Virtual Human Physiotherapist Framework for Personalized Training and Rehabilitation

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1 Motivation and Related Works

For patients recovering from injuries, or individuals that require a system to provide feedback on aspects of exercise performance, physical therapy sessions with a professional trainer can be expensive and inconvenient. In addition, privacy might be an issue for some patients who are not comfortable closely interacting with strangers. Nonetheless, personalized feedback and monitoring of the individual's performance on a specific exercise routine is crucial for faster rehabilitation and effective training. Moreover, improper training may even lead to injury.

We present a framework that employs a Virtual Human Physiotherapist (VHP) towards personalized training and rehabilitation. The VHP is an inexpensive alternative to training with a real person. Using a virtual human for training allows the user to train on their own schedule and in the privacy of their own homes. In addition, the gender, race and age of the virtual human can be altered to match the needs of the user, making the user more comfortable in interacting with the VHP. Finally, the VHP provides a uniform and accurate training experience. Unlike real people, virtual humans are not affected by 'having a bad day' or being tired. The VHP is always happy and ready to assist the user in training for a particular exercise. There is also no limit on the amount times the user can repeat an exercise.

Researchers have shown that a virtual human interface can provide feedback to individuals using a variety of verbal and non-verbal behaviors. Anecdotal evidence suggests that human communication consists of a high bandwidth of several modalities such as gestures, facial expressions, speech, and body language [1]. In addition, researchers have found that demonstrating a task can be far more effective than trying to perform it, especially when that task involves spatial motor skills [2]. Using a virtual human interface minimizes the need for training users, since they already know how to interact with other people [1]. Finally, Zanbaka, *et al.*, found that people respond to virtual humans similarly to the way they respond to real humans. The authors were able to elicit social inhibition from female participants, using a virtual human [3].

Virtual humans have already been used in training. Slater, *et al.,* examined the use of virtual humans by actors and a director to rehearse for a live performance and found that a performance level was reached in the virtual rehearsal which led to a successful live performance, one that could not have been achieved by only learning of lines or video conferencing [4]. Virtual humans are also being used to allow medical students to experience the interaction between a patient and a medical doctor using natural methods of interaction with a high level of immersion [5]. At UNCC, a VR training tool for nursing students is being developed which will allow a nurse to verbally interview, observe, and examine a digital patient similar to the way she would interact with a real patient [6]. Researchers at Carnegie Mellon University have developed a virtual reality Tai Chi training application where the user is able to observe and mimic the presented virtual character of a Tai Chi master. However, the system does not give automatic feedback. The accuracy of the user's body position is determined only by the user's own perception of the virtual character [7].

2 System Framework

The VHP framework uses the Straps system which enables the tracking and recovery of 3D position of color markers in the scene [8]. The color markers are used in order to obtain skeletal joint position of the user. The color markers were placed in the positions on the exercising arm and shoulders of the user. The proof-of-concept exercise used in VHP is the bicep-curl. Figure 1 shows the position of the color markers on the user's body which were tracked by the Straps system. The Straps system sends skeletal joint position information of the user to the rendering and animation component of the VHP framework.

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The rendering and animation component of the VHP framework uses the Haptek virtual human authoring tool for Virtual Human animation and rendering. At the start of the program the virtual human (Diana) shows the user how to perform the bicep curl in a frontal and lateral pose (Figure 2). Diana then requests the user to perform the exercise for a period of thirty seconds while she monitors the user's performance. After thirty seconds Diana provides verbal and non-verbal feedback to show how the user performed the exercise. If the user performed the exercise correctly then Diana commends the user's performance. However, if the user does not perform the exercise correctly, then Diana shows what the user did incorrectly and shows how the exercise should be carried out in the right posture. She then asks the user if he wishes to repeat the exercise.

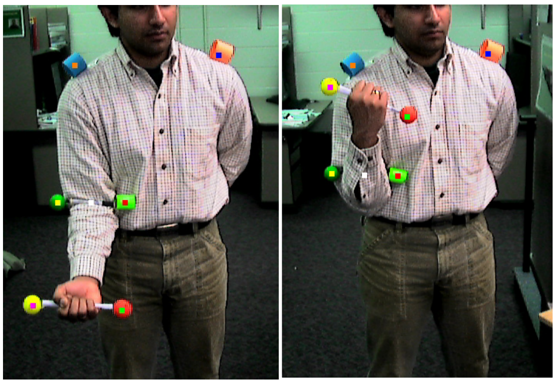

Figure 1: Shows the position of the tracked color markers to detect user's torso and arm exercise posture.

Figure 2: From left-to-right shows screen shots of Diana performing the exercise to show the user the correct torso and hand posture.

The decision component of the VHP framework uses a discourse model that consists of a sequence of interaction states and the appropriate predefined verbal and non-verbal responses of Diana for each event. This model is pre-scripted and is loaded for each exercise. The decision component of the framework also detects if the user is performing the exercise properly. This is done through the classification of the 3D position data pertaining to the color markers denoting the user's posture provided by the Straps system. The user's exercise posture for the bicep-curl is classified into six error states based on deviations of the user's torso and hand posture from the predefined correct exercise posture.

3 Summary and Future Work

The VHP enables users to accurately and inexpensively perform physical therapy exercises in the comfort and privacy of their own homes. It also allows users to work on their own schedule and gives them the flexibility in choosing the ethnicity and gender of the virtual trainer.

In the future, we would like to make the VHP framework extensible and add more exercises. We would also like to automatically capture new exercises by extracting the motion data from a professional performing the exercise. Finally, we plan to evaluate our system by comparing it to training with a real physical therapist through a controlled user study.

References

[1] Cassell, J., Sullivan, J., Prevost, S., and Churchill, E., (eds.), *Embodied Conversational Agents*, MIT Press, Cambridge, MA, 2000.

[2] Johnson, W. L., and Rickel, J. Steve: An animated pedagogical agent for procedural training in virtual environments. *SIGART Bulletin,* vol. 8, pp. 16 – 21, 1998.

[3] Zanbaka, C., Ulinski, A., Goolkasian, P., Hodges, L. F. Effects of Virtual Human Presence on Task Performance. *Proceeding of the International Conference on Artificial Reality and Telexistence (ICAT)*, pp. 174-181, 2004.

[4] Slater, M., Howell, J., Steed, A., Pertaub, D-P., Garau, M., and Springel, S. Acting in Virtual Reality. *ACM Collaborative Virtual Environments (CVE'2000)*, pp. 103-110, 2000.

[5] Johnsen, K., Dickerson, R., Raij, A., Lok, B., Jackson J., Shin, M., Hernandez, J., Stevens, A., Lind, D. S. Experiences in Using Immersive Virtual Characters to Educate Medical Communication Skills. To Appear in Proceedings of *IEEE Virtual Reality 2005 (VR 2005).*

[6] Ziemkiewicz, C., Ulinski, A., Zanbaka, C., Hardin, S., Hodges, L. F. Interactive Digital Patient for Triage Nurse Training. To appear in the Proceedings of the *First International Conference on Virtual Reality*, Las Vegas, Nevada 22 - 27 July, 2005.

[7] Chua, P., Crivella, R., Daly, B., Hu, N., Schaaf, R., Ventura,D., Camill, T., Hodgins, J., and Pausch, R. Training for Physical Tasks in Virtual Environment. In Proceedings of *IEEE Virtual Reality 2003*, pp. 87-94.

[8] Jackson, J., Lok, B., Kim, J., Xiao, D., Hodges, L.F., Shin, M.C. Straps: A Simple Method for Placing Dynamic Avatars in an Immersive Virtual Environment. *Technical Report, Future Computing Lab*, University of North Carolina at Charlotte, Feb, 2004.