Two-finger touch interface activation method for wearable devices

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Abstract – **Wearable device interfaces are challenging due to the devices' small factors and their rich features. Research in this paper proves that it is possible for a wearable device computer-human interface to be activated based on recognition of a two-finger touch on the device surface which is around the display (bezel, rim) while the user's fingers don't hinder the user's sight on the device display.**

Keywords – **Wearable, Smartwatch, Touch, Interface**

I. INTRODUCTION

The wearable devices and in particular smartwatches and fitness trackers are becoming more and more popular during the last few years [1]. Despite this fact the methods used for interaction between the user and the device remain the same as those used typically in the classic electronic watches - push buttons as well as in the smartphones - touch screen based interfaces. Touch based interfaces, being efficient and intuitive used in smartphones, when performed over a small surface like a smartwatch display, often face the common "fat finger" problem [2] - due to the small target icons and other interface controls the user can't aim and push them correctly due to the line of sight obstacle caused by their own finger. There is also a common issue with the confirmation of the taken action.

Trying to solve these issues and to make their devices more usable some of the leading vendors in the smartwatch area have implemented in their recent models, different non-touch display and non-push button interfaces. These are ones like rotating digital crown [3], rotating bezel [4], touch sensitive rim around the display [5]. All of them are addressed to solve the above mentioned fat finger and user experience problems but the common disadvantage is that an interface pre-usage action is required (push a button in all examples above) in order for these interfaces to be activated. Due to the high power consumption and limited battery size/capacity wearable devices typically work in idle or power save mode and an intended action should be performed such as pushing a button or specific device movement (acceleration) in order for the device interface (access to the device menu) to be activated. That is why we consider that the methods of alternative interfacing with wearable devices and specifically those which allow instant interface activation have to be further researched.

II. RELATED WORK

The touch based interaction with wearable devices has been researched by many authors. Some of them have made research in areas of evaluating touch or pressure technologies on the device components other than on the display such as the devices' sides [6], band/strap [7], back [8] or changing the devices' position according to the band [9]. Others have explored the area and surfaces around the device like touches on user's skin close to the wearable device [10] or using touch sensitive fabrics close to the device [11]. There is also research about replacing standard touch interfaces with those based on taps [12] and [13].

The most closely related research [14] evaluates the interaction at the edge/outer side of round wearable devices. The major differences between the mentioned research and ours are: the sensors' position place - while on the mentioned model they are on the edge, in our model they are on the bezel which is a much more accessible part of smartwatch devices which are worn on the wrist; the experimental model size - our one is about 30% smaller (42 mm in diameter against 60 mm) and the same as most of the current smartwatches; two-finger multi-touch positions had never been researched nor evaluated during the above mentioned research.

In order for a better approach to be found for wearable device interface activation, this paper presents two Experiments where

Fig. 1. a). 3D Model for Experiment 1; Fig. 1. b). Compare the 3D Model and other smartwatches; Fig. 1. c). Experiment 1 process

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the users interactions with wearable device models are researched and analyzed.

III. EXPERIMENT 1

The goal of the Experiment 1 is to prove that two finger touches in two separate and distinguished areas on the device bezel is possible to be registered in order for the device interface to be activated and further interface actions to be performed. In order the goal of the Experiment 1 to be achieved it is need to be proven that, during the two finger touch over the devise bezel, there are enough bigger non-touched spaces (the second and the forth in the sequence "Thumb finger (touched)", "Thumb finger to Other finger (non-touched)", "Other Finger (touched)", "Other Finger to Thumb finger (non-touched)") remained between the two touches. As enough bigger space will be counted a space with 2 or more non-touched hour marks.

Equipment:

In order for the touch areas on the bezel to be observed, a dedicated 3D model was designed and printed (Fig. 1. a).). The aim was the 3D model to be as close as possible to a real watch/smartwatch (Fig 1. b).). The dimensions of the 3D model are - diameter: 44 mm, height: 15 mm, bezel angle: 45^0, bezel width: 4 mm; color: white; material: PLA. As the aim of the model is bezel touch activities to be recorded no other standard watch/smartwatch interfaces like buttons or crown were added to the model. For more precise observation and the fingers touch areas recording 12 engraved lines were made - one per each 12-houred analogue watch hour mark. The model had lugs for standard 18 mm watch strap to be used.

Group:

The test group for the Experiment 1 consisted of 12 people (male 10, female 2), aged 25-47 (Average 36.5), all right handed, without disabilities, all volunteers.

The process:

The following instructions were given to each participant: To wear the model like an ordinary watch on his left hand and to stand in a relaxed position. After that to raise his/her left hand in a position to see the model's virtual display. He/she was instructed that the only way to interact with the device is to touch the bezel with two fingers. Finally he/she was asked to put his/her leading hand (the right one) thumb and one of the other fingers over the bezel in a way to be able to also see the model's virtual display (Fig. 1. c).). The touched by user fingers engraved hour mark lines were manually recorded in MS Excel spreadsheet. Each participant made three consequential attempts and the data from all three attempts was recorded (there was no try attempt). After each attempt the participant was instructed to go back to a relaxed standing position.

Results:

During the experiment process, after half of the attempts were made (6 from 12), it was decided that the visual measurement process is not precise enough and the data wouldn't be reliable for the purposes of the experiment. Due to this decision the experiment was cancelled and it was decided to proceed directly to Experiment 2.

IV. EXPERIMENT 2

The goal of the Experiment 2 is the same like as Experiment 1 but using a much more precise way of measurement - recording touch areas via electronic touch sensors mounted into the device. For the purposes of the goal of the Experiment 2 as enough bigger non-touched space will be counted a space with 2 or more non-touched sensors (i.e. two areas with 2 or more non-touched sensors from 12 sensors in total).

Equipment:

For the Experiment 2 a new 3D model was designed and printed (Fig 2. a).) - the same as the one used in Experiment 1 with the following differences - engraved hour mark lines were removed and the model was hollow with an open back in order to access the sensors and their wirings provided. On the bezel of the model 12 capacitive sensors (3x10 mm conductive metal metric screws with 6 mm in diameter heads) were mounted (Fig 2. b). The distance between each two sensors was also 6 mm. The experimental model was driven by an Arduino Mega 2560 computer with a 12 capacitive ports MPR121 extension board connected to it. The 12 capacitive sensors were connected to the MPR121 extension board sensors' ports. To each sensor was assigned an ID from 1 to 12 corresponding to the 12-hour standard watch hour mark place of each sensor. Specially developed for the research purposes software in the Arduino language was used for the experiment. The software detected the starts (touching contact) and the ends (releasing) of the touches made by the participant's fingers independently for

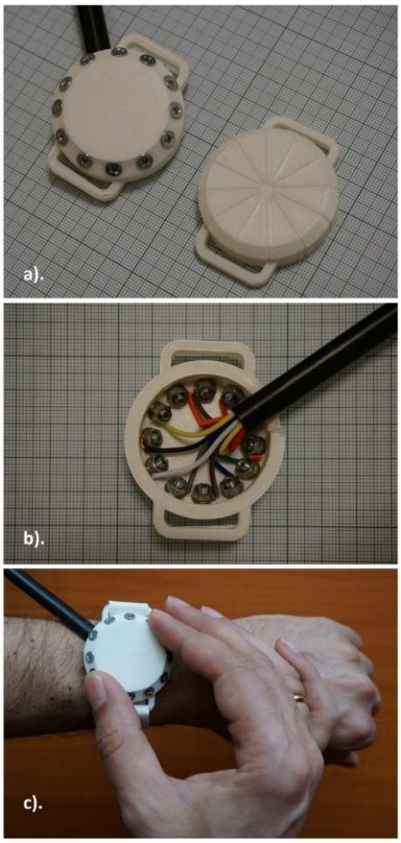

Fig. 2. a). 3D Model for Experiment 2 (left) compared to the 3D Model for the Experiment 1; Fig. 2. b). Experiment 2 3D Model sensors wiring; Fig. 2. c). Experiment 2 process

each sensor. The Arduino Mega 2560 computer was connected to a notebook via USB interface and sent the data to the Arduino IDE Serial Monitor. The raw data was then transferred to MS Excel for further processing.

Group:

The test group consisted of 20 people (male 16, female 4), aged 25-49 (average 36), all right handed, without disabilities, with clear and dry hands, without any other worn watches or hand jewelries, all volunteers.

The process:

Each participant was given the same instructions as during the Experiment 1 process. The experiment was held in office conditions. The IDs of the touched sensors were recorded in order the two finger positions to be precisely determined. Each participant made three consequential attempts and the data from all three attempts was recorded (Fig. 2. c).).

Results:

All 60 measurements which were made using the specially designed and printed 3D model for the Experiment 2, were successful and the raw data is presented in Table I.

TABLE I
EXPERIMENT 2 RAW DATA

Att. No.	Sensor ID (X - touched; Blank - non-touched											
	1	2	3	4	5	6	7	8	9	10	11	12
1	X	X					X					
2	X	X					X					
3	X	X					X					
4	X	X	X				X	X	X			
5	X	X					X	X				
6	X	X					X	X	X			
7	X	X					X	X				
8	X	X					X	X				
9	X	X					X	X				
10	X						X					
11							X	X				X
12	X						X	X				
13				X	X						X	
14					X						X	X
15				X	X					X	X	
16		X					X					
17	X	X					X					
18	X	X					X	X				X
19	X	X				X	X	X				
20	X	X				X	X					
21	X	X					X					
22	X	X					X	X				
23		X	X				X	X				
24		X	X				X	X				
25		X					X	X				
26	X	X					X					
27	X	X	X				X	X	X			
28	X	X				X	X	X				
29	X	X				X	X	X				
30	X	X				X	X	X				
31	X	X				X	X					
32	X	X				X	X	X				
33	X	X				X	X	X				
34	X	X	X				X	X				
35		X	X				X	X				
36	X	X					X	X				
37	X					X						X
38						X						X
39	X					X	X					X
40	X					X						X
41	X	X				X	X					
42						X						X
43	X					X	X					
44					X	X						X
45	X					X	X					
46	X	X					X	X				
47	X	X	X				X	X				
48	X	X					X	X				
49	X	X					X	X				
50	X	X					X	X				
51	X						X					X
52		X					X					
53	X					X	X					X
54		X	X				X	X				
55	X	X					X	X				
56	X	X					X	X				
57	X	X					X	X				
58	X	X					X	X				
59	X	X				X	X					
60	X	X				X	X					

The summarized data is presented in Table II where are shown the Average number of touched/non-touched sensors, Minimum and maximum number of touched and non-touched sensors, and Median of touched/non-touched sensors, per each of the two touched (by thumb and other finger) and the two non-touched (between the fingers touches) areas. The direction determining non-touched areas in columns 2 and 4 is clockwise.

TABLE II
EXPERIMENT 2 SUMMARIZED DATA

Sensors numbers	Thumb finger (touched)	Thumb finger to Other finger (non-touched)	Other Finger (touched)	Other Finger to Thumb finger (non-touched)
	1	2	3	4
Average number	1.90	4.42	1.88	3.77
Minimum number	1	3	1	3
Maximum number	3	6	3	5
Median value	2	4	2	4

In all of the 60 measurements the participants activated two touch areas (averages 1.90 for thumb activated sensors and 1.88 for the other finger activated sensors and medians of 2). No case with less than 3 non-touched sensors between both touch areas was recorded (Table II, Row "Minimum number", columns 2 and 4 values). The symmetrical results for both touched areas and both non-touched areas says that very probably the similar results would be obtained if a research for people with left leading hand is performed.

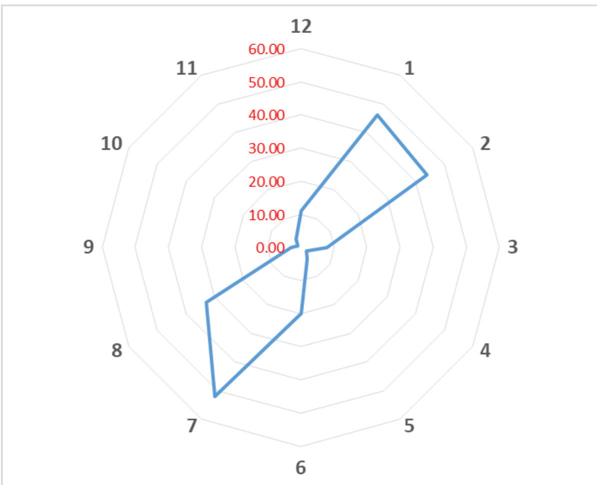

Fig. 3. Radar chart of the number of touches per sensor in all 60 measurements

The radar chart showing the numbers of touches per each touch sensitive sensor of the 3D wearable device/smartwatch model used in Experiment 2 during all 60 measurements is shown on Fig. 3.

V. Future work

As the goal of this paper is only to prove if a device interface could be activated intentionally by the user, following the results published in the paper, a research evaluating which kind of computer-human interfaces could be activated, executed and how they could be implemented in the process of wearable device input would be made in the best way and further results would be published.

The experiment model could also be improved in hardware aspect - capacitive board to be embedded into the device in order for wider range of experiments to be done. Measurement and recording Arduino software could be additionally developed for two-finger touch commands recognition.

A further investigation could be performed to evaluate if it is possible for the user pose (standing, sitting, laying) to be determined based on the activation of the different multi-touch areas over the bezel of smartwatch when the user is in a different pose.

The two-finger touch interface activation could be evaluated also for other wearable devices as well as for touch interaction on other touch sensitive surfaces.

VI. Conclusion

During the research described in this paper two experiments were made. The goal of the experiments was to be proven that it is possible to determine an intended two-finger touch on touch sensitive surface around the device display - the wearable device (smartwatch) bezel.

In order for the research goal to be achieved the users' interaction process with models of wearable devices was studied. For these purposes two special 3D models of smartwatches were designed and printed - a mechanical model for the Experiment 1 and electronic model with touch sensitive bezel for the Experiment 2.

For the Experiment 2 a dedicated experimental set of Arduino Mega 2560 computer and MPR121 capacitive sensors board was built and specialized Arduino software was developed.

The Experiment 2 results clearly prove that two-finger touch on the bezel of rounded wearable device with standard watch size could be unambiguously determine in 100% of the users' attempts. It is possible based on two-finger touch (two point multi-touch) over the wearable device (smartwatch) touch sensitive bezel the human-computer device interface to be activated (the device to be waked up from its' idle mode) and order action or set of actions to be performed such as menu navigation, menu items selection, confirmation, cancellation, information input etc. In a respective way it is possible for the interface to be deactivated (the device to go back to idle mode) based on the recognition of the full release of the touched areas or a release of a specific area.

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