International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:9, No:6, 2015

Design Guidelines for an Enhanced Interaction Experience in the Domain of Smartphone-Based Applications for Sport and Fitness

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Abstract—Nowadays, several research studies point up that an active lifestyle is essential for physical and mental health benefits. Mobile phones have greatly influenced people's habits and attitudes also in the way they exercise. Our research work is mainly focused on investigating how to exploit mobile technologies to favour people's exertion experience. To this end, we developed an exertion framework users can exploit through a real world mobile application, called *EverywhereSport Run* (EWRun), designed to act as a virtual personal trainer to support runners during their trainings. In this work, inspired by both previous findings in the field of interaction design for people with visual impairments, feedback gathered from real users of our framework, and positive results obtained from two experimentations, we present some new interaction facilities we designed to enhance the interaction experience during a training. The positive obtained results helped us to derive some interaction design recommendations we believe will be a valid support for designers of future mobile systems conceived to be used in circumstances where there are limited possibilities of interaction.

Keywords—Human Computer Interaction, Interaction Design Guidelines, Persuasive Mobile Technologies for Sport and Health.

I. INTRODUCTION

PHYSICAL inactivity is a well-recognized risk factor for many health problems. Several research studies put in evidence that an inactive lifestyle together with other unhealthy habits can be the cause of heart diseases, type two diabetes, high blood pressure, and many other illnesses [8] [9].

Despite the many benefits of regular exercise, the adherence to long-term exercise routines is extremely rare among people. Fletcher et al. [10] report that only the 50% of people that start an exercise routine will continue to keep the habit for more than six months. This statistic is very significant given that the benefits of exercising regularly occur only after long periods of time. This is the reason why scientists from various disciplines are working together to develop strategies and systems to persuade people both to start and to encourage long-term adherence to exercise routines.

There exist many technological systems, coming both from academia and industry, designed to stimulate people to conduct a more active lifestyle. Indoor systems exploit personal computers to enrich the exercise experience with digital content (see, for example, [2]). Famous game consoles such as Microsoft XBox, Nintendo Wii, and Sony PlayStation have been equipped with ad hoc controllers to play fitness games. The idea is to transform the traditional gaming experience from passive to active letting the users move for real during the game.

The most trending mobile applications exploit the ubiquitous nature of smartphones and their ability to exploit the principle of Kairos [20] to provide systems able to guide users in real time during their exercises (see, for example, [3] [4] [5]). There are also web platforms strictly interconnected with mobile applications and social networks designed to offer users a comprehensive ecosystem to manage the organization and sharing of physical activities (see [21]).

Our research work is mainly investigating how to enhance both the interaction functionalities and the user experience of mobile applications in order to help people stay adherent to exercise routines. To this end, our team developed a real world mobile application that aims at guiding users step by step during their running routines by fostering social interactions between users and real trainers. The application is specifically designed to help beginner runners to get training plans directly from qualified real coaches in order for them to properly program the virtual trainer with a training routine specifically designed for their needs.

Past studies and evaluations of the application, experiences and insights from real users along with results from research studies on how to help people with visual impairments, gave us a starting point to study and to develop an innovative and more effective interaction model to favor a better user experience during a workout.

In such a context the interaction between humans and devices is a key factor to favour exertion. This kind of limited interaction can be somehow compared to the interaction that people with visual impairments is forced to have while interacting with some sort of technological device. Indeed, runners must have an immediate and as flexible as possible interaction with their devices during a training. This led us to introduce a set of new features to improve the interaction capabilities of our system and consequently the exertion experience.

Given our particular usage scenario, we opted to extend the common interaction pattern made up of uncomfortable visual and audio cues (available only at a predefined time or distance intervals). This has been achieved by introducing the possibility to trigger the vocal synthesis system to reproduce predefined training statistics on demand, by means of multiple common 2D touch gestures as well as the possibility to follow

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virtual trainer's cues by exploiting haptic impulses.

The main contribution of this work, in addition to the introduction of the aforementioned features, is the proposal of a core set of design guidelines to facilitate the real time interaction between users and mobile applications in constrained scenarios.

The rest of this paper is organized as follows: Section II surveys the state of the art in the field of human to artifact interaction. Section III briefly describes the application whereas, Section IV contains the results of the experimentations, and Section V reports our interaction design guidelines proposals. Section VI concludes the paper.

II. Related Work

This section reports some studies and technological gesture-based systems designed to improve the interaction with mobile devices in different usage contexts.

Guerreiro et al. [11] developed NavTouch a gesture-based text-entry method designed to aid vision-impaired users with mobile devices equipped with touch screens. Using NavTouch, people navigate the alphabet by performing directional gestures on the screen. To complement navigation, special actions (such as "ok" and "erase") are available on screen corners.

Kane et al. [17] developed Slide Rule, a set of accessible multi-touch audio-based interaction techniques for touch screen interfaces that enable blind users to access touch screen applications. Slide Rule provides a completely non-visual interface that repurposes a touch screen as a "talking" touch-sensitive surface. Slide Rule uses a set of four basic gesture interactions: 1) a one-finger scan to browse lists, 2) a second-finger tap to select items, 3) a multi-directional flick gesture to perform additional actions, and 4) an *L*-select gesture to browse hierarchical information. Slide Rule requires a standard multi-touch screen and audio output, but no additional hardware.

Negulescu et al. [12] analyse the relative cognitive cost of motion, tap, and surface gestures as input for smartphone devices under conditions of light distraction. They show that, for both walking and eyes-free input, the cognitive cost of motion gestures (measured as a function of reaction time) is statistically indistinguishable from the cognitive costs of tap and surface gestures. As a result, motion gestures represent a viable input alternative for situations where eyes-free input may be required.

Li in [13] presents Gesture-Search a tool that allows a user to quickly access various data items on a mobile phone by drawing gestures on its touch screen. Indeed, modern mobile phones can store a large amount of data, such as contacts, applications, and music. However, it is difficult to access specific data items via existing mobile user interfaces.

Zhai e Kristensonn in [14] present the results of a research in the field of word-gesture keyboard. On a word-gesture keyboard, instead of tapping individual keys or wiping through a sequence of letters connected on the keyboard, the user can write each and every word in a lexicon via a word gesture. A word gesture approximately traces all letters in the intended word, regardless if they are adjacent. In comparison to tapping-based touchscreen keyboards, gesture keyboards do not require up and down movements for each letter improving efficiency.

Ruiz et al. in [18] describe the results of a guessability study for motion gestures which elicits natural gestures from end-users as follows: given a task to perform through the device (e.g., answer the phone, navigate in a map and so on), participants were asked to specify a motion gesture that would execute that task.

Ashbrook and Starner in [19] presented MAGIC, an interactive system for exploring and designing motion gestures. MAGIC encourages iteration in design, provides facilities for retrospection of input, and allows the designer to test the created gestures against a corpus of activities to ensure that the gestures will not be unintentionally activated by a user.

Kane et al. [15] conducted two user studies that compared how blind people and sighted people use touch screen gestures. They found that blind people have different gesture preferences than sighted people, including preferences for edge-based gestures and gestures that involve tapping virtual keys on a keyboard. In addition, they also found significant differences in the speed, size, and shape of gestures performed by blind people versus those performed by sighted people.

Ruiz and Li [16] present DoubleFlip, a motion gesture designed as an input delimiter for mobile motion-based interaction. The DoubleFlip gesture is distinct from common motion gestures available on a mobile device. Based on a collection of 2,100 hours of motion data captured from 99 users, they found that DoubleFlip recognizer is extremely resistant to false positive conditions, while still achieving a high recognition rate. Since DoubleFlip can be easily performed and unlikely to be accidentally invoked, it provides an always-active input event for mobile interaction.

The most famous commercial applications designed to support people during their running activities such as Runtastic, Endomondo, Strava, and Runkeeper just to name a few (see [22]–[25]), similarly to the previous versions of EWRun, provide a limited and not flexible interaction experience during a workout because of the problems listed in the previous section. To the best of our knowledge, only Nike+ [4] offers on demand audio cues to report aggregate statistics of the current activity activated through a 2D gesture. Differently from Nike+, our application is able to provide multiple statistics by means of different 2D gestures in addition to exploit haptic impulses to provide concise information to users.

III. Mobile Application Overview

The mobile application has been previously described in [5]. To sum up, the application is able to provide real time guidance to runners during a workout. It has been conceived both to let experienced sportsmen design their own workouts plans and let beginner users receive a plan seamlessly inside the application directly from a qualified trainer. In Fig. 1, the workout creation screen is shown. In particular, it is depicted a simple workout

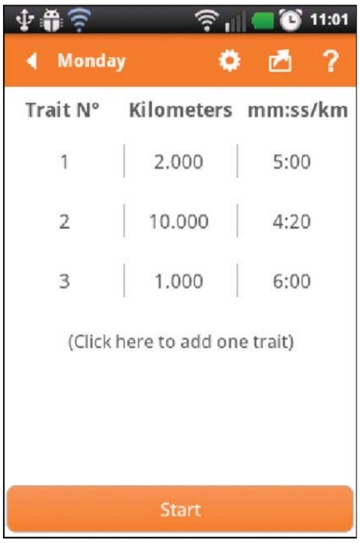

Fig. 1: Workout creation menu.

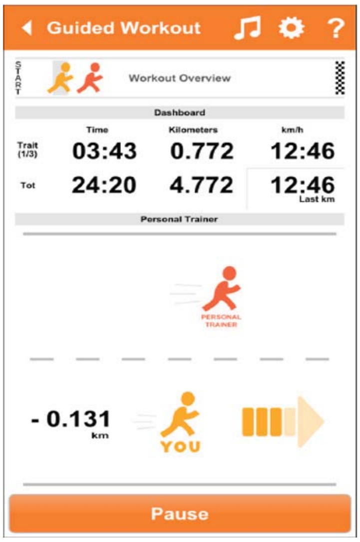

Fig. 2: Personal trainer screen.

called "Monday" composed of three training sessions called "traits". Each trait is characterized by a distance interval and by the speed (or pace) the user intends to run this distance. As an example, consider the trait number one: the user wants to run 2Km at a pace of 5 minutes per kilometer.

Once a workout has been defined, the user can start the training guided by the internal virtual personal trainer that is in charge to give users proper directions to successfully run all the traits at the predefined pace. Fig. 2 shows how the virtual personal trainer feature appears to the user: the virtual trainer, embodied by the orange stick man at the center of the screen, acts like a pacemaker, in this way the runner (the yellow stick man just below the trainer), has just to follow the virtual trainer to successfully complete the workout. This screen is also in charge to report current user's speeds, distances, and other statistics associated with both the current trait and the whole workout. At the bottom left is reported the distance gap between the user and the trainer, whereas the big arrow at the bottom right is a coarse indicator that changes its orientation and its coloring accordingly to the user's performance. The ongoing training depicted in Fig. 2 shows a situation where the user is behind the virtual trainer of 100 meters so the arrow is filled proportionally to signal that the user has to speed up to match the predefined pace.

Virtual trainer's cues, together with other statistics, are also available by means of the vocal synthesis system of the device. The user, by means of a settings menu, can fully customize vocal cues options in terms both of the type and the timing of information he needs during a workout.

Thanks both to the virtual personal trainer screen and the vocal synthesis system the runner was supposed to be effectively guided during the whole workout. This was not true. Indeed, the feedback related to the interaction features improvements/issues we received over the last 2 years (about 150 e-mail messages) suggested us that the interaction scheme could have been improved.

In particular, 42% of the users complained that the virtual personal trainer screen (see Fig. 2) provides too much information. It was difficult for them to read the statistics with a quick glance at the screen while running. As an example: "I'm not able to look at the screen while running. It's uncomfortable [the user wore an arm belt] and sometimes I have to pause the training to look at it". Instead, 39% of users complained that they did not have the possibility to request certain statistics at a specific moment by means of vocal cues: "It would be great if I could somehow request some of my favorite statistics when I really need them. Waiting every time for 100 meters [in general, a certain distance interval] it's annoying...". The remaining users instead, hate to wear headphones during the training only to hear virtual trainer's directions: "I find hard to run with headphones! They often fall to the ground and I miss virtual trainer's cues. It's frustrating!". These are the reasons why we decided to design and to develop new features to allow an enhanced and more flexible interaction during a training. To this end, to let the users run without the need to look at the screen or wait a predefined amount of time to listen to the vocal cues, we decided to enhance the interaction scheme of the application. The new system allows users to trigger vocal synthesis for some of their preferred statistics only when they really need it, i.e., on demand. From a technical point of view, we realized it by exploiting common 2D gestures.

The virtual trainer screen, just after the start of a training, enters in a locked mode to listen to some common gestures (see Fig. 3). As soon as the system detects a known gesture, it triggers the synthesis of the associated information. In this way, a user can request vocal cues without losing focus on the training and, even better, without the need to pause the workout only to look at the screen.

We addressed the third aforementioned problem, i.e., the reduction of the running equipment, by exploiting vibration impulses. In order to let the users exercise without the need to wear headphones only to listen to virtual trainer's cues, we map some of these cues to a combination of vibration

International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:9, No:6, 2015

Fig. 3: On demand vocal cues guide.

Fig. 4: Device vibrates to signal a wrong pace.

impulses. As an example: one impulse can be mapped to the speed up command, whereas the slow down command can be associated to two impulses or vice versa. All that is fully configurable by the user in terms both of the number and the intensity of impulses for each virtual trainer's command (see Fig. 4). The result is that now the users are free to choose to exercise using only their smartphones without any extra equipment required.

IV. Evaluation

In this section, we will report the results of the tests we conducted to evaluate the new interaction features we presented in the previous section.

A. Usability Evaluation

The first evaluation we carried out is a standard and well known usability test that will allow us to investigate the effectiveness of the new interaction features in terms of usability. The evaluation will follow a standard A/B testing methodology. In particular, we want to evaluate the perceived usability of the application equipped with the new interaction features with respect to the old version of the application.

In general, an A/B test consists of comparing two variants of the same system. Differences between the two variants can range from the different disposition of the elements of the layout, to a different set of features, to a different style of color, and so on. This study aims at identifying some elements that are responsible of increasing a certain metric of interest. The evaluation of the usability for the new and the old interaction features has been conducted through a standard System Usability Scale questionnaire [1]. SUS has the advantage of being a well known tool (it counts more than 600 citations [7]), it is technology independent and it has been used both by academics and industries to test web sites, hardware, consumer software, and much more. The questionnaire is composed of 10 questions with 5 response options with each question rated using a Likert scale ranging from 0 (“strongly disagree”) to 5 (“strongly agree”).

To perform the evaluation, we recruited 25 sportsmen who trained with both versions of the application for 15 days (they alternated 15 days with one version and the remaining days with the other version). The sample consisted of 16 males and 9 females with an age ranging from 15 to 61 (average 32.48 and standard deviation 12.32).

Almost all the users exercised regularly two or three times per week and they all have had a previous knowledge of similar applications but they never used our application before.

Given that the same sample of testers has been used to evaluate the two different versions of the application, we alternated the version of the system the testers encountered first in order to reduce the risk of carryover effects.

Before starting the evaluation we illustrated participants the main features of the application with particular focus on the features available during a workout, i.e., visual and audio cues (with no reference to the new interaction capabilities). We then sent an extra explanatory video by email to explain both how to configure and how to interact with the new features to the users that started the evaluation with the new version of the software. The same video and the new version of the application has been sent 15 days later to the testers who started the evaluation with the base version.

Table I shows the aggregated results obtained from the SUS questionare required for the rest of the evaluation that will follow the well-known method proposed in [6].

In order to statistically prove the effectiveness of the new features, we adopt a paired t-test given that the population mean and the standard deviation are obviously not available to apply Empirical Rule and z-scores [6].

The paired *t*-test will allow us to prove if there is a

TABLE I:
SUS SCORES

User	New	Old	Difference
1	75	70	5
2	87.5	60	27.5
3	90	57.5	32.5
4	82.5	42.5	40
5	97.5	75	22.5
6	70	45	25
7	90	55	35
8	100	42.5	57.5
9	85	55	30
10	100	68.5	31.5
11	90	55	35
12	100	57.5	42.5
13	95	55	40
14	100	75	25
15	85	65	20
16	92.5	57.5	35
17	92.5	70	22.5
18	65	62.5	2.5
19	70	62.5	7.5
20	97.5	55	42.5
21	72.5	42.5	30
22	90	55	35
23	85	57.5	27.5
24	90	55	35
25	100	77.5	22.5
Mean	**88.1**	**58.94**	**29.16**

significant difference between SUS score means for the two versions of the application. To calculate the test statistic *t*, (1) has been used:

$$t = \frac{D}{\frac{S_d}{\sqrt{n}}} \quad (1)$$

where: *D* is the mean of the difference scores, S_d is the standard deviation of the difference scores, and *n* is the sample size. In this case, (see Table I) *D* is equal to 29.16, S_d is equal to 12.25 and the sample size (*n*) is 25. Given the data of Table I, we obtain from (1) a value for *t* equal to 11.9.

We remain to prove if this value is statistically significant or not: looking up a the *p*-value using the Students distribution with *n*-1 (24) degrees of freedom, we obtain 1.48×10^{-11}. This value is very small, thus, we can conclude that the two scores are different with a probability very close to 100%.

This result give us a statistical evidence of the difference of scores, but we are interested in understanding whether or not this difference is relevant for users. We will calculate the confidence interval around the difference to figure out that. The Formula (2) will allow us to estimate the confidence interval:

$$D \pm t_\alpha \frac{S_d}{\sqrt{n}} \quad (2)$$

where: *D* is the mean of the difference scores, *n* is the sample size, S_d is the standard deviation of the difference scores and t_α is the critical value for *n*-1 degrees of freedom. For a 95% confidence interval and 24 degrees of freedom, t_α is equal to 2.063. Plugging in all the values in (2) we obtain 29.16 ± 5.054. In sum, we can be 95% confident the actual difference of scores is between 24.10 and 34.21.

B. Usage Statistics

In addition to the usability study, we set up another evaluation in order to collect usage statistics related to the new interaction features. We set out to understand how often sportsmen used the new interaction facilities during their workouts. To this end, we equipped a prototype version of the application that supported the new interaction scheme with a software library able to anonymously collect both usage and interaction statistics.

For this analysis we collected six months of statistics of 20 beta testers users that already known the application and the new features. The sample was composed of 9 males and 11 females with an average age of 30.68 (standard deviation equal to 11.72). All participants exercised regularly at least 3 times per week.

From the statistics collected we observed that all the participants made use of the new features during a workout. In particular, runners used 2D gestures to trigger vocal cues an average of 3.9 times every 21 minutes of training, whereas eighteen users out of twenty preferred haptic impulses over vocal cues with regard to virtual trainer directions.

V. Design Guidelines to Improve the Interaction Experience

The results presented in Section IV point up that the new interaction model we have proposed is well perceived by users both in terms of usability and in terms of perceived usefulness during a training routine.

In this section we will list some design recommendations we propose to enhance multimodal systems interaction features in sport persuasive mobile applications designed to provide real time support to people during a workout.

Our recommendations are mostly derived from users' feedback and insights, from the results obtained from the evaluation of the new interaction scheme (see Section III, and Section IV), and more in general by exploiting previous results about the interaction between multimodal systems and people with visual impairments. Indeed, during a running activity, it is not possible to look at the screen or handle the smartphone frequently. In this scenario, the interaction with the application must be as fast, functional, and unobtrusive as possible to provide a better and effective training experience.

Nowadays, new generation mobile smartphones do not differ very much from traditional computers in terms of interaction modalities. Indeed, we interact with our mobile devices mostly through sight, hearing, and touch. What really changes are not the used modalities, but the context where the interaction takes place, the provided flexibility, and the new usage scenarios smartphones are making possible. Among these new usages, there are the so called mobile persuasive technologies that is, technologies that run mainly on new generation phones used to foster some behavioral change in users. Our application, as previously mentioned, is one of these systems expressly designed both to help and to motivate people during a running workout in order to achieve a more active lifestyle.

During a training session this kind of applications interact with the user mostly through the audition modality, that is by means of audio cues that are triggered only at a predefined distance or time intervals with little flexibility for the user. However, other problems may arise by exploiting only the audition modality: our users reported that in some cases they were forced to train with extra obtrusive equipment such as earphones only to listen to the virtual trainer's vocal cues. For these reasons we decided to introduce the new interaction features described in Section III.

The positive obtained results presented in Section IV together with the feedback of our testers (see Section III), guided us defining a set of design guidelines that designers should consider when designing the interaction functionalities of their mobile persuasive systems:

- *Provide domain information on demand*
  Avoid to provide real time and critical information only in a deterministic way that is, with predefined patterns. Provided information should also be available on demand when really needed and with the least possible effort for the users.

- *Limit critical and/or domain information to essential*
  Avoid to overload the information flow. By providing only basic information (in our case study the virtual trainers cues) has allowed us, at a later time, to exploit haptic feedback to provide the same information that in the past was available only through vocal synthesis.

- *Interaction facilities should not rely on any extra equipment*
  By allowing users to map some audio cues to haptic impulses (see the previous point), gave us the opportunity to let the user choose the preferred equipment for his workouts. Indeed, the unobtrusiveness is a key factor to promote this kind of mobile applications. Many users can stop training, or for example, the most advanced ones may continue to prefer other devices such as running watches that are unobtrusive by design but at the same time lacked most of the innovative features available on a smartphone that are a key factor for stimulating motivation.

Our continuous and fruitful interaction with users of our application suggested us that this class of mobile softwares were lacking some critical interaction functionalities. For this reason we designed and developed an innovative interaction system that, since the first designing stages, has been aimed at meeting sportsmen needs. Indeed, no other mobile system designed to support people during running workouts is able to provide such a rich and flexible interaction experience able to overcome the common problems and limitations listed in Section III. The experimentations conducted to validate the new features formally demonstrate the goodness of our proposals and give value to the just presented design recommendations that we hope will be a useful guidance for designers of mobile persuasive systems.

VI. Conclusions & Future Work

In this work we presented the innovative interaction facilities we introduced in EverywhereSport Run! and three design guidelines to enhance the interaction experience during a training routine.

Inspired by users' feedback and by the results of some studies concerning the interaction design for people with visual impairments, we have been able to design and implement a set of innovative features to facilitate and enhance the interaction experience of runners during a training. Thanks to the positive results obtained by a usability evaluation conducted on 25 users and the positive usage statistics collected over a six month period on 20 testers, we have been able to derive three key design guidelines recommendations to help designers build a more flexible and user-oriented interaction paradigm for this class of systems.

With our work, we believe to be helpful to all designers of sport oriented mobile persuasive technologies in order for them to exploit our experience and design recommendations to favour, through a more flexible interaction model, the exertion experience of their users.

Our future research activity will aim at further investigating the relationships between interaction features and user motivation by exploiting a greater amount of data we will be able to collect once we will finish to integrate all the aforementioned features into the production version of our application.

Acknowledgment

This work is partially funded by Regione Sardegna under project SocialGlue, through PIA - Pacchetti Integrati di Agevolazione "Industria Artigianato e Servizi" (annualità 2010).

We also gratefully acknowledge Sardinia Regional Government for the financial support (P.O.R. Sardegna F.S.E. Operational Programme of the Autonomous Region of Sardinia, European Social Fund 2007-2013 - Axis IV Human Resources, Objective l.3, Line of Activity l.3.1 "Avviso di chiamata per il finanziamento di Assegni di Ricerca")

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