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Beyond Traditional Practices: Unveiling the Potential of Infrared Thermography for Livestock

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Abstract
Infrared thermography (IRT) is an invaluable and non-invasive imaging technique that detects and captures infrared radiation emitted by objects, converting it into visual representations based on heat distribution. Its widespread adoption in veterinary medicine has proven beneficial for disease prevention, control, diagnosis, and treatment. Additionally, its novel application in animal production offers numerous advantages, including low cost, rapidity, efficiency, and the ability to gather critical information without direct contact with the animals. IRT's versatility allows for continuous monitoring of multiple animals simultaneously, facilitating swift identification of health issues or injury, which is particularly crucial in large herds. Its non-invasive nature minimizes stress on the animals and enhances their overall well-being. Moreover, this technology enables veterinarians and farmers to detect potential problems in real-time, improving the efficiency of livestock management practices. In conclusion, IRT is a game-changer in veterinary medicine and animal production. Its ability to assess the heat patterns of various body regions provides vital information about an animal's health, making it an indispensable tool for proactive healthcare and management practices in the agricultural industry. Its non-invasive, cost-effective, and efficient nature revolutionizes the way we care for and ensure the well-being of our farm animals.

Keywords: Infrared, livestock, mastitis, thermography, welfare

Introduction

Infrared thermal imaging, initially used in military equipments is rapidly gaining civilian use specially after outbreaks of COVID pandemic. The thermographic technique has found numerous practical applications principally in construction industry, Gas leakage detection, search and rescue operations, border patrolling, human and veterinary medicine, animal husbandry, scientific research and many more. Its largescale use in screening human at large gatherings, entry and exit points at public places post COVID-19 got attention of researchers in all areas of science. It is a useful and harmless imaging technique for accessing of temperature distribution patterns on the surface of the body. Thermal imaging is very sensitive in detecting temperature differences of less than 0.05ºC which is 40 times more sensitive than the human hand.

Advantages: It is a modern, non-invasive, non-contact, fast, real time, remote technique which does not require sedation and avoids travelling stress for animal.

Disadvantages: Although, thermal camera remains expensive and lack specificity regarding the etiology, thermography provides valuable facts for the presence of pathology.

How it works: All objects on Earth with temperature above absolute zero produce radiant heat in the infrared portion of the electromagnetic spectrum that can be absorbed by other bodies around them. Hence, with the use of digital thermography method, it is possible to sense this type of radiation detecting even minutest temperature differences. Living tissues and inflamed tissues emit more heat than do dead tissues. Skin surface temperature replicates the underlying flow and tissue metabolism in response to changes in blood flow and allows early detection of lesions before they are clinically visible. Thus, mapping skin surface temperature using IRT may evaluate various physiological and health parameters. It shows the animal's physiological state by graphically mapping skin surface temperature in response to changes in blood flow and allows early detection

of lesions before they are clinically visible. Thermal camera capture and generate an image of an object by using infrared radiation emitted from the object in a process that is called thermal imaging. These infrared radiations in the form of temperatures are digitized and processed by computer and displayed the result in the form of a thermal map over the animal, which give a thorough analysis of the temperature profile. The created image denotes the temperature of the object being monitored. Originally, the underlying technology of the thermal imaging cameras was first developed for the military operations.

IRT is a useful tool in studies of livestock, wild animals, and zoo animals as it doesn't require direct physical contact with the surface of the body monitored, which significantly decreases stress levels on animals. Veterinary Medicine is a broad term which covers various different subjects dealing with the health and wellbeing of animals. It deals with the prevention, control, diagnosis, and treatment of disease, disorder, and injury in animals. In human and veterinary medicine, thermal imaging cameras are used to measure body surface temperature which reflects the status of tissue metabolism and blood circulation. Abnormal thermal patterns may indicate areas of superficial inflammation or circulatory impairments associated with stressful environmental conditions. Thus, the physiological status of farm animals could possibly be judged by measuring skin temperature of the specific animal regions such as udder, foot, rectal, neck, eye, rump, rib, thigh, flank and belly using infrared thermography. Thermal imaging has been widely used in animal studies to determine the causes of lameness in cattle; to diagnose infectious diseases, estrus and pregnancy; and to control animal welfare and stress levels.

Applications

To assess udder health: IRT has been used to estimate changes in udder temperature and to explain possibilities for early diagnosis of mastitis in dairy animal. Mastitis is a common and costly inflammatory condition of the udder, which can negatively impact milk production and overall animal health. IRT enables early detection of mastitis by identifying temperature variations in the udder. When an udder is infected, there is an increase in blood flow and metabolic activity in the affected quarters, leading to a localized rise in temperature. The screening of subclinical mastitis by recording the udder surface temperature has high predictive diagnostic potential similar to the California Mastitis Test (CMT).

To estimate hoof health: The competence of IRT to detect effects on hoof temperature in dairy cows and relationship to visual abnormalities of the hoofs that are indicative of laminitis. It has been observed in various studies that IRT may prove to be useful for early diagnosis of lameness, in particular in earlier stage of lactation in cattle. IRT is a valuable tool for early laminitis detection because it can identify changes in hoof temperature, which are indicative of inflammation and increased blood flow to the affected areas. The inflammatory response in the hoof results in localized heat, which an infrared camera can detect and visualize as temperature variations.

Disease diagnosis: The infrared technique has also implemented as an early detection technique to identify animals infected with Bovine Viral Diarrhoea Virus and foot and mouth disease. Thermography can also be used in orbital temperature measurement for early disease detection in calves, pain identification and aid localization in horses and for the detection of ectoparasites, which are accessed as limiting factors for beef and dairy cattle productivity.

To assess breeding soundness: The surface temperature of the scrotum is highly correlated with deep testicular temperature and thus IRT can be used for the detection of abnormal testicular thermoregulatory mechanism and can be used to predict decreased fertility in bulls that showed acceptable testicular size and semen quality. Several studies revealed that the scrotal surface temperature positively influences the motility and sperm concentration. Climatic factors like temperature and humidity also influence semen quality and thus suggested that IRT could be used for the evaluation of reproductive efficiency of bull.

Estrus detection: During estrus, animals experience an increase in blood flow to their reproductive organs, leading to a rise in temperature in those areas. Infrared thermography can accurately capture these subtle temperature variations, making it a valuable tool for farmers and veterinarians in identifying the optimal time for breeding. By using infrared cameras, farmers can continuously monitor their herds, detecting signs of estrus promptly and improving the overall

reproductive efficiency. This technology also helps reduce the need for physical examination, minimizing stress on the animals and potential health risks.

Thermal stress estimation: Production animals which are exposed to high ambient temperatures experience heat stress which consequently affects their overall productivity and reproductive performance. Heat stress arises when the effective temperature of the environment exceeds the animal's upper critical temperature depending on animal breed, age and their physiological state. Core temperature is one of the most trustworthy signals of heat stress in livestock. Additionally, it is an economically significant measure due to the close connection with health, reproductive performance and overall productivity. Thermal imaging is one of the remote sensing methods used in livestock as a tool for investigating thermal status by measuring the surface temperature of an animal's infrared radiation. It minimises the level of human interference, improves animal welfare and describe an accurate depiction of thermal status.

Conclusion

IRT can be used for study and research in farm animals such as pigs, cattle, sheep and poultry. Currently, IRT has been successfully used in detection of mastitis, estrus and hoof disorders. It is also used in screening of calf diarrhea as well as bovine respiratory complex. IRT also plays important role in determining welfare status of animal and animal house too. Therefore, IRT can be recommended as a method that can produce important information where the possibilities of conventional diagnostic techniques have been exhausted. There are, however, certain limitations and factors that must be considered when using IRT in animals.

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