# Improving Engagement Assessment in Gameplay Testing Sessions using IoT Sensors

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## ABSTRACT

The video game industry is a multimillionaire market, which makes solo indie developers millionaire in one day. However, success in the game industry is not a coincidence. Video game development is an unusual kind of software that mix multidisciplinary teams: software engineers, designers, and artists. Also, for a video game to become popular, it must be fun and polished: exhaustively well tested. Testing in video game development encompasses different types of tests at different moments of the development process. In particular, assessing the players' gameplay in a test session can drive the development drastically. The designers analyze the players' actions and behaviour in the game. They can then decide if a feature/level requires rework. They often spend many man/work hours reworking a feature just because it is not engaging. As the designers (usually) assess the gameplay session by hand, they cannot be sure that a specific feature is engaging enough. They would benefit from meaningful data that would help them better assess the gameplay and take the decision to keep, rework, or remove a feature. Consequently, we describe the need for an IoT framework to assess players' gameplay using IoT sensors together with game devices which will produce a rich output for the game designers.

## KEYWORDS

iot, sensors, game-development, testing, game-design, gameplay

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## 1 INTRODUCTION

For decades, playing video games has been a joyful hobby for many people around the world [5]. The video-game industry is multi-billionaire, surpassing the cinema and music industries combined [11]. However, fantastic graphics and smooth gameplays hide constant and non-ending problems with game development [13], mostly related to bad development practices and poor management, leaving a trail of burnout developers after long period of crunchs[1] [4].

A game must be a well-polished product to be well received by players. Hence, game testing is an essential tool to obtain such a product. It implies searching for bugs and identifying features in the game that are not engaging. It thus implies gameplay testing, either through a prototype, a slice of the final product, or the whole game. Gameplay testing requires endless iterations by development teams in the last mile of the production. These iterations sometimes involve months of crunches by the team [17].

Gameplay testing is crucial to delivering *fun* and, thus, successful games. It requires testers to play a specific build of the game, often without knowing the game, while game designers assess the level of the game or a recently-implemented feature. It pertains to large numbers of actions [10], which cannot be automated [12].

Moreover, while game designers want to assess whether the game is engaging during gameplay testing, they can only analyze the testers' actions and their vocal or corporal expressions. This lack of evidence can lead to wrong interpretations, which can cause delays in the development or even the commercial failure of a game. Moreover, they must rely on the testers' and their "feelings" of engagement (or lack thereof) because engagement is an abstract attribute of games without, currently, objective, related measures.

Consequently, gameplay testing is hard and game designers would benefit from an approach to collect meaningful data that would help them better assess the gameplay and take decision to keep, rework, or remove a feature. We propose an IoT framework to collect, analyze, and report on the players' gameplay through IoT sensors together with game devices, which produce a rich, meaningful, and objective assessment for the game designers.

This paper is organized as follows. Section 2 shows the overview of the approach. Section 3 presents the related work and relates our approach. Section 4 describes the IoT architecture. Section 5 discusses the benefits and some limitations of our approach. Section 6 concludes with future work.

## 2 OVERVIEW OF THE APPROACH

We divided the framework in different steps to be implemented. Therefore, this paper presents the reasoning behind the concept of a high level framework for video game testing aiming to improve the understanding of the "fun factor" in games. The steps to reach this goal are described below:

(1) *Conceptual:* Define the underlying gameplay variables (details), that could be measured and identify what each one represents when related to finding the *fun* in games. This

[1] In video game development, crunch time is the period during which developers work extra hours to deliver their game in time.


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will be made by doing a Systematic Literature Review on biometrics in game development and the "search for the fun factor".

(2) *IoT Architecture:* According to the previous defined variables, define the set of measurements and the responsible sensors to gather the data from the players (game testers), also defining the underlying IoT architecture.
(3) *Experiment:* Set up the experiment to evaluate the idea. In this case, play the game (or games) and compare the results using a questionnaire as oracle after the game session.
(4) *Data analysis:* Analyze the data and correlate the sensors' values with the questionnaire's results. Search for patterns and "spikes" that indicate change in the players' humor.
(5) *Framework:* Propose the a framework (tool) that encompass the IoT architecture of the devices, the application responsible for manage the data, and the dashboard that will allow the end user (game developer) to take advantage of.

To narrow the scope of the paper, we will focus on the IoT Architecture and its sensors. The proposal is to use biometric data, together with a screen recorder and joystick input tracker to enhance what the game designers can see about the behaviour of the testers. It can show spikes in the data related to a specific moment in the game.

Figure 1 shows the workflow of the process we propose. The yellow blocks represent the game development team; the red block is regarding the test team, which may or may not be part of the main team; and finally, the blue blocks depict where our approach lies. As the development is iterative, we can consider the beginning when the development team produce a new build of the game (sometimes referred to as vertical slice). The tester then plays the game while the sensors capture the data, synchronize the information and compile a video with all the information. Lastly, the game developers analyze the video with the information and make his/her judgment. The process is then restarted as soon as the team decides to produce a new build or check a new feature.

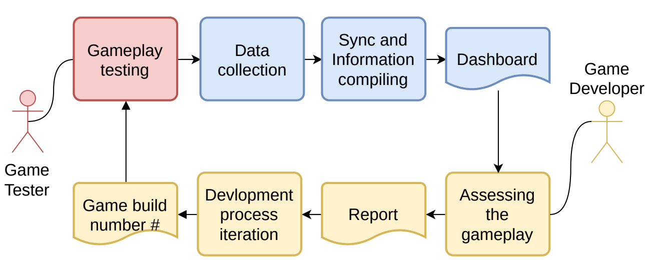


**Figure 1: Workflow of the testing process using the IoT framework.**

## 3 RELATED WORK

Some authors already tried to use biometrics feedback to assess the gameplay session. Clerico et al. [3] proposed a "predictive model" that show the fun experience of players based on the physiological responses by using biometric indicators as Electrocardiography (ECG), Electrodermal Activity (EDA), Electromyograph (EMG), and respiratory activity. Martey et al. [9] attempted to measure the engagement of players using self-report, content analyses of videos, electrode-dermal activity, mouse movements, and click logs. Johnson et al. [8] tested how diversity in games affect players. They used psychophysiological measure like electrodermal activity (EDA) and heart-beat rate (ECG) as well as post-experimental forms in video game sessions. Moura et al. [10] propose a method to better analyze players' behaviour in a specific set of games, in this case, RPGs or Action/Adventure where navigation, collection and talking with NPCs are important for the game. Roose [16] proposed a method to evaluate the skill of players by using interviews (Cognitive Task Analysis) and eye tracking.

On the other hand, authors also used non-biometric approaches to assess the gameplay. Fowler [6] proposed a method to qualify and quantify the learning aspect during video game sessions in children from 3 to 5 years old where the assessment consisted only in normal observation. Ravaja et al. [14] investigated the emotional response patterns with 37 players by playing different games in random order. They assessed by using post-experiment forms.

Our approach borrow some of these ideas and brings it to the light of IoT and Software Engineering. We are trying to extend the analysis of gameplay sessions by combining more sensors. Also, we do not rely on players feedback using forms or interviews. Many, if not all approaches cited, use a off-the-shelf solution (black box), which is expensive and not extensive/customized. Our focus is on low cost sensors and programmable devices where the development team can modify by their needs. Finally, we are focusing in a tool to aid developers, more specifically, game designers. Aside form the work from Moura et al. [10], other authors had other objectives in theirs papers.

## 4 IMPLEMENTING THE ARCHITECTURE

In this section we show a simplified version of the IoT architecture for gameplay testing. Figure 2 shows the proposed architecture in UML2 component diagram. The whole system is based on low cost sensors and Arduino (https://www.arduino.cc/). The basic setup for a game session is the *screen*, *game system* (console, computer, etc.) plus the game (version of the build to be tested) and a input device, *joystick* in this case.

The *screen recorder* and the *input tracker* are simple software to record and get the inputs (game commands) respectively. As for the *camera*, there is no caveats. It is a camera focusing on the tester, all the time. The data is then sent directly to the main server as it does not need treatment. The *force sensitive resistor* is attached to the joystick to capture the pressure force made by the tester. It then sends this data to the server (or an edge node) to be normalized and then stored in the main server. The bio-metrics are taken by a set of sensors, *ECG*, *EMG*, *EDA*, and *GSR*. These sensors are connected with an Arduino board which is responsible for gather this data and send them to the server.

*Electrocardiography (ECG or EKG)* is the process of recording the electrical activity of the heart over a period of time using electrodes placed over the skin. We can add electrodes on the skin of the tester to monitor the changes provoked by the hear beat. As the output is line with a pattern, we can check the variance and spikes and, therefore, correlate with the level/area in the game.

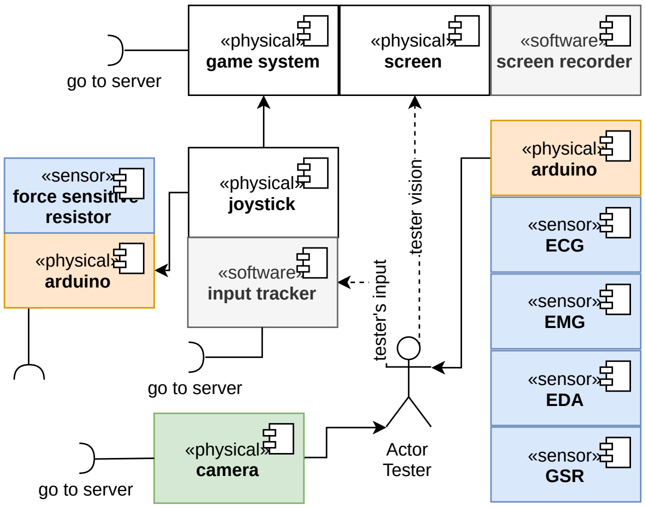


**Figure 2: Proposed architecture in UML2 component diagram.**

The principle of *Electrodermal Activity (EDA)* is that skin resistance varies with the state of sweat glands in the skin, which sweating is controlled by the sympathetic nervous system. In this way, skin conductance can be a measure of emotional and sympathetic responses [2]. EDA is associated with emotion and cognitive processing, moreover, some emotional responses, like threat, anticipation, salience, and novelty, may occur unconsciously [7]. Additionally, EDA peak (height and rate) describe the stress level of a person [18].

*Electromyography (EMG)* is a technique that record electrical activity produced by skeletal muscles [15]. The output of this measure is the electromyogram. It detects potential difference that actives the muscle cells, which can be used to detect abnormalities in the movement. The less invasive method to measure EMG is using electrodes to control the overall activation of the muscle [1].

*Galvanic Skin Response (GSR)* is the property of the human body that causes continuous variation in the electrical characteristics of the skin. GSR measure the electrical condictance of the skin, which varies according to sweat glands, which in turn is controled by the sympathetic nervous system, finally indicating psychological or physiological arousal [1]

*Force Sensitive Resistor (FSR)* is a sensor that detects physical pressure, squeezing and weight. We can attach this sensor on the joystick and measure with which intensity the tester are holding it. It can show how he behave facing certain scenarios of the game. With a proper baseline, we can even infer the player boredom and excitement.

The idea of the *Joystick Input Tracker* is to get all the commands (input) performed by the tester and map it to a virtual representation of the same and display it on the screen. It can help keep track of some detected bug of failure captured during the gameplay session and reproduce it during the development. The purpose of the *camera* is simple: record the tester and to observe his reactions. The body expressions might reveal interesting things about the tester emotions. Moreover, we can apply some image pattern recognition.

Finally, the *screen recorder* is the main link between all the sensors and data. Without the gameplay video the game designers cannot correlate the gathered information and the part of the game. The final output is a *dashboard* containing all the information synchronized with the gameplay footage.

## 5 DISCUSSION AND THREATS

Our approach aims to use the concepts of finding fun and engagement to aid game designers to assess their game features, on the development phase, during the gameplay sessions, by making use of biometrics. It focuses on low-cost sensors and an extensible platform.

The idea also can be applied for the validation of a game concept, during the pre-production, where the developers test new ideas with prototypes. In this case, a more robust measurement can prevent many months of rework or even years of development.

Although the related problem is to help video game designers in their task, the underlying issues on how to build and synchronize the IoT architecture is real. The related works that used biometrics to asses the gameplay focused on black-box solutions, which prevent any change or adding new sensors that the developers might want to use.

With the amount of information gathered from the sensors, we can apply, for example, a cluster technique on some of the attributes (pattern recognition) and transform them into metrics. For example, a determined type of spikes in the ECG graph can imply a specific emotion or difficulty in the game. A bug, for instance, can induce a typical reaction of the tester, and with this, we can generate a report with all possible bugs to investigate.

Aside from testing new features, this kind of enhanced feedback can bring new light to the game design. By observing the tester reaction and data, we can make correlations with parts of the gameplay that it enjoyed more. With that, developers can extract the core mechanic and apply to other games. It can become a library of core mechanics, rated by “fun level”, that can be useful in new projects.

The output of this project can be interesting for researches in the design field as well. There are many attempts to measure the engagement in video games, and a framework that is customizable should help them to propose and test new hypotheses.

As threats, we need to mention that the setup of the board with the sensor may disturb the tester during the session. Finally, the synchronization of all the sensors data is very sensible, the delay of seconds can lead to a wrong interpretation of the results.

## 6 PRELIMINARY CONCLUSIONS

In this paper, we present an conceptual IoT architecture to assess video game testing. It is composed of a set of sensors and applications forming a low-cost framework which can be afforded by independent studios and developers. The goal of this approach is to provide a contextual output of the gameplay session, that is, besides the gameplay video, information regarding the biometrics of the tester or user as well as technical details of the game. With such solution, game developers (especially game designers) can use and customize their game projects, by gathering a more rich set of data from the gameplay test sessions, and, therefore, improve the quality of their games.

The outcome this tool can provide is broad regarding what can be done with the gathered data. By reasoning on the extracted information, we can create a model to evaluate, with a set of metrics, the gameplay session attributes, like engagement and fun. Then, our approach can improve the time to assess the gameplay session and its efficiency.

## ACKNOWLEDGMENT

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