Smart Gyms Need Smart Mirrors: Design of A Smart Gym Concept through Contextual Inquiry

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Abstract
Much research on smart environments has focused on homes and offices. With increasing physical inactivity and its health effects, augmenting gyms to motivate, assist and coach users to track and achieve their fitness goals is important. In this paper, we propose using smart mirrors to automatically detect and count repetitions of exercises, and to provide coaching, motivation and information to users. We present the concept and use cases, developed with 7 users (novices and fitness fanatics) through contextual inquiry, and discuss how the concept can be realized with current technologies.

Author Keywords
Smart gym concept; Smart mirrors; User interaction design.

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: User-centered design

Introduction
Research in smart environments has focused on smart homes and offices, while augmenting fitness areas such as gyms are largely unexplored. The benefits of physical activity are well documented [7] and people who attend the gym are more likely to meet recommended exercise levels and to be in better health [5]. Amateurs and self-trained gym

users may not be able to determine an appropriate exercise plan to follow or judge the correctness of their posture/form, which could lead to injury. As a first step to understanding how to support these users through a smart gym, we conducted a day of observation and interviews at a University gym in Japan with 7 users (5 male, 2 novices/irregular attendees). Participants identified 4 services (virtual coaching, body statistics monitoring, motivating/entertaining and providing information) as necessary in smart gyms, and a smart mirror was viewed as an ideal way to provide these services.

Related Work

Many works have focused on creating smart equipment to automatically recognize exercises and count the number of repetitions (reps). Sundholm et al [6] used a textile pressure sensor matrix in an exercise mat to identify 10 exercises. Similarly, Zhou et al [8] developed a wearable, textile sensor system for recognizing and counting leg exercises. Jang et al [4] developed a smart mat connected to the cloud, and lighting on the mat was used to provide spatial guidance on how to adopt the correct exercise pose.

Smart mirrors for coaching users have been studied in [2] and [3]. In [2], the FitMirror system was developed to help users get up in the morning and motivate them for the day. Iwabuchi et al [3] used a smart mirror to coach people on applying makeup easily and to make the process enjoyable.

Research Method

We observed and conducted individual semi-structured interviews with 7 University students (5 male, 2 novices) at a University gym in Japan. The main questions were: (1) Imagine a smart gym - a room filled with sensors, private and public displays for feedback and automated machines. What type of services do you want the gym to offer you, (2) What smart devices are offering these services? (3) What type of information do you want to be presented by each of the different devices and how do you want to interact with them?

Figure 1: A participant demonstrates a lateral dumbbell raise in front of a mirror and explains how a smart mirror could coach users on the error in their form (left) and help them adjust to the right form (right)

Results

Participants envisioned a smart gym would offer (in decreasing order of importance): coaching, monitoring, motivational/entertainment and information services. All participants suggested coaching, motivational and entertainment services be primarily offered via smart mirrors, while monitoring services could be provided by smart exercise equipment (dumbbells, mats etc.). Smart mirrors were deemed most preferable as their position directly in front of users would allow them to easily see information while holding different exercise poses, and users would be free to use both hands for exercise. Personal devices were only deemed preferable for displaying private information such as weight, and participants wanted the ability to individually select what information is displayed on the smart mirror and on their devices. Table 1 presents a summary of the desired features envisioned by the participants for each type of service. Figure 1 shows a participant explaining how a smart

mirror could guide on bad (left) and good (right) forms for lateral dumbbell raises.

Realizing the Proposed Smart Gym Concept

The proposed smart gym centers around a smart mirror that connects to personal smart devices such as smartphones and to sensor-enabled gym equipment. These devices need to perform: activity (exercise) recognition, error detection (user form), visualization (avatars and other game elements, currently active muscles etc.) and information display.

Several research and commercial systems addressing many of these functions have already been developed. Implementing a smart mirror for instance can be achieved by integrating several existing technologies. As shown in Fig. 2, one option is to mount a motion-sensing camera such as that on Microsoft Kinect on top of regular gym mirrors for activity recognition. Existing exercise and posture recognition algorithms such as [1] can be used, and once the exercise has been recognized, a simple database search can be conducted to obtain a description of the target muscles and similar exercises. A wide screen multi-touch monitor such as Planar Helium PCT2485, can be connected to the camera and used to provide the visualization and information and features, and for user interaction. An advantage of using Kinect is the near real-time recognition and skeletal rendering of the user's pose, which can aid estimation of incorrect form, and the ability to recognize more than one user at a time.

Overall, much of the proposed smart gym is therefore feasible with existing commercial and research systems. We propose that researchers focus on integrating these various systems to implement and evaluate prototypes of smart

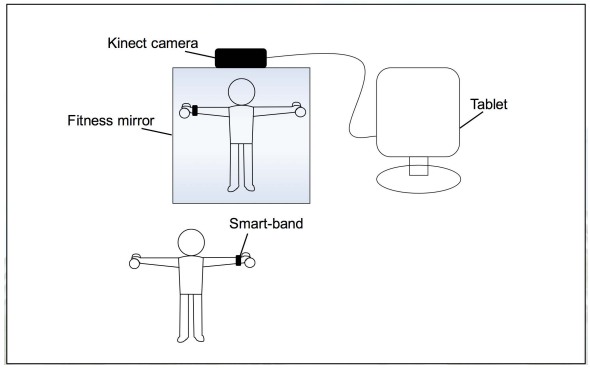

Figure 2: An overview of a smart mirror consisting of a Kinect camera connected to a wide-screen multi-touch monitor

gyms, as they are an important part of the future smart environment.

Conclusions

We proposed a smart gym concept, focusing mainly on the use of smart mirrors for coaching , monitoring and providing information, motivation and entertainment services to users. We show the feasibility of achieving prototypes of this concept and urge increased research on smart gyms.

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Type of services	Desired features
coaching	Getting technical advices from the system: • what exercises to do to achieve a goal, • how to correct form when doing the exercises, • audio-visual instructions on appropriate settings to use on electronic equipment
Monitoring	Display and monitor: • body vitals constant (Heart rate, pulse,...), • currently active muscles set and amount of contraction/extension, • caloric expenditure
Motivation & entertainment	Make the workout sessions fun by: • enabling social and gamification features • cheering up voices and encouragement words/sounds

Table 1: Desired features for each type of services

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