Objective: To investigate the motion of an object in two dimensions; to gain familiarity with video analysis techniques

Apparatus: QuickCam webcam, lab PC & software, golf balls, toy cars, coffee filters

Introduction

In this lab you will create your own movie of motion in two dimensions using a webcam. The movie will be imported into Logger Pro with which you can analyze the data, breaking up motion into its X and Y components. You will start with performing video analysis on an existing movie, then you will make two movies of your own and analyze those.

Procedure

Sample Movie

1. In Lab Apps on your PC desktop, open Logger Pro. Go to File --> Open --> Experiments --> Sample Movies --> Basketball Shot. Double-click on “Basketball Shot.cmbl”; you should see a movie of a man holding a basketball. Click on the Play button (leftmost button) on the movie and watch him “shoot” the ball in the air. Note that there is a two-meter stick at on the floor below the ball; it is there as a distance scale reference. Play the movie again - is this one dimensional motion or two dimensional?

2. Click on the Video Analysis (VA) button (rightmost button, three red dots on it), which exposes the VA toolbar. Click on the Set Origin button (third from top) and click on a spot in the movie that you'd like to set as your (X=0, Y=0) point. After you do that you should see the X and Y axes.

3. Now let's set the distance scale - click on the Set Scale button (fourth from top). Click and hold on one end of the two-meter stick (on the floor) and drag it to the other end and...
release. A Scale window will pop-up, asking you for the length of this green line you created - the default value will be 1m, so you should change it to 2m. Click OK.

4. You will need to digitize the motion. Click on the Rewind button (two buttons to the right of the Play button on the movie) to go back to the first frame. Drag the slider to the point of interest - namely, the time just before the ball leaves his hands. You can "fine tune" the choice of frame by clicking on the Previous Frame or Next Frame buttons, to the right of the Rewind button.

5. When you are ready to start digitizing, click the Add Point (single red dot) on the VA toolbar. From this point on, you will be clicking on the center of the ball as it moves. Luckily, the movie advances to the next frame every time after you click, so that you can just follow the ball by clicking. When the ball has returned to the level from which it was released, you can stop clicking. Look at the graph on the right of the movie - it is a plot of both X and Y versus time. What can you say about the motion?

6. Let's do curve fitting now. With your cursor, click and drag horizontally across the range of points on your graph to select your data to curve fit. Go up to Analyze --> Curve Fit. Select "VideoAnalysis:X" and click OK. Now choose a General Equation from the bottom, one that could potentially fit the curve well. Click on Try Fit and see if the line has gone through the points well. If you're satisfied, click on OK and your curve fit and fit coefficients will be displayed on the graph. What do each of these coefficients mean? (think of the equations of motion) Can you determine the X velocity of the ball?

7. Repeat the curve fitting, this time for the Y motion. What do these coefficients mean? Can you determine the ball's acceleration during the time it is out of the man's hand?

Make your own movie

1. Make sure the QuickCam is plugged into one of the PC's USB ports. In Logger-Pro, go to Insert --> Video Capture. There are some items in the room - golf balls, coffee filters, and toy cars - which you'll use to design four experiments (two 1D experiments and two 2D experiments) to determine the type of motion (constant velocity, constant acceleration, constant acceleration interrupted by sudden changes, etc.) of these objects. You can count yourself or your lab partner as an object (but think of your center of mass). Feel free to throw or drop things about the room, but be careful not to hit people or equipment/computers.

2. Position your camera. Make sure you frame the experiment, i.e. Make sure all motion will be seen in the frame. You can focus by turning the black lens on the camera. Practice the experiment motion a few times. For best results, the motion should occur perpendicular to the camera's line of sight. Before you begin, you also should increase the frames-per-second to 30 fps by going to Options --> Camera Settings. When you're ready, press Start Capture and then set the experiment in motion; press Stop Capture when you are done. The movie will appear in the Logger Pro window. Play to see if the movie you made is satisfactory. (To move the movie window out of the way, hold down
CTL and left click simultaneously while dragging.)

3. Analyze the X and Y data of each video separately. Is there constant velocity in the X direction? Y direction? Is there acceleration in the X direction? Y direction? What happens physically during the regions where constant acceleration is interrupted by sudden jumps in velocity or position? It is not necessary to print graphs, but briefly describe your experiments, and record the values of the velocities and accelerations that you obtained from your analysis.

4. Let's now see if the people who make commercial movies pay attention to physics. In Logger Pro go to Insert-->Movie and open the video ct-hd.mov which is a clip from Crouching Tiger, Hidden Dragon (Sony Pictures 2000). It's located in the same folder as this write-up. Do you think this is physically possible (without special effects, wires, etc)? Using Logger Pro examine the clip in detail. For a distance scale, you can use Chow Yun Fat's listed height of 5'11" (he's the guy that jumps first).