Albatross: An Ergnomic Keyboard

A Final Report

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The Albatross is a custom ergonomic keyboard designed to reduce repetitive strain injury (RSI) for frequent typists. Leveraging user research, a split-fixed layout and optimized key spacing were developed to enhance comfort and usability. The keyboard incorporates a custom PCB designed with KiCad, powered by the Elite-C microcontroller, and features a laser-cut acrylic plate for acoustics and aesthetics. Silent linear switches and botanical-themed keycaps further align the design with aesthetic and sensory considerations. While challenges arose in materials and PCB design, the Albatross demonstrates the potential of customizable ergonomic keyboards. Future work includes refining materials, layout variations, and exploring wireless options.

Background

Over the last few years, 3D printing has become an important skill and has been used in many domains — be it food tech, electronics, space, drone technology, or even ornithology and behavioral ecology [1,2,3,4,5]. In the mechanical keyboard community, 3D printing and laser cutting are often used to build custom cases, keycaps, and even entire keyboards. While ortho-linear keyboard layouts are the most common, there are actually a multitude of layouts currently available [6]. In this section, I will explore ergonomic keyboard layouts and their potential impact on reducing strain on the wrists of typists.

Frequent typists are often victims of Repetitive Strain Injury (RSI) — a condition that occurs when tissue is damaged by repeated physical actions [7]. There are many solutions that can reduce the impact of RSI — one of them being the use of ergonomic keyboards [8]. Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance [9].

Ergonomic keyboards, specifically, are defined as computer keyboards designed with ergonomic considerations to minimize muscle strain, fatigue, and other problems [10]. However, many commercially available ergonomic keyboards still have limitations, such as a lack of customization options, suboptimal key layouts, or high costs. This proposal is to design and build a novel ergonomic keyboard.

The proposed ergonomic keyboard will incorporate features such as a fixed-split design and optimized key layout. These features have been shown to reduce the risk of developing musculoskeletal disorders and improve comfort and productivity for frequent typists. The split design allows the keyboard to be positioned in a more natural, angled position for the user's hands, reducing strain on the wrists and forearms.

Technical Approach

User Research: Process and Insights

To start off, a semi-structured interview guide was developed [11]. The qualitative interviews focused on understanding the pain points users face with their current keyboards, detailed information about their current setup, and their preferences and potential solutions they have looked at to reduce wrist pain/RSI. In addition, a survey was created to reach a larger audience and gain an overview of people's opinions. The survey focused on a person's usage of external or laptop keyboards and asked them to highlight their key pain points. Since the survey was for preliminary research, convenience sampling was used to recruit participants. The key highlights from the survey showed that over 63% of users with external keyboards reported that their wrist position while typing was uncomfortable.

Here are the findings found by conducting qualitative interviews to get a deeper understanding of the mentioned pain points:

- **Wider key spacing:** Reduce finger cramping by slightly increasing key spacing, ensuring the layout isn't too wide to cause extra strain.
- **Softer materials for support:** Use softer materials for wrist rests and keyboard edges to prevent discomfort from prolonged use.
- **Mechanical key switches:** Incorporate mechanical switches that require less force, enhancing tactile feedback while reducing finger fatigue from heavy keystrokes.

Layout Design

Based on these findings, a layout was created for the keyboard. With the Alice layout as a starting point, these changes were made:

- Bigger space bar: Changing the space bar from 2 and 2.75u to 2.75 and 3u
- Reducing keys: By reducing some of the keys (PgUp, PgDn, etc.), additional space freed up on the board, which ensured better spacing between keys.

Keyboard Layout Editor (KLE) was used to finalize the layout of the board [12]. I used a KLE JSON of an Alice layout as a starting point on the editor [13].

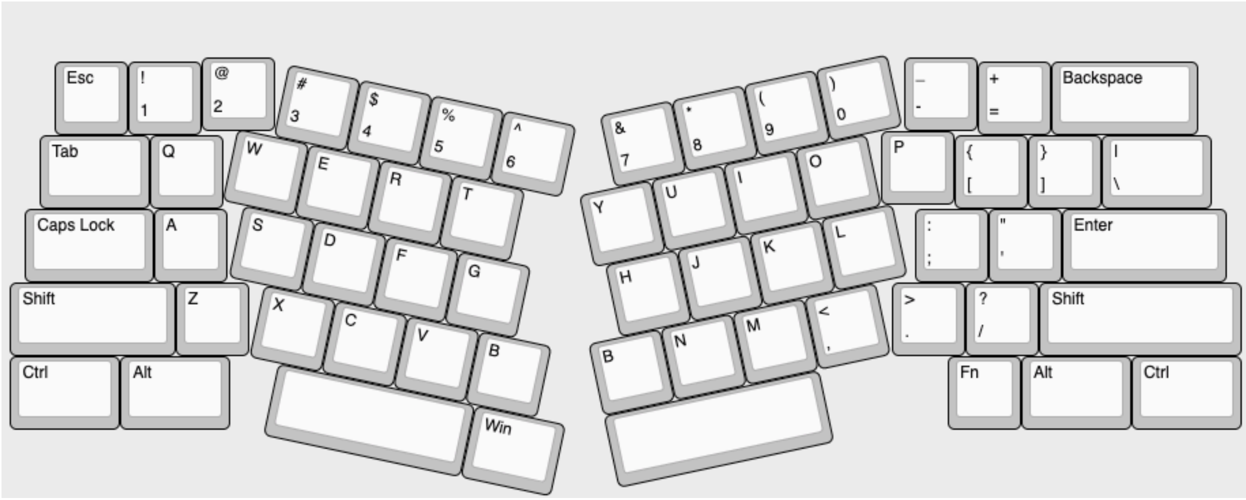


Figure: The finalized layout of the Albatross

PCB Design

KiCAD, an open-source electronics CAD software, was used to design the PCB [14]. ScottoKeebs and Keebio have a library with schematics and footprints, which was used to create a circuit that consisted of 5 rows and 14 columns consisting of 62 keys arranged in a split-fixed ergonomic layout [15, 16, 17]. Each key was connected to a diode which prevented "ghosting". The one-way current of the diodes ensures that the microcontroller knows which key is being pressed without current flowing in multiple directions.

These rows and columns were connected to a microcontroller — the Elite-C. The Elite-C is a slightly modified USB-C variation of the Pro-Micro which is driven by the ATMega32U4. The board has a rounded shape and an arrow pointing towards the top at the center bottom of the board [18]. ATMega32U4's datasheet indicated which GPIO pins could detect interrupts — those were assigned to the rows, and the rest were assigned to the columns based on ease of wire routing [19].

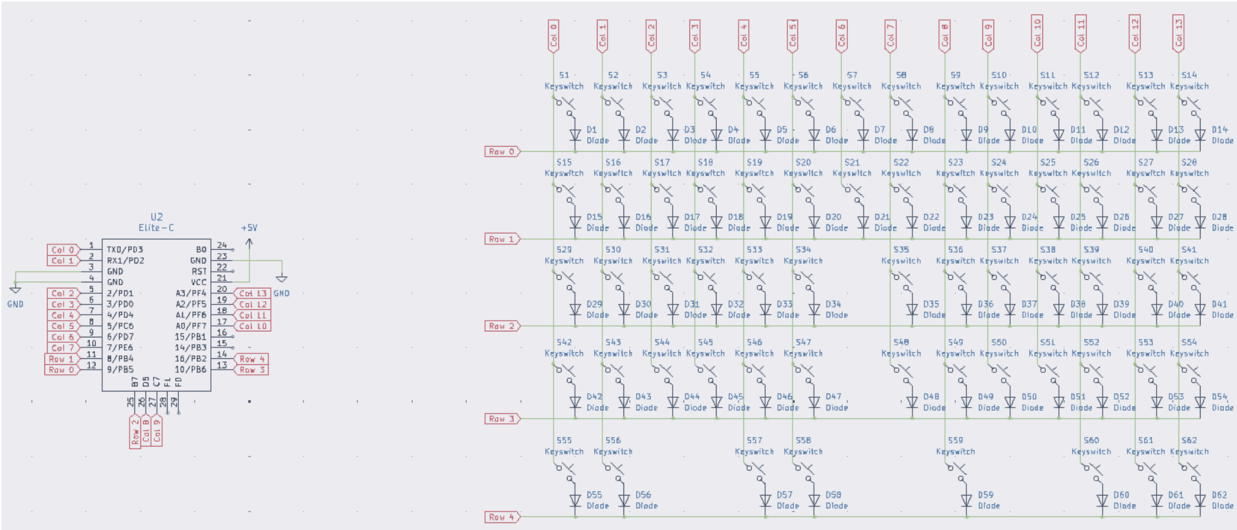


Figure: Schematic showcasing 5 rows and 14 columns connected to the microcontroller

This schematic was imported into KiCAD's PCB editor, and a 2-layer PCB was created by routing the wires, adding edge cuts, and making appropriate indications on the silkscreen. Diodes were placed on the back side for ease of soldering and an aesthetic choice.

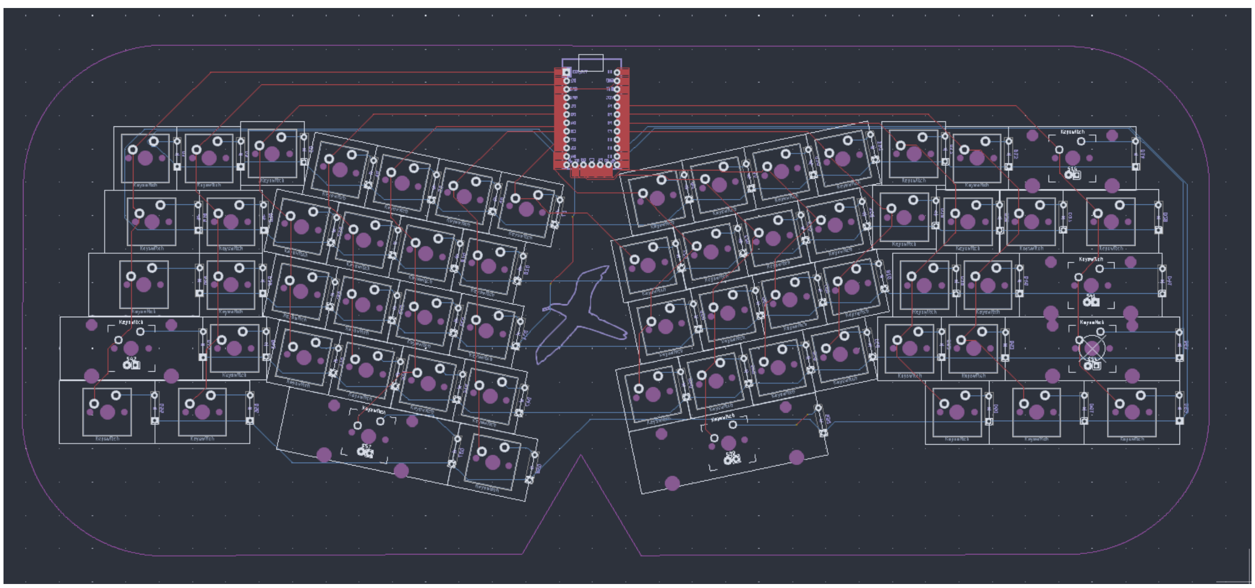
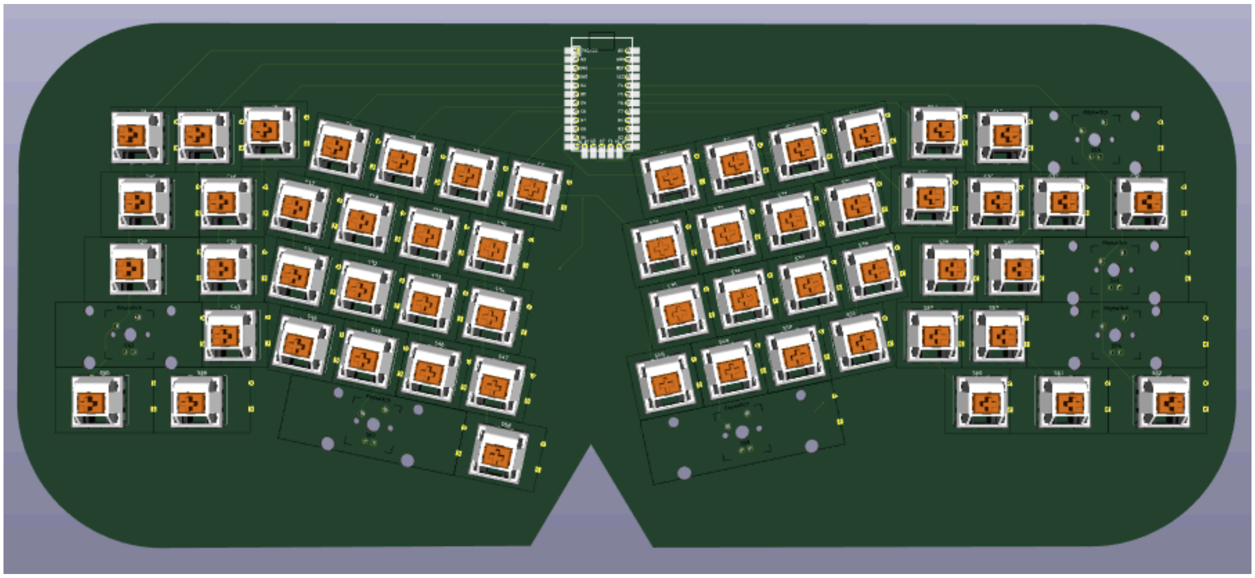
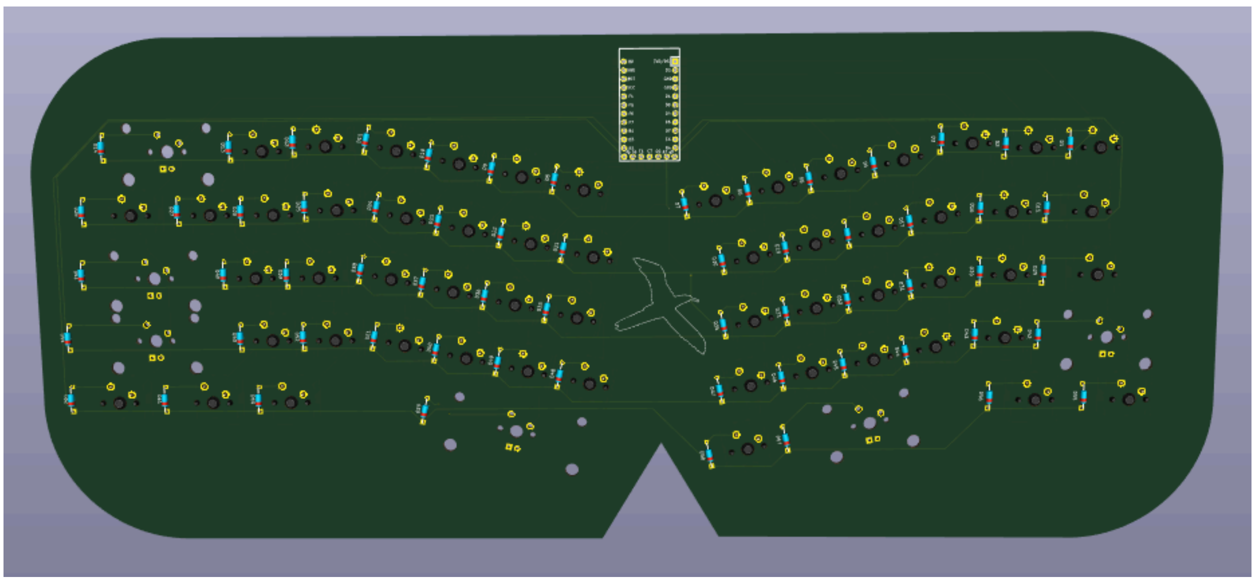


Figure: KiCAD's PCB editor with all keys placed in position along with the microcontroller

The 3D viewer gave a preview of what the PCB would look like post-fabrication.





Figures (top to bottom): Showing the front and back of the PCB in KiCAD’s 3D viewer

Firmware and Flashing

The desired layout was used to create the firmware on a QMK-based keyboard firmware designer, where the wiring of the PCB, along with the pins used on the Elite-C had to be matched. After selecting the wiring and pins, the keymap was set according to the layout, along with an additional layer which was activated using the “fn” key. Once the firmware was ready, it was downloaded as a “.hex” file and uploaded to the microcontroller using the QMK Toolbox [20].

Material Choice and Assembly

Using linear silent switches ensured that the keys were easy to press with minimal sound, leading to reduced finger fatigue while ensuring the keyboard was easy to use for people with sensory issues. The case was laser cut using a 1.5mm clear acrylic sheet. The case was designed using ai03's plate generated and modified in Illustrator according to the layout developed on KLE [21]. The material was cut using an Epilog Mini/Helix laser cutter with 20% speed, 80% power, and 5000 Hz frequency.

Aesthetic Choices

The Albatross is a unique bird. One of its skills, called dynamic soaring, is a zero-energy flight technique, which seems nothing short of intuitive to the naive tubenose; it allows the bird to fly thousands of miles without flapping its wings. Like the Albatross, we rely on intuition while doing our chores or completing any simple or complex daily task. With technology at the forefront of almost every industry, we rely on computers for assistance with our chores. Technology and its applications are seen as carefully crafted experiences incorporating human psychology with design principles in a little package delivered to us as a product. As a technologist, one of my primary goals is to make information systems accessible and usable for everyone. Keeping up with this mission, I designed this modified version of the Alice layout — the Albatross.

The cut at the bottom of the case and PCB has an upward arrow highlighting the albatross's soaring techniques. The case is made from a clear 1.5mm acrylic sheet — staying true to the idea of transparency and usability — the case is see-through, and everyone can see the inner workings of the board easily. The botanical keycaps represent flora; paired with the albatross outline on the silkscreen of the PCB, which represents fauna, we get a 360 picture of nature. The switches are silent and linear; the keyboard allows you to immerse yourself in the sounds of your surroundings without the distraction of clattering keys.

Results

Here is a picture of the final board!

Discussion

The entire process, while fulfilling, was definitely time-consuming, and I ran into challenges that I would consider when revising this keyboard. First off, learning new skills like PCB design was challenging as the resources geared towards keyboards are very scattered online — there are no standardized libraries that are used for schematics and footprints on widely used platforms like KiCad. Using unconventional sizes of stabilizers like the 3u was difficult to find in the market. I was left with insufficient time to test the long-term ergonomics of my project.

This keyboard's assembly and PCB design would have been impossible without the support and help of many folks, especially Joey Castillo. Huge shoutout – thanks, Joey!

Future Work

Using a thin material like 1.5mm acrylic for the keyboard proved beneficial for aesthetics and acoustics but required careful handling due to its fragility, as a small crack occurred during assembly. Planned improvements for the next iteration include adjusting the spacing between the “>” and “:” keys for better usability, adding a silkscreen design to the top layer for enhanced aesthetics, and designing a cover with an integrated wrist rest for improved ergonomics. Additionally, since this is a sensory-friendly board, creating a cover to hide the bright blue light from the Elite-C microcontroller is a priority. Exploring a switch to a BLE-supported microcontroller paired with a long-lasting battery is also under consideration. Further plans involve testing more variations of ergonomic layouts and experimenting with different case angles to optimize comfort and functionality.

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