# Development of an Electrical Waste Plastic Sorting System Using Laser-Induced Breakdown Spectroscopy and Convolutional Neural Networks

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**Keywords:** Laser induced breakdown spectroscopy, electronic waste, smart sorting system

With the rapid growth in global consumption of electronic products, the management of waste electrical and electronic equipment (WEEE) plastics has become a critical environmental challenge. According to reports by the United Nations, a record 62 million tons of electronic waste were generated worldwide in 2022, while the global recycling rate remained as low as 22%. Current recycling systems largely rely on manual sorting, which faces significant limitations in efficiency and accuracy when dealing with discarded electronic plastics of complex compositions that often contain hazardous additives. These challenges severely hinder the realization of closed-loop resource recycling.

The objective of this study is to develop an automated intelligent sorting system by integrating laser-induced breakdown spectroscopy (LIBS) with a convolutional neural network (CNN). A total of 256 WEEE plastic samples were collected and classified into six material categories based on their polymer properties: acrylonitrile butadiene styrene (ABS), acrylonitrile butadiene styrene/polycarbonate blend (ABS/PC), polypropylene (PP), polystyrene (PS), poly(methyl methacrylate) (PMMA), and polystyrene/poly(methyl methacrylate) blend (PS/PMMA).

In terms of model development, this study systematically investigated key CNN parameters, including input data representation, spectral matrix construction, the number of convolutional layers, the number of convolutional kernels, and kernel size. The experimental results indicate that when the LIBS spectra were reshaped into two-dimensional matrices of size 79 × 144, and the CNN architecture consisted of three convolutional layers, each with 64 kernels and a kernel size of 3 × 3, the proposed model achieved a classification accuracy of approximately 98% on the test dataset, demonstrating excellent classification performance and robustness.

This study confirms the feasibility of integrating spectroscopic techniques with multidimensional deep learning models for rapid, non-contact sorting of WEEE plastics, and highlights its strong potential as a technological solution for achieving industrial-scale automated recycling.

Keywords: waste electrical and electronic equipment (WEEE), plastic recycling, laser-induced breakdown spectroscopy (LIBS), convolutional neural network (CNN), intelligent sorting.

**Table (a)**、 LIBS parameters

| | 雷射(mJ) | 頻率(Hz) | 射擊次數 |
|---|---|---|---|
| 1 | 150 | 5 | 5 |
| 2 | 150 | 10 | 5 |
| 3 | 100 | 5 | 5 |
| 4 | 100 | 10 | 5 |
| 5 | 50 | 5 | 5 |
| 6 | 50 | 10 | 5 |

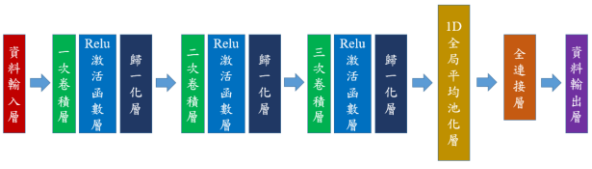


**Figure 1** CNN architecture design flow chart for the study