INFORMATION AND COMMUNICATION TECHNOLOGYS IN CATTLE LAMENESS DETECTION

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Tina Bobić[1], Maja Gregić[2], Pero Mijić[3], Vesna Gantner[4]

Abstract

Because lameness is a common problem on dairy farms, it is necessary to use techniques that help reduce the frequency of lameness. Using information and communications technology (ICT) to detect and prevent lameness in dairy cows is possible and has a future. Automatic lameness detection methods can collect large amounts of data in a short time, which can improve the accuracy of lameness prediction. Various ICT technologies are present on the market, and can be useful in detection and prevention of cow's lameness. Those technologies can improve dairy production, lower costs and improve animal welfare. It is necessary to include more factors and various experts from different fields to ensure the success of the application of such advanced and expensive technology.

Key words: *ICT, cattle, lameness detection, dairy farms.*

Introduction

Information and Communication Technology (ICT) includes the application of various devices, tools or applications that allow the collection or exchange of data through interaction or transmission. ICT is a collective term that includes everything from the radio to satellite images, mobile phones or electronic money transfer. Through the research and applying technological innovations, i.e. information and communication technologies, encourages the development of Precision Livestock Farming (Benjamin and Yik, 2019.). According to Bewley (2010.), Precision Livestock Farming implies the use of technologies to measure the physiological, behavioral and production in-

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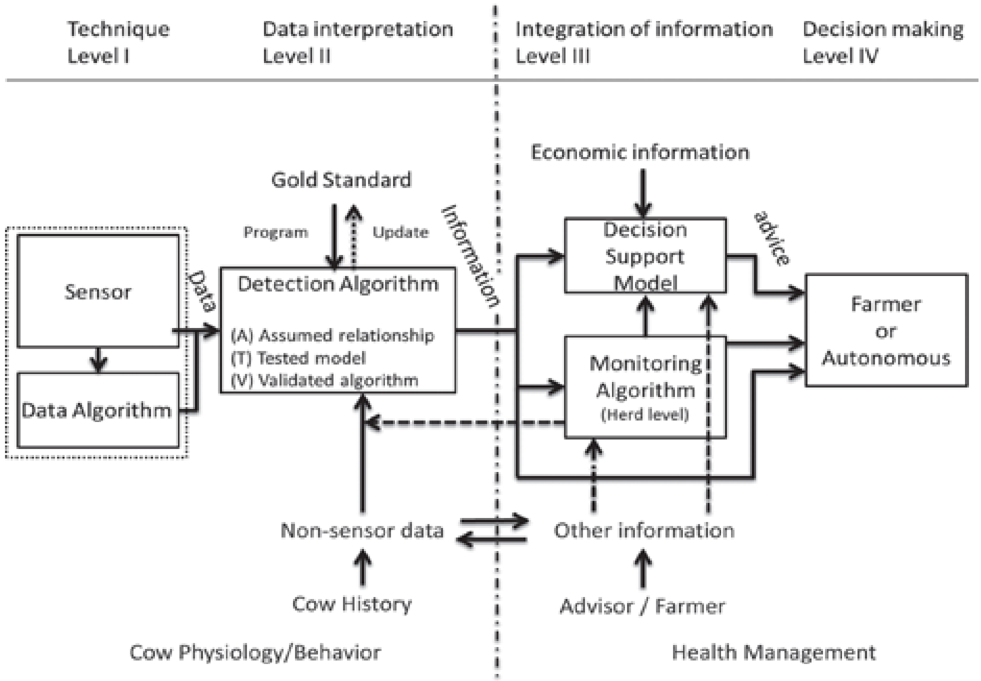
dicators of animals. Methods used in precision livestock production include continuous measurements and monitoring of animal signs or responses and real-time data collection for proper production management (Norton and Berckmans, 2017.). Benjamin and Yik (2019.) state that the application of various sensors, images, sounds and movements in combination with algorithms serves to monitor the welfare of animals and their productivity. Furthermore, provide early warnings of possible violations of animal welfare or illnesses. Andonović et al. (2018.) point out that it is very easy to recognize early signs of animal diseases by monitoring their individual conditions. Digital technologies can be extremely useful because they offer the opportunity to improve and increase the efficiency of production and at the same time provide a safer process of production itself. In recent decades, there has been a great digital revolution, and with it, the methods of automated measurements are becoming more and more widespread.

Various information and communication technologies are present on the market. They are similar to each other in certain points of contact regarding the need for real-time logging, good software and setting thresholds. They differ in the technology of obtaining daily records because it depends on the type of animal, on the type of problem being observed, financial possibilities, etc. Software technologies are applied that include measurement of different states of animals, such as rumination, food consumption, lying down and standing. According to Boldizsár (2012.), today's new ICT technologies should have the purpose of improving the farm management strategy itself and improving production properties. It is necessary to develop and apply technologies that will:

- be as well adapted as possible to animals and their natural behavior, causing as little stress as possible
- influence the increase in productivity
- facilitate insight into the necessary information and data of animals
- serve for early disease detection and thereby reduce the use of drugs and act as a preventive health measure.

Figure 1. The use of sensor information in dairy farm management (Rutten et al., 2013.)



Using of ICT technology's is complex process which includes different pathways (Figure 1.), e.g. from sensor on the farm which getting data's from animals (technique, Level I) to the algorithms in the computer which convert those data's in usable information's (data interpretation, Level II), further to the integration of those information's (Level III) and finely to making some decision (Level IV).

The aim of this paper was to present some of the ICT technologies, which can be used for cattle lameness detection.

Cameras and sensors

In recent times, it was increasing interest in objective analysis of movement and body characteristics of dairy cows by digital cameras. Salau et al. (2015.) stated that camera-based studies have achieved a high rate of lameness detection. Using cameras and image analysis have some advantages, because there no physical contact with animals and one camera can monitor a large group of animals which reducing the costs (Norton and Berckmans, 2017.). According to Marchant et al. (1999.), there are two types of cameras, two-dimensional (2D) and three-dimensional (3D) that provide digital information that can be used to monitor and estimate the growth rate, moving etc., of animals. The application of 2D cameras requires certain spatial conditions such as ambient lighting and a contrasting background. For example, white animals need a black background, etc. Three-dimensional (3D) cameras are sensors equipped with a high-resolution camera, an infrared illuminator, and depth sensor, which produces color. Infrared light is crucial in applications during low light and nocturnal behavior monitoring (Kongsro, 2014., Wang et al., 2018.). According to Mittek et al. (2017.) depth sensors determine the proximity of the animal to the camera. Today's cameras require a built-in cover to protect the sensors from ammonia, dust, moisture, and insects (Benjamin and Yik, 2019.).

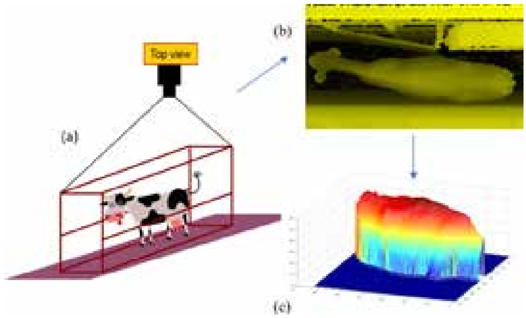


Figure 2. The example of the measurement installation for collection of field data using a top-view camera (a), depth camera image of the walking cow (b), and depth data illustrating the back profile of the cow as it walks under the camera (c) (Norton and Berckmans, 2017.)

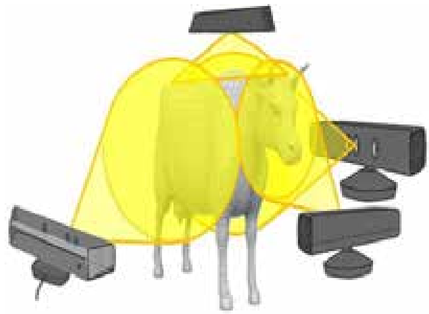
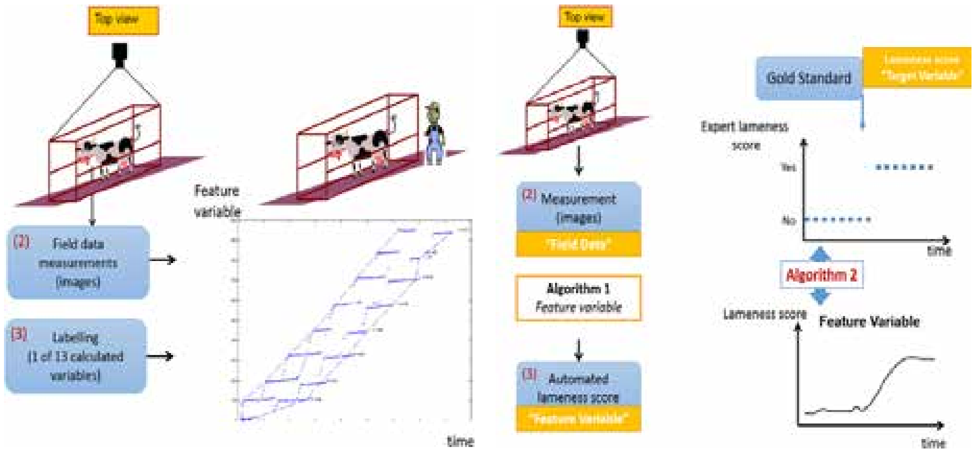


Figure 3. The three-dimensional (3D) optical sensors cameras (Pezzuolo et al., 2018.)

Cameras can be used as real-time monitoring of lameness of dairy cows by using real-time image analysis. Flower and Weary (2009.) have simply explained the possibility of applying data in real time in the following way: "*If we start from the fact that lameness can be considered as deviation in cows gait resulting from pain or discomfort from hoof or leg injuries or disease, than we can detect those deviation in movement and promptly react*". The lameness is one of the biggest problems regarding of the animal welfare in dairy cows. Therefore, the development of a robust algorithm for lameness detection is very important for dairy farmers. Norton and Berckmans (2017.)

emphases that for lameness detection it’s crucial to have a continuous monitoring and management tools. The same authors stated that is need to connect a few things: linking field data (e.g. images or videos of cows walking), target and future variable (e.g. step Overlap, stance time, back arch), gold standard, and labeling (Figure 4.). It is very difficult to connect all data in real time and get reliable and usable data, so it is crucial to develop the best possible algorithm. A good algorithm allows linking all field data and including the possibility of error to suggest the possible occurrence of disease.

Figure 4. Measurements, labeling, and gold standard to develop algorithms (Norton and Berckmans, 2017.)



Pastell et al. (2006.) conducted research to develop a system for detecting lameness of cows in a milking robot using sensors, in order to obtain an early warning of possible hoof problems. Figure 5. shows an example of automatically recorded leg load dynamics during milking, and Figure 6. present the connection between leg load index and kicking behavior of cows.

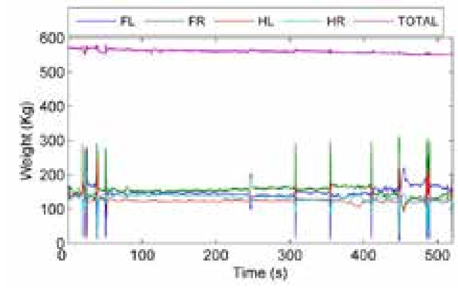


Figure 5. Leg load dynamics of a cow during one milking (Pastell et al., 2006.)

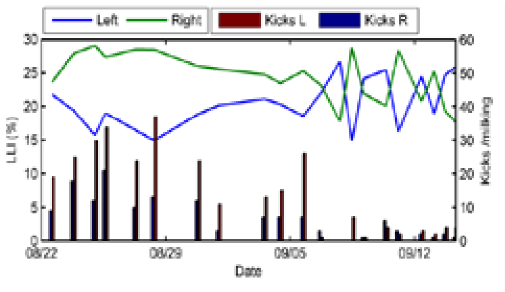
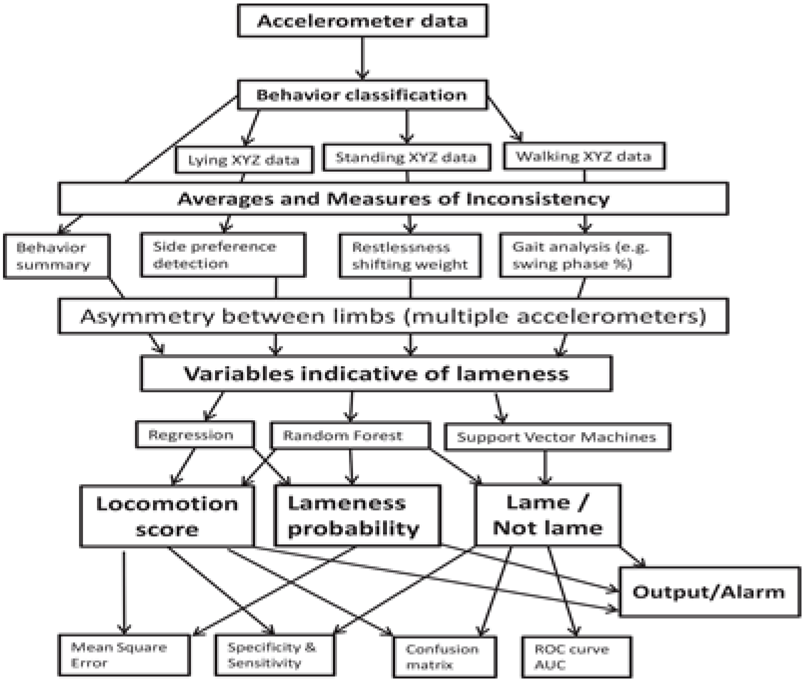


Figure 6. Leg load index (LLI) and the number of kicks per milking with hind legs of a cow during white line separation and after treatment (Pastell et al., 2006.)

Accelerometers

An accelerometer is an electronic device with one or more sensors that measures, records, and transmits acceleration data (relevant to various motor behaviors) in one or all three dimensions. According to Benjamin and Yik (2019.) the best technologies for monitoring the movement and behavior of animals are wearable sensors that contain accelerometers. The data generated by accelerometers and their corresponding systems can be processed by algorithms that have been created to interpret movements into specific behavioral patterns (Chapa et al., 2020.). An electronic unit placed in the animal's collar continuously records individual movements of the neck and muscles using a three-axis accelerometer. When a cow enters the reception area of the base station, which can be located in a pasture or a milking parlor, the measured data on the collar is processed using advanced software and wirelessly transmitted to a computer. The specific status and condition of the cows, as well as warnings, are monitored using a computer. Each collar remembers patterns of behavior and in the event that significant changes occur, a warning appears and based on this, a timely reaction can be made.

Figure 7. A schematic diagram of how lameness classification could be implemented using accelerometers (O'Leary et al., 2020.)



Pastell et al. (2009.) reported that lame cows exhibited higher asymmetry of variance during acceleration compared to healthy cows. Likewise, Chapinal et al. (2011.) reported that lame cows with high gait scores had a greater asymmetry of variance during acceleration in both front and rear legs. O'Leary et al. (2020.) proposed a lameness detection system using accelerometers (one per cow; resolution <100 Hz) with gait measurement capabilities to balance cost and data requirements. The same authors presented a schematic diagram of the use of accelerometers for lameness classification (Fig. 7) and stated that high priority should be given to developing novel gait measurement methods and testing their ability to differentiate between lame and non-lame cows.

Infrared thermography

Infrared thermography is a non-invasive diagnostic tool that can detect lameness and lameness-related hoof pathology by measuring changes in skin surface temperature (Nikkhah et al., 2005.; Alsaood and Büscher, 2012.; Poikalainen et al., 2012.; Bobić et al., 2018.). The hoof surface temperature in dairy herds could be monitored regularly to assess hoof health status, and with infrared thermovision cameras can be detected foot lesions well before the appearance of clinical signs (Bobić et al., 2017.). Detecting the inflammatory process of the hoofs in cows is of great importance, especially during early lactation, because it affects milk production (Racewicz et al., 2018.). The possibility of using infrared thermography in the detection of lameness is reflected in the fact that when inflammation occurs in the legs, an elevated temperature is created that can be detected using infrared thermovision cameras (Schaefer and Cook, 2013.).

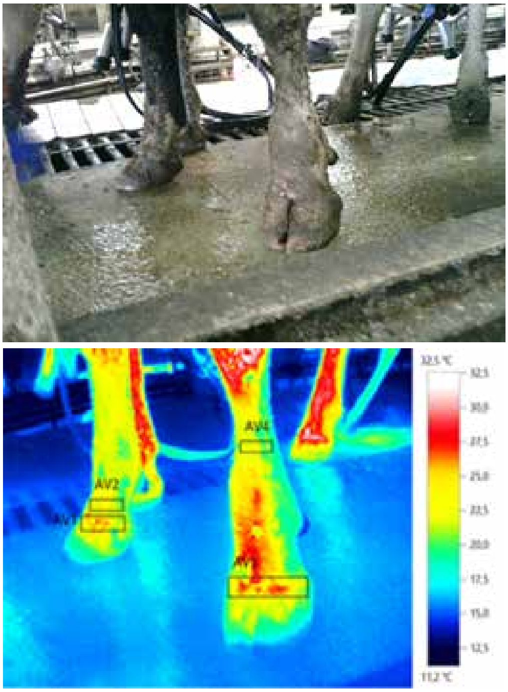


Figure 8. Digital and infrared picture of the cows hoof (Bobić et al., 2020.)

Alsaaod et al. (2015.) state great possibilities in the application of this technology in the detection of diseases on the hooves, but also state the susceptibility to environmental influences, which must be controlled in order to avoid erroneous readings of the results. Lokesh Babu et al. (2018.) state that the application of infrared thermography is possible in the detection of inflammatory changes on the hooves of cows, especially if changes in the temperature of the coronal part of the hooves are observed (Figure 8.). The same authors state that the temperature of the surface of the leg affected by inflammation will be warmer compared to the surface of a healthy leg, and in this way lame cows can be detected as well as those that are about to become lame. Lokesh Babu et al. (2018.) also point out that the application of infrared thermography can help reduce veterinary costs, costs due to reduced production, fertility and costs of excretion from production, but they also entails a number of other standard procedures and factors that must be taken into account and incorporated (Figure 9.).

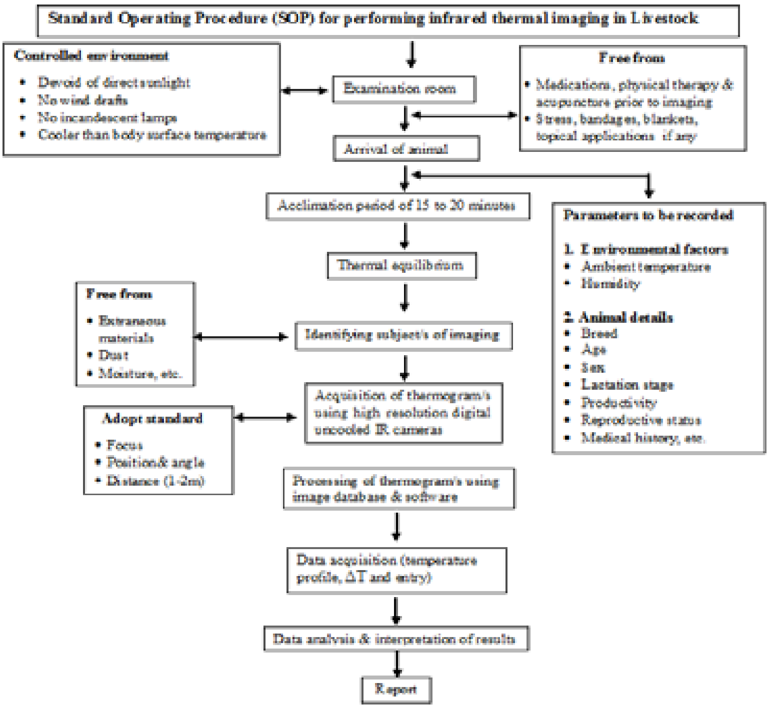


Figure 9. Standard operating procedures for performing infrared thermal imaging in animal production (Lokesh Babu et al., 2018.)

Conclusion

Various information and communication technologies are present on the market, and can be useful in detection and prevention of cow's lameness. Those technologies can improve dairy production, lower costs and improve animal welfare. It is necessary to include more factors and various experts from different fields to ensure the success of the application of such advanced and expensive technology.

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