Advanced Robotics solutions for Recycling

Introduction

Currently, the United States follows a linear economic model that relies on a “take-make-use-dispose” consumption pattern [1]. The current model is unsustainable because it has a negative impact on the environment. In order to combat the effects of the linear economy it is necessary to move towards a more circular economy, which focuses heavily on reuse. In 2013, only 34.3% of the 243 million tons of municipal solid waste generated in the US were recycled [2]. The first step towards a more circular economy is improving this number. This paper reviews current applications of robotics in recycling plants and how they are making recycling more efficient.

Commercial Robotics Applications in Recycling Plants

There are currently three significant robotic recycling solutions on the market. The first is the ZenRobotics Recycler. This robot was released in 2011 and was the world’s first robotic waste sorter. The ZenRobotics Recycler is used for sorting construction and demolition waste. It works 24/7 and the latest model, which was released in 2017, is able to sort 6000 items per hour with 98% accuracy. The system costs 1.3 million dollars and it able to pay itself off in 1-2 years [3].

Next is a robotic arm called Wall-B. A Spanish company called Sadako released Wall-B into the market in 2016. The Wall-B is used to recover recyclable items from municipal and household waste streams. It is able to pick 1200 items off of the conveyor built per hour and costs $90,000 [4].

The last robotic recycling solution is called Clarke. Clarke is a robotic arm similar to Wall-B. It is the latest robotic recycling solution; released in 2016 by US based company AMP. It is specifically used to identify and pick cartons out of the container line of a recycling plant [5]. The focus is placed on cartons because they can be recycled to make paper products. This product is able to pick 3600 cartons per hour with 90% accuracy. Additionally, it is said to be 50% faster than a human being [6]. The cost of this product could not be found.

All three of these robots can greatly increase efficiency at recycling plants. A human only works 8 hours a day with breaks in between; this amounts to 1000 working hours a year. In contrast, these robots are able to work 24/7, which amounts to 8000 working hours a year [7]. Recycling plants also have the capacity to make money by selling the materials they recover using these robotic solutions. The profit from reselling one ton of metal is $250 while the cost of disposing one ton of metal is $80. As a result the net savings/profit for each ton of metal reclaimed by the ZenRobotics Recycler is $330 [7].

Underlying Technology

All three of these robots rely heavily on Machine Learning and Computer Vision. Computer Vision is used to help the computer “see” what is happening in the world around it and record the information in a meaningful way. Machine Learning looks at the Computer Vision data, learns from it, makes predictions about the world around it, and then translates its predictions into actions [8].

Building Blocks

All three of these solutions depend on a conveyor belt to continually bring a stream of recyclable waste to them. The robot hangs over the conveyor belt and monitors the waste stream using a camera. The camera stream is parsed using Computer Vision. In addition to a camera, the ZenRobotics Recycler also uses a network of sensors to sense the objects it is looking at. Some of the sensors it uses include Near Infrared Spectrum (NIR) sensors, 3D sensors, imaging metal detectors, and Visual Light Spectrum (VIS) sensors [3].

Machine Learning is applied to the data collected via Computer Vision and sensors to determine which objects should be picked out of the stream of waste. Machine learning helps the robots learn patterns over time. For example Clarke is initially able to identify a basic carton. However, over time Clarke is able to train itself to identity other aspects of cartons such as labels, common shapes, colors, and etc. Learning to identify these additional factors allows it to identify cartons even when they are partially covered by other objects or ripped apart. The main goal in employing Machine Learning is to make the machine start applying the same decisions making skills humans apply when they are sorting through items. The predictions made using Machine Learning are used to move the robotic arm and pick the correct object off of the conveyor belt.

Each of the robots uses a slightly different robotic technology to physically pick objects off of the conveyor belt. The ZenRobotics Recycler has to work with items that are more versatile in size, shape, and weight so it uses a robotic arm with a gripping hand attached to it. The gripping hand is able to grip objects between the sizes of ¾ of an inch to 20 inches with a maximum weight of 45 pounds [9]. ZenRobotics Recycler uses Computer Vision and Machine Learning not only to identify and locate objects, but also to determine how wide the grip should expand and where the gripping points are on the object. Wall-B and Clarke both use suction cups to lift things off of the conveyor belt. The objects they pick are relatively small in size and their weight is negligible so a suction cup works well for their applications. The only difference between Clarke and Wall-B is that Clarke has two suction cups to make picking faster while Wall-B has one.

References

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