Product: BraillEd
Team: UpliftEd

Abstract

Our product, BraillEd, will be a tool for use in a mainstream learning environment, assisting blind and partially sighted students in gaining familiarity with braille and touch-typing through an inter-connected keyboard, braille display and speaker/microphone functionality. The success of this project is primarily defined by the integration of its input and output components, as smooth translation between them when needed is essential for matching learning alongside other students during class.

Consequently, as the system will be deployed in a classroom environment, its base components must be made robust and intuitive to learn from and capable of handling repeated use by young students. Ideally, this base functionality will be expanded by the addition of a camera and image recognition capabilities, allowing for written text to be reproduced in braille and expanding the capacity for the system to assist in more advanced learning, though this is not necessary for the base product to be of use.

1. Pitch

59% of blind children attend mainstream schools (Chanfreau & Cebulla, 2009). However, they often lack the appropriate resources to support them, particularly when learning to read and write (Royal National Institute of Blind People, a). Students who are unable to follow a fully sighted curriculum can instead learn to read braille, offering them the same skills as someone who has learned the visual English system. This opportunity is not regularly provided to blind or partially sighted students, thereby causing them to lose the opportunity to learn such an essential skill (Sue Keil, 2002). The lack of tools and support is currently severe enough that 95% of blind and partially sighted children are not taught braille (Janis Sugden, 2009).

BraillEd aims to assist in this area, offering a robust and intuitive system that mainstream primary school students can use to practice literacy skills alongside their peers, giving them the literary groundwork all children should have. Exercises teachers provide to students learning to read and write are highly varied, including both verbal and text based activities, which necessitates our product's interconnected systems to support blind and partially sighted children in completing these tasks. The primary focus of designing this system is therefore to facilitate and reinforce learning braille in schools without disruption to the students or teachers, with due attention to usability and damage proofing.

If adopted by schools, we hope this will encourage blind and partially sighted children to grow, flourish and achieve greater self and social fulfilment while being taught in a mainstream school, and aid them in achieving their full potential as more independent individuals (Dr. MNG Mani).

2. The team

2.1. Nikodem Bieniek

[Software Team & Assisting with Hardware Integration]

I'm passionate about speech processing and accessibility, influenced by my experience as a deaf individual. While I will focus on speech processing and website development, I'm also eager to explore electronics, particularly manufacturing. Engaging in discussions might be a challenge due to my deafness, but with clear communication and collaborative note-taking, I'm confident in our success.

2.2. Daniel Hill

[Hardware Team & Development of Braille Display and Integration]

My core interests lie in Artificial Intelligence and Machine learning. I have knowledge in speech processing and experience in coding machinery from HYPED, a UoE society. I have acute interest in AIs applied use in robotics and thus want to build experience in hardware building while lending a hand to the software side if needed. With limited experience this could cause a steep learning curve but with eagerness to learn I'm sure issues will be resolved quickly while adding skills to my repertoire.

2.3. Ripley Curtis

[Hardware Team, Development & Integration of Braille Display]

While I don't have many industry skills from outside my course, I am talented at engaging with a team and problem solving on the fly. I don't exactly enjoy a challenge, but I can commit myself to solving them to a high standard which is a useful trait to have in Informatics. The area I am most interested in within this project is the hardware side, mainly just because it will be fun to tinker with design and mechanism. Although I have a lack of hardware engineering experience, I doubt this will be an issue here with the range of expertise and resources available.

2.4. Nikita Rameshkumar

[Software Team & Hardware-Software Integration]

My passion lies in software engineering as I meticulously like to engage in research and problem-solving. Through my internship experiences, I methodically progress through analysis, design, implementation, documentation, testing and evaluation. I integrate them into a cohesive development process to achieve the best possible solution. My strengths lie in full-stack development. I am also open to

working with hardware that correlates with the project's software that I will work on. Additionally, I am a great communicator, presenter, and team player that will be useful for demos and collaborative team efforts. I tend to work more efficiently closer to deadlines which might be a challenge while the team expects consistent effort. However, setting up broken down deadlines and regular meetings have helped me stay in pace with the team.

2.5. Souparna Mandal

[Hardware Lead & Assisting with Software Integration]

I am a very curious, passionate, and problem-oriented individual who loves challenges and working towards solving them. My core interests lie in engineering, though I have experience in computer architecture, project management, and machine learning from a previous summer internship. In the past, I have done large-scale coding projects ranging from open-source projects to developing for EUFS, a UoE society. For this course, I would like to focus on the hardware side, primarily because I have a background in electronics from my degree, and I have worked with robots to some extent from my own personal projects. I tend to sometimes get focused on a certain problem and lose track of time, which may be something that I have to keep a check on for the team to be successful. Further, I prefer to push work until the deadline, which might be challenging while fitting in with the work pattern of the rest of the team. Additionally , I would also like to take this opportunity to work on new software-based skills, this could involve strengthening my grip on machine learning or exploring the realm of web development. These skills in particular would be useful as I progress towards a career in industry.

2.6. Poppy Hughes

[Software Team & Research]

With a keen interest in both linguistics and machine learning, I'm looking to primarily focus on assisting with the software side of the project. I'm also very interested in the nuances of how unfamiliar technology intersects with the real-life experience of both users and bystanders, and I'm using this lens to stay on top of the analysis and research elements of the project. I primarily study remotely, which could present some issues for group work, but this has presented few issues for our ability to meet so far, and I'm using it as an opportunity to hone my usage of tools such as GitHub Projects, Slack, etc.

2.7. Ol Rushton

[Project Manager & Research]

While my main area of experience is software, I have also had a small amount of hardware and electronics experience. Furthermore, I am interested in education as well as ethics and societal effects of technology, so I am happy to contribute to areas such as strategy and impact research. I have some project management experience, so I am happy to take up the role of project manager, integrating my software and hardware experience to help get an overall view of the project. My main weakness would be time commitment; especially with project manager being a large role I think there may be difficulties balancing SDP with my other courses as well as student society commitments. However, I think that over the course of my time so far at university I have developed the time management skills necessary to make sure I can balance my time appropriately.

2.8. Florian Sawicki

[Software Team & Research]

As a software engineering student, the hardware aspect of the project certainly isn't my forte, however the combined power of both hardware and software is something that I am keen on exploring. The driving force behind my interest in computer science is seeing your creation, that you worked tirelessly on, function as designed for the very first time and having a physical object that embodies this feeling is a great motivator for the future of this project. While my practical skills extend only to those explored in my university course, my interests within the field lie in algorithms—ones that not only work as intended, but also provide the greatest performance while not sacrificing reliability and good standards of code writing. I can imagine that applying my skills in a hardware-software environment will be different from what I'm used to, but I hope that by the end I will feel much more comfortable in similar circumstances.

2.9. Balint Szilagyi

[Hardware Team & Integration]

I've been interested in computer science for a number of years and garnered experience with coding various algorithms and simulations. However, I would love more exposure to all the processes that come with being on the hardware team. I have inklings of past involvement with fabrication, 3D modeling, and electronics through hobby projects. I'm confident I have enough base knowledge of the vital areas involved in this project to be able to efficiently research further if I feel stuck. Based on my experiences from past large projects, a weakness I will be consciously trying to overcome is my tendency to be caught up in perfecting one component which could prevent me from completing all necessary tasks.

3. Users

3.1. Primary User: Blind and Partially Sighted Schoolchildren

The main use case scenario for the robot is blind and partially sighted children in mainstream primary schools. The Royal National Institute of Blind People emphasises the importance of blind and partially sighted children learning braille from a young age, since this makes it easier to learn (Royal National Institute of Blind People, b).

Mainstream schools require a team to guide the blind and partially sighted students which include, family, support staff, mainstream teachers, a teacher with responsibility for Additional Learning Needs (ALN), Qualified Teachers of children and young people with Vision Impairment (QTVIs) as well as Registered Qualified Habilitation Specialists (RQHSs) for mobility and independent living skills (Royal National Institute of Blind People, c). The guidance process is manual and schools therefore, lack braille teaching. There are also no well defined educational policies that encourage teaching braille in mainstream schools as it is taught only externally (Royal National Institute of Blind People, a). Additionally, braille support in schools is, in a majority of cases, only provided to students that already know braille (Janis Sugden, 2009).

Our belief is that a robot that facilitates the learning of braille and handling of resource conversion will:

- Improve the percentage of blind and partially sighted students/people with an understanding of braille.
- Improves mainstream schools' ability to provide adequate resources catering to the needs of blind and partially sighted children without much extended costs and effort.
- Assist blind and partially sighted children to learn to touch type, which is a crucial skill as they progress in life.
- Allow blind students to be at an equal footing with their peers in terms of education received from mainstream schools.

The robot is expected to be utilised both during a classroom lesson and while self-learning. In a classroom setting, the child will utilise BraillEd , which will be a laptop-style form factor, to read words spoken out by the teacher as they are being translated into braille in real time. This process helps the student learn braille as it translates familiar English speech to braille which they are unfamiliar with (i.e. reinforcement learning). They will also touch type to practice typing while the rest of the class writes on notebooks. An example use case may be when the teacher writes down a sentence on a whiteboard and speaks it out loud as well, this can then be picked up by BraillEd and translated into braille for the child to refer to later. Further, the child can utilise the robot for reinforcement learning to self-learn braille. This can be done by the child speaking out a word, and feeling how it is displayed in braille, then attempting to type it out and get auditory feedback via an optional system to verify if they have typed in the right word.

If we are able to progress ahead to the implementation of the camera system, the students will also be able to read books in braille. This would allow them to read the same books as their peers, even if the school was not able to source the particular title in a braille format.

To prepare the robot for use in a classroom environment, it has to be designed to be durable, and rugged and should be able to withstand being dropped and be water-proof. Additionally, it should be battery-powered and not be plugged into mains for safety reasons.

3.2. Additional User: Teachers

When blind and partially sighted students are unable to practise their reading skills they may fall behind their peers and require additional support. While schools still need to provide additional support to students with disabilities to ensure they realise their full potential, having access to a resource such as BraillEd would make it easier for teachers. It would also make it easier to provide reading resources for the students if the teacher is able to use the same books for blind and partially sighted students as they use for fully sighted students through use of BraillEd's scanner feature.

A teacher's responsibility is to facilitate the learning and provide knowledge that the students require to further their education and inspire students to find passion in their work. As more blind students attend mainstream schooling it can pose difficult for teachers to adapt to teaching those they have not taught before in a different style they are used it. It puts responsibility on teachers to acquire new resources and find a new teaching style to effectively provide the same education to that of peers. This can prove difficult, especially if this is a teacher's first or second experience having to cater towards blind students.

With our robot's inclusion, provision of education can become more streamlined and assist a teachers ability to give a useful education. Due to simple inputs, seen in everyday life: microphone and camera, and an output source, the braille display, little training will be needed on the teachers part to understand and effectively demonstrate the robots use to a student unfamiliar with the technology. Due to the conversion of resources teachers will no longer be tasked with finding adequate resources and can instead focus on providing education equally with blind students being able to effectively follow along with the same resources of their peers. Teachers can also walk through students with the learning of braille by sitting with them and using the microphone input to help the student visualize words provided by teachers in a classroom setting more geared for education with more discipline than that of independent learning.

3.3. User Stories

- As Alex, a partially sighted 10 year old, I want to touch type, so I can practice schoolwork. However, I struggle to read the computer display to check the sentences that I have typed.

  With the robots ability to give auditory feedback to what keys are pressed and what words have been typed, touch typing is a feasible goal to learn by using our device, giving the chance to learn a keyboards layout through repetition.

- As Max, a blind 11 year old, I want to be able to read what the teacher writes, so I can keep up with the class

rather than having to wait for the teaching assistant to read the page to me.

The camera scanner provided will allow quick text to braille translation, so when a student has the knowledge of braille reading anything written or given in print will be quick and easy.

- As William, a mainstream school teacher, I want to help Anna, a partially sighted child in my class to follow along with the same books so that everyone in the class has an equal opportunity to learn. However, I find myself struggling to find books that are available in the necessary format.

  With BraillED, Anna will be able to develop her braille understanding she learnt from her specialist mentor and practise reading it quickly. From there, the device will offer the chance to convert the same resources peers have into material readable for her.

- As Sascha, I want to learn to read and type, so that I can continue my hobby of reading books after recently meeting with an accident that has led to sight loss.

  Although the device's primary use is in classroom scenarios, those who have experienced sight loss later in life can use this robot as an introduction to braille giving adequate resources and braille conversion to give those, determined enough, the chance to read again and work again.

- As Ellie, a blind 9 year old I want to hear what I type, so that I can practice my touch typing on my own to enforce my learning, so that I can email my Grandma without help from my dad.

  The system's audio output will give those the opportunity to get feedback on what words are display including what key the user has clicked, allowing user to become comfortable with keyboard layout and letter feel.

4. Impact

We expect the core target market for our product to be mainstream primary schools. We will focus on targeting local education authorities and multi-academy trusts who would be able to make large purchases to give a couple of devices to each of the various schools they oversee, as this would allow the price to be kept low to allow as many schools as possible to have the kit. This would also keep the price affordable for individuals who wish to purchase it. This is important because many existing accessibility tools are expensive and it is important that everyone who can benefit from them to have access. It is also important to distribute our product to as many schools and individuals as possible in order to help contribute to overall social benefit.

Despite an uptake in prevalence of braille material, only a small fraction of blind and partially sighted people are currently taught braille, and it is thought that this may contribute to the higher rates of unemployment among blind and partially sighted individuals (Damon Rose, 2012). The teaching of braille to a greater proportion of the blind and partially sighted community as children is likely to help them to be more independent in the world as they will be more confident in using braille.

Of course, this must be accompanied by a continuing greater uptake of braille signage, books and other material across different areas in society. The increase in blind and partially sighted students' use of braille in mainstream education could promote more inclusiveness across society by helping to teach fully sighted people the importance of braille. People who in the course of their careers have to make design and policy decisions may be more likely to remember to take into account the need for things such as braille to include everyone.

5. Outcomes

The system should support a braille input and output, ideally using a braille keyboard and display respectively. The system should then be able to effectively translate text and speech to braille as a first tier of success. Furthermore, it can include a scanner module, which would be a camera sensor utilizing computer vision to convert typed and handwritten text to braille.

The speech to braille will allow young children to feel the words they speak providing an introduction. The keyboard with audio capabilities will act as a way to teach students touch typing on keyboards, and considering keyboards/laptops have become widespread in education and work we believe providing the capability to learn this skill is important to keep blind students on par with their peers. Linking with audio output, the system will have the option to repeat what has been typed back so students can learn what letters are where on the keyboard.

The system also benefits people in later stages of life, trying to learn braille or touch typing for the first time, as the optional audio feedback on typing and the option to speak out words and see them being represented in braille, are key features that promote independent learning of braille without much external help being needed.

These features enable blind and partially sighted students to establish themselves as independent learners without the explicit need or help of trained individuals. The system also helps them learn to use a keyboard, which is a very useful skill which will help them access and interact with digital content independently.

We believe an introduction to typing without sight while having confidence in what you are typing will be highly important for those seeking employment in fields where typing is mandatory, which is becoming more prevalent in society. The hope is that and early introduction to touch typing will set up blind students for challenges later in life, such as higher education where every assignment is typed.

Our Minimum Viable Product (MVP) would contain the

English to braille translation on the software side and hardware inclusions would be: braille adapter, microphone, braille keyboard and audio output device. We believe these are the minimum requirements for the device to feasible facilitate the learning and understanding of braille while still being worth the cost for the device. These components would function by having a keyboard that allows the user to type in some text which would be stored in the system. They would then be able to scroll through this text on the braille display, as well as press another button to hear it read aloud. Furthermore, there would be a switch to enable a feature whereby each keypress would be audibly announced. Similarly, the text can be entered by holding down a microphone button and speaking into the device. All buttons and controls would be of a shape which makes it easy to find the desired button without sight.

An optional goal is to add the camera. It would function by the user pressing a button which takes a picture, and then the device uses computer vision to detect text within the photograph and place this in the stored text field. While we still hold it as extremely valuable this can be viewed as an extra since the product still has a useful benefit without it. We believe the cameras function holds most of its utility once braille has been learned, as a tool to understand preexisting written material. We still view this as important and will aim to complete it due to the function it provides, provided implementation of the MVP goes smoothly enough to leave sufficient time to do so.

We can validate achieving our goal by demonstrating a durable robot that supports the features of our MVP and works reliably in a simulated classroom environment. This simulated environment can involve showing how each of the features work, how they would aid a blind or partially sighted individual, as well as unforeseen circumstances including dropping the robot from a height.

6. Tasks

Our system is comprised of several hardware and software subsystems to deliver full functionality.

Starting with the hardware, the main components are a braille display, a keyboard, a speaker, a microphone, and various buttons. Additionally, we have planned to reserve developing a scanner feature once we have implemented our MVP. The braille display will be comprised of several refreshable braille cells, which will be able to display any letter of the Roman alphabet. The keyboard will be a standard QWERTY layout which will feature custom braille textured keycaps. The speaker and microphone complete the I/O options, working to provide audio feedback for key presses and providing another form of input respectively. These components will be linked by a micro-controller and will provide functionalities in specific conjunctions. The scanner, if implemented, will work to expand the capabilities of our device to be able to translate written text to braille via a camera.

On the software side, the desired core components are speech processing, conversion of text to the corresponding braille dots, and creating a website for marketing purposes. Given that development is fast enough, computer vision will be implemented in order to perform optical character recognition The usefulness of the microphone is heavily reliant on implementing speech processing so that we can understand what the user wants to input and then pass the user's input for translation to then display with braille. Similarly, the braille display itself is also reliant on the robot being able to translate English inputs into a form that is effectively displayed with our setup of braille cells.

Beyond the development of these components, we will also have several other types of tasks, such as research and development (R&D), testing, and market research among others. R&D will be essential for enabling us to develop our subsystems, such as reasonably sized braille cells for keeping the design from and a computationally inexpensive speech processing method. Furthermore, conducting tests with potential users will be imperative in proving our product's value for its target audience. In order to complete each task efficiently, our team will split into a hardware and software team, alongside one member who will primarily focus on project management and organization. During our weekly meetings, tasks will be assigned in order of priority. This order will be decided upon based on the goals for the upcoming deadline. Each team will feature a lead member who will coordinate the completion of assigned tasks within their group. Our direction is to prioritize tasks that are essential for a working prototype first, then for implementing the MVP, and finally for polishing our product for the target operating environment and implementing our reach goals such as the scanner feature.

Firstly, for **Demo 1**, our main goal is to showcase a robot with the mechanism for at least a single braille display cell working, and being able to process speech into displayable braille data. In order to effectively demonstrate the efficacy of our subsystems, it will be beneficial to also have an interface that can display the information as it is processed, such as the text stored. Subsequently, **Demo 2** is when we are hoping to be able to showcase our MVP, implementing all hardware and software core components, with enough braille display cells included to showcase its usefulness. Finally, for **Demo 3** we are looking to have full functionality of our MVP in a school-appropriate package possibly including our further development goals. Furthermore, between Demo 2 and Demo 3, we are going to create the product website and promotional material.

The Gantt chart (Figure 1) summarises all of the above.

7. Risks

One area of concern is with ensuring that children using our product feel included in the classroom and that they are not being picked on by their peers. We hope to leverage the ubiquity of laptops/tablets in today's educational landscape, as a means to provide a familiar and inclusive learning en-

vironment. We hope to achieve this by designing a product that of similar form-factor to a laptop or tablet. We also believe we can design it in such a way that we cultivate a sense of empowerment and 'coolness', ensuring that our product resonates positively with its users.

For a product designed for use in a classroom environment, a key concern is ensuring the product will actually be viable in the environment. Particularly when using electronic hardware, it's crucial to ensure it's durable enough to survive use by children. A product that is too fragile runs the risk of satisfying all our use cases on paper but being almost useless in an actual deployment environment. At each stage in our design process, we must keep this factor in mind, primarily for the housing of the system but also when considering the internal structure and connections. In general, this points to the importance of keeping the actual use case for our product forefront in our minds for the entire development for the system.

In this vein, it's also crucial to ensure the product actually serves its users. When creating a product for accessibility purposes, it's key to ensure we are designing a tool to enhance agency for our target market, as opposed to trying to intervene on their behalf. As with the durability issue, it's key that we, as designers who are not ourselves blind or partially sighted, do sufficient research and communication with the relevant community to ensure our design is shaped by the needs of our users. If possible, we should get in contact with someone who can read braille and is willing to test out our product to verify that it is readable for them. We can also work towards this by seeking to interview teachers who have had experience teaching blind or partially sighted children.

We acknowledge the need for strategic planning to mitigate the risk of under-delivery. We have implemented a focused strategy: prioritising the release of a MVP first. This approach will ensure that we meet the essential requirements efficiently before exploring additional features.

An inherent risk to our success is maintaining team cohesion and alignment, especially given we have some team members participating predominantly remotely. To address this, our team has decided to use Slack as our main communication platform, because of its prominence in the industry. Additionally, during our meetings, whether in person, hybrid or fully remote, we diligently record minutes. This not only ensures clarity in our discussions but also provides a tangible record for future reference. By consistently revisiting these minutes, we can solidify our collective understanding and work towards the same goals and expectations. This practice has proven effective thus far, and we will continue to utilise this method.

Especially in a fast paced environment like SDP, where efficient use of time and collaboration, is absolutely critical, we need to make sure we are able to collaborate on code effectively to avoid version conflicts. To this end, we will use GitHub. Besides having the flexibility to rollback changes in the event of a 'breaking' change, we can also use it to review eachother's code, enhancing the overall quality of our work. Furthermore, we strive to minimise the software 'friction' - avoiding the use of many tools which may hinder rather than facilitate our workflow. A notable example of this is our decision to utilise Github Projects as a substitute for the widely recognised Kanban platform, Trello, for the reason that we were already intending to use Github.

References

Chanfreau, Jenny and Cebulla, Andreas. Educational attainment of blind and partially sighted pupils. *London: RNIB*, 2009.

Damon Rose. Braille is spreading but who's using it? https://www.bbc.co.uk/news/magazine-16984742, February 2012. Accessed: 2024-01-24.

Dr. MNG Mani. The role of integrated education for blind children. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1706061/. Accessed: 2024-01-25.

Janis Sugden. Teaching braille. https://www.ssc.education.ed.ac.uk/courses/vi&multi/vsep10ii.html, January 2009. Accessed: 2024-01-25.

Royal National Institute of Blind People. Braille resources for schools. https://www.rnib.org.uk/living-with-sight-loss/education-and-learning/braille-tactile-codes/learning-braille/braille-resources-for-schools/, a. Accessed: 2024-01-25.

Royal National Institute of Blind People. Modern day braille. https://www.rnib.org.uk/living-with-sight-loss/education-and-learning/braille-tactile-codes/braille-through-the-years-past-present-and-future/modern-day-braille/, b. Accessed: 2024-01-24.

Royal National Institute of Blind People. How your child can be supported in a mainstream school. https://www.rnib.org.uk/living-with-sight-loss/education-and-learning/education-for-younger-children/how-your-child-will-be-supported-in-a-mainstream-school/, c. Accessed: 2024-01-25.

Sue Keil. Teaching braille to children. https://media.rnib.org.uk/documents/teachingbraillechild.doc, November 2002. Accessed: 2024-01-25.

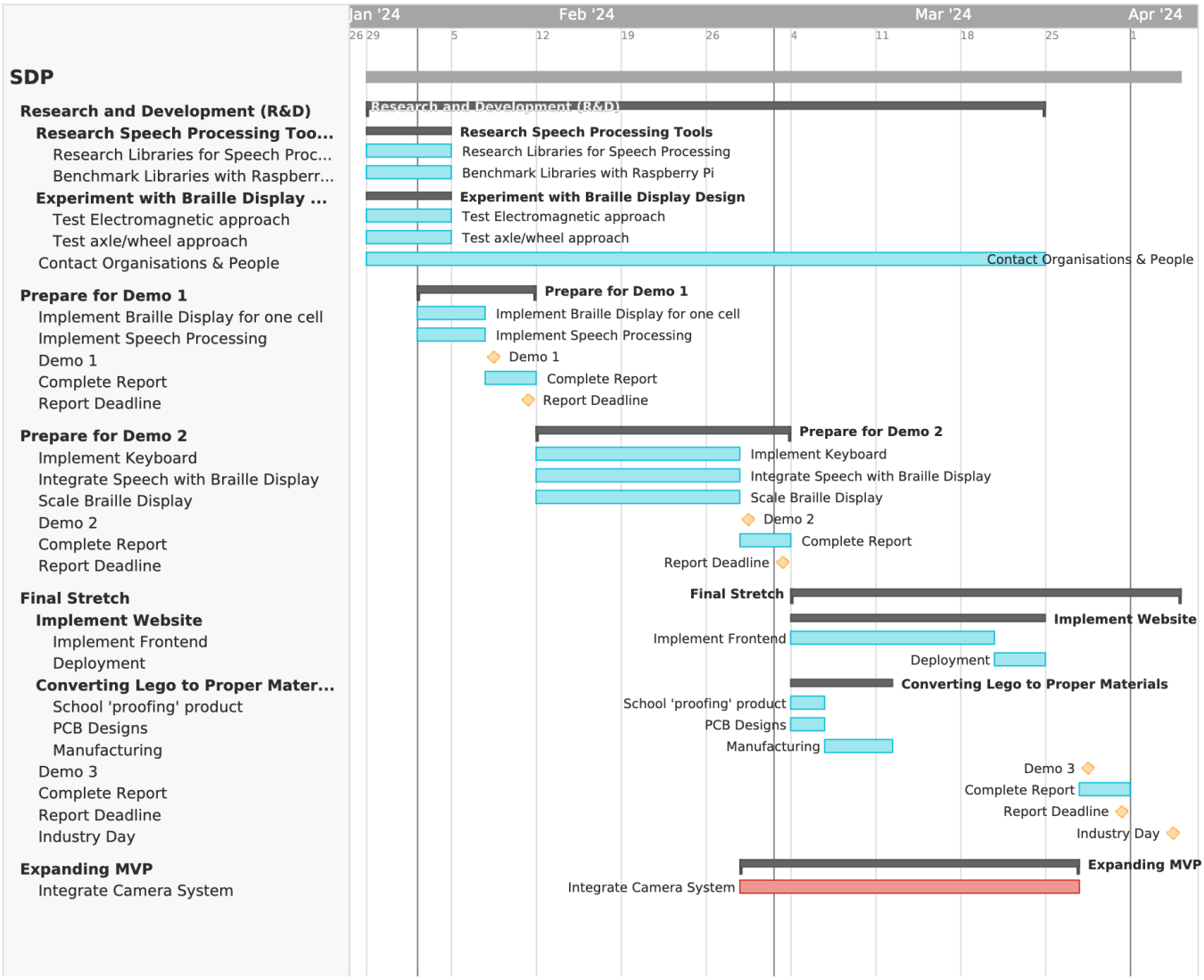

Figure 1. Gantt Chart