LogMe: An Application for Generating Logs in Immersive Interactions for UX Evaluation

Victor Klisman, Luan Souza Marques, João Pedro de Lima, Leonardo Marques, Genildo Gomes, Tayana Conte and Bruno Gadelha

Institute of Computing, Federal University of Amazonas, Manaus, AM, Brazil

Keywords: User Experience, Immersive Experience, Log, Interaction, UX, Log Application.

Abstract: Immersive applications aim to stimulate interactions between the physical, virtual, and simulated world. Such applications stand out for transforming the public, often limited to a passive spectator, into an active participant in an event. Assessing the experience promoted by immersive applications is a challenge, as it involves difficulties inherent in the context of immersion. As an example, the user cannot be interrupted when he is immersed in the experience. In this sense, a non-intrusive way of collecting data is needed that can indicate whether the experience was positive or negative. The methods available in the literature are dependent on the spoken and observed reports of users during the interaction, but they are not applicable in all dimensions of evaluation and contexts of interaction, such as immersive events. The use of methods such as log capture can assist in the investigation of user interactions. In this work, we propose an application capable of recording logs from mobile devices while the user interacts with a certain immersive application. This will allow interactions to be recorded as they actually are, facilitating the investigation of the user's feelings when performing a certain task.

1 INTRODUCTION

Technologies that promote the sensation of immersion have been used to modify the way users interact and engage in different immersive environments. As an example of these technologies, we can mention Augmented Reality (AR), Virtual R eality (VR), and Mixed Reality (MR). These technologies tend to eliminate or reduce the boundaries between the physical, virtual, and simulated worlds (Suh and Prophet, 2018).

Immersive environments should provide a good user experience (UX)(Tcha-Tokey et al., 2017). Such experience is a subjective concept, dependent on the context and dynamics of the interaction(Law et al., 2009). The user experience goes beyond performing tasks in an application and focuses on hedonic aspects of use, such as fun and pleasure. For this, evaluations that focus on aspects beyond usability and their instrumental values must be applied(Hassenzahl, 2018).

In order to perform UX assessments, UX evaluators use several techniques and methods available in the literature. Rivero and Conte (2017) present a mapping of these techniques and organize them in seven categories: *scales*, such as Likert scale or semantic differentials; *forms*, with open questions, with free expression, and/or restricted, as multiple choice; *checklist*; *interviews*, with questions predefined by the moderators; *exploration with acquaintances*, where there is an exchange of users experiences and thoughts about what is being evaluated; *probes*, materials such as multimedia and objects to involve users in the evaluation process; *experience sampling and controlled user monitoring*, psychophysiological responses through coupled sensors.

When considering contexts of immersive experiences, traditional UX techniques may not be feasible to use, as the evaluation must be carried out in such a way that the user experience is not interrupted (Marques et al., 2020). In this sense, ways of capturing user experience data in a non-intrusive way, without interrupting the experience or disturbing the user, should be considered.

Through continuous records of user data (logs), it is possible to capture more information about the context of the interaction and the user experience while having an immersive experience (Menezes and Nonnecke, 2014). However, the vast majority of applications do not provide user logs or make them publicly available for analysis. The sensors logs can help to

Klisman, V., Marques, L., Pedro de Lima, J., Marques, L., Gomes, G., Conte, T. and Gadelha, B.
LogMe: An Application for Generating Logs in Immersive Interactions for UX Evaluation.
DOI: 10.5220/0010460105490556
In *Proceedings of the 23rd International Conference on Enterprise Information Systems (ICEIS 2021) - Volume 2*, pages 549-556
ISBN: 978-989-758-509-8

infer the actual behavior of the user since the interaction is recorded exactly at the moment when it occurs (Menezes and Nonnecke, 2014). But the absence of this information by most applications demands the use of intrusive UX assessment methods, requiring direct contact between the moderator and the user.

In this sense, this paper presents LogMe, an application that provides data inherent to the context, capturing and storing logs of immersive applications without interfering in the user experience. For this, geolocation data, motion sensors, and external environment, such as luminosity, are collected to assist in the analysis of the user behavior.

2 BACKGROUND

As new technologies emerge, organizers of entertainment events seek to provide different ways of interaction and engagement with the public at their events. This industry branch is gaining prominence and is constantly expanding (Martins et al., 2020).

An example of this expansion is reflected in the creation of applications to increase audience engagement or make it more active in entertainment events, such as StageCast (Funkquist, 2019) and Echobo (Lee and Freeman, 2013). Another example is the Bumbometer (Martins et al., 2020), which consists of a competitive and collaborative game for crowds. The Bumbometer allows two opposing teams to play matches through the continuous movement of their mobile devices. A screen displays two thermometers that indicate each teams' engagement (Figure 2 in Section 4.1). The speed of the thermometer is defined by adding the acceleration points (x, y, and z) provided by the device's accelerometer sensor. The team that manages to get the thermometer to the top wins.

For this type of technology to fulfill the role of encouraging user interaction, it is necessary to analyze the experiences they provide to users. In this sense, UX evaluations are a way to analyze these experiences lived by the public. As stated earlier, traditional evaluation techniques of UX are not the best alternative in the context of immersive experiences, as they interrupt the user during immersion. On the other hand, UX evaluations based on indirect observation can be a viable alternative (Marques et al., 2020). They can be automatically done by capturing the user's logs, while the user interacts with the application, allowing the understanding of their interaction and engagement without direct interference.

Hussain et al. (Hussain et al., 2018) proposed the Lean UX Platform, a platform for capturing and analyzing user data of a given software at the moment of interaction. The platform is focused on recording and processing user data. The Lean UX Platform uses several ways to collect interaction logs, such as facial expression analysis, eye tracking, video and voice capture, and electroencephalography (EEG). When applying a test on another platform, the authors realized that capturing information in a synchronized way allows a better interpretation of the data. And the use of several methods and devices provide more accurate information about the user when interacting with the product.

The web also adheres to log capture as it is a powerful resource for business research and market, benefiting a series of applications(Preece et al., 2015). The UX-Log tool uses such logs to infer and recreate user behavior after an experiment (Menezes and Nonnecke, 2014). A test was carried out where 10 usability experts, watched the user experience recreated by UX-Log and evaluated the use of the tool. The experts were able to understand the user and his intentions. The authors stated that the tool was efficient in recreating user behavior from logs.

Based on the aforementioned works, we can say that interaction logs allow the analysis of the context, attitudes, and emotions of the users during their experience. Logs analysis allows UX experts in carrying out UX evaluations without interfering in the user's experience. In this work, we propose an application for capturing logs from mobile devices in order to enable UX experts to evaluate UX on different mobile applications. Our proposal differs from the others presented in this section in that it focuses on logs of immersive experiences.

3 METHOD

In order to propose a way of evaluating UX in immersive experiences in a non-intrusive manner, we adopted a research method based on 4 stages as follows: *(i) exploratory*, where we reviewed literature in order to understand both UX evaluation practices and immersive technologies; *(ii) experimentation*, where we proposed LogMe, a tool for capturing logs from different sensors in smartphones; *(iii) Pilot Study*, where we conducted a pilot test; and finally the *(iv) Feasibility Study*, corresponding to the feasibility study on the use of LogMe.

In the *(i) exploratory* stage, we aimed at understanding UX concepts and techniques, and immersive applications. During this stage we analyzed some papers that dealt with the exploration of interaction logs and data cataloging. A snippet of this review is presented in Section 2. These papers gave us the background to understand the ways of capturing logs and their application for analyzing users' behavior. Also, they aimed at a better interpretation of the final experience of those who used a particular application (Menezes and Nonnecke, 2014).

After reviewing the literature, we proceeded to the *(ii) experimentation stage*, which started with a comparative study between technologies for developing mobile applications. During this study, we decided on the most suitable technology for log collection in mobile devices. After that, we began with the development of LogMe in an incremental-iterative way. In each iteration, we made some improvements and added more sensors' data. Section 4 details the development of LogMe.

Before proceeding with the feasibility studies, the *(iii) Pilot Study* stage took place, which consists of conducting a pilot test with four simultaneous users through video conferencing. The purpose of the test was to verify the usability and efficiency of the LogMe data capture, while the participants used a specific interaction app that stimulates the movement of the device. The pilot test can be seen in more detail in Section 4.1.

In *(iv) Feasibility Study* stage, we conducted a feasibility study to verify the use of LogMe in practice. We aimed at verifying whether the quality of the logs recorded by LogMe were as good as those of the Bumbometer itself. For such comparison, the analysis was performed based on the data collected by both LogMe and Bumbometer apps. The study was conducted entirely online via video conference and had a total of 13 simultaneous participants. Section 4.2 details this study.

4 LogMe

Smartphone apps can mediate many immersive experiences. But, in most apps, we do not have access to log files with information about user interactions. This fact makes the evaluation of the UX during immersive experiences in a non-intrusive way more challenging. This scenario motivates the development of LogMe.

LogMe is a mobile app developed for collecting and registering sensor and contextual data from mobile devices. LogMe reads data from a set of sensors comprising: accelerometer, gyroscope, magnetometer, and light sensor. Besides sensors data, LogMe also reads and registers the location and battery level as contextual data.

The choice of these sensors is justified by the fact that through them it is possible to infer the behavior of users, through body gestures and the way they manipulate the device. Thus, it is possible to associate such behaviors with sentimental characteristics such as stress, dissatisfaction, and fluidity. It is also possible to record contextual information of the user, for example, it is possible to collect the signal strength of the wi-fi network in relation to the distance from the router, understand when the user is moving or how the device reacts to the battery charge level. This last point is emphasized due to some functionalities of mobile devices being reduced or disabled when they are at low load levels.

The context of the use of the immersive experience under evaluation must be taken into account when analyzing the logs provided by LogMe. Apps used in entertainment events, for example, can generate a lot of movement data and this does not characterize stress or anger on the part of the user, but joy or enthusiasm.

The usage of LogMe is simple. The user must activate the app, set the time interval for collecting sensors and contextual data and press the "Start" button ("Iniciar", in Portuguese) (Figure 1 on the left). After pressing the start button, LogMe keeps running in background and registers sensors data while the user interacts normally with the smartphone during an immersive experience. After the experience, the user activates LogMe and press the "Stop" button to finish the data collection.

During data collection, LogMe records the data in a text-based log file. LogMe captures information from sensors and components that can be classified into 4 groups: *Motion Sensors*, capable of capturing any movement of the device; *Position Sensors*, allows you to recognize the device's position in the physical space; *Environment Sensors*, allows you to capture information external to the device; *Location Components*, allows you to collect the geographic location of the device; In addition to these, the timestamp provides the date and time for each line in the log file. An example of a generated file is also presented in Figure 1.

Depending on the context in which the application is used, it is more feasible to use a certain capture time. For this, the option of configuring the time interval to capture sensor data was added. In this way, the user can choose intervals from 0.1 to 2.0 seconds. This allows greater control and makes it more flexible during use combined with other applications.

LogMe enables the sharing of the generated log file. In the case of a UX evaluation, the user can send their file to UX evaluators. This file-sharing is performed manually by the user after the log genera-

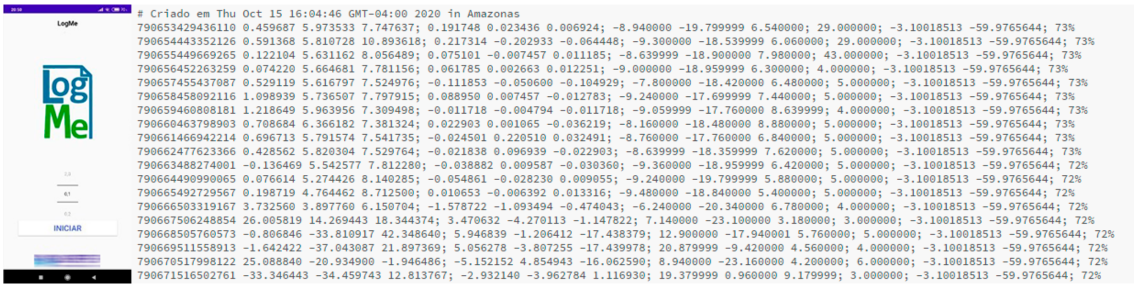

Figure 1: On the left, a LogMe home screen. On the right, an example log file.

tion has ended, through an option that appears on the screen, where the user determines where to send the log file.

4.1 Pilot Study

After developing LogMe, we conducted a pilot study in order to verify if the generated log is comparable with a native log of an application that provides immersive experiences. The pilot test aimed to improve the data collection plans and procedures that will be followed to validate the study. For this, the steps that comprise this test are described below.

4.1.1 Preparation

In order to conduct the study, we had to select an app that provides an immersive experience. The requirements for this selection were: (1) the interaction in the app must be motion-based; (2) the app must be used in an on-line setting (given the scenario of social isolation due to the COVID-19 pandemic) and; (3) the app must provide a log of user interaction to serve as basis for comparison with LogMe generated logs.

Based on these requirements, we chose Bumbometer as an app for conducting the pilot study. Bumbometer, as mentioned in Section 2, is an app designed to be used during an entertainment event where two teams compete by shaking their smartphones to see who is the most animated. Bumbometer provides an immersive experience during entertainment events engaging its users in the battle. Bumbometer works entirely on-line which enables its use in a non-presencial environment. Bumbometer's backend application generates an log with the interaction of its users. This turns possible to compare the data with log provided by LogMe.

The pilot study was conducted with four participants that installed both Bumbometer and LogMe apps in their smartphones. Due to the context of the Covid-19 pandemic (Roser et al., 2020), it was conducted entirely on-line via video conference using Google Meet. Google Meet enabled the sharing of the Bumbometer's feedback screen, displaying the termomethers as we can see in Figure 2.

4.1.2 Execution

With the applications installed on their devices, the participants started LogMe and were instructed to initially set the interval time of 0.1 seconds for capturing sensors data. Soon after, they were able to start recording the logs and leave the application running in the background. That done, they started the Bumbometer app and choose their favorite team (Blue Team - Boi Caprichoso or Red Team - Boi Garantido).

The feedback screen with the teams' thermometers was presented and the round started. Thus, the participants were able to shake their smartphones to take their team to victory. Normally, interaction with the Bumbometer takes an average time of 20 seconds. After the round, the participants stopped the record of logs in LogMe and shared the generated log file to the researcher that conducted the study. Figure 2 illustates the feedback screen shared in Google Meet during the study.

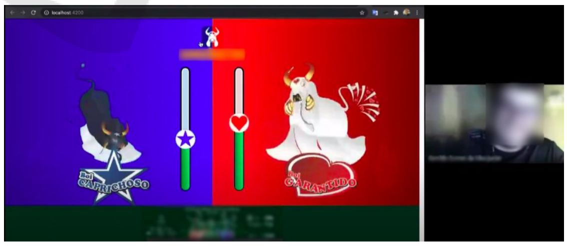
Figure 2: Pilot test being performed remotely.

Four more rounds were performed with the following intervals defined in LogMe: 0.5 seconds, 1 second, 1.5 seconds, and 2 seconds. At the end of all rounds, the participants shared all LogMe generated files with the researcher that conducted the study. We also collected Bumbometer's five log files related to the five rounds during the study. In the next section we present the analysis of the log files from both LogMe and Bumbometer.

4.1.3 Results Analysis

The structure of Bumbometer's native log is different from LogMe generated logs. The data is divided by teams, where each individual accelerometer value is summed to form the team's acceleration value. Bellow the team information, the log presents information about each user comprising: id of the user, accelerometer value, and GPS location values. Figure 3 shows an example of Bumbometer's native log file for one round of the study.

Different from Bumbometer's log files, LogMe generated file stores data for just one user. So, to analyze and compare both log files, we needed to collect LogMe generated logs of each participant of the study. After that, we had to organize the logs from all the participants in the same structure as Bumbometer's native log. Table 1 shows LogMe files' data organized for comparison with Bumbometer's native log file.

```
2020-10-15 16:10:14
AZUL Aceleracao:56.14465396574985 Jogadores:2
ID:7v768i ACELERACAO:21.039661663324182 LOCALIZACAO:-3.0711885,-60.0314638
ID:uw6bfw ACELERACAO:35.10499230242567 LOCALIZACAO:2.8260259,-60.6897871

VERMELHO Aceleracao:74.68981828361262 Jogadores:2
ID:0f2osr ACELERACAO:47.63734449462106 LOCALIZACAO:-3.2813253,-60.6267607
ID:soe0sn ACELERACAO:27.05247378899157 LOCALIZACAO:0,0
```

Figure 3: Example of log generated by the Bumbometer application.

Table 1: Organization of LogMe data for comparison with Bumbometer logs.

	X acceller-ation	Y acceller-ation	Z acceller-ation	Total Individual	Team Total
			Blue Team		
participant 1	4.298.388	3.996.705	6.078.269	14.373.362	
participant 2	2.473.210	3.335.123	12.919.112	18.727.445	33.100.807
			Red Team		
participant 3	0.683.738	5.584.887	8.002.572	13.587.459	
participant 4	0.689.530	2.861.071	9.907.207	12.768.278	23.355.737

For each second counted in LogMe, the accelerometer data (x, y, z axes) for each user were added and later added to the total value of the chosen team, resulting in a single value. This value was compared with the opposing team. The time interval for the execution of each test was also considered.

Among the 5 rounds performed, we considered only rounds 2 and 3 (intervals of 0.5 and 1 second) for the comparison with the records generated by the Bumbometer app. This was due to the interval times for rounds 2 and 3 are the closest to the Bumbometer's native log, obtaining a more consistent result.

The test with the capture interval of 1 second had a total interaction time of 15 seconds. In comparison with the results of the Bumbometer's native log, 11 results were obtained with an accuracy of 78.57%. The final result of the winning team was confirmed by the logs collected from LogMe. The variation in team acceleration can be seen in Figure 4 and the winner of the round in Table 2.

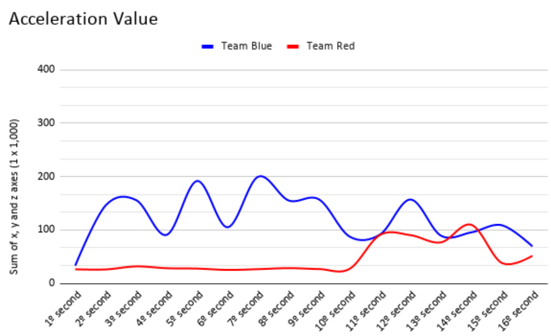

Figure 4: Graph of the acceleration variation during the interaction between the teams in round 3 (1-second interval).

Table 2: Total acceleration for each team and the winner within 1 second.

Team Blue	1.935.595.156
Team Red	732.001.560
Round Winner	Team Blue

For the test with the interval time set to 0.5 seconds, the LogMe data had to be considered in pairs. Every two lines of 0.5 seconds the data were added to match the time of 1 second in the Bumbometer's log. The interaction lasted 11 seconds and obtained 7 coincident values and the confirmation of the winner by LogMe (seen in Table 3).

Table 3: Total acceleration for each team and the winner within 0.5 second.

Team Blue	1.467.652.366
Team Red	2.362.262.779
Round Winner	Team Red

It is considered that, due to the flexibility of capture time and individual registration, LogMe logs can bring more efficient results when analyzing the interaction. This flexibility allows verifying the user who collaborated and engaged the most (Table 4). In addition, based on individual data, it is possible to find the winning team in a clearer, more objective way and without loss of information. The Bumbometer also obtains this information, but calculates the acceleration value over a very large interval and still passes it to a database via the internet, which can be lost during this process.

Table 4: Total acceleration of participants and who contributed most during the round.

Team Blue		Team Red	
Participant 1	1.436.432.830	Participant 3	414.089.883
Participant 2	499.162.326	Participant 2	317.911.677
Biggest contributor: participant 1			

LogMe's utility stands out for collecting data from other sensors present in the device, allowing to understand the context and mode of experience, engagement, and interaction of each user more deeply. In general, the pilot test met the expectations of the study concerning ease of use and gaining information that may have been compared to the logs of the applications to be evaluated.

4.2 Feasibility Study

In order to confirm the results from the Pilot Study, we conducted a feasibility study. This study aimed to verify the feasibility of analyzing multiple LogMe generated files from many users interacting in the same immersive experience. So, in this study, we invited 13 participants to engage and interact virtually using Bumbometer. The study is detailed in the following sections.

4.2.1 Preparation

For this study, we elaborated an Informed Consent Form (ICF) explaining the motivation and execution process of the research highlighting the information that would be collected from the participants. All participantes digitally signed the ICF that was available through the Google Forms platform[1]. As in the pilot test, the study was carried out by videoconference using the same interaction application.

The study started with a short presentation to the participants contextualizing them and explaining the functioning of the LogMe and Bumbometer apps. The procedures of the study was also explained to the participants.

As in the Pilot Study, the Bumbometer's feedback screen with each team's thermometers was shared with all participants in Google Meet. We also created a group on a message exchange platform (Telegram[2]) with all the participants to send their log files for analysis.

4.2.2 Execution

In total, 13 people participated in this study. All of them downloaded both LogMe and Bumbometer apps. During the presentation about the study, we answered all participant's questions and doubts. We also asked them to sign the ICF through an online form link, where everyone agreed to use their data anonymously for scientific purposes.

After signing the ICF, the rounds were initiated and carried out like the pilot test, Session 4.1. For each round, the LogMe data logging interval varied between 2 seconds for the first round, 1.5 seconds for the second round, 1 second for the third round and 0.5 for the fourth round. The Figure 5 shows the feedback screen and the participants shaking their smartphones. In the end, the individual logs generated by LogMe were sent to a group on Telegram. These logs were received for further analysis.

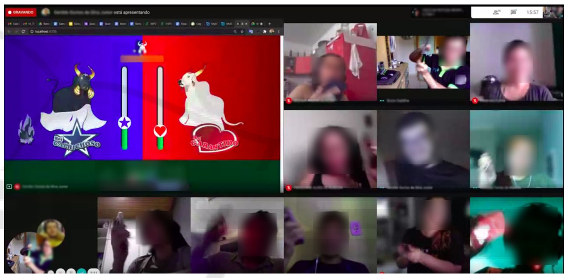

Figure 5: Test performed with 13 people remotely.

4.2.3 Results Analysis

Through the analysis of the logs, we could infer the total of both individual and collective engagement during the interactions. We could also observe in which rounds the participants collaborated more and which team was more engaged in the immersive experience. Figure 6 shows the total engagement for each round. As we can see, the Blue team won rounds 1, 2 and 3. The Red Team won only the last round.

As in the Pilot Study, for comparison purposes, we organized LogMe generated logs following the same organizational structure of the data generated by Bumbometer's native-logs.

The third round had to be discarded from the analysis. The reason for that is that one of the participants had trouble with sharing the log referring to this round. Bumbometer's native log has data from this participant, but without the log from LogMe, the comparison was not possible.

The comparison of the data returned by the Bumbometer, the adapted data from LogMe and the percentage of equivalence is shown in Table 5. It is

[1] https://docs.google.com/forms

[2] https://telegram.org/

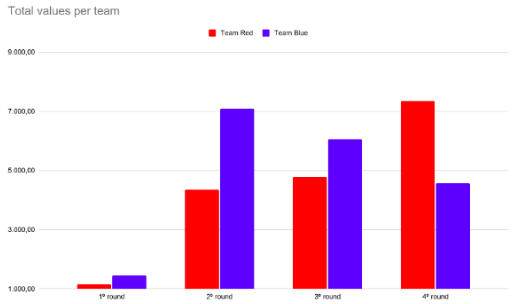

Figure 6: Comparison table of the winners during the 4 rounds.

Table 5: Matching results between Bumbometer and LogMe.

	Round 1	Round 2	Round 4
Capture time	2 sec	1,5 sec	0,5 sec
Values returned by the Bumbometer	15	14	14
Corresponding values with LogMe	12	13	13
Accuracy	80%	92,85%	92,85%

possible to observe that the adaptation of the LogMe data, in its great majority, becomes equivalent to the data generated by the Bumbometer, achieving excellent accuracy.

The study showed that the logs generated by LogMe are as good as those generated by the evaluated application. During the three valid rounds carried out in this study, we obtained an average of 88.56% of correct answers. This allowed us to verify that the logs generated by LogMe could be used to correctly determine the winner of all valid rounds (1,2 and 4).

5 DISCUSSIONS

The objective of this work is to investigate whether LogMe is capable of producing useful data for the evaluation of UX, specially on applications that provides immersive experiences. As seen during the study, it is feasible to use logs to assess user engagement, interaction and collaboration. According to the results obtained through the studies, we noticed that the LogMe data compared to the Bumbometer, had significantly similar results, which can be verified in the Session 4.2.

This allows us to state that LogMe provides information comparable to the information provided by Bumbometer's native log. Information on logs from LogMe manages to be more accurate with less loss of information. It is worth mentioning that the presence of more sensors available, allows loading detailed information of the interaction, thus generating more consistency in the inferences of users behavior during immersive experiences. LogMe can also be used in other contexts using different applications if the interaction can be analyzed by logs of motion and contextual sensors.

As explained in Marques (Marques et al., 2020), some UX measures need the user's direct opinion, but there are indirect measures, such as engagement. These measures can be found through LogMe since it is possible to assess how much the user has actively contributed to the interaction.

Therefore, LogMe can help UX evaluators to adopt non-intrusive techniques as an alternative to traditional UX techniques. This is an important issue given the context of immersive entertainment, where the user experience cannot be interrupted. In this scenario, the evaluation through traditional UX techniques may not be feasible. In this sense, LogMe captures and provides data for the UX assessment to be carried out indirectly.

About the limitations of LogMe, we can point that the app was developed exclusively for Android devices, limiting the reach of users. LogMe is still a proof of concept. We developed it firstly for Android devices because Android is the most used mobile operating system (Alzaylaee et al., 2020). We intend to develop an IOS version of LogMe, covering a wider range of devices.

Another limitation of LogMe as to do with its log sharing function. This function is not yet exclusive to LogMe, that is, the user can choose the destination to which he wants to make the generated logs available (WhatsApp, Telegram, etc.). This can lead to sharing errors and file loss. Subsequently, we intend to create automated file management, where log files would be uploaded to the cloud and stay accessible only for UX evaluators, thus reducing the chance of errors in sharing.

6 CONCLUSION AND FUTURE WORK

Immersive applications are gaining ground in entertainment events, and evaluating the user experience (UX) while using the application without directly interfering is a challenge. For that, we proposed an application to capture data inherent to the context, capable of generating interaction logs through the sensors of mobile devices. And through the analysis of these interaction logs, infer the user's real behavior. Thus, the LogMe application was developed and subjected to feasibility studies and comparison analyzes to verify the efficiency of log captures.

Through the results collected, LogMe proved to be a satisfactory product, achieving an excellent similarity rate in contrast to other applications, proving to be efficient and effective in capturing details of the user's behavior without interfering with their experience. It also allows the understanding of user behavior, and the extension of the utility to test any types of applications that require behavior inference.

As future work, we intend to expand the use of the application by creating a multiplatform version of LogMe, as well as adding support for more sensors, registering the name of the application used in the foreground, and allowing automatic sharing of the log files. Besides, there is also a need to validate LogMe together with other applications, since in this paper, the data were compared only with an immersive application.

ACKNOWLEDGMENT

This research, carried out within the scope of the Samsung-UFAM Project for Education and Research (SUPER), according to Article 48 of Decree no 6.008/2006(SUFRAMA), was funded by Samsung Electronics of Amazonia Ltda., under the terms of Federal Law no 8.387/1991, through agreement 001/2020, signed with Federal University of Amazonas and FAEPI, Brazil. Also supported by Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - Financing Code 001, CNPq process 311494/2017-0, and Foundation for Research Support of the State of Amazonas (FAPEAM) - POSGRAD and process 062.00150/2020.

REFERENCES

Alzaylaee, M. K., Yerima, S. Y., and Sezer, S. (2020). Dl-droid: Deep learning based android malware detection using real devices. *Computers & Security*, 89:101663.

Funkquist, M. (2019). Study of the impact and usage of an audience engagement tool at live events.

Hassenzahl, M. (2018). The thing and i: understanding the relationship between user and product. In *Funology 2*, pages 301–313. Springer.

Hussain, J., Khan, W. A., Hur, T., Bilal, H. S. M., Bang, J., Hassan, A. U., Afzal, M., and Lee, S. (2018). A multimodal deep log-based user experience (ux) platform for ux evaluation. *Sensors*, 18(5):1622.

Law, E. L.-C., Roto, V., Hassenzahl, M., Vermeeren, A. P., and Kort, J. (2009). Understanding, scoping and defining user experience: a survey approach. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 719–728.

Lee, S. W. and Freeman, J. (2013). echobo: A mobile music instrument designed for audience to play. *Ann Arbor*, 1001:48109–2121.

Marques, L., Amazonas, M., Assuncao, W., Castro, T., Zaina, L., Gadelha, B., and Conte, T. (2020). Ux trek: A post-interaction journey from immersive experience logs. *IHC 2020 - XIX Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais*.

Martins, G., Gomes, G., Conceição, J., Marques, L., Silva, D. d., Castro, T., Gadelha, B., and Freitas, R. d. (2020). Enhanced interaction: audience engagement in entertainment events through the bumbometer app. *IHC 2020 - XIX Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais*.

Menezes, C. and Nonnecke, B. (2014). Ux-log: understanding website usability through recreating users' experiences in logfiles. *Journal ISSN*, 2368:6103.

Preece, J., Sharp, H., and Rogers, Y. (2015). *Interaction design: beyond human-computer interaction*. John Wiley & Sons.

Rivero, L. and Conte, T. (2017). A systematic mapping study on research contributions on ux evaluation technologies. In *Proceedings of the XVI Brazilian Symposium on Human Factors in Computing Systems*, pages 1–10.

Roser, M., Ritchie, H., Ortiz-Ospina, E., and Hasell, J. (2020). Coronavirus pandemic (covid-19). *Our World in Data*.

Suh, A. and Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior*, 86:77–90.

Tcha-Tokey, K., Loup-Escande, E., Christmann, O., and Richir, S. (2017). Effects on user experience in an edutainment virtual environment: comparison between cave and hmd. In *Proceedings of the European Conference on Cognitive Ergonomics 2017*, pages 1–8.