PINNACLE BIOMETRICS

ENSC 305W/440W

Progress Report

for

Floe: the Athletic Balance Monitoring System for Skiers

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Glossary

API: Application Program Interface; set of routines, protocols, and tools used for software application development

BLE (Bluetooth LE): Bluetooth Low Energy; a low-energy wireless data transmission protocol

BMH: Boot-Mounted Hardware; system component of *Floe* pertaining to the ski boot-mountable enclosure containing the SoC, signal-conditioning circuit, and power supply

FSR: Force-Sensitive Resistor

SoC: System-on-Chip; single chip with integrated circuit that gives it all components of computer/electronic system

UART: Universal Asynchronous Receiver/Transmitter

1 Introduction

At Pinnacle Biometrics, we are working to assist athletes in meeting their true potential by relieving them of learning limitations imposed by performance analysis that is exclusively qualitative. *Floe*: the Athletic Balance Monitoring System for Skiers will provide the amateur and professional skier with accessible quantitative analysis on their performance. Through the use of force-sensitive insoles, SoCs, Bluetooth technologies, and the Android API, *Floe* will collect weight distribution data during a skier's performance and convert it into useful information to be displayed as real-time prescriptive feedback in a heads-up display or post-run performance statistics on a mobile device.

This document will outline the current progress state of our proof-of-concept model described in our Functional Specifications document [1]. After reviewing the initial schedule we composed for the project, this document will summarize the financial situation, and then proceed to report on the progress of *Floe*, organized as a breakdown into four components: hardware, firmware, software, and physical.

2 Original Schedule

The development timeline of *Floe* was originally divided into four broad steps. The first called for a bare-bones app and single-boot setup that could be used for testing interactions between hardware/firmware/software. The second step called for the integration of two boots and real-time functionality for the app. The third step, ending on 28 March, called for all parts of *Floe* to be functional, and ready for system-wide testing on ski slopes. The fourth and last step mostly consisted of fine-tuning and bug fixes.

In practice, different components of the project were developed at different rates, leading to the current situation with hardware development complete, firmware development nearly complete, while software development behind schedule, but also nearing completion. This means that system-wide testing is not yet possible, as crucial connections between different system components are not yet functional. While this places us behind schedule in terms of the previously defined milestones, we expect that the remaining work on software and firmware can be completed within two weeks, and system-wide testing can be done before the project deadline.

3 Financial

A cost breakdown of *Floe's* expenditures to date can be found below in Table 3.1.

Table 3.1 - Up-to-date project expenditures

Item Description	Cost
2 x Nordic nRF52 Development Kits	171.31
8 x Flexiforce A201 FSR Sensors	165.27
9 x Interlink 402 FSR Sensors	65.00
4 x MCP6004 Opamps	2.64
10 x 3296 1MOhm Trimpots	32.93
3 x TL7660 Voltage Inverters	6.60
Tax and Shipping	80.71
Total	524.46

The funding of *Floe* came solely from the ESSEF grant, upon which we received a total of $513.00. Although we are currently slightly over budget, we are in the process of returning the Flexiforce FSRs, having made the change to use FSRs from Interlink in their place. Doing so will revert our expenditures to below budget.

4 Progress

4.1 Hardware Design

Completion: 100%

Hardware design is complete. We have ordered and received all parts and they are currently being utilized for the development of *Floe*. The signal conditioning printed circuit board has been designed, cut, and soldered, allowing the development board to be connected to the insoles.

4.2 Firmware Design

Completion: 80%

The firmware team is responsible for developing the low level code running on both Nordic SoCs. For the proof of concept design, the firmware team will implement periodic sensor sampling for real time data collection as well as Bluetooth data transmission to the mobile application. Currently, the team has successfully been able to set up sensor sampling off of one analog pin every 100ms, utilizing timers and events.

Still to be implemented is the ability to read off all four analogue pins sequentially to capture all sensor data at once. In addition, BLE transmission has been completed. The entire framework for packaging data into structured packets has been coded and tested. Using Nordic's UART service, we have successfully sent sensor data over Bluetooth to an Android application. Currently, the team has used the Nordics UART Android application to receive the data. Integration with the software team is underway to fully integrate proper data collection from the SoCs.

4.3 Software Design

Completion: 65%

As detailed in our Functional Specifications document [1], the *Floe* companion app at the proof-of-concept design level must include the ability to receive data from the BMH over BLE, to record and store data from a given ski run, to review such data from the mobile device, and the ability for the user to view their current state of balance in real time on their mobile device.

The software development team experienced some setbacks at the very beginning of development, especially in mastering the workings of the Android API and ways to design and implement mobile applications. These domains were unknown to all members of Pinnacle Biometrics, which led to some delay in getting help from experts external to the team.

To date, the software development team has completed all research and the complete design of the entire app, including the design and function of each individual module, as well as how the different modules interact with one another. The user interface has been implemented, allowing the user to access every mode of operation of the app. The calibration mechanism, which allows *Floe* to accurately calculate the user's centre of pressure, has also been implemented. The data storage and recovery mechanism has been implemented, but requires further testing to ensure its complete reliability under real operating conditions. Work on the real-time balance data display has started, but issues with composing the image have slowed progress. Data reception from the BMH over BLE is in development, but is much more complex than initially expected. This has caused significant

delays in software development. The run data review functionality of the *Floe* companion app has yet to be implemented, but we expect it to be simpler than the other two areas of the app still in development, since it does not involve any exchange of data with external elements.

4.4 Physical Design

Completion: 40%

The physical design team is in the midst of creating the force sensitive insoles, as well as housing for the BMH. Materials have already been obtained for the insoles, and they are currently under fabrication. Furthermore, the team is under the process of curating housing for the BMH that can facilitate its size requirements.

5 Remediation

The software development part of *Floe* is behind schedule. This is due to difficulties at the beginning of software development, as well as larger troubles with the complexity of data reception from the BLE protocol. The initial issues with understanding of the development environment and process have been largely resolved, and residual uncertainties are quickly resolved with the help of team members or outside resources. The main outstanding issue with current software design is communications between the BMH and the companion app.

This issue is likely to be quickly surmounted now that the firmware development team is done with a lot of the implementation and testing of the BLE service. With the help of the firmware team, the software team will be able to develop the missing pieces of code needed for data transmission to occur properly between the BMH and the companion app. The estimated time frame for this is approximately one week of work. Remaining development of the real-time feedback and run data review parts of the app are expected to be complete in close to one additional week of work, given the relatively small amount of extra functionality they require. Following that, true system-wide testing of *Floe* will be able to get underway, with enough time for remaining bugs to be solved before the final project presentation.

6 Conclusion

The hardware and firmware sections of *Floe's* development are both largely complete, and work properly together. The software development of *Floe* is, however, behind schedule. Original plans for system-wide testing to begin on 28 March are no longer achievable. The main issue with software development lies with data reception, which is why the firmware development team is lending a helping hand to the software team. We expect the remaining problems with software to be solved within at most two weeks, allowing at least one week of system-wide testing before the final project presentation. Our original project schedule included many weeks of flex time, which are proving very useful and will allow us to finish development on time for our project on April 19th.

References

[1] *Functional Specifications for Floe: the Athletic Balance Monitoring System for Skiers*, 1st ed. Pinnacle Biometrics, 2016, pp.4-12.