ARM: Streamlining Recyclable Waste Identification With Highly Scalable Deep Learning Algorithms

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Automated Recyclable Management (ARM) is a synthesis object detection network and affordable hardware prototype designed to automate the process of recyclable waste classification. By employing an EfficientNet backbone as well as a bi-directional feature pyramid network (BiFPN), the anchor-free detection algorithm is able to classify real-time conveyor belt data across 11 unique categories–metal, glass, paper, cardboard, polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), as well as other plastics. Trained on both web-scraped and human generated training images, the lightweight artificial intelligence model achieves extremely high accuracy and proves capable of real-world material recovery facility (MRF) deployment due to the compact architecture and the miniscule likelihood of misclassification. ARM attains a mean average precision (mAP) score of 70.91 when tested on random real-time data previously unseen by the algorithm. Alongside a small scale conveyor belt prototype, ARM achieves state-of-the-art (SOTA) accuracy on test data which exhibits the potential for fully automated sorting within MRFs. As the first ever attempt at automating the waste management process with deep learning, ARM proves extremely capable at significantly reducing the amount of misclassified or contaminated recyclable materials. Additionally, ARM can help to reduce labor costs and safety risks associated with manual sorting in factories, portraying a significant advancement in the cost-effectiveness and sustainability of recycling efforts. With further research and development, ARM has the potential to become a vital tool in the fight against environmental pollution.