HARVESTING TECHNICAL NOTE

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Measuring Skyline Deflection with the LineSmarts App

Summary

Computers are increasingly being used to support forest management activities and new technologies, and software is rapidly being developed in other industries which may have application in the forest industry. This report evaluates the LineSmarts software application developed for the engineering of overhead lines in the electricity sector. The 'app' is designed to allow users to calculate the distance between power poles and estimate cable deflection. The LineSmarts App offers another method for measuring span length and deflection of skylines used in cable logging. Results of both lab and field testing showed the App closely estimated span length, but in comparison to a simplified field method for measurement of deflection (called the Clinometer method), LineSmarts overestimated the deflection.

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INTRODUCTION

New technologies and software are rapidly being developed in other industries, and may have application in the forest industry if they can withstand the demanding environment in which they are required to be used. Computers are increasingly being used to support forest management activities. Both forest managers and loggers in New Zealand have access to mobile phones and tablet computers which are increasingly being used for various tasks in the workplace, especially the ruggedized versions which perform well in the outdoor environment. There are suites of new applications ('apps') being developed for these mobile computers, some of which could be useful to the forest industry.

One application in cable logging is the measurement of deflection in the skyline cable for steep terrain harvesting operations. Currently, nearly half of all logging operations in New Zealand are being conducted on steep terrain, and therefore require the use of cable logging systems (Visser *et al*. 2014).

When using a yarder for cable extraction, the main criteria determining the extraction method to be used are the ground slope, or profile, of the area to be harvested and the available skyline deflection (Visser 1998). Skyline deflection (or sag in the skyline) is the vertical distance between the chord slope and the skyline, measured at mid-span and expressed as a percentage of the span length (Figure 1).

In planning cable logging operations, determining the skyline deflection that the terrain will allow is critical to ensure the tension in the cable will not exceed the desired factor of safety. Skyline deflection dictates ground clearance, cable tension and therefore the maximum allowable payloads (Lysons and Mann 1967).

Payload analysis software programmes, such as LoggerPC, CYANZ, SkylineXL and Cable Harvest Planning Solution, or CHPS (an extension integrated into ArcGIS™ software), calculate deflection for a skyline design based on maps or a Geographic Information System. There is however still a need to ensure the cable logging system is set up according to the design so that planned cable payloads can be achieved and production targets can be met.

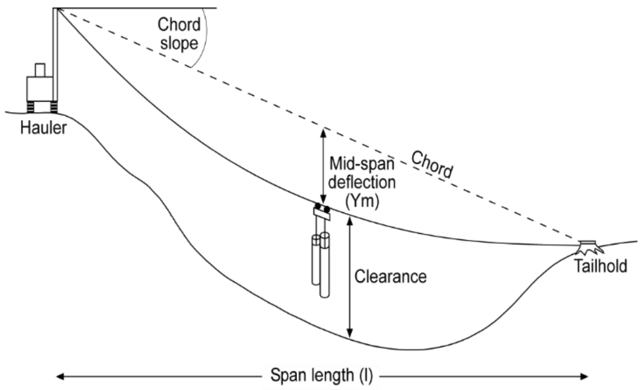

Figure 1: Measurement of deflection

As part of the FFR Cable Rigging Efficiency project, field methods for measuring deflection have been investigated. A field method for measurement of deflection was proposed by Sessions (1976). This method was a surveying procedure known as the Abney method, and required a few measurements from the surveyor followed by the use of a mathematical equation to derive an estimate of deflection. Another possible solution for measuring in-field deflection is an app working from a digital photo. An existing app called LineSmarts, which was developed for the engineering of overhead lines used

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in the electricity sector was evaluated in this report. The LineSmarts app (the App) allows users to, among other things, calculate the distance between power poles and estimate cable deflection (LineSmarts, 2015).

OBJECTIVE

The primary objective of this study was to explore the opportunity to use the LineSmarts App to measure skyline deflection for cable logging operations and to assess its accuracy compared to the more traditional surveying method (known as the Clinometer method).

METHODS

Study Sites

Both a laboratory and a field study site were chosen to test the LineSmarts App. The laboratory site was located on the University of Canterbury campus and utilised the School of Forestry's 1:15 scale model yarder. The field study site was a small farm forest block located near Mt Thomas in central Canterbury, where B&L Logging Ltd were operating a Washington 88 swing yarder with a Falcon Series 2 motorised grapple carriage.

LineSmarts App

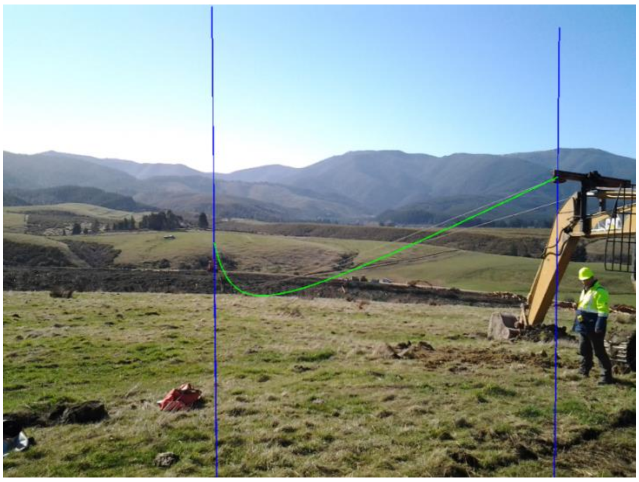

Figure 2: LineSmarts photo processing showing tail hold position and estimated shape of skyline catenary.

The LineSmarts method of deflection measurement was tested using the LineSmarts App installed on a Samsung tablet running the Android operating system version 10.1. Before use, the tablet was calibrated using a routine in LineSmarts, following the company's video instructions provided on their website. The procedure was to take a photo using the tablet's built-in camera. A range finder was then used to enter the distance to both ends of the suspended skyline (i.e. from the fairlead of the yarder to the tail hold). On the tablet, the locations of the two skyline ends as well as the mid-span location were entered using the touch screen (Figure 2). The App then calculated the span distance and the deflection.

The same equipment was used to measure deflection at both the laboratory and field study sites. For the more traditional Clinometer method, the deflection measurements were collected using a laser range finder (field site) and by tape measure (for the lab site) and a clinometer.

Testing

For the lab test, the model yarder's skyline was set up with a single span. The actual span length and actual deflection were measured with a tape measure and mid-span was marked with a piece of flagging tied to the skyline. Using a clinometer, the chord slope from the tail hold to the tower, and the slope from the tail hold to the carriage at mid-span were measured. The difference between the two slopes was then divided by two, to calculate the percent mid-span deflection. This is referred to as the Clinometer method (Harrill and Visser 2015).

The lab test consisted of one skyline span measured using the Clinometer method while two estimates of deflection from two different positions were measured using the LineSmarts App.

At the field study site with the Washington 88 swing yarder, three different spans were set up, and the clinometer measurements of deflection were calculated the same way. Span distance was measured using a laser range finder, and the carriage was positioned at mid-span through the use of the range finder and radio communication with the yarder operator. The LineSmarts App was then used to measure deflection at each site.

RESULTS

Lab Test

In the lab test the actual span, as measured by tape was 4.35 m. The actual deflection as measured with a tape suspended from the red line acting as the chord in Figure 3A at mid-span was 0.66 m or 15.2%.

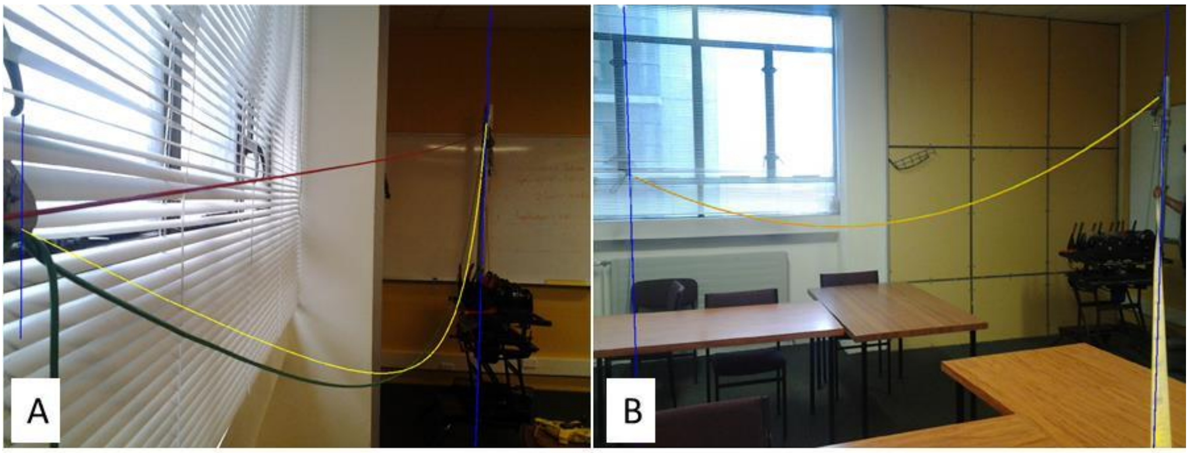

Figure 3: LineSmarts photo processing from Lab Test 1: Photo taken at tail hold (A) and from side (B), showing support positions and estimated shape of skyline catenary.

Table 1: Summary of Lab test and field test results

Study Site	Test	Measurement Method	Span Length (m)	Deflection (%)
Lab	1	Clinometer	4.35	15.4
		LineSmarts @ Tailhold	4.41	18.1
		Δ	1%	18%
		LineSmarts from Side	4.30	20.9
		Δ	-1%	36%
Field	1	Clinometer	267.5	4.25
		LineSmarts @ Tailhold	270.8	5.1
		Δ	1%	20%
	2	Clinometer	267.5	2.75
		LineSmarts @ Tailhold	270.8	3.9
		Δ	1%	42%
	3	Clinometer	268.6	4.0
		LineSmarts from Side	266.6	4.5
		Δ	-1%	13%

In the lab test, the App was able to estimate the span length within 1% of the Clinometer method from either photo position. Given the support locations and an indication of mid-span, the App was also able to estimate the shape of the catenary (Figure 3B). The shape of the catenary was best estimated when the photo was taken from the side than the tail hold view.

In the lab test, regardless of where the photo was taken, the LineSmarts App overestimated the deflection, which varied considerably from tail hold view by 18% and from side view by 36%, compared to the Clinometer method (Table 1).

Compared to the actual measured deflection, the LineSmarts App overestimated the deflection by 19% at the tail hold position (18.1% vs. 15.2%), and by 38% from the side view (20.9% vs.15.2%).

In comparison, the Clinometer method was able to predict within 1% of the actual measured deflection (15.4% vs 15.2%).

A follow-up lab test was conducted later in Dunedin to address the inaccuracy issues encountered in the earlier tests. The follow up test used a Samsung S6 and a Tablet Pro 8.6 to measure two spans and both

devices were capable of estimating the deflection within 0.96%–2.65% of the actual defection.

Developers of LineSmarts recommend using the higher end range of tablets with quality cameras and to make sure that the device and App are calibrated correctly. Also, correctly identifying the end supports and the cable in the photo is crucial, as small discrepancies can produce substantially different estimates of deflection.

Field Test

The field test consisted of three spans with varying deflection. In the first two tests the yarder was located in the same position, so span length did not change. Again the App was able to estimate span distance within 1% of that measured using a laser range finder in all three tests.

There was still difficulty in projecting the shape of the catenary, resulting in considerable variation in estimated deflection between the two methods. Results of deflection measurements using the LineSmarts App were 20%, 42% and 13% higher than those for the Clinometer method.

One difficulty experienced when using the App was the need to fit the entire span in the image for processing, which was particularly difficult from the side view where the user had to stand about one span length away due to the fixed camera zoom.

Another important aspect for both the App and Clinometer method is that the carriage must be visible at mid-span to record accurate measurements. A second field test was attempted in Otago but could not proceed for this reason. All field deflection measurements undertaken in Canterbury were low (i.e. hauler settings where deflection is less than 6%), as required for measurement purposes as described above, and did not represent the deflection obtained during actual operations.

While the App produced what could be described as "ball park" or rough estimates of deflection, users should proceed with caution in using the LineSmarts App to determine physical feasibility of hauler settings where it is estimated that deflection is low (i.e. less than 6%), as the App appears to overestimate deflection available.

CONCLUSION

Understanding skyline deflection helps logging planners, contractors and operators to plan and manage their operations safely. Measuring deflection in the field enables superior positioning of equipment (yarder and tail trees) and selection of the best methods to maximize payloads and production.

The LineSmarts App offers another solution to measuring deflection of skylines used in cable logging. In comparison to a simplified field method for measurement of deflection (the Clinometer method) the App closely estimated span distance with consistency. However the App overestimated deflection, which varied considerably between spans and also within the same span depending on where the picture was taken. For best results using the App, a high end device should be used and correctly calibrated. In addition the user should seek training on correct use of the software including identification of endpoints and cable position, with all of which the developers can assist.

The Clinometer method for measurement of skyline deflection has been taught at the FFR/UC Cable Rigging Configurations Workshops (Harrill and Visser 2015) and is being developed into a software application. This alternative app requires in-field measurements of slope and distance, followed by simple calculations to give an accurate estimate of deflection.

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