新型基础设施的底座：物联网芯片与物联网操作系统

- 让IoT 开发更加便捷

主讲人：何小庆

嵌入式系统联谊会
www.esbf.org

单片机与嵌入式系统应用
Microcontrollers & Embedded Systems

目 录

《物联网新型基础设施建设三年行动计划》 (2021-2023年)

- 物联网是以感知技术和网络通信技术为主要手段，实现人、机、物的泛在连接，提供信息感知、信息传输、信息处理等服务的基础设施。随着经济社会数字化转型和智能升级步伐加快，物联网已经成为新型基础设施的重要组成部分。

- 物联网连接数2023年年底突破20亿。

- 创新能力突破的目标是实现高端传感器、**物联网芯片**、**物联网操作系统**、新型短距离通信等关键技术水平和市场竞争力显著提升。

三年行动计划：物联网创新能力提升

□ 突破MEMS传感器和**物联网芯片**的设计与制造

□ 研发轻量级/分布式**物联网操作系统**

□ 加快**边缘计算**等技术研发与应用

□ 释放数据价值，开展语音、视频识别，机器学习、物体运行机理模型和知识图谱等**人工智能**技术研究

专栏1：创新能力提升指引

关键核心技术。支持多源、海量数据接入的智能感知技术攻关，推动低功耗、高安全、高速率的新型短距离通信技术发展，加强高可靠、广覆盖的北斗定位和高精度室内定位技术研发，突破MEMS传感器和物联网芯片的设计与制造，研发轻量级/分布式物联网操作系统。加快边缘计算、数字孪生、IPv6等技术研发与应用。

技术融合创新。持续优化低时延、低功耗、大连接等方面技术，增强5G对物联网的通信支撑。开展感知数据清洗、物理世界数据的标准建模及特征分析、多源异构数据集成与共享等大数据技术研究，进一步释放物联网数据价值。开展语音识别、视频识别、机器学习、物体运行机理模型、知识图谱等人工智能技术研究，丰富感知终端交互手段，增强物联网服务中的知识模型沉淀和专业化水平升级。深入开展轻量级、低能耗分布式账本、非对称加密等区块链技术在物联网实际应用部署中的适用性研究。

物联网芯片现状

☐ **MCU + IoT 模组** 比如 STM32F103+ ESP8266

☐ **IoT MCU（通信）** 比如MT26XX（Arm）、 STM32WB(Arm)、CC2530 (8051)

☐ **RISC-V IoT MCU** 比如 ESP32-C3(RISC-V)， Hi3861 （RISC-V）

☐ **AIOT SoC (32位)** 比如 BL606P, RISC-V + 5合一 多模 IoT，启英泰伦
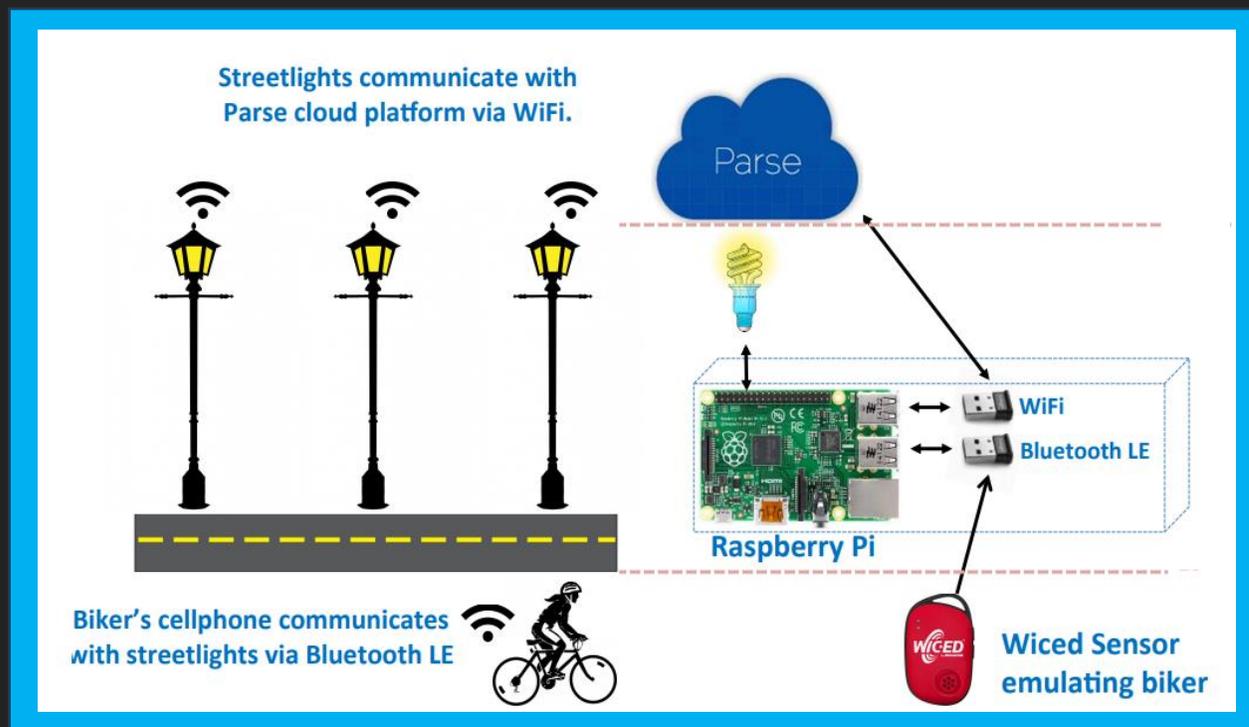
☐ **AIoT SoC （64位）** 比如 嘉南K210/230 ,瑞芯微、全志

物联网软件开发工具的现状
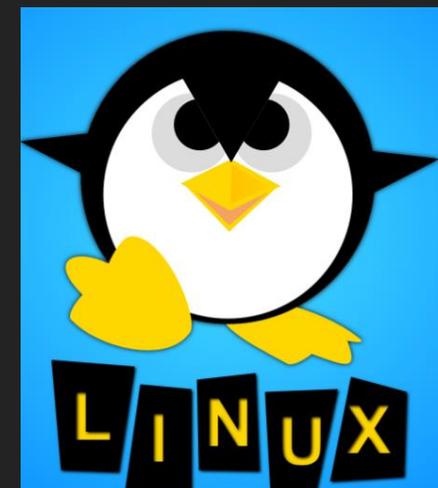
传统的物联网开发模式- 网关

☐ 选择IoT 开发板
☐ 开发板固件开发
☐ 嵌入式操作系统适配
☐ 云端的连接
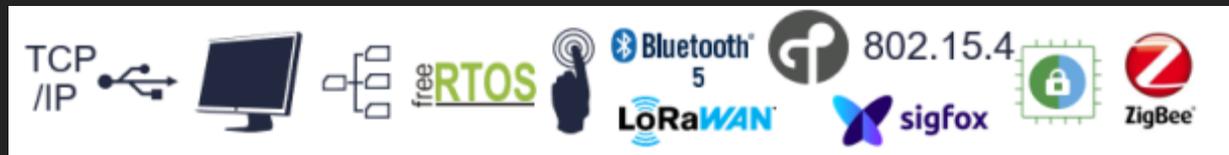☐ 云平台物和设备适配管理
☐ 云端的数据处理和展示

传统的物联网开发模式 – 手机

□ 选择IoT 开发板
□ 开发板固件开发
□ 云端的连接（BLE)
□ 手机APP或者微信小程序
□ 数据处理和展示

物联网开发的难点

□ 物联网应用的碎片化
□ 种类繁多的传感器
□ 各种无线和有线连接方式
□ 众多的公用和私有云
□ 日益严重安全隐患
□ 加速增长的边缘智能需求

IoT产业发展需要物联网OS

□ IoT市场在不断增长。2020年，IoT联网设备（如：智能网联汽车、智能家居、工业联网终端）的数量首次超过非IoT联网设备（如：智能手机、笔记本电脑和台式机）。

□ 2020年底，全球217亿个活动联网设备中，IoT设备达到117亿（占比约54％）。到2025年，预计将有超过300亿的IoT连接，全球平均每人将近4台IoT设备。

□ 物联网时代对操作系统提出新要求：
　　□**安全性、端云结合、低功耗、多平台和分布式**

□ 没有统一物联网的操作系统，导致物联网软件迭代慢、成本高，生态闭塞。软件开发重复性大，成为制约物联网发展的重要因素之一。

PC时代有Windows OS 、移动互联网时代有Android 和IOS，为什么物联网时代没有一种物联网操作系统呢?

什么是物联网操作系统?

- **管理物的能力**
  - "物"是"嵌入式实时的低功耗传感器设备"。
- **泛在的通信能力**
  - 支持各种无线和有线,近场和远距离的通信协议。
- **设备管理和维护**
  - 支持设备的安全动态升级和远程维护。
- **物联网安全**
  - 物联网安全包含设备、通信和云安全,具备防御外部安全入侵和篡改能力,具备安全认证和授信的功能。
- **物联网云和边缘计算**
  - 通过云平台完成远程设备管理,数据存储、分析和展示,安全控制和业务支撑,设备端逐渐导入人工智能处理能力。

如何让IoT 开发更便捷?

以 RT-Thread 为例- 丰富的IoT 组件

```
    RT-Thread Kernel   --->
    RT-Thread Components  --->
    RT-Thread online packages  --->
    Hardware Drivers Config  --->
```

```
[*] mbedtls: An portable and flexible SSL/TLS library  --->
[ ] libsodium: A modern and easy-to-use crypto library (NOT Recommended for MCU. Use lib
[ ] libhydrogen: A lightweight, secure, easy-to-use crypto library suitable for constra
[ ] TinyCrypt: A tiny and configurable crypt library  ----
[ ] TFM: Trusted firmware for M class (NEW)  ----
[ ] yd_crypto: Encryption and decryption algorithm library for microcontroller. (NEW)
```

```
--- AT DEVICE: RT-Thread AT component
[ ]     Quectel M26/MC20 (NEW)  ----
[ ]     Quectel EC20 (NEW)  ----
[ ]     Espressif ESP32 (NEW)  ----
[*]     Espressif ESP8266  --->
[ ]     Realthread RW007 (NEW)  ----
[ ]     SIMCom SIM800C (NEW)  ----
[ ]     SIMCom SIM76XX (NEW)  ----
[ ]     Notion MW31 (NEW)  ----
[ ]     WinnerMicro W60X (NEW)  ----
[ ]     Ai-Think A9G (NEW)  ----
[ ]     Quectel BC26 (NEW)  ----
[ ]     luat Air720 (NEW)  ----
[ ]     Gosuncn ME3616 (NEW)  ----
[ ]     ChinaMobile M6315 (NEW)  ----
[ ]     Quectel BC28 (NEW)  ----
[ ]     Quectel EC200T/EC200S (NEW)  ---
```

```
[ ] LoRaWAN_Driver : Support for LoRaWAN Network(Semtech) (NEW)  ----
[*] Paho MQTT: Eclipse Paho MQTT C/C++ client for Embedded platforms  --->
[ ] umqtt: A light weight, powerful, customizable, easy-to-use and embeddable mqtt clien
[ ] WebClient: A HTTP/HTTPS Client for RT-Thread  ----
[ ] WebNet: A lightweight, customizable, embeddable Web Server for RT-Thread  ----
[ ] mongoose: Embedded Web Server / Embedded Networking Library  ----
[ ] MY MQTT: Eclipse Paho MQTT C/C++ client, A new efficient and stable way to realize f
[ ] kawaii-mqtt: a mqtt client based on the socket API, support QoS2, mbedtls. (NEW)  --
[ ] BC28 MQTT: connect to Aliyun with Quectel BC28 model (NEW)  ----
[ ] WebTerminal: Terminal runs in a Web browser  ----
[ ] FreeModbus: Modbus master and slave stack  ----
[ ] nanopb: Protocol Buffers for Embedded Systems  ----
    Wi-Fi  --->
[ ] CoAP: A C implementation of the Constrained Application Protocol  ----
[ ] nopoll: A OpenSource WebSocket implementation (RFC 6455) in ansi C  ----
[ ] netutils: Networking utilities for RT-Thread  ----
[ ] cmux: connection multiplexing protocol for RT-Thread, support GSM0710 .etc (NEW)  --
```

以 RT-Thread 为例- 丰富的外设

```
IoT - internet of things  --->
security packages  --->
language packages  --->
multimedia packages  --->
tools packages  --->
system packages  --->
peripheral libraries and drivers  --->
AI packages  --->
Signal Processing and Control Algorithm Packag
miscellaneous packages  --->
```

```
[ ]  GT9147 touch driver package.  ----
[ ]  GT1151 touch driver package.  ----
[ ]  GT917S touch driver package.  ----
[ ]  GT911 touch driver package.  ----
[ ]  FT6206 touch driver package.  ----
[ ]  FT5426 touch driver package.  ----
[ ]  FT6236 touch driver package.  ----
[ ]  xpt2046 touch driver package  ----
[ ]  Please add description of cst816x in English.
```

```
[ ]  Using ENC28J60 SPI Ethernet network interface (NEW)
[ ]  Using RW009/007 SPI Wi-Fi wireless interface (NEW)
-*- Using Watch Dog device drivers
[ ]  Using Audio device drivers
[*] Using Sensor device drivers
[*]   Using Sensor cmd (NEW)
[ ]  Using Touch device drivers
```

```
[ ] LSM6DSM sensor driver package, support: accelerometer, gyroscope, step, temperatur
[ ] LSM6DSL sensor driver package, support: accelerometer, gyroscope, step.  ----
[ ] LPS22HB sensor driver package, support: barometric,temperature.  ----
[ ] HTS221 sensor driver package, support: temperature, humidity.  ----
[ ] LSM303AGR sensor driver package, support: accelerometer, magnetometer.  ----
[ ] BME280 sensor driver package, support: barometric, humidity.  ----
[ ] BME680: Digital 4-in-1 sensor with gas, humidity, pressure and temperature.  ----
[ ] BMA400 sensor driver package, support: accelerometer, step.  ----
[ ] BMI160/BMX160: Digital 6-axis and Digital 9-axis sensor  ----
[ ] SPL0601: Digital pressure sensor  ----
[ ] MS5805: Digital pressure sensor  ----
[ ] DA270 sensor driver package, support: accelerometer.  ----
[ ] df220 sensor driver package, support: force sensor.  ----
[ ] hshcal001 sensor driver package, support: temperature, humidity.  ----
[ ] bh1750 sensor driver package, support: ambient light.  ----
-*- mpu6xxx: Universal 6-axis sensor driver package,support: accelerometer, gyroscope.
-*- AHT10: digital humidity and temperature sensor driver  --->
[ ] ap3216c: a digital ambient light and a proximity sensor ap3216c driver library.  -
[ ] TSL4531: a digital ambient light and a proximity senseor tsl4531 driver library.
[ ] DS18B20 sensor driver package,support: temperature.  ----
[ ] dht11: Digital temperature and humidity sensor(Single bus)  ----
[ ] DHTxx one-wire digital temperature and humidity sensor.  ----
```

```
> scons --target=mdk5
scons: Reading SConscript files ...
```

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以 RT-Thread 为例-方便的云连接

```
    RT-Thread Kernel  --->
    RT-Thread Components  --->
    RT-Thread online packages  --->
    Hardware Drivers Config  --->
```

```
(2048) Set main thread stack size
(10) Set main thread priority
    C++ features  --->
    Command shell  --->
    Device virtual file system  --->
    Device Drivers  --->
    POSIX layer and C standard library
    Network  --->
    VBUS(Virtual Software BUS)  --->
    Utilities  --->
[ ] Using light-weight process
```

```
[ ] Application of AT Command on ZigBee Coordinato
    IoT Cloud  --->
[ ] NimBLE:An open-source Bluetooth 5.0 stack port
```

```
-*- Enable AT commands
[ ]     Enable debug log output (NEW)
[ ]     Enable AT commands server (NEW)
-*-     Enable AT commands client
(1)     The maximum number of supported clients (NEW)
-*-     Enable BSD Socket API support by AT commnads
[*]     Enable CLI(Command-Line Interface) for AT commands (NEW)
[ ]     Enable print RAW format AT command communication data (NEW)
(128)   The maximum lenght of AT Commonds buffer (NEW)
```

```
[*] OneNET: China Mobile OneNet cloud SDK for RT-Thread  --->
[ ] GAgent: GAgent of Gizwits in RT-Thread  ----
[ ] Ali-iotkit: Aliyun cloud sdk 'iotkit-embedded' for RT-Thread
[ ] Azure IoT SDK: Microsoft azure cloud SDK for RT-Thread  ----
[ ] tencent-iot-sdk:  Tencent Cloud IoT Explorer Platform SDK fo
[ ] jiot-c-sdk: JIGUANG IoT Cloud Client SDK for RT_Thread  ----
[ ] ucloud_iot_sdk: Ucloud iot sdk for uiot-core platform.  ----
[ ] Joylink Cloud SDK for IoT platform  ----
[ ] ez_iot_os: Ezviz Cloud IoT SDK for RT-Thread.  ----
[ ] IoTSharp-C-SDK: IoTSharp Client SDK for RT_Thread  ----
```

```
--- ota_downloader: The firmware downloader which using on RT-Thread OTA component
[ ]     Enable OTA downloader debug (NEW)
[ ]     Enable HTTP/HTTPS OTA (NEW)
[*]     Enable Ymodem OTA (NEW)
        Version (latest)  --->
```

RT-Thread物联网操作系统实例

AI+IoT 引爆边缘智能

☐ 今天人工智能（AI）技术与物联网（IoT）快速的集成。这种集成设备可以是连接到互联网的AIoT终端、边缘和服务器设备，如智能家居和工业设备实时收集、分析和处理数据。

☐ 人工智能和物联网的结合可以实现广泛的应用，包括预测性维护、自动化决策的改进。未来AIoT设备应用将非常的广泛，很多预测认为AIoT对嵌入式芯片的需求将会增加一个数量级，达到数千亿颗。

☐ "轻"智能时代渐行渐近
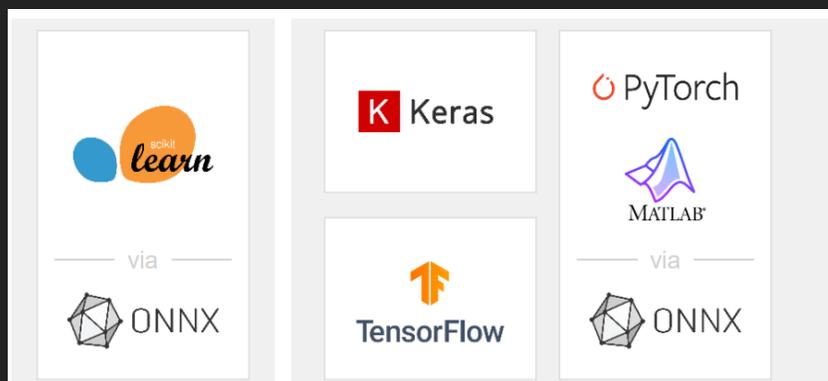 ☐ Cortex A MPU ➡ Cortex M MCU
  ☐ Linux ➡RTOS

嵌入式AI的开发方法-专家型

☐ 自带模型和数据开发方式
    ☐ 开发者自己训练模型（BYOM）– 需高算力和技能
    ☐ 开发者自己提供数据(BYOD) - 需数据处理和筛选能力
    ☐ 开发者具备TensorFlow 和 Python 编程能力
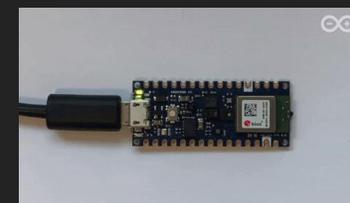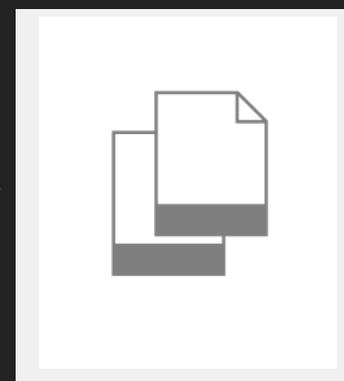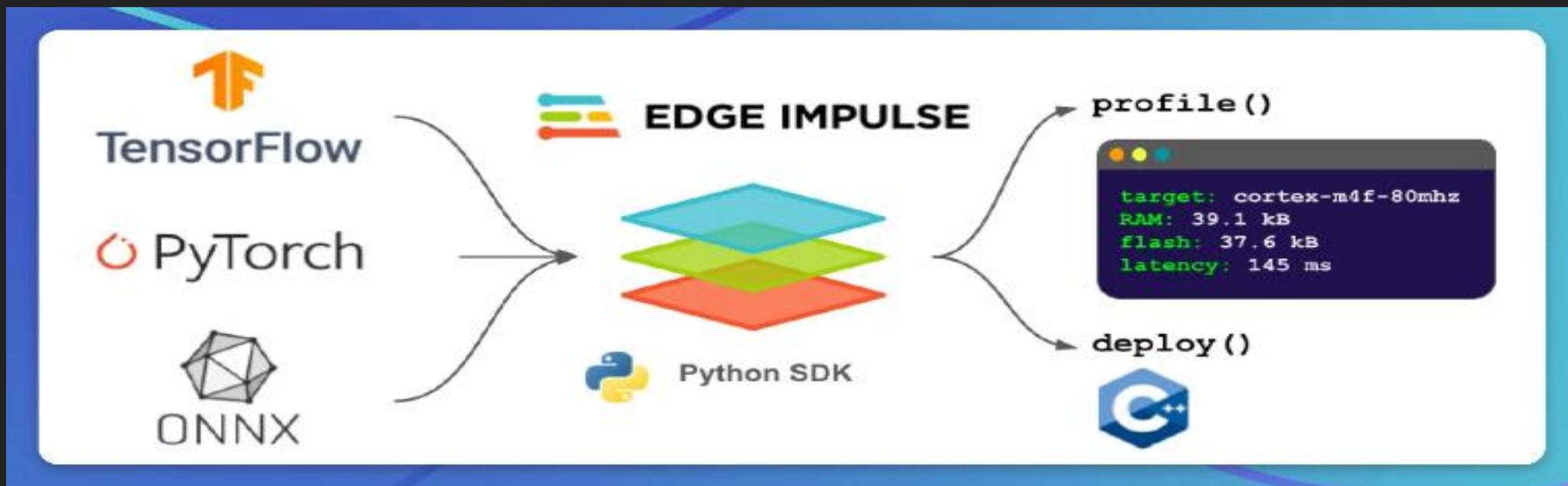

导入已经训练好的神经网络模型

优化和验证
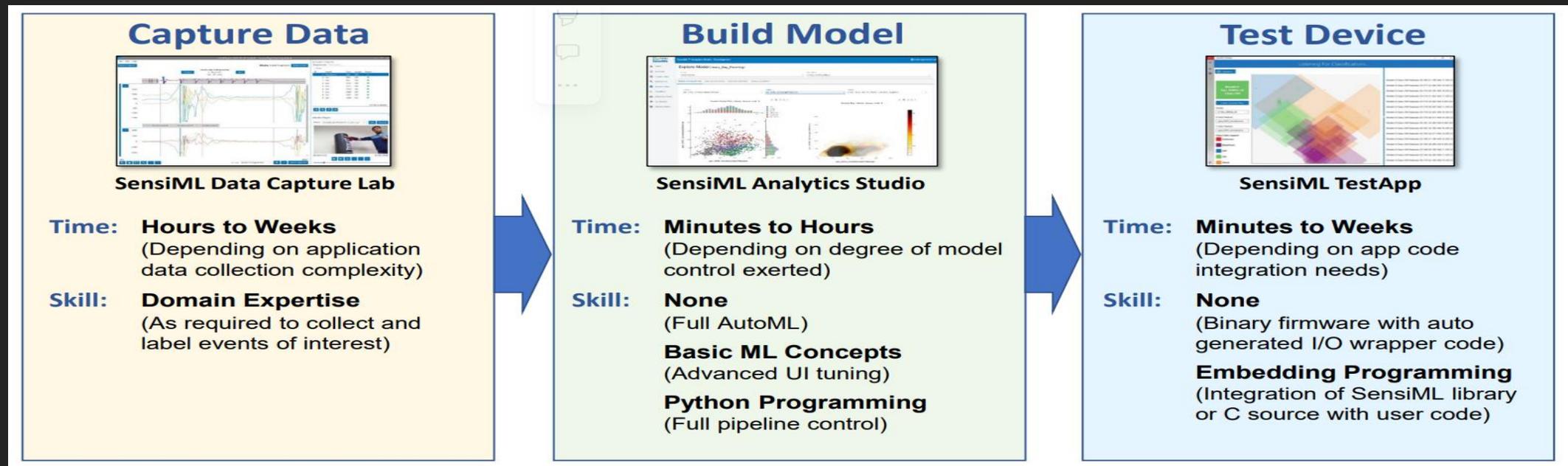你的神经网络模型

生成在MCU运行的优化的代码

嵌入式AI的开发方法 - 工具型

- ❑ 机器学习工具与方案
  - ❑ 方案提供商，如Reality AI（瑞萨）、Edge Impulse、Cartesiam（ST)、SensiML (QuickLogic), Sensory AI 等
  - ❑ 多数工具对语音模型和命令有较强识别能力，对运动有一定识别，对映像识别能力较弱。

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以 RT-Thread 为例-AI 的入门开发

```
IoT - internet of things   --->
security packages   --->
language packages   --->
multimedia packages   --->
tools packages   --->
system packages   --->
peripheral libraries and driver
AI packages   --->
Signal Processing and Control A
miscellaneous packages   --->
```

```
[ ] libann: a light-weight ANN library, capable of training, saving and loading models.
[ ] NNoM: A higher-level Neural Network framework on Microcontroller ----
[ ] onnx-backend: Open Neural Network Exchange backend on RT-Thread ----
[ ] onnx-parser: Open Neural Network Exchange model parser on RT-Thread ----
[*] Tensorflow Lite Micro: a lightweight deep learning end-test inference framework for
[ ] elapack: linear algebra library for embedded devices, compatible with matlab. ----
[ ] ulapack: linear algebra library for embedded devices. ----
[ ] quest: A simulator of quantum computers on MCU. (RTC required) ----
[ ] A C++ Constraint Programming Library ----
```

```
--- Tensorflow Lite Micro: a lightweight deep learning end-test inference framework for
     Version (latest)  --->
     Select Offical Example (No Tensorflow Lite Micro Example)  --->
     Select Tensorflow Lite Operations Type (Using Tensorflow Lite CMSIS NN operations)
```

基于 STM32H743ZI-Nucleo 开发板，使用 STM32CubeMX.AI 工具。基于训练好的 AI Model (仅限 Keras/TF-Lite)，自动生成嵌入式项目工程(包括MDK、STM32CubeIDE 等)。

小结

- IoT 快速发展已经无处不在，IoT 芯片越来越复杂，开发难度越来越大。
- IoT OS 简化开发难度，帮助从开发者"**嵌入式**"向"**IoT**"转换。
- AI+ IoT 快速形成 AIoT 应用，统一平台应对碎片化挑战
  - RISC-V 正在挑战 Arm 和X86 领导力 (**IoT 芯片RISC-V化**)
  - AI 的渗透力极大，端侧AI成为竞争新高地 （**MCU AI 化**）
  - RTOS 与 Liunx 在融合 – RTOS Linux 化，Linux 实时化，二者**混合布署**
- **组件化、虚拟化、标准化**应对复杂的AIOT 芯片和应用。

感谢您的聆听

答疑环节
Q&A

哔哩：麦克泰教育

嵌入式系统专家之声

物联网操作系统公开课