INTERACTIVE VIEWING OF SIMULATED AERIAL MOVEMENTS

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An 11-segment computer simulation model of aerial movement was used to generate a set of configuration and orientation angles for a double straight somersault with a full twist in the second somersault (back-in full-out). Computer graphics were generated in real-time using OpenInventor from a virtual head-mounted camera and were rendered at 50 Hz to a Trivisio 3scope stereo Head Mounted Display worn by the user to give a trampolinist's view. Changes in orientation of the user's head in the real world were detected by a 3D-Bird sensor and were reflected in real-time movements of the head of the virtual trampolinist. The system allowed continuous repetition of the trampoline skill and was tested by several elite gymnasts who learned the correct head movement at a reduced speed before increasing to half actual performance speed.

KEY WORDS: simulation model, virtual reality, interactive viewing, aerial movement

INTRODUCTION: A competitive trampoline routine comprises 10 consecutive skills for which achieving an appropriate landing in preparation for the following skill is a crucial aspect for successful performance. Individual trampoline movements are also used as apparatus dismounts from high bar, rings, vault and floor in artistic gymnastics and in the aerials event in freestyle skiing. To make appropriate changes in body configuration during flight in order to make adjustments to somersault and twist rotations it is of advantage to perceive orientation throughout each skill by viewing the trampoline for the majority of each flight phase. To do this it is necessary to phase the twist appropriately within the somersaulting motion and to adjust the head position continuously and to look in the correct direction. In trampolining this orientation is usually learned as an integral part of a sequence of progressive movements leading up to the final skill. In artistic gymnastics and aerial skiing such progressions are often curtailed or absent since the intermediate landing positions on the back or front are not available unless the twisting somersault is learned on trampoline. As a consequence the correct head movement and viewing strategy may not be developed as easily in these sports. Learning the appropriate head movement during an actual performance of the complete skill is complicated by the competing need to attend to other technical aspects of a twisting somersault. This paper describes a system for learning to view a given skill independently of performance in a virtual environment using computer simulation and interactive computer graphics.

METHODS: An 11-segment simulation model of aerial movement (Yeadon et al., 1990) was used to produce a hypothetical simulation on trampoline of a double straight somersault with a full twist in the second somersault (Figure 1). The twist was produced using asymmetrical arm abduction in the flight phase (Yeadon, 1993) and was phased within the somersault so as to reach the one quarter twist position after the first somersault. This orientation allows a view of the trampoline by looking "down" during the first half twist and looking "up" during the second half twist. The inertial parameters for the simulation model were calculated from the anthropometric measurements of a world trampoline champion (Yeadon, 1990). The input for the simulation comprised the initial body orientation and configuration together with the angular momentum about the mass centre. The output comprised the pelvis location, orientation angles describing somersault, tilt and twist together with three configuration angles at each of 10 joints at intervals of 0.01 s. This output file was modified manually so as to correspond to realistic movement during contact with the trampoline bed at the start and end of the simulation.

Figure 1: A simulated double straight somersault with a full twist in the second somersault (back-in full-out); (a) end view without mass centre displacement, (b) side view with extra horizontal displacement.

Computer graphics were generated in real-time from a fixed external camera position and from a virtual head-mounted camera using an OpenInventor graphics system running under X11 using the SoXt toolkit allowing earlier work on rendering and tracking to be used to give both spectator and trampolinist views. The virtual environment comprised a trampoline with end mats within a room with walls and ceiling of various colours to aid the perception of orientation. Changes in orientation of the user's head in the real world were detected by a 3D-Bird sensor from Ascension Technology Corporation (Figure 2a) using a custom written Linux driver and were reflected in real-time movements of the head of a virtual trampolinist. The internal trampolinist's view was rendered at 50 Hz to a Trivisio 3scope stereo Head Mounted Display (Figure 2b) worn by the user and connected via a splitter to the VGA output on the PC. The system was developed on a Dell Precision 650 workstation with a 2.8GHz Xeon processor, 2GB of RAM and an Nvidia Quadro4 900 XGL graphics card running under Linux using custom software written in C++ and Perl with displays of both spectator and user views on two screens. The system was also implemented on a Pentium 4 based laptop to give portability. To allow the system to make use of multiple streams of data simultaneously, the application and the Linux driver for the 3D Bird sensor were designed to be threaded using the "pthread" POSIX compatible threads library, which is supplied with most Linux distributions to allow multiple execution strands within a single process image.

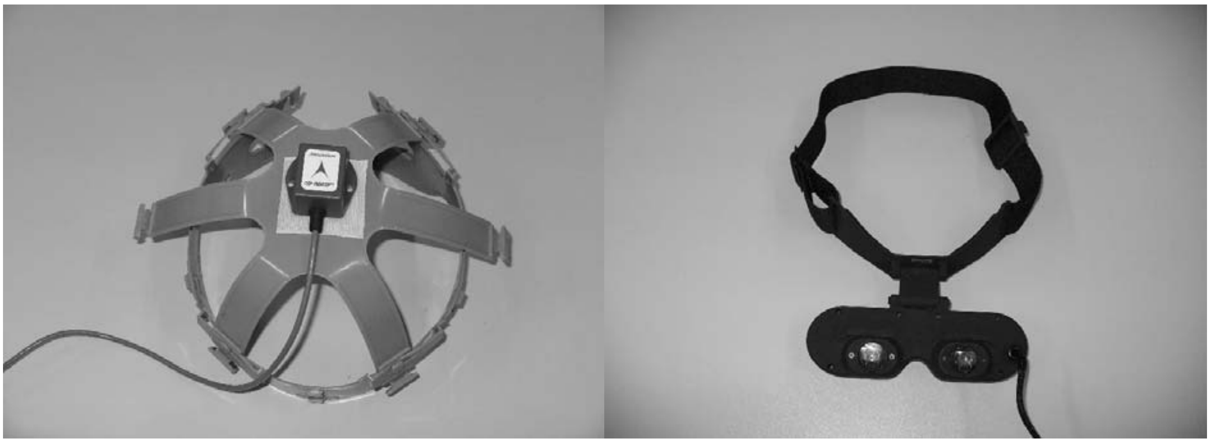

Figure 2: (a) head orientation detected using 3D-Bird sensor, (b) Trivisio 3scope Head Mounted Display

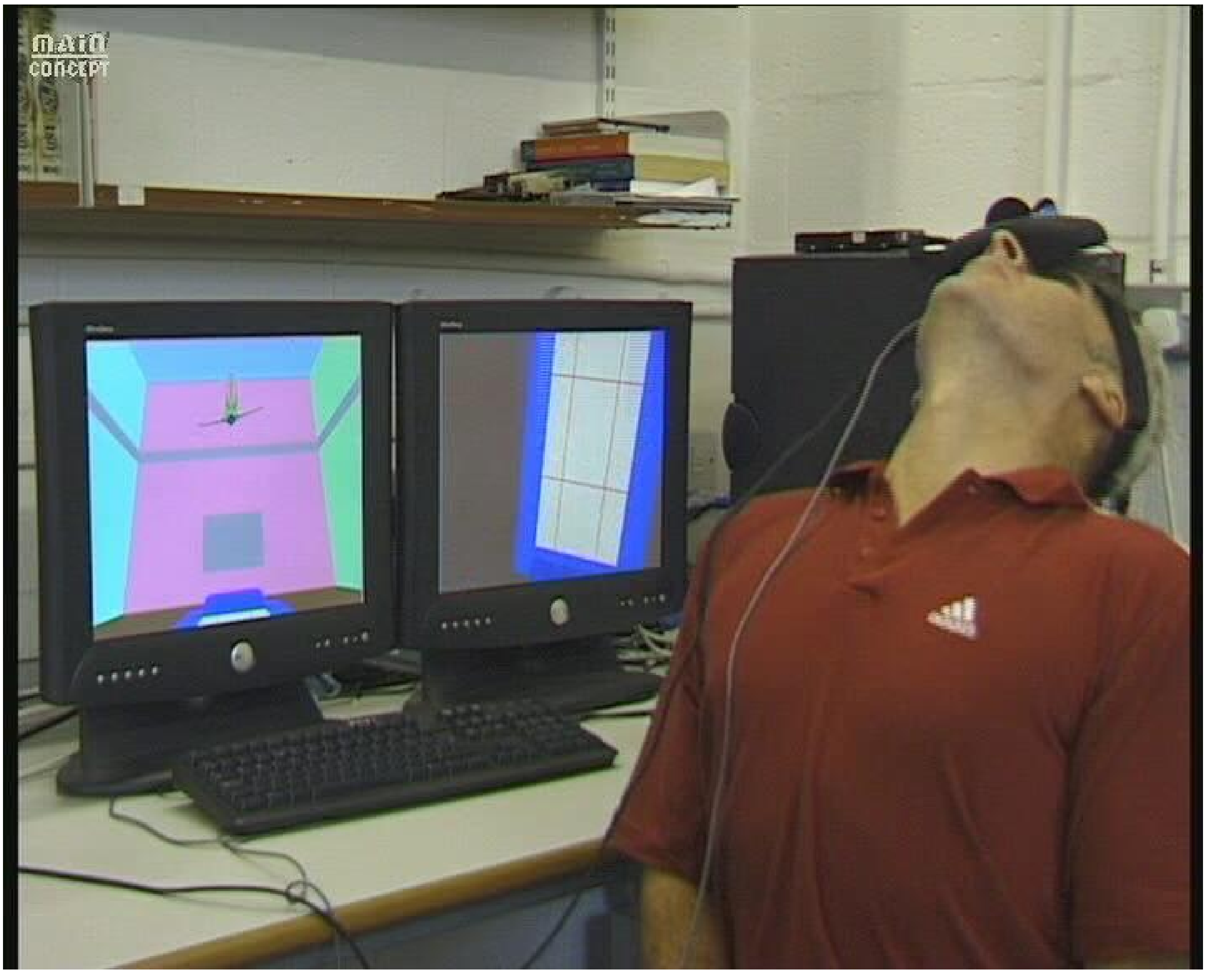

Figure 3: Use of the head mounted display by a former elite gymnast with viewpoints of trampolinist and spectator displayed on computer screens.

RESULTS: Tests were made to see if a single virtual camera view was acceptable or if separate left and right eye views had to be generated. Several elite gymnasts found the "cyclops" view usable, so the system was implemented with a single virtual camera mounted at eye level in the middle of the virtual head, the rendered output being fed to both eyepieces of the Head Mounted Display. This cut down on rendering overheads and allowed the display of both the trampolinist and the spectator virtual camera views (Figure 3) on separate monitors with the development platform using the dual headed Nvidia Quadro4 900 XGL graphics card. The system was also run successfully on a Pentium 4 based laptop which provided system portability. The images were displayed at 50 Hz without frame dropout or decrease in expected speed when only the trampolinist's view was displayed giving a time of four seconds for each cycle of the twisting somersault which corresponded to half of real speed but was sufficiently fast to feel realistic. Running the movement at slower speeds allowed the viewing movements to be learned comfortably. Once the viewing strategy had been practised it was possible to increase to higher speeds with the user still maintaining tracking. The system was well-received by elite gymnasts who rated it as helpful, realistic and useful. One gymnast who had learned an unsighted back-in full-out straight dismount from high bar used the system to view the skill prior to successfully relearning the dismount with full sighting throughout.

DISCUSSION: This virtual reality system shows the potential of learning motor control skills in an environment that is free from the confounding influence of additional demands of skill performance and safety. In the future it is planned to extend the system to allow free simulation of aerial movement in which arm and leg movements are monitored and are used to drive the simulation in real-time. This will allow the user to produce aerial twist in a somersault by means of asymmetrical arm or hip movement (Yeadon, 1993) and to adjust somersault and twist rotation prior to virtual landing on the trampoline. As a consequence complex skills could be learned safely and quickly in a virtual environment before being attempted in training.

CONCLUSION: This virtual reality system has the potential to enable faster learning of the correct head movement and viewing strategy for maintaining orientation in twisting somersaults. Areas of application include trampolining, tumbling, artistic gymnastics, diving and freestyle aerial skiing.

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