HARVESTING TECHNICAL NOTE

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Predicting Skidder Payload Using Grapple Openness – Pilot Study

Summary

The potential for automated measurement of the payload of each cycle in a grapple skidder logging operation was investigated by using an accelerometer to measure the degree of openness of the grapple in relation to the size of the haul. This pilot study has shown that a cheap, automated method of determining payload is feasible.

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Introduction

Initial work in the Future Forests Research harvesting programme in real time data collection identified the need to develop tools to better monitor logging productivity. Existing tools that record operating hours lack the ability to also gather data such as payload, limiting their use (Marshall, 2008).

To obtain an accurate productivity figure for a piece of logging equipment, it is extremely important to get a good measure of the volume produced, or payload. Measuring payload of each logging cycle is, however, one of the most difficult tasks in doing production studies. Currently the three most common methods are to measure the volume of the load directly, or indirectly either by measuring the diameter of stems extracted and relating diameter to volume, or by counting the number of stems and multiplying by the average volume of a sample of harvested stems.

In many operational situations, using either of the first two methods is physically impossible or too dangerous. In most cases when these methods are employed it requires one person dedicated to taking these measurements. The third method, while requiring less time, still requires a person to count the stems in each load. The method also has a limited degree of accuracy. What is needed is a method that measures payload automatically.

The goal of this pilot study is to investigate whether there is a relationship between payload and the degree of openness of a skidder grapple. In this case, the openness of the grapple is measured by an accelerometer that can measure tilt in all three dimensions (x-, y-, and z-axis).

Figure 1. The location of the accelerometer on the grapple.

Methodology

An accelerometer is a sensor for measuring acceleration and gravity-induced reaction forces. Tilt of the accelerometer can be determined using gravity acceleration, and it is that tilt that was measured in this study. The accelerometer used in this pilot study (Onset HOBO® Pendant G Data Logger[1]) is a small, rugged, waterproof and reasonably cheap device costing just over $NZ100. It will measure tilt and acceleration in three dimensions every second for 6 hours (approximately) before data are down loaded.

[1] HOBO Pendant G Logger Data Logger (http://www.onsetcomp.com/products/data-loggers/ua-004-64)

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Data Collection

The study was carried out on a Tigercat 630C double arch grapple skidder operating in a central North Island Radiata pine clearfell operation. A steel tube was welded onto the grapple of the skidder in the location marked in Figure 1. The accelerometer was placed in the steel tube and was held in place by tightly packing the tube with foam.

As this study was designed to determine the strength of the relationship between payload and degree of openness of the grapple, both variables were collected for each grapple load. To get accurate assessment of payload volume, sixteen stems were numbered and cross-sectional diameter measurements at intervals no greater than 3 metres were taken.

The skidder operator then picked up the stems in different random combinations of stems. The identification number on each stem in the load was recorded, as well as the time the load was grappled.

The cross-sectional diameters were used to calculate the volume of each stem using Smalian's volume formula. These stem volumes were then used to calculate the volume of each load. The load volumes ranged between 1.6 m^3 and 12.6 m^3.

Analysis

The data were downloaded from the accelerometer. As the accelerometer made measurements every second, it picked up the smallest movements of the grapple which in this study were unimportant. To remove all those insignificant movements and isolate the grapple opening and closing event, a 5-second rolling average smoothing function was applied to the data. Figure 2 shows the smoothed accelerometer data for the x-axis, y-axis, and z-axis for a sample of time during the study.

From observation, it was determined that when the grapple was open, the Y tilt (red line) was at a local maximum and the Z tilt (green line) was at a local minimum.

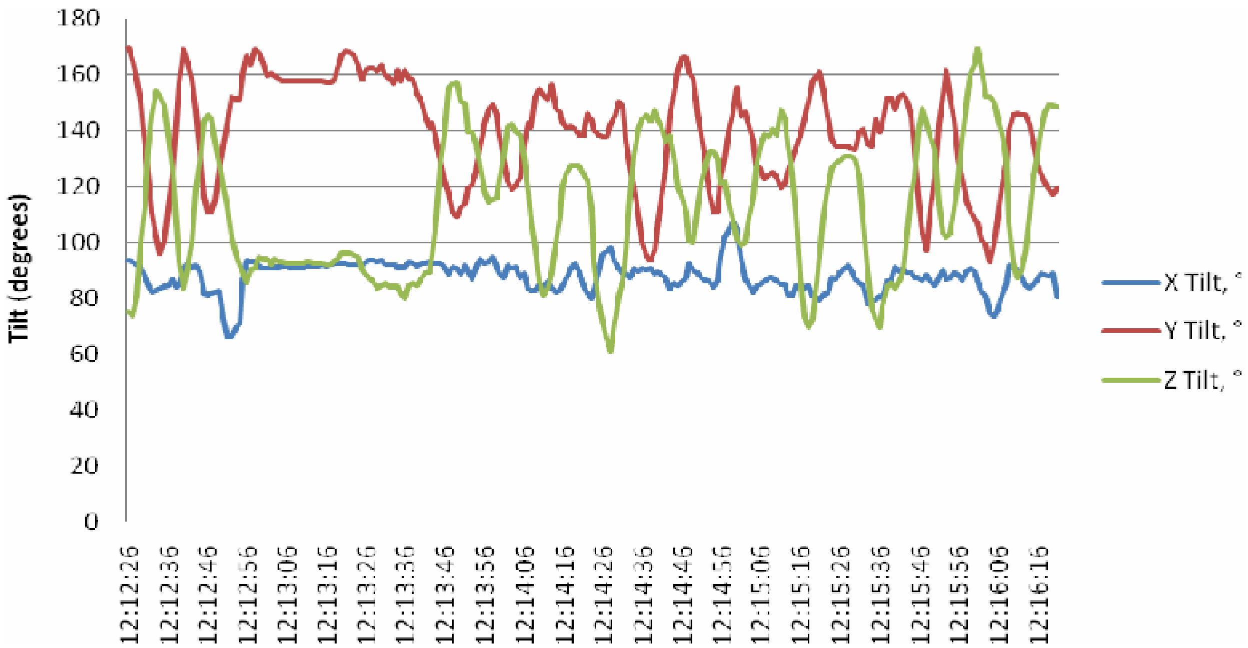

Figure 2. Sample of 5 second rolling average data for the X, Y and Z tilt axes from the accelerometer.

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Conversely, the low points for the Y tilt and high points of the Z tilt occurred when the grapple was closed around a load, The localised low values of Y tilt and high values for Z tilt, and the real times at which they occurred were recorded, and matched with the load volumes.

Results

Relationship of Tilt values to Payload

The Y and Z tilt values, which could both be used to represent the degree of openness of the grapple, were related to the payload of the corresponding grapple load (Figures 3 and 4) . It can be seen from both graphs that there is a relationship between degree of grapple openness and payload (m^3). In this study, the Y tilt data gave the best results in terms of fit to payload.

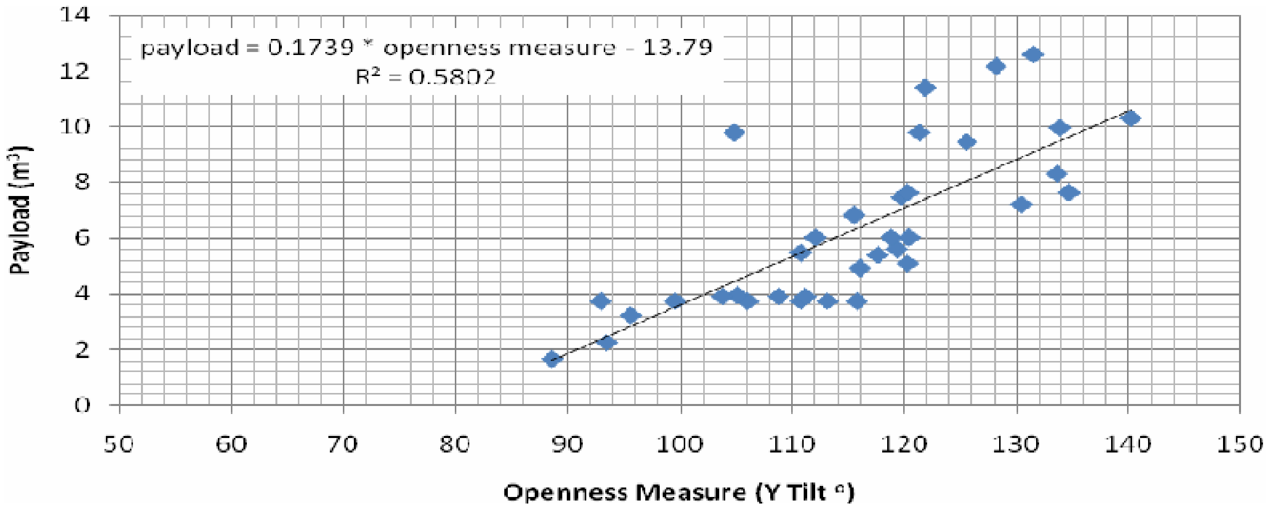

Figure 3. Openness Measure (Y Tilt^0) versus Payload (m^3)

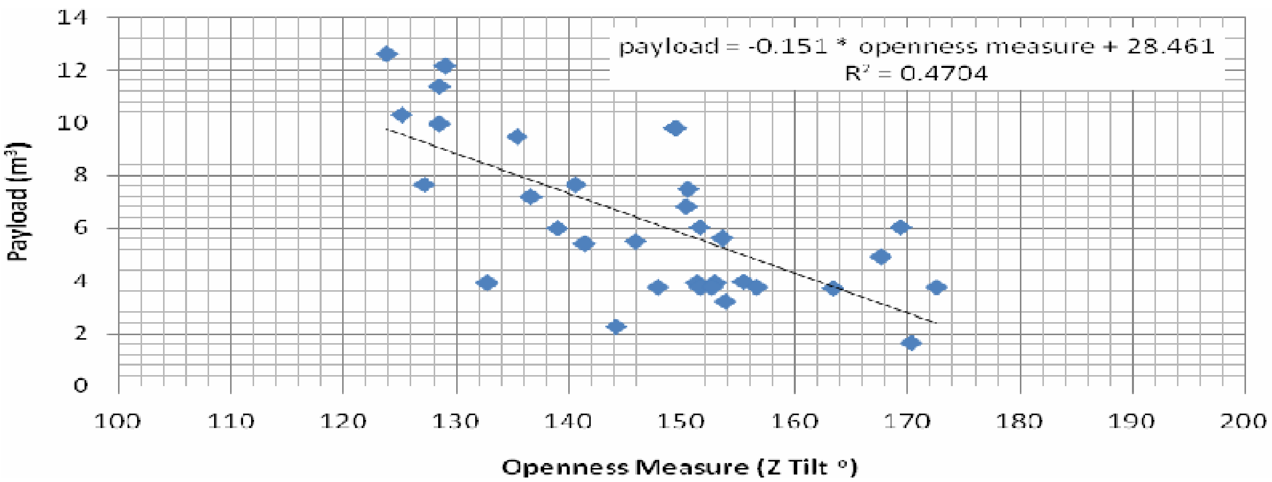

Figure 4. Openness Measure (Z Tilt^0) versus Payload (m^3)

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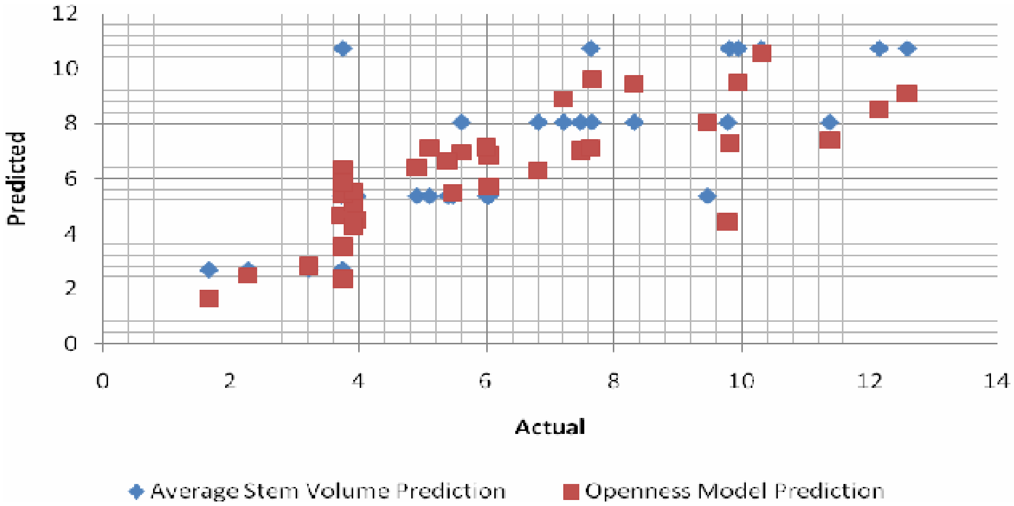

Figure 5. Predicted Vs Actual Payload (using prediction methods)

Validation

In this pilot study there were insufficient data to carry out a statistical validation exercise. However, as a way of measuring the potential of this new method, the payload as predicted from the model:

Payload (m^3) = 0.1739 * Y Tilt ^{0} - 13.79

was compared with the payload predicted by the common method of multiplying the number of logs per load by the average stem volume.

Figure 5 shows that the grapple openness model predictions are highly variable, but no worse than the variability resulting from the average stem volume prediction method.

Discussion

The concept of determining payload by measuring openness of a grapple using an accelerometer was tested in this study. Although this method did not give any better predictions of payload than simply counting the number of stems and multiplying by average volume of stems, it does have the following advantages:

- Data are automatically collected, requiring no human recording of data.
- The data collected by the accelerometer could also be used to determine other machine movements of interest.

One of the problems with this study was that stems were held in the grapple for only a couple of seconds before being dropped. In a production operation, loads would be held for much longer as they are skidded to the landing, thus allowing for a more accurate determination of the grapple openness for each load.

This pilot study has shown that a cheap, automated method of determining payload is feasible. If the accelerometer was installed in a production operation, and more data collected, a better model for predicting payload could be developed.

Reference

Marshall, H. (2008) Logging Productivity Monitoring. Harvesting Technical Note Vol. 1, No. 1. Future Forests Research Ltd. Rotorua.