Braille Study Aid : Luis Aragon, Emma Erickson, Aris Karnavas

1. Introduction

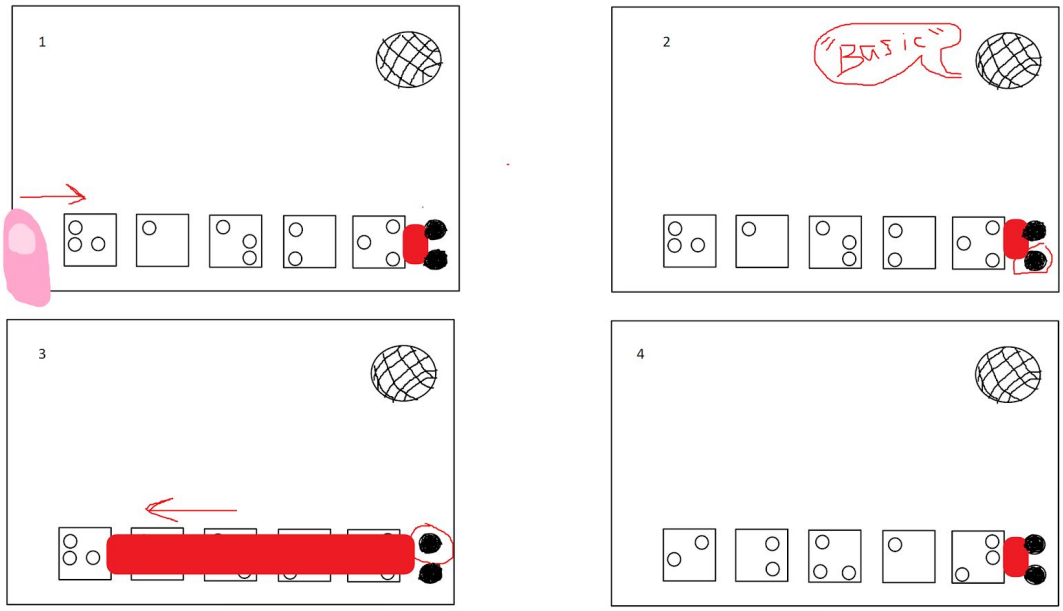
1. Problem and Solution Overview:

One to two paragraphs explaining the context of the problem to be solved by your project, including any relevant references to justify the existence and/or importance of the problem (i.e., the need or want for a solution). Justify the novelty of your solution or explain the expected improvements of your solution over previous results.

Braille is a tactile written language used by people with visual impairments. Our goal is to create a device to help introduce and improve braille literacy. Because most seeing teachers are not familiar with Braille, we want to provide an easier way to learn independently. The study aid will allow for a quick succession of practice at the user's own pace while providing audio confirmation on each word. The aid will cycle between a hundred introductory words, displaying Braille and auditory representation.

2. Visual Aid

A pictorial representation of your project that puts your solution in context. Not necessarily restricted to your design. Include other external systems relevant to your project (e.g. if your solution connects to a phone via Bluetooth, draw a dotted line between your device and the phone). Note that this is not a block diagram and should explain how the solution is used, not a breakdown of inner components.



3. **High-level requirements list:**
   A list of three to four objective characteristics that this project must exhibit in order to solve the problem. These should be selected such that if any of these requirements were not met, the project would fail to solve the problem. Avoid vague requirements that can be interpreted a number of ways (e.g. "The radio subsystem should work reliably.").
   Each high-level requirement must be stated in complete sentences and displayed as a bulleted list.

1.4.1: The study aid must display five braille characters.
1.4.2: The study aid must provide audio for the word being displayed.
1.4.3: The study aid must allow the user to switch to the next word.

2. **Design**

1. **Block Diagram:**
   A general block diagram of the design of your solution. Each block should be as modular as possible and represent a subsystem of your design. In other words, they can be implemented independently and re-assembled later. The block diagram should be accompanied by a brief (1 paragraph) description of the high level design justifying that the design will satisfy the high-level requirements.

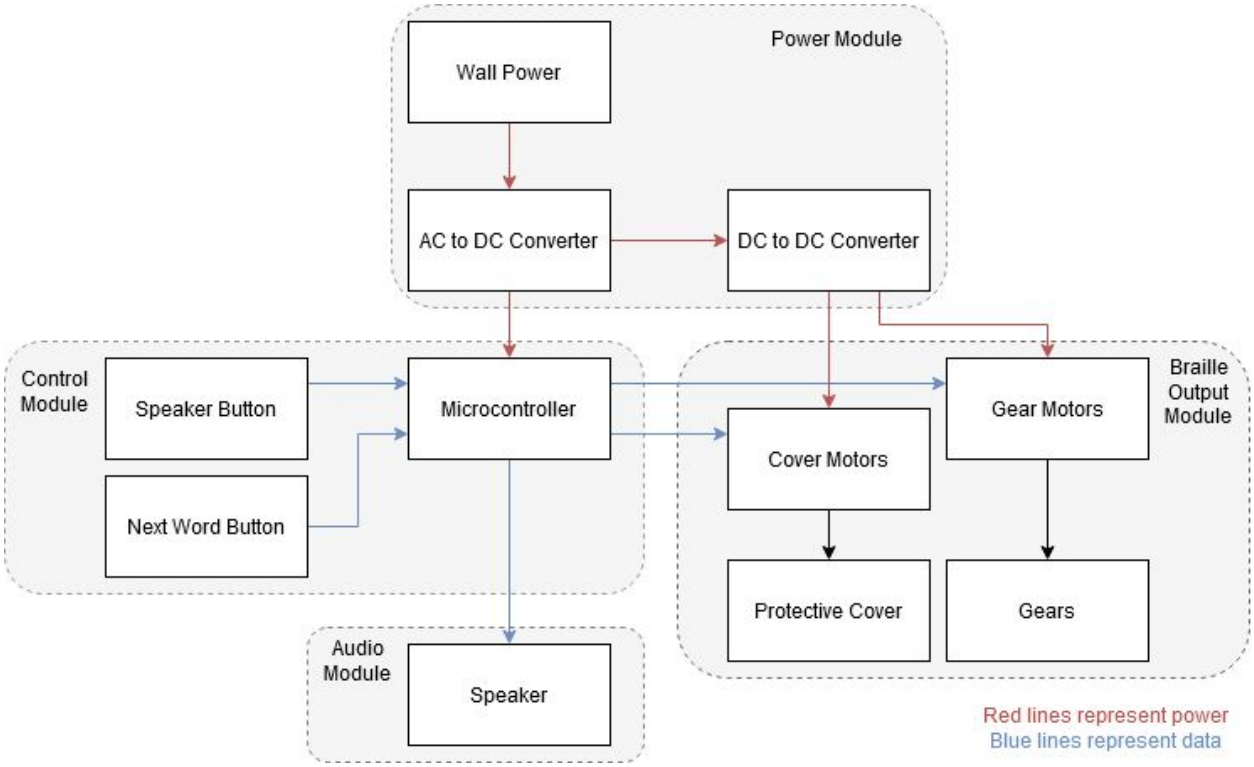


Figure 2: Braille Study Aid block diagram

In order to implement our Braille teacher to the specifications described, we require four main modules: power, control, audio, and Braille output. The power module will convert AC wall power to the DC power specifications of both the controller and motors. The control module will convert user input into instructions for the motors and speaker, positioning the motors appropriately and activating the speaker at the user's request. The audio module is responsible for reading out the word being tested. Finally, the Braille output module accomplishes the goal of displaying the tested word in Braille using the gear mechanism. It includes a protective cover to prevent confusion or interference as the gears move between turns.

2. **Physical Design (if applicable):**
   A physical diagram of the project indicating things such as mechanical dimensions or placement of sensors and actuators. The physical diagram should also be accompanied by a brief one paragraph description.

The following is a physical representation of our design. We intend to include 5 slots for Braille characters to be shifted out to the user. They will rotate through a section of bristles to help separate the user from the moving parts. Our design also includes a speaker to output an audible representation of the currently displayed word. The two buttons will cycle between new words and queue the speaker to provide audio feedback. All moving parts and wiring will be contained in a metal casing.

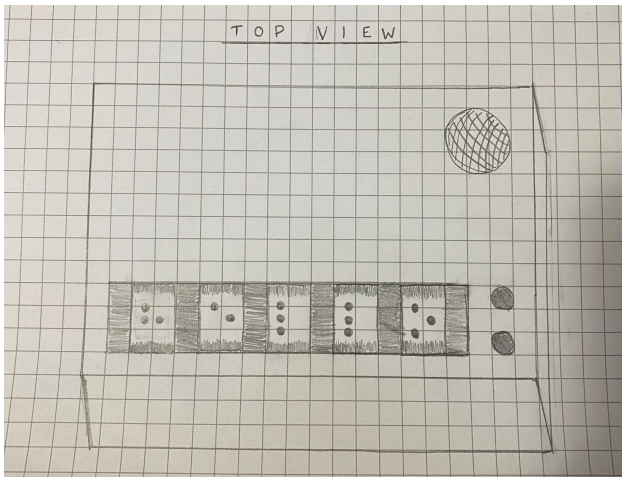


Figure 1: Anticipated exterior design of the Braille Study Aid

3. **[SUBSYSTEM NAME]**
   For each subsystem in your block diagram, you should include a highly detailed and quantitative block description. Each description must include a statement indicating how the block contributes to the overall design dictated by the high-level requirements. Any and all design decisions must be clearly justified. Any interfaces with other blocks must be defined clearly and quantitatively.
   Include any relevant supporting figures and data in order to clearly illustrate and justify the design. Typically a well justified block design will include some or all of the following items: Circuit schematics, simulations, calculations, measurements, flow charts, mechanical

diagrams (e.g. CAD drawings, only necessary for mechanical components).
You must include a **Requirements and Verifications** table. Please see the R&V page for guidance on writing requirements and verification procedures.

Power Module - Take in 120V AC from the wall socket and utilize an AC-DC converter to bring this down to a usable DC voltage that will supply power to microcontroller, motors, and speaker. This must deliver 5V with a small ripple continuously to the PCB which will be stepped down to 3.3V to supply the microcontroller. The power module must supply each gear motor and cover motor with 4.8-6V at 550-650mA. Finally the power module must supply the speaker module with 5V at 600mA.

Power Supply AC-DC Converter:

Requirements	Verification
The power supply must step down 120V AC from wall socket to 4.5-5.5V DC at maximum 5A.	1) Test open circuit output voltage with voltmeter to ensure output voltage in desirable range 2) Apply resistive load to measure current at varying loads.

DC-DC Converter:

Requirements	Verification
Design DC-DC to step output voltage from power supply from 5V to 3.3V	1) Test open circuit output voltage with voltmeter to ensure output voltage is at 3.3.

Control Module - Microcontroller is responsible for communicating servo orientations necessary to form a Braille word when the next word button is pressed. It also sends the speaker a PWM signal for the current word when the speaker button is pressed. This must be able to simultaneously output 6 PWM signals at once each with a minimum pulse width of 0.7ms. The control module must also communicate with the speaker to play 8kHz audio. The

microcontroller must start communication when respective “play word” and “next word” buttons are pressed.

Microcontroller: Microcontroller is responsible for communicating servo orientations necessary to form a Braille word. It receives input from buttons, determines the orientation of each gear in the next word, computes transitions between the current and next state, and transmits signals to gears. Additionally, it controls the cover motor and determines its orientation during transition and display. Finally, it is responsible for transmitting 8kHz audio to the speaker matching the displayed word.

Requirements	Verification
Microcontroller must transmit six separate PWM signals to the gears and cover. Microcontroller must transmit audio signal to speaker. Microcontroller must be able to play same audio sample multiple times. Microcontroller must change between words. Microcontroller must contain X MB of memory. Microcontroller must have a maximum latency of 0.1 sec.	1. The output node to the motors should be probed with oscilloscope to view PWM signal. 2. The audio channel should first be tested with pure (single frequency) tones, verified on an oscilloscope. 3. Hitting the “Speaker” button does not affect the output state of the device. 4. Hitting the “Next Word” button triggers a state change, activating cover, gears, and current audio sample.

Buttons: Two buttons allow users to interface with the device. The “Next Word” button informs the microcontroller to change words. The “Speaker” button informs the microcontroller to play the audio sample associated with the word.

Requirements	Verification
Buttons must be debounced, and not skip or trigger words too early.	1. Verify the button’s debounced output signal versus signal jitter using oscilloscope

Audio Module - Take signal from microcontroller to audibly output the current word on the gear display. The speaker is activated by the microcontroller when the speaker button is pressed. This must output audio at least 8kHz to encompass the frequency content of human voice. It will be powered with 5V at 600mA from the power supply

Speaker

Requirement	Verification
Ensure Speaker can output characters and words audibilly to the user.	1) Send speaker messages from microcontroller/arduino to ensure the speaker outputs audible speech.

Braille Output Module - Motors take signal from microcontroller detailing what position each gear needs to be to display the next word. Upon a new word button press the protective cover motor will move out to prevent the user from accessing the spinning gears and the cover will retract once new word is in position. Servos must be capable of rotating 360 degrees and stop at 26 equally spaced points along this rotation. Servos will be powered with 4.8-6V at 550-650mA by the power module. Character gears must be able to accommodate 26 braille cells along their circumference. Given the dimension of a single Braille cell, the circumference of the gear must be approximately 2.75in.

Gear Motors: The 5 gear motors (exact product) will receive signals from the microcontroller and turn the gears an appropriate amount to display the correct Braille symbol. The motors will also receive power via the AC/DC power converters from the Power Module. The motors will need to operate under relatively precise constraints, given the 28 characters and small radius of gears.

Requirements	Verification
Cycle between each Braille character, stopping precisely at an expected orientation	1. Motor will be able to cycle to every character from varying displacements (1, 8, 15, and 22 characters away) 2. Operate under [appropriate] power constraints. 3. Motors will move with the press of the “Next Word” button.

Gears: The 5 gears will be manufactured to have 28 teeth with unique Braille characters representing all letters of the alphabet, a numeric indicator, and a blank space. The gears will need to be uniform size and rotate smoothly in their harness. Additionally, the gears should rotate freely among the brushes at the display level.

Requirements	Verification
Gear must be uniformly manufactured so that all teeth are equidistant.	1) Gears will be drafted from the same template and must have identical features. 2) The clearance of each gear from the display must be uniform. 3) Only one character per gear should be displayed at one time.

Cover Motor: The cover motor will be similar to the gear motors, but will serve to move the protective cover over the Braille characters during the orientation of the gears. The motor will receive power from an AC/DC power converter in the Power Module. The motor will need to orient the cover in six specific locations (covering each character, and open).

Requirements	Verification
Cover motor will be able to cycle from open position to all five character positions	1. Motor will move from open position to cover each Braille character, representing each possible length of a word. 2. Motor will operate under [appropriate] power constraints. 3. Motor will move with a press of the “Next Word” button.

Protective Cover: The protective cover will slide over the interactive Braille character space to separate the user from the moving gears. The cover will have six unique positions, covering each space and a fully open position. The cover will also serve to block unused characters for words that use less than five characters. The cover will be mechanized by the cover motor.

Requirements	Verification

Protective cover should move fluidly over Braille character spaces	1. Cover should move in smooth motion as a result of the motor. 2. Cover should rest well over each of the six positions.

4. **Tolerance Analysis:** Through discussions with your TA, identify the block or interface critical to the success of your project that poses the most challenging requirement. Analyze it mathematically and show that it can be feasibly implemented and meet its requirements. See the Tolerance Analysis guide for further guidance.

Gear manufacturing

3. **Cost and Schedule**

1. **Cost Analysis:** Include a cost analysis of the project by following the outline below. Include a list of any non-standard parts, lab equipment, shop services, etc., which will be needed with an estimated cost for each.
    - Labor: (For each partner in the project)
      Assume a reasonable salary
      ($/hour) x 2.5 x hours to complete = TOTAL
      Then total labor for all partners. It's a good idea to do some

research into what a graduate from ECE at Illinois might typically make.
- Parts: Include a table listing all parts (description, manufacturer, part #, quantity and cost) and quoted machine shop labor hours that will be needed to complete the project.
- Sum of costs into a grand total

PARTS LIST: microcontroller, speaker, servos (6), power supply, linear regulator, buttons (2),

2. **Schedule:**
   Include a time-table showing when each step in the expected sequence of design and construction work will be completed (general, by week), and how the tasks will be shared between the team members. (i.e. Select architecture, Design this, Design that, Buy parts, Assemble this, Assemble that, Prepare mock-up, Integrate prototype, Refine prototype, Test integrated system)

3/1	Finalize Part Orders, Finalize Machine Shop Design
3/8	Draft PCB Design, Initial Code Creation

3/15	Test Motor Movement Separately
3/22	Test Audio Output Separately
3/29	Test Power Supply, Complete PCB Build
4/5	Test Together, Debug
4/12	Prepare Mock Demo, Debug
4/19	Mock Demo. Debug If Needed
4/26	Prepare For Presentation

4. **Discussion of Ethics and Safety:**

    1. Expand upon the ethical and safety issues raised in your proposal to ensure they are comprehensive. Add any ethical and safety concerns that arose since your proposal.

Our design is aimed at mitigating any potential safety concerns. Our mechanism for interchanging the Braille characters will involve a spinning gear, so in order to avoid the user from mistakenly halting the motor or jamming a finger, we intend to shift a cover over the characters to block the gears from the user while they reorient. This cover will ensure that the interaction between the user and a moving gear can be isolated.

Another design aspect centered around safety is our decision to use a typical AC wall outlet as our power source. Instead of relying on a portable power supply, we can use the standardized 120V/15A source to ensure consistent and safe inputs. Our design also includes several power converters that will allow for appropriate levels of power to be supplied to the microcontroller and motors.

With a predetermined catalogue of words being imputed to our study aid, we are eliminating any potential ethical issues regarding inappropriate words, such as profanity or harassment, from being taught. This mitigation aligns with IEEE Code of Ethics, 7.8.II: “To treat all persons fairly…” [4]

2. Document procedures to mitigate the safety concerns of your project. For example, include a lab safety document for batteries, human/animal interfaces, aerial devices, high-power, chemicals, etc. Justify that your design decisions sufficiently protect both users and developers from unsafe conditions caused by your project.
   Projects dealing with flying vehicles, high voltage, or other high risk factors, will be required to produce a Safety Manual and demonstrate compliance with the safety manual at the time of demo.

5. **Citations:**

   Any material obtained from websites, books, journal articles, or other sources not originally generated by the project team **must be appropriately attributed with properly cited sources** in a standardized style such as IEEE, ACM, APA, or MLA.