High-Res Headband Document Scanner & Transmitter

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Create Program

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Team

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Background

The Need

Smile Farms is a workplace for physically disabled people and is responsible for providing them with work. This includes various tasks which can range from watering plants to shredding paper in bulk.

Randy is our main POC at the farm and is immobile from neck down with some control over his fingers. He aspires to work in the paper scanning department and has requested us to build a device to scan documents in a way that does not require him to use his hands. After doing extensive market research we were unable to find any product that could help people with disabilities in scanning documents.

As a result we came up with the idea of having a wireless scanner which can transmit the scanned documents wirelessly to a computer without much if any human involvement needed. Upon successful completion of the project, we aim for the final product to be deployable on a larger scale to cater to other individuals in the same situation/condition as Randy.

Statement of the Problem

Big Picture

The big picture of the project is giving Randy and other individuals with same or similar characteristics a possibility to adapt to a work environment at the facility. On our visit the director of the facility gave us an idea of Randy’s situation with daily problems. The volunteers were asked to think like Randy. The volunteers still didn’t understand the director until they were asked to take their phone out of their pocket without using their hands. They couldn’t find a way so they finally understood the struggles of Randy's everydays life. The simple idea of scanning documents isn't just of ability but also more motivation towards adapting at the facility.
Objectives

For this project we are aiming to use an automated scanner that will be attached to a headband or some type of hat. At the facility in Staten Island there were other individuals with full mobility of their heads sitting on the chairs. We are focusing on implementing the device on a part of their bodies where they have mobility control. Since most of the individuals aren’t able to move their arms or physically able to grab an object. The idea was to have a self adapting scanner that adapts to the document's parameters. We also plan to develop a software that will transfer the scanned documents to a database. In order to transfer the scanned documents from the scanner to the database we need to create some type of wireless usb.

Rationale

Proposed Approaches

As our plan, we will use a camera attached to a microcontroller as a scanner attached to a headband or similar headwear in order to take scans of the paper. Using an image detection algorithm as well as Optical Character Recognition (OCR), the scanner will be able to detect and focus on the page. There will also have to be a way the scanner can send the image to a computer or a real-time video in order to show the best results. This can be done with a USB dongle transmitter to show the image to a screen Using OCR the page can be converted into a PDF or Word file. There are also two final points regarding the scanner, one of them being the detection algorithm. It has to be able to differentiate between objects that are papers or books and those that are not. The other point is the camera, which has to take high resolution photos in order for the OCR to work properly.

Alternative Approaches

During our brainstorming phase of the project, we came up with a few alternative approaches before conjuring up a finalized solution. The first alternative would implement the use of a rover to assist the user in completing the scanning process. Since an individual with limited mobility wouldn’t be able to physically have much or any interaction with a traditional scanner, this rover serves as a way for people to complete the task without having to do much at
However, the drawbacks of this approach include the cost and time to actually design and implement the machine, along with the rover potentially being an inconvenience in terms of maintaining it and also bringing it along with you every time. Another alternative was creating glasses instead of a headband. Although this scenario seems to be a good approach for portability, this would create some issues concerning the ease of use for the audience and in the implementation of a microcontroller and battery compact enough to not cause a disturbance for usability.

**Project Summary**

Our project is creating a wireless, Hi-Res headband document scanner and transmitter that can identify and scan objects such as text, images, and various content on paper and relay this information to a database for storing. In terms of the process, we plan on implementing a portable camera attached to a headband for capturing information and utilizing object recognition algorithms for identifying and organizing the data for display. The main significance of this project is that it will enable people with limited mobility to be involved in the workforce and allow them an opportunity to achieve a task that is currently unfeasible for such individuals.

**Marketing Requirements**

After communicating with Randy and observing the tasks involved in the scanning documents at Smile Farms we came up with the following requirements that our products needs to fulfilled in order to be successful:

1. The System must be lightweight/portable
2. The System must be able to take high-resolution pictures
3. The system must be robust for daily use
4. The System has to be easy to use
5. The system has to seamlessly transfer data

**Engineering Requirements**

The engineering requirements are derived based on the marketing requirements and on how they can be satisfied. Our engineering requirements are as follows:
1. In order for the system to be lightweight and portable, we will be making the scanner modular with a headband and make sure the total weight of the system does not exceed 100 grams.

2. In order for the system to take High-Res pictures, the scanner will be equipped with a 10-megapixel camera which has auto-focus capabilities. Also, the object recognition algorithms would need to be at least 90% accurate.

3. To be robust for daily use, our system will have a rechargeable battery with at least 10 hours of life. This should be inline with the average length of a workshift. Also, the system will be housed in a shatterproof casing to prevent damage and provide safety to the internal components of the scanner.

4. For the system to be easy to use, we are aiming to minimize the human interaction needed to scan documents by using a one button interface for the user. Secondly, we are looking to provide the user with an 8” screen so that they can view the images that the camera sees. Given that the system will not necessarily be handled by technical personnel, the system will be easily upgradable in software terms.

5. To satisfy this requirement we will be using bluetooth(Classic or LE) technology to transfer images from the scanner to a computer. The scanner and computer will be interfaced with a USB dongle programmed to receive/transmit data.

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**Design**

**Needs Identification**

For the needs identification, we created an Analytical Hierarchy Process to help determine solutions and good decisions for our design. We determined three selection criteria for our design such as High-Quality Imagery, User-Friendly, and Portability. By using the Pairwise comparison method, we deemed Portability and User-Friendly to be very important. After calculating the geometric mean and weight of each category, we concluded that User-Friendly has the largest geometric mean and weighs the most. Thus, this specific criterion holds the greatest importance in the decision-making process for the execution of our project. These selection criteria were established based on the identification of the product’s marketing requirements.

The headband scanner needs to be capable of scanning documents in a high-resolution format while maintaining customary optical system and digital image processing capabilities such as autofocusing and edge detection for objects. In regards to the usability of the device, the
device has to be lightweight and comfortable to wear without any inconvenience associated with wires because the target audience have physical disabilities that limit their movement. So, our product cannot be burdensome to wear and operate. Additionally, a minimalistic design promotes efficiency and effortless undertaking of the task.

<table>
<thead>
<tr>
<th></th>
<th>High-Quality Imagery</th>
<th>User-Friendly</th>
<th>Portable</th>
<th>Geometric Mean</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Quality Imagery</td>
<td>1</td>
<td>1/5</td>
<td>3</td>
<td>0.84</td>
<td>0.19</td>
</tr>
<tr>
<td>User-Friendly</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>3.27</td>
<td>0.73</td>
</tr>
<tr>
<td>Portable</td>
<td>1/3</td>
<td>1/7</td>
<td>1</td>
<td>0.36</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Figure 1: Ranking of Criteria

![Objective Tree Diagram](image.png)

Figure 2: Objective Tree
System Overview

The above diagram shows a high level implementation of our scanner system. The visual data of the image gets captured by the image sensor and sent for processing to the Image processor. The result of this processor is then displayed to the user on an LCD screen for real-time viewing and at the same time sent to a computer with the scanning software. The scanning software takes the image file and processes it to extract all relevant information to produce a scanned copy of the original image.

Functional Decomposition

Below we present the level 0 diagram and tables that describe the input and output of our Headband Document Scanner. The Headband Document Scanner (microcontroller) will be provided with 5 volts of power and will take an input of image data which will be compiled into a file that is the output to be sent to the software system. The input image from the camera will also provide a live feed of what's being captured to a display so the user can see what he is capturing.

<table>
<thead>
<tr>
<th>Module</th>
<th>Headband Document Scanner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>Power: 5 V (battery)</td>
</tr>
<tr>
<td></td>
<td>Data: Image</td>
</tr>
<tr>
<td>Outputs</td>
<td>Document Image File</td>
</tr>
<tr>
<td>Functionality</td>
<td>Takes a Picture of a Document and compiles it into a image file (JPeG/PNG)</td>
</tr>
</tbody>
</table>

Figure 3: System Overview Tree

Figure 4: Functional Decomposition Level 0 Tables
For level one, we explain in greater detail each of the modules of the inputs and outputs and how each module interacts with each other. The System has four modules that are the Camera, Microcontroller, Mobile Application, and Software Engine. The camera captures an image of a document and uses Image Detection Algorithm to only capture a piece of paper and not other random objects. The microcontroller completes two tasks which it provides a live feed of the camera to help the user to be able to see what he is capturing and that it’s in view of the camera. The second task is the microcontroller will process the image data and convert it to an image file which will be sent to a Software engine via bluetooth or Zigbee. Once the Software engine receives the image file it will then process the file with the Optical Character Recognition algorithm and convert the file into a scanned pdf document.

<table>
<thead>
<tr>
<th>Module</th>
<th>Camera</th>
<th>Module</th>
<th>Microcontroller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>A document</td>
<td>Inputs</td>
<td>Image of Document</td>
</tr>
<tr>
<td>Outputs</td>
<td>Image of Document</td>
<td>Outputs</td>
<td>Image File</td>
</tr>
<tr>
<td>Functionality</td>
<td>Captures an image of a document</td>
<td>Functionality</td>
<td>Uses the I.D.A to detect a piece of paper</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module</th>
<th>Mobile Application</th>
<th>Module</th>
<th>Software Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>Live Image</td>
<td>Inputs</td>
<td>Image File</td>
</tr>
<tr>
<td>Outputs</td>
<td>Display</td>
<td>Outputs</td>
<td>Scanned PDF Document</td>
</tr>
<tr>
<td>Functionality</td>
<td>Display a live image of what the camera sees for the user</td>
<td>Functionality</td>
<td>Uses O.C.R to compile the image into a scan document file</td>
</tr>
</tbody>
</table>
Use-Case/Behavioral Model

We have three Use-Case systems which are Document Scan, Zigbee/Bluetooth, and Display Output. There are also four actors (components) and they are the Camera, Microcontroller, Display, and the Document Database. The actors interact with the Optical Character Recognition Software. Firstly, the camera captures the document where the Document Scan processes the picture into a file and sends it to the Microcontroller. The Display Output shows a real time view of the document that's being scanned and then shows the document file that was processed. Finally, the document file that was processed and sent to the microcontroller uses Bluetooth/Zigbee to wirelessly transmit the file to the document database. The visualization of the process is shown below.
Based on our data flow diagram, the camera, upon the user’s request, snaps a scan of the desired document and relays this information to the microcontroller. The microcontroller then sends this information to the OCR software. Meanwhile, the display shows a real-time view of the scanning process so the user is able to gauge how satisfactory the scan was. If the user chooses to keep the image, the display shows the file which was just processed, upon receiving it from the software. Lastly, the picture is transmitted to the database wirelessly via Bluetooth/Zigbee.
Testing Plan

In the testing plan we want to test each subsystem individually to confirm that each subsystem is operating correctly before putting the system together for a prototype. Once the prototype System is assembled the team plans to spend a month on refining the system and solving any minor issues. This plan is to help ensure that we are giving a system we can be confident say is complete and giving Randy an opportunity to be able to scan documents.
Cost Estimation

Below is the table of estimated costs of components needed to complete the system we want to create. The parts included are those that would be essential for the scanner to work, such as the camera and the microcontroller in order to take the picture and send it to whatever computer in the network. The battery is needed to keep the microcontroller operational for a certain amount of time. The flash unit is needed in order for the camera to take the best picture in possible low light environments. The UI involves the software part, which is the implementation of the primary picture to a scanned image. The tablet is needed to show a real time video of what the camera is showing in order to take the best picture. Also, miscellaneous components such as wires and cables would be needed as connections to other components. Finally, an enclosure would be needed to protect the hardware.

<table>
<thead>
<tr>
<th>Components</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>1</td>
<td>$50.00</td>
</tr>
<tr>
<td>Battery</td>
<td>1</td>
<td>$70.00</td>
</tr>
<tr>
<td>Microcontroller</td>
<td>1</td>
<td>$50.00</td>
</tr>
<tr>
<td>3D printed enclosure</td>
<td>3</td>
<td>$100.00</td>
</tr>
<tr>
<td>Circuit Design/PCP Print</td>
<td>5</td>
<td>$100.00</td>
</tr>
<tr>
<td>Camera/Flash unit</td>
<td>1</td>
<td>$80.00</td>
</tr>
<tr>
<td>User interface</td>
<td>1</td>
<td>$100.00</td>
</tr>
<tr>
<td>Tablet</td>
<td>1</td>
<td>$150.00</td>
</tr>
<tr>
<td>Electronic Components</td>
<td>20</td>
<td>$100.00</td>
</tr>
<tr>
<td><strong>Total Cost:</strong></td>
<td></td>
<td><strong>$800.00</strong></td>
</tr>
</tbody>
</table>
References