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ABSTRACT

Parachute simulation originated to solve the dilemma of providing safe training for a hazardous activity, specifically smoke jumping for firefighting. This idea was quickly adapted for training aircrew, who have far less jump options and may face even more critical situations. As the simulation concept evolved, enhancements were made to address the needs of other applications, such as sport jumping, arcade and theme park entertainment, operational military training, mission planning and rehearsal including GPS navigation.

This progress has in turn been applied to improving aircrew training. This paper details recent enhancements as they pertain to teaching skills for emergency parachuting and lessons learned during their application by aviation physiology, life support, and survival training organizations.

INTRODUCTION

This paper discusses improvements to a virtual reality parachute descent training device that has been described previously[1-4]. This training device was originally developed for smokejumpers, but was soon adapted for aircrew emergency training[5, 6]. The design of the training device has evolved considerably in response to aircrew training needs[7, 8], and recent improvements to the device and training methodology are discussed herein.

Simulator and Training Enhancements from Other Applications

SmokeJumper

The USDA Forest Service (FS) had the classical training problem with their smokejumpers (civilian fire fighting parachutists operating round parachutes in extremely difficult conditions): jumpers were being hurt in training injuries, but there would be more injuries if training were not provided. The earliest versions of the simulator were developed to solve this problem. In particular, the USDA FS sought this device to train for an emphasis on smooth controls handling, a concern shared equally with aircrew emergency parachuting. In the fall and winter of 1999, the FS replaced all of their existing pre-VR systems. They requested that their new VR simulators include a simulator scene based on the real-world complex mountainous jump site they trained in, one with challenges that are also very possible to encounter in aircrew mishap situations. A view of this database is illustrated in Figure 1.

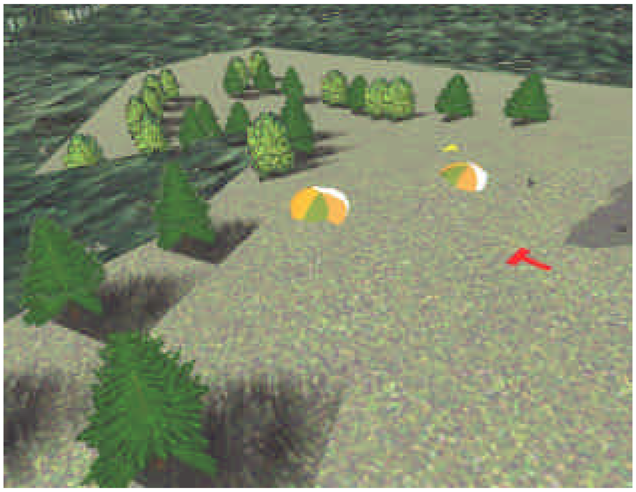


Figure 1. Mountain Terrain Database

Visualizing 3D features like ambient winds can be a difficult concept. The streamer visualization feature as illustrated in Figure 2, shows a line representing a 3-d view of the actual path taken by a streamer dropped from directly above the selected target. This allows the instructor to demonstrate the effects of wind change with altitude and alert the student to any potential problem areas. When this feature is in use, the student's monitor shows the jump scene selected on the startup options screen with a yellow curving line starting at the initial altitude selected over the jump spot. The simulator takes a few seconds when this mode is first selected to quickly compute a simulated path that streamer would take when dropped in the particular wind field selected.

Figure 2. Streamer Visualization

Previous post-simulated jump view options were available to show the jump exactly as seen by the jumper or via a remote view of the jumper and jump scene from a view angle that can be moved by a joystick. While this perspective was particularly useful in viewing the effects of malfunctions and jumper motions, it and the previous jumper view playback mode presented problems in terms of understanding and critiquing of the navigational and collision avoidance tactics adopted by the trainee. For this reason and at smokejumper request, a jump review was added where the observer's eyepoint tracks along the windline above the jumper, and the joystick is not used. The jumper in the previous run is marked with a circle to distinguish it from any jump partner. This observation is useful for understanding the parachutist's path over the ground and relative to other parachutists.

Sport ParaSim:

When a version of ParaSim was developed specifically for sport jumpers, it became obvious that a number of common sport training concepts had equal application in training aircrew. The "sight picture concept" seems particularly useful and can be readily taught with a simulator. The idea is that the trainee should hold a fairly fixed view and observe the motion of his target landing spot: if this spot stays fixed in his view, he will land there. If it moves up in his view, he will not make it with his current flight strategy, and should perhaps select a closer target. If it moves down, then he should adopt a strategy to lose altitude by maneuvering back and forth, while keeping the target in view. Certain operational and emergency parachutes can be flown in brakes, though this requires more skill, which in turn makes these tactics a good candidate for simulator learning.

Entertainment:

A version of the parachute simulator has been adapted for arcade entertainment systems. The application shown in Figure 3 was designed and is manufactured by Illusion Inc. This version is based

Figure 3. Entertainment Application

on the MS Windows platform, and uses the Quantum 3D OpenGVS rendering engine. (The earlier DOS versions of the parachute simulator use a proprietary TGE library and file format from Triac Inc.). The Windows graphics library uses the widely adopted Open Flight file format originated by Silicon Graphics Inc. The parachute dynamics, head tracker, and jumper input sensor interface were ported to Windows by STI as part of this effort. Windows allows more versatile hardware compatibility and the use of a broader range of program and graphics scene generation tools.

Mission Planning and Rehearsal

STI is in the middle of a Phase II Small Business Innovative Research contract from the Special Operations Command (SOCOM) to develop a version enabling rapid generation of real world scenes based on digital terrain, photos, and weather data. This process involves porting the current MS-DOS version to a MS Windows implementation with a more modern graphics user interface (GUI), much better compatibility with modern PC hardware, and readily incorporate networking so that actual (rather than simply pre-recorded) interaction between parachutists will occur.

Figure 4 shows two ram-air jumpers jumping above a scene replicating a desert area near Yuma Arizona. Figure 5 shows the process of generating real world simulator scenes. All of this is immediately applicable to, and has been specifically requested for aircrew training.

Figure 4. Desert Terrain Graphics

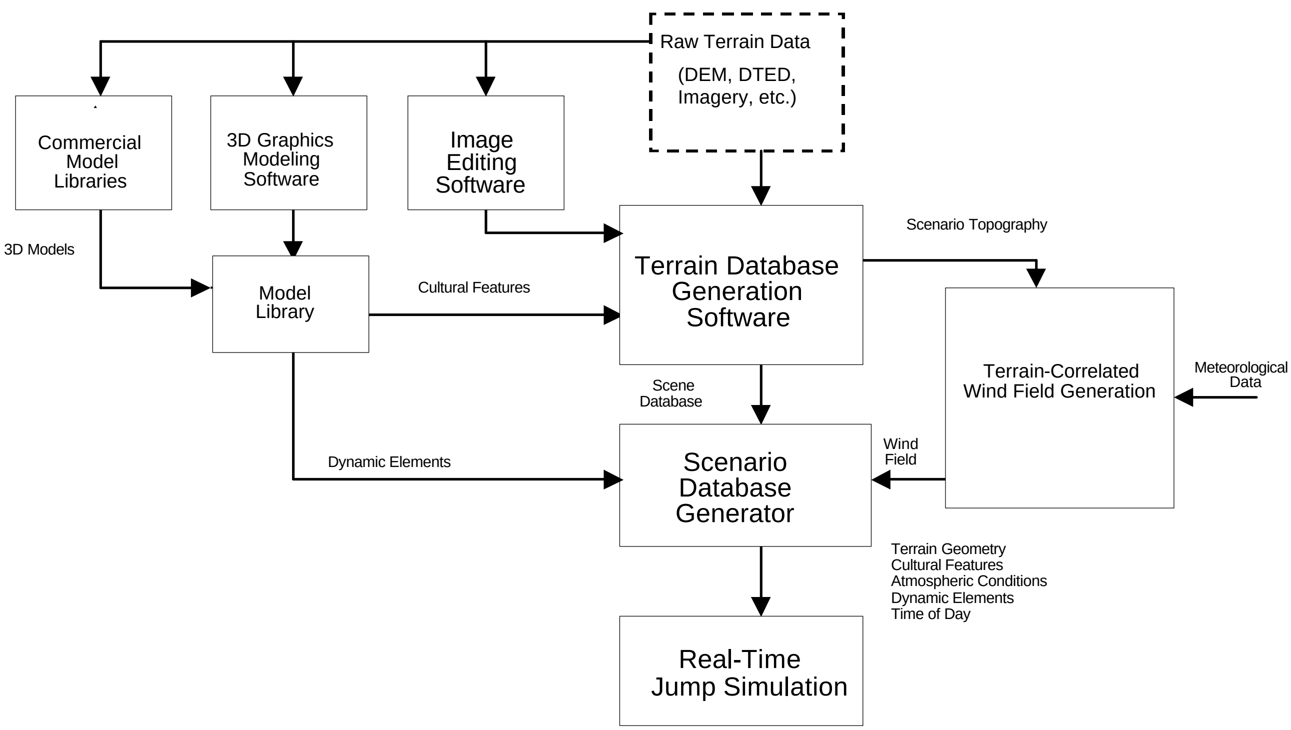


Figure 5. Process for Generating Mission Rehearsal Scenarios

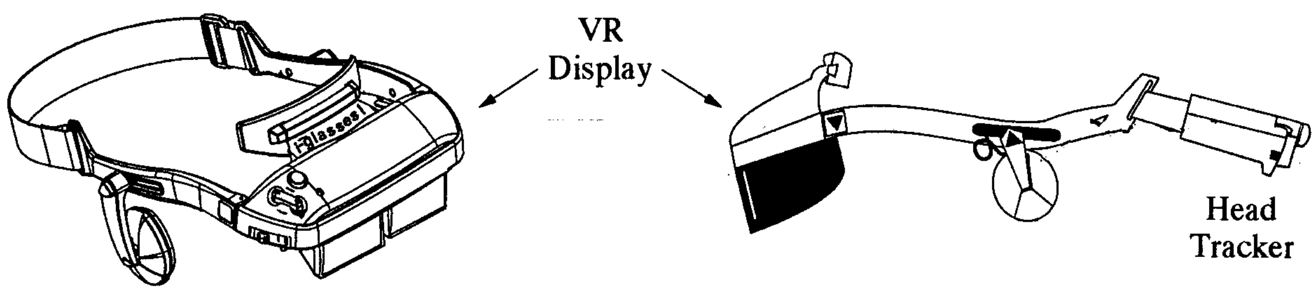
Aircrew Specific Version Enhancements

<u>US Air Force:</u>

The process of delivering and installing simulators in quantity to the US Air Force Air Combat Command (ACC) and the Reserve Command (AFRC), provided an opportunity for review of ParaSim™ by a wide variety of experienced life support and SERE (Survival, Evasion, Rescue, and Escape) instructors with a number of suggestions for improved training capabilities. In particular, scoring criteria were revised to accept a broader off-wind landing angle to align with aircrew parachute landing (PLF) goals and to allow for the high reverse landing speeds which may be encountered on the best of landings under the strong winds which can be encountered during emergency parachuting.

Although there have been earlier attempts to use the HMD with the elastic band under a flight helmet and attach the tracker to the rear of the helmet[8], this had been unsuccessful due to interference between the HMD earpieces/earphones and the helmet. As a result, these procedures were taught prior to removing the flight helmet and donning the combined VR HMD/tracker for the simulated parachuting experience. However, the aircrew emergency training community expressed a strong desire to address complete training scenario issues in a single device in a continuous training experience.

In response to these concerns, the HMD has now been modified to remove the earpieces and attach the elastic band to the brow portion as illustrated in Figure 7a. Audio is supplied to the normal helmet earpieces, and the tracker is attached to the rear of the helmet with the visor cut away to clear the HMD as illustrated in Figure 7b.



a) Without Head Tracker b) With Head Tracker

Figure 6. VR Head Mounted Display (HMD)

Additional improvements are in development. These include a VR system designed to be worn with a flight helmet and improved riser force sensors. Almost all current ParaSim™ installations use a VR head mounted display (HMD) which can be worn alone with an elastic band between the ear pieces, or with an tracker substituted for the elastic band as shown in Figure 6.

Aircrew emergency procedures call for raising the visor and removing the oxygen mask (while wearing flight gloves) during descent under parachute canopy. Since aircrew would only experience actual parachute procedures and equipment operation as a dire and hopefully extremely infrequent occurrence, it was perceived as particularly important that training experiences replicate the actual event as closely (though safely) as possible.

a) HMD worn with elastic brow band b) Tracker attached to helmet

Figure 7. HMD Modified to Wear Under Helmet with Visor Attached to Helmet

Use of a Personnel Lowering Device (PLD) is also required by certain aircrew emergency procedures. A lowering strap is snapped to the riser straps and then the harness fasteners are released (Figure 8). Sturdier riser sensors are being developed which include damping devices to withstand the abrupt shock from this sudden drop and unloading. This capability will remove the need to train for this procedure in a separate hanging harness device.

Figure 8. Using Personnel Lower Device

US Navy:

Aircrew emergencies can occur under far more difficult conditions than operational jumps, which have limits on terrain, weather, etc. that obviously do not apply to emergency situations when mishaps can occur over any terrain. Thus, simulators were supplied to the US Navy Aviation Survival Training Centers (and previous US Air Force Life Support units) which featured weather conditions such as rain, fog, overcast, and improved night lighting renditions. Additional scenes emphasizing over water and coastal locations were also supplied. The Instructor's screen reminds of the need to coach the trainee below 200 feet altitude to minimize maneuvering, prepare for parachute landing fall, and watch the horizon. A typical jump scene is shown in Figure 9.

New Jumper Suspension Frames

Hanging harness training has long been mandated for operational, and especially for aircrew-emergency parachute training. The trainee hangs in an actual harness, suspended from above by riser straps, wearing flight suit, gloves, helmet with oxygen mask and visor, etc. Some of these rigs were suspended from a ring-attached overhead to a single point. These existing systems often had pulleys attached to the ring adjacent to the risers,

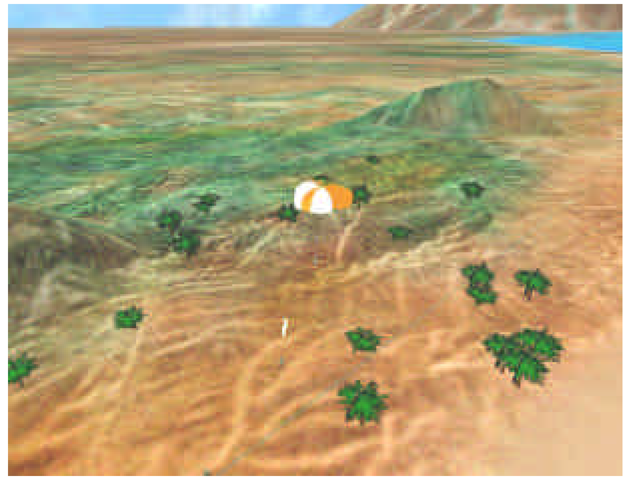


Figure 9. U.S. Navy Aviation Survival Training Jump Scene.

and control lines were then run back and attached to the wall behind the jumper. When the jumper pulled on the lines, he was physically rotated in the direction he pulled. This was seen as advantageous in systems without a simulator, even though the control-motion-to-visual correlation was poor. Earliest versions of the VR parachute simulator system were installed with existing hanging harnesses. Attaching the controller box to the wall or floor modified these systems, and the control lines were routed from the box down through the pulleys to the jumper.

Some initial aircrew training installations used the single ring harness attachment discussed above, but it was clear that undesirable motions occurred during the simulated jump. More recently the frame shown in Figure 10 has been developed to give a consistent installation that stabilizes the trainee, and also allows for installation of four riser strap sensors that are used in conjunction with malfunction training.[7, 8]. With a VR simulator, the lack of synchronization between physical motion cues and visual motion due to the dynamics of the simulated parachute would be worsened further by the effects of the physical motion on the jumper's head tracker. When possible, to minimize this problem, horizontal suspension rings were attached via lines tied to fasteners anchored in adjacent walls.

Figure 10. Frame for Aircrew VR Trainer Installation

CONCLUDING REMARKS

The Parachute descent VR training device is still evolving to meet the needs of smokejumper and aircrew training, and new applications such as special operations mission rehearsal. The VR device which currently runs under MS-DOS is being ported to run in the MS-Windows environment. This will allow more flexibility in setup of the simulator-training configuration, and compatibility with new computer and graphics accelerator hardware. The upgraded graphics accelerator hardware will also allow the development and presentation of more sophisticated visual databases. New concepts in apparatus are also being considered, that will allow the jumper to simulate helmet and oxygen mask procedures and extraction from hanging in trees.

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BIOGRAPHIES

Jeffrey R. Hogue is a Principal Specialist at Systems Technology, Inc. in Hawthorne, California. He has more than 37 years of experience in analysis, design, simulation, and test of flight vehicles. He has a B.S. degree in Aeronautics and Astronautics from the Massachusetts Institute of Technology and a M.S. degree in Mechanical Engineering from the University of Connecticut. He holds a Registered Professional Engineer License, and is a co-author of a simulation display patent and the VR Parachute Simulation patent.

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