HARVESTING TECHNICAL NOTE

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Production Trials of the HarvestNav Machine Navigation System

Summary

Providing the feller buncher operator on steep slopes with an on-board navigation system on a computer tablet showing the harvest plan, a forward view of the terrain profile and warnings when user input machine slope limits are exceeded has the potential to improve the safety, productivity and efficiency of steep terrain harvesting operations.
Enabling the operator to see exactly where the machine is positioned in the forest block relative to boundaries and exclusion zones and major hazards increases the margin for safety. Providing a clear forward view of the cutover terrain reduces the risk of machine incidents, such as rollover. Having the harvest plan in the cab of the machine also enables better operational planning of layout of felled trees for extraction, and potentially increases extraction productivity. This report details production field trials of the commercial model HarvestNav on-board navigation system at two harvesting sites in the North Island. The objective of the study was to evaluate the performance of the HarvestNav in a range of operational conditions. Results highlighted some operational issues with the HarvestNav that are being addressed by the developer.

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INTRODUCTION

One of the goals of the Forest Growers Research (FGR) Steepland Harvesting Programme is to improve the safety of harvesting operations on steep slopes through the development and implementation of new technology.

The Steepland Harvesting Programme supported the development and use of mechanised felling to remove workers from the hazardous tasks of manual tree felling. With the increased use of feller bunchers using winch-assist technology on steep terrain, the potential of on-board navigation systems to assist machine operators was recognised.

At the start of the programme in 2010 the potential of Light Detection and Ranging (LiDAR) to develop highly accurate and detailed digital elevation models of surface topography (terrain) for improved forest engineering and harvesting operations was recognised (Marshall, 2011).

LiDAR-derived digital terrain models can reveal topographical features that cannot be seen in either aerial photos or on the ground, such as difficult side slopes, unstable soils, historic tracks, roads or streams. The integration of the technologies of Global Navigation Satellite Systems (GNSS), LiDAR-derived digital terrain models, detailed harvest plans in a Geographical Information System (GIS) and digital accelerometers to measure machine slope, and mobile computing to display the output on a computer tablet in the operator's machine cab, was seen as one way to improve the safety feller bunchers working on steep terrain.

The environmental benefits in terms of maintaining machine positioning using GPS to ensure machines did not encroach over harvest area boundaries was also recognised. Improving the machine operator's forward view of the terrain, including exclusion zones (such as riparian areas) or hazards such as rock bluffs or sinkholes (tomo) during felling operations would reduce risk.

BACKGROUND

From the commencement of the FGR Steepland Harvesting Programme in 2010, a project has been active to develop an on-board machine navigation system comprising a computer tablet with internal GPS, and software (Figure 1) for mounting in the machine cab (Marshall, 2012).

Figure 1. The HarvestNav installed in the cab of a harvester

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HARVESTNAV SYSTEM OVERVIEW

Over the past five years, Forest Growers Research Ltd (FGR) has developed the HarvestNav on-board machine navigation system.

Originally HarvestNav was developed solely as a software application. The software application provided a real-time display of the position of the machine on digital terrain and slope models, displayed important spatial information to the operator such as boundaries, roads and watercourses, projected the terrain profile to show topographical features ahead of the machine, and included an operator warning system.

The concept was that contractors could download the software onto their own Windows-based computer tablet for free. However the problem with this concept was that firstly there were a limited number of Windows tablets with integrated GPS available on the market, and secondly that these tablets had extremely short commercial shelf life, due to the dynamic market for computer tablets. This resulted in contractors purchasing a tablet to soon find that further units of the same model were no longer available. It was decided that to overcome this problem, HarvestNav would be further developed and commercialised as low cost bespoke hardware, with pre-loaded software.

The FGR project resulted in the development of the current commercial model of the HarvestNav hardware, which comprises:

- Windows 10 single board computer (Lattepanda)
- 18-cm (7-inch) LCD screen
- 18-cm (7-inch) touch screen overlay
- USB GPS (GlobalSat 355S4
- USB accelerometer (Yoctopuce 3D)
- Micro USB power supply (min 5V, 2.1 Amps)
- 2 USB cables
- 3D printed case.

The HarvestNav is powered using the 12 or 24 volts power socket. All the parts are sourced from the internet, mostly out of China. The combined costs of the parts is less than US$500.

HarvestNav software runs on the Windows 10 Operating System utilising the external GPS receiver to monitor the machine's position on the terrain. It also uses the digital accelerometers in the tablet to measure the pitch and roll of the machine. The operator can set slope limits for the machine, and HarvestNav has been programmed to warn the machine operator when the maximum allowable slope of the machine is about to be exceeded.

The application can also utilise LiDAR data to better visualise not only the terrain at the machine's current location but also the terrain immediately ahead of the machine through the use of improved digital terrain and hill shaded models.

The main purpose of this system was to provide the operator of winch-assisted harvesters, such as the ClimbMAX steep slope harvester, with real time information about the terrain. It must be stressed that using a decision support tool such as HarvestNav using LiDAR-derived topographical maps does not replace operator observation and skills in avoiding obstructions, such as stumps and fallen trees which are not featured on the DTM.

The initial application was designed for use by felling machines in steep country, but it also has potential in ground-based operations such as skidders and roading machinery used in forest road construction. HarvestNav could also be adapted to work in a cable yarder, tracking the location of the carriage along the skyline corridor.

The commercial model HarvestNav (Figure 1) was launched in June 2017 at the HarvestTECH 2017 Conference in Rotorua.

OBJECTIVE

The primary objective of this study was to evaluate the performance of the HarvestNav hardware and software in a range of operational settings.

METHODS

Three of the new commercial model HarvestNav units were built: two were used for field trials while the third was used as a demonstration model for the FGR field days held in 2017.

This study with designed to test:

- the suitability and reliability of the HarvestNav hardware,
- the usability of the software, and
- operator perceptions of the overall usefulness of the system.

HarvestNav was installed in each of the test machines, and the operator was given some basic training on how to operate the software. It took only about 10-20

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minutes to install the system. The system was left in each machine for a minimum of 2 weeks. Once the trial had finished the HarvestNav was removed from the machine. The operators were interviewed to obtain their opinions of HarvestNav and any suggested improvements.

Study Sites

Site 1: The HarvestNav was installed on a Caterpillar 325FM excavator-based harvester at Blue Mountains Logging Ltd. The crew was a ground-based harvesting operation, working in Kawerua Forest in the Western Bay of Plenty. The site was rolling with a large number of archaeological sites. The operator was comfortable with computers and was already using Avenza Maps, a mobile map ‘app’ for downloading maps for offline use on iOS or Android smartphones or tablets and on Windows 10 devices. The built-in GPS on the smartphone was being used to track his location on the .pdf map on his mobile phone.

Figure 2. Site 1 in Kawerua Forest

Site 2: The HarvestNav was installed on a TigerCat 635G six-wheeled skidder (Figure 3). The HarvestNav was not really designed to operate in a skidder. The operator at this site had used the old version of HarvestNav on his own 10-inch tablet (with integrated GPS and accelerometers). Although he uses it in his machines, he has also used the HarvestNav app to walk the harvest unit prior to harvest.

The site was located just north of Dargaville in Northland. Again the site was rolling.

Figure 3. The Tigercat 635G six wheeled skidder

Figure 4. Site 2 located north of Dargaville, Northland

RESULTS & DISCUSSION

Site 1:

HarvestNav operated without issues for 12 days, but unfortunately a piece of software that had been installed to restart HarvestNav if it had crashed had corrupted the HarvestNav’s setting file, resulting in it crashing on start-up. The Restart software was removed from the HarvestNav to solve this problem. Some additional code has been added to fix this problem if it does occur again.

The operator found HarvestNav useful but did have a number of suggestions for improvements, some of which are easily implemented, and some not so easy.

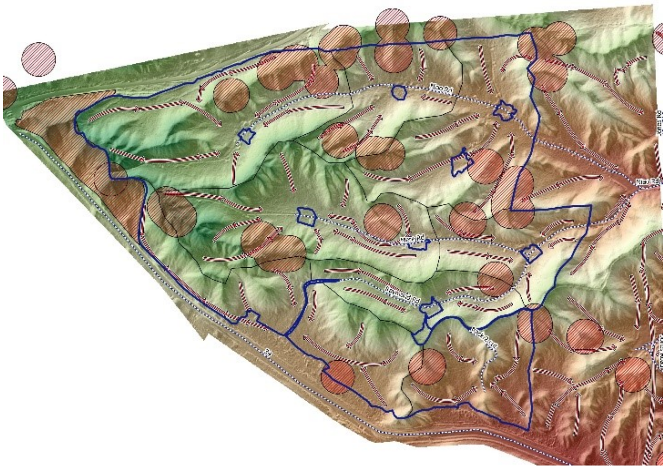

Figure 5. The harvest plan for Site 1 – this is the view the operator saw on HarvestNav.

The operator made the following comments:

1. Early in the morning before the sun is up the brightness of the screen was blinding. (There are software products that adjust the colour and brightness of the screen based on your location and time of the day. One such product is f.lux)
2. The colour and design of the location indicator on the screen was often difficult to see. (Changes have been made to the colour and design of the location indicator)
3. The operator thought that the screen size was perfect and that any larger would block his visibility. (This is an interesting comment – given that many people like a bigger screen).
4. It would be good if the road and skid warning was more flexible. (Currently the road and skid warning is based on fixed buffer and cannot be changed by the operator. This can be changed to work like the other warnings.)

Site 2:

Unfortunately HarvestNav only operated for a couple of days on this site. In this case it was a hardware failure. The 3D printed on/off switch came loose from its position in the 3D printed case. It caused a cover on the single board computer to be knocked off. This meant the single board computer would not start.

Once the HarvestNav unit was returned to Margules Groome the problem was easily fixed. The operator had used previous versions of the HarvestNav software. He said that he still preferred the bigger screen of his 10-inch tablet. He also was worried about all the cables to the GPS and accelerometer. It should be noted that on this site HarvestNav was installed in a skidder, and this was only a temporary installation.

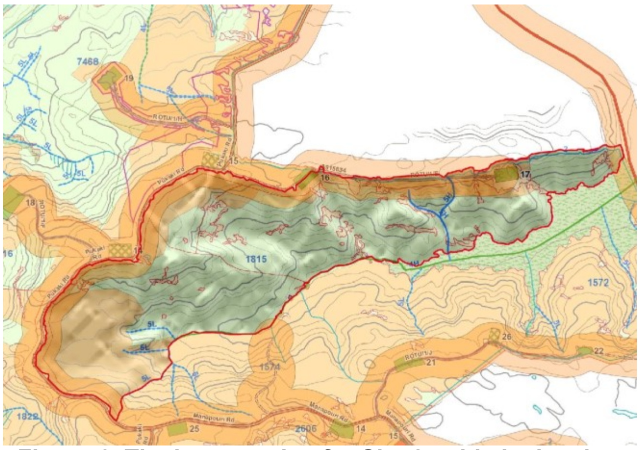

Figure 6. The harvest plan for Site 2 – this is the view the operator saw on HarvestNav.

CONCLUSION

This initial set of field trials highlighted a number of issues with both the hardware and software of HarvestNav. With the exception of Site 2 the hardware performed extremely well. The fix for this problem was extremely simple.

Operator perceptions of the overall usefulness of the system were that both operators found HarvestNav easy to use after some basic training. They both provided a number of suggestions for improvements.

ACKNOWLEDGEMENTS

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