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Precision Dairy Farming: The Next Dairy Marvel

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Abstract

India emerging as world's largest producer with the annual milk production reaching to the level of 133 million tons in 2012-13 (BAHS 2012-13). Dairy farming is the single largest contributors to Indian GDP and employment. It contributes 5 percent of GDP and involves 70 million farming households. The productivity in the sector is six times below its potential at current factors costs. Poor yield (output per dairy animal) explains the gap between current and potential productivity. The yield is low due to inadequate dairy management, poor animal husbandry and poor quality animals. So, there is need of suitable and proper managemental techniques which can improve the efficiency of production. Precision livestock farming can become a tool in this context.

Precision Livestock Farming is the principal means by which sensors will be used in livestock farming. Unlike traditional mechanization, which depended on large equipment applied to large production units, "precision dairy management" uses sensor-based management tools that define animal needs and automatically delivers individual management applications.

Keywords: Dairy Farming; Precision dairy; Livestock farming

Precision Livestock Farming(PLF)

Berckmans [1] explains PLF as: monitoring, collecting and evaluating data from on-going processes. Collection of data from animals and their environment, by innovative, simpleand low-cost techniques, is followed by evaluation of the data by using knowledge-based computer models. Currently; considerable PLF researchis directed toward development and validation of various techniques for datameasuring and registration on livestock farms. PDF is a subset of precision livestock farming.

Precision Dairy Farming (PDF)

Eastwood et al. [2] defined Precision Dairy Farming as "the use of information technologies for assessment of fine-scale animal and physical resource variability aimed at improved management strategies for optimizing economic, social and environmental farm performance".

According to Schulze et al. [3] a PDF system is constructed of the following components: a sensor that generates data, a model that gives a physiological interpretation of the data, a management decision making process and finally decision execution. The PDF systems can be divided into two categories: those used for diagnostic and those used for management and the same sensor can serve both categories.

Objectives of precision dairy farming

Maximizing individual animal potential, Detecting diseases earlier - Early detection of disease reduces the cost of disease to the farm and increases the length of animals' lives. Minimizing the use of medication through preventive health measures [3]. Supplements observation activities of skilled herd persons - Technologies for physiological monitoring of dairy cows have great potential to supplement the observations of skilled herd's persons, which is especially critical as more cows are managed by fewer skilled workers. Optimize economic, social and environmental farm performance. Make timely important decisions - A precision dairy farming technology allows dairy producers to make more timely and informed decisions, resulting in better productivity and profitability.

Components of PDF includes

- Computers
- Global Positioning System (GPS)
- Geographic Information System (GIS)
- Remote Sensing (RS) and
- Application control

Currently used Technologies in Precision Dairy Farming

The list of precision dairy farming technologies used for animal status monitoring and management continues to grow. Because of rapid development of new technologies and supporting applications, precision dairy farming technologies are increasingly more feasible. Many precision dairy farming technologies are already being utilized by dairy producers are: Electronic (radio frequency) identification systems and associated management software, Automatic body condition scoring, Automatic recording devices (rumen temperature, pressure, pH) by electronic rumen bolus, Robotic milking systems - daily milk yield recording, milk component monitoring (such as fat, protein and SCC), daily body weight gain measurement, Robotic calf-feeding systems, Pedometers for heat detection, for health monitoring i.e. measuring lying time and standing bouts, Milk analyzer, Parturition sensors, Milk conductivity indicators.

Other theoretical precision dairy farming technologies have been proposed to measure jaw movements, reticular contractions, heart rate, animal positioning and activity (to compare low activity to high activity where low activity may indicate a sick cow or a cow lying down), vaginal mucus electrical resistance, feeding behavior, odour, glucose, acoustics, progesterone, individual milk components, colour (as an indicator of cleanliness) and respiration rates. Further in the future the remote sensing of cow condition, GPS based cow tracking in fenceless

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farms may be included in commercially available precision dairying technologies. Some of these technologies are discussed as follows:

Electronic (radio frequency) identification systems

Electronic identification (EID) systems have provided a technological approach to the previously intuitive process of individual cow management. In 2000 the National Livestock Identification Scheme (NLIS) made the use of radio-frequency identification (RFID) tags, these tags contains a microchip that can be read electronically in a fraction of a second by producers who have a suitable reader. Electronic identification systems provide accurate identification of cows and linked to pedigree, management events, treatment records, electronic milk meters, computer controlled feeding, automatic sorting and weighing, etc.

Radiofrequency tags can be used to record animal events such as heat detection, treatments, calving interval, sire selection, etc. This can result in increased production and profitability by allowing better management of an individual cow's performance through the analysis of the collected data.

Automatic body condition scoring

Body condition scoring (BCS) is a method to evaluate fatness or thinness in cows that can be utilized to adjust dairy herd nutrition and improve the health of the cow. It is usually determined visually and manually by experienced experts tocalculate body reserves and conducting body condition scoring and evaluate each animal.

Roche et al. [4] stressed out the significance of body condition score for animal. Automated Body Condition Scoring (BCS) through extraction of information from digital images has been demonstrated to be feasible; and commercial technologies are under development. Ferguson et al. [5] assessed the ability to assign a BCS to a dairy cow directly from digital photographs.

Automatic recording devices (rumen temperature, pressure, pH)

Determination of ruminal pH, temperature and pressure in animals can be crucial to suppress the occurrence of health problems such as sub-acute rumen acidosis and bloat. Owen et al. [6] reported that rumen acidosis is a serious problem in dairy and feed-lot sectors, resulting in animal deaths, morbidity and diminished productivity.

Rumen temperature: Technology is being developed to continuously monitor intra-ruminal parameters such as temperature and pH [7]. Al-Zahal et al. [8] reported that the relationship between rumen temperature and rumen pH may be an indicator in the diagnosis of SARA (Sub Acute Rumen Acidosis). A bolus containing a mote (temperature sensor, processor and radio) was placed in the rumen of a fistulated cow to monitor body temperature. Rumen temperature was measured every minute and stored in the internal buffer of the mote.

Rumen pressure: Rumen motility can be assessed by measuring changes in rumen pressure [9]. Thus rumen pressure can be used to determine bloat in ruminants. There is not a lot of rumen pressure data for cattle. Therefore, the boluses would be a very useful tool for assessing the relationship between rumen pressures on bloat in cattle [10].

Rumen pH: Several important factors such as average ruminal pH, the pattern of ruminal pH over time, duration of suboptimal ruminal pH and the variation in the pattern of ruminal pH can be processed by artificial intelligence or other advanced computational programs to evaluate the significance of ruminal acidosis in cattle performance as well as in defining the relations between intake and acidosis [11].

Monitoring ruminal fluid pH is a reliable method to determine acute acidosis or SARA [7]. For research monitoring of rumen pH, a permanent device in the rumen is required to continuously monitor rumen pH remotely without interfering with the normal behavior of the animal [12].

Robotic milking: Milking robot is a part of automatic milking system, having a sensor system to locate the position of the teats and a manipulator to attach the milking unit to the teat. Sensor systems for milking robots, published by Artmann [13], identified several distinct sensing tasks:

i. Animal identification

ii. Teat location

iii. Monitoring Automatic Milking System functions

- Ensuring proper machine function
- Protecting people and animals from injury

iv. Measuring milk quantity and composition

v. Monitoring other aspects of Animal health

Robotic calf feeding: Robotic calf feeding system consists of the following four parts:

i. The calf feeder unit that mixes milk replacer with water

ii. The processor for controlling the feeder and data processing

iii. The transponder around the neck of the calf for identification

iv. The milk feeding stall where the calf drinks the milk.

Automatic calf feeders consist of a self-contained unit that heats the water, dispenses a programmed amount of milk replacer, and mixes the milk replacer and water in a container from which the calf can suck it out via a nipple feeding station. Each calf as identified by their EID.

Calves start robotic feeding on day 10. It requires one day to train them to use the feed stall. They stay there until they are weaned at approximately 45 days. Initially, each calf on the robotic feeder gets about 6 quarts of milk. That is increased to 9.5 quarts by 35 days. The feedings are spread out over the course of each day. The system only allows calves to be fed milk up to five times each day. Advantages are that calves are fed large amounts of milk replacer and so they gain weight rapidly. Their calves double their weight in 45 days.

Pedometer for estrus detection: Estrus behavior in dairy cattle is accompanied by increase in physical activity. Kiddy [14] was the first to use leg mounted pedometers to determine whether physical activity related to estrous varied enough compared with non-estrual animal which will be a useful method for estrous detection in dairy farming.

Comparison among various statistical procedures that use pedeometry data in lactating dairy cows indicate that 70% of estrous period and 99% of non-estrual periods can be accurately predicted using currently available pedeometry systems [15]. Lehrer et al. [16] reported efficiency of visual observation at 45% and for pedometers at 78% to 96%.

Parturition sensors

- Sensors fixed on pregnant animal - Vaginal temperatures (VT) of cows were collected by a data-logging apparatus with a thermocouple sensor.

- Sense the change in body temperature - useful to save work and trouble at perinatal parturition of cattle. Predicting the onset of parturition is an important requirement and enables the rescue of newborn calves and mothers in difficult birthing situations. It has long been known that body temperatures decrease prior to parturition in cattle [17].

Potential Benefits of Precision Dairy Farming

Benefits of precision dairy farming technologies include increased efficiency, through large-scale mechanization and economies of scale, reduced costs, improved quality and food safety through better animal identification and traceability, minimized environmental impacts, improved animal health and well-being through improved health monitoring and individual care. It gives more timely and informed decision [18].

Clinical symptoms are typically preceded by physiological responses not seen by the human eye (for example, changes in temperature or heart rate). Thus, by identifying changes in physiological parameters, a dairy manager may be able to intervene sooner.

Limitations

- Information obtained from precision dairy farming technologies is only useful if it is interpreted and used effectively in decision making.
- Slow adoption rate due to uncertain return on investment, high fixed costs of investment and information acquisition, and lack of demonstrated effects of these technologies on yields, input-use, and environmental performance" [19]. Such technologies are adapted by younger and well-educated farmers which, additionally, operate larger enterprises and gain higher profits, to a larger extent.
- Animal ID may sometime read errors.
- Equipment failure may occurbecause often they are sophisticated to handle, low temporal resolution, require good visibility of the subjects.
- Data transfer error may be due to over-supply of data, and the time-consuming handling of software programme.
- Lack of validated research results concerning the effects of application, high capital input and high costs.
- Applicable to a restricted spatial area

Conclusion

Precision dairy farming is a new golden era of dairy industry. Precision Dairy Farming technologies provide tremendous opportunities for improvements in individual animal management on dairy farms.

Combined, all devices will provide data that measures cow comfort, which can then be extrapolated to make changes in the dairy's facilities. Cow comfort can lead to better overall health, which lowers the cost of animal care and/or treatment and can increase animal longevity and boost milk yield.

"Our goal should be to determine how useful the information provided by different technologies is and then to conduct analysis to determine whether they are worthwhile investments & make decisions about the usefulness of these technologies".

Precision dairy farming in many developing countries including India is in its infancy but there are numerous opportunities for adoption. Progressive Indian farmers, with guidance from the public and private sectors, will adopt it in a limited scale as the technology shows potential for raising yields and economic returns. Effective coordination among the public, private sectors and growers is, therefore, essential for implementing new strategies to achieve fruitful success.

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