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February 20, 2017

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 405 Requirements Specification for a Wearable Posture Correction Device

Dear Dr. Rawicz,

The following document outlines the requirements specification for the VertAlign. Meerkat Biotechnologies is designing a wearable device that aims to help improve a user's posture by providing reminders and feedback. Whenever the user's posture drifts out of proper position for a prolonged period of time, VertAlign will notify the user with a light vibration. VertAlign will also be able to send alerts via android application.

Our requirements specification provides a set of high-level requirements for the system's functionality in regards to proof-of-concept, prototype, and production phases of development. Project managers and design engineers can refer to this document as a guideline for research and development activities.

Meerkat Biotechnologies is composed of five experienced engineering students in their fifth year: Kushank Aggarwal, Erik Hoddevik, Julian Lo, Matthew Malinab, and Jason Park. The team has a diverse skill set as it consists of majors in Biomedical, Computer, and Systems Engineering. Please direct any questions or concerns about our proposal to me by email at mmalinab@sfu.ca.

Sincerely,

Matthew Malinab
Chief Communications Officer
Meerkat Biotechnologies

Enclosure: Requirements Specification for a Wearable Posture Correction Device

VertAlign by

meerkat
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ABSTRACT

This report provides the requirements specification for the VertAlign system. Included is the basis for the system's design, usage, and high-level overview. The key elements of this report also include system requirements, sustainability, and usability for intended consumers.

The system overview describes the basic operational process of the VertAlign in the form of a flowchart. A system diagram outlines the layout of the physical components of the device, such as power supply, microcontroller, sensors and other modules.

Also covered in this report are a wide range of requirements pertaining to the hardware, software, and firmware of the VertAlign, including its physical and electrical specifications. Justification for these requirements are discussed in detail. The notation on each listed requirement defines which development stage the requirement applies to (e.g. proof-of-concept, prototype, or final prototype).

Finally, considerations for sustainability and safety are discussed. Temperature, radiation, and ergonomics are essential factors regarding the personal safety of our product's users. Sustainability plays a major role in our selection of materials and our decision to design with ease of disassembly in mind.

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GLOSSARY

CPU: Central Processing Unit

CSA: Canadian Standards Association

DAC: Digital to Analog Converter

DPS: Degrees Per Second

GUI: Graphical User Interface

LED: Light Emitting Diode

PCB: Printed Circuit Board

RAM: Random Access Memory

RoHS: Restriction of Hazardous Substances

ROM: Read-Only Memory

USB: Universal Serial Bus

1. INTRODUCTION

Chronic back pain is a significant problem endemic to today's society. Without proper attention, improper postures develop when using computers and phones, and, when sustained, can result in permanent damage to the neck and back.

VertAlign is a posture correction device which aims to promote healthy posture in individuals such as office workers. The user simply activates the device and wears it around their neck. VertAlign acquires real-time positional data using multiple gyroscope sensors and performs analyses to determine whether the user is sitting in correct or incorrect posture. If incorrect posture is sustained past a user-defined time threshold, a notification is issued to the user in the form of gentle vibration.

1.1 SCOPE

This requirements specifications document outlines the requirements for VertAlign as proposed by Meerkat Biotechnologies. The set of requirements define the proof of concept and final marketable product, and these must be met to provide a functional, usable, reliable, and safe product. The design process and testing of VertAlign will be driven by the listed requirements and specifications to ensure success in our final product.

1.2 INTENDED AUDIENCE

The intended audience of this document includes, but is not limited to, the members of Meerkat Biotechnologies and potential stakeholders of this product. This document shall be used by all the team members as a guide for the system requirements throughout development, and shall be referred to by design engineers should there be a conflict. Engineers responsible for quality assurance shall refer to this document to prepare the test cases and procedures, and ensure that the product conforms to the specified requirements and standards. Potential stakeholders shall refer to this document to evaluate the progress and verify the functionality of the product.

1.3 CLASSIFICATION

Throughout this document, the following convention will be used to define a requirement:

[Req a.b.n - p]

Where **a.b** represents the section number, **n** denotes the functional requirement number and **p** indicates the priority of the documented requirement in Roman numerals.

The priority of the functional requirement is defined as follows:

i --   High priority: this requirement is very essential for the product. A proof-of-concept must meet this requirement

ii –   Moderate priority: this requirement is vital for the marketable product. A prototype may meet this requirement.

iii --   Low priority: this requirement is applicable to iterations of development after delivering a working prototype.

2. SYSTEM REQUIREMENTS

2.1 SYSTEM OVERVIEW

A new user must calibrate their target posture through a simple and intuitive process when they use VertAlign for the first time. The user will be able to press the calibrate button on the device to start the calibration process. During this process, the user will hold their target good posture for no longer than 10 seconds while multiple gyroscopes collect and optimize the data, after which the target posture data will remain stored in the local memory of the device.

Sensors will actively monitor the posture of a user and compare it against the data stored in the memory within a reasonable threshold. The block diagram in Figure 2.1 models the high-level operation of VertAlign. The device will gently vibrate and send a notification to the companion app when poor posture is maintained past a defined time threshold. The purpose of the time threshold is to avoid sending an excessive amount of feedback, because drifts in posture for short periods of time are not likely to have a lasting negative impact on the user's health.

The VertAlign will also alert the user after they have been sitting for an extended period of time. A different vibration pattern will remind the user to stand up and go for a walk or have a quick stretch.
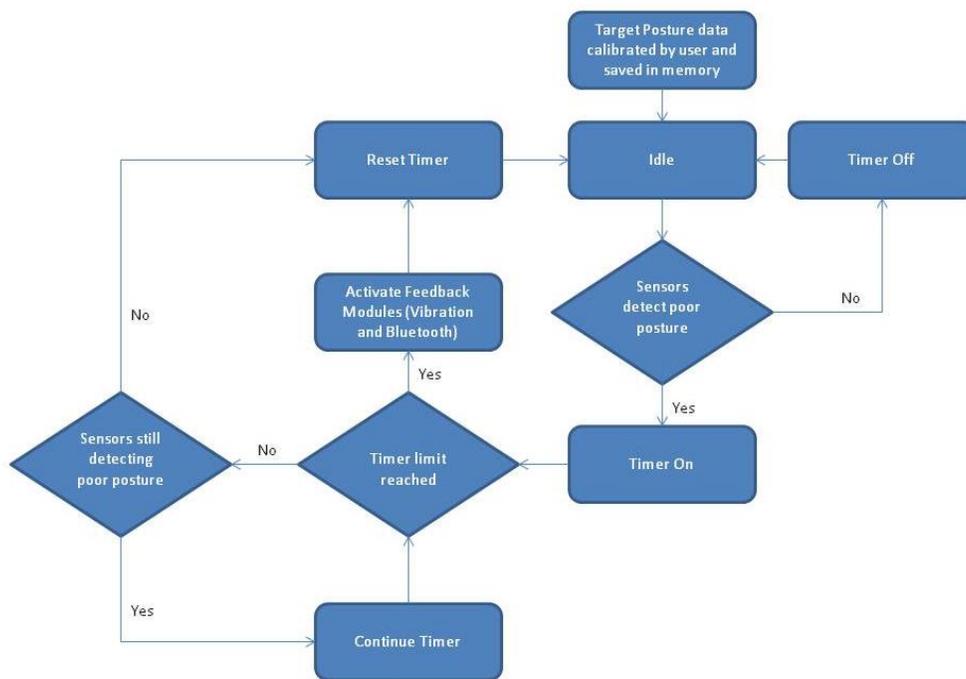

Figure 2.1: VertAlign High-Level Functional Block Diagram

Figure 2.2 below provides a rudimentary design of the VertAlign system. Multiple sensors and modules have been interfaced with a single microcontroller that has onboard memory. All hardware components will be housed in an ergonomic hardware case. Furthermore, VertAlign will have a pairing capability with a companion android application via a Bluetooth module. Only a micro-USB plug-in to recharge the battery, calibration button, and power button will be accessible to a user in the proof of concept. The prototype and marketed product will additionally feature a button for adjusting timer lengths.
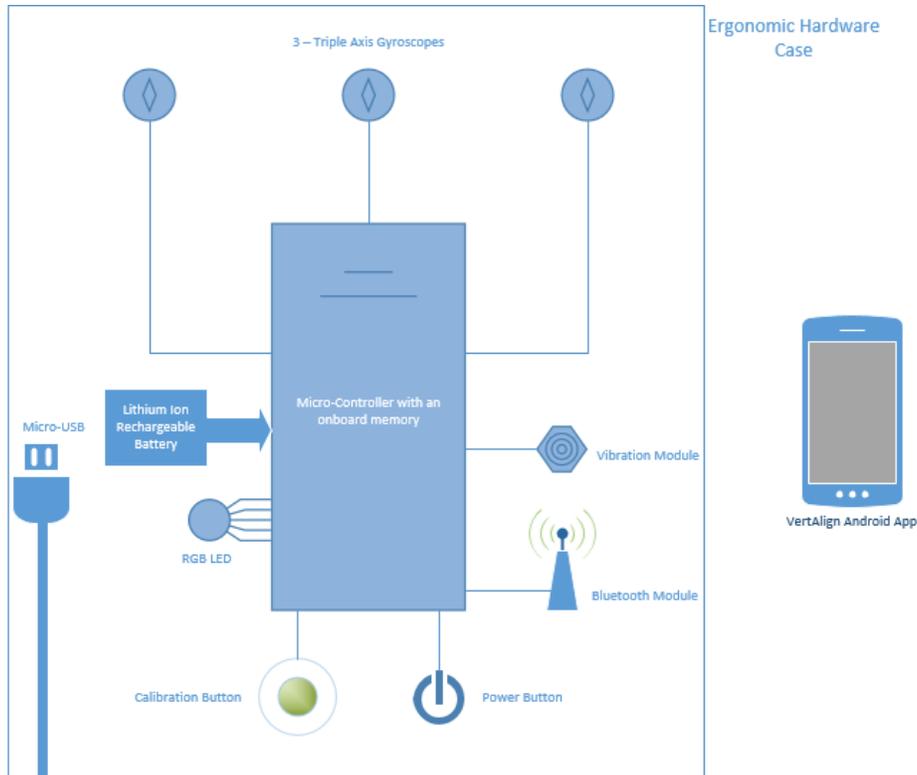

Figure 2.2: VertAlign System Design

Figure 2.3 shows the approximate target location of the three triple axis gyroscopes which will be used to collect the necessary data.
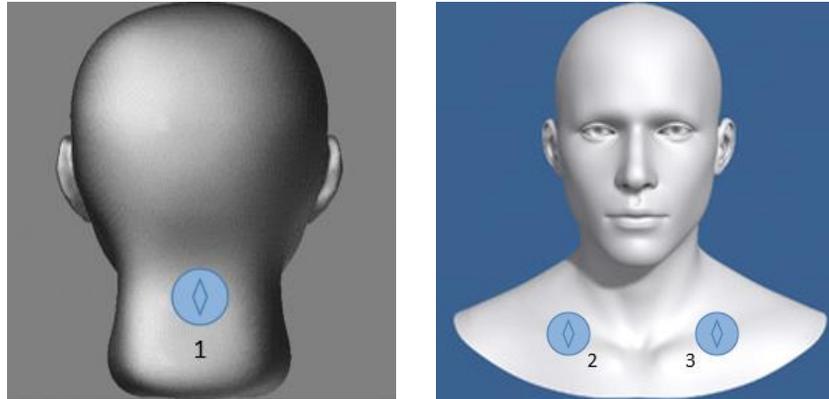

Figure 2.3: Possible Gyroscope sensor positions [1,2]

In addition to providing notifications, the Android application will provide weekly and monthly analytics for the purpose of tracking progressions and improvements. There is a risk associated with granting the user the freedom to set their own target posture, which is that a user may reinforce poor posture habits due to incorrect calibration. Meerkat Biotechnologies is aware of this possibility, and to alleviate this the companion Android application must come with an educational tool or guide which raises the user's understanding of healthy posture and gives key points to assist the user in determining healthy posture.

2.2 SYSTEM REQUIREMENTS

The following section outlines the general requirements of the VertAlign system as a whole. These encompass general aspects such as usability and safety, and provide a framework in which subsequent requirements can follow.

GENERAL REQUIREMENTS

Walking posture is a complicated task that varies widely between individuals. Therefore, it is a much simpler task to measure only sitting posture. Placing the device on the shoulders and draped around the neck gives the device a prime location for monitoring shifts in shoulder and neck position, which are good indicators of posture. A cheap price points widens the potential market for consumers of the product.

[Req 2.2.1 - iii]   The device shall cost the consumer no more than $75 CAD.

[Req 2.2.2 - i]   The device shall be mounted on the user's neck.

[Req 2.2.3 - i]   The device shall work in all indoor environments.

[Req 2.2.4 - i]   The device shall solely monitor sitting posture.

Usability Requirements

The device must be self-contained for the case where smartphones are not allowed in the office environment. The device must be simple enough that everyone can understand and use it, and unobtrusive enough that no one wants to throw the device out after using it for a day.

[Req 2.2.5 - i]   The device shall be minimally intrusive to the user.

[Req 2.2.6 - i]   The user shall be able to use the device either with or without the companion application.

[Req 2.2.7 - ii]   The user should be able to understand the system after less than five minutes.

[Req 2.2.8 - ii]   The device shall contain adequate documentation for ease of usage.

[Req 2.2.9 - i]   The RGB LED shall communicate the current status of the device.

[Req 2.2.10 - ii]   The user shall be able to calibrate the device in less than 10 seconds.

Safety Requirements

As the device is worn around the neck, it's important that the weight and size of the device do not cause damage to the spine or impede the motion of the user's head. The device must also not emit harmful levels of radiation, contain sharp edges that may cut or otherwise abrade the user's neck and shoulders, or otherwise cause harm to the user from wearing the device.

[Req 2.2.11 - i]   The device shall not emit radiation harmful to its users, including from excessive heat.

[Req 2.2.12 - i]   The device shall not interfere with the operations of any other devices.

[Req 2.2.13 - i]   The device shall not emit toxic fumes or produce any environmental hazards.

[Req 2.2.14 - ii]   The device shall not contain sharp or rough edges.

[Req 2.2.15 - i]   The device shall not produce any unnecessary pressure points on the user's body.

[Req 2.2.16 - i]   The device shall contain hypoallergenic components.

2.3 Hardware Requirements

Physical Requirements

The physical requirements of the device are driven by the need to have it be operable without the phone application and the need for ergonomics. The device must be comfortably worn for up to eight hours a day during a workday, and therefore must be a manageable weight to avoid straining the user. Equal weight distribution is important for the same reason. To make sure the device is usable as a standalone

product, it must have buttons built-in to the case that cover all operational requirements such as power on/off and calibration.

[Req 2.3.1 - ii]   The device shall not exceed 150g in weight.

[Req 2.3.2 - ii]   The device shall not exceed 9" x 7" x 2" in size.

[Req 2.3.3 - ii]   The device shall be housed in a semi-rigid case.

[Req 2.3.4 - ii]   The device shall not uncomfortably adhere to the user's neck.

[Req 2.3.5 - i]   The device shall have equal weight distribution.

[Req 2.3.6 - i]   The device shall contain one button for power on/off.

[Req 2.3.7 - ii]   The device shall contain one button to perform calibration.

[Req 2.3.8 - iii] The device shall contain one button to cycle pre-set timer lengths.

[Req 2.3.9 - i]   The device shall contain one RGB LED to indicate device status.

[Req 2.3.10 - ii] The device shall contain one USB charging port.

[Req 2.3.11 - i]   The device shall contain one panel to allow access to its components.

[Req 2.3.12 - ii] The device shall not break if dropped from a height of 2 metres.

[Req 2.3.13 - ii] The device shall be water resistant and must withstand occasional spills.

[Req 2.3.14 - ii] The surface temperature of the case shall be within the range of human body temperature.

OPERATIONAL REQUIREMENTS

Similar requirements to above. The device must be operable through the entire workday and not become uncomfortable.

[Req 2.3.15 - i]   The device shall have an operating temperature range of 0C - 40C.

[Req 2.3.16 - ii] The device shall have a battery life of at least 8 hours when in use.

ELECTRICAL REQUIREMENTS

All circuitry must run off the supplied battery. There will be no space available for a secondary power supply, nor would such a redundant power supply be considered optimal.

[Req 2.3.17 - ii] The power supply to the device should be a USB-rechargeable battery.

[Req 2.3.18- i]   The battery must charge off wall charger operating between 100-240V at 50-60 Hz AC or a computer using a USB to micro-USB cable

[Req 2.3.19 - i]   The current required by the system should be less than 25mA.

[Req 2.3.20 - i]   The power supply should be consistent across all sensors and modules

[Req 2.3.21 - i]   The vibration module, Bluetooth, RGB LED and gyroscopes must be operational at 5 V.

[Req 2.3.22 - i]   Any vibration must not be continuous for more than 2s.

[Req 2.3.23 - i]   The gyroscopes must be triple axis.

[Req 2.3.24 - i]   The gyroscope's sensitivity must be at least 250 DPS.

[Req 2.3.25- i]   The Bluetooth module must be compatible with Bluetooth 3.0 or higher

[Req 2.3.26 - i]   Both Bluetooth module and gyroscopes shall have a 16 bit DAC resolution

2.4 FIRMWARE REQUIREMENTS

As an embedded system, VertAlign shall have its own dedicated firmware. As explained in the System Overview, the firmware must be capable of saving posture calibration data, comparing current posture data with target posture data, and tracking time spent sitting and time spent in poor posture. The minimum memory specification was taken using the memory specification for the Alex posture device as a reference. As Alex is a device with very similar application to ours, we expect this to be a reasonable reference point [3].

[Req 2.4.1 - i]   The firmware shall utilize non-volatile memory in order to retain the user's calibrated target posture data even when the device is turned off.

[Req 2.4.2 - i]   The firmware shall be programmed to rewrite the saved target posture data when the user activates the calibration button to recalibrate.

[Req 2.4.3 - i]   The firmware shall perform comparison operations between target posture data and current posture data taken from the sensors.

[Req 2.4.4 - i]   The firmware shall keep track of multiple timers simultaneously: time spent in poor posture and time spent sitting.

[Req 2.4.5 - ii]   The firmware shall interface with the mobile application, sending appropriate data from the device to the phone via Bluetooth.

[Req 2.4.6 - ii]   The firmware will use a minimum memory size of 256KB for internal ROM and 16KB for internal RAM.

[Req 2.4.7 - ii] The firmware will utilize a 32-bit ARM processor.

2.5 SOFTWARE REQUIREMENTS

GENERAL REQUIREMENTS

The software must take in data from the device and store this data, but not overly stress a user's CPU, battery, or data plan. The software must also be available to a wide user base, which is why Android 4.4 is chosen as the earliest supported version allowing us to provide the app for 90% of Android users. [4]

[Req 2.5.1 - ii]   The application shall be able to interface with the device through a Bluetooth connection.

[Req 2.5.2 - ii]   The application shall be compatible with Android 4.4 and higher.

[Req 2.5.3 - ii]   The application shall be minimally taxing on the phone's CPU

[Req 2.5.4 - ii]   The application shall be able to run in the background.

[Req 2.5.5 - ii]   The application shall be able to conduct the calibration procedure, and complement it through a GUI display.

[Req 2.5.6 - ii]   The application shall store data in the local memory of the phone in a compressed format to save space.

[Req 2.5.7 - ii]   The application shall provide weekly and monthly analytics through a GUI display.

[Req 2.5.8 - ii]   The application shall receive data from the firmware and convert it to a format that can be displayed on the GUI.

USABILITY REQUIREMENTS

The application should be simple and intuitive, with a user interface that can be easily navigated and guides users to areas of importance. Calibration and posture detection settings should be available to users with a minimal number of taps, meaning they are featured on the main screen of the app or behind at most one menu.

[Req 2.5.9 - ii]   The application shall contain a minimalistic interface for simplicity.

[Req 2.5.10 - ii] The user interface will follow conventions that allow users to already be familiar with certain features, e.g. settings icons

[Req 2.5.11 - ii] The user shall be able to configure the intrusiveness of push notifications.

[Req 2.5.12 - ii] The user shall be able to configure the threshold for bad posture sending a notification.

2.6 STANDARDS REQUIREMENTS

The device and application should follow the standards outlined below if we were to sell this product in Canada. Standards for the individual parts (such as IEEE 802.15 for the Bluetooth Module) will not be mentioned, because the relevant certifications are handled by their respective manufacturers.

[Req 2.6.1 - ii]   The device shall follow all provided CSA standards when a quote is requested [5].

[Req 2.6.2 - ii]   The device shall comply with the RoHS directive, which limits the use of hazardous substances in our product, which include lead, mercury, and cadmium [6].

[Req 2.6.3 - ii]   The device shall comply with the IEEE 1621 standard for user interface elements in power control of electronic devices employed in office/consumer environments [7].

[Req 2.6.4 - ii]   The device shall comply with the IEEE 1680 standard for environmental assessment of electronic products [8].

[Req 2.6.5 - ii]   The system will comply with the UL Standard 60950-1 standard for general information technology equipment safety [9].

4. SUSTAINABILITY AND SAFETY

To address environmental concerns, we at Meerkat Biotechnologies have chosen to use recyclable parts in the construction of VertAlign to promote environmental sustainability [10]. We have also meticulously analyzed safety requirements before finalizing our requirement specifications. The result is a device that is sustainable and safe for all.

VertAlign consists of a soft silicone rubber enclosure around an integrated circuit containing electronic components including multiple sensors, a Bluetooth module, wiring, and a rechargeable lithium-ion battery. We aim to guarantee user safety above all other requirements like aesthetics, cost, and quality. We chose a soft silicone rubber as our casing material because of its recyclability, biocompatibility, and water resistance [11][12][13].

With a tight sealed casing, we can protect against typical safety concerns associated with wearable devices, which include electric shock, adverse chemical reactions, burns, and skin abrasions [12]. The electronic components of our system will comply with UL Standard 60950-1 information technology equipment safety general requirements [9]. Because our device requires a relatively low level of power, the risks of burns, shocks, and explosions is greatly minimized.

A large portion of our device uses environmentally-friendly materials which can be reused or recycled [14]. However, we do expect to produce some non-recyclable waste at end-of-life for the product. The wasted materials come from electronic components like sensors and integrated circuit which are not easily recycled. The current process of recycling electronic components is very complex [15] and to accommodate such difficulties, we will make our integrated circuit components and battery module for easy disassembly and disposal. We strive to reduce the environmental footprint by utilizing recyclable or reusable material and following design concepts that aim to extend product life span, such as providing access to the battery for easy replacement.

As specified in section 2.3.1, VertAlign will be water resistant which will safeguard the system from any occasional spills. The safety of a user in an event of an unforeseen malfunction must be taken into consideration. The system will be designed to automatically shut down in an event of an electrical malfunction. It is prudent to note that an electrical system can overheat so VertAlign's exterior case will be designed using a thermally insulating material. The device will comply with all the requirements mentioned in section 2.2.4 to keep a user safe from any harmful radiation exposure, allergic skin reactions and unnecessary pressure points.

5. CONCLUSION

VertAlign's requirements specification encompasses many important aspects that Meerkat Biotechnologies has taken into account regarding our product design. VertAlign will be a safe, user friendly, and eco friendly product that adheres to CSA, RoHS, and applicable IEEE standards. Our requirements set guidelines for elements that will affect comfort such as weight, size, rigidity, materials, and operating temperature.

Functionally, we have set accomplishable goals for hardware, software, and firmware of the device. Our software requirements apply primarily to the mobile application our system while the hardware and firmware requirements apply to the VertAlign device itself.

The requirements will serve as a roadmap for future design and development decisions moving forward. It should be noted that these requirements are part of an iterative process, and are therefore tentative and subject to change.

APPENDIX

A.1 REFERENCES

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