Effects of Aerodynamics in Virtual Reality Sky Diver and Parachute Jumper Training Simulator for Sri Lanka

KVP Dhammika#, WRC Ariyarathna and VN Liyanapathirana
Centre for Research and Development (CRD),MOD Sri Lanka
#kvpdhammika@gmail.com

Abstract— Sky diving and parachuting are sports and kind of military maneuver technique which actions started with the exiting from a moving aircraft or from a relatively stable platform (aero plane, helicopter, higher platform etc) and returning to earth under the influence of the gravitational force and atmospheric frictions. Entire process is involved in aerodynamic physics. The basic training for skydiving involves learning how to exit from an aircraft and stabilize oneself in freefall and then deploy the parachute. When a paratroopers jumps out of a plane he starts to accelerate downwards under a certain amount of free fall, until reaching to the terminal velocity. This is the speed at which the drag from air resistance exactly balances the force of gravity pulling him down. With the manipulation of the body postures a skydiver can generate turns, forward motion and backwards motion and even lift. During the last part of the jump the slowing down is handled using a parachute maneuvering. With the proposing simulator system, a Sri Lankan paratrooper will be able to get a virtual reality experience to practice skydiving and parachute maneuvering skills under realistic physics approximated for Sri Lankan environmental conditions. In this paper we describe what is our approach to model aerodynamics within a computer generated virtual world to create near real environment and experience to the trainees.

Keywords— *Virtual reality, Aerodynamics, Terminal velocity and Cross-sectional area*

I. INTRODUCTION

Sky diving is an adventure sport quite amount of physics involved. The physics behind skydiving involves the interaction between gravity and air resistance. Once a skydiver jumps out of a higher platform he starts accelerating downwards, until reaches terminal speed (Figure 1). This is the speed at which the drag from air resistance exactly equal to the force of gravity pulling him down.

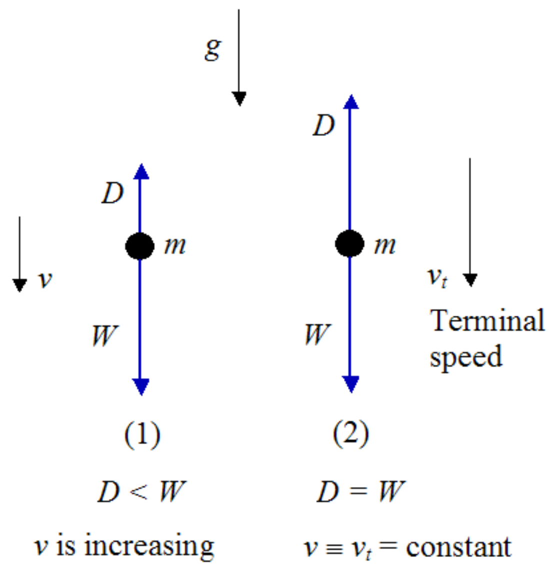

Figure 1 - A free fall diagram

Where:

g - the acceleration due to gravity
m - skydiver's mass
D - the drag force apply upwards
W - the force of gravity pulling him down
v - the speed at which he falls
v_t - the constant (terminal) speed he reaches when $D = W$.

Air resistance increases as diver's speed increases. So when he first starts dropping and moving slowly, gravity is stronger than the air resistance and he speed up, accelerating towards to the ground. However the faster he drops, the stronger the air resistance is and so eventually he is moving so fast that the air resistance is equal in strength to gravity and he doesn't accelerate any more. The Skydiver has reached terminal velocity for his current body posture.

A skydiver typically reaches speeds of around 120 mph in the spread-eagle position (Figure 2). But he can reach speeds up to 200 mph if he orients his body with head pointing down, thereby decreasing air resistant area.

Figure 2 - Spread-eagle position

During free-fall a skydiver can perform a variety of acrobatic maneuvers such as spinning, moving forward, moving backward, just by changing the shape of his body to catch the wind a certain way. By doing this he is essentially changing the direction of the drag force acting on his body, much the same way airplane wings can be oriented to produce a desired motion for the plane.

The air resistance encountered by the skydiver depends on two main factors.

1. The speed of the skydiver
2. The cross-sectional area of the skydiver

An increase in the speed and/or the amount of cross-sectional area leads to an increase in the amount of air resistance encountered.

The equation for air resistance applying on a body is,

$$D = \frac{1}{2} C \rho A v^2$$

Equation 1

Where:

C - the drag coefficient, which can vary along with the speed of the body,

ρ - the air density,

v - the speed of the body relative to the air,

A - the projected cross-sectional area of the body perpendicular to the flow direction.

Even though a sky diver reaches to his terminal velocity, he is still traveling at an incredibly high rate of speed. In order to land safely on the earth, he needs to slow down significantly. He can do that by getting increased his cross-sectional area through the use of a parachute.

When the parachute is opened the force of air resistance becomes greater than the force of gravity because of the increase in the cross-sectional area. That causes a decrease in the skydiver's velocity until once again another terminal velocity is reached. This terminal velocity is now slow enough for skydiver to land safely on a terrain.

III. SIMULATION BASED TRAINING AND LEARNING

With the development of hardware and software technologies simulation has been used for practicing and learning real world disciplines without being exposed to the live situations. Virtual reality parachute simulation originated over 26 years ago for training to improve the safety and performance of smoke jumpers and military parachutists. While improvements and developments continue on these areas number of simulations were introduced for the applications for sport jumping, entertainment, aircrew emergencies training and operational mission planning and for rehearsal.

These parachute maneuvering applications includes base equations of motion for both round and square canopies that include typical oscillating behavior caused by overly aggressive control inputs. The operating environment can include other jumpers and a range of ground scenes as provided by the visual data base model. Sound feedback includes components due to rushing air past the canopy and shrouds, and fabric flapping. Than the higher resolution displays with wider field of view are available at significantly higher cost, most of the programs use head-mounted display with a 30^0 eye field of view to provide visual feedback. A head mounted sensor provides pitch, roll and yaw signals to the simulation computer, which then presents the appropriate line of sight to the jumper that allows a fairly unrestricted head movement field of view.

This approach permits the jumpers to look at the ground for the landing zone, watch for and avoids other jumpers, and also allows viewing the parachute overhead for malfunctions. It is also possible to cut away a malfunctioning chute and deploy a reserve canopy.

III. METHODOLOGY

For the development of the suggesting simulator we have selected to use the software visualization resources from open source sky diving visualization program called Flightgear and the developer edition of open source video game called BASE Jumping Game PRO Edition. Figure 3 represents the overview of the suggesting simulator system.

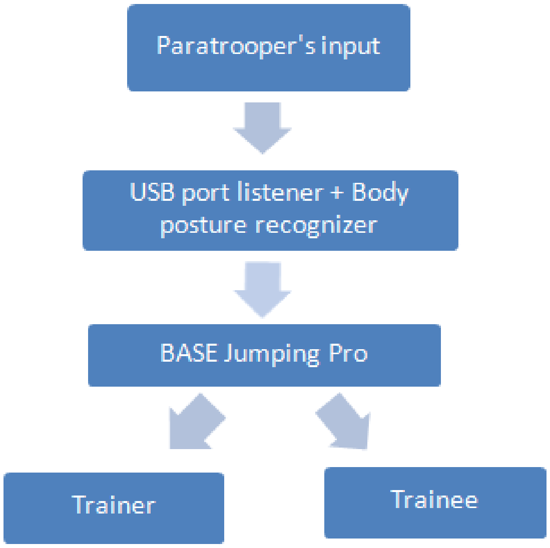

Figure 3 - Suggested methodology.

The suggesting platform will be consisting of two major components called trainer/instructor station and trainee station. Initially the instructor will decide the suitable training scenario for the trainee considering his observation on trainee. Then instructor will initiate the training session by registering the trainee to the simulator system (Figure 4) and then selecting a suitable training area (Figure 5) considering the weather (day/night, rain, wind) conditions.

Figure 4 – Registering a trainee.

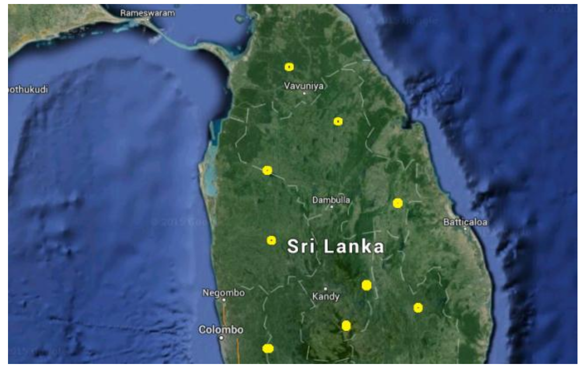

Figure 5 – Selecting training area.

There the instructor will be able to change / adjust the parachute physical properties (Figure 6) to be related to the environmental conditions or to evaluate trainee on various guidelines. All the above mentioned processes will be incorporate to the simulator system by using BASE Jumping Game PRO edition.

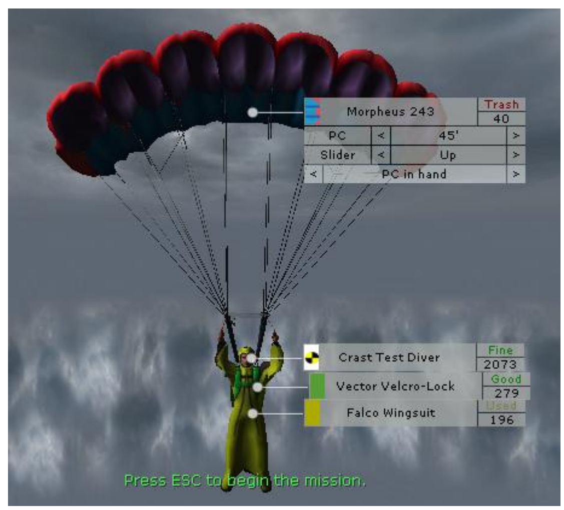

Figure 6 – Adjust parachute parameters.

Figure 7 – After parachute is launched.

To track the body postures and movements of the trainee we will be using Kinect sensor which is a motion sensing input devices by Microsoft for video game consoles and Windows PCs. The Kinect will be deployed for the skeletal tracking of a trainee. That represents body posture very accurately and will send those data to the connected PC through USB interface. Considering the input handling mechanism of the BASE Jumping Game PRO game, we will use a middleware to make the communication happen between Kinect and the game.

That middleware will listen for the USB data and identify each body postures with the help of Kinect SDK which includes Windows operating system compatible drivers. Then it will simulate signals for body movements and parachute controllers which can be recognized by the BASE Jumping Game PRO game. The game will be rendered two separate outputs for instructor and trainee. Instructor will monitor and control the whole scenario through a PC, while the trainee is interacting with the simulator through a head mounted display view.

The aerodynamics related to skydiving process and parachuting will be calculated separately through the PhysX, which is a proprietary real-time physics engine middleware SDK combining with BASE Jumping PRO. In the sky diving time period the virtual character model will be capable of involving various aerodynamics using sensible combinations of pre-defined body poses, identified through Flightgear sky diving visualization program. Those predefined body poses are,

- Box - a neutral pose minimizing rotational or translational motion
- Left & Right Translation - mirrored poses that induce a slide either to the left or right
- Anterior Translation - a pose that induces a forward slide
- Posterior Translation - a pose that induces a rearward slide
- Left & Right Dorsoventral - mirrored poses that induce a left or right rotation
- Dorsal - a spread eagle pose that maximizes surface area and thus minimizes decent rate
- Ventral - a compressed pose that minimizes surface area thus maximizes decent rate

Even after launching the parachute all the affecting aerodynamics will be calculated using PhysX until the end of a single jump scenario from landing on the ground. To incorporate Sri Lankan atmospheric conditions to the system we will be referring to the data measured using Visala Metrological System by launching a balloon. Those data represents Sri Lankan atmospherical presure, temperature and humidity variaotion with hight from different locations all over the country.

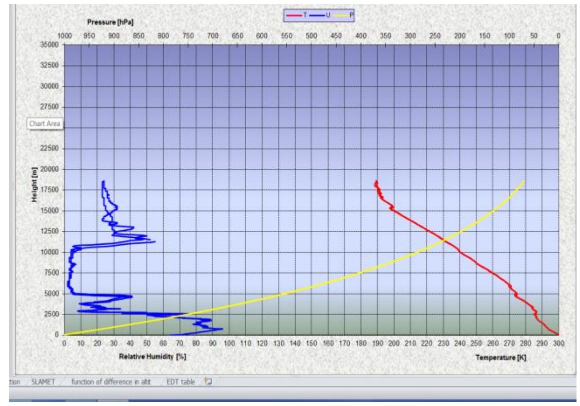

Figure 8 – Air pressure variation against the height.

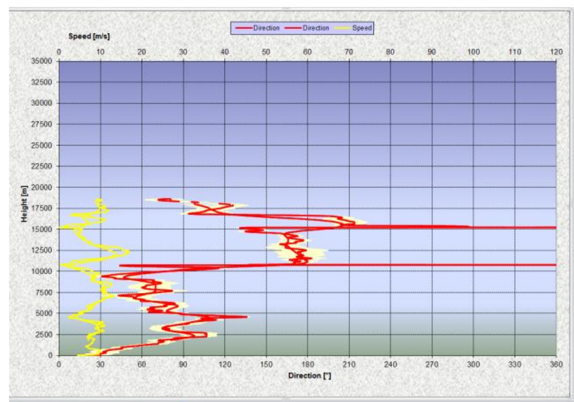

Figure 9 – Wind speed variation against the height.

Also with the suggesting simulator system we are planning to model parachute malfunctions to provide more effective training experience. We could identify two major categories can occur while handling parachute. They are called,

1. High speed malfunctions
2. Low speed malfunctions.

As the high speed malfunctions we could identify pilot chute in tow, bag lock, horseshoe and slider hang-up malfunctions. Also line over, two canopies out, line twist and closed end cells malfunctions could identify as the low speed malfunctions. While a training session is going on with a parachute malfunction, uncommon aerodynamics will affect on the player and the parachute. There a trainee has to gain control back with the parachute maneuvering skills and experience. These kinds of training scenarios will lead to more effective and realistic training program.

After completing the single jumper training environment, we have considered extending the system to use in class room environment by introducing multiple jumper support. It will be connecting all trainees to the same scenario initiate by the instructor through the network and in a process to make feasible to communicate between the jumpers while jumping by introducing virtual transceivers.

IV. EVALUATION

While the development is going on and after completing we hope to test and evaluate the simulator system in single jumper mode and multiple jumper mode for its usability and accuracy with the help of experienced paratroopers from Commando Training School, Kudaoya.

REFERENCES

Hogue, Jeffrey R., Walter A. Johnson, R. Wade Allen, Dave Pierce, "A Smoke-jumpers' Parachute Maneuvering Training Simulator," AIAA Paper 910829, American Institute of Aeronautics and Astronautics 11th Aerodynamic Decelerator Systems Technology Conf., San Diego, CA, April 9-11, 1991.

Hogue, Jeffrey R., Walter A. Johnson, R. Wade Allen, "A Simulator Solution for the Parachute Canopy Control and Guidance Training Problem," SAE Paper 920984, 1992 Society of Automotive Engineers Aerospace Atlantic Conf. and Exposition, Dayton, Ohio, April, 7-10, 1992.

Hogue, Jeffrey R., W. A. Johnson, R. W Allen, Dave Pierce, "Parachute Canopy Control and Guidance Training Requirements and Methodology," AIAA Paper 931255, RAes/AIAA 12th Aerodynamic Decelerator Systems Technology Conf., 10-13 May 1993, London-UK.

"Parachute Simulation," Aviation Week & Space Technology, April 22, 1996.

Hogue, Jeffrey R., W. A. Johnson, R.W. Allen, "Parachute Canopy Control Simulation: A Solution for Aircrew Emergency Training," Systems Technology, Inc., P-473, presented at the 29th Annual SAFE Symposium, Las Vegas, Nevada, November 11-13, 1991.

Physics of Skydiving :: physics skydiving. 2015. Physics of Skydiving :: physics skydiving. [ONLINE] Available at: http://www.123helpme.com/physics-of-skydiving-view.asp?id=153581.

Hogue, Jeffrey R., and R. W. Allen, "Virtual Reality Simulation in Aircrew Emergency Parachute Training, "Systems Technology, Inc., P-529, presented at the 34th Annual SAFE Symposium, Reno, Nevada, Oct. 21-23,1996.

Sky Diving Visualization | FlightGear Flight Simulator. 2015. *Sky Diving Visualization | FlightGear Flight Simulator.* [ONLINE] Available at: http://www.flightgear.org/tours/sky-diving-visualization/.

PhysX - Wikipedia, the free encyclopedia. 2015. *PhysX - Wikipedia, the free encyclopedia.* [ONLINE] Available at: https://en.wikipedia.org/wiki/PhysX.

TERMInal VELocity » Downloads | BASE Jumping Game: Pro Edition. 2015. *TERMInal VELocity » Downloads | BASE Jumping Game: Pro Edition.* [ONLINE] Available at: http://www.termivel.eu/category/downloads/.

Kinect - Wikipedia, the free encyclopedia. 2015. *Kinect - Wikipedia, the free encyclopedia.* [ONLINE] Available at: https://en.wikipedia.org/wiki/Kinect.

Physics Of Skydiving. 2015. *Physics Of Skydiving*. [ONLINE] Available at: http://www.real-world-physics-problems.com/physics-of-skydiving.html.

Malfunction (parachuting) - Wikipedia, the free encyclopedia. 2015. ONLINE] Available at: https://en.wikipedia.org/wiki/Malfunction_%28parachuting%29.

BIOGRAPHY OF AUTHORS

Lt Col KVP Dhammika, Chief Coordinator Radio and Electronic Wing Centre for Research and Development Ministry of Defence Sri Lanka and Visiting Senior Lecturer Sir Jhon Kotalawala Defence University Faculty of Engineering. He was a student of an Isipathana Mahavidyalaya Colombo 05. He had joined to KDU Intake XI as officer cadet and obtained BSc(Defence) Electronic Engineering degree as his first degree. After that he joined to the Sri Lanka Signal Corp of the Sri Lanka Army as a commissioned officer. After that he followed many overseas courses in countries like USA, Australia and Pakistan. He obtained M.Phill degree in Electronic and Telecommunication Engineering from the University of Moratuwa Sri Lanka. He had been served as Military Liaison Officer to United Nation Mission in South Sudan.