Project Title: AI-Enabled Hyperspectral Imaging Augmented with Multi-Sensory Information for Rapid/Real-time Analysis of Non-Recyclable Heterogeneous MSW for Conversion to Energy

Applicant: North Carolina State University

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Project Objectives: The objective of this work is to develop and demonstrate a fully functional Smart MSW management system that combines spectroscopy, computer vision and artificial intelligence that enables spectroscopy/object recognition-based technology for rapid identification and characterization of organic fractions (food, plastic, paper & paperboard, rubber, leather and textile) of MSW in real time.

Project Description: We are proposing to use computer vision and deep learning in combination with visual imaging and hyperspectral imaging for rapid identification and characterization of various organic fractions of MSW to enable the production of conversion-ready feedstock for energy generation. A machine learning visual imaging model (MLVIM) will serve as front-end discrimination of a broader classification of the materials based on shapes and color and a machine learning hyperspectral imaging model (MLHIM) will then identify materials based upon being trained on specific material spectral signatures to obtain intelligently labeled hyperspectral images, augmented by multi-sensory information. The MLHIM will be applied in real time for precise and rapid analyses of shape and chemical composition followed by efficient mechanical sorting to deliver conversion-ready feedstock for production of biofuels and bioproducts.

Methods to be Employed: Deep learning neural networks will be trained to perform chemical based rapid identification and characterization through the combined use of hyperspectral imaging and computer vision of organic fractions (food, plastic, paper & paperboard, rubber, leather and textile) of MSW in real time. Datasets of the chemical composition, calorific value identification and visual characterization will be built from control clean organic fractions as well as contaminated MSW. These datasets will be used to train an AI-driven system designed to provide informed decisions on the overall quality of the detected material, determine its level of contamination, determine the calorific value of the material and which fuel upcycling path it should be redirected toward. This redirection path may then be coupled with a robotic system allowing for proper redirection of the material to the appropriate upcycling path.

Potential Project Impact: Currently, only 38% of MSW is recycled and 12% is used for energy recovery whereas 50% of MSW ends up in landfills. The main challenges that limit the efficient utilization of MSW as a feedstock for fuel production are its heterogeneity, and lack of fast and robust sensing technologies that are capable of detecting and characterizing the MSW components accurately and efficiently. The proposed technology will allow high-throughput characterization of a low-cost heterogenous MSW for the production of conversion-ready feedstock. The technology will allow to recycle >33% of non-recyclable fraction of MSW enabling its valorization to cost-effective and sustainable biofuels, reduction in domestic landfills, and GHG emissions.

Major Participants: North Carolina State University (NCSU), National Renewable Energy Laboratory (NREL), Town of Cary and IBM, Inc.