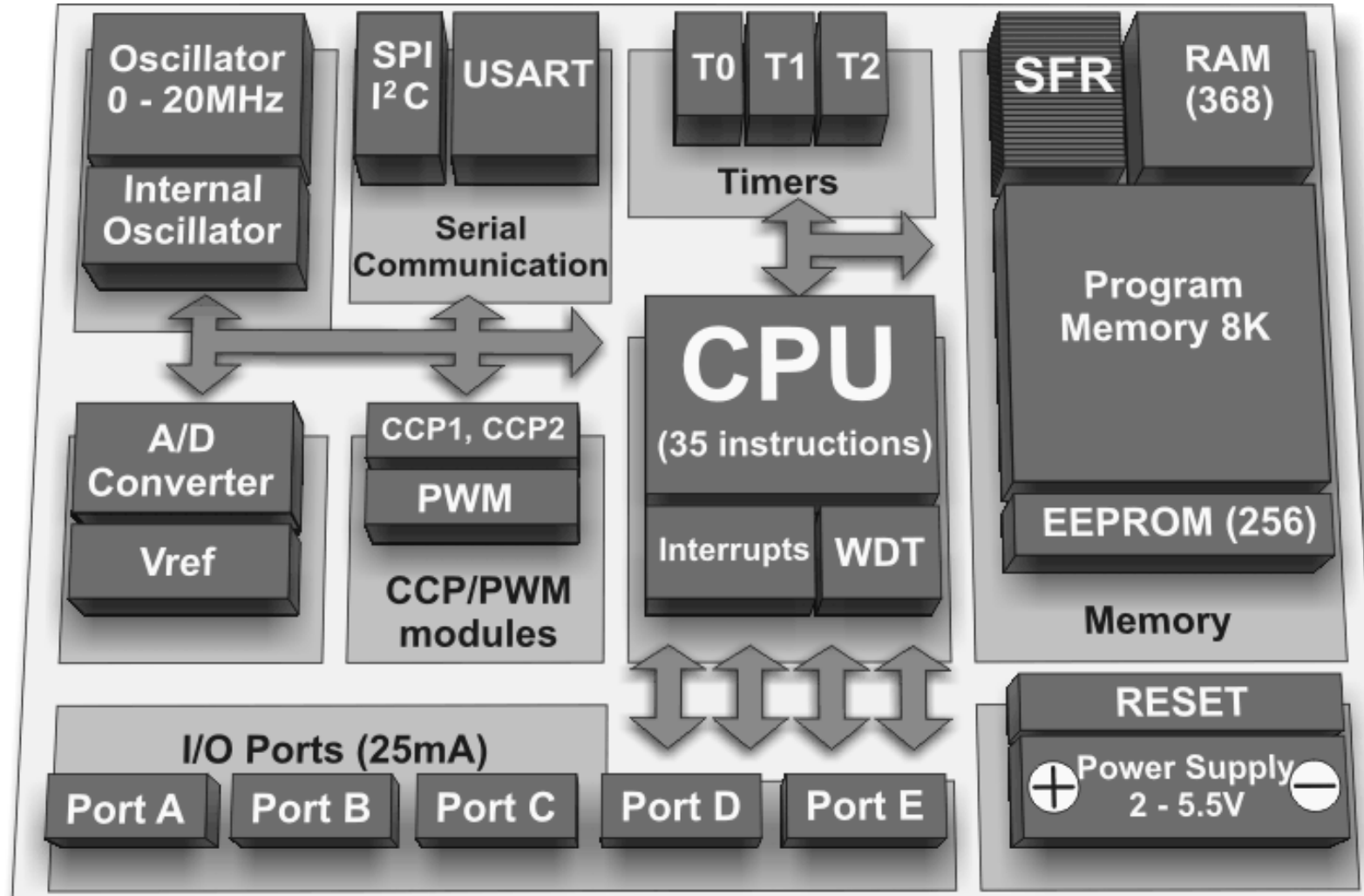
Physical Size of a MCU



Ir

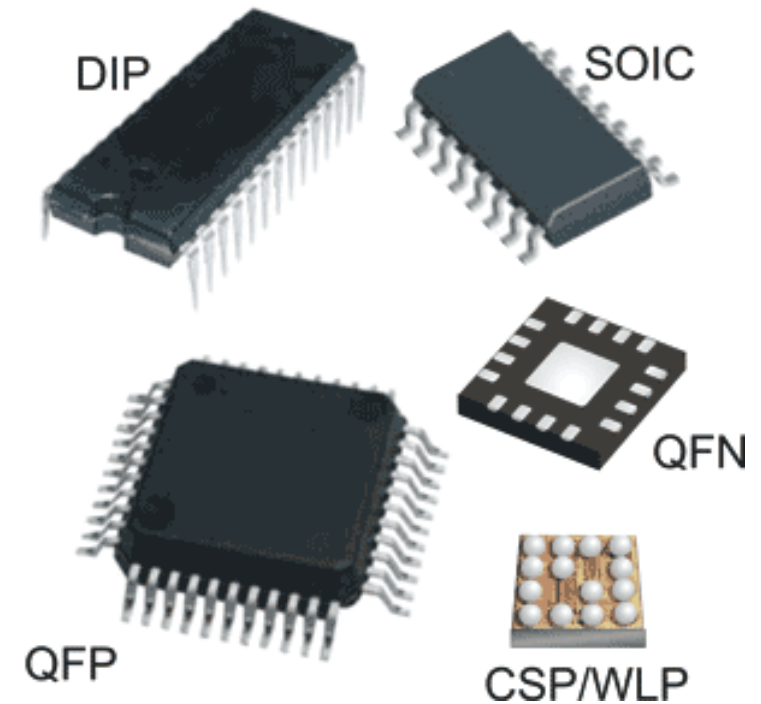


Inside a MCU

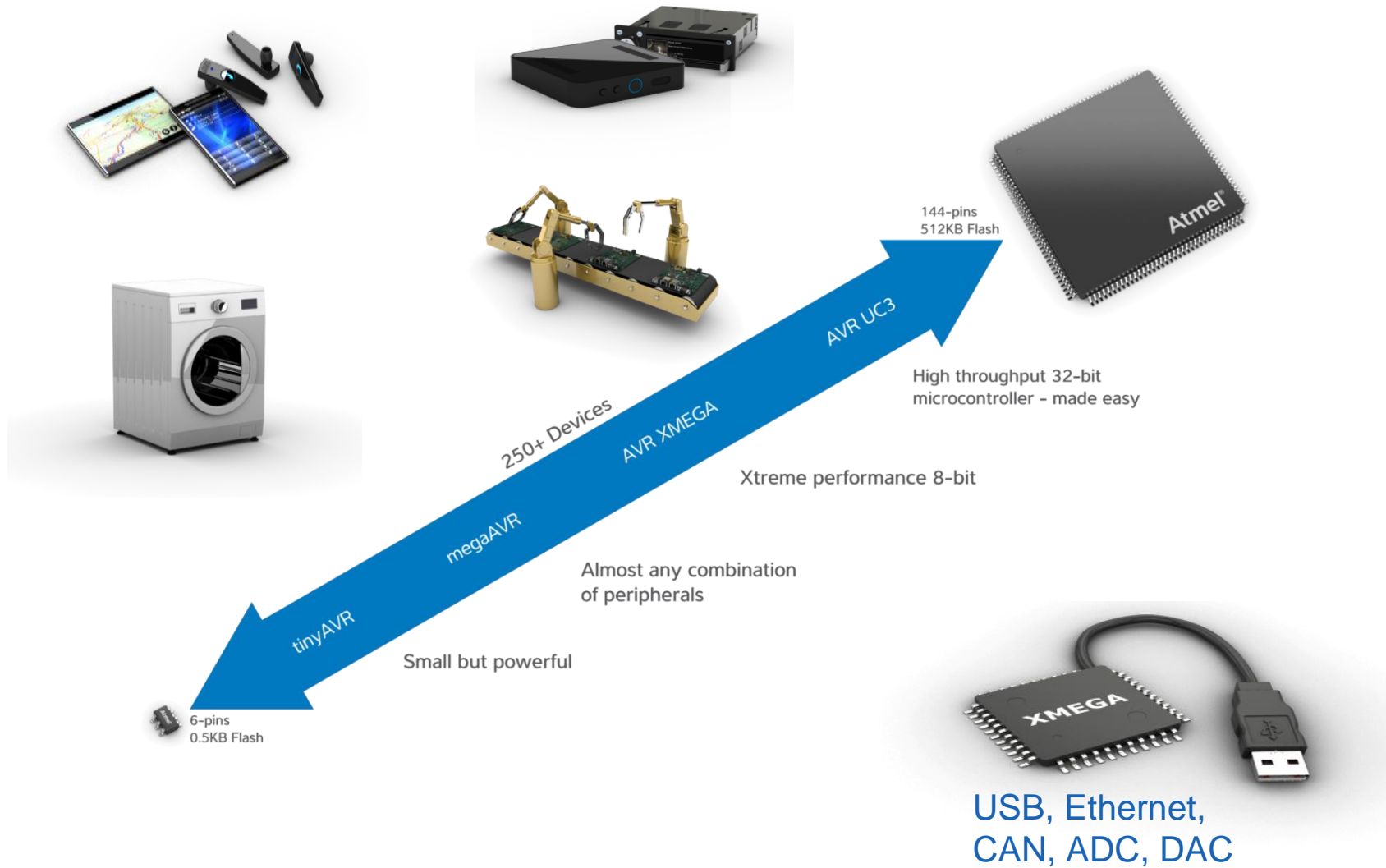


How to Choose a MCU?

- Number of I/O pins
- Bits
- Memory (RAM and ROM)
- Clock frequency
- Power consumption
- Internal functions (ADC and PWM)



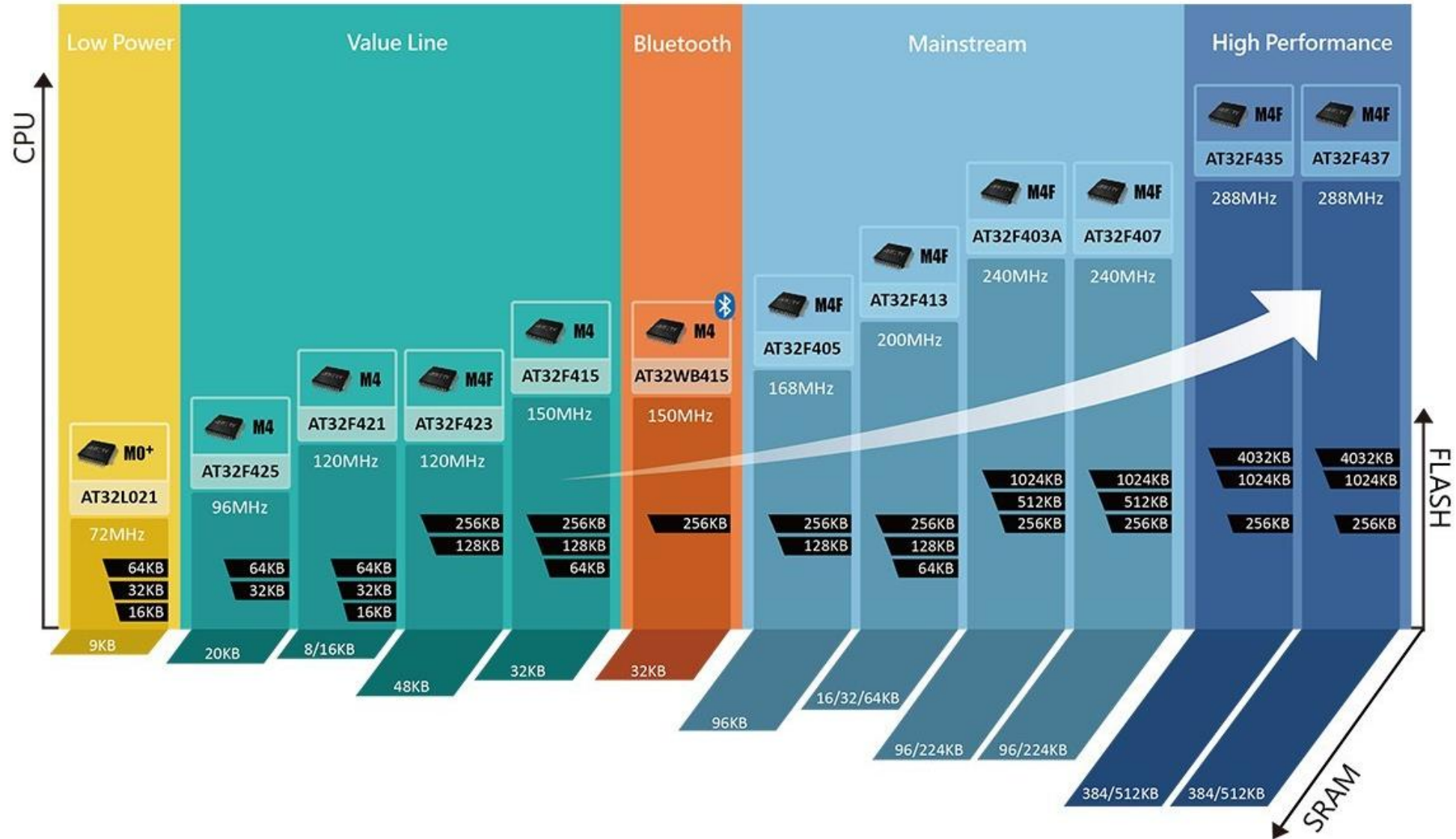
Number of I/O Pins



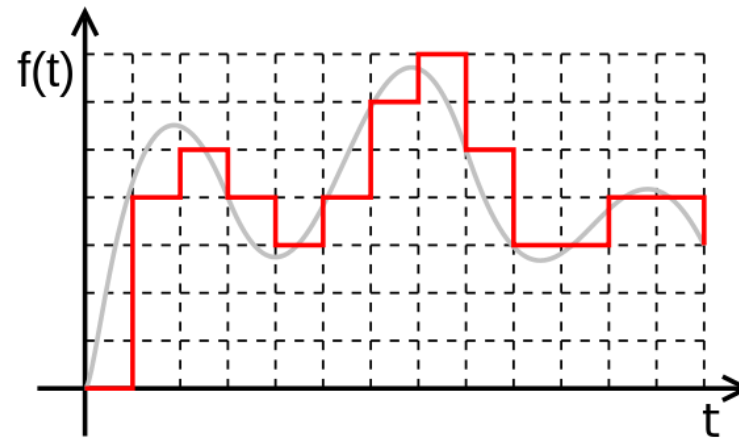
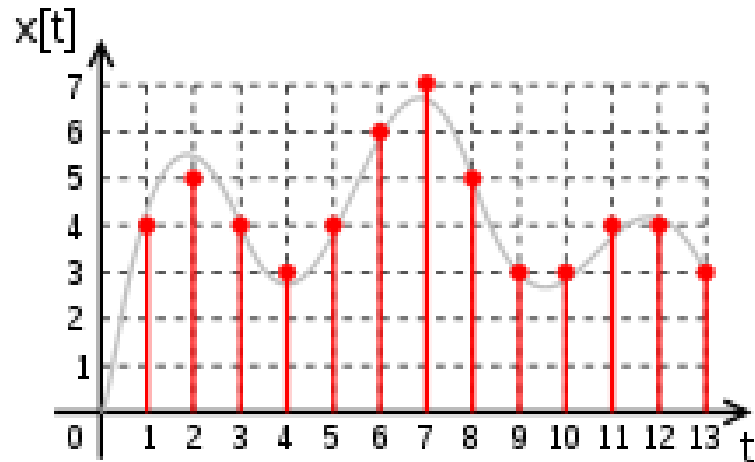
Bits and Memory



Clock Frequency



Analog-to-Digital Converter (ADC)

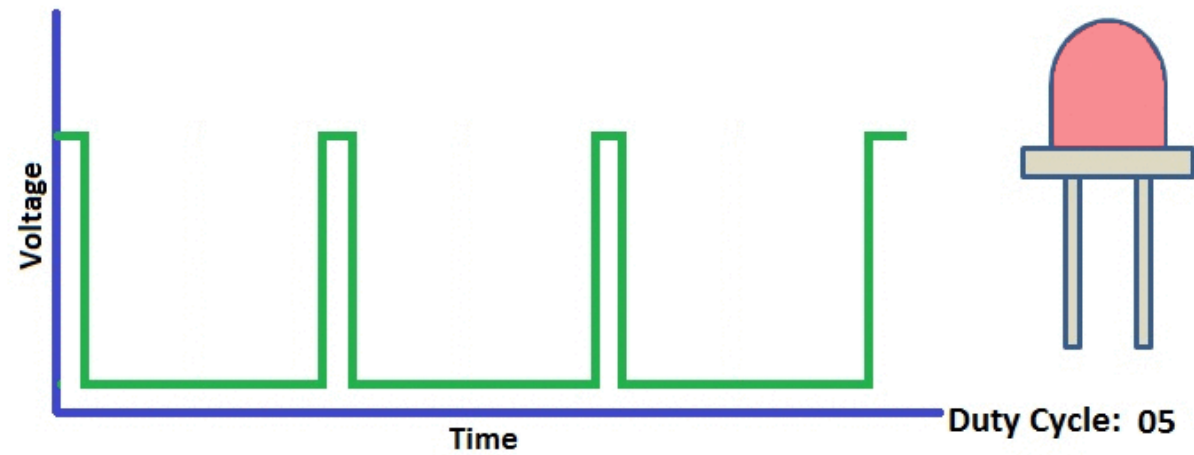


Considerations:

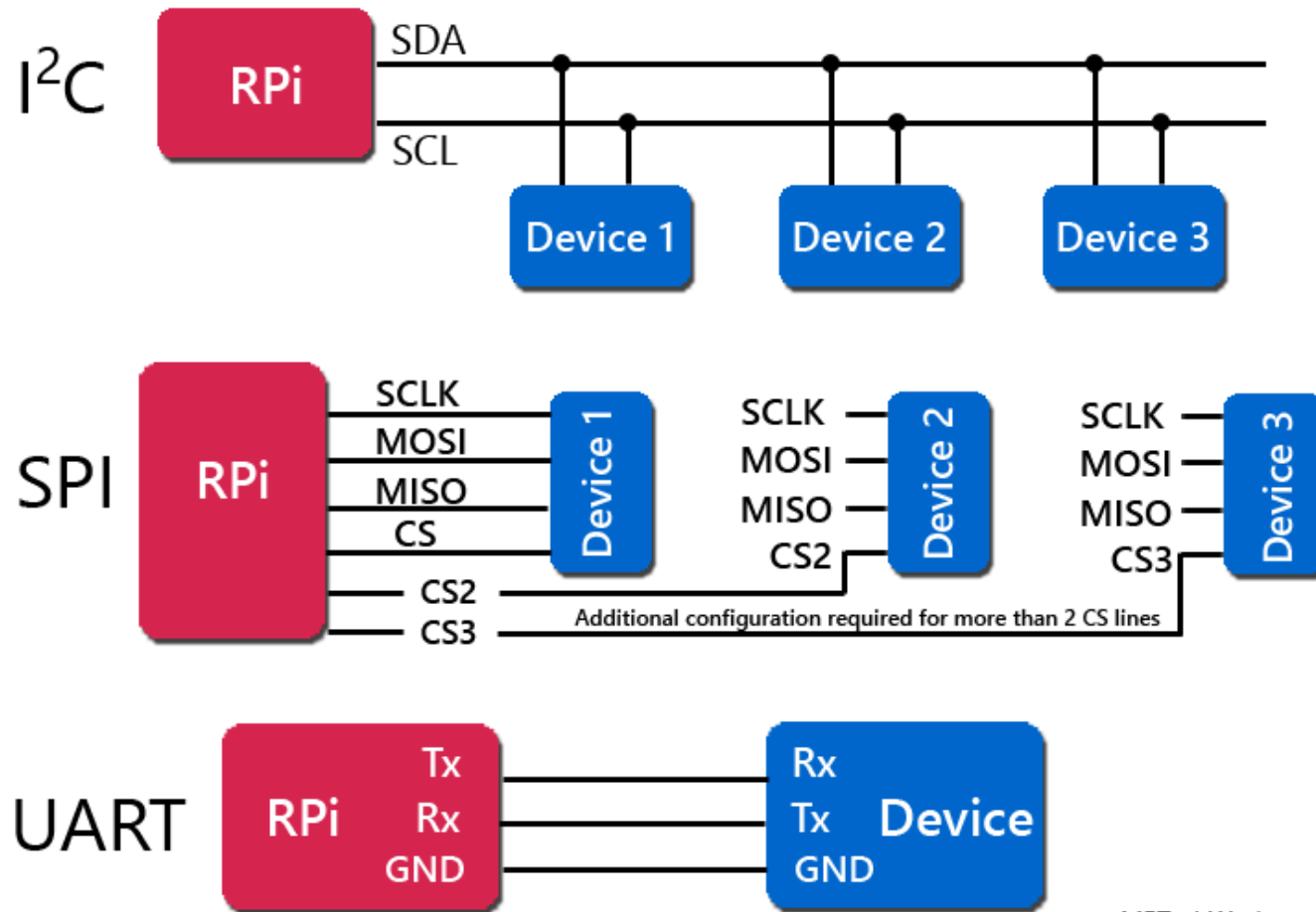
- Resolution
- Sampling freq.
- Input range
- # of channels



Pulse width modulation (PWM)

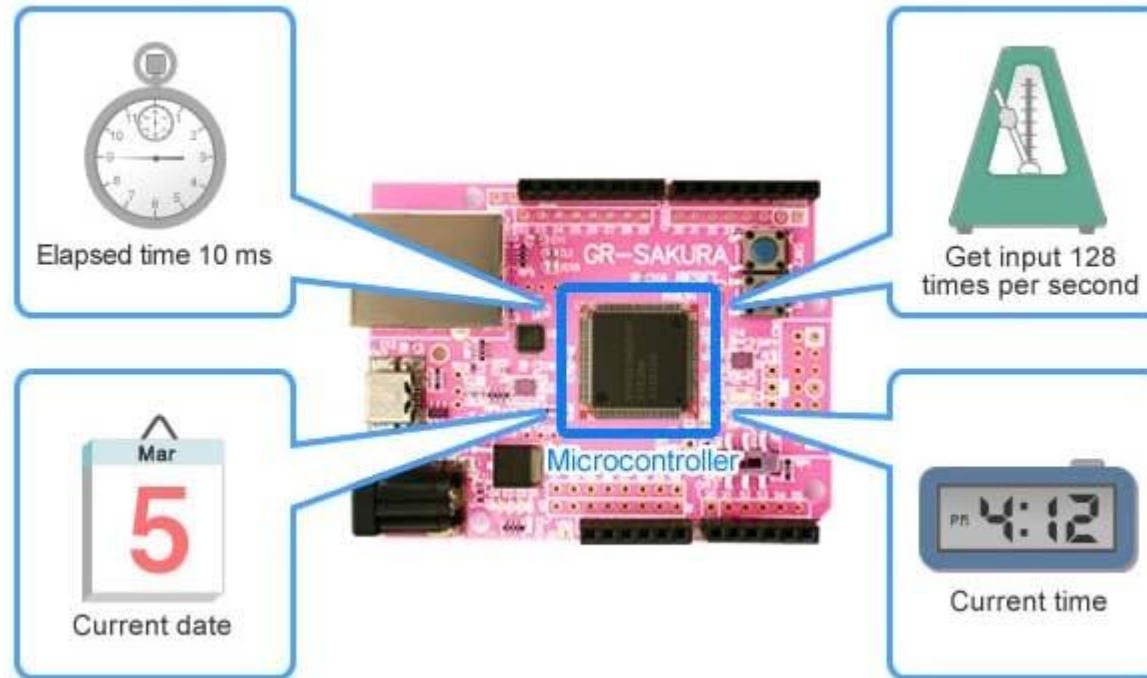


Wired Communications – I2C, SPI, and UART

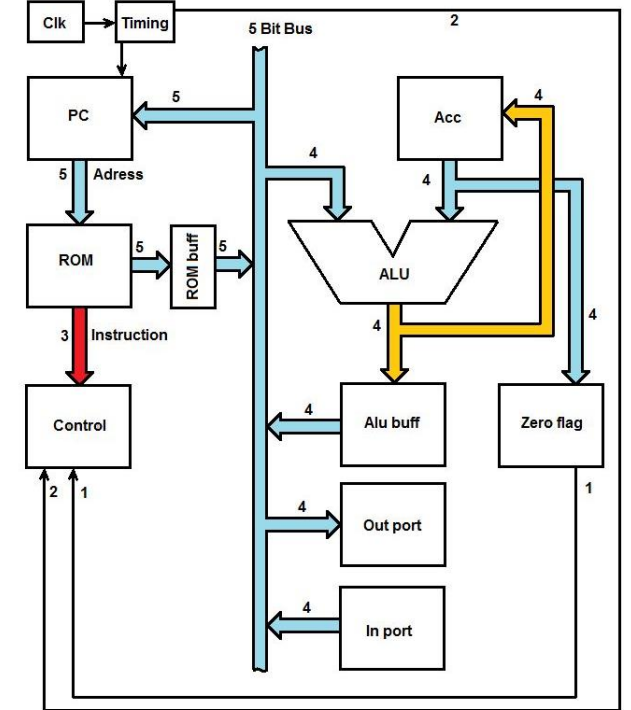
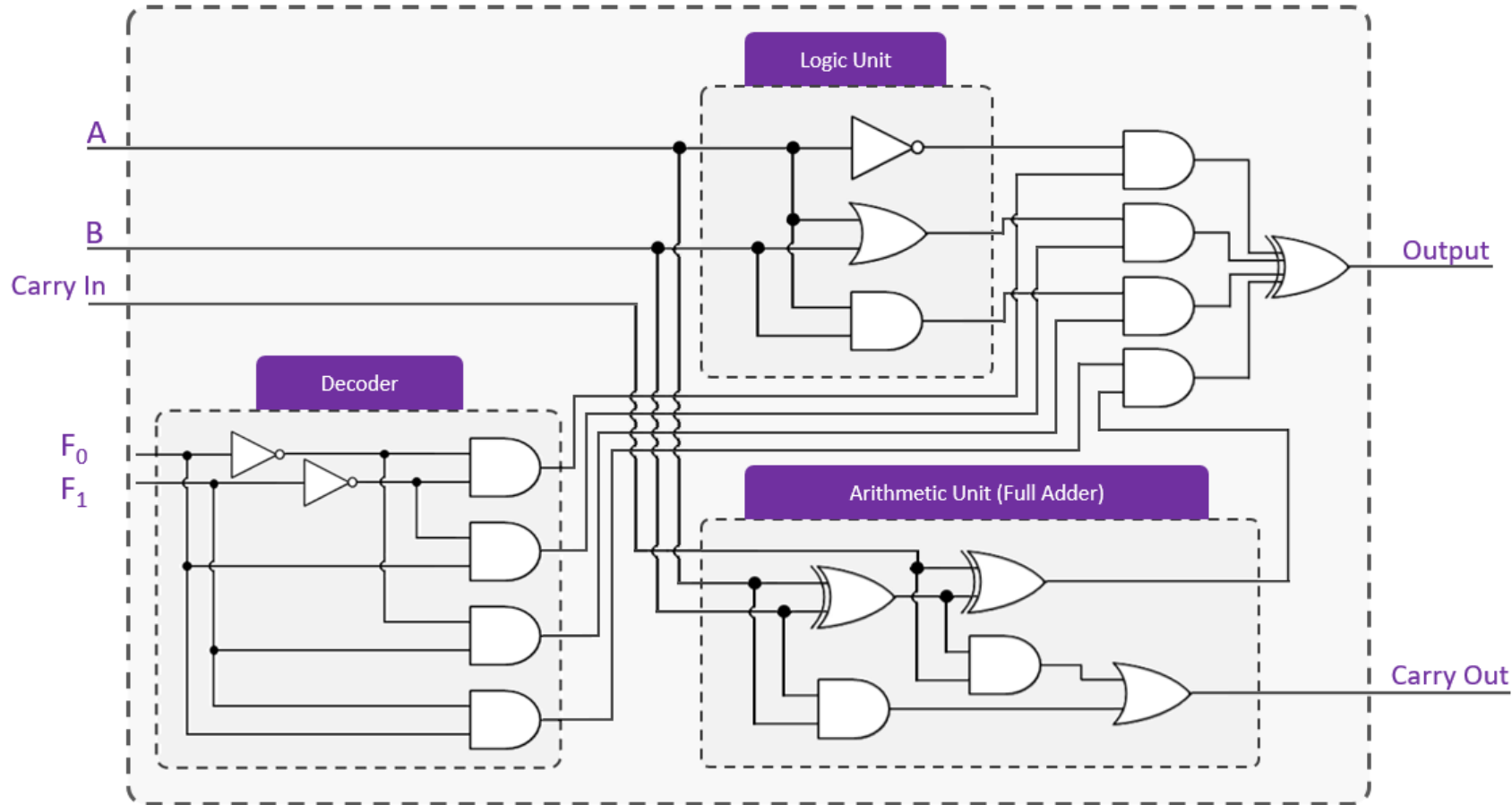


MBTechWorks.com

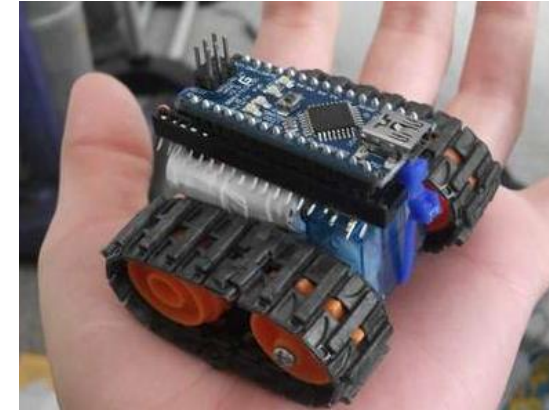
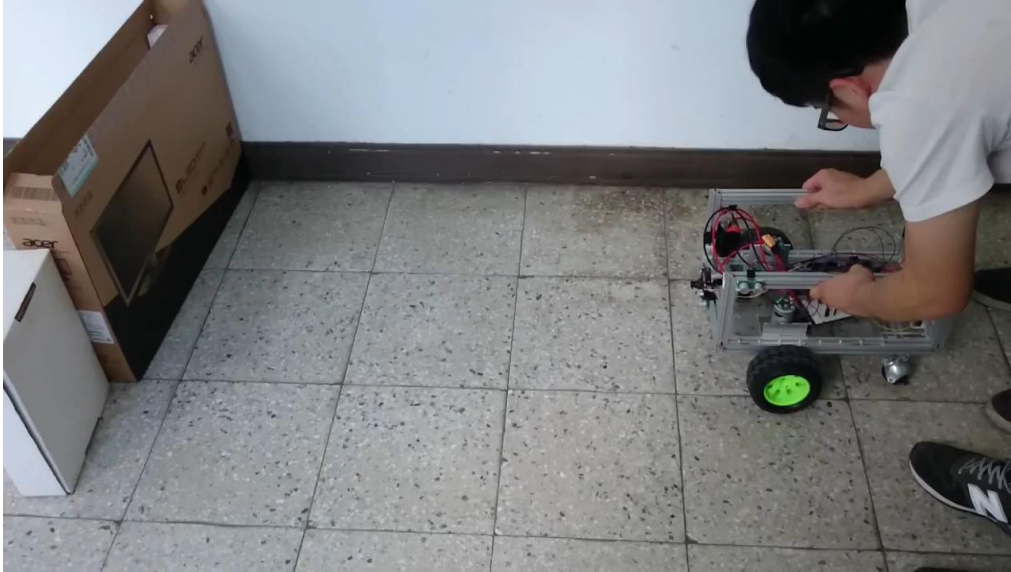
Timer



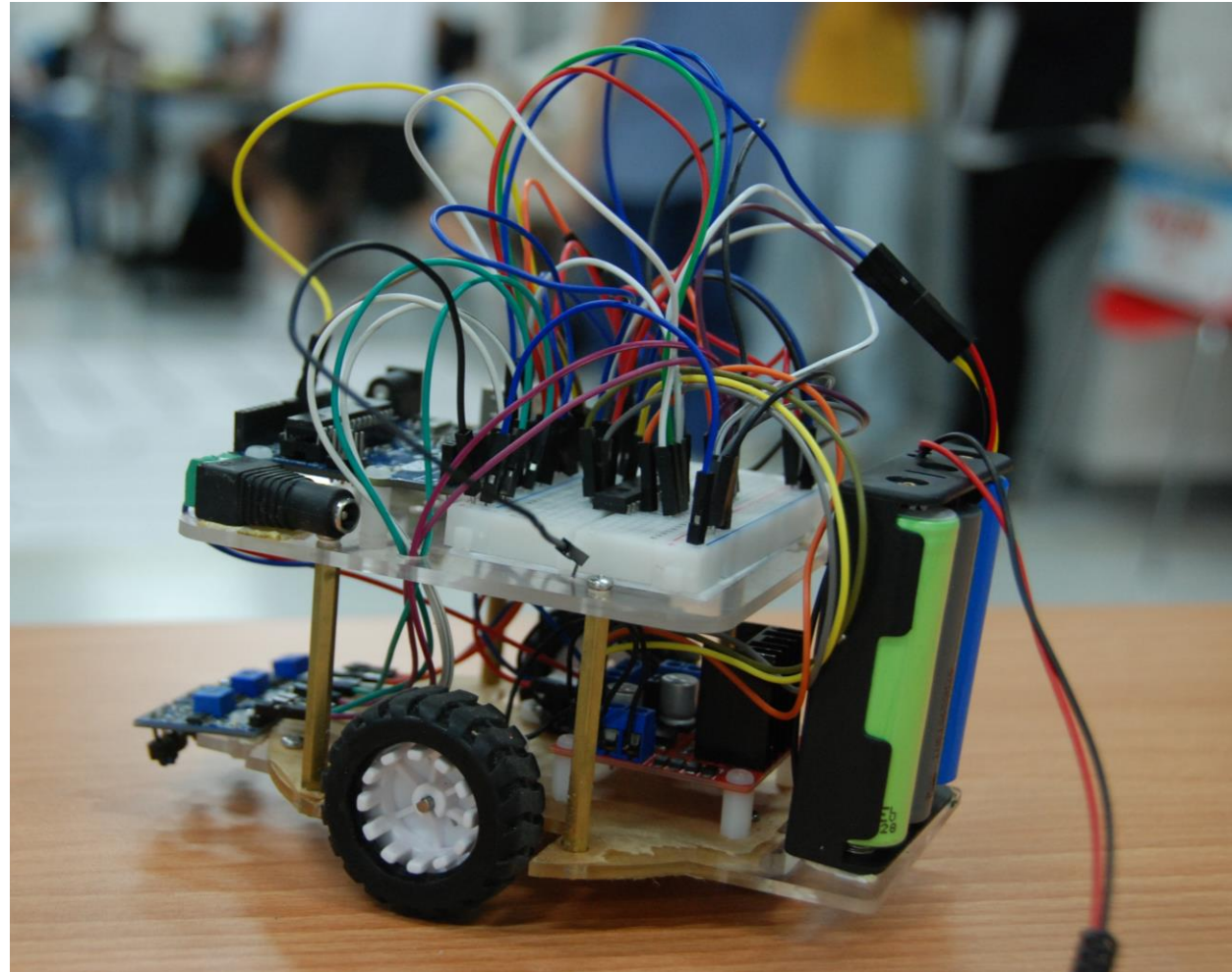
Computer Architecture



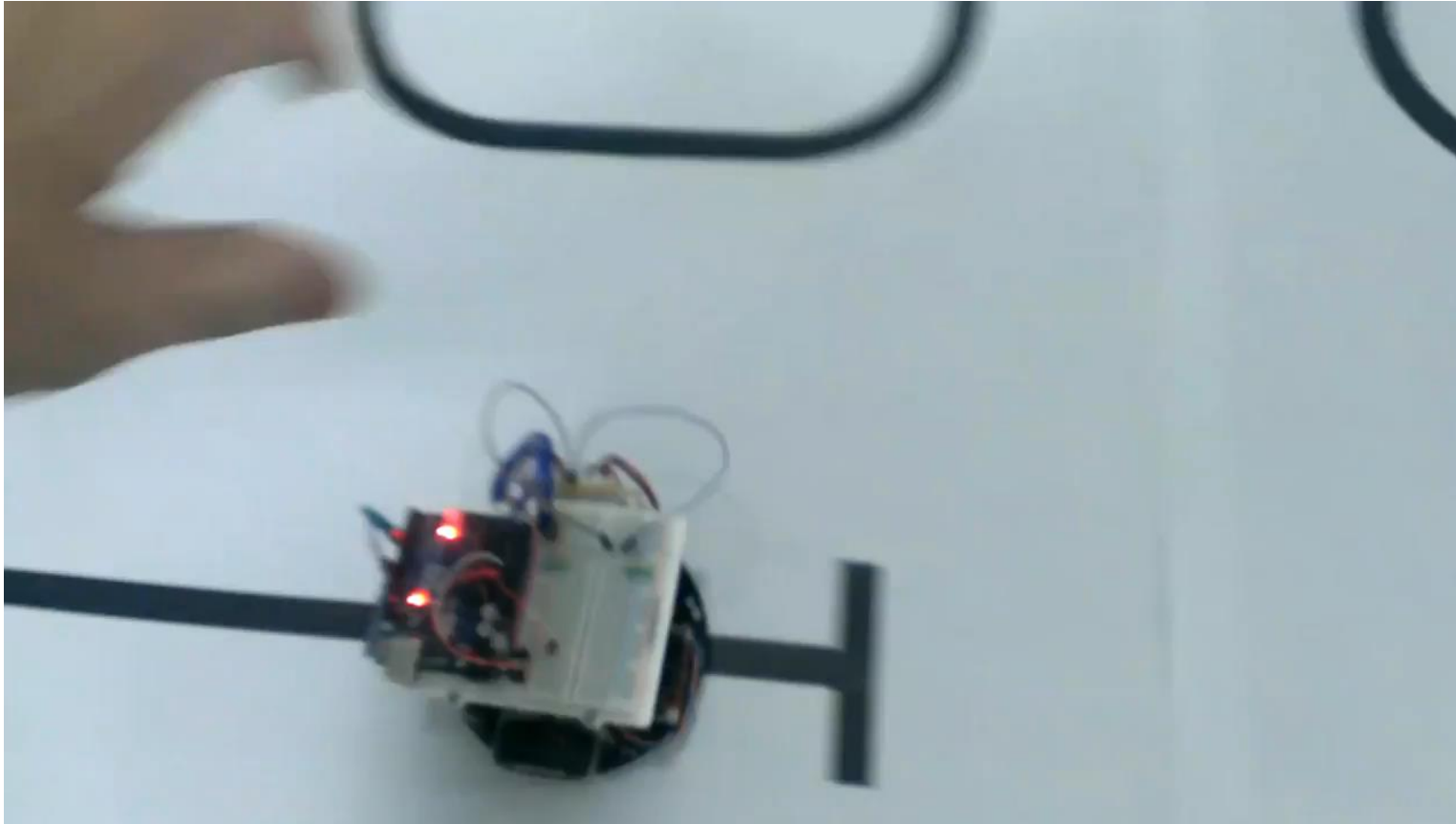
MCU Applications at NTU



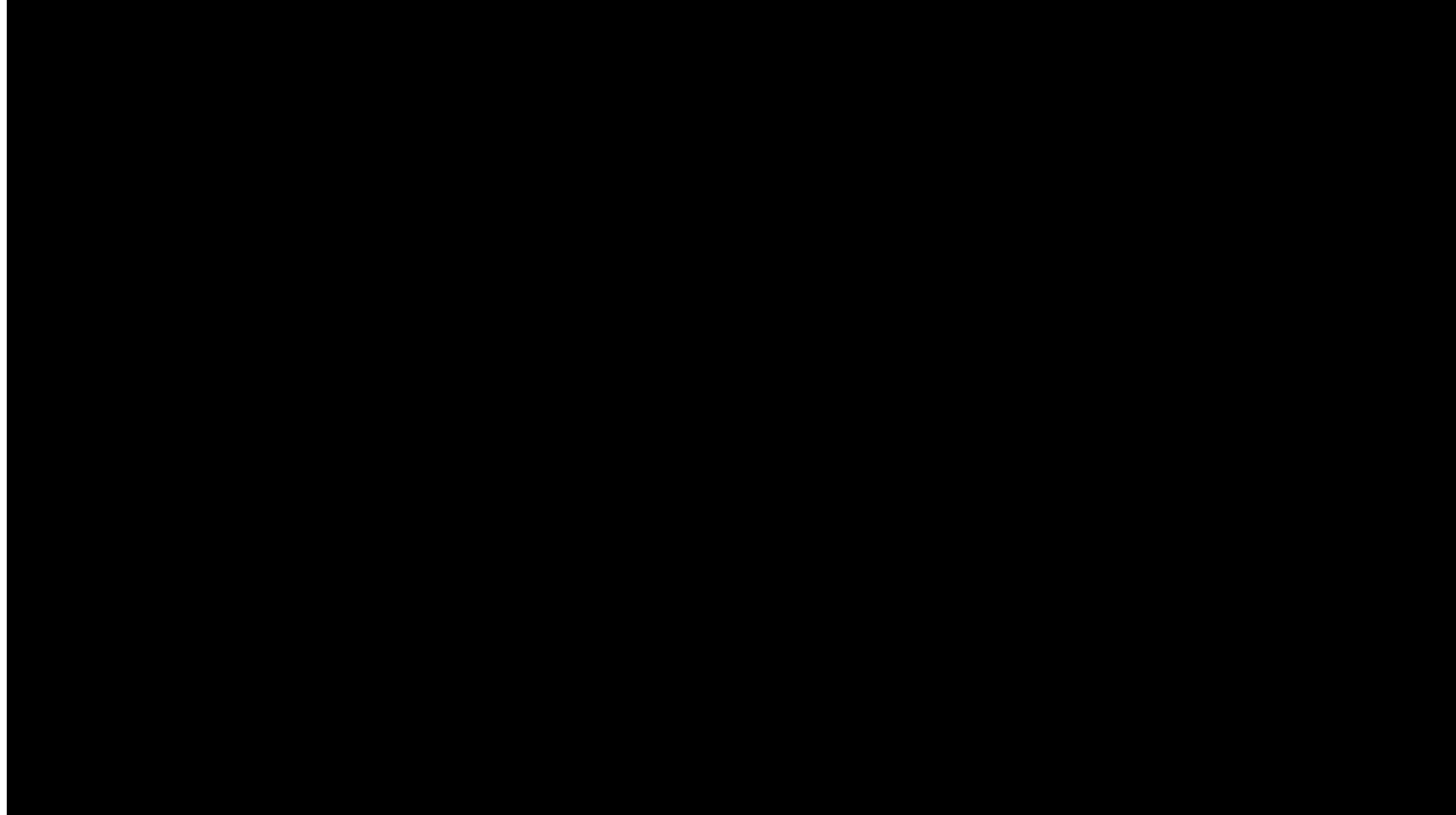
What Do I Teach in the MCU Course at NTU?



Line Tracking and Maze Running

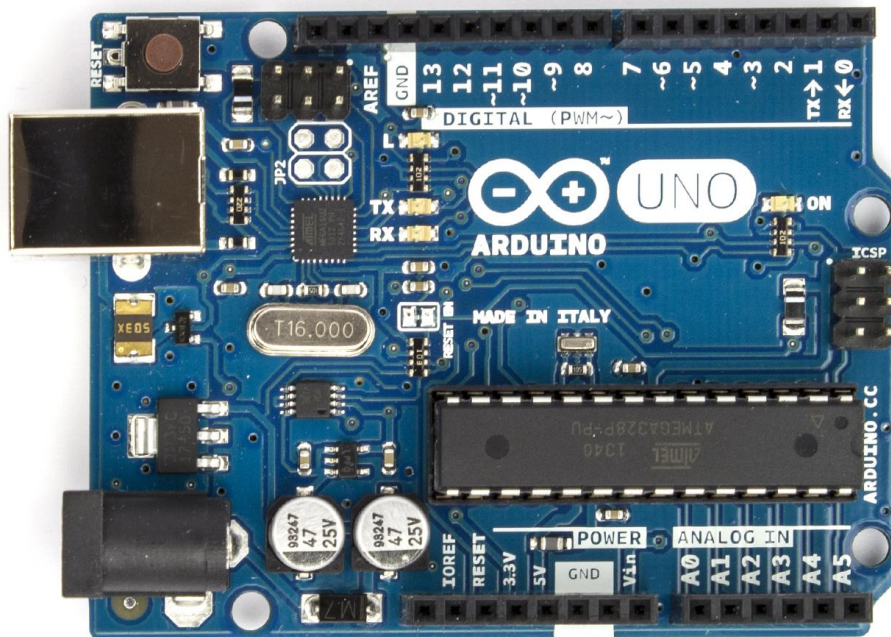


Field Robot Competition



What Will You Learn in the AIoT 農業先鋒班?

- Arduino UNO – an integrated microcontroller
- Using Microchip ATmega328p

A screenshot of the Arduino IDE interface. The window title is "Blink | Arduino 1.0". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". The main text area contains the following code:

```
/*
 * Blink
 * Turns on an LED on for one second, then off for one second, repeats...
 * This example code is in the public domain.
 */

void setup() {
  // initialize the digital pin as an output.
  // Pin 13 has an LED connected on most Arduino boards:
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH); // set the LED on
  delay(1000);            // wait for a second
  digitalWrite(13, LOW); // set the LED off
  delay(1000);           // wait for a second
}
```

At the bottom of the window, a status bar shows "Done uploading." and "Binary sketch size: 1556 bytes (of a 258048 byte maximum)".

Why Arduino?



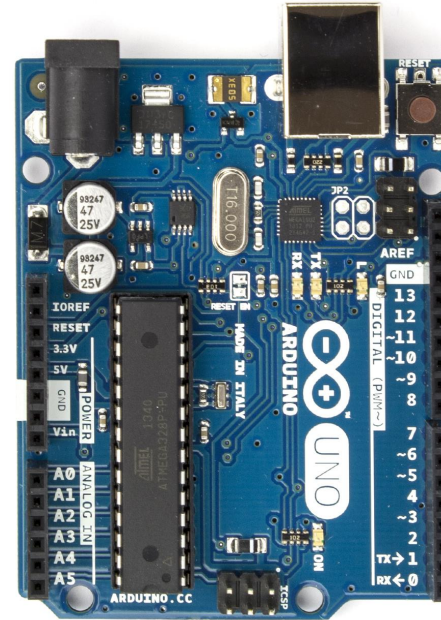
- Open source
- Low-cost – less than \$30 USD
- Easy to use – less hardware logic
- Friendly programming environment
- Dominating the market



Arduino UNO



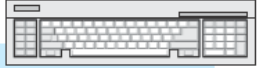
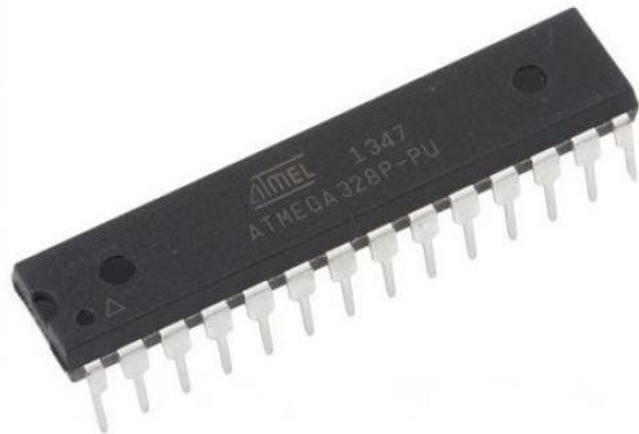
Intel 80286 (1982)



Arduino Uno (2010)

Programming Arduino

- Using sketch – a language very similar to C language
- The essential functions of MCU are packaged as functions



```
void main() {  
  
    TRISB = 0;           // All port B pins are configured as  
                        // outputs  
    PORTB = 0b01010101; // Logic state on port B pins  
}
```

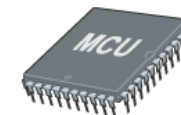
Program written in C

; ADDRESS	OPCODE	ASM
\$0000	\$2804	GOTO _main
\$0004	\$	_main:
;Test.c,1 :: void main() {		
;Test.c,3 :: TRISB = 0; // All port B pins		
\$0004	\$1303	BCF STATUS, RP1
\$0005	\$1683	BSF STATUS, RP0
\$0006	\$0186	CLRF TRISB, 1
;Test.c,4 :: PORTB = 0b01010101; // Logic state		
\$0007	\$3055	MOVLW 85
\$0008	\$1283	BCF STATUS, RP0
\$0009	\$0086	MOVWF PORTB
;Test.c,5 :: }		
\$000A	\$280A	GOTO \$

Compiled Program

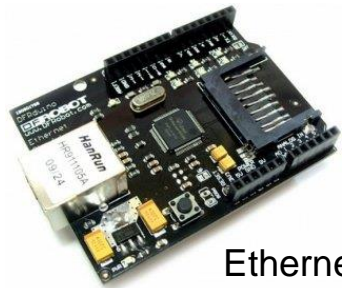
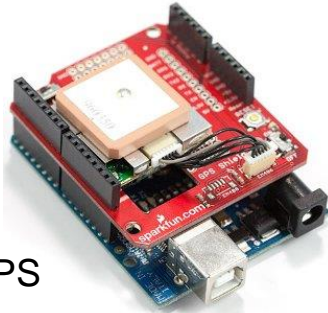
```
:10000000428FF3FFF3FFF3F03138316860155304F  
:10001000831286000A28FF3FFF3FFF3FFF3FFF3F5D  
:04400E00F22FFFFF8F  
:00000001FF
```

Executable Code of the program (HEX code)



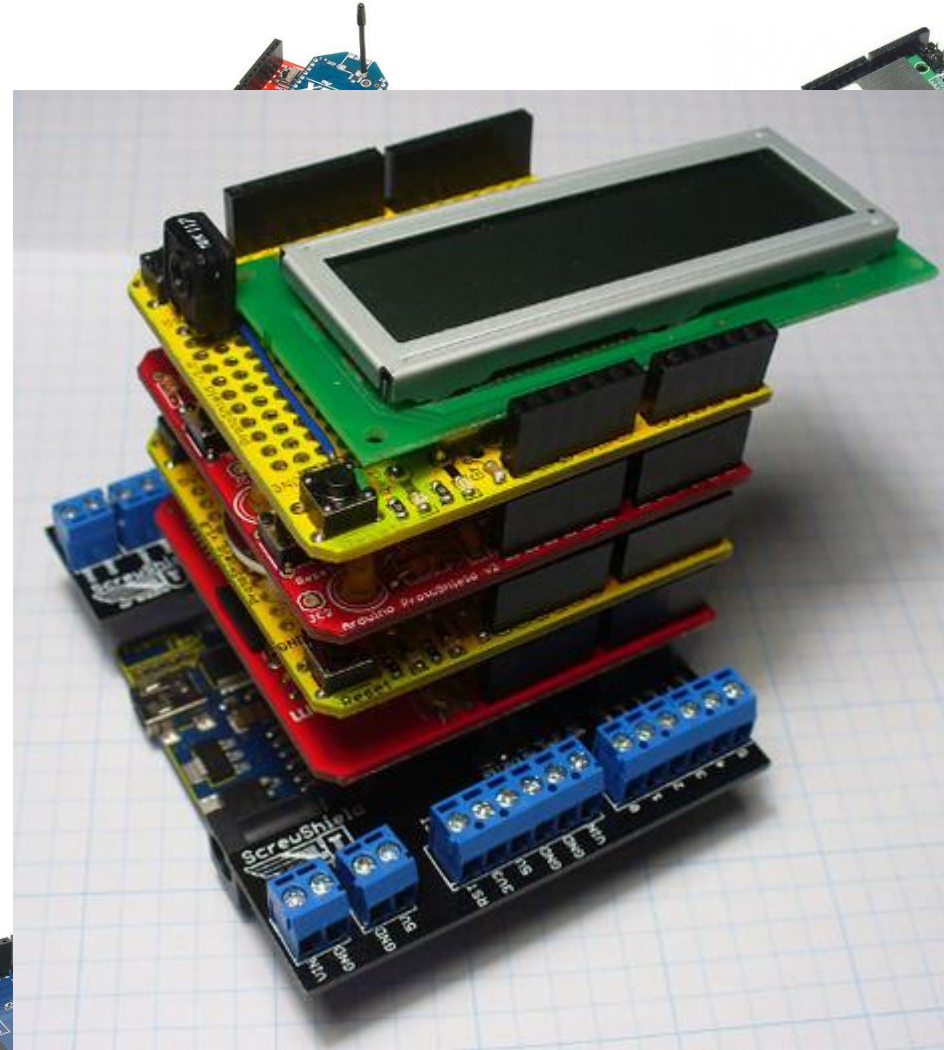
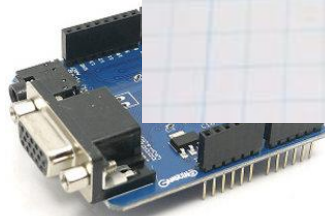
Arduino Shields

GPS

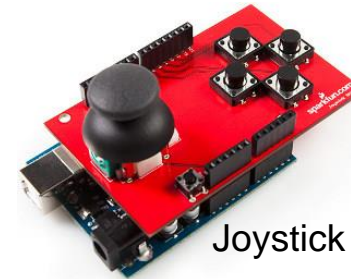


Ethernet

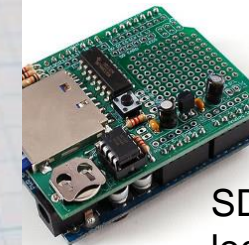
VGA



WiFi



Joystick



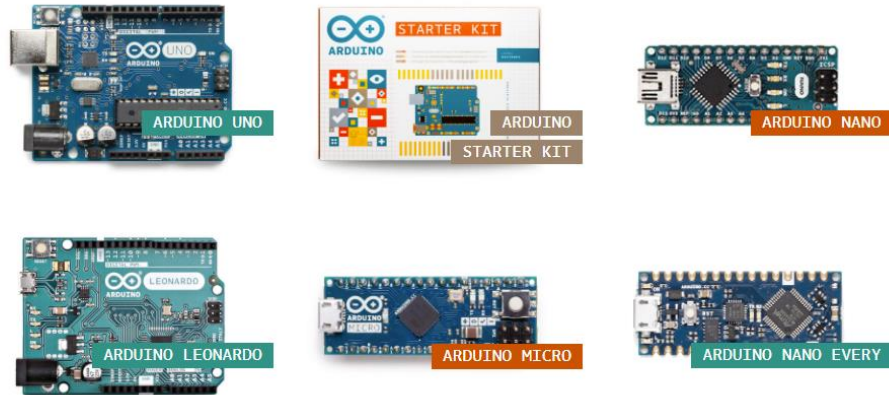
SD card logger

Motor controller



Arduino Family

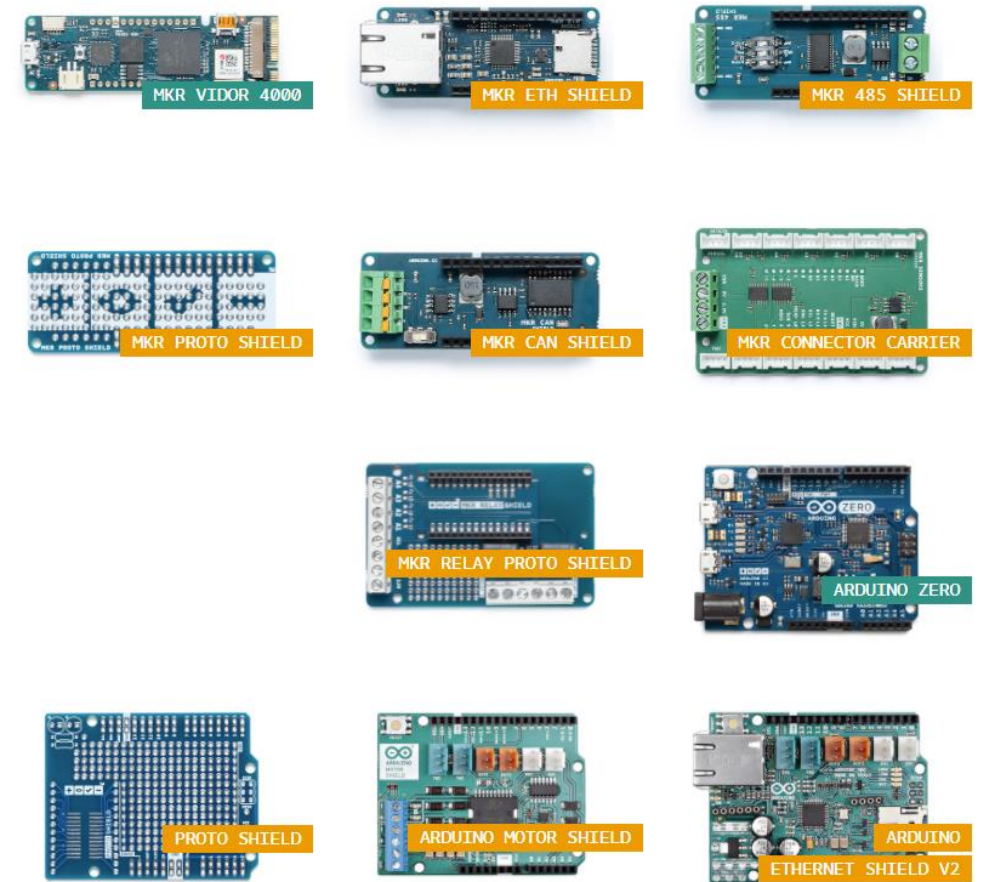
Entry Level



IoT

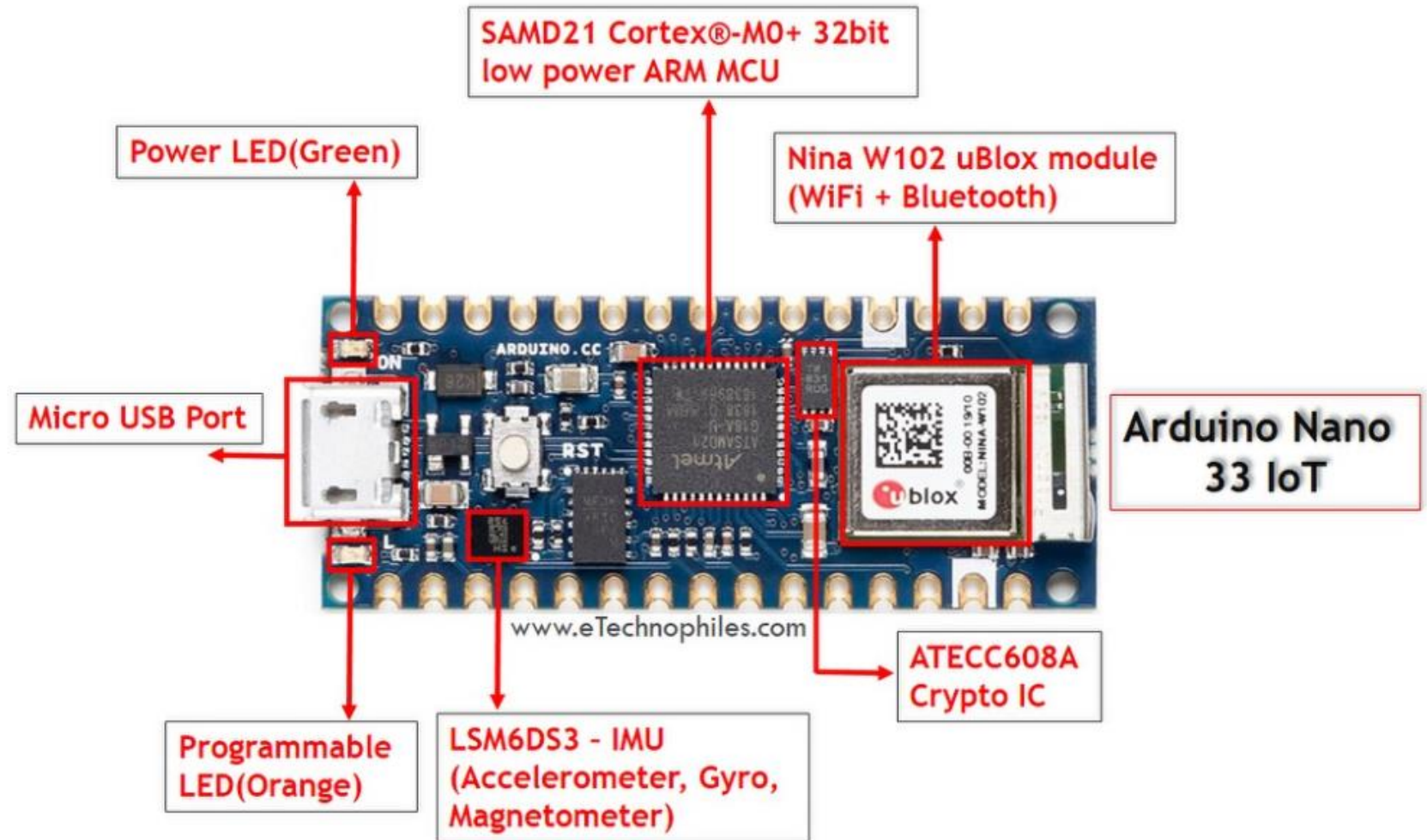


Enhanced Features

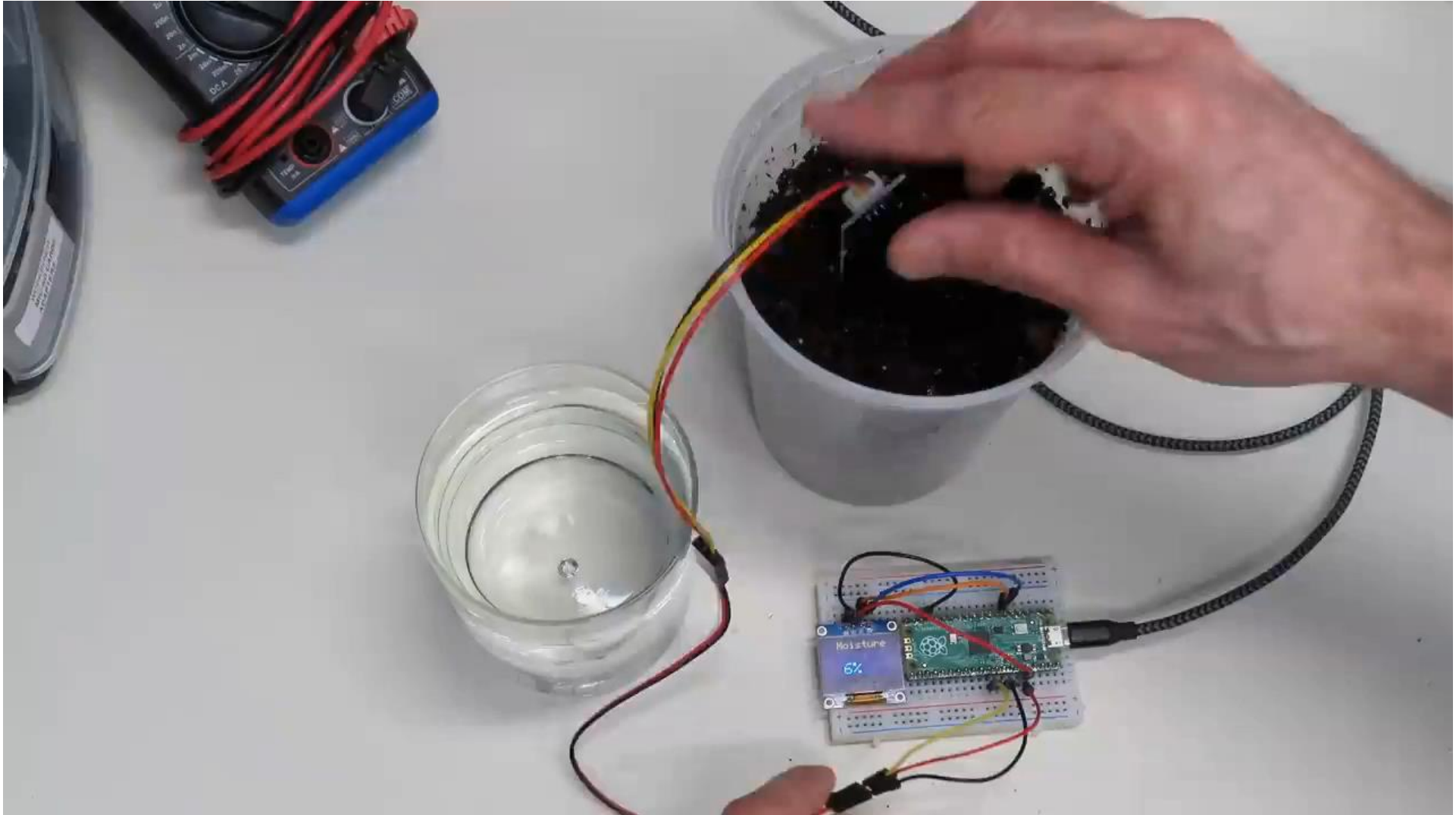


Arduino Nano 33 IoT

- Embedded WiFi and Bluetooth
- Low power consumption
- Integrated Arduino IoT cloud



An Arduino IoT Project



My Teaching Videos

Search

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Professor @NTU BME,
Lab of Machine Learning and Machine Vision
機器學習與機器視覺實驗室, aka 工具人實驗室

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<https://sites.google.com/view/mlmv/teaching/matlab>

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MATLAB 的工程應用 1:44:24

MATLAB 的工程應用 1:40:38

MATLAB 的工程應用 1:42:14

MATLAB 的工程應用 1:20:40

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台大生機系大一必修課程 微控制器原理與應用 課程材料:
<https://sites.google.com/view/mlmv/teaching/microcontroller>

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微控制器 原理與應用 46:43

微控制器 原理與應用 55:36

微控制器 原理與應用 39:46

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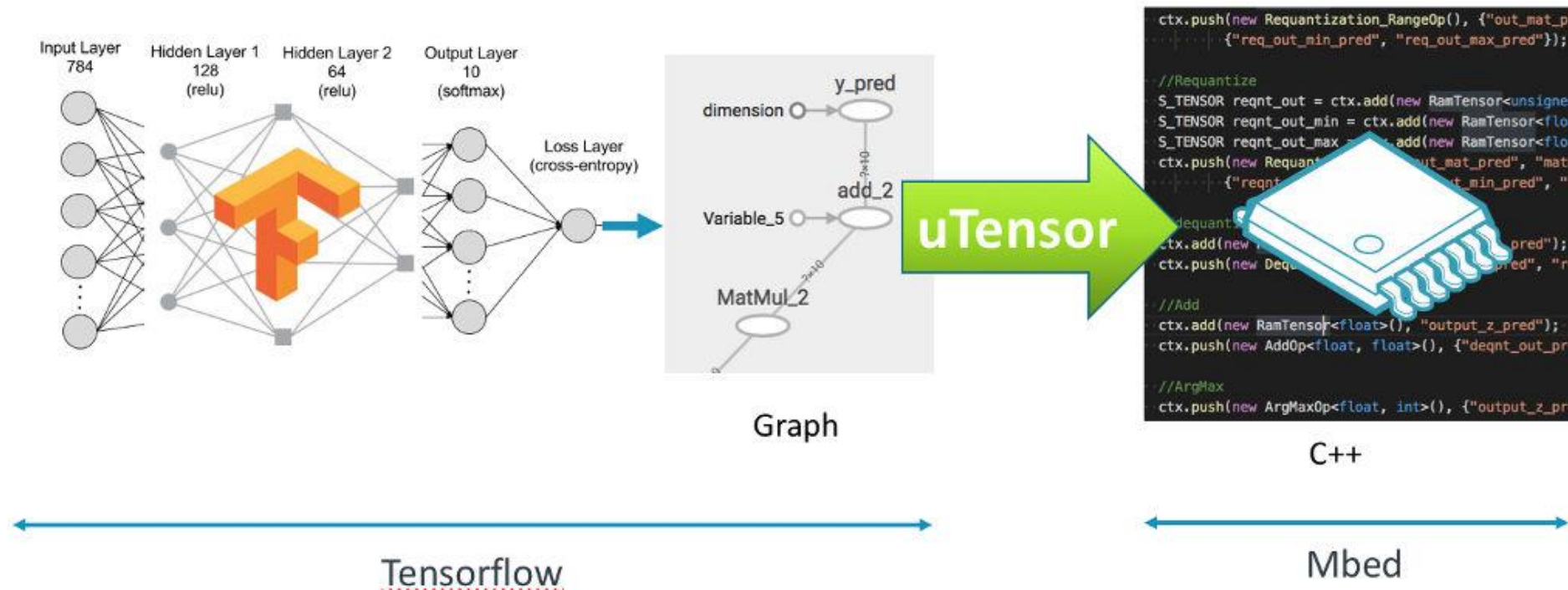
Source: <https://www.youtube.com/c/yanfukuo>



Yan-Fu Kuo
Dept. of Biomechatronics Engineering

AIoT?

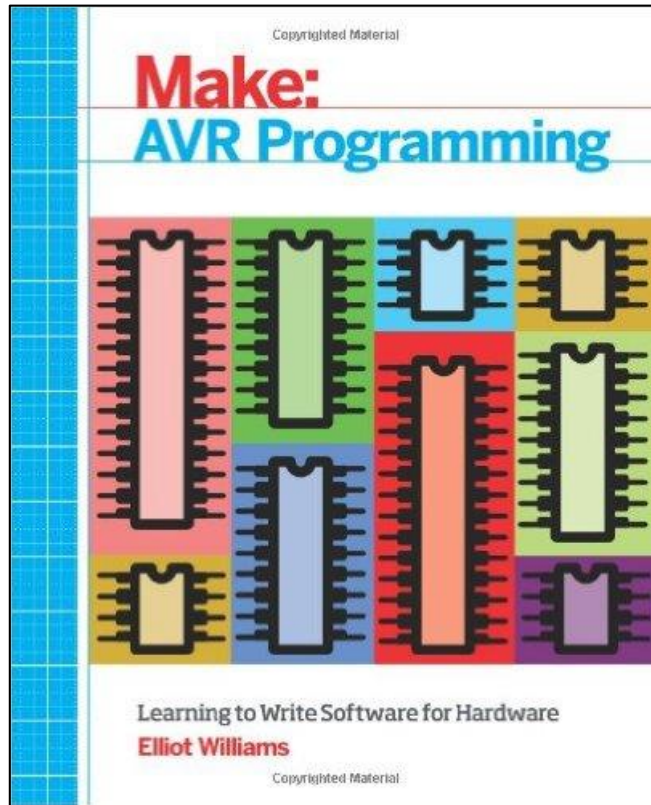
- Embedding AI on chips



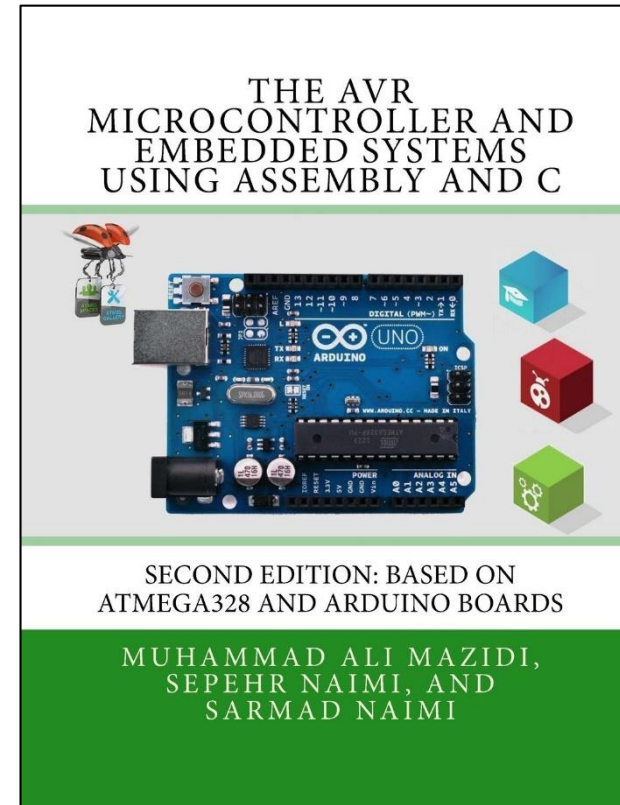
Source: <https://www.youtube.com/watch?v=IGHi4Vjg9SY>
<https://os.mbed.com/blog/entry/Mbed-and-Machine-Learning/>

Reference Books

"Make: AVR Programming - Learning to Write Software for Hardware" by E. Williams

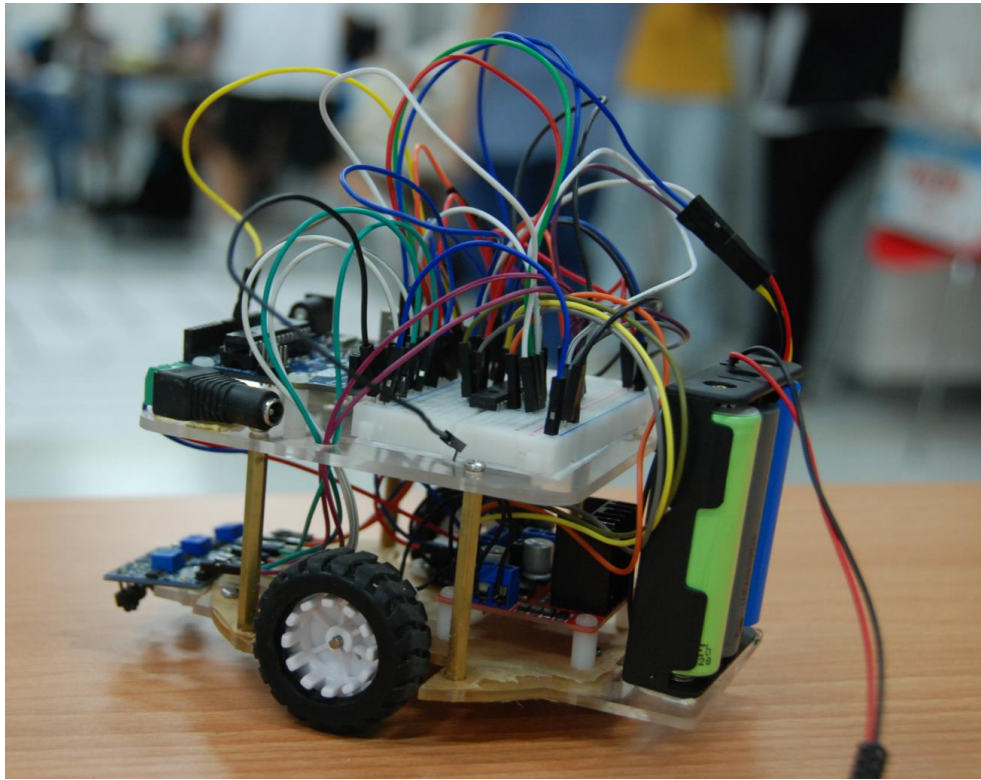


"The AVR Microcontroller and Embedded Systems Using Assembly and C" by M. A. Mazidi, S. Naimi, and S. Naimi

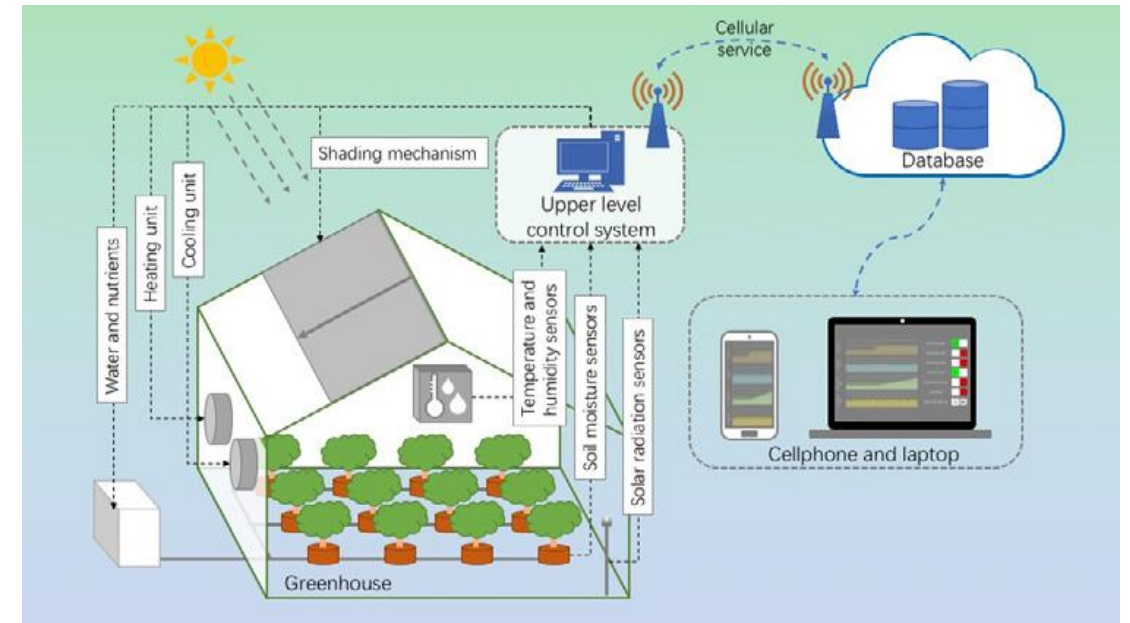


What Project You Would Like to Do in the AIoT Course?

1. Car?

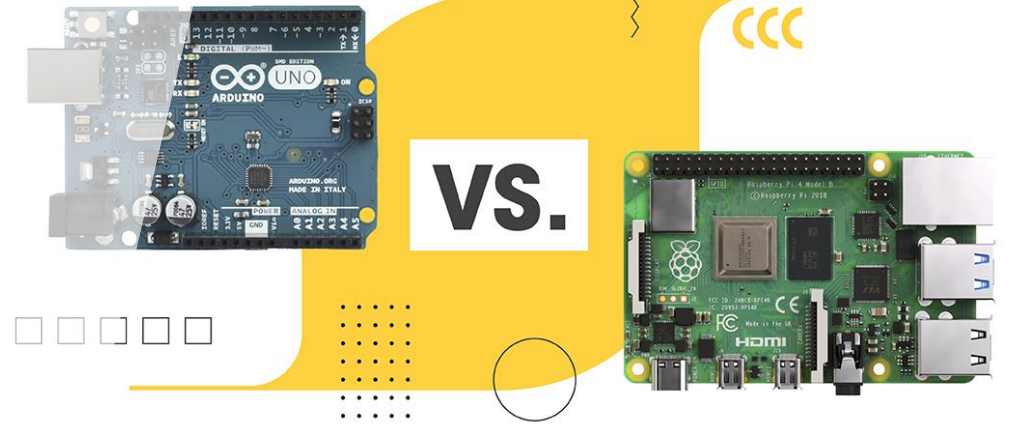


2. Greenhouse?





National Taiwan University
Biomechatronics Engineering



NTU X COA

Thanks for listening

Yan-Fu Kuo | 19, June 2023

