Home Exercise in a Social Context: Real-Time Experience Sharing Using Avatars

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Abstract. This paper reports on the design of a vision-based exercise monitoring system. The system aims to promote well-being by making exercise sessions enjoyable experiences, either through real-time interaction and instructions proposed to the user, or via experience sharing or group gaming with peers in a virtual community. The use of avatars is explored as means of representation of the user's exercise movements or appearance, and the system employs user-centric approaches in visual processing, behavior modeling via history data accumulation, and user feedback to learn the preferences. A preliminary survey study has been conducted to explore the avatar preferences in two user groups.

Keywords: Exercise monitor, avatars, pose analysis, experience sharing, social networks, user acceptance.

1 Introduction

A plethora of published research in the past years has underscored the relationship between regular physical activity and physical as well as mental well-being [15]. As a consequence of these findings, public awareness and efforts to promote exercise behavior at home and in fitness centers has considerably increased. The focus on a healthier lifestyle and on increased physical fitness has prompted people to introduce exercise programs into their daily lives. Nevertheless, while the benefits of exercise are widely known, preoccupation with career demands and other daily obligations and activities have caused difficulty for many in finding time to incorporate regular exercise at the gym or outside the home into their schedules. Exercising at home is a viable alternative, but it has two main disadvantages compared to exercising in the gym. The first disadvantage concerns the absence of human coaches that guide a person in following an effective exercise program and provide motivational and educational feedback. The second disadvantage concerns the lack of social factors that may be helpful to enhance motivation and realize commitment to previously formulated exercise intentions such as the company of other exercisers or an exercise friend.

Modern technology opens an enormous space of possibilities for enabling such coaching, motivational and social support in situations where human face-to-face contact is unavailable. Many technological solutions aimed at enriching the

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A. Nijholt, D. Reidsma, and H. Hondorp (Eds.): INTETAIN 2009, LNICST 9, pp. 19–31, 2009.

exercise experience have been developed to monitor the user's exercise behavior and physiological variables relevant for exercising (e.g., heart rate). These developments are supported with studies from the field of traditional sports and exercise psychology that showed the importance of feedback for motivation and performance [5]. In several studies, it was shown that measuring physical activity (e.g. with pedometer, activity monitor, or self-report) and providing feedback about measured activity enhances physical activity participation (e.g., [11]). Based on the literature we believe that enhancing the concept of exercising at home with interactive elements (e.g., monitoring movements and feedback) and with elements of social connectedness (e.g., connecting with a coach or other exercisers) may be a powerful way to provide the coaching and social support that motivate people to stay with their exercise routine. An important element in the overall user experience is the entertainment factor. In [14], the authors present a comprehensive survey of the area of computational entertainment with several examples spanning the concept of entertainment in ambient intelligence environments, both within and beyond the smart home.

One way to monitor and provide feedback about the exercise movements of an exerciser, while also introducing the notion of entertainment and gaming, is through the use of a real-time image processing system. A camera and a display unit can be used to build an avatar model of the user and project the model and its body movements onto a screen. This system may be used not only to give feedback about exercise motions to the exerciser, but also to share the exerciser's model with relevant others, such as a trainer/coach, an exercise buddy or a group of other exercisers in a virtual community. Depending on user preferences, the graphical model can be displayed at various levels of abstraction through an avatar, ranging from a de-personalized avatar, to a semi-personalized body model avatar, or a personalized view similar to a mirror image.

In such a system, avatars have two roles: i) offering the exerciser immediate visual feedback, and (ii) serving as a communication token that finds relevance in a social context, or where others (e.g., a coach or other exercisers) can see the avatar. In a study experimenting with the former role, it was found that people who watched an avatar that looked similar to themselves and ran on a treadmill for approximately five minutes exercised more the next day than people whose avatars weren't similar in appearance to themselves with regards to body weight, height, and age. Also, those who viewed their avatars lounging around exercised less than those whose avatars were active [3]. Displaying exercise movements through a personal avatar and sharing it with a coach or with other exercisers is expected to enhance the user's awareness of his/her appearance, body shape and movements. Therefore, the level of satisfaction with one's own appearance and body shape and the level of self-confidence about one's own exercise capabilities may impact user preferences with respect to the degree of personalization of the avatar, i.e., the degree to which the avatar reflects the bodily characteristics (i.e., appearance) of the user. Moreover, levels of preferred personalization may vary across different social contexts (defined as the groups with whom the avatar is shared). In short, we expect that user characteristics and the type of social

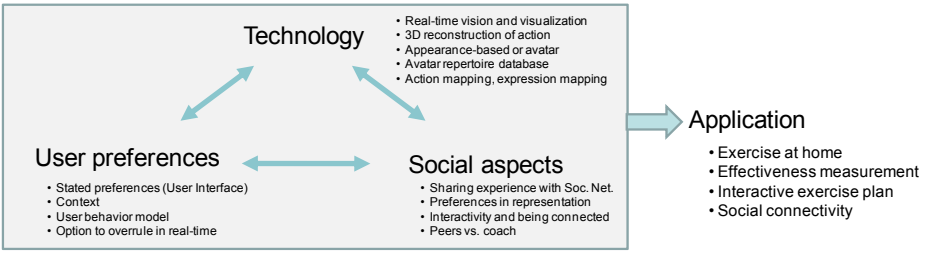


Fig. 1. Interactive design of technology based on user preferences and social aspects

context affect the preferences with respect to the level of personalization of the avatar. Therefore, it is important to gain insight into the relationship between avatar preferences and relevant user characteristics in various social contexts.

In this paper, we propose a design for a home exercise monitoring system that incorporates the notions of interaction with the user and communication with others into a real-time avatar-based representation of the user's exercise. Fig. 1 illustrates our approach to system design for this application, regarding user preferences and social aspects as important factors. In addition, this paper presents a preliminary exploration study into user preferences with respect to avatar types employed in an exercise sharing context. The system offers instructions to the user, measures the movements, and allows sharing the avatar with others, hence providing an enjoyable exercise experience.

In section 2 an overview of the user interface and vision processing modules is presented. The use of avatars as a means of visual connectedness is explained and the visualization options are described. Section 3 introduces user characteristics believed to influence the acceptance of the technology and affect the choice of visual communication through avatars. In particular, we discuss self-image/body-image and gender. We also present our study methodology aimed at gaining insight into avatar preferences by users, and discuss the results of user study surveys conducted with different age groups on the avatar-based exercise experience. Section 4 offers some concluding remarks.

2 Exercise Monitoring System

In order to realize a home exercise system that allows for visual feedback of the user's movements and the possibility of sharing these movements in a social network setting, we need to consider: 1) technology for monitoring the body and the body movements of the exerciser, and 2) possibilities to display the monitored data in a user-friendly way. The system is composed of an interactive module that detects the user's gesture and measures the exercise actions in real-time, and a communicative module that transmits a visual representation of the user to others according to the selection of avatar graphics made by the user. Fig. 2 illustrates the relationship between the different components of the system.

The use of camera and computer vision technology presents a wide scope of possibilities for monitoring the user during exercising. Video taken of the user

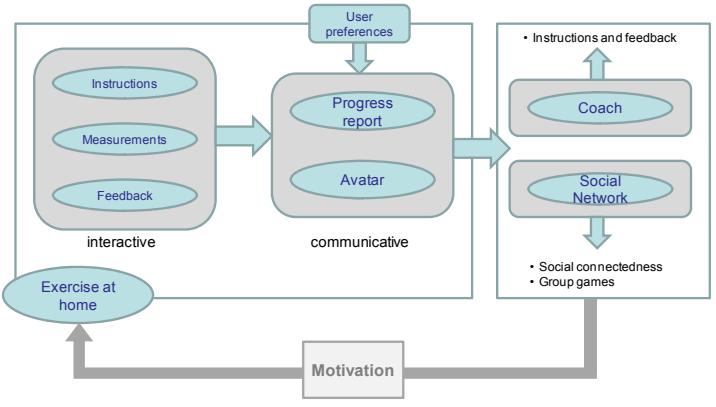


Fig. 2. The overall system block diagram showing the interactive gesture analysis module and the communicative module connecting the user to the outside world. Social connectedness provides further motivation for exercising.

by a camera as he performs exercises can be displayed to him in real-time as a simple means of visual feedback. Such video can be processed locally to extract measurements of the user's body movements such as the number of repetitions and the relative position of joints. In addition, the actions of the exerciser can be mapped onto an 3d model displayed through an avatar in real-time, allowing the user to receive visual feedback which may be augmented with annotations related to the performance or deviations from the ideal routine. The processing involves methods of human pose and gesture analysis. Such methods which are based on extracting positions of the body joints as the user movements are registered between video frames have been reported extensively in the literature [4,16,17,19,20]. Multi-camera implementations in real-time using embedded

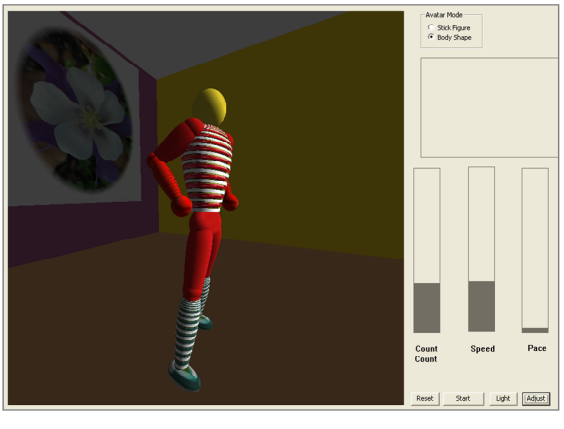


Fig. 3. The interactive module of the system offers measurements such as count, speed, and pace of specific exercise routines

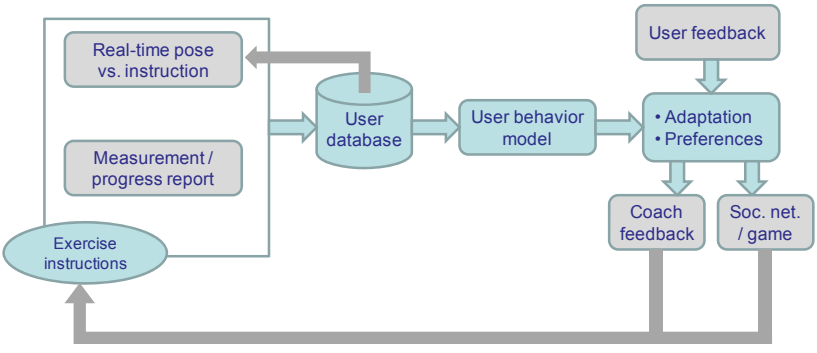


Fig. 4. Schematic overview of the employed mechanisms: pose analysis, behavior modeling, user preference assessment, and creation of exercise instructions

processing have also been reported, for example in multi-player games with networked cameras [25].

The pose estimation output is used to map the user's actions onto an avatar, while analytic measurements are also obtained from the observations. Fig. 3 displays a screen shot of an exercise plan in which the measurements of the count, speed, and pace of the exercise are recorded in the interactive module.

2.1 System Design

The design employs several mechanisms based on the observations and specific behavior models and explicit input from the user. These methods are illustrated in Fig. 4 and briefly described in this section.

Pose estimation: The system suggests an exercise routine to the user, which is displayed on an avatar for the user to follow. The user's pose is detected via a silhouette matching operation using banks of saved silhouettes (see Fig. 5). The knowledge of the specific exercise action being suggested to the user is employed

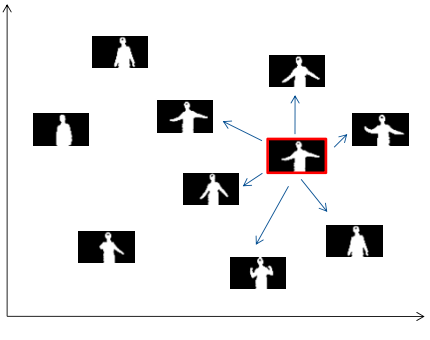


Fig. 5. User's pose is detected using a database of silhouettes accumulated from the user

as prior knowledge to limit the search for matching silhouettes. This yields a processing efficiency gain, enabling a real-time markerless vision-based operation. The silhouettes are created and collected for each exercise routine based on a two-layered method. A generic set of silhouettes is created and embedded in the system for each exercise routine. Then, at the initialization stage of the system the user is asked to follow a simple exercise action through which the system captures the observed silhouettes from the user and builds up a user-specific silhouette set. This silhouette set is used to perform matching in the subsequent instances of the same exercise routine, and the system updates and refines the user silhouette bank for the exercise over time.

Behavior model: The system measures and stores the analytics of the exercise in a database. These include the frequency, duration, pace, and other numeric measurements obtained by visual processing of the exercise and the progress made for each specific routine. The behavior model is used to keep a progress report and to suggest further exercise routines aligned with user's progress. The behavior model also maintains the history of the exercise plan which can be accessed by the user or by a trainer if the user opts for that. Further application of the accumulated data from the user is the subject of our on-going development.

User feedback: The system inquires from the user about the preferences both in the exercise content and in the mode of communication with the outside world. The user's choice of the exercise level and the pace of advancing to higher exercise levels can be adjusted by a simple menu, and the mode of communication offers a choice between sharing the mirror image, a semi-personalized body shape avatar, and a de-personalized, skeletal avatar.

2.2 Representation by Avatars

The experience of the user is determined partly by the graphical representation that is communicated to the user and to the user's social network. Privacy issues as well as cognitions and confidence regarding body image and comfort of exposing one's self to other people may impact a user's willingness to use personal avatars as a visual representation both when exercising alone or in a social context.

The use of avatars has been studied extensively within the domain of virtual communities. Avatars can range from imaginary to realistic, depending on the application, system design and user preferences. The most popular use of avatars has been on instant messaging services in cyberspace. People can use avatars to build their own different identity [7,8]. More recently, the use of avatars has been considered for virtual reality applications such as Second Life (www.secondlife.com) [1] and Qwaq Forum (www.qwaq.com) [24]. Fitness applications for avatars have also been explored to motivate healthy practices by creating and keeping track of a body model avatar online.Interactive avatar applications for exercising have appeared based on devices held by or attached to the body of the user. Gaming platforms such as the Nintendo W*iiFit*^{TM} have been used for interactive exercise sessions involving the display of an avatar [18].

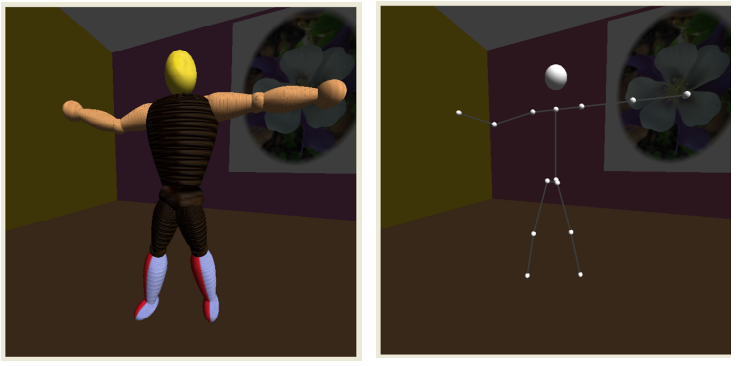


Fig. 6. The user can select a semi-personalized (muscle model) avatar or a de-personalized (skeletal model) avatar for sharing with the social network

The communication function of avatars is most relevant in a social context where others can see the avatar. Considering the identity-expressive properties of an avatar, we expect that avatar preferences vary with certain user characteristics as discussed in section 3. In the context of exercise monitoring applications, it is expected that the use of an avatar and the preferences for the type of avatar become specifically relevant when others (coach, exercising friends) are watching.

In our development, 3 types of representations are available to the user:

- Mirror image (raw video with optional superimposed annotations)
- Semi-personalized avatar (called body shape or muscle avatar)
- De-personalized avatar (called skeletal or stick figure avatar)

Fig. 6 displays examples of the muscle model and skeletal model avatars. The avatars are displayed in a three-dimensional room and the system offers the following flexibilities and selections for the avatar appearance as well as the appearance of the room:

- The viewing angle to the avatar can be set by the user or changed during the session (Fig. 7).
- The user can choose various clothing colors and preset textures for the muscle model avatar (Fig. 7).
- Based on the user input the system can represent the muscle model avatar with body size and proportions reflecting those of the user. The body part proportions can be individually set or a whole body configuration can be selected from a set of sizes from skinny to muscular (Fig. 8).
- The virtual room can be decorated with wall posters and different lighting backgrounds by the user (Fig. 7).

2.3 Current State and Work in Progress

The system operates in real-time on a laptop computer equipped with a regular webcam at the VGA resolution. Operation runs at around 15 frames per second.

Fig. 7. The user can select various clothing configuration for the avatar. The viewpoint, lighting condition, and wall posters can also be set by the user.

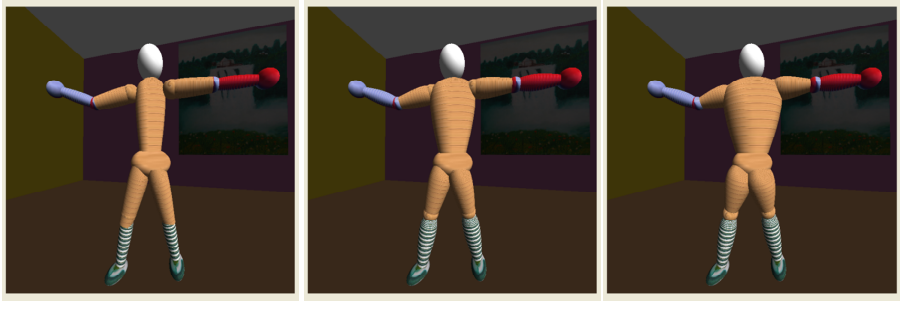


Fig. 8. The body size and proportions of the avatar can be selected by the user or be set to reflect the user's build or fitness indexes such as BMI and WHR

The existing exercise set involves upper body movements, while on-going work consists of embedding several exercise routines in the silhouette database bank, extending the analysis to full body, and the mapping of user's body proportion and fitness information such as body mass index (BMI) and waist-to-hip ratio (WHR) values. The current vision processing for gesture extraction is based on a single camera, restricting the type of the exercises to those occurring in a plane parallel to the image plane. Although an extension to a multi-camera setup may allow more complex exercise routines, the complexities associated with installation, calibration and processing load may introduce disadvantages in home-based applications. A stereo camera system may offer a compromise, and is the subject of further development.

3 Preliminary User Preferences Study

The study entails an initial exploration into user preferences for the degree of personalization of the graphical image (avatar) across different social contexts. It is expected that user characteristics impact these preferences as well as the acceptance of the technology and willingness to use it in the home. The user

characteristics that may play a role in shaping these preferences include self-image/body-image (including social physique anxiety (SPA)), personality traits (extraversion, openness), age, self-confidence, self-efficacy, and gender. For our current explorations we focus specifically on self-image/body-image (in particular level of SPA) and gender, to observe preference trends for avatars in different social contexts. We briefly describe the role of these characteristics in influencing user preferences.

Self-image is the way in which a person perceives himself, either physically or as a concept. Self-image has important implications in a person's self-esteem and confidence.Body-image is the feeling a person has specifically about his physical appearance.Related to body-image is the concept of social physique anxiety (SPA). SPA indicates how anxious an individual may be about his body when around others. Although related to self-image and self-esteem, SPA is different in that it is the comfort level of an individual when there are others present. In an experiment regarding social physique anxiety and exercise behavior, it was found that individuals with high SPA were less likely to participate in exercise in situations where their bodies could be criticized [12]. Lantz's results may imply that an individual with high SPA will feel uncomfortable exercising in a social environment where others can see his physique. Such an individual may for example not feel comfortable sharing his mirror-image avatar with a coach or exercise friends.

Several studies have shown that men and women can differ in motivation and reasons to exercise, body perceptions and cognitions, and willingness to engage in competition and comparison with others [2,10,13,21,22]. While these factors may be indicative of gender differences in preferences for the avatar type, no study we know of has directly assessed gender differences in avatar preferences in the field of exercise. However, several studies have examined the correlation between gender and avatar preferences in the context of communication in virtual communities. For example, in a study about the use of avatars in computer-mediated communication, females were more likely to use avatars that were less similar to themselves, whereas males didnt mind using avatars that were somewhat representative of reality [8].

3.1 User Survey

While many types of user characteristics may affect a user's avatar preferences in various social contexts, the survey in this work focuses on the relationship of avatar preferences with gender and body-image (in particular level of SPA). We would like to explore to what extent preferences for avatar type and avatar privacy in the exercise monitoring application vary with gender and level of SPA.

For our survey, we included questions inquiring about user preferences for three types of avatars: skeletal "stick-figure", body-shaped "muscle", and mirror-image. The questions related to the degree of acceptance for sharing each avatar type with a coach, peers in the user's network, and other unknown people. Factors such as enjoyment, comfort, and helpfulness of using an avatar when exercising were also included in the questionnaire.

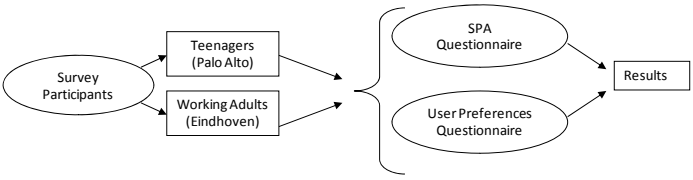
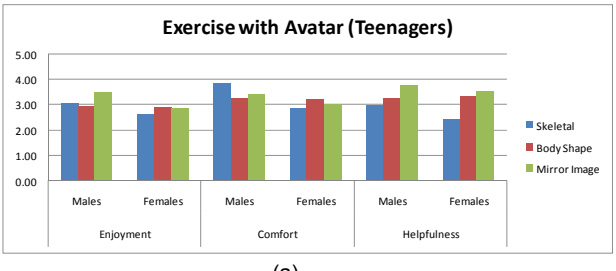


Fig. 9. Components of the user preference survey

We administered an anonymous survey to males and females of two different age groups, namely high school students in California and working adults in the Netherlands. The survey introduced the exercise monitoring project and provided the participants with images of the three types of avatars. Survey takers then proceeded to answer questions rating their view of each type of avatar to see, to share with a coach, exercising friends, or others. Then, we measured their SPA using the 12-point SPA questionnaire [6]. Fig. 9 illustrates the components of the survey.



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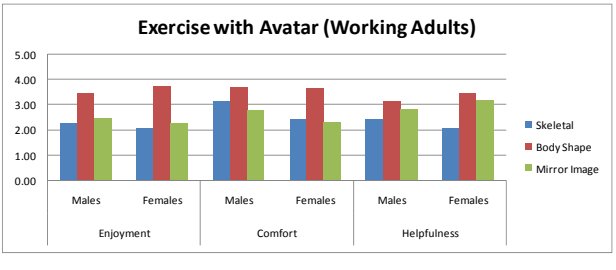


(b)

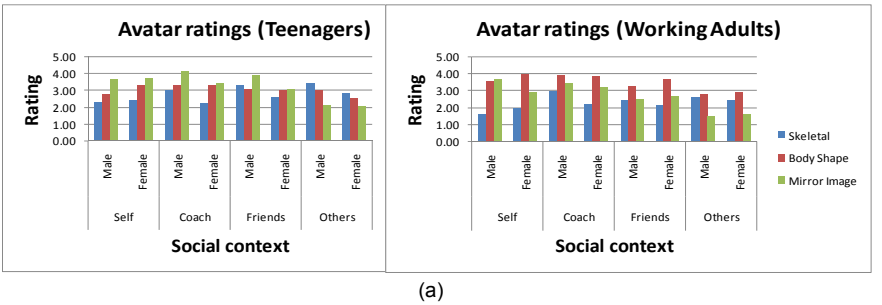
Fig. 10. Opinions on exercise with avatars in different survey groups

3.2 Survey Results

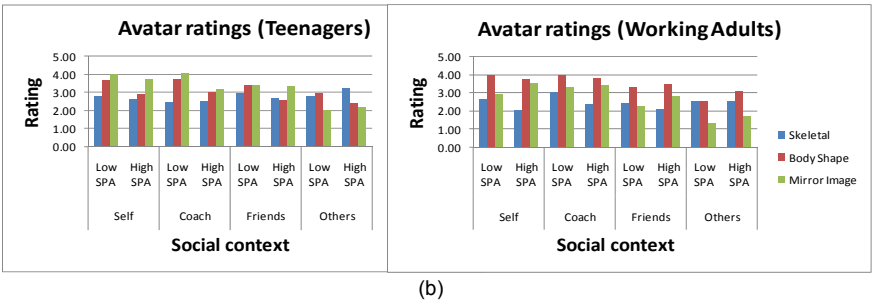
A summary of the survey results is presented in the graphs of Figs. 10 and 11. The most significant observation from these results is the noticeable preferences in the Working Adults group for the body shape (muscle model) avatar, while the interest in the Teenagers group is on the mirror image followed by the body shape

avatar. Skeletal avatar receives favorable views only when sharing the exercise experience with unknown others. Other observations from the graphs include:

- Males have a more favorable view of the skeletal avatar than females (Fig. 10).
- Males more easily share mirror image avatar with coach and friends than females (Fig. 11(a)).
- Males and females have somewhat similar view of body shape avatar (Fig. 10).
- Body shape avatar is preferred over skeletal avatar when sharing avatar with coach and friends (Fig. 11(a),(b)).
- Mirror image is not favored when sharing avatar with unknown others (Fig. 11 (a),(b)).
- Skeletal avatar is least preferred except for when sharing with unknown others (Fig. 11(a),(b)).
- Among high SPAs, body shape avatar is more preferred in Working Adults sample than in Teenagers sample (Fig. 11(b)).
- Among high SPAs, skeletal avatar is more preferred in Teenagers sample than in Working Adults sample (Fig. 11(b)).



(a)



(b)

Fig. 11. Avatar type preferences in different survey groups

4 Conclusions

Experience sharing has been a driving force for many of today's social networks applications. As interesting a real-time connectedness concept involving visualization of participants might sound, venturing to develop such a technology calls for a careful system and interface design that closely registers and follows the

user preferences for representation and privacy. The work reported in this paper aims to address such a design. An important design element concerns the user's preferences with respect to an avatar through which exercise behavior can be communicated to the user and to peers. Also the avatar can be shared with a coach to receive feedback. This is supported by other system elements, which employ vision to extract the user's pose in real-time, and offer instructions based on history, as well as group gaming options to the user.

References

1. Bell, L.: Who's on third in second life? Online Magazine (July/ August 2007), http://basie.exp.sis.pitt.edu/1904/1/Who's_On_Third.pdf (Retrieved December 31, 2008)
2. Bowden, R., Lanning, B., Irons, L., Briggs, J.: Gender comparisons of social physique anxiety and perceived fitness in a college population. Research Quarterly For Exercise and Sport 73(1), 87 (2002)
3. Dell, K.: How second life affects real life. Time Magazine (2008), http://www.time.com/time/health/article/0,8599,1739601,00.html (Retrieved January 1, 2009)
4. Dimitrijevic, M., Lepetit, V., Fua, P.: Human body pose detection using Bayesian spatio-temporal templates. CVIU (104), pp. 127–139 (2006)
5. Hagger, M.S., Chatzisarantis, N.L.D.: Intrinsic Motivation and Self-determination in Exercise and Sport. Human Kinetics, Champaign, IL (2007)
6. Hart, E.H., Leary, M.R., Rejeski, W.J.: The measurement of social physique anxiety. Journal of Sport and Exercise Psychology 11, 94–104 (1989)
7. Jordan, T.: Cyber Power: The Culture and Politics of Cyberspace and The Internet. Routledge, New York (1999)
8. Kang, H., Yang, H.: The visual characteristics of avatars in computer-mediated communication: Comparison of Internet Relay Chat and Instant Messenger as of 2003. International Journal of Human-Computer Studies 64, 1173–1183 (2006)
9. Kilpatrick, M., Bartholomew, J., Riemer, H.: The measurement of goal orientations in exercise. Journal of Sport Behavior 26, 121–130 (2003)
10. Koivula, N.: Sport participation: Differences in motivation and actual participation due to gender typing. Journal of Sport Behavior 22, 360–381 (1999)
11. Lacroix, J., Saini, P., Homles, R.: The Relationship between Goal Difficulty and Performance in the Context of a Physical Activity Intervention Program. In: Proc. of the 10th Int. Conf. on Human-Computer Interaction with Mobile Devices and Services (MobileHCI) (2008)
12. Lantz, C.D., Hardy, C.J.: Social physique anxiety and perceived exercise behavior. Journal of Sport Behavior 20, 83–93 (1997)
13. Martin Ginis, K.A., Prapavessis, H., Haase, A.M.: The effects of physique-salient and physique non-salient exercise videos on women's body image, self-presentational concerns, and exercise motivation. Body Image 5, 164–172 (2007)
14. Nijholt, A., Reidsma, D., Poppe, R.: Games and Entertainment in Ambient Intelligence Environments. In: Aghajan, H., Delgado, R.L.-C., Augusto, J.C. (eds.) Human-centric Interfaces for Ambient Intelligence. Academic Press, London (2009)
15. Penedo, J.R., Dahn, F.J.: Exercise and well-being: A review of mental and physical health benefits associated with physical activity. Current Opinion in Psychiatry 18, 189–193 (2005)

16. Rittscher, J., Blake, A., Roberts, S.: Towards the automatic analysis of complex human body motions. Image and Vision Computing (12), 905–916 (2002)
17. Robertson, C., Trucco, E.: Human body posture via hierarchical evolutionary optimization. In: British Machine Vision Conference, vol. III: 999 (2006)
18. Schiesel, S.: O.K., avatar, work with me. New York Times (2008), http://www.nytimes.com/2008/05/15/fashion/15fitness.html (Retrieved December 31, 2008)
19. Sigal, L., Black, M.J.: Predicting 3d people from 2d pictures. In: Conference on Articulated Motion and Deformable Objects, Mallorca, Spain (2006)
20. Sminchisescu, C., Triggs, B.: Kinematic jump processes for monocular 3d human tracking. In: Computer Vision and Pattern Recognition, Madison, USA (2003)
21. Smith, A.: Measurement of social physique anxiety in early adolescence. Med. Sci. Sports Exerc. 36, 475–483 (2004)
22. Sorgen, C.: His and hers fitness (2004), http://www.webmd.com/fitness-exercise/guide/his-hers-fitness (Retrieved July 11, 2008)
23. Taylor, A.: Gender differences in exercise motivation. Tarleton Journal of Student Research 1, 18–23 (2006)
24. Vesperini, E. (ed.): Virtual laboratories and virtual worlds. International Astronomical Union, Princeton (2008)
25. Wu, C., Kleihorst, R., Aghajan, H.: Real-time human posture reconstruction in wireless smart camera networks. In: Information Processing in Sensor Networks St. Louis, USA (2008)