Running Performance Simulator

Evaluation Results and Analysis
CS 4590 Final Project Deliverable

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ABSTRACT

In this paper, I describe my design paradigms, methodologies, and outcomes of my CS 4590 audio sonification project. This running sonification simulator sonifies a user running medium to long distances by way of measuring their cadence, heart rate, stride length, and step impact to better optimize their performance and lower risk of injury. The evaluation phase involved testing 4 people, 2 experienced runners and 2 non-experienced runners. The assessment focused on measuring the relationship between participants experience levels while using the simulator and their performance results, all while gathering qualitative feedback regarding user experience. The data obtained from user testing proved instrumental in assessing the effectiveness of the simulation design. Overall, the results revealed that the running simulator was well-received and that the chosen sonification methods positively contributed to refining their experience. However, the study also identified potential areas for improvement and highlighted certain areas that could enhance the simulator's performance and user satisfaction.

CCS Concepts

Applications → Information systems → Audio Engines → Audio Simulations → Sonification System → Running Simulator

Keywords

Running; Sonification; Computer Audio; Physical; User Interface; Energy Efficiency; Simulator; Georgia Tech.

1. INTRODUCTION

Running has been a cornerstone of my life, becoming an integral part of my daily routine. From a young age, I engaged in various sports and recreational activities, and running had always emerged as a common denominator throughout. The countless health benefits and effect it had on my life moving forward convinced me that running is a practice everyone could enjoy and benefit from.

Not only are the health benefits of running bountiful, but as are its positive influence on one's own mental state and awareness. I recently discovered firsthand the significance of proper training methods and heightened physical awareness in optimizing performance and preventing overtraining injuries. And while smartwatches and other wearable devices have become popular tools for monitoring training metrics like heart rate and cadence, they predominantly rely on visual cues and displays. Unfortunately, this visual approach presents limitations, as runners must divert their attention from the path ahead to check their progress on a small screen, thus compromising their form and attention to the task of running itself. Additionally, they do not have systems capable of sonifying this information to runners making the reliance on a visual display difficult to undergo. Overall, its simply not an efficient medium for relaying information and could be better refined by sonifying this important data to runners using audio implementation.

My running sonification simulator aims to bridge this gap by sonifying crucial information like heart rate, cadence, stride length, among other components of a runner's form to stay in the moment, fully focused on their movement and form. This audible feedback is the kind of information I think could empower many runners to make instant adjustments and optimize their performance without visual distractions.

Beyond the immediate benefits of performance optimization, the goal of the different sonifications in the engine was also that so runners could develop a deeper connection with their bodies and understanding the relationship between their physical efforts and resulting auditory feedback. As someone who has struggled to maintain composure and discipline while running my own mileage, it was my aim to foster heightened awareness, discipline and focus for a strong mind-body connection.

Finally, I was hoping to design something that would cater to individual preferences, allowing users to customize their training parameters based on their distance goals and current fitness level. Whether it's achieving a personal record, or simply experiencing the joy of running, I wanted to be able to accommodate a diverse set of goals.

2. SIMULATION ENGINE OVERVIEW

2.1 User Interface

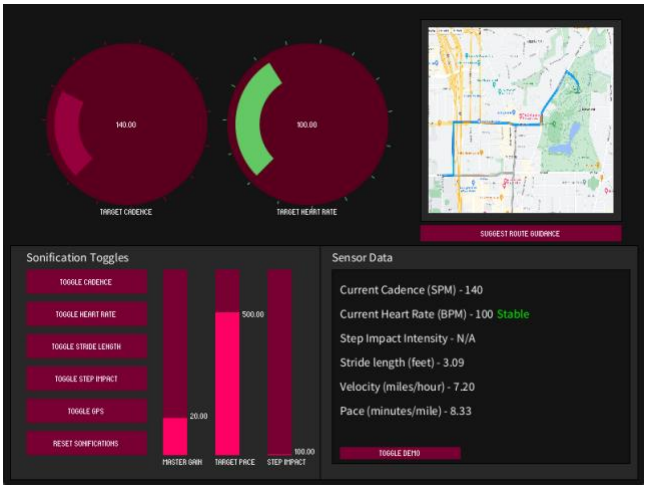

Figure 1: Running Simulation Engine

The system is comprised of buttons for enabling their respective sonifications, accompanied by sliders and knobs that modify the data streams. The simulation offers continuous sensor data interpretation and provides users the ability to manipulate the data values to alter the sonic qualities of various sonifications within the program. For the sake of convenience, the simulation engine presents the data in a visual format, enabling users to grasp the correlation between sound and data changes visually.

2.2 Sensor Data and Data Streams

Table: Data Streams and Corresponding Default Values

Information/Data	Default Value
Cadence	140 SPM
Heart Rate	120 BPM
Stride Length	3.09 ft
Step Impact	Moderate

2.3 Sonification Design Methodology

- Cadence stream and pace influence stride length synth
- Heart Rate dictates cadence frequency
- Stride length increases in pitch as it gets smaller and decreases in pitch as it increases in distance.
- If heart rate and cadence both reach > 160 VPM the system sonifies a TTS alert system telling the user to maintain good breathing
- If heart rate > 185 BPM then the simulation will sonify to the user that heart rate is too high and will subsequently lower the user's target cadence using linear interpolation, slowly lowering the cadence until the user's heart rate has reached a healthy level.

3. METHODS

3.1 Participants and Recruiting

In my evaluation, I will be involving individuals from two groups: recreational runners and experienced runners. Fortunately, I have a strong connection with many avid runners who can truly benefit from a sonification engine. By providing them with this system my aim is to observe their response and behaviors in response to my evaluation tasks to better understand the value and utility of my design. Their valuable feedback and insights will be essential in refining the engine and possibly making it even more effective in the future by catering to the specific needs of the running community.

3.2 Research Questions

To comprehensively assess the value and effectiveness of my simulation engine, I formulated a set of qualitative research questions that explore various aspects of my sonification design. These questions served as a framework to gain valuable insights and better understand my goals and outcomes.

1. Are the enabling of the different sonifications too intrusive or overwhelming?
2. Are the chosen sonifications appropriate for representing the measured variables effectively?
3. How does the incorporation of TTS alerts for heart rate and cadence adjustments impact the simulator experience?
4. Were participants able to accurately interpret the changes in the different sonifications throughout the program?
5. On a scale of 1- 5, with 5 being the highest rating, how would participants rate the overall usefulness and effectiveness of the sonification engine?

3.3 Measures

In my evaluation, I will gather both qualitative and quantitative data to gain comprehensive insights into the effectiveness of the engine.

Qualitative Data - Participants comments and feedback during the evaluation was collected, focusing on their perceptions of sonification clarity and relevance, as well as their experience with TTS alerts.

Quantitative Data - Response time to changes in sonifications, accuracy in sonification mapping to data, and participant performance on tasks assessing the impact of sonification on running performance. This data will be aggregated into a value ranging from 1-5 and will assess their level of proficiency with the simulator called their performance rating.

Subjective Data - Participants attitudes and enjoyment levels regarding the sonification system and its influence on their running experience will be recorded.

Combining these data types, I will obtain a comprehensive understanding of the user experience and the value/utility of the sonification system.

3.4 Protocol and Evaluation Tasks

The following are the tasks that I will use to interview and assess the participants with. During the evaluation, participants will engage in several tasks to assess the effectiveness and user experience of the running sonification simulator.

1. Task 1: Cadence and Pace Adjustment.

Participants will be instructed to adjust the cadence knob and pace slider to achieve specific target values while keeping the heart rate constant. They will be asked to share their comfortable running pace and asked to set it accordingly in the simulation by adjusting the slider. Following this, participants will listen to the corresponding sonifications and provide feedback on the sound design and accuracy of the sonifications.

2. Task 2: Pacing and Stride Length Adjustment

In this task, participants will enable stride length sonification and set a target pace using the pace slider. They will be told to observe the changes in the stride length synth and adjust the pace and cadence to achieve different stride lengths. Subsequently, participants will provide feedback on their experience with the sonification system.

3. Task 3: Heart Rate Alert and TTS Reminders

During this task, participants will be asked to gradually increase their cadence and heart rate to trigger the heart rate alert. They will receive TTS reminders to lower their cadence and observe the system's response as it gradually decreases the cadence using linear interpolation and told to decrease their heart rate and again observe the behavior of the system.

4. Task 4: GPS Navigation

Strictly a qualitative task, for this task participants will enable GPS and listen to predefined audio cues indication upcoming turn and landmark. After experiencing the GPS integration, they will provide feedback on the clarity and usefulness of this feature.

Quantitative data will be collected regarding their overall performance rating and will be measured by the overall efficiency with which the participant adjusts the sensor data in the task in accordance with the sonifications in the simulator. Participants attitudes and enjoyment levels regarding the sonification system and its influence on their experience will also be documented.

3.5 Analysis

Quantitative data and findings will be presented through tables. On the other hand, qualitative data will undergo thematic coding to identify recurrent patterns or user experiences reported by the participants. The aim for this analysis will be to shed light on the strengths and weaknesses of the design, usability, relevance, and overall experience of the sonification system. There might be a couple of limitations to my evaluation, however. The first is that I was only able to evaluate a relatively small sample size of people. Age, sex, BMI, relative fitness level, etc. were not considered or documented in this study which could have provided more concrete and insightful results. The second limitation was the lack of evidenced performance data, that could have been used to make conclusions about the actual resulting performance of a runner in a medium to long distance run.

4. RESULTS

4.1 Sample Size

I was able to get in touch with 4 people to conduct my evaluation tasks. Following the predefined instructions, I facilitated their engagement with the simulation using user interaction mode as planned.

4.2 Data

Task 1: Cadence and Heart Rate Monitoring

Participant	Experience Level	Performance Rating	Value Rating
A	E	5	4
B	E	4.5	5
C	N/E	3.5	4.5
D	N/E	4	4

Task 2: Pacing and Stride Length Adjustment

Participant	Experience Level	Performance Rating	Value Rating
A	E	4.5	4
B	E	5	4.5
C	N/E	4	4
D	N/E	3	5

Task 3: Heart Rate Alert and TTS Reminders

Participant	Experience Level	Response Time	Value Rating
A	E	5	5
B	E	5	4
C	N/E	4	4.5
D	N/E	4.5	5

Task 4: GPS Navigation

Participant	Experience Level	Value Rating
A	E	4
B	E	5
C	N/E	4.5
D	N/E	4

Post Evaluation Comments

Participant	Enjoyment Rating	Comments
A (E)	4	“Overall, I felt it was a functional simulation, the GPS could be a little more sophisticated.”
B (E)	5	“I thought it was good, looks like there could definitely be plenty of room for improvement.”
C (N/E)	4.5	“The sonfications were hard to distinguish when all of them were turned on. But good overall.”
D (N/E)	5	“I like it. Personally though, I think the addition of a breathing guide would have been nice.”

5. DISCUSSION

5.1 Result and Findings

Overall, it was clear through both the performance ratings, enjoyment levels, and post-study comments that the experienced runners were more adept at using the simulator but were also more critical. They pointed out that the intensity of the sonifications, particularly heart rate, and having multiple playing at once made the interpretation challenging, although they recognized their relevance. This is a valid point, and I think my design could have been improved by the addition of an event listener that would prioritize each sonification and given a priority value should the engine deem the specific audio segment urgent for the user to hear, like the dangerous heart-rate TTS threshold. Additionally, participants expressed a desire for a more feature-dense GPS system. Regretfully, I would have liked to implement a dynamic GPS system and provide the user with more interesting sonfications like sounds specific to certain terrain and periodic updates on user navigation. Nevertheless, the consensus was the same, and the participants saw value in my running simulation design.

Undoubtedly, the results of my study could have been improved with a larger sample size. While the valuable insights from my 4 participants provided a solid foundation, a more extensive study with a diverse range of runners would offer a deeper understanding of the quantitative impact of a running sonification system. If possible, I would be really interested to explore the potential of a full-fledged sonification system, and how it could propel runners to surpass their personal best times. Of course, that is a question that will have to be answered in a future study.

6. CONCLUSION

The evaluation of my running simulator revealed valuable insights from both experienced and non-experienced runners. Experienced runners displayed greater proficiency in using the simulator, but also offered more critical feedback regarding the intensity and multiple overlapping sonifications. Their input highlighted the need for an event listener to prioritize sonifications, especially for essential alerts like dangerous heart-rate levels. Additionally, participants expressed interest in a more feature-rich GPS system, which was a limitation in the current design.

Despite the technical limitations of my design and areas for improvement, the participants recognized the value of my running simulation and its potential to optimize performance and reduce injury risk. Moving forward, the next logical steps in developing a more sophisticated running simulation engine would involve implementing the suggested improvements, fine-tuning based on user proficiency, and expanding the GPS features to enhance the overall user experience. Further user testing with a large and diverse group of runners could provide additional insights and validate the simulator's effectiveness in meeting the needs of various runners. The goal would be to create a comprehensive and user-friendly running simulator that serves as a valuable tool for both recreational runners and athletes at all competitive levels, contributing to the enhancement of their running performance and overall enjoyment.