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Dance! Don't Fall – Preventing Falls and Promoting Exercise at Home

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Abstract. Falling is a serious danger to older adults that is usually only addressed after a person has fallen, when doctors administer clinical tests to determine the patient´s risk of falling again. Having the technological capability of performing fall risk assessment tests with a smartphone, the authors set out to design a mobile application that would enable users to monitor their risk themselves and consequently prevent falls from occurring. The authors conducted a literature review and two observation sessions before beginning the iterative design process that resulted in the Dance! Don't Fall (DDF) game, a mobile application that enables users to both monitor their fall risk and actively reduce it through fun and easy exercise.

Keywords. Fall risk assessment, older adults, mobile applications, physical activity, dance games

Introduction

Falls are the most common cause of injury and injury-related death among people 65 and older, and one in three older adults suffers a fall every year [1]. To assess fall risk, doctors conduct clinical tests in which the patient attempts to perform simple movements like balancing on a chair, standing without assistance, and walking forward for three meters – called gait test [2]; they also administer questionnaires to assess factors that influence fall risk including the patient´s vision, cognition, balance, medication, and environment [3]. However, doctors typically only begin doing these types of tests when a fall has already occurred. Furthermore, the infrequency of the tests – once every couple of months – renders them ineffective for detecting sudden changes that may be dangerous.

Researchers at Fraunhofer AICOS developed technology for conducting and evaluating the gait test using a smartphone as a sensor that the user wears against his or her lower back [4]. The team wished to demonstrate this capability at the Mobile App Showdown of the 2011 CES in a way that would appeal to users and had the idea of incorporating the gait test into a dance game. Upon further reflection it became clear that the benefits of using a dance game are wider than simply acting as a package for the gait test; the game could actually reduce users´ risk of falling as well.

One of the major factors contributing to fall risk is decreased strength and flexibility caused by a lack of physical activity [1], so counteracting the trend of

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increasingly sedentary lifestyles is a key way to prevent the occurrence of falls. It is important to encourage older adults to stay active by taking part in pastimes that provide exercise, such as gardening, walking, swimming, and dancing. Older adults particularly enjoy dancing as a form of exercise, but often are not able to because of a lack of specific opportunities to dance and the difficulty fitting classes or events into their schedules [5]. In this way, a mobile dance application could be more than just a means to administer clinical tests at home, but also an activity that would motivate users to exercise regularly, actually reducing their risk of falling.

1. Process

The DDF project progressed extremely rapidly in order to meet the submission deadline for the Mobile App Showdown. All phases of research, design, and development occurred in less than two months, primarily consisting of two phases: research, and parallel design and development.

1.1. Literature Review and User Research

Setting out to design a dance application for older adults, the authors began by conducting a brief review of literature on interactive technologies for dancing [5] [6] [7]. This research indicated the success of dance games and confirmed the authors´ notion that dancing is well-liked among older adults. In order to better understand how older adults enjoy dancing, the authors proceeded to conduct both video and live observation of dances.

Video observation primarily consisted of viewing relevant YouTube videos. Two researchers conducted searches for phrases like "dance for seniors", "older adults dancing", and "easy dance" on www.youtube.com, resulting in over 50 videos of dances. These observations were not formally coded, but the researchers noted characteristics and trends apparent in the videos. Three key points arose: Firstly, most videos featured groups or pairs dancing, demonstrating that dance is an activity naturally done together. Secondly, dance choreographies for older adults were generally simple and repetitive, making them more appropriate for those experiencing age-related changes in memory and dexterity. Finally, the authors observed that many dances for older adults are derived from traditional dances that were common during the time of the dancers´ youth or early adulthood.

The live observation was conducted at a dance event at a senior center near Porto, Portugal. The two researchers attended the event, observing 14 older adults dance Rancho [2] over a period of about three hours. The researchers again made notes regarding the characteristics of the dances, also recording video to revisit later. This observation session confirmed the findings derived from the initial video observation and led to several additional conclusions. First of all, dance steps were in general smooth and small – quick or large movements were rare, and not made by all dancers. Furthermore, the researchers perceived that clapping or otherwise producing sounds with the hands was an important part of the dance. Besides helping to keep the rhythm, it stimulated the enthusiasm of the group. Also worth noting was the joy evident in both the faces of the dancers and those watching in the audience.

[2] Rancho is a traditional Portuguese dance

Based on the findings described above, the authors defined a number of characteristics that a dance system for older adults should have, namely: i) to enable dancing with others; ii) to feature simple and repetitive choreographies; iii) to take influence from traditional dance styles; iv) to require small, smooth movements; and v) to encourage clapping.

1.2. Design and Development

The design and development of Dance! Don't Fall was an iterative process that consisted of three different teams working concurrently: one team designed the user interface, another developed the engine to detect the dance moves, and another implemented the user interface and developed the communication system that enables multi-player dances and utilizing a TV display.

The design team began by prototyping a smartphone user interface on paper, fostering discussion and critique across the project team. The designers iteratively refined this prototype in terms of functionality, information architecture, and graphic design. At the same time, the design team chose a song and began working on the dance choreography. The choreography was also iteratively refined, based on feedback from the dance engine team, to ensure the system would be able to detect the dance steps with the necessary degree of accuracy.

2. The Dance! Don´t Fall System

Dance! Don't Fall is an Android application that gives users feedback on both dance performance and risk of falling based on analysis of their movement as they perform choreographed moves along with audio or video dance instructions.

2.1. Description

To play DDF, the user wears the mobile phone on the lower back to track the dance steps. The game gives feedback on four aspects of the dance performance, namely accuracy, timing, stability, and grooviness. For every dance, the score for each of these factors can be LOW, OK, or HIGH. The fall risk assessment is based on the quality of the user´s locomotion and supplemented by a brief clinical questionnaire when it appears that a problem may exist.

DDF currently features one song and dance, which is based on a simple line dance choreography.[3] The researchers chose this style of dance because the application was intended for presentation at the Mobile Apps Showdown and thus targeted at an American market; furthermore, line dances easily accommodate the characteristics the researchers deemed necessary for a dance for older adults. However, as will be discussed below, more dances should be included in the future.

The DDF user experience is enhanced when a Google TV is available to display the dance coach demonstrating the steps for the user. A tablet can also be used to serve this purpose. If no other device is available, the smartphone will verbalize the steps for the dancer.

[3] A line dance, most commonly associated with country-western music, features a group of people facing the same direction and performing the same sequence of steps.

The application has three modes: Learn, Perform, and Compete. In the Learn mode, the dance instructor teaches users the individual dance steps and then outlines the choreography. In the Perform mode, one user dances to the music alone. Finally, the Compete mode allows users to challenge their friends to a group dance contest.

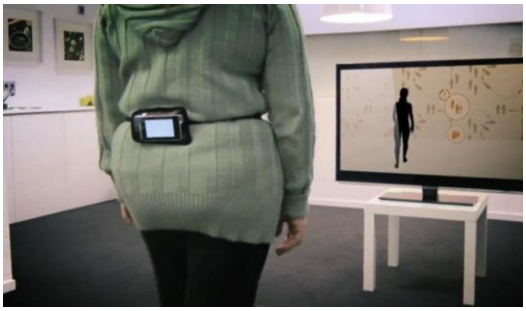

Figure 1. Dance! Don't Fall system showing both smartphone and Google TV user interfaces

2.2. Advantages and Disadvantages

The Dance! Don´t Fall system has several key advantages to other dance games, particularly for older adults. First of all, it does not require the purchase of a video game console or physical game media. Anyone who owns a smartphone meeting the minimum requirements can download and play the game at any time. Mobile phone ownership is already prevalent among older adults today, and the number of seniors with smartphones continues to grow [8]. For this audience, DDF significantly lower not only the effort but also the commitment required to try a new physical activity.

Furthermore, leveraging the smartphone as a wearable sensor provides a hands-free dance interaction that is more enjoyable than games that require the use of an external control device. In a study of a digital television exercise application for older adults, the participants generally enjoyed the exercise activities but were distracted by issues related to manipulation of the control device [6]. DDF enables users to simply concentrate on dancing.

While DDF supports dancing with others, the dances themselves cannot involve movements that are coordinated as pairs, since the system cannot distinguish multiple actors with different sets of movements. However, the authors argue that this form of group dancing is actually well-suited to older adults´ needs and preferences. A study by Keyani et al. [5] revealed that one factor preventing older adults from attending dance events is not having a partner, but group dancing similar to that supported by DDF gave users the feeling of dancing with others even though they did not have a designated partner.

3. Evaluation

The authors conducted a study with ten older adults to assess how usable and fun the game is for the target audience. The participants' ages ranged from 60-89 years, with an average age of 74.2. Eight were female and two were male. Three team members

conducted the tests: two observing and one moderating. The moderator led the tests and danced with participants in two of the tasks.

The tests consisted of five tasks comprising the most important functionalities of DDF: i) to input the personal data necessary to begin; ii) to identify the Learn mode as the first step; iii) to accept a dance invitation from the moderator; iv) to comprehend the results of the dance; and v) to invite the moderator to participate in a dance competition. Following the completion of the five tasks, one of the observers conducted a debriefing interview to inquire about the participant´s opinions of the game, in addition to background information related to health, exercise, dancing, and falls.

The overall reaction to DDF was positive, so much so that participants from one senior center subsequently requested to hold an event at the center to play the game. The study confirmed the two fundamental ideas behind DDF – that is, that falls are a serious concern for older adults (all ten participants knew someone who had fallen, while seven had fallen and been injured themselves); and that dancing is a well-liked activity among older adults (all ten participants confirmed that they enjoyed dancing). Moreover, nine of ten participants reported that they liked the game very much, while the other participant liked it somewhat but was not satisfied with the dance selection.

The study did reveal several ways to improve the game. Most importantly, the team should explore better ways to provide the user with the dance instructions. All participants focused almost solely on the silhouetted figure as they performed the dance, paying no attention to the icons on the right half of the screen that indicate the number of times to do the current step and preview the upcoming step. As a result, participants had difficulty making changes between steps and often fell behind. To improve the quality of the dance instructions, the DDF team should consult a dance instructor or choreographer in order to learn common methods for teaching and leading dances.

Another important high-level finding derived from the study is the need for embedded positive reinforcement. Throughout the tests the moderator was compelled to offer participants reassurance or praise when DDF gave low dance scores, stating that the participant had done well considering it was his or her first time playing the game. The moderator´s comments reflect the fact that DDF does not accommodate the need to first become familiar with a dance in order to perform it well. To address this problem the game should provide encouraging messages similar to those spoken by the moderator. Moreover, DDF should offer the option of playing the game without receiving an evaluation, so that users can perform dances as a trial before actually being assessed.

4. Discussion and Future Work

One methodological issue to consider is the degree of the facilitator´s involvement in the tests. Because older adults often feel apprehensive around unfamiliar technology, the moderator gave more priority to making participants feel at ease and enjoy themselves than collecting detailed numerical data. He played an active role in the tests, dancing in the competitions and offering verbal guidance when participants had difficulty following the dance. He also strayed from the script to provide helpful prompts and explanations. This was adequate for the purposes of this study, but future studies should evaluate the system with a greater precision.

Also beyond the scope of the evaluation described above is the accuracy of the fall risk assessment, as discovering whether users´ risk levels decrease would require a large-scale, medically validated study tracking the results of participants´ DDF assessments as well as standard clinical tests and questionnaires over an extended period of time. Nevertheless, future work will include technical refinements that enable the system to better detect the movements of physically impaired users, improving the accuracy of the gait evaluation. As DDF grows more robust, it has great potential for reducing the most common physical injury to adults 65 and older.

In addition to the recommendations described in the evaluation section above, the team should aim to work with an instructor or choreographer in order to adapt popular dances to DDF. A major drawback of the present system is the lack of variety. With only one song and dance option, users may lose interest before the system is effective as a long-term preventative measure. In the future the selection of songs and dances should include a range of styles and levels of difficulty. Besides keeping users interested in the game, offering more difficult dances will also encourage improvement over time and make the game appeal to users with a wider range of fitness levels.

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