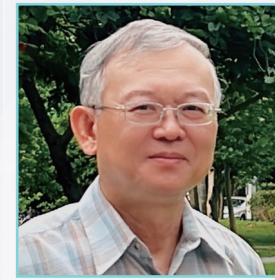# 帳單類別信件的自動辨識與分揀機器人
Automatic Recognition and Sorting Robot for Bill Type Letters

隊伍名稱｜郵務機器人 Postal Robot
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交通大學電子研究所博士，現為中央大學電機工程學系講座教授兼教務長。至今已發表了189篇SCI期刊文章，曾獲IEEE Fellow、國科會傑出研究獎、教育部學術獎等。

研究領域

自動控制、影像處理、模糊理論、AI

✦ 作品摘要 ✦

本作品旨在設計一個針對帳單類別信件的自動郵件分揀系統，此系統可讓使用者將多封郵件不分正反面直接放入個別郵件發放裝置，裝置即會逐封送出至郵件載台，再透過影像處理定位及辨識該封信件之郵遞區號，隨後使用六自由度機械手臂夾取信件送至對應的郵件分類櫃存放。

圖一為系統整體外觀圖，紅框（A）為個別郵件發放裝置及透明郵件載台，整體結構為自行利用向量繪圖軟體設計，由雷射切割機產出並組裝而成。該裝置能暫存多封郵件，並可逐一發送信封至郵件載台上拍攝兩面影像供後續辨識。綠框（B）為一六自由度的機械手臂，在郵遞區號辨識演算法傳送辨識結果後，機械手臂將會夾取該封郵件送至對應的郵件分類櫃，也就是藍框（C）。

圖二為郵遞區號辨識演算法的流程圖，共可大致分為六個部分：（1）辨識信封正反面、（2）辨識信封在郵件載台上的傾斜角度並加以校正、（3）定位及裁切郵遞資訊框（信封透明窗口）、（4）中文字、數字字元分類、（5）利用深度學習網路（ResNet）辨識數字、（6）提取郵遞區號之演算法。其中使用到高斯模糊、高斯雜訊、灰階直方圖轉換等影像增強技術以利模型訓練，以及Canny Edge Detector、Hough Line Transform、Contour-Finding、Dilation等影像處理技術以達成上述各種子功能。

本論文在最後測試實驗中，數字辨識的辨識準確度為99.45%，郵遞區號辨識演算法的辨識正確率為94.6%。透過郵遞區號演算法中的多種錯誤防堵機制，可進一步保持系統最後輸出結果的正確性。實驗結果顯示本作品確實能建立了一套穩定且具有強健性的帳單類別信件自動分揀系統。
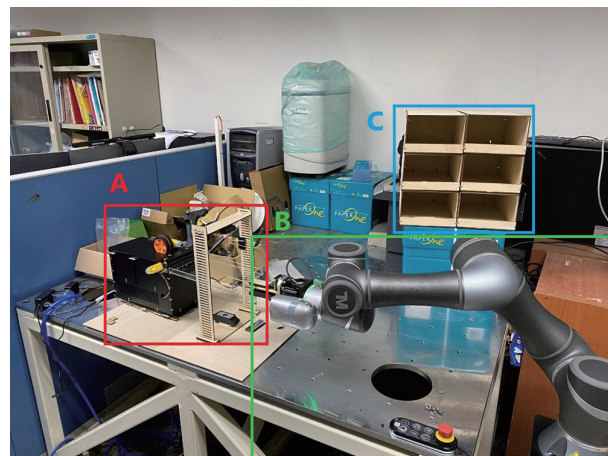
圖一 系統整體外觀圖。
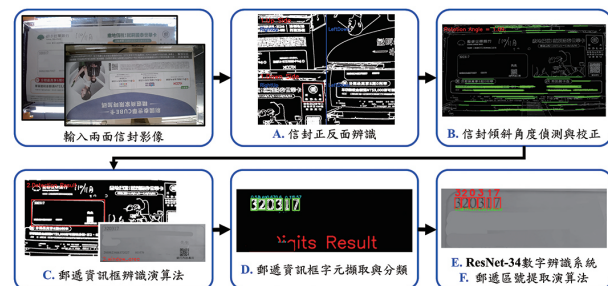
圖二 郵遞區號辨識演算法整體流程圖。

✦ Abstract ✦

This project designs an automatic mail sorting system for bill-type letters, allowing users to insert multiple letters directly into individual mail delivery devices, regardless of orientation. The device sends each letter to the mail platform one by one. Image processing then locates and recognizes the letter's postal code. A six-degree-of-freedom robotic arm subsequently picks up the letter and places it in the corresponding mail-sorting cabinet. Figure 3 illustrates the detailed operation process.

The hardware of the system is primarily divided into three main parts: the individual mail delivery device and transparent mail platform, the mail sorting robotics arm, and the mail sorting cabinet. First, the individual mail delivery device and transparent mail platform, we designed and assembled the structure using vector graphics software with a laser cutting machine. This device temporarily stores multiple letters, sending them one by one to the mail platform to capture images of both sides for recognition. Second, the mail sorting robotics arm, which is a six-degree-of-freedom robotic arm. It picks up the letter after the postal code recognition algorithm transmits the recognition results. Then the letter is placed in the corresponding mail sorting cabinet.

The postal code recognition algorithm can be divided into six parts: (1) recognizing the front and back of the envelope, (2) recognizing and correcting the tilt angle of the envelope on the mail platform, (3) locating and cropping the postal information box (the transparent window of the envelope), (4) classifying Chinese characters and numeric characters, (5) using a deep learning network (ResNet) to recognize numbers, and (6) extracting the postal code. We employ image enhancement techniques such as Gaussian blur, Gaussian noise, and grayscale histogram transformation to facilitate model training. We use image processing techniques like Canny Edge Detector, Hough Line Transform, Contour-Finding, and Dilation to achieve the sub-functions.

In the final test experiments, our number recognition accuracy reached 99.45%, while the postal code recognition algorithm achieved a 94.6% accuracy rate. Various error prevention mechanisms in the postal code algorithm further ensure the correctness of the system's final output. The experimental results confirm that this project successfully establishes a stable and robust automatic sorting system for bill-type letters.
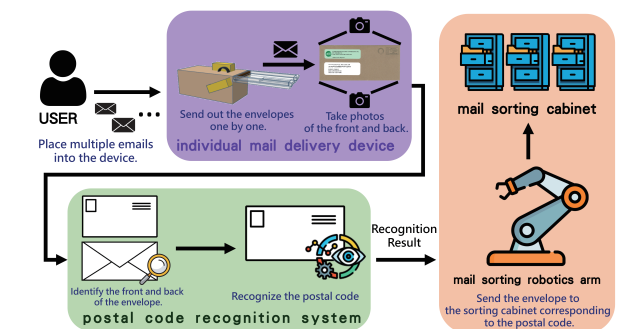
Fig. 3 System operation process.