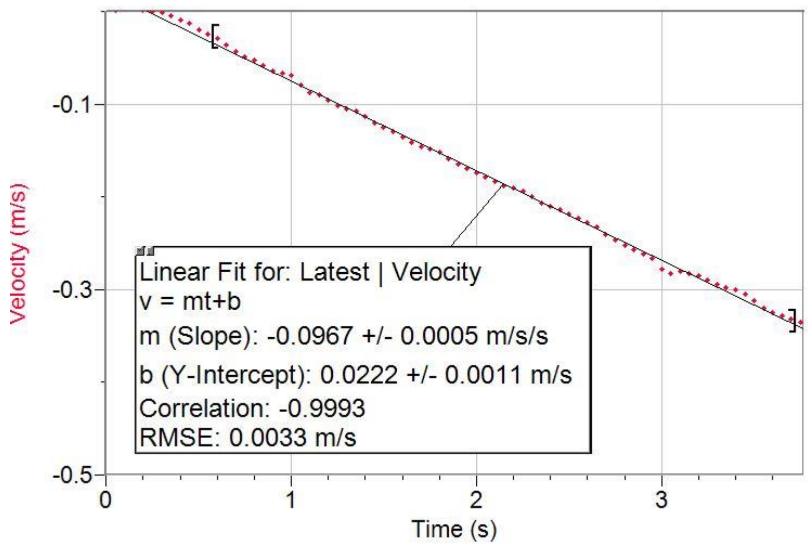
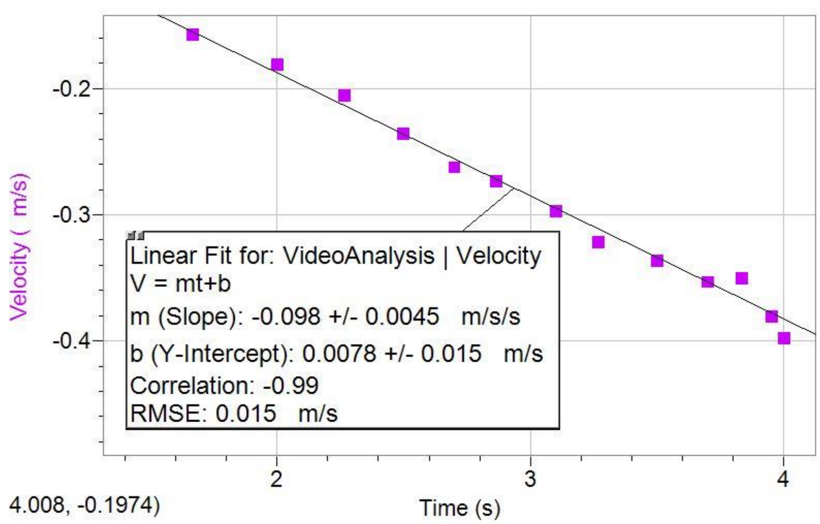
Motion Detection and Video Analysis

As an exercise in learning to use video analysis and motion detection to measure a constant acceleration, students were asked to put together a one page word document with two velocity graphs and to state the measured accelerations with errors.

Sample graphs are shown below.





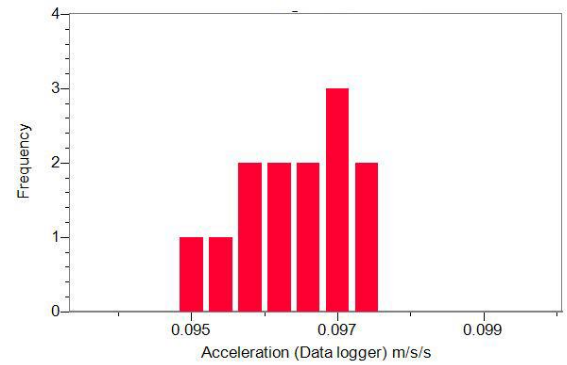
Quoting the calculated errors in the slope calculations the measured accelerations appear to be …

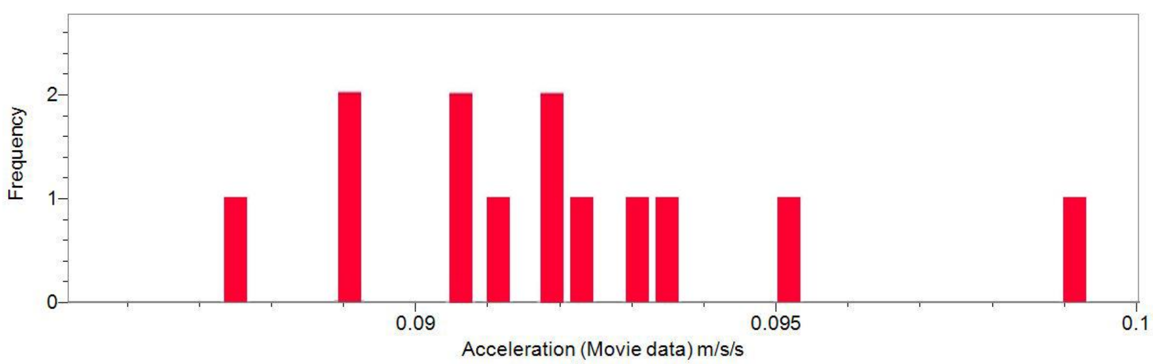
From motion detector data 0.0967 ± 0.0005 m/s/s

From video analysis data 0.098 ± 0.005 m/s/s

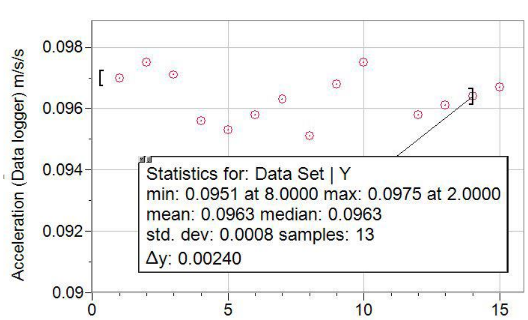
It appears that motion detector is more accurate by a whole decimal place. This is not surprising, given that both collect 30 data points per second but the video analysis was done with only a third of the available points and it is not possible to mark the points on the video frames exactly.

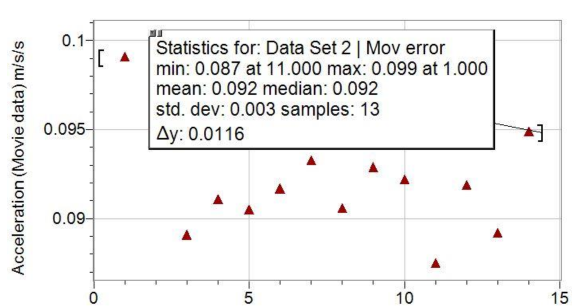
As a more reliable test values returned independently by a number of students was compiled in a new data file and analyzed for mean and standard deviation. The distributions are shown below.





The upper histogram (to the right) shows reported accelerations from the same Logger Pro file. The lower histogram shows accelerations reported from the analysis of the same video clip by the same students. Clearly in this situation more consistent results are obtained from the data logger and the two mean values are not the same. The means and standard deviations are on the graphs below (data logger on the left).





The revised accelerations are …

From motion detection data 0.0963 ± 0.0008 m/s/s

From video analysis data 0.092 ± 0.003 m/s/s

The errors are now the standard deviations of the data sets.

Discussion

The calculated standard deviations show that the interpretation of motion detection data was more consistent and more accurate than video analysis. The ranges do overlap, but it is likely that the video data has returned a lower value for the same acceleration. Random errors are much larger for the video analysis and there appear to be systematic errors that affect one or both types of measurement.

There are several possibilities. A motion detector measures the return time of an ultrasound pulse and the distance is calculated using the known speed of sound. The default setting of the speed of sound for 20°C was used. This may have been in error by as much as 4°C and if so this would have introduced a small systematic error in the motion detector measurement.

The frame rate of the video is expected to be accurate but video analysis depends on the setting of a scale. This was done with a 60 cm steel rule laid on the table under the cart close to the distance of the dot on the ball from the camera. A small error in placement would cause as systematic error in position marks. Errors in dragging the scale line over the 60 cm rule are random and may account for the greater range of the video histogram.

The dot on the ball does not remain always in the centre of the image of the ball as it passes from right to left because of a slight change of viewpoint. If the dot is used as a location without correction this will introduce a systematic error. There is some distortion of the field of view in the video frames, especially towards the edges, and this may also affect the data.

Conclusions

More work would be required to establish the source of any systematic errors, but the discussion above indicates that both random and systematic errors are likely to affect video analysis measurements more than measurements made with motion detection. Video analysis should be used in situations for which motion detection is not possible. Errors introduced at the interpretation stage are larger (in this case) than errors in the recorded data for both motion detection and video analysis. In this case stated accelerations are accurate to within ±0.5% for motion detection but to no better than and ±3% for video analysis.