A Non-Invasive Body Temperature Measurements in Cow using IR Thermometry

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Original Article

Keywords: Cows, Surface Temperature Measurements, IR thermometry, Non-invasive

Posted Date: January 29th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-157985/v1

Abstract

This research deals with continuous surface body temperature measurements in cow using IR based thermometry. Body surface temperatures were estimated contactless utilizing recordings from an IR thermometry fixed at a specific region in the cow. The body surface temperatures were dissected reflectively at two regions: the rectal region (behind the tail) and abdominal region (nearer the stomach) in the cow. The traditional invasive rectal temperature filled in as a kind of perspective temperature and was estimated with a computerized thermometer at the comparing time point. An aggregate of ten cows (Redsindhi, HF cross, Kangayam) was inspected. The normal most extreme temperatures of the territory of the rectal (mean ± SD: 38.69 ± 0.5°C) and the abdominal region (38.4 ± 0.51°C). The temperatures of these regions in the cow were 95% accurate than the traditional invasive rectal temperature measurements. Notwithstanding, the most extreme temperatures as estimated utilizing IR thermometry expanded with an expansion in cow rectal temperature. These temperature readings are then been communicate to the remote server for continuous monitoring of the condition of cows. This communication is carried out by using Bluetooth/Wifi medium. Since this framework comes out with a non-invasive fashion measuring surface body temperature, will be an alternate way of taking a reading of temperature rather than computing the internal body temperature in an invasive fashion. Subsequently, this IR thermometry shows potential as a marker for consistent temperature estimations in cows.

1. Introduction

The rectal temperature measurements are one of the main infection pointers in domestic animals. The method itself, be that as it may, is tedious and requires direct contact with creatures. Conversely, Infra-red based thermometry speaks to a non-intrusive, contactless technique of measuring the surface temperature of animal's body, which can be utilized as a pointer of center for internal heat level in steers [1]. Utilizing the traditional rectal temperature is a typical technique utilized by veterinarians and ranchers; be that as it may, there are impediments to this strategy. Examinations demonstrated that both the procedure utilized while managing a computerized thermometry and the various thermometry type can influence the estimated values [2].

Different advancements have been created to constantly record internal heat level in steers. Infra-red based thermometry is utilized to quantify heat radiation from the outside of a subject and makes an interpretation of the radiation into a point-explicit surface temperature. Infra-red thermometry has been utilized lately as a non-obtrusive technique in numerous creature species just as in people. The strategy is a valuable apparatus in anticipating increments in neighbourhood [3] or foundational body temperature, which can fill in as an instrument to survey pressure in dairy bovines [4] and sport ponies [5] and to foresee cow oestrus [6]. Besides, demonstrated the utility of Infra-red thermometry in assessing the warm status of cows and buffaloes. Different investigations have additionally portrayed a connection between the feed productivity. An expansion in the nearby temperature was utilized in mix with natural temperature checking as an early recognition strategy for mastitis [7], to distinguish foot sores in dairy cows [8] and, by estimating the foot temperatures of cows, to distinguish foot-and-mouth infection.

The temperature of limits gives off an impression of being more impacted by the surrounding temperature than the eye temperature. The foot temperatures in cows significantly rely upon surrounding temperature [9], though eye temperatures are not essentially influenced. In the wake of considering factors, for example, daylight, dampness, surface soil and climate conditions [10], the aftereffects of past contemplate demonstrate that Infra-

red thermometry states the potential apparatus for the early acknowledgment of temperature increments and in this manner of infections.

Our past investigations showed the capability of video accounts from an Infra-red thermometry camera as a non-invasive (non-intrusive) framework to gauge internal heat level in calves [11]. The most extreme temperature of the whole head or body region can be utilized as a delegate temperature for the region of eye or the rear of the ear, individually. This would be beneficial for future programmed checking frameworks since it is simpler to characterize a fixed region than to discover. Nonetheless, the target of the present study was to decide if it was adequate to characterize just a single bigger zone of the whole creature and to utilize the most extreme temperature of this region. This paper composed of five segments. Section 2 examines related work highlighted with the distinctive temperature measurements in cow. Section 3 depicts the materials and methods used in proposed IR thermometry. In Sect. 4, the results are discussed and in Sect. 5, concludes the works done.

2. Related Work

In [12] thermo vision cameras are used to monitor surface temperature from the planned calving date of 9 to 35 days for 86 pregnant cattle. Such measured information is processed in the cloud through the gateway before the sensor is connected to the cattle to determine the surface temperature. Thermo vision attained the emissivity of 0.95. In [13] Portable infrared camera (IRC) for calf skin temperature measurement in the form of thermographic videos. IRC temperature range from − 20 ° C to 900 ° C, 7.5 to 13 μm spectral range, 0.04 K sensitivity and

0.1 ° C resolution were achieved. The distance between the calf feeder and the IRC lens was up to 150 cm. Calf rectal temperature is regarded by (ApoNorm®, Hillscheid, Germany) as a reference temperature. Accuracy and the resolution of the unit was 0.1°C. The calf's rectal temperature measurement was between 32.0 ° C and 43.9 ° C. Body temperature of cattle with various anatomical positions such as reticulum-rumen, vagina of the ear (tympanic), rectum and udder (milk). The author concluded in [14] that the core body temperature of the rumen was shown to be the safest and most efficient measurement compared to other locations. In [15] Continuous ruminal pH (RpH) and ventral ruminal temperature measurements of the Radio Telemetric Bolus (RTB) for each time and every minute of Day 20 and 21. RTB with a diameter of 3cm, 8.5cm in height and weight, and 120g inserted into the ventral sac of the rumen through the fistula. The data logger was used to track each cow's vaginal temperature every minute on days 20 and 21. In [16] the core-body temperature calculation of poultry, beef cattle, swine, and dairy cattle was performed with miniaturized ambulatory receivers/loggers that were smaller in size (12 * 6 * 2.5 cm) and light weight (< 200 g). One of the transmitters sent the stored data at the time of transmission, so the battery stood up for about 10 days. In [17] Non-invasive remote control with passive radio frequency identification (RFID) of the core body temperature (BT) of cattle. 22.8 to 42.08C was the body temperature of the heifers when the RFID tag was used.

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In [18] for all small ruminants, the Bolus gun was used to calculate the temperature of Re Ru. When the temperature readings were transmitted, the Bolus gun was linked to the base station through a radio connection. In [19] Infrared thermometry is used in crossbred cattle to measure skin temperature. In various regions such as the collar, lumbar, hip, hind leg and fore leg, temperature was calculated. The body temperature was calculated by the author in [20] using four techniques described as: 1. Golden norm (clinical thermometry) 2. Thermography in infrared (two dissimilar regions), 3. Technology for RFID. The 2 different sites for measuring body temperature

using infrared thermography are the eyeball and ear centre. The transponder measured the temperature of the body in the 0 to 50°C range. The temperatures below and above the range are validated at 33.0°C and 43.0°C. Temperature-sensing reticular boluses (TSRB) are used in [21] to monitor the rectal temperature of dairy cattle when mastitis and pneumonia are detected early. The TSRB is placed in the cow's reticulum and provides continuous temperature control. The author thought in [22] that, compared to infrared guns and microchips, infrared thermometers are the best way for calculating the body temperature of pigs. For 24 male castrated piglets, the author tested the core body temperature using 3 techniques such as infrared thermometers, infrared guns and microchips. By rectal thermometry1) 39.3 ± 0.5°C. 2) 39.0 ± 0.7°C by microchip transponder 3) 34.3 ± 1.0°C by infrared thermometry, the author obtained a temperature measurement.

In [23], the author uses Digital Rectal and Microchip Transponder Thermometry to compare body temperature ferrets. The author tested 16 (8 male, 8 female) purpose-bred domestic ferrets using these two techniques to measure body temperature and proposed that the micro ship is the alternative digital rectal temperature process. The primary rectal digital thermometer is 26.7 to 43.3°C ± 0.1°C, the second rectal digital thermometer is 32.2 to 44.3°C ± 0.1°C, and the microchip transponder is 32 to 43°C. In [24] Infrared thermography images of the hind foot of each animal using a digital infrared camera were monitored for hoof lesions caused by dairy cows. Infrared thermography images of the hind foot of each animal using a digital infrared camera were monitored for hoof lesions caused by dairy cows. Infrared thermography was one of the non-invasive surface temperature measurements of a dairy cow. 10–40°C temperature; skin emissivity: 0.98. In [25] the surface temperature of buffalo bulls is measured using infrared thermography (IRT) in the separate orbital area (ORB), right flank (RF), left flank (LF) and scrotum (SCR).In [26] To evaluate the vaginal temperature that was put in the intravaginal sheep, iButton® temperature logging devices were used. The two distinct regions of the neck and tail calculate the vaginal temperature every 10 minutes. For the calculation of skin temperature with an emissivity of 0.98, the infrared radius thermometer was used in [27]. In the distinct ear area, right side udder, "neck side", chamfer (forehead), front shank, back shank, and between legs, temperature was measured. Nursing buffaloes must be shielded from direct solar radiation when the environmental temperature is above 30 ^{0}C during the summer months. The tail-attached sensor [28] was used to measure the surface temperature of pregnant dairy cattle between 9 and 35 days prior to calving. Measured temperature values are continuously tracked via the gateway and recorded in the cloud. With the assistance of the machine learning approach, predict the temperature value.

3. Materials And Methods

The examination was performed at a RPR Multi Agro farm in Virudhunagar, India. By and large, 15 cows (**Redsindhi, HF cross, Kangayam)** were utilized. The skin and body temperature of the cows were estimated during the visits of the calf feeder. The calves were observed toward the beginning of the day until each calf had visited the calf feeder at any rate once. Estimations from the evening were not used to lessen upsetting impacts because of diurnal changes in body temperature and climate conditions. The skin temperature accounts were performed with the versatile infrared based thermometry in the structure recordings. The IR thermometry included a temperature range from − 20°C to 150°C with a goal of 0.1°C, an unearthly reach from 6.4–12 micrometres and a coefficient of 0.03 K. The emissivity was changed in accordance with 0.627 dependent on proposals for human skin [29].

Table 1
Features of existing Temperature sensor and proposed temperature sensor for measuring the temperature of cow.

S.NO	Sensor	Temperature range	Accuracy	Emissivity	Communication
1.	**FLIR T1030sc** **Infrared Camera**	-40°C to 2000°C.			Thermal imaging cameras
2.	**Video-Based Infrared Camera (IRC)**	14°F to 932°F (-10°C to 500°C)		0.10 to 1.00	Infrared Camera
3.	**Smaxtec**	0°C – 80°C	± 0.05°C/± 0.09°F		GSM
4.	**TRI-88 Infrared Thermometer**	-20 to 270°	± 3.8°F (2°C) or ± 2%	0.95	Infrared
5.	**RFID Animal Glass Transponder**	-10˚C – 45˚C			ISO 11784/ 11785 FDX-B, GB/T 20563 – 2006(Transponders)
6.	**K-Life KLT-100 Digital Thermometer**	0°C – 104°C	± 0.1℃		
7.	**Mabis Thermometer**	90°F- 111.9°F	± 2°F		
8.	**HTEC IPTT-300**	20.0°C to 42.0°C	1. 0.2°C from 34°C to 42°C 2.0.5°C from 30°C up to 34°C 3.1.0°C from true at 20°C up to 30°C		32 alphanumeric characters onto the transponder
9.	**Microchip Transponders**	-40 to 85	± 0.16°C		
10.	**FLIR SC620**	40°C to 500°C	± 1%		Thermographic
11	**IR Thermometry (Proposed)**	-20°C to 500°C	± 0.5°C	0.1	IR and Bluetooth

This work proposes IR thermometry for monitoring the variations in temperature of cows. This thermometric device is designed IR-Photodiodes the transmitter (Tx) and receiver (Rx). This IR-Photodiodes transmits the incoming analog continuous signal using Tx-IR-photodiode along with resistor, which will resist the signal at higher voltage and received to destination node by using Rx-IR-photodiode. In between Tx and Rx photodiodes, there's a voltage divider which will equally divide the signal voltage for transmission and receiver. Temp is placed over the epidermis of in vivo; to measure the temperature. In order to decrease the decease related to temperature, an in vivo will be continuously monitored and communicated to the server. These monitored information are automatically updated with higher data rate using an implemented Energy Efficient Bio-Inspired Mimosa Pudica protocol [30] using the Bluetooth as the medium of communication, is embedded into raspberry pi for long range transmission. Unique ID will be assigned to every Temp for recording temperature as featured in Table 1.

This proposed temperature measurement differs from the traditional invasive measurement of temperature in the rectal region of cow. The proposed IR thermometry is a non-invasive, and it is measured on the surface region of rectal and abdomen respectively with the precision of ± 0.5°C as depicted in Table 1. These two regions result in the similar temperature value. Whereas, the traditional invasive measurement of temperature of every cow was estimated as a kind of perspective temperature when the calf entered the calf feeder. A similar advanced thermometer [31] was utilized, consistently by a similar individual. The estimation scope of the thermometer was from 33.2°C to 44.0°C, with a precision of ± 0.6°C and a goal of 0.3°C. The rectal temperature was constantly estimated at a similar addition profundity (8 cm) to limit predisposition in the estimating cycle [32].

4. Results And Discussions

To build up our framework for internal temperature level account in trial cow considers, we have tried an electronic checking framework dependent on the subcutaneous addition of IR based thermometry. This IR based thermometry have been measured in this animal, subcutaneously just as intraperitoneally, which the results of this shows 95% accuracy with traditional rectal temperature measurements for inner body temperature computation in an invasive fashion.

As an option in contrast to rectal tests, the framework is portrayed as a simple, dependable, and non-invasive innovation which gives further points of interest including 1) creature government assistance viewpoints, for example decrease of pressure related with taking care of and limitation, and 2) refinement of altruistic end-point models in trial settings utilizing consistent estimations of internal temperature level as an enhancement to life/demise standards. Right away, the framework, in this way, appeared to establish an appealing instrument for surface temperature measurement estimations to be tested in our exploratory cow animal model. Move of this innovation to huge creatures may confront some pragmatic difficulties since the thermometry is intended to be placed on the surface of rectal and abdominal regions of cow. This temperature measurements will be recorded in the remote server for continuous monitoring of temperature deviations of cow.

Accordingly, we began by testing the innovation through the inclusion of IR based thermometry at different regions of the body surface in cow: The picked positions were recommended with respect to 1) Surface body temperature measurements in non-invasive fashion, to attain the similar results of internal body temperature, 2) effectiveness of addition of Bluetooth/Wifi for communication of temperature values to the remote server, and 3) effectively available readings by continuous measurements. The outcomes indicated that the situation of the IR based thermometry in the cow is profoundly basic with respect to temperature level and temperature consistency.

Figure 2. Illustrates the surface body temperature measurements in the cow and continuous monitoring using IR based thermometry. These measurements will be more effective for the animals for checking their body conditions without harming and disturbing them routinely.

Table 2
Traditional rectal temperature measurements in an Invasive technique Vs Surface temperature measurement using IR thermometry in Non-Invasive technique

S.No	Type of Cow's					
	HF Cross		Red Sindhi		Kankeayam	
	Traditional Measurements (ºC) – Rectal region (invasive)	IR Thermometry (ºC) – surface region (Non-Invasive)	Traditional Measurements (ºC) – Rectal region (invasive)	IR Thermometry (ºC) – surface region (Non-Invasive)	Traditional Measurements (ºC) – Rectal region (invasive)	IR Thermometry (ºC) – surface region (Non-Invasive)
1.	38.7	38.63	38.9	38.74	39.0	38.67
2.	39.4	39.06	38.7	38.45	39.2	38.89
3.	39.2	39.3	38.8	38.67	39.1	38.91
4.	39.1	38.67	38.6	38.43	39.3	39.1
5.	38.5	38.45	38.8	38.62	39.1	38.9
6.	38.5	38.58	38.7	38.59	39.2	38.95
7.	39.2	39.03	38.9	38.71	39.5	39.42
8.	38.36	38.4	39.1	38.86	38.61	38.75
9.	38.62	38.5	39.26	39.03	38.96	39.0
10.	38.9	38.74	38.94	38.78	38.8	39.1

As experimented, the traditional rectal temperature measurements are compared with the proposed surface temperature measurements of different types of cows using IR Thermometry results 95% accuracy as depicted in Table 2. This non-invasive technique will play huge role in not harming and disturbing the animal, at the same temperature of that animal is monitored continuously.

Figure 3. illustrates the different methods of temperature measurements in invasive and non-invasive fashion techniques for different families of cows. This results that IR thermometry can be used as an alternative for traditional invasive temperature measurement techniques due to its accuracy non harmfulness, continuous measurements and monitoring from remote area and the reading can be recorded continuously in the remote server.

5. Conclusion

The Infra-red (IR) based thermometry recordings can be utilized to examine continuous temperature measurements of different families of cow animal. This surface body temperature can be communicated to the server via the bluetooth/Wifi medium. Infra-red (IR) based thermometry recordings might fill in as an observing framework for surface heat level in cows. The temperatures of the of these regions in the cow were 95% accurate than the traditional invasive rectal temperature measurements. The methodology includes estimating relative

contrasts between one estimation and the mean of past estimations at tantamount occasions of day. this framework comes out with non-invasive fashion measuring surface body temperature, will be an alternate way of taking reading of temperature rather computing the internal body temperature in an invasive fashion. Subsequently, this IR thermometry shows potential as a marker for consistent temperature estimations in cows.

Declarations

Acknowledgement

The author thank the animal care centre in India, at Tirunelveli, Veterinary College and Research Institute. The author also thank the manager of RPR Multi Agro farm in Virudhunagar, India to examine the study. Our sincere thanks to veterinary Hospital ,Nenmeni to acknowledge the study.

Conflict of interest

The authors declare that they have no competing interest.

Ethical statement

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. Ethical approval was done by the veterinary medical center , nenmeni,Virudhunagar,India.

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Writing-review and editing:: Sundara prem

Funding Acquisition; N/A.

Resources: N/A.

Supervision: Kalpana Murugan

Sources of funding

Sources of funding not applicable for this research.

Consent to participate: Not applicable.

Consent for publication: Not applicable.

Code availability: Not applicable.

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Figures

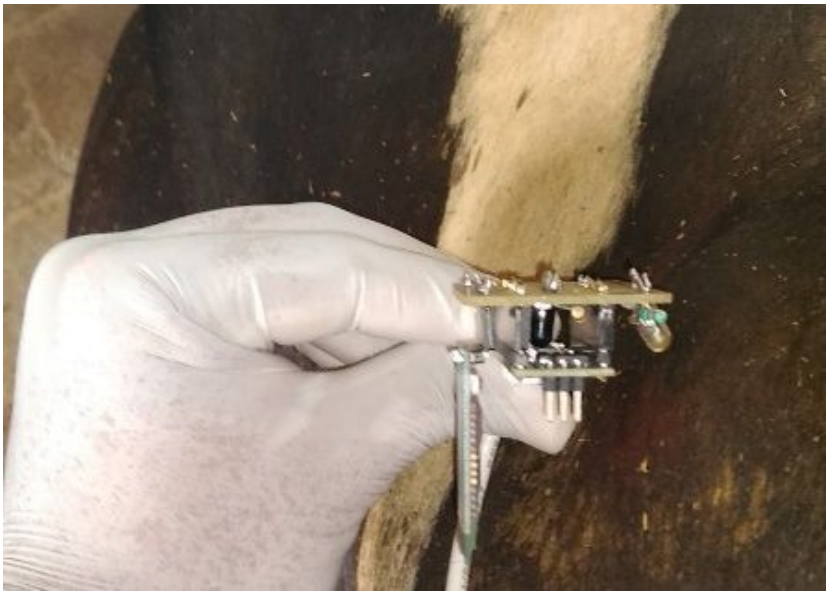
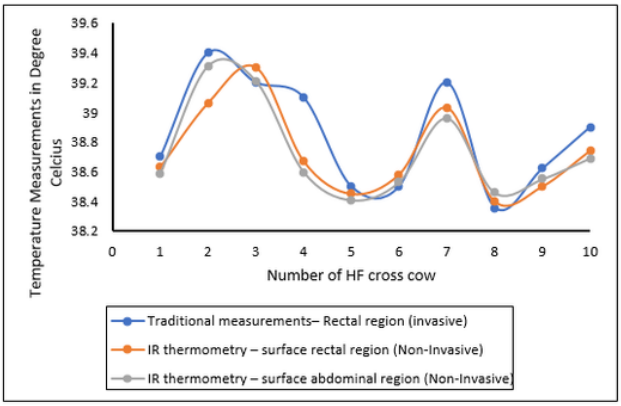


Figure 1

Cross sectional view of proposed IR based Thermometry

Figure 2

Temperature measurements in rectal and abdominal regions of cow using IR based Thermometry



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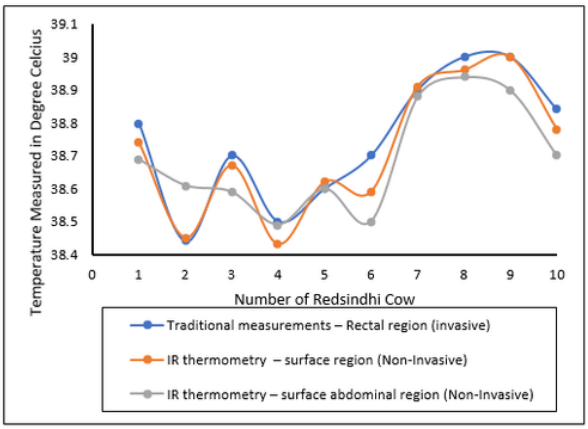

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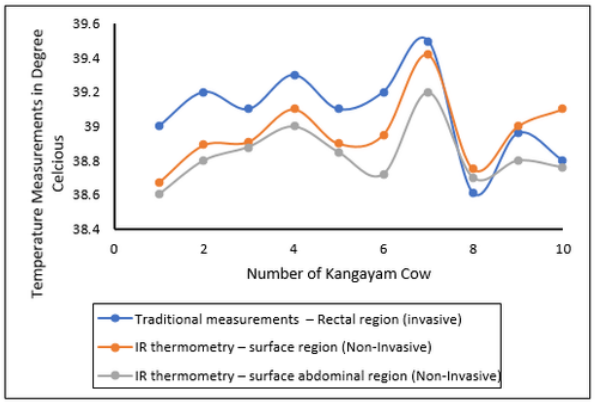

(c)

Figure 3

Graphical representation of Invasive Rectal, Non-Invasive Rectal and Non-invasive Abdominal temperature measurements of different family of Cows (a) HF Cross Cow Temperature measurements, (b) Red Sindhi Cow Temperature measurements and, (c) Kankeayam Cow temperature measurements