Precise Picking Height Positioning on Wild Blueberry Harvesters using Electric Linear Actuators

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Background

Wild blueberries are an important crop to northeastern North America contributing $491 million for 117 million kg of blueberries over 93,000 ha of fields in 2012 (Yarborough, 2013). Mechanical harvesting remains the most cost-effective method for picking wild blueberries. Harvesting low bush blueberries presents a challenging task as the field topography and plant height vary throughout each field. Doug Bragg Enterprises (DBE) of Collingwood, NS incorporated a hydraulic cylinder with a 20 cm stroke to the rear of their harvester head to allow for adjustment of picking height in the field to optimize yield recovery. The current hydraulic system requires the operator to manually adjust the height while monitoring the terrain and driving the tractor. An inexperienced operator can lose significant amounts of berries (Farooque et al. 2014). This led to the development of a precise picking height positioning system using electric linear actuators with internal feedback (Fig. 1). The feedback allows the operator to know exactly where the actuator is within its stroke at all times. This system still requires input from the operator, but makes the task less challenging for them.

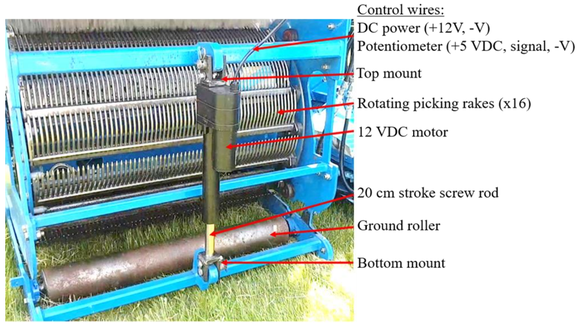

Fig. 1: Mechanical wild blueberry harvester showing attached electric linear actuator for precise head height positioning

Methodology

The precise picking height positioning system was developed using an Arduino Mega microcontroller, two dual direction H-bridge DC motor drivers, and two heavy duty electric linear actuators with built-in potentiometric feedback. A 20x4 LCD was used to display the position in the tractor cab and standard momentary buttons and rocker switches were used for operator input (Fig. 2). The components were selected with the design specifications outlined in Table 1.

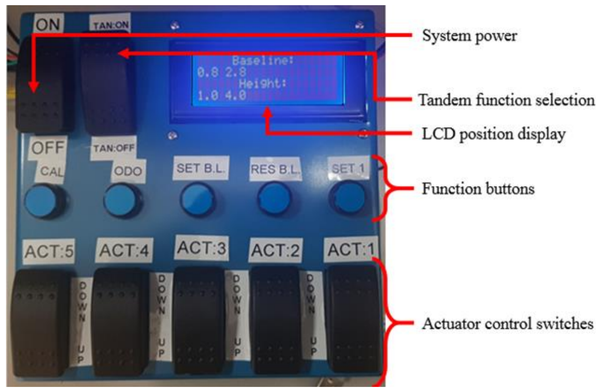

Fig. 2: Operator user control interface

Table 1: Summary of design criteria and specifications for linear positioning system

Design Criteria	Specification
Minimum lift capacity (kg)	540
Position feedback	Yes
Minimum positioning accuracy (cm)	± 1.27
Stroke (cm)	20.0
Minimum speed (cm/s)	5.0
Minimum duty cycle (%)	40
Synchronization across heads	Yes

Four control functions were incorporated into the system to increase the functionality compared to its hydraulic predecessor. Each function was proposed by industry partners as they saw practical application for them during harvest. The four functions include:

1) **Calibrate** fully retracts, then fully extends the electric linear actuator, taking a reading at the bottom and top of its stroke. The difference between the two readings is scaled to 0-20 cm to be displayed in the cab.
2) **Multiple On** allows the operator to move all actuators at once while maintaining the positions relative to one another.
3) **Baseline** allows the operator to select a precise position for each actuator that will be commonly used in the specific field they are harvesting. If the operator needs to move the actuators to avoid an obstacle, a particularly weedy patch, tall plants, and so on, they can easily return to the predefined positions.
4) **Set to One** allows the operator to set all actuators to the same position as actuator one.

Results

The mean discrepancy between the measured and displayed values in the cab was found to be -0.1645 cm. The results from the other three control function tests and comparison between hydraulic cylinder and electric actuator are summarized below.

Table 2: Summary of results for Multiple On test

Initial Offset (cm)	Final Mean Discrepancy (cm)
5.08	-0.0557
2.54	-0.0850
0	0.0074
-2.54	0.0150
-5.08	-0.0200

Table 3: Summary of results for Baseline test

Initial Set Position (cm)	Final Mean Discrepancy (cm)
4.445	-0.0333
7.62	0.0185
13.97	-0.0519

Table 4: Summary of results for Set to One test

Initial Position of Actuator 1 (cm)	Final Mean Discrepancy for Actuator 2 (cm)
5.08	-0.1037
11.43	-0.1778
16.51	-0.0630

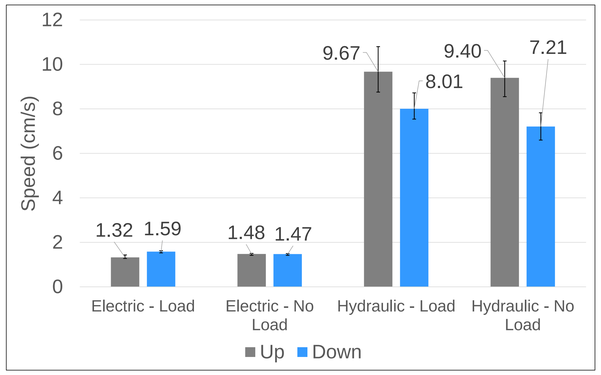

Fig. 3: Operational speeds both under and without load for the electrical and hydraulic actuators used in this study

Conclusion

The results of this study have the potential to greatly aid wild blueberry harvester operators by providing enhanced ability for picking height control. The closed loop control system worked flawlessly during field testing however the major limitation was the slow operational speed of the DC motor operated electric linear actuator system as compared to the hydraulic system currently being used. Loaded operational speeds of the electric actuator were 1.32 cms^{-1} (up) and 1.59 cms^{-1} (down) which proved far inferior to the 9.67 cms^{-1} (up) and 8.01 cms^{-1} (down) achieved using the hydraulic actuator. Despite the slow speeds, the precision of the system proved to be very high with absolute discrepancies across all tests never exceeding 0.60 cm, which was well within the required 1.27 cm accuracy set out by the harvester manufacturer.

References

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