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Research on Core Algorithms of Desktop Scanning Platform

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Abstract

With the in-depth advancement of informatization and digitalization, the demand for rapid and precise scanning of paper documents in various industries is increasing day by day. Traditional scanning devices have become difficult to meet modern demands in terms of efficiency, accuracy and ease of use. This paper introduces the design and implementation of an artificial intelligence-based desktop scanning platform, which utilizes the powerful machine vision system OpenCV and combines advanced image recognition, enhancement and correction algorithms. Using a personal computer as the hardware platform, the images of paper documents are collected through an external camera. The OpenCV image processing technology is utilized for image segmentation, color correction and shape correction, and ultimately high-quality JPG and PDF format documents are generated. The system also supports contactless scanning and OCR preprocessing, making it suitable for long-distance text recognition and the digitization of precious documents. The research adopts the joint programming of C and OpenCV, designs a user-friendly interactive interface, and realizes automatic correction through edge detection and 3D reconstruction technology. The test results show that the system performs outstandingly in terms of scanning accuracy, efficiency and stability. It is suitable for personal and professional use, especially for the needs of enterprises, educational institutions and government departments.

Keywords

Document scanning; image processing; automatic correction; document digitization

1. Introduction

With the acceleration of informatization and digitization, there is a growing demand across various industries for fast and accurate scanning of documents, images, and other flat objects. For instance, the medical industry needs to scan and analyze medical images, libraries need to digitize their book collections, and enterprises need to electronically archive their documents. Therefore, developing an AI desktop scanning system based on OpenCV image processing can meet the market demand

for efficient and precise scanning systems.

As a powerful image processing software, OpenCV possesses rich algorithms and functions for image processing, enabling efficient image processing, analysis, and recognition. When combined with document camera hardware, it can build a powerful intelligent scanning system.

This research aims to design a desktop scanning platform that utilizes advanced image processing algorithms to overcome the limitations of traditional scanning systems, thereby providing a more accurate and flexible document scanning solution.

2. Mechanical Analysis

The system uses a personal computer as the hardware platform, with an external camera connected to capture images of the scanning target. Through the computer's interactive interface, users can control the camera, issue commands to open the camera for photo capture and display, and close the camera after processing.

The document scanning system is mainly composed of four modules: image acquisition, image preprocessing, image correction, and PDF document generation. The overall scanning system design framework is shown in Figure 1. The software part consists of image processing algorithms and interactive interfaces, performing preprocessing operations including noise reduction, grayscale conversion, and image enhancement on the acquired images. Accurate document areas are obtained through edge detection. Then, affine transformation and projection transformation are applied to the document area to obtain corrected images, which are finally exported as PDF or image documents according to user settings.

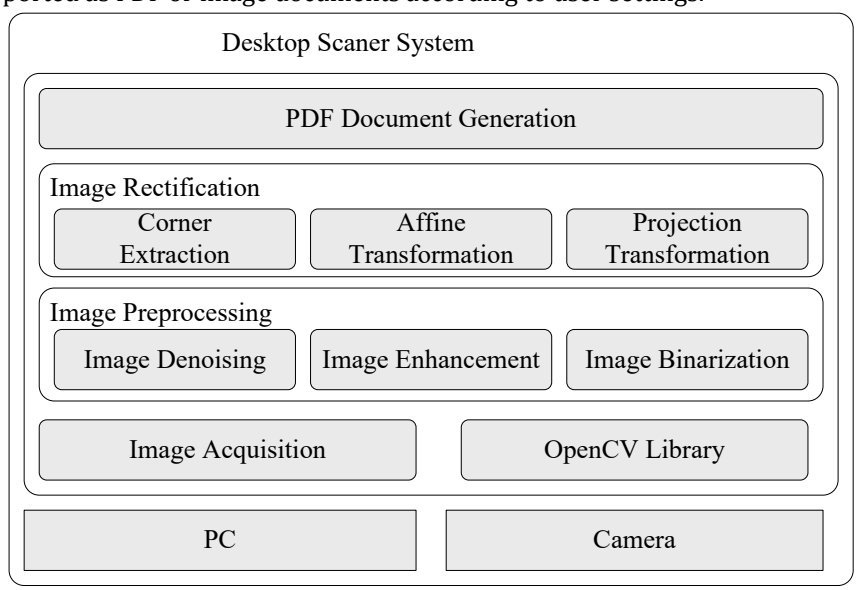


Fig 1. Overall Framework of the System

3. System Implementation

3.1. Image Acquisition

Image acquisition is a necessary task in all image vision processing applications, mainly involving interaction with image acquisition devices. OpenCV supports most image capture cards and IEEE 1394-driven acquisition devices, as well as USB cameras using DirectShow applications. Halcon provides a large number of interfaces for interacting with image acquisition devices, greatly improving the efficiency of image vision processing.

Due to the inconvenience of using the computer's built-in camera for document capture, our system uses an external camera instead. This camera features 1080P 60fps high-definition resolution and can be connected to the computer via USB interface, meeting daily requirements.

3.2. Image Preprocessing

The captured images are affected by external factors such as uneven lighting, spots, and camera delay, resulting in noise in the captured images and affecting subsequent image processing. To eliminate these interferences, certain preprocessing is required for the images. The preprocessing in this system mainly includes three parts: noise reduction, image graying, and image enhancement.

1. Image denoising: As edge detection will be performed next, it is necessary to maintain complete edge information while achieving good denoising effect. Therefore, this system adopt median filtering for image denoising processing. Median filtering can preserve better edge contour information while denoising.

2. Image Grayscale ConversionIn this system, we adopt the weighted average method for grayscale conversion. Compared to other methods, the weighted average method performs better in detail preservation, noise removal, and local over-brightness control. This algorithm converts the RGB color values of each pixel into a single grayscale value, where the red, green, and blue channel values are added together with different weights to generate the grayscale value.

$$\text{Gray} = 0.299 \times \text{Red} + 0.587 \times \text{Green} + 0.114 \times \text{Blue} \quad (1)$$

3. Image enhancement: The grayscaled image undergoes image enhancement processing to scale the image gray values and expand the image contrast. According to the application scenario of this system, an adaptive linear transformation method is adopted for image enhancement. The slope 'a' and offset 'b' of pixel mapping in the transformation are automatically calculated according to formulas (2) and (3).

$$a = 255/(G\_max - G\_min) \quad (2)$$

$$b = -a \times G\_min \quad (3)$$

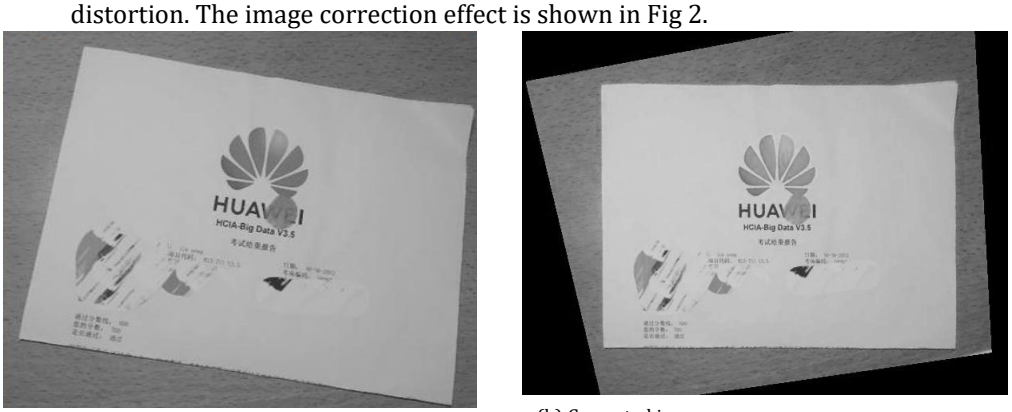
Where G_max and G_min represent the maximum and minimum gray levels in the image.

3.3. Image Correction

Images may become distorted or tilted due to environmental factors or human influence during the shoot, which can cause inconvenience when viewing. This system employs edge detection and projection transformation techniques to obtain high-quality electronic documents. The image correction module consists of contour extraction and image projection transformation.

After determining the document's position in the image through edge detection, the region is converted into contours using edge detection algorithms. Due to the clear and distinct straight-edge boundaries of paper documents, the contours can be segmented into straight lines. Approximate line calculations are performed on all lines to fit each line, while simultaneously saving the starting point of each edge as a vertex.

Projection transformation involves applying projection transformation operators to perform projection transformations on the four vertices of the input image based on a given projection transformation matrix, thereby achieving correction of image distortion. The image correction effect is shown in Fig 2.



(a) Original grayscale image

(b) Corrected image

Fig 2. Schematic Diagram of Image Correction

3.4. PDF Document Generation Module

After passing through various image processing modules, the paper image has been corrected into the proper electronic image. The next step is to convert the corrected image into a PDF format document. PDF documents have strong compatibility, meaning users don't need to worry about whether the recipient can open or view the document, thus facilitating document sharing and transmission. This system uses the Libharu library to embed images into PDF documents

4. Conclusion

This research introduces the design and implementation of an AI-based desktop scanning platform, which utilizes OpenCV image processing and artificial intelligence technologies to provide high-precision and automated document digitization solutions. The platform can automatically correct image distortion, enhance scanned

documents, and generate high-quality PDF files, making it a valuable tool for enterprises and organizations. With the further development of machine learning and image processing technologies, this platform shows great potential in becoming a crucial tool for digital transformation in document management

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