Bill Tech Dollar Identifier

Team 11

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1. Objective and Background

1.1 The Problem

In the United States, paper currency cannot be easily identified by those with either visual impairments or blindness. This reality is a uniquely American one, as America is one of the few nations that does not have tactile makers or different sizes in its paper Currency [2]. For those who are blind in the United States, many have developed identification systems that require folding bills in unique ways [2]. This system works when the identity of the bill is known in advance but it can become messy when the user is given unknown bills. Without the help of another person this can be a difficult task and for those who live alone, almost impossible. In order to aid those with visual impairments who live alone, we propose a desktop device that can identify any paper legal tender in the United States, the Bill Tech Dollar Identifier.

1.2 Our Solution

The Bill Tech Dollar Identifier works by taking a picture of a piece of currency. The user puts the piece of currency on a tray and pushes a button on the physical device. After a brief delay, the device will take a picture of the bill and after a few seconds, the microprocessor will be able to correctly identify the value of the bill and output its value from the speaker of the device.

This device differs from mobile app solutions because it does not require a phone to use. The device will be following design standards for ease of use that make it more accessible. The Bill Tech Dollar Identifier only uses a button and power switch as inputs from the user, allowing the user to easily become familiar with the controls.

1.3 Visual aid

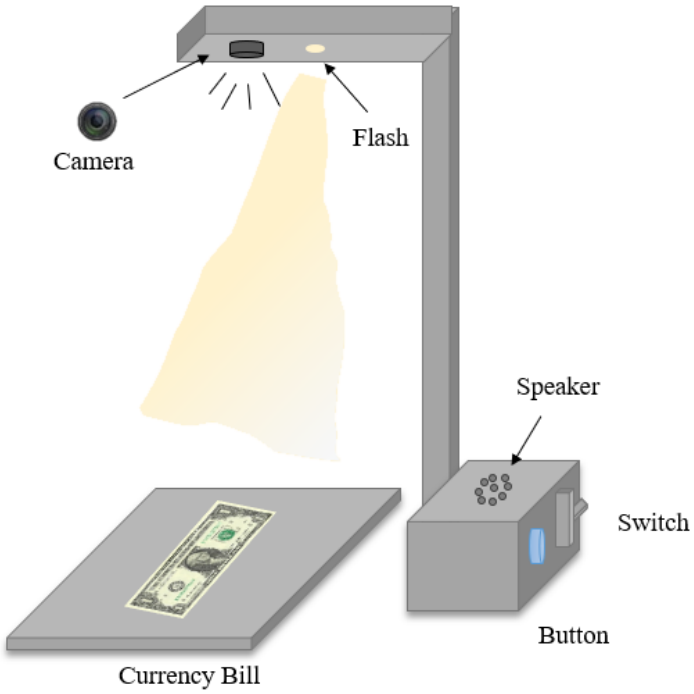

Figure 1: Bill tech visual aid

1.4 High-Level Requirements List

1. The machine is able to correctly identify the bill presented on the loading tray with an accuracy rate of 0.95 and an error rate of 0.03.
2. The machine should produce differentiable audible responses upon identification of different bill types. For instance, a one-dollar bill would produce one beep while a five dollar bill would produce two beeps.
3. The machine should be able to run independently on battery power for at least 1 hour on a single charge.

2 Design and Requirement

2.1 Block Diagram

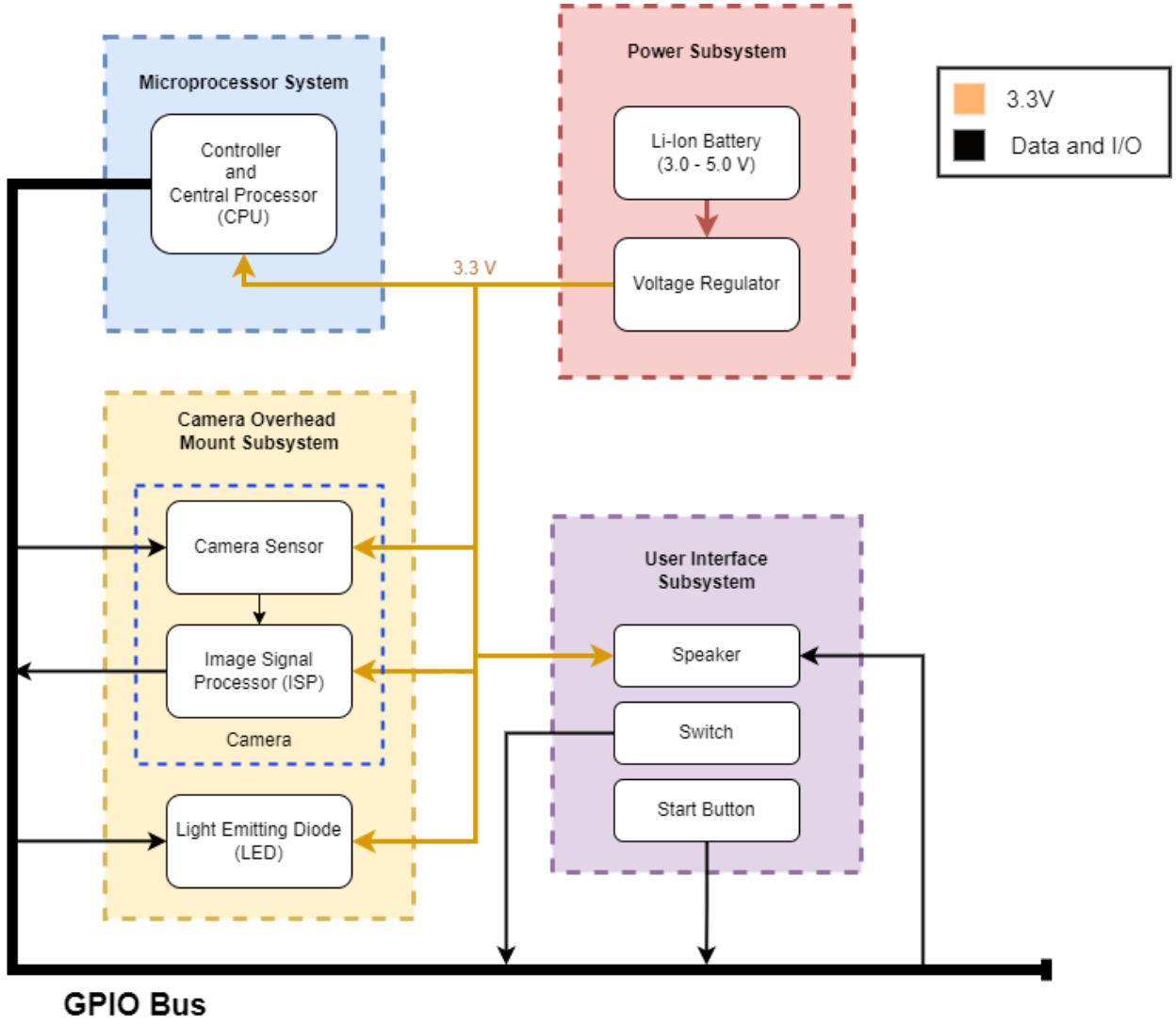

Figure 2: Block diagram

2.2 Block descriptions

User Interface Subsystem

The User Interface block includes the switch, start button and the speaker. It is through these elements how the user physically interacts with our device. The switch and the button detect the user's inputs and send the signal to the microcontroller. The speaker works as an output, producing differentiable audible responses so the user can identify the bill value.

Requirements

- Switch
- Button
- Speaker
    - At least 60 dB in volume
    - Frequency range between 500 Hz and 2 kHz
    - Operating range between 3.3 and 5V

Camera Overhead Mount Subsystem:

This system ties directly with the microprocessor and the user interface. When the user presses the start button with the device turned on the microprocessors system sends a control signal to the camera and the LED. The LED will then turn on to illuminate the tray, which holds the dollar, and the camera system will take the picture. The ISP on the camera will then process the photo and go through Analog to Digital Conversion and send this data through the GPIO to the microprocessor for image analysis.

Requirements

- Camera
    - Resolution of 1 MP (+/- 0.2)
    - Built-in image signal processor (ISP)
    - Operating range between 3.3 and 5V

- LED light
    - At least 30 Lumens in brightness
    - Operating voltage of 3.3V

Microprocessor System Mount Subsystem:

This block takes care of both controlling the individual elements like the LED and the speaker, but also performs most of the image analysis. This system will have an image processing model loaded on its flash memory and will use this model to identify bills. After Image processing is finished signals will be sent to the speaker so that the user can know the identity of the bill.

Requirements

- Microprocessor
    - 2 MB of flash memory
    - 512 kB of RAM
    - 200 MHz clock speed
    - 6 or more lanes of GPIO
    - Operating range of 3.3V

Power Subsystem

This block has to do with powering each of the components in the stable range. Through the use of a batter and a voltage regulator this block is able to safely power multiple components with varying voltage requirements. This system interacts with the LED, the speaker, the camera, and the microprocessor. This system works in tandem with the microprocessor to both regulate voltage as well as turning off voltage levels to each of the components.

Requirements

- Battery
    - Rechargeable Li-Ion battery
    - Capacity 3500 mAh
    - Operating voltage 3.3 - 5V

2.3 Tolerance Analysis

As our device works by taking a picture of a bill and using a model to know its value, making a good picture is an important component in our project. To get a good image we have to take the picture at a suitable distance from the bill, about 10 inches and use a LED with a suitable luminance because the picture quality depends on the bill brightness.

3 Ethics and Safety

The main ethical concerns come from taking pictures of legal currency. Individuals are allowed to take pictures of currency if the pictures are either smaller than 75% of the size of the original bill or bigger than 150% of the size and the picture shows only a single side of the bill. These pictures also need to be deleted after use [3].

The model will be trained by pictures of bills that will be gathered by the group. This training data will be deleted after the identification model is built. The device itself will only need to keep the picture of the currency in memory for the amount of time it takes the model to come up with a classification, approximately 5 seconds. After the bill has been identified the picture will be deleted, complying with federal standards[3].

In terms of safety concerns this device is operating with both low Voltage and Current levels which do not pose a risk to any of the group members. LEDs will not be of a strong enough luminance to pose a risk to vision and speakers will not produce a loud enough sound to cause hearing loss. In order to uphold safety standards, members of the group will comply with all safety precautions in the senior design lab as well as carefully following instructions on proper etiquette and technique when it comes to soldering components.

We will be following all codes of ethics from IEEE [1] by both upholding moral and ethical standards amongst ourselves and others, continually thinking of ethical solutions to problems that do not introduce conflicts of interest, and always thinking about and communicating with the visually impaired and blind community of which this product is centered around helping.

4 References

1. IEEE. “IEEE Code of Ethics” IEEE.org https://www.ieee.org/about/corporate/governance/p7-8.html (accessed Feb. 10. 2022)

2. “How Do People Who Are Blind or Visually Impaired Identify Money?” chicagolighthouse.org https://chicagolighthouse.org/sandys-view/identifying-money/ (accessed Feb. 8. 2022)

3. U.S. Currency Education Program. “Currency Image Use” uscurrency.gov https://www.uscurrency.gov/media/currency-image-use (accessed Jan. 28. 2022)