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2022 Synopsys ARC AIoT Design Contest - 決賽作品

Foodie Fortress

智慧冰箱管理系統

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709 KINGS of BOARDS

User Pain Point

你的共用冰箱是不是有這種問題？

不小心誤吃到
別人的食物

被遺忘的食品
佔據空間、腐敗

出門購物時
忘記要添購的食材

FoodieFortress 智慧冰箱管理系統

“ AI+IoT技術保護食品歸屬，記錄存取紀錄，提醒食品新鮮度
解決共用冰箱誤取、過期食品和食材選購的問題。

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Agenda

1. System Introduction
2. Model Overview
3. System Architecture
4. Conclusion

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1. System Introduction

System Features

Food Classification

Use **CV model** to classify the food and keep record in DB.

Dash Board Display

Intergrate with DB and use **Line Bot** as **User Interface,** help user keep track on their own food.

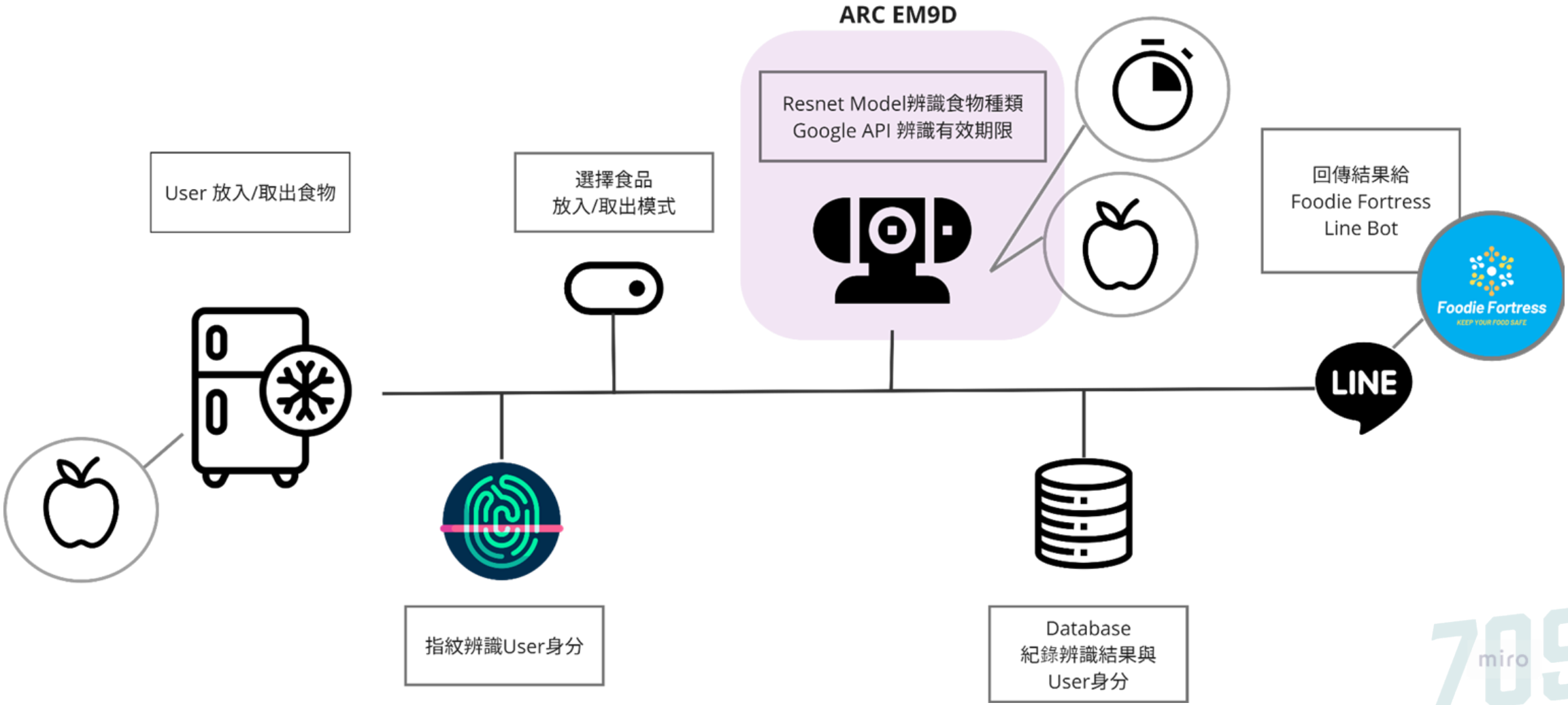
Expire Food Notification

Use **Google Vision (OCR) API** to detect expire date, notify user when the food goes bad.

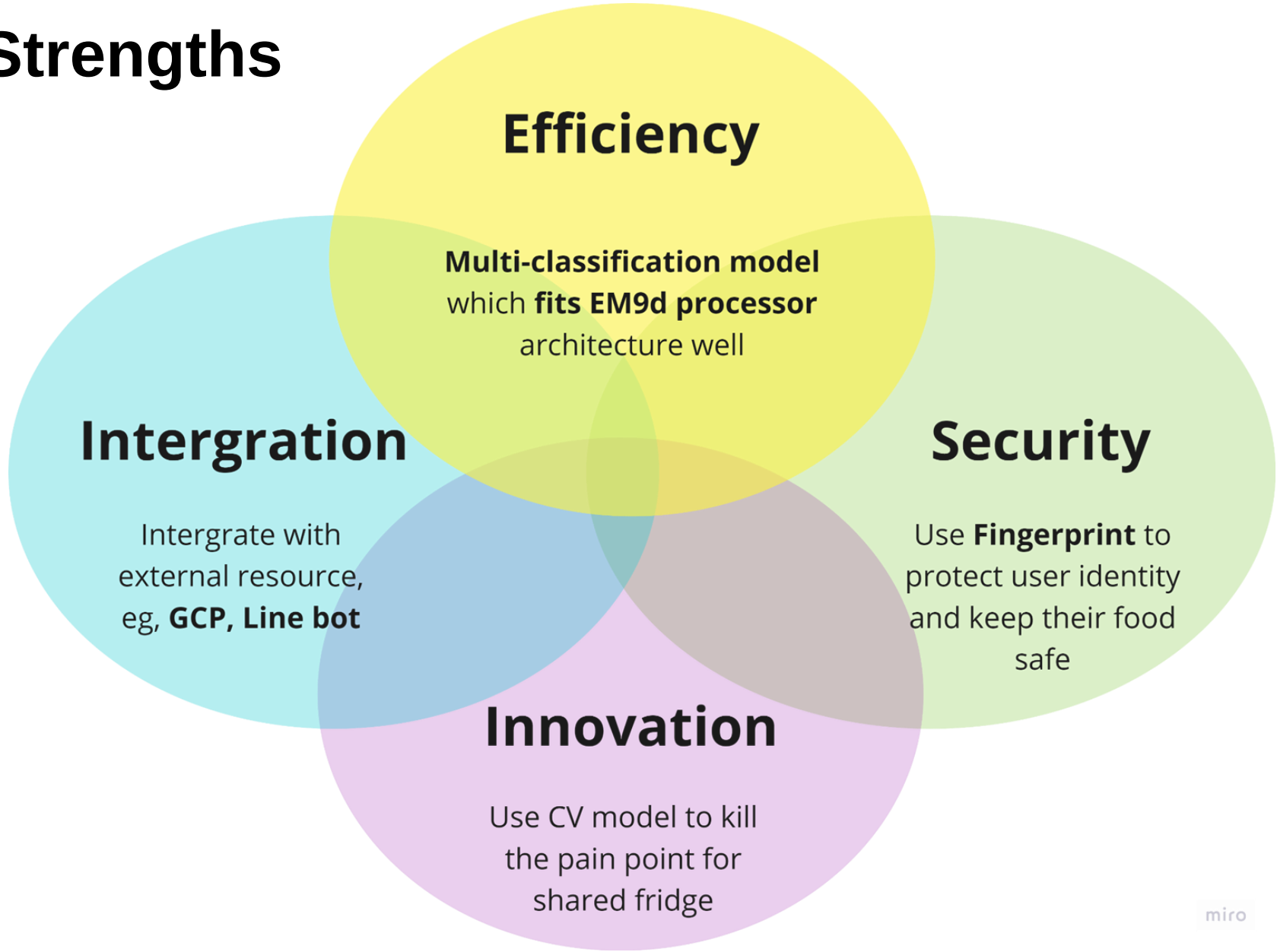
User Authentication

Use **Fingerprint** and Line bot **token** to authenticate a user.

System Process



System Strengths



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2. Model Overview

Food Classification Model

Dataset ：Fruits360 + Self-generated dataset

1. 以資料集為Fruits360為基礎
   - Kaggle public dataset, over 2600 upvote fruit pictures
   - Take 10 class as below, and ~440 pictures for each class：

     Apple

     Banana

     Corn

     Eggplant

     Guava

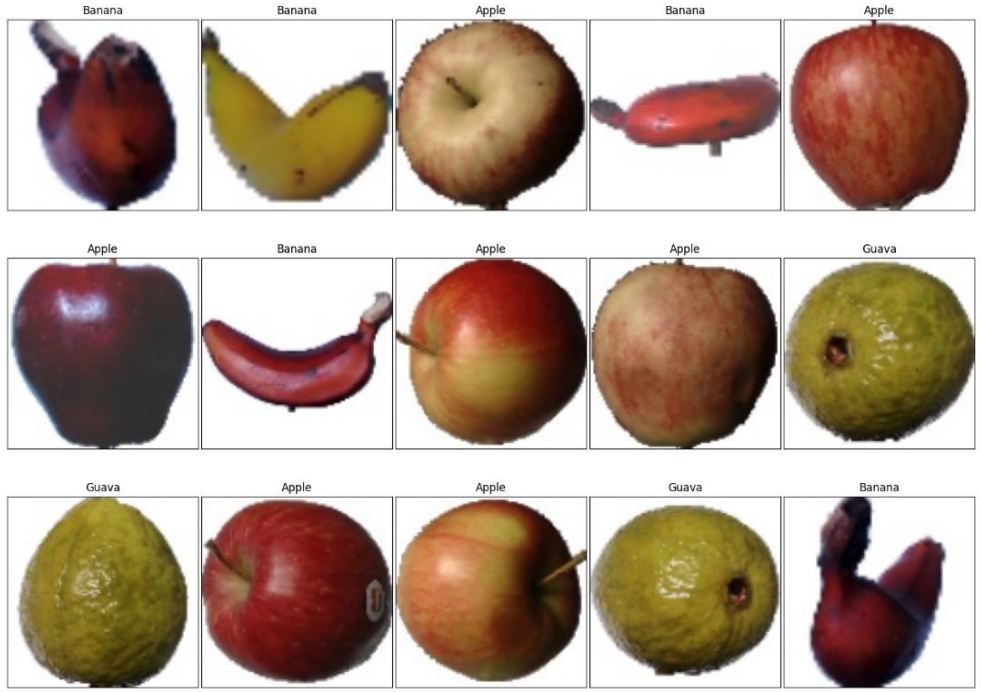
     Lemon

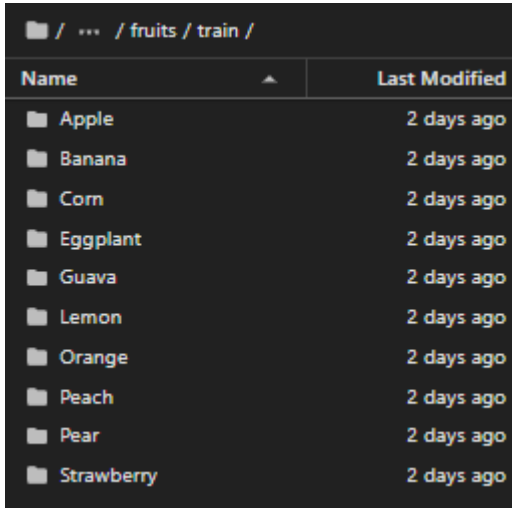
     Orange

     Peach

     Pear

     Strawberry

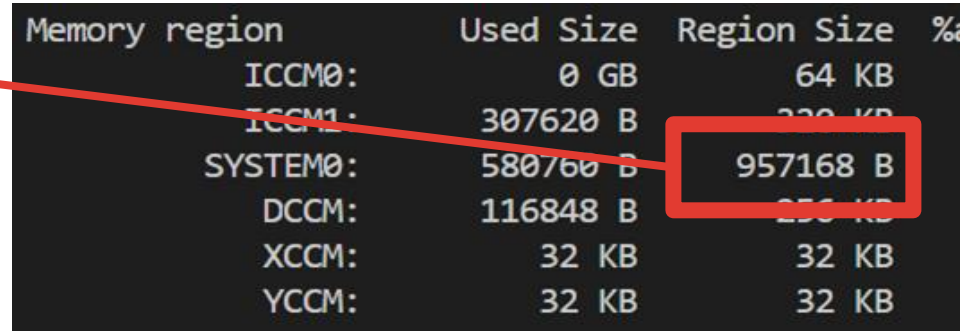




Difficulties

1. **Memory Limitation**：System0 < 957168 B

   困境：大部分CV model 參數太多



1. **Low muli-class accuracy**：

   困境：黑白圖片難以達成食物辨識的多種Class分類

→ **Custom ResNet Model**

Classic CV Model Comparison

```
evaluate accuracy on tflite: 43.000000007 %
```

	Yolov8-cls	Custom CNN Sequential	Custom-ResNet
Total Parameters	~2.7M	~50K	~70K
Tflite Accuracy	0.92	0.53	0.7

```
Ultralytics YOLOv8.0.123 🚀 Python-3.9.12 torch-2.0.1+cu117 CUDA:0 (NVIDIA GeForce RTX 2080 Ti
YOLOv8n-cls summary (fused): 73 layers, 1443847 parameters, 0 gradients
WARNING ⚠ Dataset 'split=val' not found, using 'split=test' instead.
               classes   top1_acc   top5_acc: 100%|██████████| 5/5 [00:01<00:00,  4.78it/s]
                   all          1          1
Speed: 2.1ms preprocess, 6.1ms inference, 0.0ms loss, 0.0ms postprocess per image
```

```
evaluate accuracy on tflite: 73.58%
```

Preliminary: ResNet

➔ **解決Degradation Problem：**
Convolution層 中間多開了直通連路(Skip Connection)，將每一層的輸出改成 原本學習到的特徵 + 上一層的結果， 解決 Degradation Problem。

➔ **降低學習難度：**

直通連路與卷積層 直接相加而非用連接的方式，將學習目標改為降低殘差(Residual)，降低模型學習難度。

➔ **減少模型參數量：**

殘差塊使用 bottleneck形式， 將3x3卷積核拆成1x1, 3x3, 1x1 卷積核，可以在減少模型參數量的同時兼 顧到更高的維度。

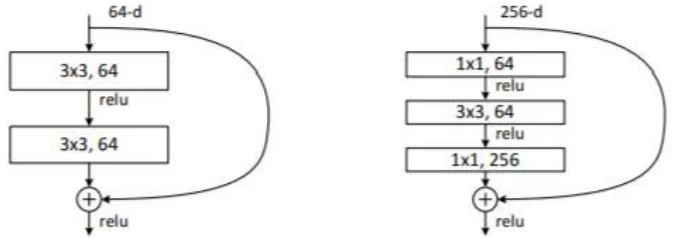


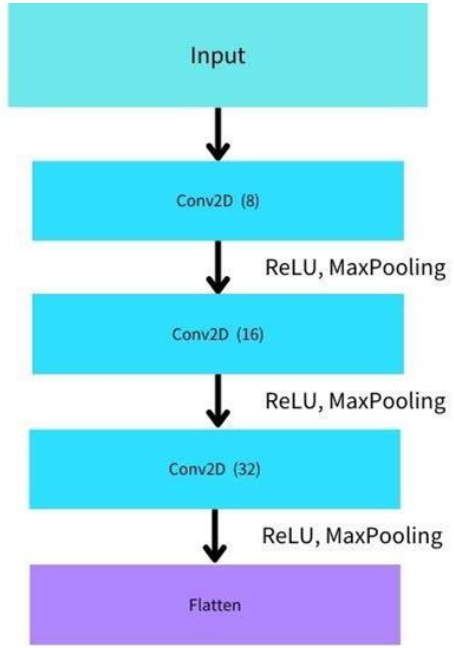
Figure 5. A deeper residual function $\mathcal{F}$ for ImageNet. Left: a building block (on 56×56 feature maps) as in Fig. 3 for ResNet-34. Right: a "bottleneck" building block for ResNet-50/101/152.

Custom ResNet vs. Common Sequential Model

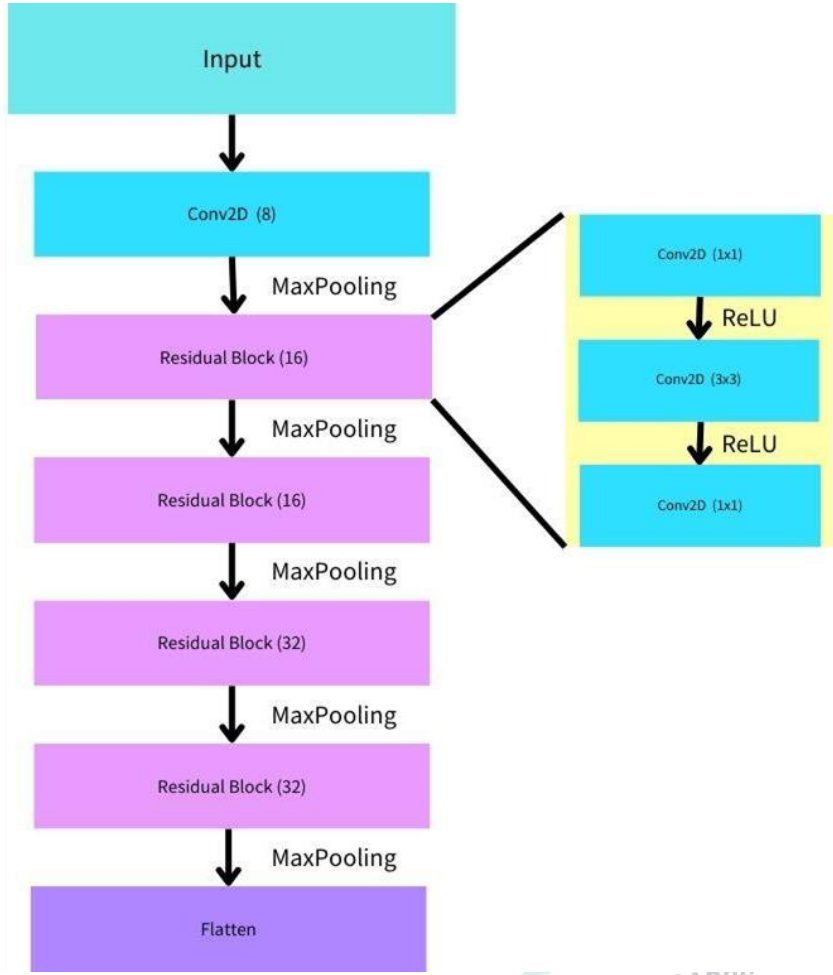
ResNet significantly **improved the accuracy**

with acceptable numbers of parameters.

	Sequential	Custom-ResNet
Total Parameters	**~50K**	**~70K**
Tflite Accuracy	**0.53**	**0.7**



Common Sequential



Custom-ResNet

Hardware Compatibility with EM9D processor

- **Low Latency Three-Stage Pipeline:** Residual blocks can be efficiently executed in a low latency three-stage pipeline due to its relatively shallow depth.

- **Low Power Consumption:** ResNet models, especially those with fewer parameters, can be computationally efficient, which aligns well with the processor's goal of achieving low power consumption.

source: ARC EM9D and EM11D RISC + DSP Processors datasheet

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3. System Architecture

Hardware Architecture

ARC EM9D AIoT DK

Web Camera

USB 3.0

UART

光學指紋感應器

GPIO control

Raspberry pi 4

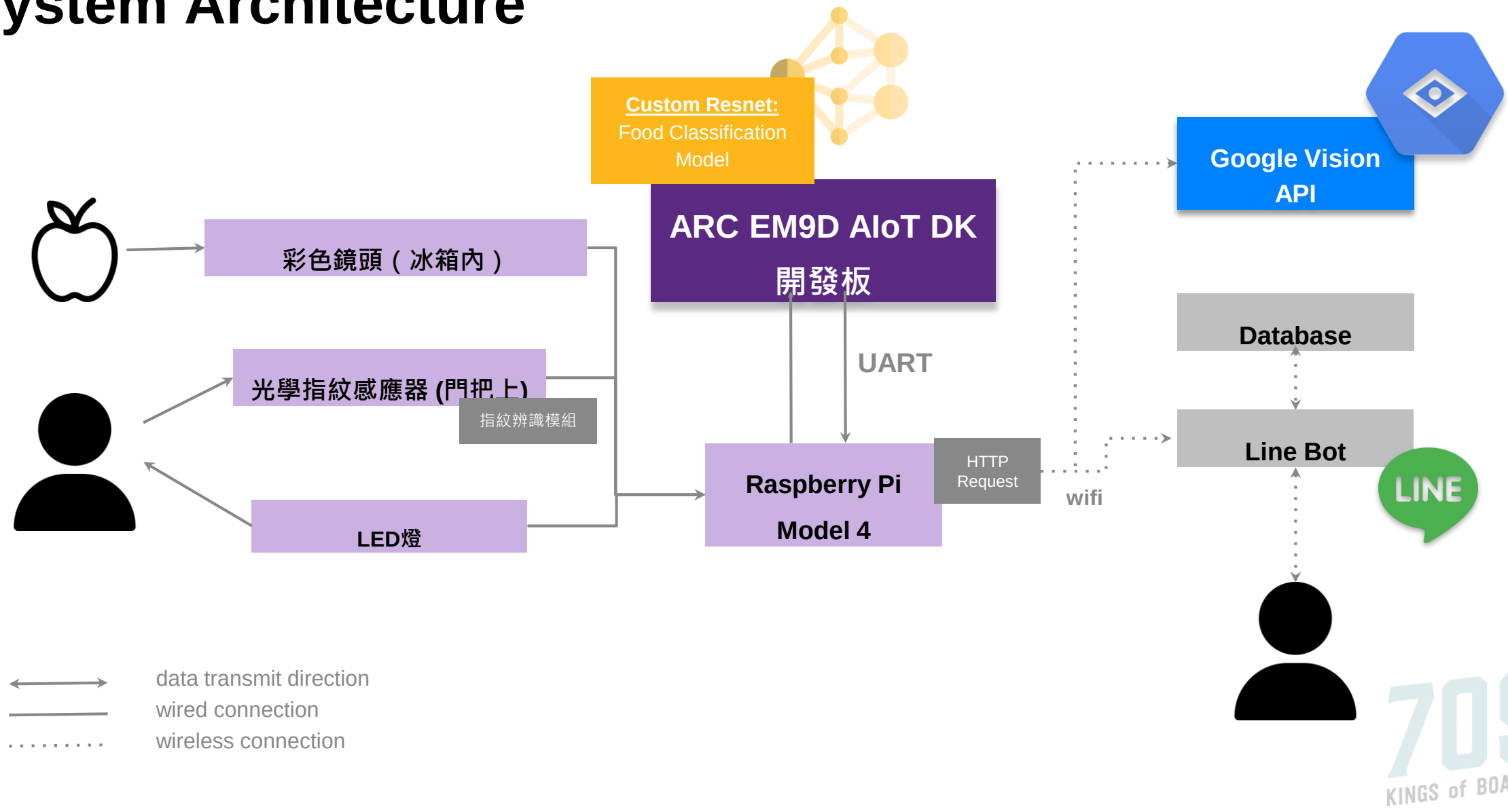
GPIO control

GPIO control

LED 燈

兩段式開關

System Architecture



Hardware Spec

1. ARC EM9D AIoT DK 開發板
2. 光學指紋感應器：AS608 Optical Fingerprint Reader Sensor Module
3. 食品影像辨識鏡頭：Logitech c310 webcam
4. Raspberry Pi 4

Software Spec

1. 食品辨識模型
   - CV CNN model：Self-Develop ResNet Model
   - Dataset：Fruits360
2. 指紋辨識模型
3. User Interface：Line Official
4. Database：MySQL Lite

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4. Conclusion

Benefit of FoodieFortress

解決共用冰箱問題

食物不會被亂拿、
不再有過剩食品佔據
空間。

設計Custom Restnet Model

Multi-class的 food classification model，符合Em9d處理器特性

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