The AI-based Waste Classifier on the Rubbish Bin

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Project Introduction

- Community Partner's Problem

The Hong Kong Construction Association, Limited (HKCA) which has over 300 members aimed at improving the construction industry's standard in Hong Kong. They found that disposal of construction and demolition waste has been an increasing concern to the public. They believed one practical method to reduce the waste is to encourage on-site sorting before dumping. However, not a great improvement is observed after the execution of that method.

- Problem Break Down

With the continuous increasing in waste quantity over the years, the construction workers might be the main reason which impedes the implementation of on-site efficient sorting. Three reasons may cause the results:

1. The workers may not be trained well about how to do sorting;
2. They may not have motivation to do waste sorting by themselves;
3. They may not notice the waste is put in wrong place.

- Solution

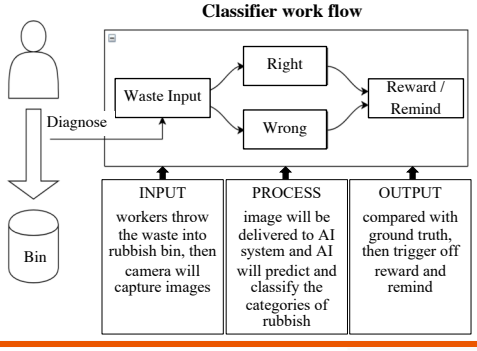
To solve HKCA's problem, the goal is to develop **an AI-Based Waste Classifier** on the Rubbish Bin to monitor waste disposal on-site, and also encourage workers' right behavior by triggering off a reward and reduce improper waste dumping by reminding.

Design of Product and Workflow

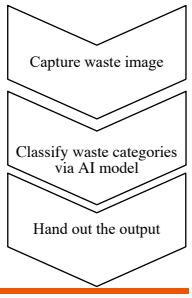
- The Smart Rubbish Bin

1. Can correctly recognize different types of rubbish, e.g., plastic, metal;
2. Can compare with the ground truth and generate signals as feedback;
3. Can trigger off reward and remind.

Classifier work flow



AI: How does the classifier work?



Details of Product

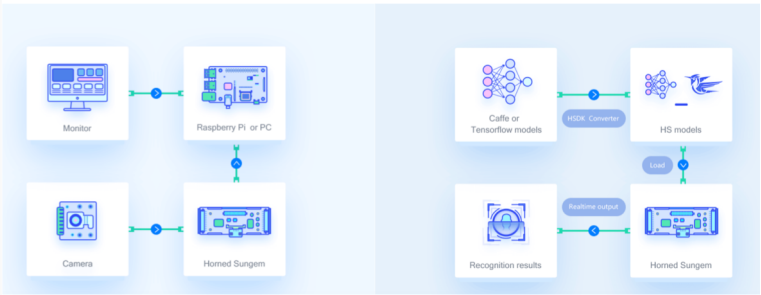
- The hardware support of AI System - Horned Sungem

Plug and AI - Horned Sungem (HS), is one of the simplest and wieldiest AI device to allow all developers to create their own AI applications with ease. Without any dependency on deep learning frameworks or complex libraries, your device will be ready to see and understand the world after you plug HS into the USB port and run a short installation script.

Portable with good performance - Using a unique and integrated front-end design, HS is able to achieve high performance at low power consumption (<3W).Besides, HS development toolkit is based on Python API so it is simple to use and deploy. Most importantly, it's open-sourced and developers can train their own models through popular frameworks and convert them to HS-formatted model to replace existed models.

Horned Sungem

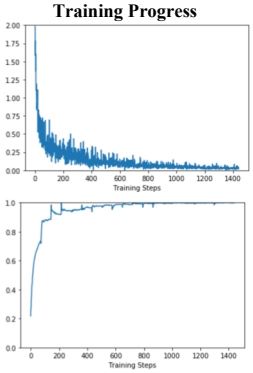
HARDWARE **SOFTWARE**



- The software support of AI System - Image Classification

The AI model is used to recognize the pictures shot from the camera which is installed on the top of the rubbish bin. The state-of-art technology behind the AI model is **Deep Transfer Learning** with pre-trained image classification model. As the computer vision industry has developed in the past decades of years, modern machine learning engineers and scientists have created a lot of models for various needs. Transfer learning helped us create own model for certain requirements by modifying hyper parameters and weights on pre-trained model instead of starting from zero. Indeed, it reduced a lot of training time.

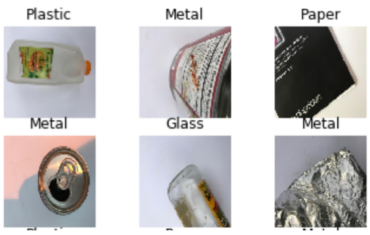
Training Progress



The most popular neural network for image classification task is **Convolutional Neural Network**, shorten as CNN. Among the various CNNs, we chose the MobileNet, which is a family of neural network architectures for efficient on-device image classification and related tasks, with **TensorFlow** Framework. The model is well downloaded into HS board. After image captured from on-board front camera, CPU will perform complex computations and hand out the output.

- **Dataset**: 500 images with 5 classes of waste. (100 for each). Due to small dataset, data argumentation method is applied to increase the amount of training data.
- **Accuracy: 98.99%** at training data, all correct on sample test data.

Demo : Predict and Classify



- Reward and Remind

Compared with ground truth, AI-system will give reward and Remind to workers.

Reflection

- The U-STEMist Scheme

1. This experience enabled us to learn from each other by cooperation and collaboration, and it also strengthened our teamwork ability and awareness.
2. The activities of this scheme were very richful and diversified, and covered various aspects that were either interesting or practical. It let us have a chance to touch the cutting-edge technology, which broadened our horizon.
3. The organizer were very dedicated to make sure the activity to run smoothly. We engaged in the scheme in different ways such as meeting with the community partner, presenting the proposal of the project, doing hands-on experiments and so on.

- The HKCA Project

This project led us to notice the sever issue of improper dumping of construction waste, which matters to our community and environment, and gave us an opportunity to deeply understand the issue from the cause to the solutions. To solve the problem, we went through the whole engineering design process, including gathering information, talking to HKCA representatives to narrow down the scope of problem, brainstorm solutions, choose the feasible option, design the prototype, testing and optimizing the prototype. It was a special experience which provided us a real world project to work on and to apply what we have learned before.

Conclusion and Recommendations

- The prototype of smart rubbish bin shows a possibility to use artificial intelligence in to the construction industry to solve the disposal problem of construction and demolition waste. However, nothing can be changed without the efforts of the frontline workers. A system to improve workers' environmental awareness, to provide sufficient training on on-site sorting and to increase their motivation to actually make the job done should also be well developed.

- Consider the size and accuracy of the prototype, it could be used to train the novice workers to understand the different types of waste and how to sort them. It also can be used to enhance public awareness of environment so that they can act as a third party to supervise the improper dumping of construction waste.

- To use the idea of smart rubbish bin on the working site should consider the size of the bin since the construction waste are always big and heavy. It also requires the system to have higher accuracy to recognize the different types of waste because some of them may combine together and make it hard to tell. Also how to run the AI model without a computer should be considered.