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ORIGINAL PAPER

A Geometric Approach to Beam Type Load Cell Response for Fast Weighing

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Abstract: We propose a novel geometric approach to processing of load cell signals for inline weight measurement applications. These systems usually rely on oscillatory load cell signals which always need to time to settle. We describe the theoretical and experimental implementation of a newly proposed geometric approach for load cell signals, and verify the effectiveness of the method through experiments.

Keywords: Load cell; Geometric approach; Weighing method; Signal processing

1. Introduction

Most agricultural products are classified and marketed according to quality, size and weight standards. Inline or dynamic weighing systems are widely used for sorting and grading applications in food packaging industries to maintain these standards [1]. Basically fruit grading machinery consist of a chain mechanism that moves the fruit carriers by electrical motors and a weight measurement unit, as shown in Fig. 1, for a simplified block diagram of a dynamic weighting system.

Load cells are commonly utilized as weight transducers in dynamic and static weighting systems [2, 3]. In the packaging industry it is important to determine the weight of the product as fast as possible to obtain higher production volumes. Even though they are highly damped, settling times of the load cells are long, and the measurement system needs to estimate the final load cell signal (static loading point) while its output is still in oscillation. To eliminate the high frequency part of the load cell signal, dynamic weighing systems are commonly equipped with low pass filters. However, low pass filters downgrade the measurement speed, and, since higher speeds are always desired for production, an alternative approach to the filtering method is required. The post-harvest industry usually requires ±1 g precision at 10–15 fruit per second, and, of course, the weighing process should not physically damage the fruit. Therefore, to reduce physical damage in the sorting process, most packaging houses limit the sorting speed to approximately ten fruit per second.

Research and industrial trials have shown that a digital signal processor (DSP) can estimate the weight from filtered load cell data. DSPs process the data using a model based on load cell parameters, such as stiffness and damping ratio. However, these parameters not only tend to change in time but can also vary between load cells. An alternative method is required that is independent of the load cell parameters. We propose a parameter-independent method with high speed and precision, which can be easily implemented on low cost micro controller systems. In this work a novel geometric approach has been developed that eliminates boundaries to load cell parameters. In the proposed approach, the load cell signal is amplified and the value and position of the first three peaks and the initial conditions are determined. We estimate the fruit weight from these first three peaks rather than filtering and averaging the tail end of the signal, which it promotes high speed measurements.

Several methods have been reported addressing highly oscillating load cell output. Some studies propose analog and digital adaptive filters, and in particular linear time-varying filters have been proposed [4]. A detailed comparison of this with the proposed method is given below, but in summary, due to high settling time, this method does not address high speed applications. Adaptive filters [5] can achieve a steady state value of the mass, but this has not been verified

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