Automatic Book Scanner

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Abstract. Preserving books and documents have become a hectic problem for today’s world. Most of the documents and books were discarded due to insufficient physical storage and lots of maintenance. To overcome this problem, digitization of documents has become an important technology. The technical challenge is to realize an easy to use, high quality and high speed scanning system. The prototype is scanning large stacks of paper without using any human effort to flip pages i.e. it is using robotic arm to flip pages. The prototype is designed within small budget, to scan the standard size book i.e. (12 inches height and 9.5 inches wide), then converting the texts which are in human readable form to computer-readable digital image.

1. Introduction

Book Scanning is the process of converting physical books into digital media such as images, electronic text, or electronic books (e-books) by using an image scanner. Digital books can be easily distributed, reproduced, and read-on screen [1]. Over the years, many automatic book scanners have been designed, some examples of these scanners are [2] [3] [4] to mention a few. The digitization of book requires a scanner. Scanning the bundles of pages would definitely increase the work load and consume lot of time of user. The problems like limited physical storage, scanning bundle of books by manual flipping and Stanford University Library Digitization [5] motivated us.

Recently, many solutions and techniques have been developed to flip the page automatically but they all differs in specifications, design, speed and quality. Some are using Big Finger and Little Finger [6], mechanism of page thumbing [7] and Vacuum lift mechanism [8]. Finger flipping technique is used by M.T.Nikham [9], having roller and slider. The turning mechanism has to rotate about 45, 90, 135 and 180 degrees respectively. After the page turned the camera will capture the image and converted into several forms like PDF, CD, Word format, PC, laptops and Zerox of scanned copies.

Dany Qumsiyeh [10] who was an employee at Google developed a linear book scanner machine which uses air suction from an ordinary vacuum cleaner to isolate individual pages, scanning the front and back in one pass along the device’s prism-shaped body. After a quick 40-second setup, it can digitize a 1000-page book in a little over 90 minutes.

Yoshihiro Watanabe [11] made an automatic page turner machine that turns the pages in a contactless manner by utilizing the elastic force of the page and an air blast. The experiment was carried out in different number of paper quality and it was found that average success rate of thin-paper book was about 100% while thick-paper book is about 98.4%.

The main function in the making of “automatic-book scanner prototype” is to make it reliable, faster and economic.
2. Methodology
The flipping technique for the prototype was chosen by keeping in mind reliability, speed and economic. The prototype is cantered on a ‘robotic arm with a suction power’ to lift the page and a ‘slider’ to drive the page on to the other side of the book. Prototype is comprised of four main components:
1. Pneumatic cradle actuator
2. Robotic arm with suction pipe (whose one end is attached to vacuum pump)
3. Pneumatic slider
4. Raspberry-pi Controller along with camera
The schematically working of automatic-book scanner is shown in figure 1.

3. Working principle
To execute the process of automatic-scanning, the first step is to place the book on cradle. Robotic arm with suction pipe attached to it will move in downward direction, in order to lift the current page of the book by source of vacuum suction. Then the slider will drive the lifted page on to the other side of book and after that the robotic arm will move in 90 degrees with respect to the initial position. So it doesn’t come along on a track of camera, while capturing the pages of book .The actuator that is lay underneath the cradle will move upward, until the front page of book get stuck on platen. The camera that is mounted on top centre side of wall will take image of the entire page. Finally these images are fed into computer as PDF and thus the entire physical book is converted into e-book.

The flow of the approach is to run the book scanning process in a loop as shown in figure 2. For this purpose, a sensor is needed to sense the current process and give feedback back to controller. The sensor that is selected for this purpose is named “reed-switch”. These sensors are attached along with cradle actuator, robotic arm and a slider. All the above mentioned processes are executed step by step. The sensor cannot be able to generate the signal, until the job that is assigned to each component won’t be accomplished. These signals are fed back to controller which generate the signal to other components. After receiving the signal from feedback controller, the other component do its assigned job. As a result these sensors prevent the collision among the components.

Figure 1. Overview of scanner’s working.

Figure 2. Working flow chart
4. Construction
The construction of system was first sketched in a solid works platform, in order to get an overview of the system. The top view and side view of the system that is sketched in solid works are shown in figure 3 and figure 4 respectively.

![Figure 3. Top view of the structure.](image1)
![Figure 4. Side view of the structure](image2)

The finalize structure is about 30 inches in height and 18 inches in width as shown in figure 5.

![Figure 5. Complete project.](image3)

5. Observations and calculations
The vacuum suction pressure is calculated as:
- Diameter of Suction Pipe = 0.01m
- Radius of Pipe = 0.005m

Cross-sectional area of pipe: \( = \pi r^2 = 0.0007855 \text{ m}^2 \)

The pressure exerted on a page by vacuum strip is calculated by finding force (mass times gravity) and by using pressure (force per unit area) as:

\[
\text{Pressure} = \frac{150 \times 10^{-3} \times 9.81}{0.0007855} = 18.75 \text{ KPa}
\]
Before starting the process, the timer was brought to zero seconds. Table 1 is representing relationship between number of pages and time.

| S.No | No of pages | Time(s) |
|------|-------------|---------|
| 1    | 15          | 60      |
| 2    | 30          | 120     |
| 3    | 45          | 180     |
| 4    | 60          | 240     |
| 5    | 75          | 300     |

The figure 6 shows the linearity behaviour between these two relations. On an average a book contains 900 pages in it, therefore the time required to completely scan 900 pages book will be approximately be about sixty minutes i.e. equal to an hour.

The scanned output are shown below in the figure 7-10:
6. Conclusion and recommendation
The prototype can turn 12 pages per minute. Due to the orientation of the book lying flat, pages turn best for larger books with sturdy bindings. The camera successfully captures consistently illuminated pages, due to the camera limitations, the resolution could not be improved to the desired DPI. By using two cameras (one for each page) or obtaining a better camera would remedy this issue. During the scanning the natural error of skipping and tiring is negligible and through this auto-flipping technique all the physical documents or book can easily be converted into digital form.
In future, the scanner would have additional features like i) the range of scanning, the number of pages that could be scan (as assigned by user), ii) may have a built-in touch screen, by which the user can give the instructions

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