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Technical note: Validation of a commercial system for the continuous and automated monitoring of dairy cow activity

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ABSTRACT

Current farm sizes do not allow the precise identification and tracking of individual cows and their health and behavioral records. Currently, the application of information technology within intensive dairy farming takes a key role in proper routine management to improve animal welfare and to enhance the comfort of dairy cows. An existing application based on information technology is represented by the GEA CowView system (GEA Farm Technologies, Bönen, Germany). This system is able to detect and monitor animal behavioral activities based on positioning, through the creation of a virtual map of the barn that outlines all the areas where cows have access. The aim of this study was to validate the accuracy, sensitivity, and specificity of data provided by the CowView system. The validation was performed by comparing data automatically obtained from the CowView system with those obtained by a manual labeling procedure performed on video recordings. Data used for the comparisons were represented by the zone-related activities performed by the selected dairy cows and were classified into 2 categories: activity and localization. The duration in seconds of each of the activities/localizations detected both with the manual labeling and with the automated system were used to evaluate the correlation coefficients among data; and subsequently the accuracy, sensitivity, specificity, and positive and negative predictive values of the automated monitoring system were calculated. The results of this validation study showed that the CowView automated monitoring system is able to identify the cow localization/position (alley, trough, cubicles) with high reliability in relation to the zone-related activities performed by dairy cows (accuracy higher than 95%). The results obtained support the CowView system as an innovative potential solution for the easier management of dairy cows.

Key words: dairy cow, validation, sensor, automated monitoring system

Technical Note

The current increase in the global demand for dairy products means that the dairy industry has undergone profound changes over recent decades (Barkema et al., 2015). Economic pressures, technological innovations, demographic shifts, consumer expectations, and an evolving regulatory framework have contributed to the impetus for changes in the global dairy industry (Barkema et al., 2015), aimed at the maximization of productivity and efficiency (Gerber et al., 2011). Moreover, the consolidation of farms has resulted in larger herd sizes (von Keyserlingk et al., 2013), with relevant effects on the health and welfare of dairy cows and on management practices and systems for dairy herds (Barkema et al., 2015). However, current farm sizes do not allow the precise identification and tracking of individual cows and their health and behavioral records.

Monitoring the behavior of dairy cows is useful to assess their welfare, health status, and comfort at farm level (Mattachini et al., 2013). Indeed, changes in behavior are clear indicators of dairy cows' health and welfare problems and therefore they can be used as input to an early warning system. The time spent by the cows lying or feeding plays an important role in terms of milk production (Fregonesi et al., 2007; Mattachini et al., 2011); therefore, knowing their position is important to monitor their behavioral patterns and activity (Huhtala et al., 2007) to obtain information to control and monitor cows' health status and productivity.

However, continuous monitoring requires a lot of manpower/labor and is time consuming (Fontana et al., 2015a). For this reason, precision livestock farming approaches can combine information technology (**IT**) into online automated tools that can be used to control, monitor, and model the behavior of animals and their biological responses (Tullo et al., 2013).

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Since the 1980s, progress has been made on devices that measure health indicators in, up, on, or from an individual cow (Hogeveen et al., 2010). Examples of sensors used on dairy cows include milk electrical conductivity, milk color sensors, acceleration sensors attached to the cow's leg, and pH sensors. A sensor system consists of the device itself plus the software that processes the data to produce information or advice (Rutten et al., 2013). Several studies have confirmed the feasibility of the use of information technology, achieving excellent results in the identification and localizations of the animals, feeding pattern recognition, and estrus detection (Porto et al., 2014).

Nowadays, the application of IT within intensive dairy farming takes a key role in proper routine management to improve animal welfare and to enhance the comfort of dairy cows (Fontana et al., 2015b).

An existing application based on IT is the GEA CowView system (GEA Farm Technologies, Bönen, Germany). The CowView system is an automatic indoor localization system for dairy cattle, providing data on positions and zone-related behavior or activity of tagged animals based on triangulation of very short radio-signals (Ultra-Wide Band) with a precision of 50 cm (CowView system, GEA Farm Technologies).

This system continually records the position of each cow through a connection among sensors placed in the barn and the CowView tag mounted on the cow's collar. This system is able to detect and monitor animal behaviors based on positioning through the creation of a virtual map of the barn that outlines all areas where the cows have access. The output is a data set with the position of the animal characterized by spatial coordinates that allow the identification of behaviors. Indeed, a distinctive feature of this technology is the division of the whole area into sub-areas, which define specific cow behaviors (for example, being at the feeding table corresponds to feeding behavior).

The aim of this study was to validate the accuracy, sensitivity, and specificity of the CowView automatic monitoring system that tracks cow position and behavior.

Data collection consisted of 2 steps for the creation of 2 different data sets to be compared during the validation.

Five selected cows were equipped with the CowView electronic tag and were marked with a yellow letter on both flanks and on the back.

The first step of data collection was automatically performed with the CowView system; it resulted in an output file containing the position of each animal characterized by spatial coordinates. The second step of data collection consisted of video recordings obtained with a camera [Axis P5534 PTZ Dome Network, (Uptime-IT, Svendborg, Denmark), 30 frames per second (**fps**), and 1,280 × 720 pixels] placed in a top-down perspective under the roof of the experimental barn. Total video recordings lasted for around 42 h (150,405 s, at 30 fps that ended with 4.5×10^6 frames) over 6 d. Successively, recordings were visually checked and manually labeled, by an operator, playing the videos or observing them frame by frame (30 fps; Ismayilova et al., 2013).

These video recordings were visually processed (video labeling), following the marked cows in their behaviors and positions. Checking the video frame by frame allowed the operator to precisely detect the start time of a cow behavior/position. The shooting angles of the camera did not allow the operator to continuously follow the marked cows; therefore, parts of the videos without any marked cow were discarded. When a specific behavior/position was observed in the video, information such as classification, zone, start time, and duration were reported in a data set used as reference for the validation.

Each behavior/position was classified second by second; more precisely, an activity lasting 10 s was recorded in the data set as 10 repeated activities of 1 s.

The outcome of the video labeling was used as the gold standard for the validation of the accuracy of the system. The validation was performed by comparing both data sets obtained to check the system reliability in localizing the position of the cows and their behavior.

Data used for the validation were represented by the zone-related activities performed by the selected cows and were classified into 2 categories: behavior and position. The "feeding" behavior was considered to be taking place when the cow's head was in the fodder line, both in the manual labeling and in the development of the software. "In bed" behavior was considered to take place during the manual labeling when the cow was in the cubicle, but the system was not able to recognize whether the cows were lying down or not. The validation also included the categories "at the drinker" both as a behavior and a position. The activity was not classified as "drinking" because the CowView system could not identify this behavior.

The CowView system provided information at cow level, classifying each behavior/position second by second, listing in the output the zone, start time, and duration.

The 2 data sets obtained were merged. Only time intervals where data were available from both data sets were used in the evaluation, resulting in a final data