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Worth of Artificial Intelligence in the Epoch of Modern Livestock Farming: A Review

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ABSTRACT

Artificial intelligence (AI) is a human intelligence in machine encountered daily and impacts our lives. It is expected that the use of such technology in the livestock industry will automate the livestock processes and easy to manage. Biometric identification plays a key role in artificial intelligence which shows the individual identity, helps in the process of insurance and claim leakages, continue monitoring of farm animal is essential can be done with new technologies. Infra red temperature measurement camera is the newly added technology with sensor system in (AI). It is a temperature measuring device in the form of electromagnetic waves and the infrared radiation intensity. AI system consists of agent, sensor, actuators and effectors which are connected to cloud. It helps in the detection of estrus, animal diseases, body condition score and various physiological parameters using video surveillance data collection method. Artificial neural network is a branch of artificial intelligence (AI) which is based on a collection of connected units or nodes called artificial neurons and stored in a central database system. Sustainable economic future of dairy farms and to achieve 100% compliance rate. Modern dairy farms uses robotic system to deliver vaccines, machine milking and measurement of feed as per individual performance of the animal. AI analyzes the animal origin food quality traceability method from farm to fork. AI helps in the complete mechanized animal husbandry right from the birth of animal to production and food product. The future of AI in animal sector is not predictable, but advantages and daily increasing demand of AI over other sector will ensure future in animal sector as well.

Key words: Artificial intelligence (AI), Infra red camera, QR code, RFID.

Livestock wealth is very precious for a developing country that metamorphosed into an industry. Though the growth of livestock industry is very promising, in order to make India a global leader in animal husbandry. In the recent time, with requirements of the better yield of farm animals, AI act as a tool that empowers farmers in monitoring, forecasting, optimizing the farm animal growth. At present AI is being used in animal husbandry is an integral branch of agriculture concerned with the care and management of the livestock. It deals with all the information technologies involved in managing and ensuring better health of farm animals, including genetic qualities and behavior (Dunjko and Hans, 2018). Generating and leveraging useful information through AI will help farmers to manage their livestock efficiently with minimum supervision.

Artificial intelligence (AI) is one such technology which moves a step forward towards digitalization and its implementation ensures advancement in a sustainable livestock production. In livestock production system it is essential to know the real time data of individual animal in a modernized farm but it is not possible to record every physical data of individual animal (Snyder *et al*., 2012). To overcome these challenges, digitalization was introduced to collect, store, analyze, share electronic data and updated information in livestock sector for betterment of the future.

Artificial intelligence (AI) technology is a time saving technique and it can detect symmetric and asymmetric gradient changes of the animals which produces the meaningful data. The developments in (AI) technology over the past few decades are tremendous and offer great potential in improving animal health through various measures like effective disease forecasting, estrus detection, lameness and animal tracking etc (Li *et al*., 2017). A healthy herd needs to be monitored for productive and reproductive status continuously in order to detect even the smallest changes, which will reflect the health and well being of farm animals. Reproduction management directly affects the calving to conception interval, the calving interval and milk production, which impacts farm proût. So artiûcial intelligence (AI) helps to detect the signiûcant change in animals activities (Takeda *et al*., 2014).

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Artificial intelligence

Artificial intelligence (AI) refers similar to human intelligence in machines that are programmed to think like humans and mimic their actions. The ability of a computer or robot to perform tasks commonly associated with intelligent being. It includes learning, reasoning, algorithms and self correction process. It generates insights from data more quickly and accurately than humanly possible and is able to act automatically on that insight. The technology can be applied to many different sectors and industries. There are so many amazing ways where artificial intelligence encountered daily and impact our lives. AI assists in every area of our lives, whether we're trying to read our emails, google search, social media, get driving directions, music or movie recommendations. AI-powered assistants introduced by Amazon (Alexa), Apple (Siri), Microsoft (Cortana) and Google (Google Assistant) to ease searching for information in our daily lives. Amazon's Echo smart speaker product 'Alexa' can be queried about the weather, stream news and music on demand and serves as a robotic assistant that responds to voice commands to control home lighting and much more (Anonymous, 2020).

Mechanism of Artificial intelligence

Artificial intelligence allows producers to analyze the data collected by sensors and other hardware technologies, provide interpretations and solutions by mimicking human decision making, potentially transforming how a dairy farm operates. AI system analyses the collected data and convert it into meaningful, actionable insights where producers can look quickly and easily to make quick management decisions. An AI system consists of agent, sensor, actuators and effectors. The agents sense the environment through sensors and act on their environment through actuators.

a) Agent: An agent can be anything that perceive change through sensors and act upon that environment through actuators. An agent can be software, human or robot. An AI agent can have mental properties such as knowledge, belief, intention, *etc*.

b) Sensor: Sensor is a device which detects the change in the environment and sends the information to other electronic devices. An agent observes its environment through sensors.

c) Actuators: Actuators are the component of machines that converts energy into motion. The actuators are only responsible for moving and controlling a system. An actuator can be an electric motor, gears, rails, etc.

d) Effectors: Effectors are the devices which affect the environment. Effectors can be legs, wheels, arms, fingers, wings, fins and display screen.

Components of the artificial intelligence used in livestock sector

There are many uses for the artificial intelligence in livestock system Fig 1.

Animal identification

Identification plays a key role in every step of animal production system which shows the individual identity of the animal. It recognize and able to trace the individual's production and health history accurately. The use of modern technology over the conventional method like (tagging, ear notching, branding, tattooing) can significantly reduce the risk of spreading diseases.

Biometric methods

Biometrics is non invasive methods of animal identification. This method identifies any measurable, distinctive, physical, anatomical or molecular traits that can be used as unique identify and verify (Barron *et al*., 2009). Biometric recognition systems are now internationally adopted to verify the accurate identity of animals. It is completely contactless, capable of using images of animal faces, by exploiting AI and computer vision based technologies (Kuhl and Burghardt, 2013). There are various types of biometric methods of identification that are based on machine learning process are as follows:

Facial recognition

To develop this biometric recognition system for individual animal identification, a mobile application is needed to acquire images from different angle at the time of insurance and video streams of "cattle faces" uploaded to cloud and use it for verification at the time of claim submission. Moo ID is an AI based platform for the livestock identification system. It has application in animal insurance in reducing claims leakage.

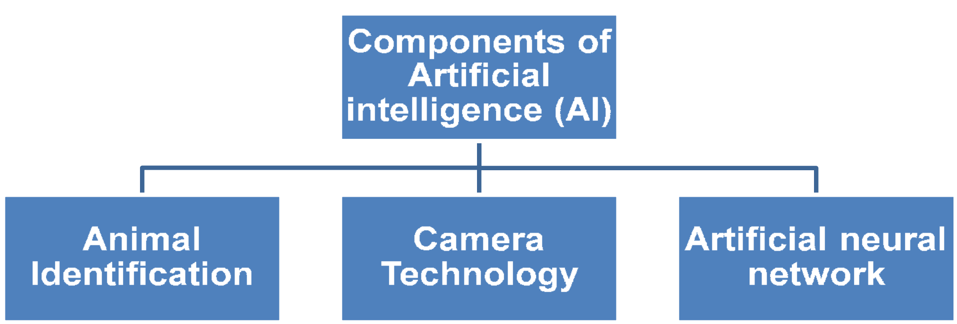

Fig 1: Components of the artificial intelligence.

Muzzle prints

This method has been used to identify the animal on the basis of the arrangement and distribution of ridges and valleys on the muzzle that remain same throughout the life. The print of muzzle are taken from the individual animals are examined for the various muzzle characteristics are recorded and can be scan with help the reader for future reference by image analysis system (Pankaj *et al*., 2010).

Retinal imaging

Retinal imaging can be used for identification of animals. An image of the blood vessels pattern on the retina is similar to that of fingerprint. This pattern fixes at birth and does not change throughout the life. Using a computer algorithm, the retinal image is converted into unique identification. Retinal imaging and muzzle prints of sheep and cattle were compared and muzzle prints were found to be a quicker method than retinal scanning (Howell *et al.,* 2008) however, retinal scans are not easy to analyze by inexperience operators.

Bar coding

Barcodes on ear tag are symbols that can be scanned electronically using laser or camera based systems. The alternate black line carries coded information about the animal, which is readable by machine format. It captures automatic data and decoded by software with 100% accuracy.

QR code (**Quick Response Code**)

The trademark for a type of matrix barcode (2D dimensional barcode) printed on ear tag. QR code uses four standardized encoding modes *i.e.* numeric, alphanumeric, byte/ binary and kanji that efficiently store data. It reads very fast and greater storage capacity as compared to barcode. QR code consists of black squares arranged in a square grid on a white background, which can be read by an imaging device such as a camera. It allows encoding over 4000 characters in a 2D barcode. The content of a QR code cannot be changed once generated, until the images can be appropriately interpreted by data base system. The required data is then extracted from patterns that are present in both horizontal and vertical components of the image and printed on ear tags (Anonymous, 2020).

Radio frequency identification device (RFID)

Radio frequency identification is a method of recording a unique number that has been assigned to an electronic identification device carried by an animal. It is used on farm to collect individual performance in a data base system or used in conjunction with an automated machine milking system. Electronic identification device (EID) of animal involves using RFID devices that can be carried by animal such as an ear tag or internally with an RFID bolus, ear tag and microchip. It is a fine data storage device, data can be easily viewed, analyzed, manipulated and sorted easily (Finkenzeller, 1999). Radio frequency identification device (RFID) is most common and latest technology which is used for the identification in livestock that plays very important role in artificial intelligence (McAllister *et al.,* 2000).

How RFID works

Radio frequency identification device (RFID) uses electromagnetic fields that automatically identify the tag by continue sending the radio waves. The scanning antennas can be permanently fixed to a surface, handheld portable antennas are also available. We can fix them into a door frame to accept data when animal passing through it. When a RFID tag passes through the field of the scanning antenna, it detects the activation signal from the antenna, that wakes up the RFID chip and it transmits the information of sensor and microchip to be picked up by the scanning antenna. The scanning antenna connected with data accumulator and hybrid network, it stored various parameters in a very short time (Singh *et al*., 2014). RFID consist of three components and they are as follows:

(1) Transponder
(2) Transreceiver
(3) Herdmans software (data accumulator)

1) Transponder: Transponder is implanted inside the body, have a silicon chip and an antenna. Silicon chip have 12 digits for identification of animals and can be of any type.

a) Ear tags: The ear tag transponder is one inch in diameter and can be embedded in plastic (Stark *et al.,*1998).

b) Bolus: The bolus transponders are covered by a capsule of biomedical glass and injected under the skin or introduced orally into the fore stomach of ruminants through a balling gun. Bolus is irretrievable until the time of slaughter. Boluses show higher readability (99.5 MHz) than visual tag (89.8%) (Garin *et al*., 2003).

c) Collar: Electronic collar are similar to that of neck chain, except that they have an attached tag with an electronic number that can be read by a scanner. Electronic collars are easy to use, but they can cause a choking if they are not adjusted properly to the growth of the animal or if they become hooked on protrusions (Kampers *et al*.,1999).

d) Microchips: Microchip is a form of identification that involves the implanting of an electronic chip, with a miniature radio transponder and antenna. Under the skin of an animal near the neck between the shoulder blades or near the base of the ear. Passes through the field of the scanning antenna (Singh *et al*., 2014). RFID tags are of two types.

✓ Active RFID tags have their own power source and the readers can get the signal from a distance however, life span of this device is less than 10 years and operates at frequencies of 455MHz with a readable range of about 20 to 100 meters.

✓ Passive RFID tags do not require batteries and are smaller in size and have a virtually unlimited life span (Tan *et al*., 2007).

2) Tran receiver/ reader/ scanner: Tran receiver is a device which sends an electronic signal to the tag, the tag gets charged and replies with the stored information. There are two basic readers

A) Fixed RFID reader: Fixed RFID reader is used at a position in which a farmer wishes to utilize an animal RFID number on a regular basis in fully mechanized farm. The fixed readers may be utilized for the animal as soon as it enters the milking parlor and subsequently recording with date, time, feeding as per milking (*e.g*. automatic feeding *etc*).

B) Portable RFID reader/handheld reader: The handheld reader can be powered by a rechargeable battery. Portable readers are capable of reading the RFID tag of an animal in the field and displaying the animal's RFID number on a small digital screen inbuilt into the portable reader. The RFID reader could be attached to a personal digital assistant (PDA) which is loaded with herd management software and the data stored on the farms central herd management software application. It can be copied to this PDA thus, effectively providing a mobile copy of the herd information. Utilizing this arrangement, the farmer can then scan a RFID tag with the portable RFID scanner and the identity and information pertaining to that can be provided on the screen of the PDA. This reader via a machine learning programming predicts the upcoming information and update animal information on the same (Kampers *et al*.,1999).

3) Herdman software: It consists of laptop and computer which work as data accumulator. Herd management software data can be entered into this software application manually, standardized interface, clouded data can be automatically entered through the use of other digital devices (such as milk parameters, animal weight scales, pregnancy status) linked to this database. Such herd management software also provides RFID devices with the information required to make a decision or conduct an action with the help of AI (Karnjanatwe, 2005).

Camera technology: Infra red thermal camera

There is a resurgence of interest in the application of infrared thermal imaging in artificial intelligence with improvements in camera technology and the promise of capturing actual data. Physiological parameters need to be precisely monitored continuously in order to detect even the smallest changes, which will reflect the health and well being of farm animals. Among all the parameters that are sensitive to the smallest changes in domestic animals is temperature. Temperature is the most important indicator of animal health as it is related to a number of important varied functions such as nutrition, reproduction, activity, stress response and preservation of the health. Thermal imaging is a time saving technique and it can detect symmetric and asymmetric temperature gradients of surface areas in animals. The skin surface acts as a cooling system radiating heat and hence enables comparatively accurate measurement of temperature gradients through thermal imaging (Weixing *et al*., 2015).

Principle of infra red thermal camera and sensor system

The principle of thermal image is that every object with a surface temperature above absolute zero will emit an electromagnetic radiation. The electromagnetic radiation can be characterized by two distinct features wavelength and intensity. Both of these features are related by simple physical laws to the surface temperature of an object (Anguita *et al*., 2003) Fig 2.

Intensity and wavelength of emitted radiation vary with the surface temperatures of the emitting source. Thus objects at a particular temperature emit radiations spread over a range of different wavelengths in the camera have temperature sensor detector. By algorithm method and operational languages it decodes in readable manner (Weixing *et al*., 2015). Infrared camera is an imaging temperature measuring device. The object radiates energy outward in the form of electromagnetic waves and the infrared radiation intensity of different objects is different (Dunjko and Hans, 2018) Fig 2. Infrared thermal imaging is to use the differentiate between temperature and emissivity, the target and the surrounding environment to generate different thermal gradients, which shows the infrared radiation energy density distribution map, that is the "thermal image". Human vision is not sensitive to infrared light the thermal image seen by humans is that the infrared radiation emitted by the object and converted by the thermal imager by decoding system (Moreau *et al*., 2009). The different temperatures of the object are represented by different colors on the infrared image, lighter the color higher the temperature of the object and the darker color lower the temperature of the surface (Hristov *et al*., 2008). Infrared camera converts infrared radiation into visible light image in two major steps.

- ✓ The first major step is to convert the infrared radiation into an electrical signal through an infrared detector. The intensity of the infrared radiation is reflected by the magnitude of the signal.
- ✓ The second step is to display the distribution of the target infrared radiation on the display through the display screen. The electrical signal completes the transition from electricity to light. This method is totally based on central data base system and capturing the real time temperature with machine learning process. (Schaefer *et al*., 2012)

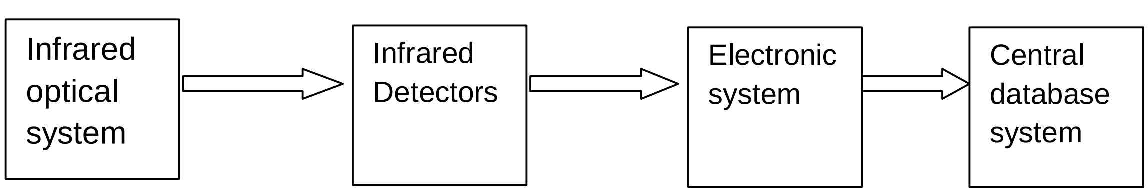

Fig 2: Principle of infrared camera working with electric signals

Types of infra red thermal camera

There are three basic types of Infrared cameras short wavelength, mid-wavelength and long wavelength. Each type has its own place in facilities maintenance, depending on use and operation.

• Short-wavelength infrared cameras typically detect infrared wavelengths in the spectral range of 0.9-1.7 microns, which is very close to the visible light spectrum. This type of camera delivers very high resolution, relative to the visible light spectrum in its shadow contrast and detail.

• Mid-wavelength cameras typically detect infrared wavelengths in the spectral range of 2-5 microns and they deliver higher resolution with accurate readings. The images are not as detailed as those produced by long wavelength cameras, due to an increased amount of atmospheric absorption within this spectral range. Cameras in this range are used for extreme high-temperature readings, such as scanning at entrance gate.

• Long-wavelength cameras the most popular infrared camera typically detect infrared wavelengths in the range of 7-12 microns. Cameras operating in this spectral range provide great deal of detail because atmospheric absorption is minimal. Both long- and mid-wavelength cameras provide accurate temperature measurements and can produce detailed differences across small or large temperature ranges for example in open paddock wide range surveillance.

Artificial neural network (ANN)

Artificial neural network (ANN) is a branch of artificial intelligence (AI) which is based on a collection of connected units or nodes called artificial neurons, which loosely model the neurons in a biological brain. Each connection, like the synapses in a biological brain, can transmit a signal to other neurons. An artificial neuron that receives a signal then processes it and can signal neurons connected to it. A digital device network is required to enable the communication of devices between one another that is RFID readers and the central herd management software. There are essentially three methods of establishing such a network-wired, wireless and hybrid. The selection of the implementation type will depend upon the characteristics and preferences of individual dairy farms (Treventham and Michael, 2008).

Now a day's Artificial intelligence using the wireless networks system. This will enable an array of devices, to be linked directly to real time data in the herd management database. Various devices include the main stream computer network devices, such as PDAs, laptops, desktop, personal computers and printers also provide the vital links to dairy farm. Some devices, such as RFID readers, temperature detection milking controller units, feed management units, drafting gates *etc* (Li *et al*., 2017).

A hybrid network involves some components of the network utilizing direct wired connections to the herd management software and server application, while other devices are provided with portable abilities. This may be the preferred option where there are devices that are intended to be permanently placed in a position, while other devices require portability (Kuhl and Burghardt, 2013).

Steps of analyzing the data

The data generated in the system are analysed in the following ways:

1) Collection of data for the analysis by generating random data values in excel that serves as the coefficient.

2) Normalizing the data from various equations, normalize the raw data within a narrow range limit in between 0 to 1.

3) Portioning of dataset into two segments. One segment known as the training set that comprises of 75% of the main dataset while the other segment contains the remaining 25% part from the main dataset is called as testing set. One of the main reasons behind bringing these partitions was to first build an artificial neural network model through the training dataset and bring out the evaluations of its performance using the testing set.

4) Train a model on the data modeling relationship between the final and initial reading taken into account in a multilayer network system. The multi layer based ANN model helps in predicting the requisite functions that we have prepared earlier in the above section. The given model provides us with a vital performance indicator called as the sum of squared errors (SSE) which is nothing but the summation of squared difference between the group mean and each individual observation. A low value of this parameter plays a significant role in judging the performance of the model to a much greater extent. The network topology diagram plotted here provides a deep insight into the black box of the ANN, leaving the information about the fitting of model aside.

5) Evaluation of model performance is the test indicator that helps us to test the fitness of the proposed model was the correlation factor. A correlation value close to one signifies presence of a strong linear relationship among the variables one takes into account. In this model the correlation value of about 0.99981 which fairly exemplify the strong linear relationship among the variables. Since we know that neural networks with more complex topologies are quite capable of dealing with more sophisticated learning process (Saxena and Parasher, 2019).

Use of Artificial intelligence in animal production system

Temperature measurement

Temperature measurement is also an effective means to assist in disease diagnosis and health monitoring. In the conventional method of measuring body temperature with mercury column is used to obtain the rectal temperature. The operation of this method is complicated and requires a large amount of labor. This kind of temperature measurement method is contact and can make the animal stressed, which is disadvantageous for the healthy growth in animals. Therefore, rectal temperature measurement no longer meets the needs of the large scale rearing system (Zhang *et al*., 2019).

Infrared temperature measurement and various device of sensing technology becomes the main means of measuring the temperature of the body surface. It is technology of capturing non invasive, long distance and real time body temperature. Continues monitoring will output the average data by using different machine models through the statistical analysis and equalization of the data, the correction formula of the body surface temperature of the different species is fitted and the diurnal variation of the temperature of body surface will obtained, which had accumulated experience in scientifically measuring the body temperature. The various hot windows includes head, forelimb, hind limb, head back, udder and vulva for surface body temperature (Straw, 2011).

Detection of estrus in animals

Animals are aggressive and restless when in estrus, so it becomes difficult to restrain the animal for health monitoring (Dongre *et al*., 2017). Accurate detection of heat (estrus) is an important factor in the success of dairy farms. The advancement in AI technology and its applications has enabled farmers to prevent losses caused by incorrect detection of estrus. The radio collar (with motion sensors) tied to the cow's neck collects all types of data related to cow 24 hours a day. AI components of the dairy automation system process the collected data to provide insights on the heat stress, change in feeding efficiency, loudness and the estrus of the cow (Schaefer *et al*., 2012).

Recording of vocalization pattern

The vocal behavior of cattle gives information on the reproductive status of the vocalizing animal and may bear upon estrus advertisement. Near the time of estrus vocalization rate was found to be increased, with the extent of vocalizations pitch depending on the status of the estrus cycle. Vocalizations are recorded continuously by a clip on microphone attached to a neck harness of the animal. Via a transmitter the recordings are transferred to a stationary receiver being connected to the sound card of the computer. By use of the available algorithm, serial signal windows are generated from the sound recording and only those with means exceeding a defined threshold are considered for detection of estrus. However, large individual variability of absolute vocalization rate might reduce the suitability of this trait for practical application (Crandall *et al*., 2003).

Lameness

Earlier methods of testing lameness required to restrain the animal and make it stand still for a long period of time which becomes improbable, even during milking. Hence infrared camera can act as a fine device to detect lameness. Lameness will show the differences in temperature between the distal and proximal ends of the limbs and the expected reason of lameness.

Pedometers attached to the leg of the cow record the number of steps taken per unit time as an indicator of walking activity being markedly increased during estrus of dairy animals. Pedometer recordings showed a diurnal rhythm in the number of steps which is important for the development of algorithms considering within individuals comparisons.

Detection of animal diseases

Artificial intelligence tool uses images allow for the early detection of the serious diseases and enable dairy farmers to take action more quickly. AI could study the pattern of the disease spread, to predict the geographical regions it will spread. Infrared camera is a device that consists of an image analyzer scanner and software (Cozler *et al.,* 2019). AI can detect by the behavior and symptoms of the disease through visuals analysis by camera with computer program (pain, dull, depress, lethargy, activity, feeding and water). Movements with stored data can predict the ovulation period of the cow in advance and it provides enough time to prepare for artificial insemination of the animals in heat (Berry *et al*., 2003).

Body condition score

Body condition scoring (BCS) estimates mobilization of energy reserves of animal. The BCS is used as a feed management tools, influences productivity, reproduction, health and longevity. The thermal camera can be attached to the barn ceiling or at the exit of the milking parlor. The cows are identified electronically by the weigh station's (RFID). BSC is estimated by machine learning Matlab software. A thermo graphic image of an animal is correlated with the cross sectionals contour models as in the software. Thus it can be concluded that thermal imaging is a great tool for monitoring of animals and better super vision in one screen (Schaefer *et al*., 2012).

Robotic system to deliver vaccines

It is very tedious to give hundreds of vaccines and reproductive medicines to animals in dairy farm. If we plan to deliver vaccines manually, each dairy farm would be required to invest heavily in labor and training. For a sustainable economic future of dairy farms and to achieve 100% compliance rate. The robotic system is integrated with a dairy automation system. The system reads RFID tags attached to the cow's ear, gets health related information and vaccination record for the cow. If the cow requires an injection, it is directed towards the injection site and the injection mechanism position itself to deliver the medication in the cow's neck (Soerensen and Pedersen, 2015).

Analyze the animal origin food quality

The automated milking booth is a section of animal husbandry which has a increasing application of artificial intelligence system. AI enabled smart sensors in automated milking units can analyze the milk quality and flag for abnormalities in the product. SENSEHUB® meat monitoring system, which is the first health monitoring system that analyzes the real time behavior of herd, so that the farmers stay in touch with their herd anytime and anywhere. The system lets farmers know if an animal is in distress or needs attention, monitoring such areas as peak time for insemination to optimize conception rates, early detection of health problems for quicker intervention, defining the most suitable feeding strategy, reporting difficult birth situations, post-natal health problems and monitoring sudden planned or unforeseen changes within herd (Aharwal *et al*., 2019).

Connected cow

Everything in the digital age is connected, including farming and agriculture. Livestock technology can enhance or improve the productive capacity, welfare, or management of animals and livestock (Awasthi *et al*., 2016). The concept of the 'connected cow' is a result of more and more dairy herds being fitted with sensors to monitor health and increase productivity. Putting individual wearable sensors on cattle can keep track of daily activity and health related issues while providing data driven insights for the entire herd (Takeda *et al*., 2014). All this data generated is also being turned into meaningful, actionable insights where producers can look quickly and easily to make quick management decisions.

Future prospects

It is quite true that artificial intelligence is at budding phase and no more confined to innovation labs only but more progress is required. Application of AI raises questions that will need to be addressed in the future. What will be the impact on farm profitability? How it will affect employment? What is the environmental impact? AI is often represented in a negative way, some would call it is a technology that endangers the mere existence of humankind as it is potentially capable of taking over and dominating human being, but in reality AI has affected our lifestyle either directly or indirectly and shaping the future of tomorrow (Snyder *et al*., 2012).

There may be "Digital divide" because constraints prevent a range of farmers from adopting digital technologies, it's possible that the benefits will only accrued to the powerful. For example, large farms are most likely to adopt AI technologies because of high costs and digitally literate farmers positioned to take advantage of such opportunities (Hebblewhite and Haydon, 2010).

The problem of common sense remains a major obstacle to progress in artificial intelligence. Here, we argue that common sense in humans is founded on a set of basic capacities that are possessed by many other animals, capacities pertaining to the understanding of objects, space and causality. The field of animal cognition has developed numerous experimental protocols for studying these capacities and, thanks to progress in deep reinforcement learning (RL), it is now possible to apply these methods directly to evaluate RL agents in 3D environments.

AI is a source of both advantages and disadvantages in different perspectives. However, we need to overcome certain challenges before we can realize the true potential and immense transformational capabilities of this emerging technology. Benefits of this technology is phenomenal are widely recognized in diversified areas ranging from medicine to security to consumer applications. There are various AI based technologies available in market for livestock sector too (Fisher and Gould, 2012).

AI is advantageous in livestock sector for their individual animal approach over average animal approach, 24x7 monitoring, faster decisions with accuracy ease the task, no human error *etc*. Artificial intelligence senses all the data points that collect from farm and make it useful and meaningful information. Now a day, AI is used mainly to recognize and monitoring the health of animal but there is lot in animal husbandry to do right from the birth of animal to production and food product. AI in livestock sector has lot of opportunity although basic requisite is to overcome challenges in future (Snyder *et al*., 2012).

Recent advances AI in Animal Health Care

- Animals understanding our language appears to be obtainable to the degree of their cognitive ability.
- A team at the Georgia Institute of Technology have created a computerised doggy vest that can help our four-legged friends better communicate with their owners – it's a new field of science they're calling "animal-computer interaction."
- Weak artificial intelligence (AI)- also called narrow AI is a type of artificial intelligence that is limited to a specific or narrow area. Weak AI simulates human cognition. It has the potential to benefit society by automating time-consuming tasks and by analyzing data in ways that humans sometimes can't.
- RESOLVE recently debuted the WildEyes AI system, a tiny camera imbued with artificial intelligence that can be trained to recognize specific animals in the field. The first version of WildEyes is trained to recognize elephants, which often come into conflict with humans when they raid crops and enter villages.
- In just the veterinary sector, there is the possibility that diagnostics and even consultation, may become fully automated.
- The American Association for Artificial Intelligence itself has expressed that the future of AI is bright, but unpredictable (Anonymous, 2021).

Internet of things

Together these technologies are creating opportunities within the dairy industry for increased efficiencies, profitability and production. The connectivity of these technologies is made possible through the use of Internet.

Agriwebb is a company using IoT for full farm recordkeeping, including field management, inventory, operations, grazing and even biosecurity. Stellapps in India leverages to offer all manner of products, from general herd management to milk evaluation, payment processing and cold chain monitoring. Dell Technologies is also heavily involved in applications and is working with dairy producer Chitale.

Cargill is working with SCiO (Consumer Physics) to create Reveal, an app designed to deliver content of feed within minutes. Previously, this type of technology was either time-intensive (waiting on lab results) or expensive (specialized equipment cost thousands of dollars). Using a micro spectrometer with NIR calibrations, Cargill and SCiO offer this simple service using producers' own devices and results are available in a minute's time (Anonymous, 2021).

Using the data

In the past, farm management applications have allowed farmers to make strategic management decisions based on the collection of farm data. Inevitably once nutritional decisions are being made, sciences such as nutrigenomics and decisions about smart nutrition are critical to taking advantage of this enhanced data and management information systems. Nutrigenomics research has shown that specific nutrients and inclusion of enzymes can greatly impact milk yield.

Previously, collected data was generalized for an entire dairy farm. Through the use of sensors, AI and other technologies, farm management apps like FarmWizard can provide individual data for each cow, allowing farmers to improve precision and accuracy when making managerial decisions (Anonymous, 2021).

CONCLUSION

Artificial intelligence has already become an intrinsic part of our daily life and it is now quite a dynamic and influential thing which is being improved at a faster phase than expected. Many businesses including livestock are trying to use it for different objectives including increasing productivity and effectiveness, saving time, eases the everyday tasks and money *etc*. The infrared camera technology can enhance and improve the productive capacity by the third eye monitoring of animals and livestock. Facial recognition and monitoring health status, livestock farmers can detect the onset of health issues often before clinical symptoms appear. It has the potential to improve productivity, enhance traceability, assist in disease prevention and provide for animal health and well-being accountability. With the increase in consumer concern for the origins and production method of meat, dairy and egg products, the AI will significantly contribute towards greater acceptance in society and an improved image for livestock production. AI powered apps and tools for farmers and veterinarians increasing continuously, but the options are limited and still in their development stages. The future of AI in animal sector is not predictable, but advantages and daily increasing demand of AI over other sector will ensure future in animal sector as well.

REFERENCES

Aharwal, B., Roy, B., Lakhani, G., Yadav, A., Baghel, R. and Saini, K.P. (2019). Livestock traceability: An overview. International Journal of Livestock Research. 9(9): 13-29.

Anguita, D., Ridella, S., Rivieccio, F. and Zunino, R. (2003). Quantum optimization for training support vector machines neural network. Advances in Neural Networks Research. 16: 763-70.

Anonymous (2020). Artificial intelligence. https://en.wikipedia.org/wiki/artificial+intelligenceo. Accessed on 10th may 2020.

Anonymous (2020). Quick response code. https://en.wikipedia.org/wiki/QR_code. Accessed on 27th April 2020.

Anonymous (2021).https://www.pashudhanpraharee.com/application-of-artificial-intelligence-ai-for-livestock-poultry-farm-monitoring/ 19th july 2012.

Awasthi, A., Awasthi, A., Riordan, D. and Joseph, W. (2016). Non-invasive sensor technology for the development of a dairy cattle health monitoring system. Theory, Design and Prototyping of Wearable Electronics and Computing. 5(4): 23-28.

Barron, U.G., Butler, F., McDonnell, K. and Ward, S. (2009). The end of the identity crisis advances in biometric markers for animal identification. Irish Veterinary Journal. 62: 204-208.

Berry, R.J., Kennedy, A.D. and Scott, S.L. (2003). Daily variation in the udder surface temperature of dairy cows measured by infrared thermograph potential for mastitis detection. Canadian Journal of Animal Science. 83(4): 687-693.

Cozler, Y.L., Allain, C., Caillot, A., Delouard, J.M., Delattre, L., Luginbuhl, T. and Faverdin, P. (2019). High-precision scanning system for complete 3D cow body shape imaging and analysis of morphological traits. Computers and Electronics in Agriculture. 157: 447-453.

Crandall, D., Antani, S. and Kasturi, R. (2003). Extraction of special effects caption text events from digital video. International Journal on Document Analysis and Recognition. 5(3): 138-157.

Dongre, V., Kokate, L., Salunke, V., Durge, S., Patil, P. and Khandait, V. (2017). Artificial intelligence for prediction of standard lactation milk yield in deoni cattle. International Journal of Livestock Research. 7(11): 167-173.

Dunjko, V. and Hans J.B. (2018). Machine learning and artificial intelligence in the quantum domain: A review of recent progress. Reports on Progress in Physics. 81: 11-16.

Finkenzeller, K. (1999). Radio frequency identification fundamentals and application. Journal of Current Issues in Media and Telecommunications. 3(1): 25-41.

Fisher, D.K. and Gould, P.J. (2012). Open source hardware is a low cost alternative for scientific instrumentation and research. Modern Instrumentation. 1(2): 8-20.

Garin, D., Caja, G. and Bocquier, F. (2003). Effects of small ruminal boluses used for electronic identification of lambs on the growth and development of the reticulorumen junction. Journal of Animal Science. 81(4): 879-884.

Hebblewhite, M. and Haydon, D.T. (2010). Distinguishing technology from biology: A critical review of the use of GPS telemetry data in ecology. Biological Sciences. 365(1550): 2303-2312.

Howell, B.M., Rusk, C.P., Blomeke, C.R., McKee, R.K. and Lemenager, R.P. (2008). Perceptions of retinal imaging technology for verifying the identity of 4-H ruminant animals. Journal of Extension. 46(5): 74-77.

Hristov, N.I., Betke, M. and Kunz, T.H. (2008). Applications of thermal infrared imaging for research in aeroecology. Integrative and Comparative Biology. 48: 50-59.

Kampers, R., Rossing, W. and Eradus, W. (1999). The ISO standard for radio frequency identification of animals. Computer and Electronics in Agriculture. 24: 27-43.

Karnjanatwe, K. (2005). How RFID tags can track livestock. Canadian Journal of Animal Science. 93(1): 23-33.

Kuhl, H.S. and Burghardt, T. (2013). Animal biometrics quantifying and detecting phenotypic appearance. Trends in Ecology and Evoloution. 28: 432-441.

Li, C., Tonghui, Q. and Shizhen, Z. (2017). Design of pig signs and breeding environment monitoring system based on wireless sensor network. Technical Automactic Application. 36(5): 61-64.

McAllister, T.A., Gibb, D.J., Kemp, R.A., Huisma, C., Olson, M.E., Milligan, D. and Schwartzkopf-Genswein, K.S. (2000). Electronic identification: Applications in beef production and research. Canadian Journal of Animal Science. 80(3): 381-392.

Moreau, M., Siebert, S., Buerkert, A. and Schlecht, E. (2009). Use of a tri-axial accelerometer for automated recording and classification of goats grazing behaviour. Applied Animal Behaviour Science. 119(4): 158-170.

Pankaj, P.K., Nagpaul, P.K., Roy, B. and Mishra, A. (2010). Prediction of age and body weight by linear muzzle measurements in Karan Fries crossbred cattle. Indian Journal of Animal Sciences. 80(10): 1028-1030.

Saxena, P. and Parasher, Y. (2019). Application of artificial neural network (ANN) for animal diet formulation modeling. Procedia Computer Science. 152: 261-266.

Schaefer, A.L., Cook, N.J. and Bench, C. (2012). The non-invasive and automated detection of bovine respiratory disease onset in receiver calves using infrared thermography. Research in Veterinary Science. 93(2): 928-935.

Singh, A.K., Ghosh, S., Roy, B., Tiwari, D.K. and Baghel, R.P.S. (2014). Application of radio frequency identification technology in dairy herd management. International Journal of Livestock Research. 4(1): 10-19.

Snyder, J.C., Rupp, M., Hansen, K., Muller, K.R. and Burke, K. (2012). Finding density functional with machine learning. Physical Review Letters. 108: 253-259.

Soerensen, D.D. and Pedersen, L.J. (2015). Infrared skin temperature measurements for monitoring health in pigs. Acta Veterinaria Scandinavica. 57(1): 5-9.

Stark, K.D.C., Morris, R.S. and Pfeiffer, D.U. (1998). Comparison of electronic and visual identification systems in pigs. Livestock Production Science. 53(2): 143-152.

Straw, A.D. (2011). Multi-camera real-time three-dimensional tracking of multiple flying animals. Journal of the Royal Society Interface. 8: 395-409.

Takeda, R., Giulia, L., Tadashi, F., Laura, G., Harukazu, T. and Shigeru, T. (2014). Drift removal for improving the accuracy of gait parameters using wearable sensor systems. Sensors. 14(12): 23230-47.

Tan, C., Sheng, B. and Li, Q. (2007). Serverless search and authentication protocols for RFID. Pervasive Computing and Communications Workshops. pp 3-12.

Trevarthen, A. and Michael, K. (2008). The RFID enabled dairy farm, towards total farm management. In: 7th International Conference on Mobile Business, ICMB 2008, Creativity and Convergence, Barcelona, Spain 7th July 2008, pp 241-250.

Weixing, Z., Liu, B. and Jianjun, Y. (2015). Pig ear area detection based on adapted active shape mode. Journal Agriculture Machinery. 46(3): 288-295.

Zhang, Z., Zhang, H. and Tonghai, L. (2019). Study on body temperature detection of pig based on infrared technology: A review. Artificial Intelligence in Agriculture. 1: 14-26.