Template for Lab 2 Technical Memo

To: James Duncan, Video Coordinator
From: XXXXXXX, student intern
Date: Sep 22, 2004
Subject: Is video an accurate and reliable tool for evaluating kickoffs? A look at "Power"

Introduction

The purpose of this memo is to present our findings from an experiment designed to test if video can be used as a reliable means of capturing projectile motion, thus as a means of evaluating, and thus improving, the Aggie kicking game. In order to perform a scientific evaluation of a football kickoff, we first reproduced the event in a controlled environment. In this way the measurement method can be verified and calibrated under controlled conditions. In order to learn what happens during a kickoff, we conducted a series of experiments that emulated the conditions of the event in a controlled environment. The objectives of each experiment were two-fold: (1) to evaluate what effect "Power" has on the kickoff, and (2) to know how accurately motion can be evaluated using a camera and analysis software. Our findings are as follows: the "Power" of the kickoff increased both the "Hang-time" and "Range" of the kick, but the accuracy of our measurement is only ±2% for the "Hang-time" and ±7% for the "Range". *Therefore, because of the degree of error produced from video analysis, it is not an accurate means of capturing projectile motion and would not be a reliable tool for analyzing the Aggie kicking game*. A more detailed description of our results is presented below.

What we found out.

Observing an object at an angle distorts our estimation of displacement. This distortion, or optical illusion, is called "parallax." The effects of parallax can be minimized if we observe the motion along a line perpendicular to and centered on the plane of motion. However, there is still some discrepancy in the perceived displacement from the center of the picture and the edges. In our experiment the discrepancy was measured to be ~1.5% and was measured in Experiments 1 and 2 of Project 1. It should be noted that this discrepancy is a function of the zoom level, and the ~1.5% is what we get if zoom is set to 1:1; thus, the higher the zoom, the smaller the discrepancy.

The captured data (shown in Figure 1) exhibits different types of motion in the horizontal (x) and vertical (y) directions. For the x and y directions we find the best fitting function to be a linear function and a 2nd order polynomial function, respectively. This suggests that the object had constant velocity in the x direction while it underwent constant acceleration (a_y = –9.6 m/s^2) in the y direction, which are expected for an object in freefall in a gravitational field.

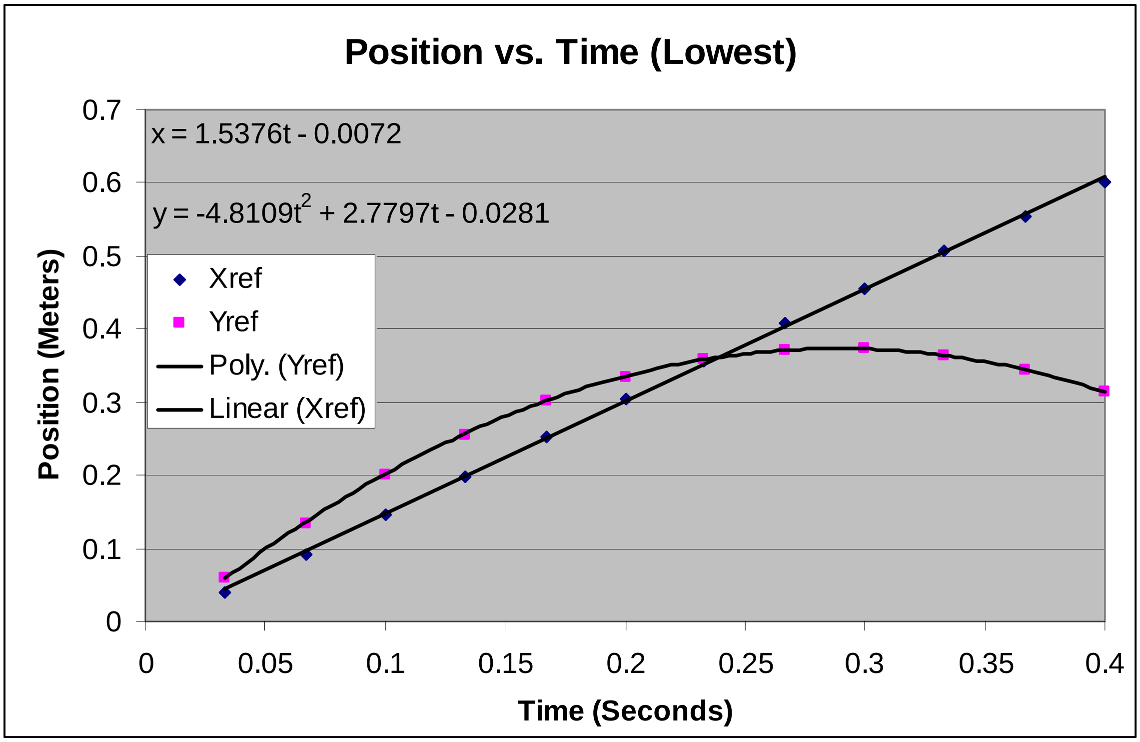

Figure 1: Position vs. Time graph for the motion of the marble at the lowest "Power" setting.

Comparing the results from two different calibrations and point selections, we estimated errors in (a) acceleration (Δa_x, Δa_y), (b) velocity (Δv_{0x}, Δv_{0y}), and (c) displacement (Δx, Δy). They are summarized in Table 1 for each of the three cases. (What you conclude from Table 1?)

	Δa_y	Δv_{0x}	Δv_{0y}	Δx	Δy
Lowest	0.22 m/s^2	0.12 m/s	0.11 m/s	0.006 m	0.007 m
2nd Lowest	0.18 m/s^2	0.15 m/s	0.13 m/s	0.005 m	0.006 m
3rd Lowest	0.28 m/s^2	0.18 m/s	0.19 m/s	0.008 m	0.005 m
Average	0.23 m/s^2	0.15 m/s	0.15 m/s	0.007 m	0.006 m

Table 1: Summary of measured errors

The "Power" of a kick is proportional to the initial velocity of the kick, thereby increasing both the "Range" (R) and the "Hang-time" (T) of the kick. Below is Table 2 showing the statistics of each of the three trajectories. Statistics were calculated using:

Initial velocity $(\boldsymbol{v_0}) = \sqrt{\boldsymbol{v_{0x}}^2 + \boldsymbol{v_{0y}}^2}$, Initial Angle= $\boldsymbol{tan}^{-1}\left(\frac{\boldsymbol{v_{0x}}}{\boldsymbol{v_{0y}}}\right)$, $T = \frac{2\boldsymbol{v_{0y}}}{\boldsymbol{a_y}}$, $R = \frac{2\boldsymbol{v_{0y}}\boldsymbol{v_{0x}}}{\boldsymbol{a_y}}$

A careful study of the data, however, suggests that increasing initial velocity increases R more than it increases T. This is because T is equal to time of flight which is proportional to initial velocity. If the distance it travels is proportional to $\boldsymbol{v_0} \cdot T$, then R is proportional to $\boldsymbol{v_0}^2$. It should also be noted that the error in the estimation of R is much greater than the error in the estimation of velocity. This makes it difficult to give an accurate measurement for the range of a projectile using video analysis. (It is not clear how you claim the size of errors in “Initial Velocity” and “Range”. Did you calculate the deviation from the average of three estimates?)

	Initial Velocity	**Initial Angle**	**“Hang Time”**	**“Range”**
Lowest	3.17 m/s	29 degrees	0.58 seconds	0.89 meters
2nd Lowest	4.31 m/s	32 degrees	0.73 seconds	1.66 meters
3rd Lowest	5.01 m/s	36 degrees	0.81 seconds	2.41 meters

Table 2: Calculated statistics for each “Power” setting (Note: “Hang Time” and “Range” information is based on back to the initial height, not to the floor) (Are they the measured values or its errors?)

Conclusion:
We found that the error in the estimation of “Range” is much greater than the error in the estimation of velocity in a projectile using video analysis. It will also be difficult to calculate anything if we are not able to view the kickoff from a reasonable angle. Parallax didn’t generate greater error in this experiment but it could if we had used a poor angle.