

Video Technology for Large Dairy Operations: from Management to Precision Agriculture

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The size and complexity of modern dairy operations in the United States require that owners and managers utilize tools that facilitate the day to day management of both animals and people. As we look at the profitability and sustainability of dairy operations into the future, it is more and more apparent that proper and effective implementation of technology will be invaluable to managers and owners. The following review will look at the use of video technology as a valuable management tool for dairy managers and owners. We will focus on two primary areas: 1) video monitoring in precision agriculture and 2) video monitoring in labor management. As this is a new and relative smaller area within dairy management most of the information presented in this review will be based on farmer testimonials and directly from the technology sector and industry consultants. It is the main goal of this review to stimulate conversation and generate ideas that will benefit dairy management for the present and the future.

Video Monitoring in Precision Agriculture

Precision agriculture refers to a system of technologies that combines sensors, information systems, specialized machinery, and data management to facilitate high-level production by accounting for variability and inefficiencies in modern agricultural systems (Gebbers and Adamchuk, 2010). At the farm level, Precision Dairy Monitoring (PDM) uses these technologies to measure physiological, behavioral, and production indicators on individual animals to improve management and farm performance (Stone et al. 2017). Video cameras can play an integral role as part of PDM. Some of the earliest uses of video monitoring were as a tool for cow locomotion evaluation using vision-based trackway analysis (van Asseldonk et al., 1999). Evolution of these methods has come a long way over the last two decades and can now be designed for use at large operations. Another powerful use for video technology is related to animal health monitoring. Recently, Stone et al. (2017) summarized the advantages and limitations of PDM for health monitoring at dairy operations. The authors mentioned video monitoring work on cow comfort as measured through laying behavior.

Precision Dairy Monitoring relies on the assumption that the animal (cow) herself is an important part of the biological production process (Berckmans, 2006). One video technology with high potential is the use of Computer Vision Tracking (Mittek et al. 2017). These video-based technologies enable managers to achieve continuous tracking of multiple group-housed animals for long durations of time. This technology would monitor animal movement and behavior in order to detect sudden changes associated with animal health status. Early examples have shown promise and

technological advances in camera (hardware) and specific software keep evolving quickly as their applications become more apparent.

Video monitoring as a PDM tool can lead to many on-farm opportunities. Starting on 2016, through collaboration with the Department of Agriculture and Biosystems Engineering at University of Arizona, we began sponsoring senior design teams that tackle on farm issues through precision agriculture tools. From this collaboration, we designed a video camera suite system that sits at the top of 4 cow pens (200 cows per pen). Every year a team tackles a new problem by enhancing the camera suite. Year one students looked at bird detection and a bird population control system. Bird detection was a particularly complex problem for the students who struggled with the shadows generated during different times of the days. In the end, students designed a two-camera system utilizing thermal imaging to properly differentiate shadows from animals. On year two students designed a camera system that would automatically trigger soakers when cows approached the feed bunk in an effort to reduce water use. This project has opened our eyes to the multitude of applications for video monitoring systems as tools for Precision Dairy Monitoring.

Video Monitoring in Labor Management

The complexity of dairy labor management is one of the most often misunderstood and mismanaged aspect of modern dairying. The challenges of managing large groups of employees, at open facilities, exposed to the elements, performing complex tasks, both day and night leads to opportunities for IT technologies that can streamline these processes. In the traditional sense, live video monitoring requires constant human monitoring. In some applications may be necessary. In other task's video surveillance requires recordings, time stamping and, post evaluation. Lastly, video surveillance with adaptive software is preferable for large data points and would generate reports and alerts without the need for an operator present.

Video cameras can be valuable tools for different areas related to employee safety, compliance, training, and security. Proper and strategic placing of cameras can be invaluable to a successful commentary tool for dairy managers. The legality of camera use on employees needs to be understood before installation at a facility. For the most part, each state's own laws control the privacy issues surrounding cameras at work. As a general rule, however, an employer needs to have a legitimate business reason for conducting surveillance using cameras in workplace spaces. Furthermore, employers should be careful about conducting any audio recordings in the workplace because of the existence of state and federal wiretapping laws, which may apply in such circumstances regardless of how legitimate the reasons behind the video surveillance might be. As a result, if video cameras at work are also capturing sound, employers may run the risk of breaking applicable eavesdropping or wiretapping laws. It is a good general rule to get legal advice before implementing a video monitoring and recording system especially if that system target employees at the farm.

The three areas for employee video monitoring of most value for dairy managers are in protocol intensive work areas (parlors, maternity, etc.), in secure areas (bulk tanks rooms, medication room, etc.) and high traffic areas (feed mixing areas, equipment traffic bottlenecks, etc.). It is important to understand that employee attitude and reactions related to the use of video equipment are positively related to the employer's communication about the intention and goals of the specific monitoring. The authors refer managers and owners to "*The visible employee: using workplace monitoring and surveillance to protect information assets--without compromising employee privacy or trust*" as a

valuable resource on labor-related video monitoring employee psychology (Stanton & Stan 2006). Video camera use in milking parlor maternity and calf facilities is quite common in large dairy operations, however, in many situations, they are more commonly used to reprimand employees. However, the real value of this type of monitoring seems to be in the identification of teachable moments (training), in the re-training of protocols (continuous education) and the identification of design and protocol flaws that may lead to employee alterations of protocols. The review of video of protocol failures is an incredibly powerful tool for employee training and communication. Saving clips of these events can also be an invaluable resource for future training as they help identify trends associated with the specific facility and how humans interact with design limitations.

Arguably, the most essential area for employee video surveillance is for secure areas in which foul behavior can have the largest consequences. Imagine the following scenario “employee is fired after working 6 months in the facility, he storms out very upset. The employee comes back later that night and stops by the bulk milk tank and dumps a chemical in an effort to sabotage and to get back at the manager. Next morning manager gets a call from the milk plant with the news of a contaminated tank”. There are obviously management and security protocol ways to prevent this type of scenario but in an open facility with work going on 24 hours it would not be hard to imagine something like this happening. Video recording systems in the bulk tank room would allow the manager to go back to time-stamped recordings. With these recordings’ management can identify the specifics of the sabotage and allow for a smooth resolution with the milk plant and streamline legal and insurance repercussions. In these security scenarios, the question over visible or hidden cameras is relevant. Putting up video surveillance without notice to employees or using hidden cameras at work may violate employee privacy rights so managers need to be sure about the legality of the processes. There may be real value to employees seeing and knowing where cameras are placed and why they are being placed, although data suggest that this behavior change may not always be sustained. One very interesting study by Pierce et al. (2015) evaluated the impact of using IT (video) monitor employee crime. Video monitoring reduced employee theft by 22% with the effect growing over time. But the monitoring actually had a much larger impact on productivity and sales. In this particular study, researchers concluded that in response to the monitoring employees increased productivity in an effort to capture bonuses or other benefits.

High traffic areas and equipment bottlenecks are other potential areas for video monitoring. Value exists in data gathering to better understand design limitations, reduce of costly bottlenecks, and for accident prevention. The ability to evaluate large video data sets is often underutilized by dairy managers but those that have taken this approach (usually through third-party service) often find great value. Safety protocols teams should consistently utilize video technology in high-risk areas and potential high equipment traffic areas in an effort to better understand preventive actions that could lead to accident reductions. On the other side of this example, recorded video monitoring could be valuable in understanding why and how a specific accident occurred. This could be invaluable for legal and insurance resolution and more important for understanding specific accidents and implementation of changes in protocols that would prevent future accidents.

As on-farm technology evolves and its use related specific tasks become more common and apparent their applications will start to be seen more commonly on farms. However, managers must understand their potential value as well as their limitations in order to be properly implemented in their operations. In general terms, looking at the technology readily available it is apparent that often in Precision Dairy Monitoring we are underutilizing this resource. A multidisciplinary approach is necessary for maximizing and expediting efforts. Collaborations between engineers, dairy scientist,

animal behaviorist, and labor management researchers are necessary to make significant contributions to this field. Dairy operations of the future will require all the resources at our disposal in order to maximize efficiency and thus contribute to the profitability and sustainability of our industry.

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