Context Aware Implicit Interactions in the Wild

Figure 1: First author and second author setting up devices for 3rd trial run on the Huckleberry Trail.

Figure 2: Simple watch interface for our heart rate implicit interaction app.

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Abstract

This paper presents a project based on the melding of the Research in the Wild, The Design of Implicit Interactions, and Context-Aware Mobile Computing: Affordances of Space, Social Awareness, and Social Influence monographs. Specifically, we designed two mobile applications, capturing the contexts of heart-rate and physical motion respectively. Each application is based on an algorithm that enables implicit interaction with digital technology, in the form of capturing in-the-moment photographs. We begin by elaborating the two algorithms, followed by comparing the timestamped data captured in each case. We also determine the emotional context (mood) using the user's heart rate patterns, and then visualize the change in the user's mood over time. This paper concludes with limitations to showcase a few pitfalls to avoid for the next iteration of this project.

Author Keywords

Mobile, in the wild, context aware, implicit interaction, sensors, hiking, android

Introduction and Related Work

Introduction

The project includes three monographs from the Morgan and Claypool, Synthesis Lectures on Human-Centered Informatics [3]. These monographs are: Research in the

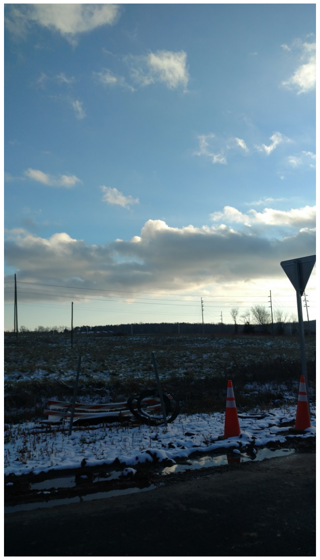

Figure 3: Photo of the heart rate implicit interaction on the Huckleberry Trail taken at 7:47.00 in relation t0 figure 4

Figure 4: Photo of the accelerometer implicit interaction on the Huckleberry Trail taken at 7:49.00 in relation to figure 3

wild (RITW), Context Aware Mobile Computing Affordances of Space, Social Awareness, and Social Influence monographs (CAMC), and The Design of Implicit Interactions (DII). These monographs are a cumulation of the knowledge in their specific areas. Additionally, each monograph puts forth an understanding on how to synthesize their topics for the advancement of Human Computer Interaction (HCI) discipline. Each monograph offers a deep dive into what models, theories, and frameworks best suit their practice of the presented knowledge.

The RITW monograph discusses a broad framework that can be applied to varying projects so long as it meets a small subset of criteria. First, researchers performing "in the wild" rely more on studies conducted outside of the lab setting with uncontrolled variables to allow the user to experience, use, and perceive how the new technology should be understood and thus used [13]. Second, Yvonne Rogers, first author of RITW, provides a framework show in figure 5 [13]. The framework working between Technology, Design, In Situ, and Theory shows that all methodologies and techniques can be integrated into the RITW philosophy.

The Context Aware Mobile Computing monograph explores context-aware computing through the lens of the Activity Theory as shown in figure 6 (context, social actor, and tool) [5] and follows a central theme of humans developing and learning when, in collaboration with others [6]. The monograph highlights theories, examines research and reports on experimental studies that apply theories of social awareness in context aware technology. Other aspects discussed include issues, considerations, challenges, conclusions and implications of context aware technologies. Additionally, the monograph explores the domain of context based persuasion, social influence, social facilitation, motivation and feedback. In the end the monograph looks at some of the

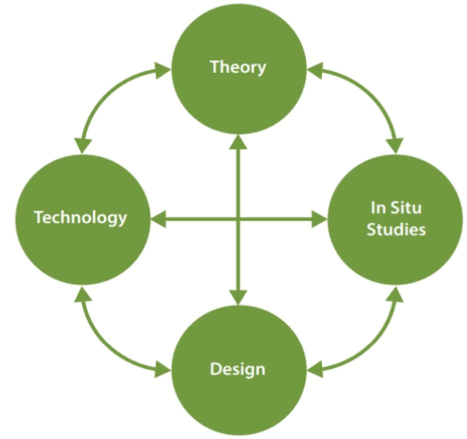

Figure 5: RITW framework used to identify 4 key elements with for an "in the wild" study.

ethical issues involved with context aware mobile computing technologies.

The Design of Implicit Interactions monograph is based on 'Theory of Implicit Interactions' [10]. According to the theory, people rely on conventions of interaction to communicate. These everyday implicit interaction patterns drive our expectations of interactive device behavior. These interaction patterns between peoples can be applied to design of interactive device. Implicit interaction must be based on tacit knowledge. Analyzing day-to-day(conventions) interactions makes better interaction design. To understand conventions of interaction helps designers to create more effective and comprehensible user experience. In figure 7 the 'Implicit Interaction Framework' [10] can be used in the translation between observations of human-human interactions and the design of human-device interactions.

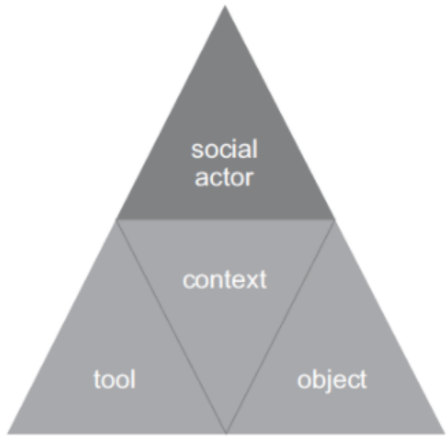

Figure 6: Activity theory is the organizational framework used to analyze the elements of context-aware computing.

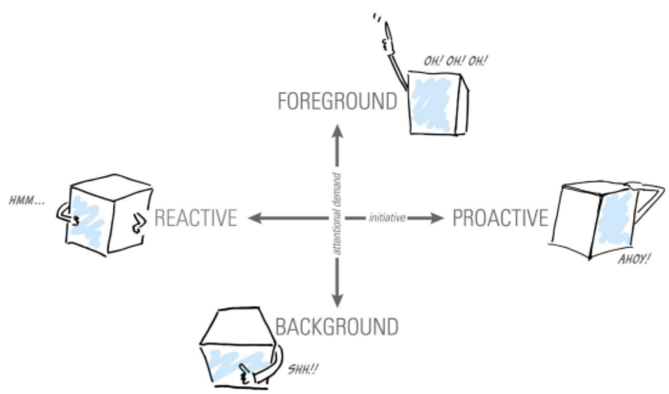

Figure 7: Implicit interactions framework [10] used to divide the space of interactions between two dimensions: attentional demand and initiative.

Related works

There have been many prior works which try to bring together the ideas of context awareness, implicit interaction and research in the wild. Most if not all of these referenced material is RITW in practice and fits perfectly in the figure 5 framework presented by Rogers. Context is a little harder to determine because it's closer to the subjectivity of the presented work. In their paper Schmidt et.al. integrate various sensors into mobile computing devices (of the times) to facilitate both context awareness and implicit interaction with these devices and with respect to the environment [7, 15]. Abowd et. al. present a mobile context-aware tour guide prototypes in 1996 which they analyze in indoor and outdoor studies "in the wild" and listed a few scenarios for future applications when designing similar applications [1]. One such evolved application and a more recent idea is the the HOBBIT Asocial app which shows us a conceptual space for creating hiking application in the wild [12]. The more interesting thing to notice is the size of the mobile technologies over time and what it took to create an infrastructure to create implicit interactions and capture context accordingly.

Ju et. al. show how to design electronic white-board interaction which use a factor of proximity between human and white-board [9]. Ju and Takayama introduce interaction design of automatic door movement that is used as gesture to people [11]. For the ambient birdhouse this project exemplifies research in the wild by giving the users an ambient birdhouse for their homes, businesses, or some space where they can bring nature into an urban space [2]. These two prior papers are interesting examples of enabling users in their own personal space to appropriate these technologies and rouse emotional connection through context awareness and implicit interactions.

Overlaps and differences of monographs

Overlaps

Based on our discussions we felt significant overlaps between the three monographs. First, many of the research in the wild studies use mobile computing devices (e.g., the probe tool used in the ambient wood study [14]). Sometimes the technology used in these studies were context aware as well (e.g. the ambient horn) [13]. The collaborative white-board interaction [9] discussed in the implicit interaction monograph is very much a context aware device. When using the white-board, it assumes that users are engaged in collaborative activity. Changes in the usersâĂŹ physical proximity to the white-board can be translated in this context. So, we feel that the integration of proxemics to construct the interactive electronic white-board makes the white-board aware of the user's presence and hence context aware [6]. The robot's gesture scratching his brow discussed in the implicit interaction monograph can be understood correctly based on context (e.g. the robot is trying to open the door, and the gesture means intention to perform forethought to human) [8]. The eMoto device presented in the context aware mobile computing monograph recognizes participant's actions implicitly through sensors [16].

Differences

We also feel that there are some differences that exist between the monographs, for example, the semantic navigation (through a museum) study [4] was a situated study and does not really fit the RITW setting because there is too much guidance from the researchers. Also many of the RITW case studies (like the ambient wood project [14]) do not necessitate implicit interaction [13]. Similarly context awareness doesn't explicitly require implicit interaction (e.g., case studies like, Social Tagging, Mindless Eating Challenge use explicit interaction). We also felt that context aware technology is not always evaluated in a wild setting such as is the MobiTags project [4]. However, it would be interesting to see how such context aware technology can be misused and "reappropriated" when used in the wild (e.g. posting MobiTags that spread propaganda messages instead of useful information). Bringing implicit interaction into the usage of context aware mobile technology in the wild might address the misuse of such technologies to an extent (e.g. virtual tagging of people's emotions on public artifacts, which have been "sensed" implicitly, instead of explicit text written by them). To overcome differences in the monographs, we agreed to use mobile devices with implicit interactions in the field.

Project description

Description

Our approved project aims to come up with two algorithms that draws from all three monographs and will be tested while hiking on the Huckleberry Trail. Our prototype are two simple android applications that will be strapped to the hiker on his chest. Each Android application has a specialized algorithmic approach used for collecting photos on the trail. The data collected from each approach will be used to analyze which approach captures the context of the hike more in tune with how the hiker experienced the hike.

Relation to monographs

For RITW, our device is explicitly made to be used for a personal setting (i.e. outside of the lab). The information we record is well documented in the RITW monograph as newer sources for data (i.e. "different ways of recording, evaluating, and discovering aspects of people's behavior and situation-that was difficult or impossible before. These include the use of smartphones and smartwatches which the users have already appropriated to their personal uses during a hike.) [13].

For Context Aware Mobile Computing, our device is context aware as it automatically detects the user's heart rate and acceleration. Our device uses mobile computing as it performs multiple tasks like data collection in the wild, using mobile computing devices such as a smartphone and a smartwatch. It also detects when the user's emotional state/mood changes and prompts the user to take photos / automatically takes photos using via heart rate over time. We are designing for Space, Place and Context in the wild, by allowing hiking users to enjoy the scenery in front of them without having to explicitly capture the moment themselves.

For Implicit interaction our device is situated as BACKGROUND and more PROACTIVE than REACTIVE. This figure 8 helps understand the dynamics of interactions and identify common patterns in interactions that can assist us when we analyze interaction design between the smarphone, smartwatch, and user [8]. The framework maps the trajectories of interactions by looking at the interplay of activities and patterns. If the user's attention is needed, it means FOREGROUND. If not, it means BACKGROUND. If an interaction is initiated by a user, it means REACTIVE. If not, it means PROACTIVE.

Android application
Below are a list of the materials used to support our project to design and develop our Android applications:

Software:

- Android Studio

Android Studio is developed by Google to be used as the official IDE (Integrated development environment) for developing Android applications. We were able to easily develop, integrate, and test our Android applications with a quick turn around.

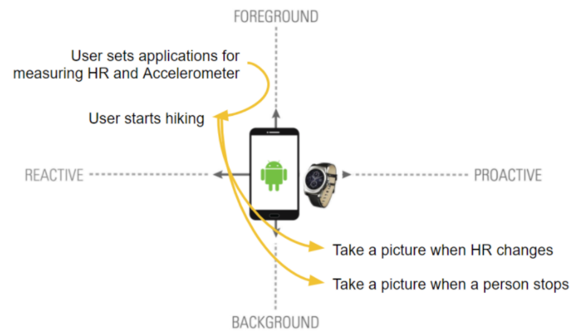

Figure 8: Implicit interactions framework used to showcase our projects implicit interaction flow.

Hardware:

- Samsung Galaxy S4 smartphone
- Motorola DROID Turbo 2 smartphone
- LG W150 Sport smartwatch
- Motorola 360 Sport smartwatch

The hardware chosen for this project was each author's personal devices. Both smartphones were utilized in the study. The Samsung Galaxy S4 smartphone was responsible for hosting the accelerometer based implicit interaction app while the DROID Turbo 2 hosted the heart rate based implicit interaction that interfaced with a smartwatch to capture the user's heart rate. The smartwatch used in the study was the LG W150 Sport watch with the Motorola 360 Sport watch as a backup should one or the other watch become unusable.

Figure 9: Photo captured by accelerometer based implicit interaction on the Huckleberry Trail near construction site on 460.

Explicit Interaction
• Clear • Deliberate • Occurs in center of attentional space • Excludes other focal targets • Can be based on tacit knowledge
Implicit Interaction
• Unclear • Inadvertent • Occurs in attentional periphery • Non-exclusive • Must be based on tacit knowledge

Methodology

Our methodology followed is simple in principle. As mentioned before, we formulated an idea to have two separate android apps where each app showcases a different implicit interaction. These interactions is based on heart rate and acceleration and represents our collection process. For the heart rate interaction, we designed the android app to take a heart rate reading every 5 seconds and thus a photo every 5 seconds as well. The heart rate interaction requires a smartwatch with a heart rate monitor that could communicate with the smartphone (which was collecting the photos whenever the 5 second trigger happened). Because of the communication protocol, we start the smartphone app via the smartwatch which also initiates the heart rate sensor. The acceleration based interaction took a picture whenever there was a recorded "stop". After each stop, the accelerometer android app had a 5 second delay before it can take an additional picture. So, the user should stop again after that time period. This was inevitable to reduce potential "flickering" of the accelerometer which would collect a false "stop" reading.

The study consisted of one hiker who had to wear two separate smartphones so as to have both android apps running simultaneously and a smartwatch to know the heart rate. Figure 1 shows the first author geared up for the study with both smartphones and the smartwatch. Each study is planned to run around 10 minutes with the expectations of recording (at max) 15 data points per minute (taking in account the 5 second delay minimum).

Once the study is completed we have a dataset that can be plotted two dimensionally. As seen in figures 10, 11, 12 the x-axis represents the total time the study took place. The y-axis represents the heart rate range. It should be noted that only the heart rate implicit interaction is mapped to the timestamps it took along with its own photo dataset. However, the accelerometer android app was running at the same time as the other android app which allows us to map it to the same graph. The red lines with blue triangle points is the heart rate interaction graphed over time. The green vertical lines are the timestamped photos taken in the accelerometer Android app (the vertical lines are meant to showcase that there was no recorded heart rate associated). Interestingly enough, if there are two separate similarly timestamped photos between the two Android apps, then there can be a case to map the accelerometer interaction to a heart rate.

Finally, figures 13, 14, 15 is our analysis of the potential moods observed through the dataset. Each box is a 60 second time segment where we determine if the mood is elation, distress, or composure. Elation (denoted blue on the figures) represents a more positive emotion being experienced. Distress (denoted red on the figures) is a more negative mood being experienced. Lastly, composure (denoted green on the figures) is a neutral mood being experienced. One major piece of criteria is that there must be at least 3 recored heart rate measures (so we have a curve to examine) to determine a mood. If we do not have that criteria fulfilled then no mood is observed.

Results

The created graphs show an interesting set of correlation of mood over each hike. The figures 10, 11, 12 allow us to compare the implicit interactions side by side with relation to time. It also serves as a map to find closely time related photos taken where we can compare the photos. However, this is heavy on subjectivity. Figures 13, 14, 15 breaks down the graph into 60 second segments to determine a mood. All photos taken in this time period represents the mood captured during that 60 seconds period. For instance, figures 3 is a photo taken by the heart rate Android app 4 is a photo taken by the accelerometer app within 2 seconds of each other on the Huckleberry Trail at 7:49.00. Following figure 15 we fall within a red box denoting a distressful mood taking place. This method of reading the results can be done with all photos taken.

One issue seen in 10, 11, 12 is the high amount of accelerometer pictures capture showing there is and issue on the smartphone knowing if the user is "stopped". Because of this, comparing the implicit interactions on this dataset is moot.

Limitations

The data collected highlight the potential to create a project using RITW, CAMC, and DII. However, this was not without it's limitations. Below is a list of limitations that could use further improvement or to be redesigned knowing the pitfalls this project came across:

1. Due to limited devices at our disposal we relied on the authors' different kinds of phones. The limitation was inconsistent functionality across the author's smartphones due to developing the Android applications on different Android operating systems and hardwares. This resulted in last minute study changes where we split the apps onto two separate Android smartphones and ran each app simultaneously.

2. Referencing [17], this study captured the heart rate in increments of 5 seconds over a 50 second period to be able to identify a pattern among the captured heart rates using a medically design belt to place on their users [17]. This project relied on a LG W150 Sport smartwatch to gather heart rate data. The observed limitation was a communication issue between the smartphone and smartwatch which causes a delay in timing on when to capture a photo. This resulted in our data having heart rates collected from 5 - 15 seconds from the previously recorded heart rate. This potentially impacted our final analysis in finding particular mood swings within a 60 second window.

3. Due to time constants we were limited to the amount of trials we could do once we had prior approval and we completed two functioning Android apps. The data collected is good to represent our project and work, however the Android apps need to be fine tuned based on the results we gathered before attempting a second study.

4. The study proved fruitful in determining mood with respect to heart rate. However, it would be beneficially to have included a post hike interview and getting a recorded first hand understanding of what the user experienced just moments prior. We can then use that to do additional comparisons on what was determined for mood to better understand our accuracy or predicting the mood.

Conclusion

This paper presented a project where we designed two separate Android apps employing a heart rate and acceleration implicit interactions and conducted a study on determining which interaction is better for the user to collect context accurate photos. The future work to be conducted is further revising of the apps user interface to be able to customize implicit interaction settings on the go. Additionally, there needs to be further investigation on correctly implementing the implicit interaction's timing. As mentioned in the limitations section, there seems to be a communication delay in recording the heart rate interaction consistently in 5 second intervals. These prior limitations are simple enough to tackle but require time we no longer have to do it.

Future work

During the presentation a member of the audience asked an interesting and fair question. The question on how do we make technologies like Google glass to fit on the background portion of figure 7. The first author responded with two points:

1. While not a technical solution, the design of aesthetics for the device is important in keeping the device in the background. We as humans are reactive creatures and anything that seems "new and interesting" draws our attention. However, if the aesthetics are designed to make the device fit in with more familiar terms.
2. The second response spoke of the user's appropriation of the device itself. The "wow" factor needs to wear off through accumulated usage and that is when the user loses foreground interest in the device.

It should be noted that these observations are not the only solutions to the question stated above. It is however important first steps to consider when asking the question on keep devices (even in general) in the background of a user's focus.

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Figure 10: In this graph, we show the first author's heart rate capture every 5 or 10 seconds along with a photo. The green vertical lines show when a photo was captured via the accelerometer. This takes place on the Drill Field. Interactive Plot: https://plot.ly/~meghs54d2/25.embed

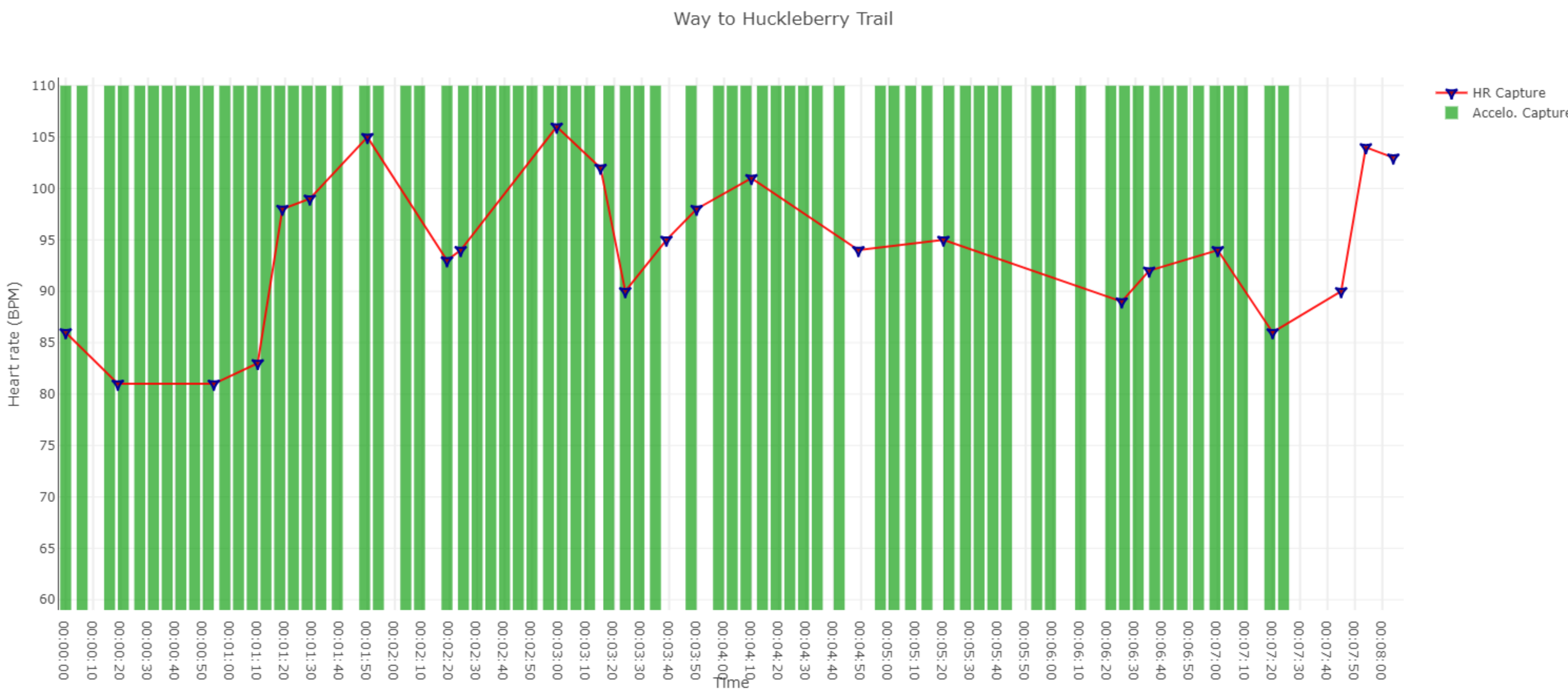

Figure 11: In this graph, we show the first author's heart rate capture every 5 or 10 seconds along with a photo. The green vertical lines show when a photo was captured via the accelerometer. This takes place on the way to Huckleberry Trail. Plot: https://plot.ly/~meghs54d2/27.embed

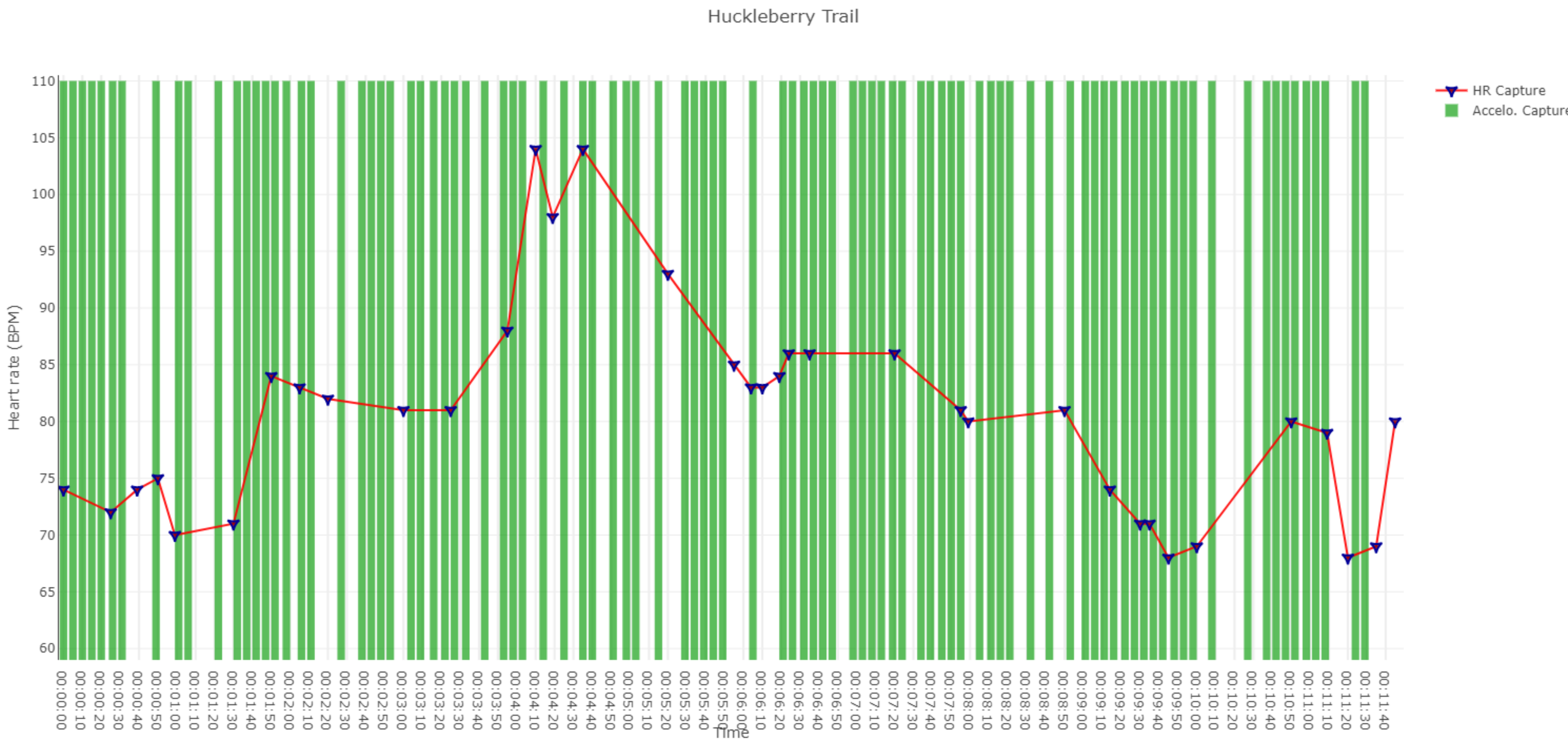

Figure 12: In this graph, we show the first author's heart rate capture every 5 or 10 seconds along with a photo. The green vertical lines show when a photo was captured via the accelerometer. This takes place on the Huckleberry Trail. Plot: https://plot.ly/~meghs54d2/29.embed

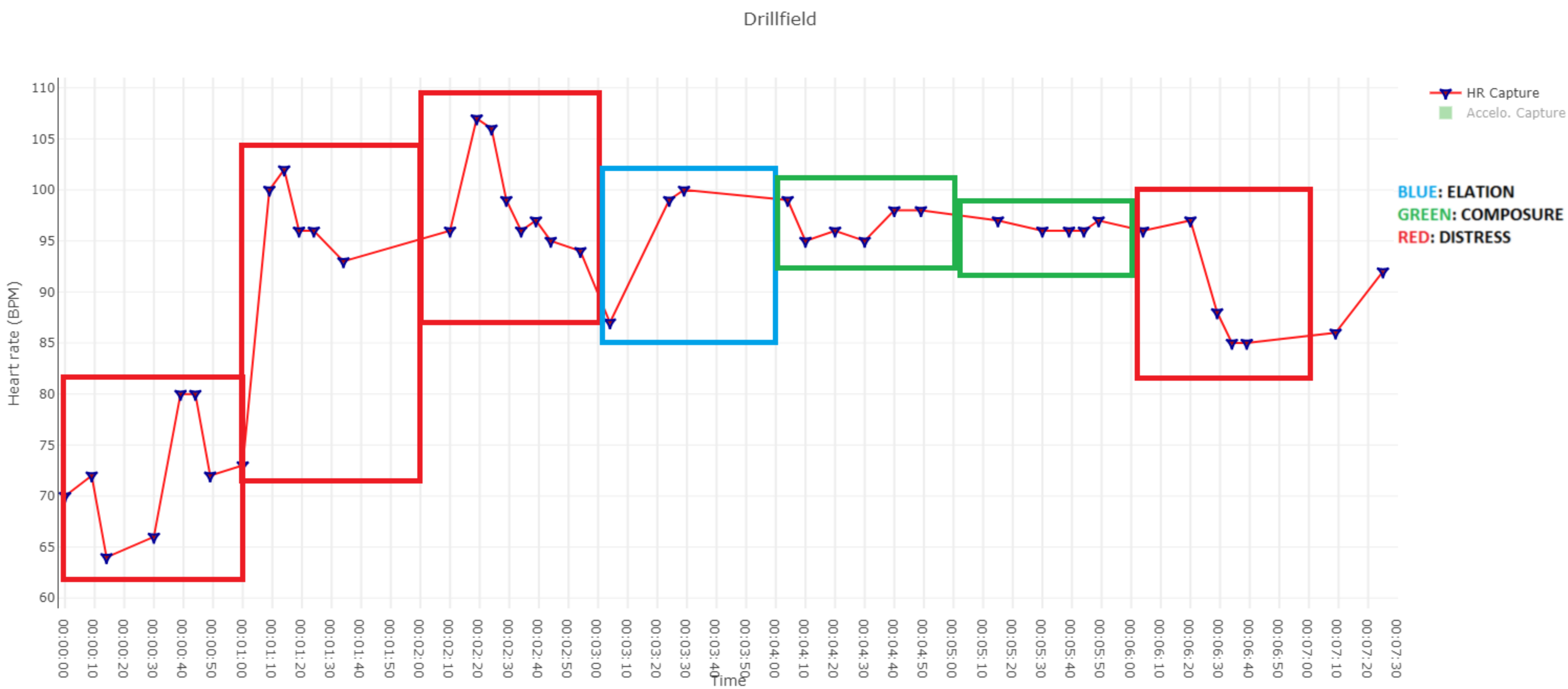

Figure 13: In this graph, we show the first author's mood based on the heart rate recorded over per minute segment.

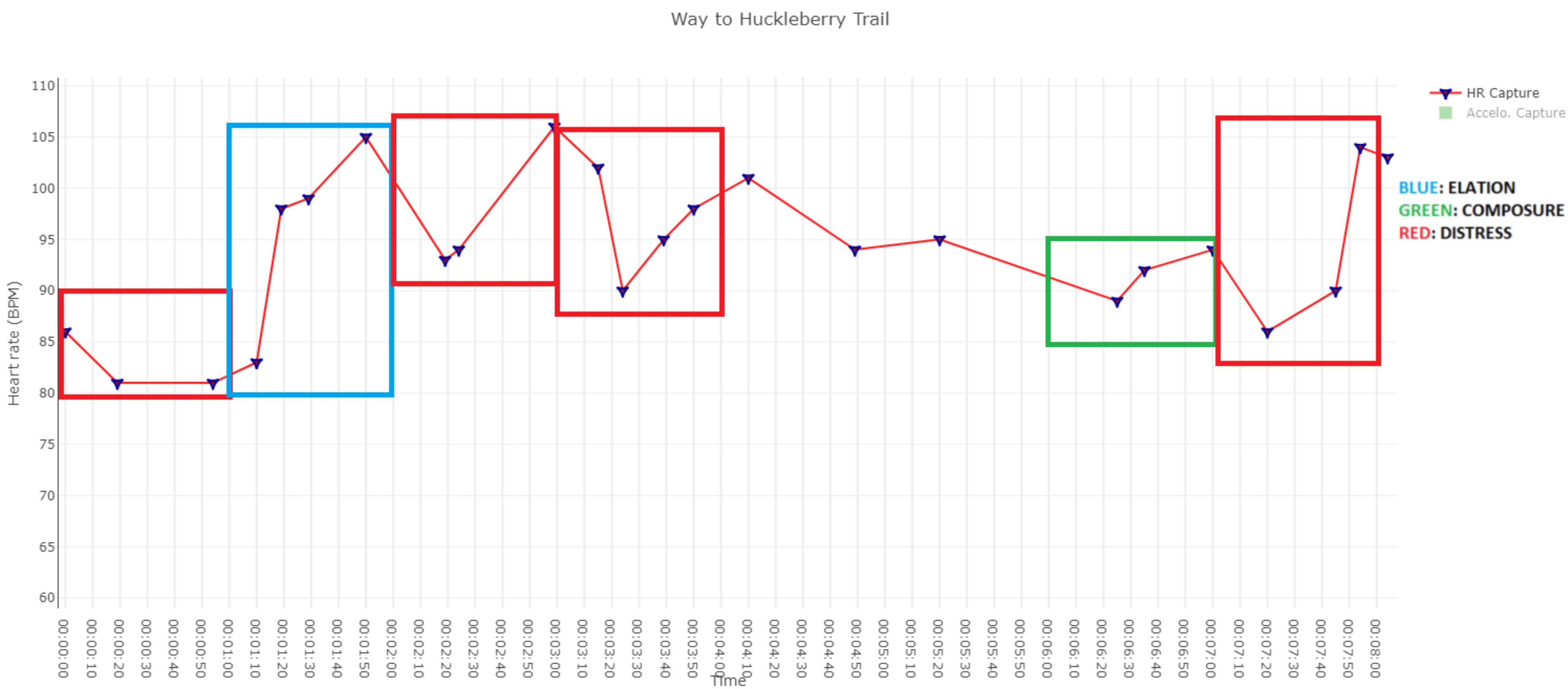

Figure 14: In this graph, we show the first author's mood based on the heart rate recorded over per minute segment.

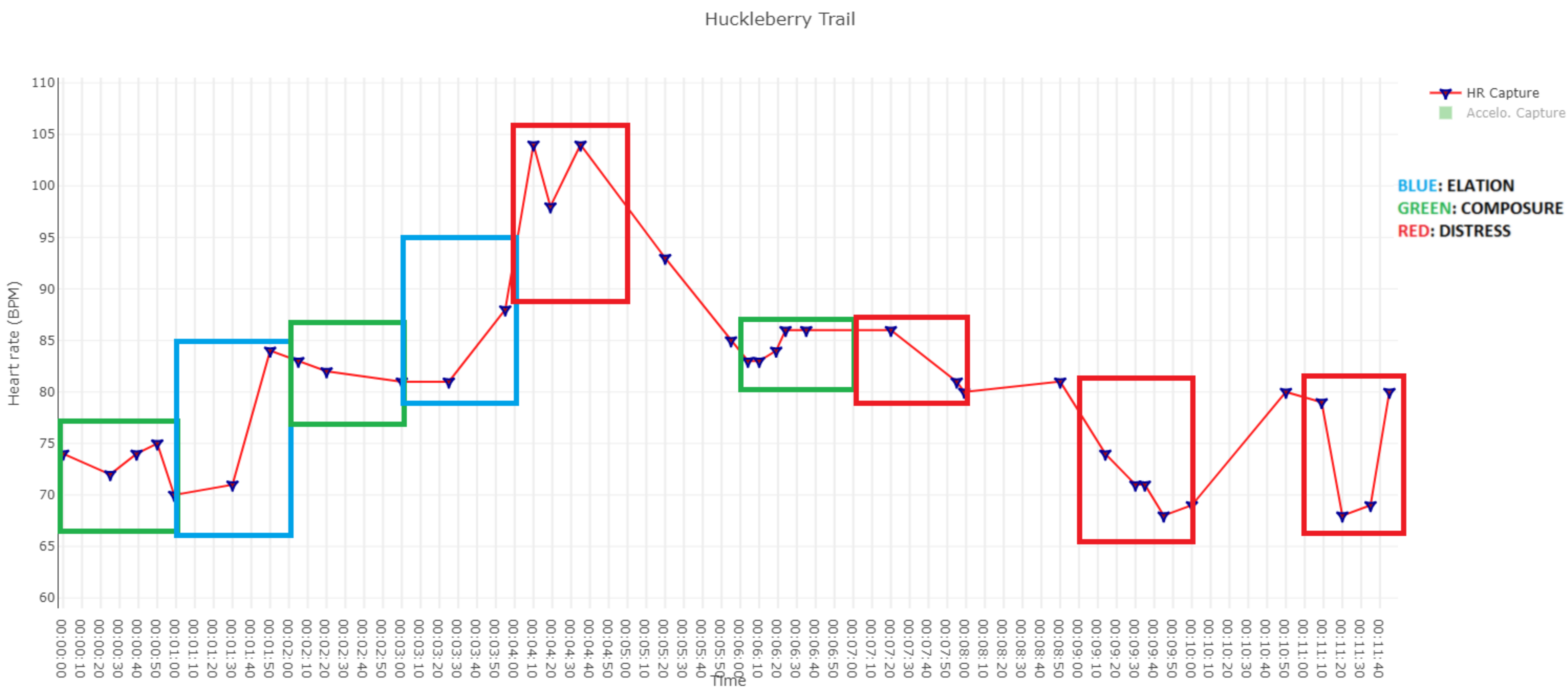

Figure 15: In this graph, we show the first author's mood based on the heart rate recorded over per minute segment.