Skydiver Project

This project focuses on modeling the fall of a skydiver and plotting their position and velocity in freefall and after they open their parachute. Modeling the motion and location of a person or parcel exiting an airplane with a parachute must account for a number of physical laws and related environmental conditions. If these are not taken into account properly, a skydiver might open his or her parachute too late to slow down before reaching the ground, a person seeking to reach a particular ground location could end up far away from the target position, or a parcel dropped to reach particular recipients on the ground would be lost. The challenge of this project is to create a model that accounts for several of the variables that affect the flight of a skydiver or parcel dropped from an airplane – predicting their velocity.

We start off with the model of a ball tossed into the air and falling back to earth as it has some of the basic components needed to model any falling object. The ball is tossed into the air at a given initial velocity. Any such object released into the air is subject to the acceleration due to gravity. This is approximately -9.81 m/sec^2. It is a negative when up is considered to be the positive direction. In order to get the position of the ball, we must model the change in velocity over time and relate this to the height of the ball.

The motion of an object in free fall is modeled by:
$y = v_0 t + 1/2\, gt^2$,

where:

- y is the vertical position
- v_0 is the initial velocity
- t is time
- and g is the acceleration due to gravity (9.81 m/s^2).

This equation accounts for the force of gravity but does not consider the drag associated with the friction of the air. The drag will be a force in the opposite direction which is related to the density of the medium the object it is moving through. Start this project by reading the references to get a better understanding of the mathematical representation of skydiving as well as the concepts involved in creating the model. The article by Mead has an excellent overview of the mathematical basis while the articles by Arney et.al. and others provide more specific empirical examples and review of the basic concepts.

Build the model assuming that you have a skydiver of “average” weight jumping from a stable helicopter at 4000 feet. Allow free fall in air of constant density until 2000 feet when the ripcord is pulled. There are several parachute shapes and related drag coefficients and areas you can find in the reading. Choose appropriate values and keep them constant.

Build your model incrementally – starting with the skydiver freefall from a stationary platform like a helicopter. Then add a section relating to the drag associated with freefall and the drag after the parachute opens. Be careful to model the time of each segment of the jump. Your initial model outputs should show velocity, acceleration, time, and the altitude of the skydiver associated with each. You want to make sure that the final velocity of the skydiver is safe for a landing. That will be associated with how far up the jump takes place and how much time there is in freefall and for the parachute to slow the descent.

Once you have the basic parachute model, use it simulate jumps and test the sensitivity of the model to different weights of the skydiver, different times for opening the parachute, and different release heights. Prepare a final submission report and presentation discussing those findings as well as any associated with the optional additional portions of the modeling assignment.

Optional Project Additions

1. Add information on the density of the air at different altitudes, changing the drag associated with the jump as the skydiver moves from less dense air above to more dense air below. Simulate these conditions and compare them to the patterns found in the original model.
2. Alter the model so that it interactively asks for the relevant inputs of height, weight of the skydiver, and drag coefficients to allow easier testing of alternative assumptions.
3. Add a component to the model that also projects the horizontal distance from the drop point to the landing point, given a steady wind from a particular direction. Assume the drop is over an urban area and that the change in the gradient windspeed matches the distribution in the diagram below (note that the units there are meters).

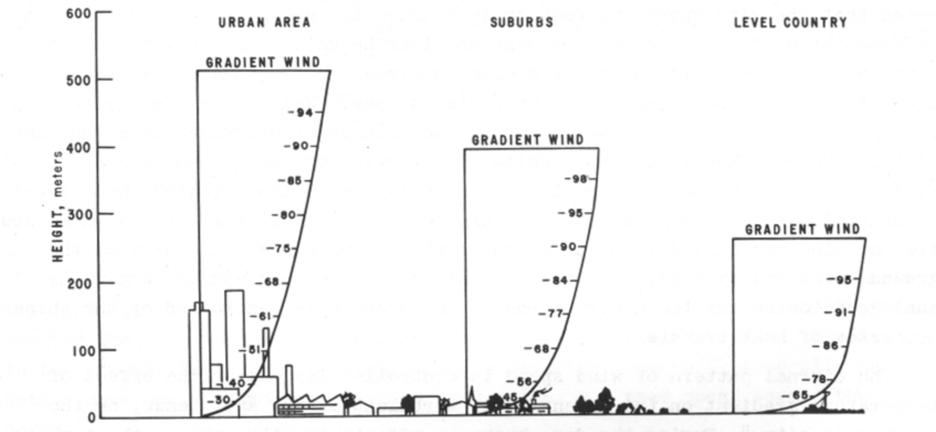

Figure 10. Examples of Variation of Wind with Height Over Different Size Roughness Elements (figures are percentages of gradient wind) [4].

References

Parachute Jumping, Falling, and Landing David C. Arney, Barbra S. Melendez,Debra Schnelle http://www.usma.edu/math/military%20math%20modeling/c5.pdf.

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