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Automatic Identification and Classification of Contaminated Biodegradable Plastics using Machine Learning Algorithms and Hyperspectral Imaging Technology

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Abstract : Plastic waste has emerged as a critical global environmental challenge, primarily driven by the prevalent use of conventional plastics derived from petrochemical refining and manufacturing processes in modern packaging. While these plastics serve vital functions, their persistence in the environment post-disposal poses significant threats to ecosystems. Addressing this issue necessitates approaches, one of which involves the development of biodegradable plastics designed to degrade under controlled conditions, such as industrial composting facilities. It is imperative to note that compostable plastics are engineered for degradation within specific environments and are not suited for uncontrolled settings, including natural landscapes and aquatic ecosystems. The full benefits of compostable packaging are realized when subjected to industrial composting, preventing environmental contamination and waste stream pollution. Therefore, effective sorting technologies are essential to enhance composting rates for these materials and diminish the risk of contaminating recycling streams. In this study, it leverage hyperspectral imaging technology (HSI) coupled with advanced machine learning algorithms to accurately identify various types of plastics, encompassing conventional variants like Polyethylene terephthalate (PET), Polypropylene (PP), Low density polyethylene (LDPE), High density polyethylene (HDPE) and biodegradable alternatives such as Polybutylene adipate terephthalate (PBAT), Polylactic acid (PLA), and Polyhydroxyalkanoates (PHA). The dataset is partitioned into three subsets: a training dataset comprising uncontaminated conventional and biodegradable plastics, a validation dataset encompassing contaminated plastics of both types, and a testing dataset featuring real-world packaging items in both pristine and contaminated states. Five distinct machine learning algorithms, namely Partial Least Squares Discriminant Analysis (PLS-DA), Support Vector Machine (SVM), Convolutional Neural Network (CNN), Logistic Regression, and Decision Tree Algorithm, were developed and evaluated for their classification performance. Remarkably, the Logistic Regression and CNN model exhibited the most promising outcomes, achieving a perfect accuracy rate of 100% for the training and validation datasets. Notably, the testing dataset yielded an accuracy exceeding 80%. The successful implementation of this sorting technology within recycling and composting facilities holds the potential to significantly elevate recycling and composting rates. As a result, the envisioned circular economy for plastics can be established, thereby offering a viable solution to mitigate plastic pollution.

Keywords : biodegradable plastics, sorting technology, hyperspectral imaging technology, machine learning algorithms
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