ISSUE 94, JUN 2009

Accessibility and Computing

A regular publication of the ACM Special Interest Group on Accessible Computing

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A Note from the Editor

Dear SIGACCESS member:

Welcome to the new look of the online edition of the SIGACCESS Newsletter – with new layout, the use of sans-serif and larger font throughout, left-justification, and the inclusion of authors' short biographies and photographs (so that you can say hi when you meet them in meetings and conference).

This issue reports three articles. The first, titled Web Toolkits Accessibility Study, investigates accessibility functions of two open source web toolkits. The second article discusses the human factors element of non-verbal vocal interaction. The third presents the development of mobile exercise companion for teenagers' weight management. Finally, this issue includes a Call for Participation for ASSETS 2009.

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We encourage submissions as word-processor files, text files, or e-mail. Postscript or PDF files may be used if layout is important. Ask the editor if in doubt.

Finally, you may publish your work here before submitting it elsewhere. We are a very informal forum for sharing ideas with others who have common interests.

Anyone interested in editing a special issue on an appropriate topic should contact the editor.

Web Toolkits Accessibility Study

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Introduction

Access to increasing number of web applications is very good news especially for disabled people. These applications become richer and offer wide variety of services used in everyday's life (document creation, instant messaging, data storage, email communication, social networking, etc.). The problem is that at the same time these rich internet applications (RIA) become less accessible. There is a Web Accessibility Initiative (WAI) 2 related to W3C 1 which is trying to cope with this problem. In particular the Accessible Rich Internet Application suite of W3C (WAI-ARIA) 3 is describing how to improve the accessibility of dynamic web content and advanced user interface controls in rich internet applications.

The accessibility issues covered by WAI-RIA can be divided into three main categories from the user interaction point of view:

- keyboard navigation in the application,
- perception of presented information,
- and user input.

RIA toolkits introduce new complex UI components and dynamically changing content. This brings problems especially in the area of keyboard navigation, which is essential for the whole web application accessibility. The question is how serious these accessibility problems are, what the assistive tools can manage and in what extent, and how can we efficiently fix these problems by means of implementation of WAI-ARIA recommendations.

We are trying to answer these questions in a framework of Sucess project 4. This three year project is funded by Sun Microsystems 5. The result of this project should be improvement of the web application development process which will result in increase of RIA accessibility. The project has three stages – first is focusing on the web toolkits, second on the integrated development environment and third on the disabled developers. From the end-user point of view we focus on the users with visual impairment where the consequences of missing accessibility solutions are most serious.

In this report we will describe the first part of our project – the analysis of two existing RIA web toolkits from the accessibility point of view. We will identify the most important accessibility problems and propose fixes by means of implementation of WAI-ARIA recommendations.

The Study

Test setup

For our study we have chosen two opensource web toolkits – Ext JS 2.2.1 6 and ICEfaces 1.8.0 7 which provide server based and client based solutions for creation of rich internet applications. In these toolkits we see big potential to develop at the end highly accessible toolkits.

Ext JS is a JavaScript library for RIA development which is available on commercial and also open source licenses. Set of JS libraries are stored on a server and functions are called from client's web browser. Component behavior can be easily modified by setting property parameters.

ICEfaces is an open source RIA framework which enables easy development and deployment of Java EE AJAX based applications. ICEfaces applications are pure JavaServer Faces (JSF) applications so there is no need for any JavaScript related development. Toolkit, which consists of approximately 50 components, can be integrated to common IDE's like NetBeans or Eclipse. For beginners it's more difficult then Ext JS to be used because of necessary Java EE development knowledge.

As a reference toolkit the Dojo web toolkit 8 was chosen.

We have prepared two test setups. First was running on OpenSolaris 2008.11 9 with Firefox 3.0 browser 10 and Orca 2.24 reader 11. The second was running on MS Windows 12with Firefox 3.0 browser and JAWS 10.0 reader 13.

Testing approach

In our tests we wanted to check the accessibility of real-life applications developed in real-life development process. For this reason we avoided the formal check of the implementation of the ARIA recommendations in the components generated by the toolkits. We also avoided checking of isolated components or pure usage of some predefined test examples.

In our case we took 21 developers who used selected toolkits and tried to develop own non-trivial real-life applications. Three were 10 developers using Ext JS, 8 using ICEfaces and 3 using Dojo. Examples of some real-life applications developed are depicted in **Fig. 1**, **Fig. 2** and **Fig. 3**.

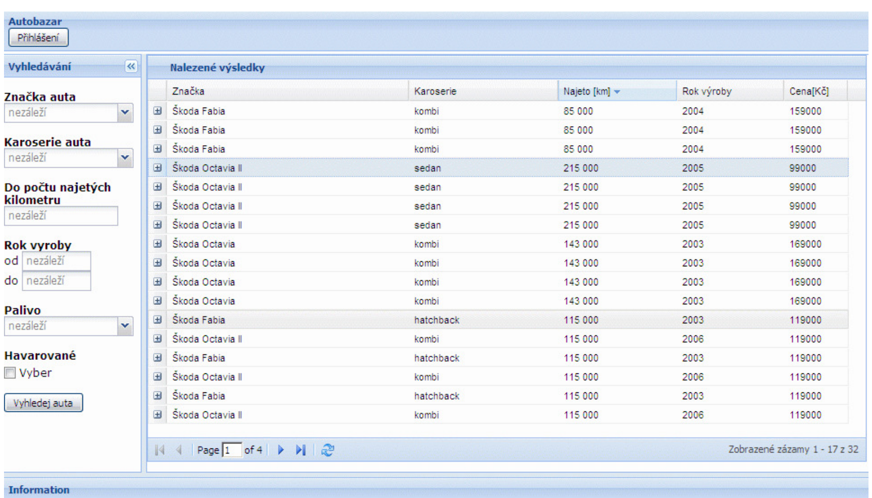

Fig. 1. Car shop website. This web represents a typical car shop web applications, where the user can login (dialogue window will popup), chose from number of listboxes and browse in table with cars with special features (sorting, expansion, paging).

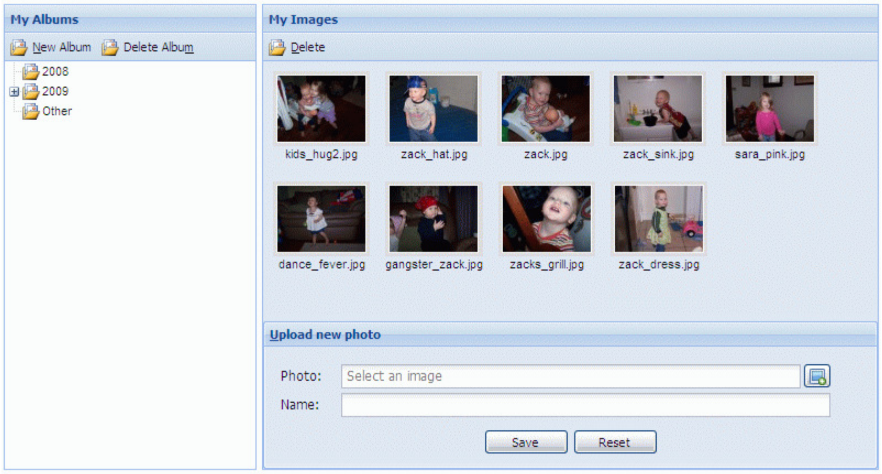

Fig. 2. Online photo album. This web represents typical photo album application, with possibility to upload photos, organize them in albums and tree structure representing time.

Fig. 3. Online cinema. This web represents a website of cinema complex, where the user can search for offered movies.

These applications were than searched for accessibility issues with Orca or JAWS reader. The tests were not intended to provide a comparative study of selected toolkits. Our goal was to cover as broad as possible range of real-life applications.

With this testing approach we have got more than 10 test applications which are very close to those developed by programmers in everyday life.

The web application components occurred in various contexts. For instance the grid component appeared in a context of a viewport, of a menu structure (see **Fig. 4**) or directly in the body of an HTML page. For each context the accessibility of such component differed.

Our test applications did not by nature cover all the existing components, but the most likely used ones.

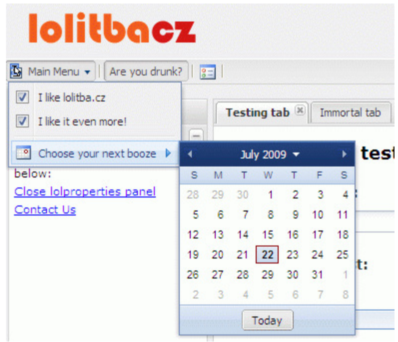

Fig. 4. Components in various contexts. Checkbox and grid (calendar) as a part of menu.

Accessibility issues analysis

Our test has identified accessibility issues in 30 components of Ext JS toolkit (in the time of finishing the report the new version of Ext JS was released, which should address some ARIA issues) and 18 components of ICEfaces toolkit. In the reference toolkit Dojo, which is considered as the best implementation in the means of ARIA recommendations, we have identified 15 components reporting an accessibility problem. The total number of accessibility issues found is larger than 100 (approximately 50 in Ext JS, 40 in ICEfaces and 20 in dojo toolkit). Table 1 provides is a list of the most important issues found in both toolkits.

component	issue description	major cause
• tab panel	• impossible to open another tab after entering one	• missing roles tabpanel, tablist, tab • missing state aria-hidden
• collapsible panel	• when collapsed disappears for the reader	• missing state aria-expanded
• grid (list of structured items)	• navigation in the grid not possible (in one row only, no information about current cell)	• each row is a special table (this disables the reader table navigation feature) • missing roles application, grid, gridcell, row, columnheader, rowheader • missing state aria-selected
• grid (calendar)	• strange behavior of the reader navigation within the grid; no information about the current cell	• missing role application • missing state aria-labelledby, aria-describedby
• dialog	• displayed dialog is ignored by the reader	• missing roles dialog • missing state aria-hidden
• alert, dialog	• reader ignores title and description	• missing state aria-labelledby, aria-describedby
• messagebox	• reader reads the focused button only; other buttons are ignored	• missing role button
• checkbox (ownerdraw)	• reader does not inform the user about the current state of the checkbox	• missing role checkbox • missing state aria-checked
• chat window	• if new message arrives, the reader starts reading form the beginning of the chat session	• missing state aria-activedescendant

Table 1: The most important issues found in both toolkits

Conclusion

The main result of our study is, that real-life applications (more than 10) created by chosen web toolkits are seriously inaccessible. Ext JS 2.2.1 (the version 3.0 already implements some WAI-ARIA recommendations) and ICEfaces 1.8.0 which does not implement WAI-ARIA recommendation unfortunately produce inaccessible application if browsed by screen reader. Even Dojo web toolkit which tries to implement the WAI-ARIA records serious accessibility issues.

It is essential to implement recommendations of WAI-ARIA properly in order to make the rich internet application accessible. The most serious issues are of the keyboard navigation nature. Based on our study we have identified five biggest accessibility issues (see Table 2). Each issue is described by a recommendation and WAI-ARIA implementation proposal.

Recommendation	WAI-ARIA implementation
• Distinguish between "application" and "document" mode of the reader.	• Implement role attribute application whenever you want to avoid interference of keyboard navigation defined by your application with the reader's navigation. You will need to provide references to the labels (aria-labeledby and aria-describedby attributes).
• Define states of owner draw user input widgets (e.g., checkboxes, comboboxes, trees).	• Implement state attributes (e.g., aria-checked, aria-expanded, aria-selected). These states must be updated by JavaScript or CSS (visual effect will be bind with accessibility states).
• Define roles for structured user interface elements (e.g., tabpanels, menus with checkboxes and radios, trees, expandable grids, toolbars).	• Implement role attribute (e.g., menuitemradio, menuitemcheckbox, tabitem, treegrid).
• Define roles for complex document structures (e.g., grids).	• Implement role attribute (e.g., grid).
• Properly describe alerts and dialog windows.	• Implement role attribute dialog and alertdialog and state aria-hidden.

Table 2: Recommendations and WAI-ARIA implementations

Acknowledgement

This research was funded by the Sucess project – Sun Center of Excellence for Accessibility & Usability (http://amun.felk.cvut.cz/coe/).

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Jan Vystrèil is a researcher and a lecturer at the CTU in Prague, Department of Computer Graphics and Interaction. His master thesis "User interface for in-door navigation of visually impaired people via mobile phone" was awarded with 2nd price in national Master thesis competition.
In his research he is interested in development of navigation system NaviTerier for visually impaired people and also other interaction with such impaired users. Currently he is involved in the EU funded project AEGIS and Sun Center of Excellence for Accessibility, where he focuses on accessibility of rich internet applications.

Pavel Slavík is a full professor at the Department of Computer Science and Engineering at the CTU in Prague, where he received his PhD (1983), Associate Professor (1994), and Professor (2003) titles. His wide range of interests includes computer graphics, scientific visualization, graphic user interfaces, and interfaces for users with special needs. He is an author or co-author of more than 200 scientific papers and articles in journals and conference proceedings. He has an extensive record of participation in various research projects, including INCO projects (WISE/E 1995-96, Virtuos 1998 – 2000), or 5th Framework projects (ENORASI, 2000 – 2001, MUMMY 2001 – 2005), or 6th Framework projects (ELU, i2home), or 7th Framework projects (AEGIS, VitalMind).

Pitch in Non-verbal Vocal Input

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Introduction

Recently, numerous prototypes of user interfaces have been presented that are based on interpretation of non-verbal sounds produced by the users, such as humming, whistling, or hissing. These sounds can be characterized by numerous properties, such as pitch, volume, or timbre. The user may intentionally change these properties while producing the sound. The properties (or their profiles over time) can be mapped to different actions. In order to trigger an action or modify an input value, the user produces a corresponding acoustic gesture.

The non-verbal vocal input (NVVI) represents an inexpensive alternative to various state-of-art technologies and techniques, such as sip-and-puff controllers or eye trackers, as no hardware additional to a standard PC is necessary.

Applications of NVVI that have been developed so far include systems able to control mouse cursor pointer [2, 7], operate computer games [3, 6], create artwork [1], or emulate keyboard [8]. Some of the user interfaces are controlled by sound timbre or volume, such as [2], some others by pitch, such as [7] or [4]. Most of these systems have been developed and deployed in the context of accessibility.

In some non-speech user interfaces, the input from the users is solicited through absolute pitch of the tone they produce. For example, in [3] the absolute pitch of tone determines the absolute vertical position of a game character.

In the pitch-to-address mapping mode of the system for NVVI emulation of keyboard (see [8], p. 147) the users produce sequence of three tones (A1, A2, A3) in order to specify the coordinates of keys on the keyboard (see Fig. 1).

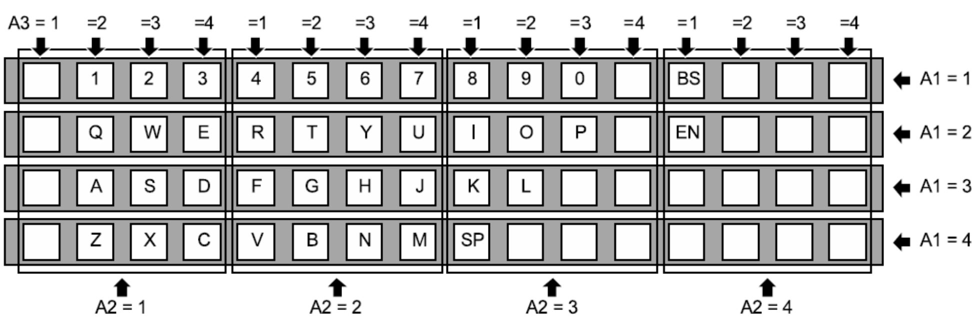

Figure 1. The address space of the keys for the NVVI keyboard. (From [8].)

Each coordinate is a number from a given interval of integers <1, *N*> (The authors of the system selected *N* = 4). Each integer is assigned a pitch interval (see Fig. 2). In order to select the desired integer, the user produces a tone that falls into the corresponding interval. Significant for selection is the pitch before the very end of the tone. The users may utilize the visual feedback that displays the current pitch of the tone in relation to the available intervals.

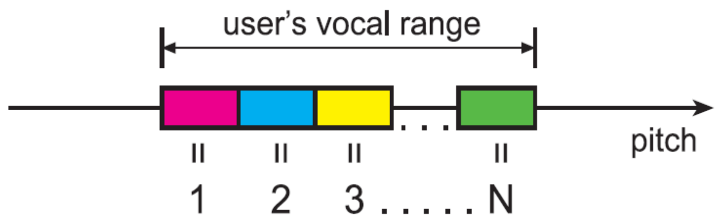

Figure 2. Selection of a value by absolute pitch of tone

There are two important physical human factors in this mode of interaction, determined by individual physiological properties of the user's vocal organs:

- The vocal range, i.e. the interval of pitch that the user is capable to produce.
- The precision of intonation, especially the ability of the user to finish a tone within given interval.

Obviously, the larger the user's vocal range is and the more precise the user's intonation is, the wider set of values can be presented to the user to choose from.

The aim of this paper is to investigate these two factors. We describe a new method for how the user's vocal range can be measured. Later in the text we present results of our study in which we quantify the ability of people to produce tones that fall into desired intervals as in the pitch-to-address method for different widths of the intervals.

Note: Unless explicitly stated, all pitch values are written in MIDI note numbers. According to the MIDI Tuning Standard [5], note number p is obtained from a frequency *f* as $p = 69 + 12 \log_2(f / 440)$. The tone middle C (261.6 Hz) corresponds to the MIDI note number 60. A tone n semitones above or below corresponds to the MIDI note number 60 ± n.

Comfortable Range of Pitch

Constrained by anatomical and physiological properties of the voice and the speech organs, each person has their own general range of pitch <*p*1, *p*2> that he or she is able to produce (see fig. 3). The trained singers can reach as much as two octaves while the range of pitches of the untrained people is usually narrower. The difficulty of producing a tone varies with its pitch. There is only a subrange <*pc*1, *pc*2> in which lay the tones that are comfortable enough to be produced over an extended period of time (the comfortable range of pitch, CPR).

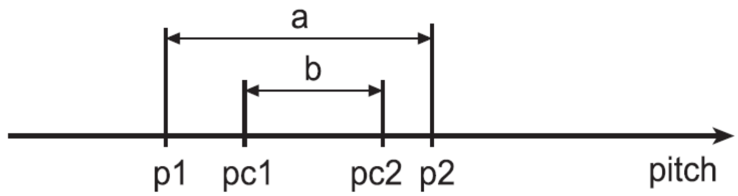

Figure 3. User Pitch Ranges. a—general range, b—comfortable range.
See text or explanation of the variable names.

In order to minimize the fatigue, it is necessary to match the non-speech user interface to the comfortable range during the system calibration, i.e. to specify the <*pc*1, *pc*2> interval.

We have developed a two-step method for estimation of the values *p*1, *p*2, *pc*1, and *pc*2 in a user. The method does not require any previous musical training on the users' part. It is based on the visualization of the pitch being produced on a tonal scale. It is a two-step process, as described below:

- **Step 1: Familiarizing the voice.** The user is made aware of their voice, especially how easy it is to produce tones at different pitch. The user goes through a sequence of attempts. In each attempt, the user is requested to produce a tone that is within a given target interval, as shown in the stimulus (see Fig. 4). The sequence of attempts should be designed in a way that the user experiences all possible pitches and his or her ability or inability to produce these.
- **Step 2: Self-assessment of difficulty.** The users go through the same sequence of attempts. However, in this step, the user is asked to evaluate how comfortable for them it was to produce a tone within the given target interval by assigning grades 1 (easy) through 5 (impossible) after producing each tones. A typical user's response is shown in the chart on Fig. 5. The pair of values *pc*1 and *pc*2 corresponds to the horizontal position of the bottom of the 'canyon' in the chart. Similarly, the pair of values *p*1 and *p*2 correspond to the edge of the canyon.

A User Study

We have used this method to measure the pitch range in 13 adult participants (9 males, 4 females, average age 37 years, SD 17), each one in an individual session taking place in a quiet room. Three of the participants had taken some music training as children. One of the participants was an advanced piano player. All participants wore headsets during the experiment. The sound signal was recorded and analyzed with their consent.

The intervals in the stimuli used in our experiment were 4 semitones wide. The intervals were selected so that they cover the complete range of human voice (55 to 1760 Hz) and that no more than two target intervals would overlap at any given pitch. A stimulus presented to the user during one attempt is shown in Fig. 4.

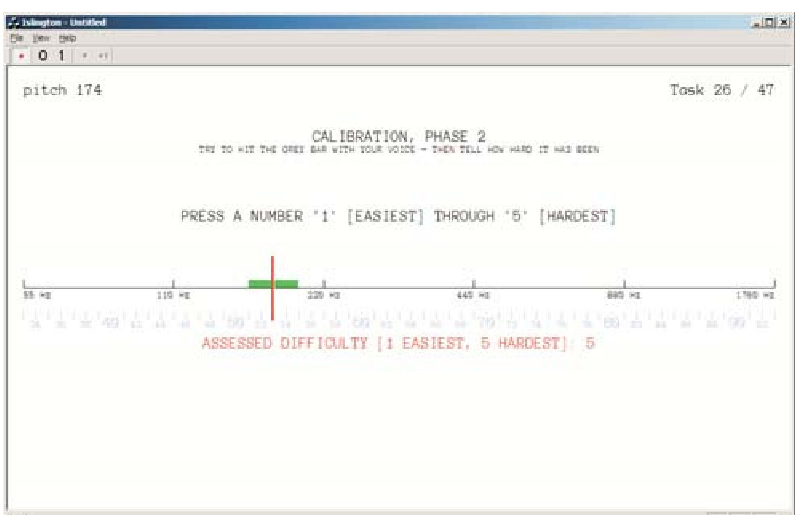

Figure 4. A stimulus. Green bar—the target interval. Vertical red line—the current pitch of tone.

The values gathered during the test are shown in Table 1. The p-values are the centers of the test intervals. The lines of the table are ordered by the width of the comfortable range interval $\Delta c12 = pc2 - pc1$.

Age / Gender	*p*1	*pc*1	*pc*2	*p*2	Δc12
29/M	43	47	51	65	4
27/M	39	45	49	69	4
22/M	39	43	51	59	8
49/F	55	57	67	73	10
59/M	35	43	53	61	10
22/M	35	43	55	81	12
24/M	39	45	59	65	14
64/F	39	47	61	71	14
51/F	43	47	61	69	14
25/M	39	45	61	71	16
61/M	35	39	57	61	18
28/F	47	53	73	77	20
24/M	39	41	63	67	22

Table 1: Participants' Ranges

The average comfortable range was 12.7 semitones, SD 5.57. Only less than one third of the participants was not able to produce tones in ranges at least 10 semitones wide.

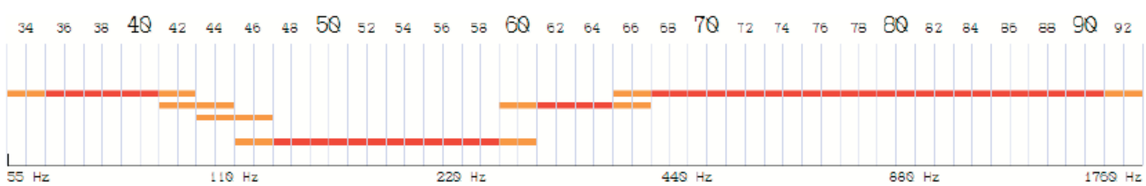

Figure 5. An example of pitch difficulty chart.
Horizontal axis: pitch [MIDI note numbers, Hz]. Vertical axis: user-reported difficulty.

Width → [semitones]	1	2	4	8
Too low	20%	14%	8%	11%
Correct	48%	54%	77%	81%
Too high	32%	32%	15%	8%
# of datapoints	112	112	111	75

Table 2. Classification of attempts by target interval width and outcome

Precision of Intonation

The purpose of this study was to compare the difficulty of intonation of tones for different required precision of this intonation. The precision was determined by the width of target interval. E.g. when a 4-semitone target interval C4–E4 was presented, the user was supposed to produce a tone that would terminate at pitch that would be between these two notes.

Method

19 users (13 males, 6 females, average age 32 years, SD 15.9) participated in the study. Two of the participants had taken some music training as children. One of them was an active musician. None of the participants had any prior experience with using this input method. All participants wore headsets during the experiment. The participants were informed on the purpose of the study and gave the consent to record and process the voice signal. The session with each participant consisted of the following two steps:

- Step 1. The participant's comfortable pitch range *pc*1, *pc*2 was measured by the method described in the previous section.
- Step 2. The participant went through a sequence of attempts. The goal of each attempt was to hum a tone whose pitch at the very end of the tone falls into a target interval. The stimulus for each attempt was very similar to the one as shown in Fig. 4. The attempts varied in target interval width (1, 2, 4, or 8 semitones) and in the placement of the target interval on the tonal scale. Only such target intervals were selected that would fit into the participant's comfortable pitch range. This way, there were usually 10 to 20 attempts in the sequence for each participant. The following data were recorded for each attempt: The width and the placement of the target pitch interval, pitch profile of the tone, duration of the tone, and the overall outcome (either "success", "tone released too low", or "tone released too high").

Results

Success rate. The Table 2 shows the counts of the stimuli, grouped by the interval width and the outcome of each attempt. The data show a trend that with increasing width of the target interval the success rate rises.

Time Requirements. The average time needed to produce a tone within a given interval width is shown in Fig. 6. The time needed to produce a tone within 1-semitone interval was significantly greater than for wider intervals (a t-test; $p \leq .05$). Only successful attempts of all users were included into this analysis. Fig. 7 shows the histogram of tone durations with 0.5 second bins. The majority of all tones were around 1 and 1.5 seconds of duration.

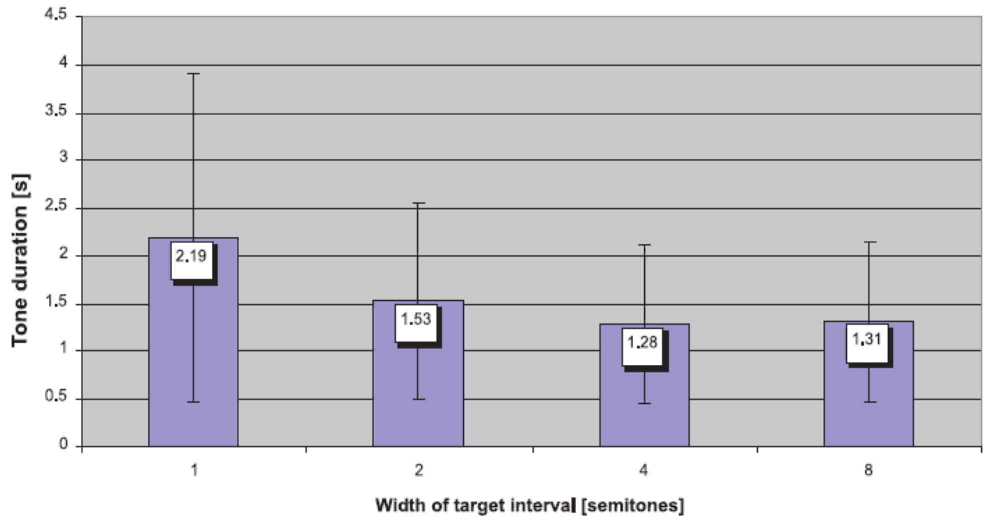

Figure 6. Histogram of tone durations in successful attempts

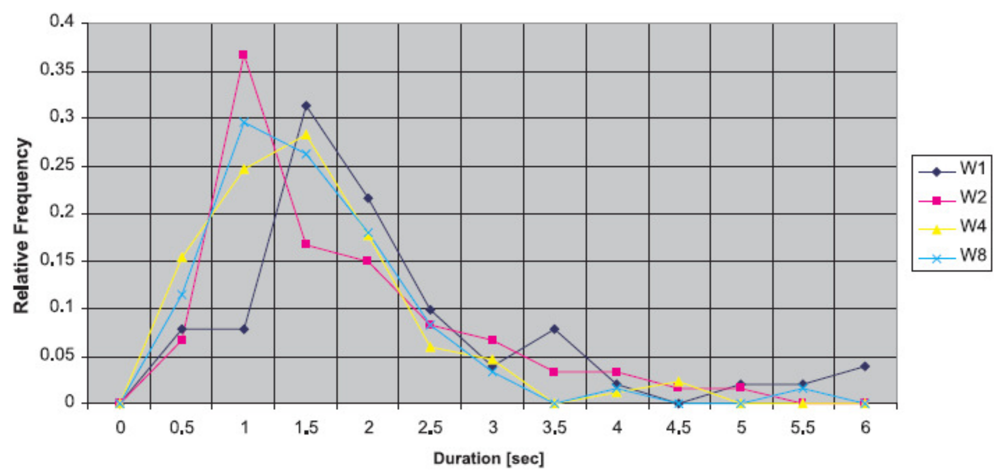

Figure 7. Histogram of tone durations in successful attempts

Discussion

On average, the comfortable pitch range was slightly wider than one octave (12.7 semitones). However, there were two people who were unable to produce a wider range than 4 semitones.

The participants were generally more successful when hitting wider target intervals. The success rate for 4-semitone interval was 77%. A further increase of width brought only a minimal improvement. We conclude that the width of 4 semitones was the most suitable target interval when considering the average width of the comfortable range. This way, the users would be able to select from 3 or 4 different values at a time.

Producing tones in order to fit 1-semitone intervals took 2.2 seconds on average, which was significantly longer than aiming at wider ones. The difference between duration of tones for 1-semitone and 4-semitone interval was almost 1 second. The shortest tones were produced for 4- and 8-semitone intervals.

Conclusion

In this paper we discussed some of the human factors that affect the performance of the pitch-to-address selection method described in [8]. Depending on the pitch of tone produced by user, a value is selected. The performance of this input method is affected by the users' vocal range and their ability of precise intonation.

We have described a new method of measurement of the comfortable range of pitch that does not require any previous musical training of the user and is easy to deploy in the end-user applications. Using this method we have measured the comfortable range of pitch in a small sample of general population. Our user study of the precision of intonation has indicated that most people can select from three or four different discrete values at once by means of pitch-sensitive non-speech sound input devices. Thus, we have verified the design of the original prototype of the pitch-to-address method of non-speech emulation of keyboard.

In some applications of the non-speech input (such as emulation of keyboard) it is necessary that users do not rely on visual feedback to the sound they produce in order to eliminate the second focus of attention. Our future work should therefore include a study of precision of intonation in which the users would not be presented the visual feedback. It may be expected that people with musical skills would outperform people without these skills. A larger user study that would be able to quantify the difference in performance of these two groups should be performed as well.

Acknowledgments

We would like to express our thanks to the students who volunteered to run the experiments. Namely, to Vojtech Jirkovsky, Ivo Jirele, Martin Strnad, Jitka Trojankova, and Lukas Wroblewski. This work has been supported by internal grant 712913 (2007) of the Czech Technical University in Prague. The work has been also supported by Student Research Project contest held by the CTU in Prague and IBM Czech Republic.

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Combating Obesity Trends in Teenagers through Persuasive Mobile Technology

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Abstract

Throughout the last decade, there has been an alarming increase in obesity prevalence among adults and teens throughout the world. Obesity has been found to increase the risk of developing diabetes, cardiovascular diseases, and some cancers. Due to the many health risks associated with obesity, an increase in prevalence has also pressured health care systems and the finances of the individual. Our research proposes to decrease obesity prevalence in adults by motivating teens to become or continue being physically active so that they can continue these healthy lifestyles as adults. Our goal is to encourage long term adoption of physically active behaviors by introducing a motivating application running on a mobile device. We use the Technology Acceptance Model, the Theory of Planned Behavior, the Theory of Meaning Behavior, and the Big 5 Personality Theory to guide our design.

Introduction

Obesity is a worldwide problem largely influenced by sedentary lifestyles and unhealthy diets. Obesity has been found to increase the risks of developing heart disease, diabetes, high blood pressure, and some cancers [1]. Not only does obesity affect an individual's health but it also puts pressure on health care systems. Overweight and obesity cost the United States as high as 78.5 billion dollars in 1998 in medical expenses alone. Out of these costs, it was estimated that about half of the amount was covered by Medicaid or Medicare, and about 12.8 billion was out of pocket for these individuals[1]. The latest statistics estimate that the prevalence of obesity in adult men and women is between 31% and 35% [1, 2]. Likewise, more than 25% of U.S. children are considered clinically obese.

The current recommendation for physical activity is 60 minutes of moderate physical activity 5 days out of the 7-day week. An estimated 40% of adolescents spend 3 or more hours watching television, and 33% of adolescents get physical education classes in school [2]. Girls have been found to be less active than boys in their teenage years [3], which potentially puts them more at risk. Previous studies have also found that some factors affecting a child's physical activity include their parents' exercise patterns, their enjoyment of physical activity, friends' support of exercise, and self-efficacy [3].

Many free or low-cost fitness and exercise programs exist, but teens do not take full advantage of them. Major contributors to the lack of consistent participation from teenagers in these programs include transportation obstacles. Teens rely heavily on their parents and their parents' schedules for transportation needs. Our system addresses this issue by running on a mobile device which can then be kept on the person at all times and can be used anywhere.

Although a lack of physical activity is not the only factor affecting obesity prevalence in teenagers, it can help them maintain healthy weights. Our system attempts to make physical activity more enjoyable, allow for friends and family to become involved, and improve their self-efficacy views by providing verbal motivational support and physical activity games running on a mobile device. In the following we begin by going over previous systems that address physical activity in adults or teens, our proposed solution, the status of the research, our contribution to the field, and information about the authors.

Background

In the literature, there exist studies and applications developed that address increasing or maintaining healthy physical activity levels in individuals by using a game-like environment, friendly competition, or physical activity awareness and monitoring. In the following, we describe a few of these prior systems.

Motivation is an essential factor that can cause a person to start physical activity, do more physical activity, and continue their physical activity routines. A lack of motivation or the wrong kind of motivation can also have negative effects in which the user stops using the system or doing the behavior. One approach to increase motivation includes encouraging friendly competition such as in Chic Clique and Houston [4 - 7]. People who used Houston stated that their physical activity was not accurately measured, which was due in large part to the limitations of pedometers. Users also complained that the pedometer was too bulky and called attention to the users.

Another approach includes physical activity based games such as Neat-o-games, Human Pacman, and Mario Fit [8 - 10]. The games are usually controlled with data from an accelerometer or GPS. However, not everyone enjoys the social interaction required to play these games, and people may not want to purchase additional hardware, as is necessary to play Human Pacman.

There are also systems that aim to assist users with their physical activity routines. An example of such a system is MOPET. MOPET is a system that records heart rate and speed and focuses on providing the user with tools to analyze their fitness progress. MOPET also has a virtual trainer that demonstrates how to do exercises and encourages the user to try them [11, 12]. The application was targeted to physical activity outdoors and jogging. They found that gentler and softened motivation was more effective. This work outlined features of a good visual display for physical activity [13]. Again this application is more suited towards users who want to develop exercise routines.

Finally, there are systems that were created based heavily on theoretical concepts. One such system is UbiFit Gardens. UbiFit Gardens was developed according to several theoretical guidelines including those from cognitive dissonance theory and the transcontinental model. They created non-intrusive physical activity technology that would blend into the user's everyday world. Their user study consisted of adults who wanted to increase their physical activity [14]. The applicability to teens was not explored.

Most of these systems target adult users who have already expressed a desire to be physically active. To our knowledge, little work has been done in addressing and predicting technology designs that would motivate teenagers to become or continue being physically active. By targeting teens we hope to encourage physical activity and healthy lifestyles at an early age to try to combat obesity and overweight trends in later years. The proposed research attempts to further research in this area by approaching the design of such a system from several theoretical models that will shape different aspects of the system design and personality theory that will help to shape the individualized motivational aspects of the system.

Proposed Solution

Fitness and physical activity teen programs face problems such as a low number of participants and inconsistent attendance by those who do sign up. One of the major obstacles for teenagers is that they must rely on their parents for transportation to the facilities where these programs are held. By developing our application on a mobile device we have eliminated the transportation issue. For our pilot work, we focused on motivation and making exercise fun. We accomplish this by asking teenagers to play games that are location or accelerometer based and that require physical activity. Our system also uses personality information as determined by the Big 5 personality theory to recommend games for the user and motivational phrases to play (see figure 1 and figure 2 for a state diagram of the system).

The main theories used to shape this design were the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), the Theory of Meaning Behavior (TMB), and the Big 5 Personality Theory. The technology acceptance model tries to predict if a technology will be accepted and adopted by users. This model says that in order for a system or technology to be accepted it must address two key components: perceived usefulness and perceived ease of use [15]. Perceived usefulness is a reference to how much the user thinks this technology will be useful and helpful to get the task done. The user must also believe that it will be easy or straightforward to accomplish the task with this new technology (perceived ease of use). TAM is used to shape the whole system design, i.e. the system is designed to perform and provide useful information for the user and the interface is designed in a way familiar to the user group.

The theory of meaning behavior accounts for how both external and internal incentives promote behavior change [16]. External incentives can be thought of as rewards for behaviors, such as getting a treat if you get good grades or a medal if you participate in sports. Internal incentives are incentives which we have internalized and associated to personal rewards such as 'personal enjoyment'. Our design begins by using external motivators such as the motivational agent and phrases. We hope the internalized motivator will be an association of physical activity to a fun and 'easy' behavior.

The theory of planned behavior says that there are key components that affect behavior. These components are perceived control, subjective norms and attitudes, and behavioral intention. In TPB, perceived control is based on how easy or difficult the individual believes performing the behavior will be [17]. Subjective norms and attitudes refer to the influences that other people whom the individual likes or considers important affects his or her behaviors. Finally, 'behavioral intention' refers to whether or not the person wants and plans to do the behavior. Our system encourages intention and perceived behavioral control through the motivational phrases spoken by the motivational agent. Likewise, we believe using games will increase perceived behavior control and will also adhere to the social norm of playing games for this target group.

The Big 5 personality theory is then used to personalize the system to each user. Personality codes are determined for each user and used to decide which games to suggest to the user and what motivational phrases to play. We believe doing so will enhance the user's experience and it will improve the likelihood that interaction with the system will be found to be more enjoyable and motivating as a result.

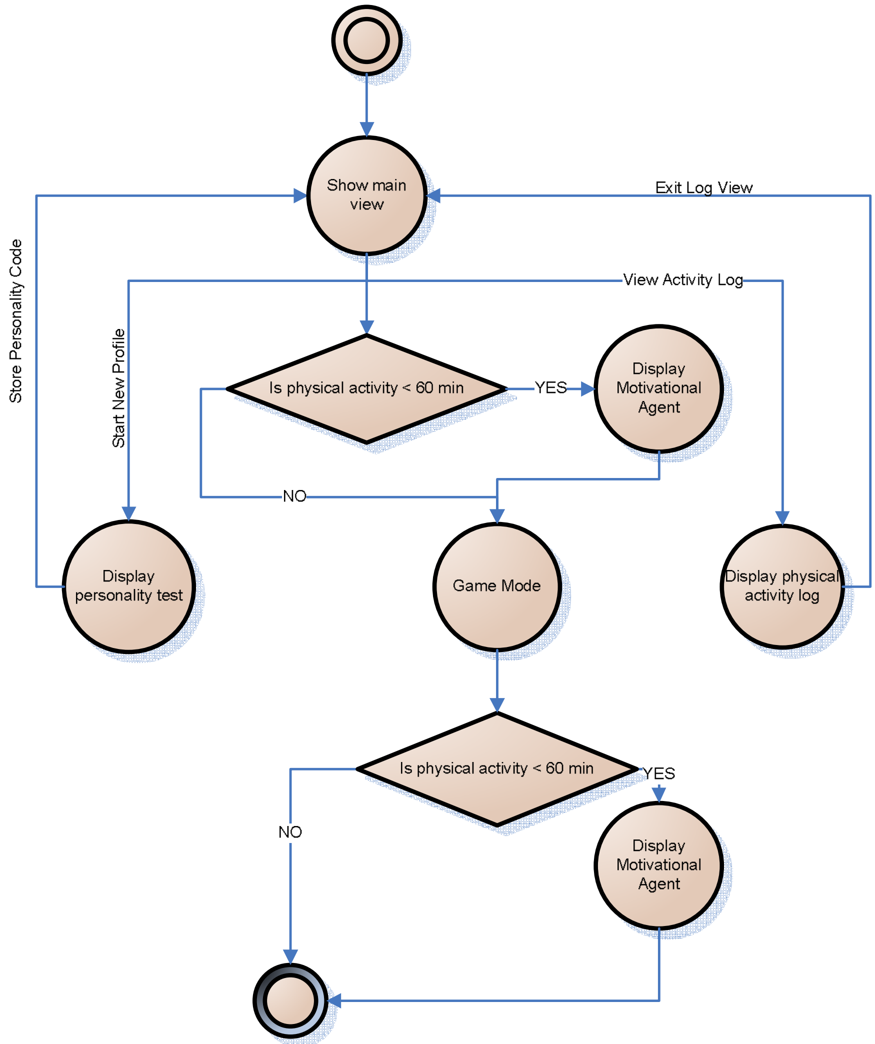

Figure 1 - State diagram of the system

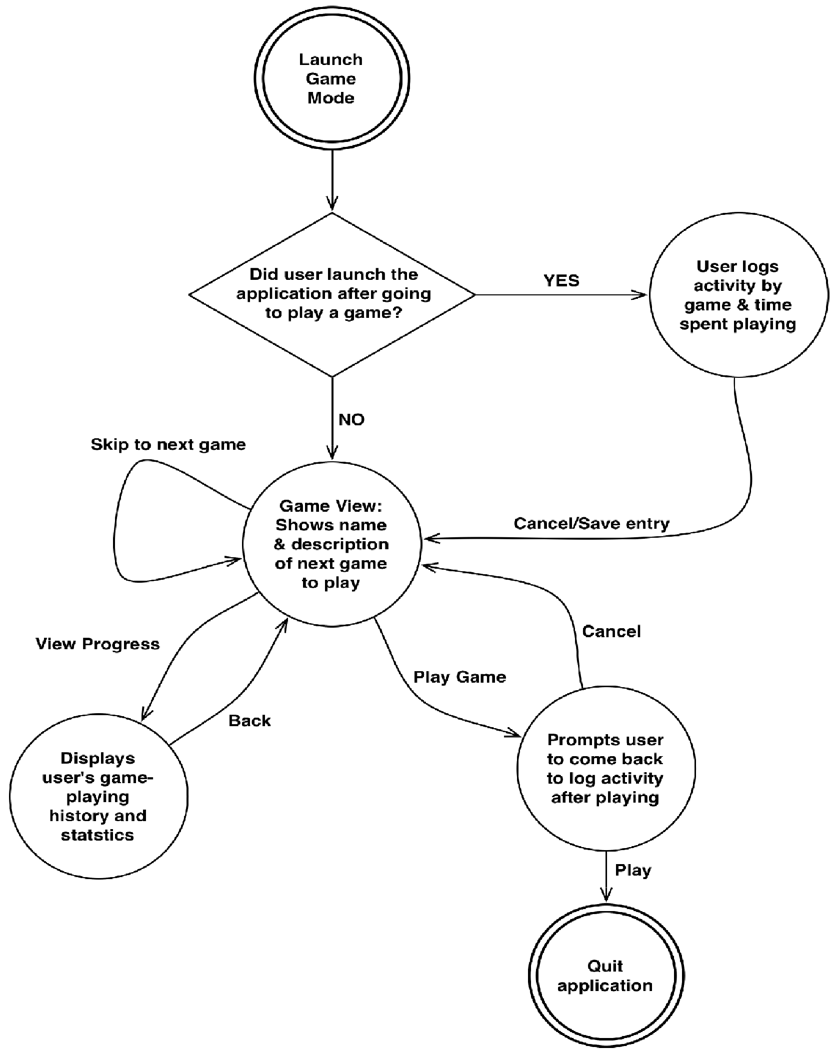

Figure 2 - State diagram of the system's 'Game Mode'

Once the application is launched, the system presents the player with a list of games tailored to their personality. For example, an extroverted teen would likely enjoy playing games outdoors with a group of friends, whereas an introvert may prefer a game that can be played alone. Each game is better or less well suited to certain personality traits, but all games involve physical activity and interaction with the real world. There is considerable variety in types of games: games that involve physically searching for a virtual treasure the player sees on a map, games that involve using the mobile device as a sword, and group competition based games.

The system recommends an ordered list of games compatible with the user's personality, but the user is free to skip forward or backward between games (see Figure 3), giving the user control over what to play next. Allowing a choice of several games should give the user perceived behavioral control (which is a motivator for behavior change according to the Theory of Planned Behavior), and allows users to avoid games they cannot play at the moment (due to constraints like not enough players, needing to stay indoors, etc.).

Figure 3 – Screenshot of the system suggesting a game to play

When a user decides to play a game, the system remembers what game it was, so that when the user opens our system again, they are prompted to log playing that game. This record goes towards a daily, weekly, and overall physical activity total, which a user can view at any time by tapping the "My Progress" button. Seeing a visual representation of their progress over time is designed to give the user feedback, which is essential in motivating continued use. After logging physical activity game play, the user is again taken to the games list and the next game is suggested. Figure 2 shows the state diagram for the user interaction for the system.

The motivational aspect of our design is accomplished through the incorporation of a motivational agent, whose spoken phrases are chosen based on the user's personality. To determine the user's personality, a shortened version of the traditional Big Five Personality test is used. This ten-question test is more suitable for use on our system because the user may not want to spend too long filling out questions prior to game-play. The personality test chosen has been shown to be a good substitute for the full, forty-question test [15].

Two agents have been created for this application to cater to different personality types (Figure 4): a polite and encouraging female agent and a male agent more akin to a drill sergeant. In a focus group, the participants reacted very positively to the female agent, saying, "She seemed really nice" and "I would keep playing if she would tell me nice things". With the MOPET system, gentler motivation was found to be more effective, so the motivational phrases have been designed to be very positive.

The agent condones physical activity levels when the user has obtained the goal of more than sixty minutes of activity on a given day, by having the agent say a phrase such as, "Great job! You are really on top of things!" If the activity level has not reached sixty minutes, the agent will say a phrase such as, "Why don't we try playing for another thirty minutes?" or "Let's try more activities tomorrow!" The phrases have also been tailored to match certain personalities; for users with a high extroversion factor an example phrase would be, “Tomorrow, invite a friend to play!” For users with a high introversion or antagonism factor, an example phrase would be, “Why don’t we try playing a game? It will be fun!”

Figure 4 – Motivational agents used in the system

Status of research

Currently, we have developed a prototype application running on an iPod Touch and iPhone. We gathered questionnaire data from over 25 teenagers, and have completed a focus group with 5 teenagers. We are currently, moving towards applying what we learned from our focus group and survey data to improve and move forward with our design. In the immediate future, we will begin a long term study to test the effects of this system on long term behavior change.

In the pilot study, we have chosen to develop our system for the iPhone and use existing iPhone games involving physical activity, rather than creating our own. Using existing games has allowed us to create a quick prototype in which we will be able to get feedback from our focus group about what games the teens did and didn’t like, and which they would be interested in continuing to play. For the long-term study, the goal would be to use this feedback as a basis to actually create our own games that teens would find fun, and integrate them as part of the application.

Although the ability to use existing games is an advantage in our pilot study, the iPhone platform is limiting in that developers cannot run their applications in the background. This means we cannot gather accelerometer data or GPS data while the 3rd party game applications are running, and must rely on the user to log their play the next time they open our application. In an integrated game system all logging would be done automatically, in order to make the interface as unobtrusive as possible.

We hope that by playing games our users will associate physical activity with positive feelings and memories. These positive associations will become internalized motivators for teens to continue physical activity for many years to come. Once these motivators are internalized it is more likely that long term behavior change will occur and the users will no longer require our system to motivate them.

Contribution to field

We hope this work will contribute to the knowledge of system designs that will encourage long term behavior changes in teenagers. We also hope this work will contribute to a better understanding of the design requirements for this targeted user group, the theoretical foundations that best describe their behavior, their mental models and how these play a role in system design.

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