Project Report

Enabling Silicon Harvesting From E-Waste

May 15th, 2021

With the guidance of:

Dr. Reneé Renner

Professor of CSCI 611 - Applied Machine Learning

Composed by:

Alshehri, Feras

Gopal Seenivasan, Keerthana

Jaiswal, Adhaar

Table of Contents

Overview

Silicon shortage is becoming a headline issue for manufacturers that use electronic components. Now is a good time to improve the e-waste recycling process. The ultimate goal remains to incentivize investors and manufacturers to partake in recycling e-waste.

Team Members & Contributions

- **Feras Alshehri:** Overview, problem to address, methods, experiment setup, interpretation of outcomes, challenges, references, project ethics.
- **Keerthana Gopal Seenivasan:** Data Sources, overview, outcomes, challenges, references, project ethics.
- **Adhaar Jaiswal:** project ethics.

Problem to Address

Problem definition

Develop a machine learning model capable of sorting a pile of e-waste based on silicon presence, replying solely on visual input. Items deemed "*Si_positive*" will be processed chemically in another facility/stage where silicon will be extracted.

Project scope

Our solution to the aforementioned problem is limited to the machine learning and computer vision aspects of sorting the e-waste pile. Any other aspects of the complete sorting system, including electro-mechanical or chemical, is not within the scope of this project, and mentioned for context only.

Sub Goals or Objectives / Tasks

1. Explore the possibility of using a simple image classifier.
2. Explore image localization methods to allow for self-supervised object detection.
3. Explore the automation of dataset annotation.
4. Explore semi-supervised object detection models.

Method(s) Deployed

1. Various utility functions to automate fetching datasets and auxiliary scripts.
2. Image classification using Keras' builtin methods.
3. Selective search object localization.

Experiment Setup

1. Colab as a the development environment
2. Keras and Tensorflow as the image classification model framework.
3. OpenCV as the object localization framework.

Challenges

1. Project's nature: Good PCB design practices advocate for the optimization of footprint needed per PCB. This results in images with crowded objects, making it difficult for the ML model to segment and localize PCB components.
2. Area of expertise: The area of this project is an unexplored area, and any available data samples found were poorly adaptable to the project's needs.
3. Data sources: Finding unobstructed top view images of PCBs, and individual pcb components in a single image.
4. Object Detection: Annotation or self-supervised object localization accuracy.
5. Model training: Self-supervised image classifiers performed poorly. This is due to the use of improper model type for the project scope. Image classifiers generally work well with a minimal number of objects per image.

Outcomes / Findings

1. Data Preprocessing - Removed corrupted files and generated a dataset with labels. Created realistic transformations to the training images.
2. Model Training - Got a ~47% validation accuracy.
3. Accuracy Report - Poor training led to inadequate accuracy of true positive and negative predictions.
4. Object localization - High false positives due to image overcrowding with too many existing components.

Interpretation of Outcomes

Benefits/significance of your study

Finding new ways to apply machine learning in unexplored areas can help expose new challenges and promote inventing new machine learning methods from a different perspective. This applies to academic research and the industry.

Implications of your findings

Basic image classification models, and exhaustive object localization methods don't work well on images with more than one object per image.

Strength & weaknesses of method(s) deployed

Image localization using Selective Search method will only work with images that contain a small number of objects in an image with high color contrast.

Status & perceived accuracy & relevance of outcomes

Due to poor training results induced by the challenges aforementioned, the accuracy of the prediction of the image classification model is not close to reliable. Different approaches must be explored to achieve a reliable proof-of-concept.

Next steps

1. Hybrid training dataset
    a. Combine manual and automated methods of object localization to get accurate annotation of training dataset.
2. Experiment with modern, faster, more accurate object detection techniques
    a. RetinaNet, YOLO, or many others.

References

Data Sources

The images were manually collected from varied websites and therefore the image data has been classified manually as negative and positive that contains the pictures in .jpeg format.

Algorithms/Methods Deployed

1. Application of deep learning object classifier to improve e-waste collection planning: https://www.sciencedirect.com/science/article/pii/S0956053X20302105
2. Focal Loss for Dense Object Detection: https://arxiv.org/abs/1708.02002
3. Selective search: http://www.huppelen.nl/publications/selectiveSearchDraft.pdf

Related Works/Tutorials/References

1. Image classification: https://keras.io/examples/vision/image_classification_from_scratch/
2. Object Detection with RetinaNet: https://keras.io/examples/vision/retinanet/
3. Object localization using Selective Search: http://vision.stanford.edu/teaching/cs231b_spring1415/slides/ssearch_schuyler.pdf

Project Ethics

AI in Healthcare - HUMANITY

General overview

Dr. Curtis put Dr.Andrews and Dr.Fei-Fei's inspiration into straightforward words-"It's amazing how wonderful personal experiences with the health system can make those motivations drive those ambitions". The eventual fate of AI in medical care will be sufficiently fit to be valuable, but instead guaranteeing their reception in day by day clinical practice. Despite the fact that AI can give people an incredible alleviation from doing different undertakings, however it can cause a more prominent effect on the positions of individuals that are supplanted by AI.In clinical practice, when it's down to Doctor versus AI, it's liked to be Doctors included AI. Dr.Andrews and Dr.Fei-Fei did spread out significant focuses that may influence mankind:

1.Privacy fairness integrity of research.

2.Data integrity.

3.Ethical design of technology ought to talk directly to the requirement for human dignity.

Tying it to the scope of Harvesting Silicon from E-Waste project, and inspecting the ethical impact of introducing AI/ML in this area, it's a natural next step for this project to create even higher demand for AI and ML engineers to explore new, and optimize existing, methods in e-waste recycling. Once this stage has been unlocked with reliable proof-of-concepts, this can also increase demand for chemical, process, automation, and integration engineering.
As this is an unexplored area, there are no jobs to be lost due to introducing AI/ML in this area.