Product: Vitruvian
Team: Vee

Abstract

Our project will aim to help improve people's posture while working from home by monitoring sedentary activity and posture, notifying them via an app or by tactile feedback on a worn device. The physical hardware, design, and integrated app will go through several prototyping stages roughly corresponding to the project demos.

The hardware team will assess physical hardware options to determine the feasibility of our chosen methods of posture detection, then develop the ones that we decide are useful. The Design team will consider the limitations placed upon them by the hardware used, then use prototyping to arrive at a comfortably wearable form factor. The app team will start by prototyping UI based on the features identified, then slowly develop navigability, add functionality and hardware integration in the later prototypes.

1. Goal description

A self-contained device that aims to maintain physical health by countering the potential negative effects of working from home due to the current pandemic. It will measure back posture and sedentary inactivity and alert the user with tactile feedback. Additionally, the user can be alerted through an Android mobile application, where they can also track progress and control device settings.

More people are working from home than ever before. Current figures are understandably very high due to the ongoing pandemic, but surveys have shown that many people are enthusiastic about continuing to work from home even after lockdown ends.

Worldwide, back pain is the single leading cause of disability, preventing many people from engaging in work as well as other everyday activities. Any system for improving health while working from home will have to address this issue. Most cases of back pain are mechanical or non-organic, meaning they are not caused by serious conditions, but rather simple mistakes such as slouching in a chair or standing with a flat back. This is something our system aims to address.

Other good posture benefits include fewer headaches, increased energy, increased lung capacity, self-confidence, better digestion.

1.1. Relevance of the system

Our self-contained device measures back posture and sedentary behaviour and alerts the user with tactile feedback, keeping track of their progress. This is a necessity in today's world where back pain accounts for more than 264 million lost work days in 1 year.

Why is our product important in a world where almost everyone is working from home? "Good posture is essential to good musculoskeletal health" according to Pamela Mehta, board-certified orthopedic surgeon at Resilience Orthopedics in an article for Women's health. "When the spine is aligned properly through good posture, it allows for proper stacking of your bones, muscles, and ligaments." This leads to better balance and ability to function during normal daily activities and can enhance personal productivity thus helping the customer work more effectively.

Researching the market, we have integrated the functionality of several existing devices into our proposed prototype. The core tech functionalities are inspired by Upright Pro Go which provides real-time posture feedback and tracking. Another feature we want to implement is the gentle vibration reminders and muscle memory training.

1.2. High-level description

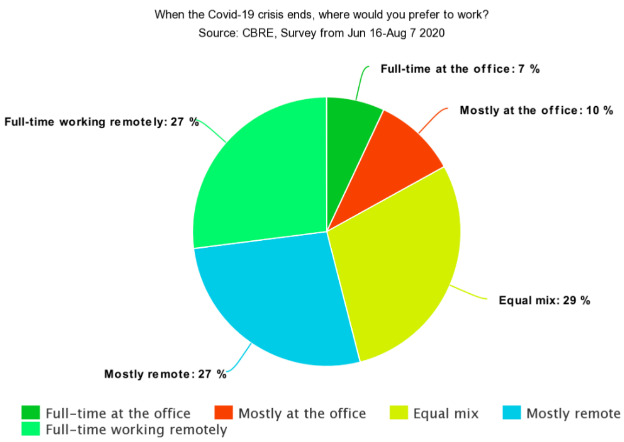
This product is designed based on the current working situation. As a worker who is forced to work from home due to the current pandemic, I want to have a healthy sitting posture so that my health can be ensured even if I must work sitting in front of a computer for a long time. This is what our product is going to achieve.

The product formed by two parts, the robotic device, and a corresponding android mobile app. The device part will stick at the back of the user using a medical grade adhesive to ensure users receive the tactile feedback directly when their back posture is in an unpleasant situation.

Within the device, there are flex sensors and accelerometers. With power supplied, they can be used to measure stretching automatically and thus determine the arch in back. When the measured arch data matches what is considered to be "bad posture", the device will automatically vibrate and send information to the phone app via Bluetooth. A notification will then be sent through the app. The device can also be turned on or off through the mobile app.

Another functionality of the app is a walking reminder. When the device detects that the user has not been moving for a long time, an app notification will remind the user to take a short walk.

- As a user of the device, perfect posture may be difficult to maintain over an extended period of time. As such, the device will also have a "record acceptable posture" function. The sensors inside the device will record the current spinal arch when receiving the "save posture" command from the app. After this, when the device senses a saved position, it will be considered healthy posture and will not vibrate.
- As a person who experiences back pain, I want to be alerted when I have bad posture, so that I can correct it as an effort to improve my back pain.
- As a person who experiences back pain, I want to view my posture over the last day/week/month/year, so that I (or a medical professional) can analyse the cause of my pain.
- As a person who works at a desk, I want to receive an alert notification when I have been sitting for too long, a reminder to walk around for a few minutes to avoid long term health issues.
- As a person who works at a desk, I want to view how many hours I am sitting for during a day/week/month/year, so that I can be aware of my activity level.
- As a user of a posture correcting device, I want to be able to turn my device off, so that I do not receive alerts when it is inconvenient for me.
- As a user of a posture correcting device, I want to be able to adjust my device and settings, so that I can receive the best possible recommendations for me.



2. Task planning

2.1. Milestones

1st Working prototype of hardware software

For First Demo (Monday 10th February):
Explicit Goal: To be able to measure the slope of a user's back using either a flex sensor or an accelerometer.
Demonstration: Ask a technician to wear the device and record results to demonstrate that it works. If not possible, we will present some level of simulation.
Notes: The device does not need to be small or comfortable at this stage. This will not be a full demonstration of slouch detection but will demonstrate early signs of how we will use the technology to achieve this goal later on.

2nd Hardware Software Prototype

For Second Demo (Monday 1st March):
Explicit Goal: To be able to demonstrate crude slouch detection and inform the app when this has been detected.
Demonstration: Ask a technician to wear the device, record results and demonstrate that the device recognises different levels of slouching and that the Android application can display the results.
Notes: At this point, we will have the scale finalised to aid the design team. Hardware for communication to Android application and all sensors will be connected and working. This will include an early implementation of slouch detection to demonstrate functionality, but not quite perfect.

3rd Hardware Software Prototype

For Third Demo (Monday 17th March):
Explicit Goal: Device hardware and software fully working and all primary features completed. Still some refinements to be made on slouch detection.
Demonstration: Ask a technician to wear the device, record results and demonstrate that the device correctly recognises good or bad posture and the Android application can correctly show live data and analysis.
Notes: All hardware finalised and matched up with the design. All software working well with only minor adjustments to be made. Slouch detection completed but refinements still to be made through more testing of different user types and scenarios. Able to inform the Android app of this detection reliably. App should be able to turn hardware on and off.

1st App Prototype

For First Demo (Monday 1st February):
Explicit Goal: A visual, non-functional, design of the Android Application that can be used to demonstrate the intended features and user interface.
Demonstration: A live preview of the application designs and its features or a prerecorded video.

2nd App Prototype

(Monday 15th February)
Explicit Goal: Have a navigable app with user interface built. Demonstrate communication between the app and the hardware by having the app acknowledge when the hardware detects slouching.
Demonstration: Ask a user to perform tasks using the user interface to test if they can navigate it intuitively and to gauge opinions on the usability.

3rd App Prototype

For Third Demo (15th March):
Explicit goal: The Android application is fully usable with a near finalised user interface design. Primary features are implemented, and able to function with mocked I/O from the hardware.
Demonstration: Ask a user to perform tasks using the application to see if they can navigate it intuitively and to test if the user gets confused by the user interface or the usability of features.
Notes: We will have a first full implementation of every "main" feature identified. Full features include: a way of switching the device off; a "tracker" that tells people when they have been slouching or sitting for too long; a display of results such as a graph that lets the user compare over time and track progress.

1st Design Prototype

For Second Demo (Monday 1st March):
Explicit Goal: Settle on a design for the device and how it attaches to the user, and provide hardware with the restrictions they need to meet.
Demonstration: Some image to demonstrate the design and a summary of what calculation was done (i.e., strength of adhesive, weight in posture harness that would affect wearer, etc)
Notes: Demonstration of the designs that were considered and research into the positives and negatives of each. A design will be chosen, but not necessarily finalised. Our current design options include a necklace, a adhesive sticky pad to the back or a harness. We will have a vague idea of what the restrictions on the size and shape of the hardware will be (thus, can be used if we need to downsize the hardware past the first prototype).

Final Prototype

For Third Demo (15th March):
Explicit Goal: Have all main functionality, implemented, all hardware, software and app interaction finished. Design is complete and demonstrable.
Demonstration: Product can be successfully attached to a user, detect accurately slouching and posture quality and provide alerts from the device and to the Android application. The app can also show live results and past progress.

For Fourth Demo (29th March):
Explicit Goal: Final product, functional app and website completed and working.
Demonstration: Demonstration of product and application and presentation with website.

2.2. Task decomposition

First demo

- Create a device which can measure its own angle (15 hours)
- Collect and analyse initial data from technicians to build algorithm (5 hours)
- Create UI designs for the Android app (5 hours)
- Build a non-functional version of the Android app (10 hours)

Second demo

- Design device and how it attaches to a body (15 hours)
- Create communication of data ability between device and Android app (15 hours)

Third demo

- Create slouching detection algorithm (25 hours)
- Create sedentary activity algorithm (25 hours)
- Finalise Android application to display correct data and results (20 hours)
- Create device and chosen accessory to attach to body (20 hours)

Fourth demo

- Test the algorithms with technicians and improve (15 hours)
- Create website and presentation material (5 hours)

Other meetings and workshops (25 hours)

Task Name	Milestone	Time	Dependency	Rough description
Design Android UI	1st Demo	5hr	-	design minimal modern UI for the app
Create Android UI	1st Demo	10hr	Design Android UI	create app skeleton
Research sensor	1st Demo	5hr	-	Research accelerometers/flex sensor
Research other Components	1st Demo	5hr	-	only essential components for functionality
Test sensor	1st Demo	5hr	Research sensor	obtain measurement from sensor
Check feasibility	1st Demo	5hr	Test sensor	consult a technician to test the hardware
Combine all components	2nd Demo	10hr	Check feasibility	connect all hardware components together
Slouch detection	2nd Demo	10hr	Combine all components	implement slouch detection function
Notification functionality	2nd Demo	10hr	Slouch detection	notify when a slouch is detected
Finalise hardware	3rd Demo	15hr	Combine all components	optimise components
Slouch detection alg	3rd Demo	10hr	Finalise hardware	test features
Sedentary activity alg	3rd Demo	10hr	Test slouch detection	Implement inactivity app alert/reminder
Accessibility feature	3rd Demo	15hr	Test slouch detection	Adjust correct posture
Finalise software	3rd Demo	15hr	Test slouch detection	finalise software side functions
Test algorithm	4th Demo	15hr	Finalise software	test the alg with technicians
Website and presentation	4th Demo	5hr	Finalise software	website and presentation material

Table 1. Task decomposition for the system

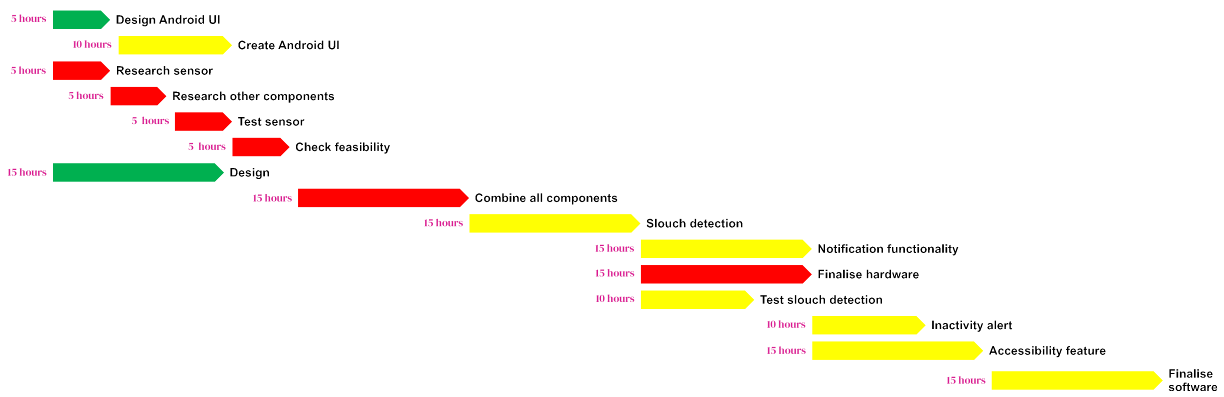
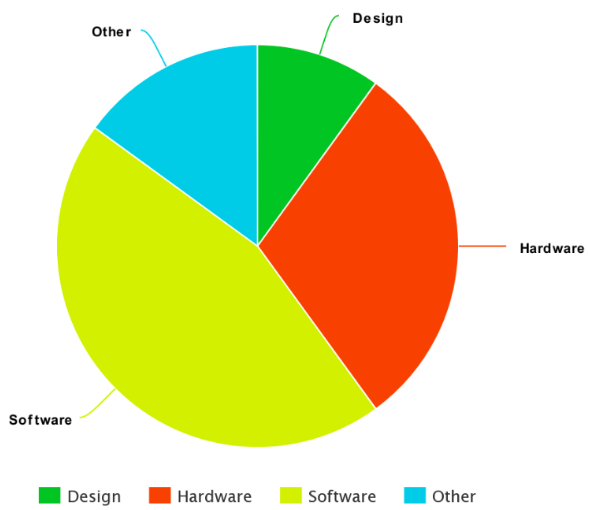


Figure 1. Gantt chart



2.3. Resource distribution

Skills

Name	Experience
Mohamad	Software, Web, Java, Python
Andrew	Python, Hardware, databases, ML
Vincent	Robotics, Java, Python, ML
Yining	Software, Marketing, Finance, Java
Morgan	Software, Python, Management
Anelise	Android, C++, databases, Web, ML
Alasdair	Java, Javascript, Git, Algorithm design
Jake	Swift, UI design, Git, Python, Android

Team division

Division	Team Members
Hardware	Andrew and Vincent
Software	Alasdair, Mohamad, Anelise, Jake
Design	Yining and Morgan

Person-hour allocation

The project is expected to take 200 person-hours per person over the course of the semester. This breaks down to roughly 16 hours per week per person.

We expect to use 3 of these hours in team meetings, and 2 in meetings with course staff (for example, workshops, or discussion with the technicians).

Group members are therefore each expected to spend 11 hours per week on “task work”, which might be anything from writing software to sketching designs for the form factor. The first meeting of each week will be a general team meeting in which we plan to further break down the allocation of person-hours into specific tasks.

We also have 3 technician-hours available to us per week. We will make a point of getting in contact with the technicians early in development, so as to not waste this time. We will use this time both to get them to build the device and to have them test it.

Equipment Available:

- Raspberry Pi
- Arduino board
- £200 budget

Resources we plan to acquire:

- Flex sensor
- Accelerometers
- Smaller Raspberry Pi/Arduino board
- Accessory for wearing the device

Tools we intend to make use of:

- Trello for project management
- Sketch for design
- Git for code collaboration

2.4. Risk assessment

Risk: The possibility that our planned method of wearable sensor-based posture detection is infeasible.
Contingency: We will move to either a chair or webcam based system. This would involve rethinking the hardware, as well as the algorithm for determining bad posture based on the inputs to use computer vision instead of sensors.

Risk: We might not be able to create a nuanced definition of “good” posture.
Contingency: We will make the best approximation possible and make clear of this in our product description and in the application. We could add an extension to allow individual users to calibrate the device to personalise thresholds to suit their circumstances. We will consult experts on this topic.

Risk: Bluetooth proves too difficult to implement in the given time frame.
Contingency: Investigate other means of communication, e.g., local network or even internet based.

Risk: System is uncomfortable
Prevention: We will avoid this by keeping the design and ergonomics of the system in mind throughout the development of the product.

Risk: Simulation in Webots proves difficult, given fabrics and flex sensors.
Contingency: We will consider other simulation environments. It is more likely that we will have a heavier emphasis on testing in the real world with technicians rather than in simulation.

Risk: Poor communication between sub teams.
Prevention: Avoid this by keeping whole team meetings regular and ensuring that the different sub teams have good communication with each other over necessary functions (e.g., communication with the app).

Risk: Device over-heating
Contingency: Dependent on the cause of the heat. If over-heating is caused by strenuous on-device processing, will move some of the calculation to the app. If caused by the battery/power source, seek alternative power sources or change design.

Risk: The lack of access to physical facilities and software makes designing and testing the system harder than expected.
Prevention: Interact with the technicians and ask them to assist us in building and testing the system.

3. Group organisation

Our group is provisionally split into three teams. The design team will create the look and feel of the physical product and the UI for the mobile application. The hardware team will plan and create the physical device using a miniature computer board, a battery and appropriate sensors that are to be decided. The software team will create an algorithm to detect the slouching using the embedded sensors, and create an Android mobile application to receive alerts, view results and control the physical device.

This team is provisional as these different aspects of the project are not exclusive. The design team will work very closely with the hardware team to create a device which is comfortable for all users and situations and can fit all components that are needed. The hardware team will also work very closely with the software team to discuss how the embedded sensors can be used to program and train the slouching detection algorithm. Finally, the design team and software team will work closely to create an app which is easy to use and understand for users of all ages and backgrounds, and which looks aesthetically pleasing.

The team will use Git to share code, possibly using Gitlab as a service and tools like SourceTree or GitKraken and will peer review code before merging into the main branch. We use Teams to organise all files for easy access to everyone.

Our team will be following Agile principles, working in incremental Sprints each lasting one week. We will hold our Sprint meetings on Mondays, in which the whole team attends, including our mentor George. Each week, we will work iteratively to analyse our current progress, adapt our plans accordingly, build our product and test to ensure quality. We have set up a Trello board with appropriate columns: Backlog, To Do, In Progress, Testing and Done. Our definition of Done is that the task has been tested, peer reviewed, documented and agreed by all members of the team. Our Trello board is visible to all members of the team and we encourage each other to track progress by writing comments on tickets to ensure visibility to the whole team.

The team leader is Jake, who will work act as Product Owner to ensure our end product meets the requirements of the customer and to ensure the Trello board is up to date. Our Scrum Master is Alasdair, who will organise meetings and facilitate collaboration. Yining will also act as Marketing Lead. The design team includes Morgan and Yining. The hardware team will be Vincent and Andrew. The software team is made up of Anelise, Mohamad, Alasdair and Jake.

The team communicates on Teams, where we discuss topics openly in meetings or in posts for visibility to the whole team and to our mentor. During our Monday weekly meeting, we create tickets for every task for the upcoming sprint and allocate tasks together to ensure that every member is happy with their task and everyone has an equal share of work to do.

Team members

- Jacob Sieradzki
- Andrew Robertson
- Morgan Kane
- Anelise Ionescu
- Yining Liu
- Alasdair Macgillivray
- Mohamad Harah
- Vincent Wu