

Automation of Front-End Loaders

Electronic Self Leveling and Payload Estimation

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Abstract

A growing population is driving automatization in agricultural industry to strive for more productive arable land. Being part of this process, this work is aimed to investigate the possibility to implement sensor-based automation in a particular system called Front End Loader, which is a lifting arms that is commonly mounted on the front of a tractor. Two main tasks are considered here, namely Electronic Self Leveling (ESL) and payload estimation. To propose commercially implementable solutions for these tasks, specific objectives are set, which are: 1) to propose a controller to perform ESL under typical disturbances 2) to propose a methodology for payload estimation considering realistic estimation conditions. Lastly, aligned with these goals, 3) to propose models for the Front End Loader under consideration for derivation of solutions of the specified tasks.

The self-leveling task assists farmers in maintaining the angular position of the mounted implements, e.g. a bale handler or a bucket, with respect to the ground when the loader is manually lifted or lowered. Experimental results show that different controllers are required in lifting and lowering motions to maintain the implement's angular position with a required accuracy due to principle differences in gravity impact. The gravity helps the necessary correction in lifting motion, but works against the correction in lowering motions. This led us to propose a controller with a proportional term, a discontinuous term and an on-line disturbance estimation and compensation as well as the tuning procedure to achieve a 2 degrees tracking error for lowering motions in steady state. The proposed controller shows less sensitive performance to lowering velocity, as the main disturbance, in comparison to a linear controller.

The second task, payload estimation, assists farmers to work within safety range as well as to work with a weight measurement tool. A mechanical model derived based on equations of motion is improved by a pressure based friction to sufficiently accurately represent the motion of the front end loader under consideration. The proposed model satisfies the desired estimation accuracy of 2\% full scale error in a certain estimation condition domain in constant velocity regions, with off-line calibration step and off-line payload estimation step. An on-line version of the estimation based on Recursive Least Squares also fulfills the desired accuracy, while keeping the calibration step off-line.

Keywords

Front-End Loaders, Electronic Self Leveling, modeling, control, disturbance estimation, payload estimation, equations of motion, pressure-based friction

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