An Autonomous Platform for use in Kiwifruit Orchards

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Abstract

This will be written last. Other uses may be mechanical weed removal, targeted spraying, and crop scouting.

Keywords:

1. Introduction

Short-term labor requirements within the New Zealand kiwifruit industry peak twice a year corresponding with pollination and harvesting cycles. The majority of employment in this industry during these peaks is filled by seasonal or casual workers (Timmins, 2009). As kiwifruit is New Zealand's largest horticultural export by value (Statistics New Zealand, 2015), automation in kiwifruit harvesting and pollination should ease growth in this industry. Additionally, the New Zealand government aims to double exports from its primary industries between 2012 and 2025 and is actively investing in programmes to achieve this (Ministry for Primary Industries, 2015).

Previous work on automated harvesting of kiwifruit has been demonstrated (Scarfe, 2012; Scarfe et al., 2009). That work presents a harvesting platform with the capability of in-orchard kiwifruit harvesting from pergola type orchards.

The robotic platform presented in this paper is a second generation unit based on that previous, more integrated, design of kiwifruit harvester. Modularity of the platform has been increased to so as to be able to fit either

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a harvesting module or a pollination module. This work discusses only the base platform, where details of the harvesting and pollination modules are published separately.

Automation in harvesting and pollinating kiwifruit demands the use of real-time computer control, state-of-the-art manipulators, and convolutional neural networks. In their current state of development these systems are bulky and have specific geometic requirements dictated by the environment they operate in. As part of a wider kiwifruit automation project, of which this research falls into, two separate modules have been developed for the tasks of artificial pollination and kiwifruit harvesting. These modules share common requirements in that they both require transport to and from orchards, electrical power, and air pressure, but differ in they way they move the orchard. The pollination module is designed to move at a well-known velcity down with minimum changes in angle, whereas the harvesting module repeatidly starts and stops, advancing set distance between cycles. The duration of any given harvesting cycle is determined by the number of fruit to be harvested during that particular cycle. As the harvester is designed to be autonomous, there must be communication between the harvester and the base platform to make efficient use of time. That communication can be as simple as a command anologous to 'harvesting completed, advance to next section', but highlights the need for an autonomous platform for the modules.

Many autonomous vehicles for use in the agricultural industry have previously been reported, many of those being conversions of existing vehicles into a self-driving form [Mark chuck some references here]. While this can reduce the initial cost for development of self driving systems, the cost of deploying such units may make them commercially unfeasible. In this work we present an agricultural vehicle designed specifically for use in kiwifruit orchards to transport modularised pollinating and harvesting units. The weight and size of these units requires a vehicle that is robust, computer controllable, low-slung, and is capable of performing turns between rows.

An electric four wheel steered robot is presented in Bak & Jakobsen (2004).

It has been stated that "since the robot development already includes a high complexity, the application itself should be of comparably low complexity" (Ruckelshausen et al., 2009).

"The implementation of additional mechatronic systems, such as weeding or seeding, will increase the complexity due to technical and logistical aspects and thus reduce the probability for the development of a robust system.” (Ruckelshausen et al., 2009).

2. Review

3. Mechanical design

Skid steering inappropriate for orchard environments due to soft ground. Pivoting front axle used to maintain three points of contact at all times; no suspension. Limited to $10\,\mathrm{km\,h^{-1}}$ by the choice of motor and gearboxes on the drive-system. Operational speed of $5\,\mathrm{km\,h^{-1}}$. Ackermann steering geometry with the ability to pivot about the centre of the rear wheels. Four wheel steering, such as presented by Bak & Hans (Bak & Jakobsen, 2004), was not deemed necessary as the headlands of kiwifruit orchards provide adequate turning areas. Additionally, control strategies for a platform having only two sterable wheels is simpler.

(Åstrand & Baerveldt, 2002) have used an ackermann steering system actuated by a single DC servo motor for their robotic beet-crop weeding platform. They have only two driving wheels placed at the rear of the system.

4. Hardware

GPS has proven to be unreliable when used under the dense canopy of a kiwifruit orchard. (Pedersen et al., 2006) shows the economics of using an GPS-RTK system, as seen in other agricultural systems (Bak & Jakobsen, 2004; Ruckelshausen et al., 2009)[Nagasaka et al from (Torii, 2000)], has considerable ongoing costs in the form of yearly fees, although the cost of these units is rapidly decreasing (Torii, 2000). Forward and upwards facing LiDAR have been used for navigation and detection of the row and canopy.

5. Safety

Relay modules connected to the main computer via the system's CAN bus give a means of shutting down subsystems. These relays monitor the platform's CAN bus to ensure that synchronisation messages are being sent out in a timely manner. In the event that the synchonisation messages begin to vary in frequency, or stop, the relays cut power to the subsystems. Both front drive motors are fitted with electromechanical brakes which engage when the power is cut. A wireless safety-rated controller, designed for use with cranes, has been adapted for use with driving robot platform. The controller provides the operator with a way of entering the platform into autonomous mode, manual control, triggering an emergency stop, or enabling/disabling auxiliary systems.

6. Software architecture

The control software is comprised of individual nodes, writen in either C++ or Python, linked together using Robot Operating System (ROS) for interprocess communication. The system runs on Ubuntu Server 16.04 on an Intel NUC, a compact x86 based PC. A model of the robot platform has been depeloped for use with Gazebo simulation software. Such a model provides a way to test steering and movement strategies before deploying them on the hardware.

7. Sensor selection

[Jamie's section]

8. Random info

"Field scouting and mechanical weeding have been identified and described as the first two niche tasks likely to become autonomous"(Blackmore et al., 2004).

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