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The Future Impacts of Robotics on the Environment

According to the International Energy Agency, the US produced 15% of the world's greenhouse gas emissions in 2015, despite only making up 4.3% of the total world population. Decreasing greenhouse gas emissions in the next five to ten years and beyond is crucial for mitigating the effects of climate change, and there are many use cases for robotics that can help achieve this goal. In this whitepaper I discuss how robotics can be used in agriculture, land use and reforestation, and waste recycling, to improve productivity and decrease greenhouse emissions.

Agricultural Robotics:

The EPA estimates that 9% of US greenhouse emissions are from agriculture, and the world food production needs are expected to double by 2050. These emissions are caused by many activities such as fertilizer application, growth of nitrogen-fixing crops, irrigation practices, methane production by livestock, and manure management. Robotics will be an important contributor to decreasing the emissions from the agriculture industry as we scale up production to meet the needs of the growing population. Aerial inspection, ground-based inspection, and transport were discussed in the 2016 U.S. Robotics Roadmap, but there are several other areas that show promise. Automated picking and harvesting systems would help address the costly, long-term labor shortages on farms in the US. Automated warehouse farms could offset some of the emissions from the agricultural industry by decreasing water use, fertilizer leaching, and transportation emissions. There are significant energy costs for powering vertical farms, but these can be offset with renewable energy, or by using full or partial greenhouses to leverage natural light. The data used by these systems could be used to monitor crop growth and soil/water health to determine additional areas for improvement in the future.

Land Use and Reforestation Robotics:

According to the EPA, 11% of the total US greenhouse gas emissions in 2017 were offset by beneficial land-use changes and forestry. While changes in the US and Europe have had the net effect of absorbing CO_2, these are offset by changes in agriculture, forestry, and other land use in the rest of the world that have contributed the equivalent of 8 billion metric tons of CO_2 or 24% of the total global greenhouse gas emissions. A recent paper in Science found that with proper reforestation around the world, the trees could capture 205 billion tons of carbon, roughly two-thirds of the 300 billion tons of extra carbon that exists in the atmosphere as a result of human activity since the Industrial Revolution. This highlights the importance of conscious choices about land use and forestry to increase rather than reduce carbon sequestration. Reforestation is labor intensive and would greatly benefit from advances in automation. Unmanned vehicles that can plant trees in high volume could decrease the need for human labor. Most trees used in reforestation are planted from seedlings but lead times of multiple years for procuring tree saplings make it impossible to reach the necessary volume in a short amount of time. Swarms of unmanned aerial vehicles (UAVs) that can map areas and sow seeds in locations with a high probability of successful germination will increase the ability to reforest quickly and in difficult to reach areas and allow the offset of greenhouse gas emissions from other economic sectors.

Recycling Robotics:

Recycling is important because it reduces the need for raw materials, saves energy, and decreases the pollution caused by harmful chemicals and greenhouse gasses released from waste in landfills. In addition to municipal solid waste such as plastics, metals, and paper, there have been large increases in electronics waste, a trend that is expected to continue. China—the primary purchaser of recyclable materials—banned imports of most scrap plastic in 2017, and significantly decreased the contamination limit for metal and paper from 5-10% to 0.5 percent. Scrap plastic imports immediately dropped 99% from 6.3 million tons in 2017 to 55,000 tons in 2018, and metal and paper imports significantly decreased. This has lowered the value of scrap materials, making recycling financially infeasible in many places. There are therefore many opportunities for the use of robotics to decrease the cost of recycling, and more effectively sort materials to meet stricter contaminant standards. Some material recovery facilities use automated equipment, but many rely on manual sorting, which is dirty, dull, and therefore has high employee turnover rates. Current robotic recycling systems are beginning to be implemented around the world that combine computer vision and industrial arms to pick at speeds of nearly 100 picks per minute compared to the 30-40 picks per minute of a human sorter. The development of technologies that more effectively, identify, sort, and process recyclable materials is a crucial research need in in the next five to ten years. Improvements will lead to higher revenue for materials recovery facilities, better safety, greater efficiency, and a decrease in pollution and landfill use.

The use of robotics in agriculture, reforestation, and recycling are just a few examples of the approaches for automation to address the environmental crisis. There should be a greater emphasis in the 2020 US Robotics Roadmap to highlight the applications, limitations, and research needs in these areas, and I hope to attend the Mid US workshop in Chicago to contribute to discussions on these matters.