Using Smartwatches as an Interactive Movie Controller: A Case Study with the Bandersnatch Movie

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***Abstract*—This work proposes the development of a method that allows the use of smartwatch as a control for interactive films using continuous recognition of gestures and conducts a case study with the film ”Black Mirror: Bandersnatch”. We developed two prototypes to interact with interactive movies. The first one uses gesture recognition on the smartwatch screen. Thus, we created a set of gestures composed of straight lines that represent the actions in the interactive movie. In this prototype, the recognition of gestures is performed by the algorithm of continuous recognition of gestures, in this way, a gesture can be recognized before the user finalize, and action is sent quickly to the movie. The second prototype uses a touch of pressure in the smartwatch to control the film. Thus, the actions to be performed in the smartwatch that represents the actions in the interactive film is proposed, the recognition of the gestures is determined by the change of the values obtained by the accelerometer. The prototypes communicate with a simulation service responsible for running the movie. The prototypes were used in a study with users, as well as in usability and experience tests, and the results show that the method has the potential to be used in everyday users to control interactive films efficiently and effectively.**

***Index Terms*—Smartwatch, interactive movie, continuous gesture recognition, controller, accelerometer.**

I. Introducion

An interactive film allows the user to interact at different times and choose the story and even the end of the film, this can provide different experiences according to the choice and preferences of each user, so the story of the film is not linear [9]. Recently Netflix has released its first interactive adult film “Black Mirror: Bandersnat”, the story shows a programmer trying to create an interactive game.

This movie can be run on devices such as Smart TVs and PCs, for example and controlled by their respective input devices: remote control, keyboard and mouse.

Considering that the smartwatch is a wearable device that gets stuck to the user’s pulse, it can be used to facilitate people’s daily lives [7, 8]. In this way, it becomes interesting to use it to control the movie “Black Mirror: Bandersnat”, because the user can control the course of the movie without using a keyboard or control, using only a device in the format of a clock.

Therefore, the objective of this work is to control the interactive films through gestures using smartwatch as a control mechanism. To do this, you will need to: define a set of gestures and their respective actions in the movie, establish communication between the smartwatch and the device that runs the movie, and finally perform the actions performed on the smartwatch in the movie.

We present in this work the results of interaction research with interactive films using smartwatches with continuous gesture recognition, conducting a case study with the film ”Black Mirror: Bandersnatch”. Fig. 1 presents a sample of a screen of choice in which the user can select one of two options presented.

Fig. 1. Viewer Choice Screen. (Adapted Sample from Bandersnatch movie)

The next sections present relevant content for the understanding of the research developed, the next section exposes the related works, in sequence we will show the prototypes

978-1-7281-2607-4/19/$31.00 ©2019 IEEE
DOI 10.1109/COMPSAC.2019.10217

for smartwatches and their functionalities, soon after will be approached the results and, finally, the final considerations.

II. Related Work

The work developed by Zhu et al. [15] presents a deep neural network based on bidirectional LSTM that can recognize the gestures movements of wrist and fingers of the users, the results show that the system has potential to use smartwatch as remote control. The work of Gkournelos et al. [3] proposed a method that allows controlling robots using smartwatch as a control mechanism. Siddhpuria et al. [11] has developed a prototype that allows the user to control the smartwatch by turning a ring on the index finger. Alanwar et al. [2] have created a device for selection and control of IoT devices. The interaction is performed only by pointing to the device and performing gestures. Smartwatches need to be equipped with inertial and ultra-wideband (UWB) sensors. The accuracy of choice for the device was 84% and gesture recognition was 97%.

In the research developed by Speier et al. [12] a prototype was developed to control a music player using a wristband attached to the user's wrist and the results of this work show that users prefer gestures that slide to touch gestures. Already Luna et al. [6], developed a method that allows the control of Smart TVs using gestures made by the pulse of a person using smartwatch. With the focus on device development, the work proposed by Volkinburg and Washington [13] has developed a wearable controller based on gesture recognition. Ike et al. [4] proposed a gesture interaction technique that shows the user the appropriate gestures to perform the actions available in the TV content navigation interface with natural and intuitive gestures.

In the work of Yeo et al.[14] a method was developed that allows interaction with smartwatches with continuous pressure taps and turns without the need to modify the smartwatches and conducted experiments with good results in seven different applications.

Research of Ahn et al.[1] presented a technique of multi-touch interaction sensitive to pressure in a bracelet, by using the bracelet for interaction the technique allows interaction without occlusion of the screen. Oakley and Lee [10] have developed a hardware prototype that allows multi-touch interaction using the edges of the sensor, thus leaving the screen free.

In our previous work we present a method that allows to control platform games using smartwatch and continuous recognition of gestures, the results of this work show that the users have adapted well to the method and that the algorithm of the continuous recognition of gestures is efficient in smartwatches [8].

As can be seen in this section, research is developed to develop new methods of interaction with smartwatches, as well as gesture-based searches and research using new methods of interaction with smartwatches.

However, none of these studies addressed the use of continuous gesture recognition in smartwatches as a mechanism for interacting with interactive films. Therefore, This work is based on the method from our previous work [8] to create a control for interactive movies using continuous gesture recognition smartwatches.

In this work we will also discuss the development of a prototype that allows the user to control interactive films with pressure touch, so the user presses the smartwatch to select or choose an option.

III. Prototypes for Smartwatch

A. Continuous Gesture Recogntion

We use the algorithm of continuous recognition of gestures proposed by Kristensson and Denby [5]. This algorithm is able to predict partial gestures, that is, one can recognize a gesture before it is finalized, in this way, it is possible to perform the action quickly.

For this, it uses a technique that considers a gesture as a model and divides it into several segments. In this way, each model is represented by a set of segments that increasingly describes the partial parts of the model [5]. Fig. 2, illustrates this technique.

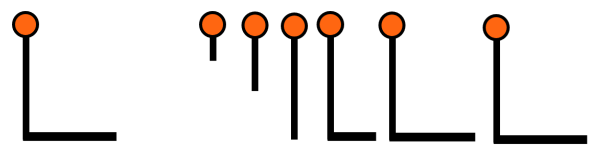

Fig. 2. Full model to the left and segments of the gesture to the right. (Adapted from [5])

A model can be considered to be a vector of ordered points in relation to time, that is, a vector of ordered points relative to the way the movement is to be produced, a gesture is segmented in several parts and in increasing movements. A model represented by w is a pair (l, S), where l is the model description and S is a set of segments that describes the complete model. Equation1, describes a complete model ordered in relation to time T [5].

$$S = [s_1, s_2, ..., s_n]^T \tag{1}$$

As the gesture is executed, the system calculates the probability of being a gesture of the set. The algorithm works with gestures that are executed more frequently, that is, it seeks to find patterns, because, normally, there are gestures that are more repeated than others.

Let $\Omega = \omega_k$ the set of models and the input vector I with i points $[i_1, i_2, ..., i_i]$.

For each new point in the index i, the posterior probability is calculated for each set $\omega_j \in \Omega$ using the Bayes rule, as shown in Equation 2:

$$P(\omega_j|I_i) = \frac{P(\omega_j)P(I_i|\omega_j)}{\sum_k P(\omega_k)P(I_i|\omega_k)} \tag{2}$$

Where $P(\omega_j)$ is the prior probability, and $P(I_i|\omega_j)$ is the probability and the denominator is the exclusion term.

B. Prototype for Interaction with Screen Gestures

We created a set of gestures that allows the user to interact with the Bandersnatch interactive movie, when performing one of these gestures the action that it represents is performed in the movie. The actions are: select option and choose option, Fig. 3 exposes the gestures and their respective actions in the interactive film.

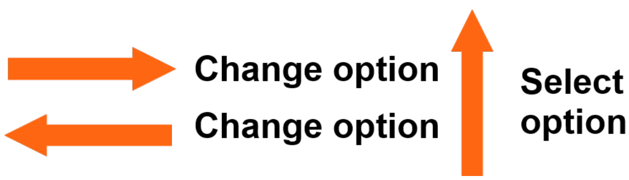

Fig. 3. Set of gestures and their respective actions in the interactive film Bandersnatch.

The linear gestures of the set were generated from the reduced equation of the line, represented in the equation below. Where x and y are the points belonging to the line, m the angular coefficient and c the linear coefficient.

$$y = mx + c \qquad (3)$$

We have developed a prototype that interacts with the Bandersnatch interactive movie. Using this prototype, the user can change and select options of interaction of the film by performing one of the gestures shown in Fig. 3 on the prototype screen. Prototype was developed for the Android Wear system, Fig. 4 illustrates a user's actions by selecting and choosing options in a smartwatch.

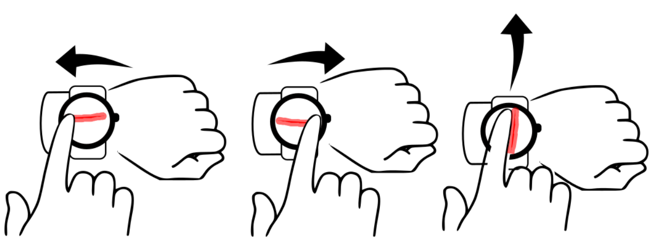

Fig. 4. Illustration of a user performing the actions of selecting the option from the left, selecting the option from the right and choosing the option selected in the prototype of gesture interaction on the screen.

Considering that when using the algorithm of continuous recognition of gestures, the recognition is continuous, a gesture can be recognized before being finalized by the user. In this way, the prototype was designed to send the action to the film when the user makes a gesture with at least 2 cm and with the minimum recognition accuracy of 70%.

C. Prototype for Pressure Touch Interaction

We also developed a prototype that allows the user to interact with the Bandersnatch interactive movie by applying a touch of pressure to the smartwatch. In this way, pressing the smartwatch left or right will activate the command left and right respectively, and pressing the smartwatch up will select the selected option.

Fig. 5 illustrates the actions described above being carried out in a smartwatch by the user.

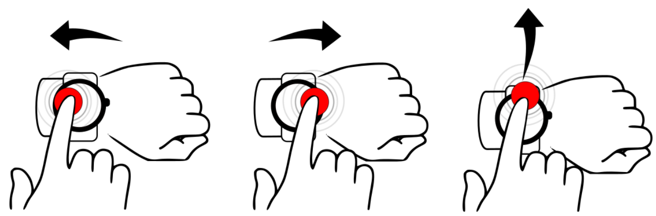

Fig. 5. Illustration of a user performing the actions of selecting the option from the left, selecting the option from the right and choosing the option selected in the prototype of interaction by pressure touch.

Using the accelerometer it is possible to identify the change in the position of the smartwatch, because it is possible to obtain the values of its location with the axes x, y e z. In this way, it is possible to identify the slope of the smartwatch when the user puts pressure on it.

However, the values obtained from the accelerometer and the gyroscope are constantly changing, so it was necessary to establish a threshold to determine if the change in values really represents a user action.

Therefore, it is constantly checked whether the change in values is small or if the pre-set threshold has been exceeded. In our tests we identified that the threshold changes according to the gesture, for the gesture of selecting the left option the established threshold was 1 positive point in the x axis, already for the action of selecting the right option the threshold was 1.3 negative points in the axis x, and for the action of choosing the selected option the defined threshold was 1.3 negative points in the y axis.

D. Communication between Prototype and Movie

The Bandersnatch interactive movie is played on a computer with an Intel Core i7-5500U 2.40GHz processor, 8GB of RAM and an NVIDIA GeForce 830M graphics card.

Considering the prototype interaction of gestures on the screen, when the user makes a gesture, the first step is to recognize the gesture using the algorithm of continuous gesture recognition, then identifies the action that it represents and it is executed in the movie. For the pressure touch prototype, the first step is to define which axis the user is pressing on the smartwatch, in sequence identifies the action that it represents and is executed in the movie. These steps are shown in Fig. 6.

The prototypes communicate with the simulation service using a WLAN network. Only a code represented by an integer is sent over the network, thus reducing any possible delay in communication.

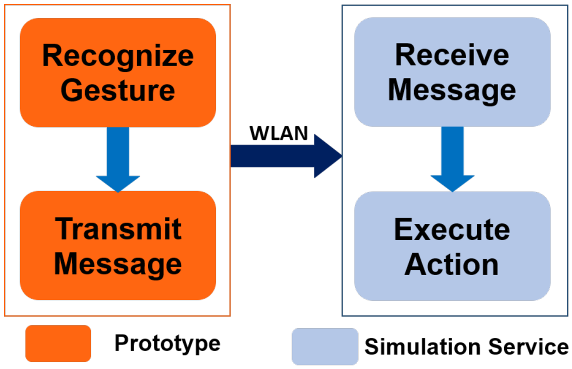

Fig. 6. Steps to perform the action in the interactive movie after a gesture is performed.

To perform the action in the interactive movie, we simulate the actions of moving the cursor and clicking the mouse on the computer.

In this way, there is an active simulation service that is responsible for receiving the messages and performing their respective actions in the interactive movie. Whenever this service receives a message, it identifies the action related to the received code and executes it. For the actions of changing between the options, the mouse cursor is positioned on top of the option, and to select an option the action performed is the mouse click.

IV. User Study

The experiment was conducted with 10 participants, aged between 26 and 54 years. Among them, 3 are from the area of computing. None of the participants have smartwatch.

About smartwatches, 1 claimed to have regular experience and the others said they had little or no experience. During the experiment all participants used the smartwatch in their left hand.

In order to validate the method, the prototypes were installed in the smartwatch *Motorola Moto 360*.

Before starting the experiment, the prototypes and their functionalities were exposed to the participants. The set of gestures shown in Fig. 3 was exposed to the participants and they were able to observe it during the whole experiment. We also explained and demonstrated to the participants the actions in the pressure touch prototype, as shown in Fig. 5.

Participants were able to choose which hand to use the smartwatch. For the on-screen gesture interaction prototype, participants used smartwatch in the position they felt most comfortable.

As for the pressure-touch prototype, so that it was not necessary to set a trigger for prototype activation or perform calibration, users used the smartwatch with their hands resting on a table.

A. Usability and Experience Test

We applied a questionnaire to the participants of the experiment to evaluate the usability and experience, as well as the experience and the effectiveness of the method and the prototypes developed. The questions were answered by the participants using the Likert scale. The affirmations applied to the participants were:

1) The proposed method is intuitive.
2) The gestures proposed for using the method are intuitive.
3) The proposed method is easy to use, ie it was easy to control the film in the first few minutes using the prototype.
4) You felt familiar with the prototype in the first few minutes of use.
5) The actions performed on the prototype are sent correctly to the movie.
6) The actions performed on the prototype are executed quickly in the movie.
7) It is nice to control the film with the proposed method.
8) I would use this method to control interactive movies in my everyday life.

To verify the experience and usability with respect to the prototype of pressure touch interaction in the smartwatch, the experiment participants answered the following statements using also using the Likert scale.

1) The actions to be performed on the prototype are intuitive.
2) It was easy to use the prototype in the first few minutes of use.
3) You felt familiar with the prototype in the first few minutes of use.
4) The actions performed on the prototype are sent correctly to the movie.
5) The actions performed on the prototype are executed quickly in the movie.
6) It is nice to control the film with the proposed method.
7) I would use this method to control interactive movies in my everyday life.

The next section will discuss the results of the user study, as well as the usability and experience test.

V. Results and Discussion

A. Screen Gesture Interaction

Prototypes developed were used in an experiment with users with a usability test and experience with the purpose of validating the proposed method, as well as, the prototype. Fig. 7 shows the responses of the experiment participants to the usability and experience test statements for the on-screen gesture interaction prototype.

Looking at Fig. 7 it is possible to see that 80% of users said they fully agree that the proposed method is intuitive, 10% said they agree, and another 10% claimed to be neutral. 90% of participants stated that they fully agree that the proposed gestures are intuitive. In relation to the proposed gestures are intuitive, 90% of users said they fully agree.

The participants' responses to item 3 show that learning was easy, since all stated that they fully agreed that it was

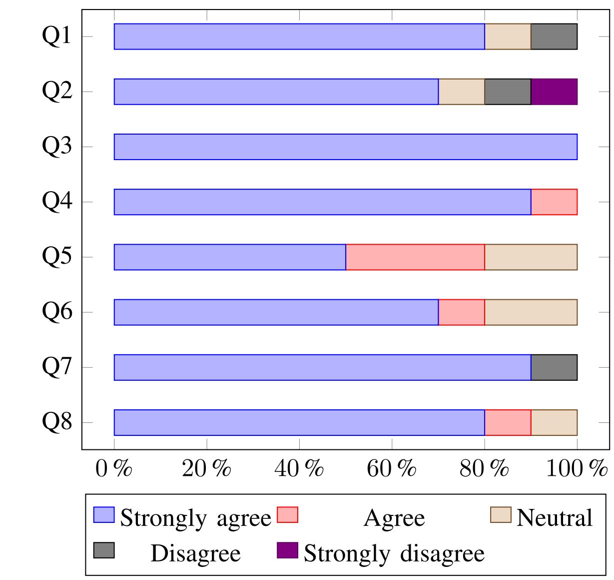

Fig. 7. Responses from the experiment participants to the usability and experience questionnaire for the on-screen gesture interaction prototype.

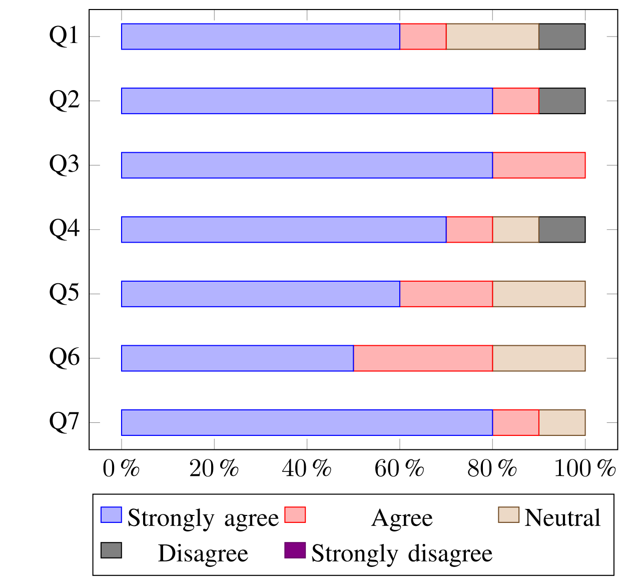

Fig. 8. Responses from the experiment to the usability and experience questionnaire of the pressure touch interaction prototype.

easy to use the method proposed in the first minutes of use. The answers to question 4, however, show that participants felt quickly familiar with the prototype because 50% stated that they fully agreed and 30% stated that they felt they were familiar with the first few minutes of use.

All participants stated that the actions performed on the prototype are performed quickly in the film, as can be seen in item 5 of Fig.7, therefore, all the participants marked the option I strongly agree or agree.

70 % of the participants stated that it would be nice to use the proposed method, since 80 % of the participants said they would use the method proposed in everyday life, as can be seen in item 8 of Fig. 7.

It can be observed according to the response of the participants that the method developed has the potential to be used in the daily life of the people, the method and the gestures proposed are intuitive. It is also observed that the response time is satisfactory and that the prototype has the potential to be pleasant when used in the daily routine.

It is also seen in Fig. 7, that most participants ticked the option I fully agree or agree to all the statements. With this, it is possible to verify that the method developed has potential to be used to control games.

B. Pressure Touch Interaction

Responses of the participants to the usability and experience test for the prototype that uses the touch of pressure in the smartwatch can be observed in Fig. 8.

It can be seen in Fig. 7, and Fig. 8 that the responses of the participants to the prototype of gesture interaction on the screen and to the pressure touch prototype are similar. However, it can also be observed that in general the prototype of gesture interaction on the screen has a better evaluation.

In item 1 of Fig. 8 it is noted that 90% of users said they fully agree or agree that the actions to be performed on the prototype to control the film are intuitive.

Checking the answers of item 2 and item 3, it is observed that the proposed method is easy to use and that users felt familiar in the first minutes of using the prototype.

Participants' responses to item 4 show that the actions are sent correctly to the film because 70% stated that they fully agree and 10% agree. In addition, 90% of users stated that they fully agree that actions are performed quickly on the film, as can be seen in item 5 of Fig. 8.

Analyzing the answers to item 6, it is possible to identify that the method developed has the potential to please the users and be used in daily life, since 90% of users marked the option agree or strongly agree to this statement. There are also indications that the method can be used in people's daily lives, since 70% of the participants stated that they agree or strongly agree with the affirmative of number 7.

VI. Final Considerations

This work proposes the development of a method to control interactive films using smartwatch with continuous gesture recognition and performs a case study with the film "Black Mirror: Bandersnatc". In this way, we present two prototypes in this work to interact with interactive films using smartwatch as a control, the first one uses gesture recognition on the screen of the smartwatch and the second uses pressure touch on the smartwatch to control the movie.

Thus, to control the Bandersnatc interactive film, the user performs the gestures shown in Fig. 3 in the prototype of gesture interaction on the screen or apply pressure on the smartwatch in the prototype for interaction using touch of pressure, as was shown in Fig. 5. In the prototype of gesture interaction on the screen, gesture recognition is performed using the algorithm of continuous gesture recognition. In the pressure-touch interaction prototype, the accelerometer data is captured and changes in values are observed according to a pre-set threshold. In both prototypes, after the recognition of the gestures, its respective action is sent by the WLAN network to the simulation platform that is responsible for simulating the actions of moving the cursor and clicking the mouse according to the gestures performed by the user.

The results of the experiment and the usability and experience test show that the method developed is pleasant to use, has easy learning and is intuitive, so the method has the potential to be used in everyday users to control interactive movies using smartwatches with recognition of gestures in an efficient and effective way.

The next step of this research will be to test the method developed in other interactive films. In sequence, a method will be developed that allows the user to control interactive movies by moving the pulse. Afterwards, it is proposed to develop a technique that sends feedback to the user through sounds or vibration when the user changes or selects an option.

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