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SENSOR SYSTEMS FOR DAIRY COW HEALTH MANAGEMENT: A REVIEW

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Introduction

In recent years, many studies concerning sensor technology in dairy farming have been published. However, a structured overview is lacking at present. Such an overview is important to identify possibilities for future research regarding sensors and to summarize what can be done with sensors at this moment. The aim of this overview is to provide a structured overview of the published studies on sensor systems for dairy health management.

Method

The progress in sensor systems can be described using the following four levels (Figure 1):

- I. technique: description of equipment that measures something about the cow (e.g., activity);
- II. data interpretation: summarizing changes in the sensor data (meaning raw or processed measurements, e.g., increase in activity) to produce information about the cow's status (sensor data processed to provide insight in the cows health, e.g., estrus);
- III. integration of sensor information with other information (e.g., economic information) available on the farm, to produce an advice (e.g., whether to inseminate a cow or not);
- IV. the farmer takes a decision or the sensor system takes the decision autonomously (e.g., the inseminator is called).

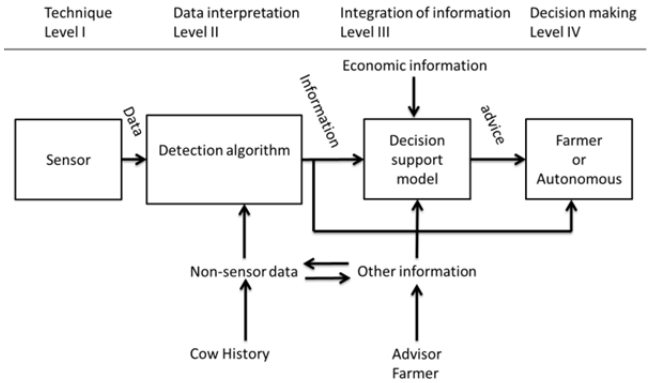

Figure 1: Framework of the use of sensor information in dairy farm management.

The publications used for this review were published in the ISI database from January 2002 until June 2012 or in the proceedings of three conferences on precision (dairy) farming in 2009, 2010, and 2011. This overview has evaluated a total of 126 publications describing 139 sensor systems. Sensor systems were categorized into four (production) diseases the systems aim to detect: mastitis, estrus, lameness and metabolic problems. Then, the systems were compared based on the four levels of Figure 1 and detection performance.

Conclusions

Most studies concerned the detection of mastitis (27%), estrus (35%), and lameness (27%), with fewer studies (12%) related to the detection of metabolic problems. Many studies presented sensor systems at levels I and II, but none did so at levels III and IV. Most of the work for mastitis (92%) and estrus (75%) is done at level II. For lameness (53%) and metabolism (69 %), more than half of the work is done at level I. Table 1 summarizes the information on found publications and development levels. In that table, 'Sensor tests' corresponds with level I and level II is split up in 'Algorithm development' and 'Algorithm + validation'. This means that a distinction is made between developing a statistical/mathematical model that relates sensor data to cow health and validating such a model with a validation dataset.

The performance of sensor systems varies, based on the choice of gold standards, algorithms and test sizes (number of farms and cows). Studies on sensor systems for mastitis and estrus showed that sensor systems are brought to a higher level of development. However, there are still possibilities to improve detection performance. For automated detection of estrus the reported sensitivity was found in the range of 80-90% and specificity >90%, for activity meters, 3D accelerometers and pedometers. Accordingly, the used gold standards were: successful inseminations for pedometers and 3D accelerometers and progesterone measurements for activity meters. Moreover, studies on sensor systems for locomotion problems showed that the search continues for the most appropriate indicators, sensor techniques, and gold standards. For locomotion the possibility of discriminating between lame and non-lame cows has been studied, several sensors were studied amongst which 3D accelerometers, pedometers and activity meters. By contrast, studies on metabolic problems show that it is still unclear which metabolic problems should be detected and what indicator is appropriate. Furthermore, no systems with integrated decision support models have been found. Although tools have been developed for insemination decisions these do not use sensor information with the inherent uncertainty of sensor information.

Table 1. Number of publications per disease group and percentage of these publications per development level. Sensor tests means that the sensor has been shown to measure a parameter from the cow, Algorithm development means that the sensor data have been statistically related to a disease and Algorithm + validation means that the detection algorithm has been validated.

	Publications (n)	Sensor tests	Algorithm development	Algorithm + validation
Mastitis	37	8%	19%	73%
Estrus	48	25%	29%	46%
Lameness	38	53%	26%	21%
Metabolic	16	69%	13%	19%

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