CONTEXT-AWARE WEARABLE SYSTEM FOR ANIMALS – AN EXPLORATION AND CLASSIFICATION

Sana Irshad [1], *Kamran Ahsan* [1], *Muhammad Abid Khan*[1], *Sarwat Iqbal* [1,3], *Muhammad Azhar Hussain* [1,3], *Farhan Shafiq* [1], *Shah Muhammad Emad** [1,2]

[1] Department of Computer Science, Federal Urdu University of Arts, Science and Technology, Karachi; [2] College of Computing and Information Sciences, Karachi Institute of Economics and Technology, Karachi; [3] Department of Computer Science, ILMA University, Karachi
Pakistan

* Corresponding Author: e-mail: shahmuhammademad@gmail.com

Abstract: In the new era of advanced technology, Wireless Sensor Networks (WSN) and Wireless Body Area Sensor Networks (WBASN) have enormous applications in various disciplines. Wireless Sensor Networks (WSN) have been used in many fields for different purpose like health care, assisting senior citizens, wireless communication, tracking, monitoring, predictive maintenance, enhanced safety and security, improve productivity, energy saving smart grid, smart home etc. to assist peoples. Wireless Body Area Sensor Networks (WBASN) in health care strongly utilized for continuous real time health monitoring of a human health as well as in animal husbandry without creating noise in their normal daily life activities. Wireless Sensor Networks (WSN) and Wireless Body area sensor networks (WBASN) provide opportunities for wireless tracking and monitoring of animals remotely. Remotely sensing systems bring another level of observing into several businesses as well as for agriculturist farmers. In this paper, survey reviewed of different cases of wireless sensors for cattle and pet animals tracking and monitoring. Classify them into different categories according to their types, domain and functionalities.

Key words: Wireless Sensor Networks (WSN), Body Area Network, Wearable Body Area Networks (WBAN), BAN for Animal Monitoring. Cattle Tracking.

1. INTRODUCTION

Agriculture is a production-oriented business that is considered as a backbone, central growth and development of the economy for developed and developing countries. It fulfil the basic needs of human and helps to enhance the economy of a country. Governments of developed and developing countries also share national budget for its development [1]. Agriculture is multi directional profession consists of crop farming, rearing

animals, livestock (dairy), poultry, fishery, etc. In order to improve economic growth and development of the country, agriculturist utilizes the latest technologies for crop reproduction, animal breeding to maximize the profit. Real time monitoring and tracking in agriculture sector is utilizing the latest technologies like sensors, smart phone to boost up the economic growth and as well make this agriculture profession easy. These innovations in sensor technology make agriculture profession, e-Agra business [2].

In this era, wireless sensor is an innovative and advance technology. It offers unlimited innovative work. Wireless Sensor Networks (WSN) used for detecting environmental parameters. Integration of mobile technology and remote sensing system bring another level of innovation in several businesses to manage system remotely [3]. WSN work efficiently for the collection of environmental parameter, then evaluate and control environments instead of wired ones. WSN are a device to measure the physiological or behavioural parameter about animal health of every cow in the field that enables the cattle farming automation. In case of rearing animals, real time monitoring and tracking critically more important to increase the economic growth.

Wireless Body Area Sensor Networks (WBASN) used for detecting medical parameters. WBASN are a sub category of WSN, it is basically utilized in healthcare application and telemedicine smartly for continuous monitoring and tracking of patients that are easily available in a wearable technology or implanted (inside the body), which helps the transition to more proactive and affordable. WBASN sensors available in bands, collars, puff band and tail, which are mounted easily to be wearable. It monitors the heartbeat, body temperature, circulating strain and so on. It provides self-ruling sensor node that screens the body work in monitoring the function of body sporting, health, entertainment, and in an emergency situation also. These sensors based systems remotely transmit real time information from the body to a home base station by using different communication technologies like 802.15.1 (Bluetooth) and 802.15.4 (ZigBee), WIFI, etc. Now WBASN not only utilized for healthcare application in human side, it also utilized for cattle monitoring, tracking and identification of their healthcare application in a same manner [4].

Wireless Wearable Body Area Sensor Networks (WWBASN) are also a categorization of wireless sensors not only utilized in cattle farming it also used for pet/ lame animal in a personal way. They are available in smart collar, belts and watch that would be easy to utilize because of wearable. In case of pet animals wireless wearable collars are very common for monitoring and tracking. WWBASN sensors are available with their application to transmit information about lame/ pet animals to their owners smartly that are waterproof and compatible with different mobile applications [5]. These sensors monitored different environmental and medical parameters as a signal for early detection of any irregular incident or in emergency case and convert these signals into a data format and transmitted to consultative organizations by using communication medium.

In cattle farming, whole productivity depends on healthy cattle, if cattle are healthy end results and growth will be increased. The continued production of cattle farming requires long term real time monitoring of animal health. A critical element of cattle evaluation about heath is to monitor fundamental information are heart rate and body temperature [9]. This article enlighten various wireless sensors which is utilized for tracking and monitoring of cattle and pet animals. Cattle farming is considered as a well-

known industry, which plays a vital role in the economy of each country. A cattle farming also provides secondary business for farmers because it fulfil the need of dairy items also that's a supplement of cattle products. Secondary business of cattle farming depends on the healthy cattle. Cattle farming needs proper monitoring and tracking of cattle for its better growth and productivity. Wireless Sensor Networks (WSN) and Wireless Body Area Sensor Networks (WBASN) sensors with the coordination of remote technology provides real time animals, monitoring and tracking for sensing the inconvenient pattern in behaviour or health. Early detection of infections could be useful to avoid the financial misfortunes in the cattle farming [6]. This can be manage by remote network through mobile phone for alarming them about any irregularities, for example, dairy cattle leaving the predetermined munching territories, early indications of sicknesses and basic levels of body temperature of cattle etc. [10].

2. CONTEXT OF CATTLE

Each cattle has some contexts. In Figure 1 shows contexts of animal which are considerable in cattle farming for increase their production. Cattle farming can be categorized into three contexts personal, medical and derived. Personal and Medical context represent in figure 1. In derived context include age; milk production and beef production which are depend on different factors. Age depends on the number of teeth because the age of cattle is determined by examination of the teeth, teeth 0-1 based cattle consider as calf, teeth-2 based cattle consider as younger, teeth-4 based cattle consider as old, teeth-8 based cattle consider as oldest one. However milk and beef production of derived context depend on cattle breeding.

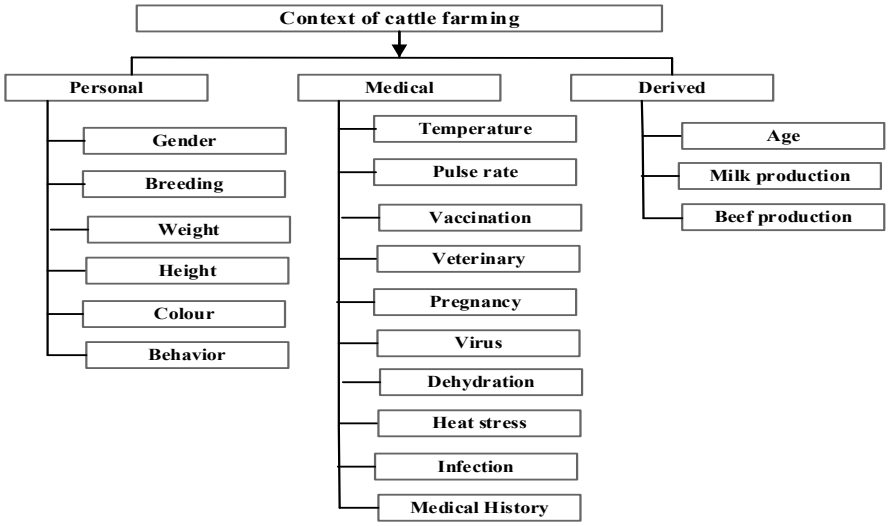

Figure 1. Context of cattle farming

WSN, WBASN and WWBASN work smartly for collecting environmental and health parameter to evaluate, control environments and health status instead of wired ones. Major advantages of these observations of cattle provide continuous real time updates about cattle. Table 1 shows many types of wireless sensor available for effective health and environmental

monitoring of human as well as animals. These available wearable sensors utilized as per requirement in a system that fulfil the need of farmers [11].

Table 1. Wireless Sensor for Cattle Monitoring and Tracking (WIFI wireless communication for all positions)

S.no	Sensor name	Type	Purpose	Deployment
1	**Temperature**	Wearable	Measure body temperature.	Collar band
2	**Pedometer**	Wearable	Measure Standing or Sitting behaviour for the detection of lameness.	Collar band
3	**Rumination**	Wearable	Utilized for monitoring of heat stress in cattle.	Collar band
4	**Sweat sensor**	Wearable	Measure the levels of glucose, lactate, sodium and potassium in sweat.	Collar band
5	**Accelerometer**	Environmental	Measure momentum of each cattle	Environments
6	**GPS**	Wearable	Measure exact location of cattle	Collar band
7	**ECG**	Wearable	To detect the pulse frequency of cattle	Collar band
8	**Force sensing resistor (FSR)**	Wearable	To detect the breath rate of cattle	Collar band
9	**Head motion sensor**	Wearable	For detection of angle of movement of the cattle head	Collar band
10	**2-D motion sensors**	Wearable	To record the lying, standing and walking behavior of animals.	Foot's band
11	**RFID**	Wearable	Assign a unique ID and tracking of cattle.	Ear Tags
12	**VeriChip**	Implanted	Assign a unique ID and tracking of cattle.	Implanted (inside the body)
13	**Moocall's Calving Alert Sensor**	Tail mounted motion sensor	Measures tail movement to monitor calving.	Tail

These entire sensors are working separately for measuring different parameters. These sensor embedded in several wearable gadget which are easy to wear by cattle. Farmer utilized these devices as per their needs. Farmers need to monitor different physical perspectives like heart rates, heartbeat, body temperature, location of animal in herd farmers additionally need to monitor the place where the animals are kept. If there would be a chance of an occurrence of any inevitabilities or predictabilities, an alert message generates immediately and sent to the farmer, health care worker or doctor. Immediate actions as early response and timely preference of medication enhance growth of animals which is directly effective on productivity [6, 7]. Table 2 shows the comparison of existing solution of cattle and pet animal monitoring systems in which above explained sensor work together for fulfil their goal.

Table 2. Comparison of Cattle/ Lame Animals Monitoring, Identification and Tracking Systems:

S.no	System	Type	Application Domain	No. of Sensor availability	Characteris-tics/Short Descrip-tion	Wireless Communi-cation
Cattle Monitoring, Identification and Tracking Systems Pet Animals Tracking and Monitoring Systems.						
1	Multifunctional particles for melanoma-tar-geted drug de-livery [12].	Ear Tags	Identification and tracking of animals	RFID based Tags	Identification and tracking	Ad-hoc net-works.
2	The role of RFID in agricul-ture: Applica-tions, limitations and challenges [13]	Ear Tags	Identification of milking cy-cle	RFID based Tags	Verification of milk-ing cycles, generates statistical Report that displays statisti-cal data pertaining to milk of the same day that was neces-sary for the milking cycle analysis	Wireless network
3	WPAN Based Cattle Health Monitoring With Lab view as A Data Log-ger [14]	Collar belt	Health moni-toring system	Temperature sensor, sweat sensor, rumina-tion, heartbeat, environmental humidity sensor	Measure psycholog-ical and external pa-rameters of dairy an-imals	ATmega16 controller, ZigBee
4	A ZigBee Based Animal Health Monito-ring System [8]	Collar belt	Health moni-toring system	Temperature sensor, rumina-tion sensor, heartbeat sensor	Measure psycholog-ical and external pa-rameters of dairy an-imals	ZigBee An-tenna
5	MooMonitor+ [15]	Collar belt	Heat detec-tion of cattle.	Heat sensor, ru-mination sensor.	Observe single ani-mal heat, feeding and rumination pat-terns, monitoring cow health status also recognizes par-ticular sorts of be-haviour.	Wireless network
6	Moocall Calving Sensor [16]	non-in-trusive, tail-mounte d sen-sor	Identification & monitoring of calving and generate alert message.	Tail-mounted sensor.	Predict each and every calving event occurrence by meas-uring of tail move-ment patterns, the Moocall sensor sends a text-based notification to farmer's phone about 1 hour preced-ing calving.	Wireless network
7	Pit Pat Pet App [17].	Collar belt	Track dog's movement continuously.	Motion Sensor, GPS.	Continuous tracking of dog movement to measure activity, be-haviour and alert dog's owner about the behaviour changes due to weather conditions.	Wireless network

8	Tab Cat by Locator App [18]	Kitty's Collar belt	Location tracing of cat	Tab Cat design with RF receiver, which displays a nearby signal on a strip of LED	Tracking of cat in case of missing through the RF receiver on a strip of LED and generate beep on TabCat	Wireless network
9	Kyon Pet Tracker App [19]	Collar belt	Location tracing of dog, health status	GPS, 3G radios, heat sensor	Track exact location of the dog and measure heart beat pulse and heat for the detection of danger while drowning and generate alerts to the dog owner.	Wireless network

Categorization of Wireless Sensor

Sensor technology is the most emerging technology that is speedily adopted by the IT industry due to its cost and accessibility. Real time monitoring and tracking is the core component for rearing animals. The study shows following categorization of sensor technology on the behalf of their types and functionality. After analyzing existing WSN, WBSAN and WBSAN sensors for monitoring and tracking of cattle as well as pet animals, wireless sensor can be categorized as a type and monitoring task.

3. CATEGORIZATION OF WIRELESS SENSOR BY TYPE

Categorization of wireless sensor according to its types can be classified into two different areas attached sensor and non-attached sensor and so on, as shown in Figure 2.

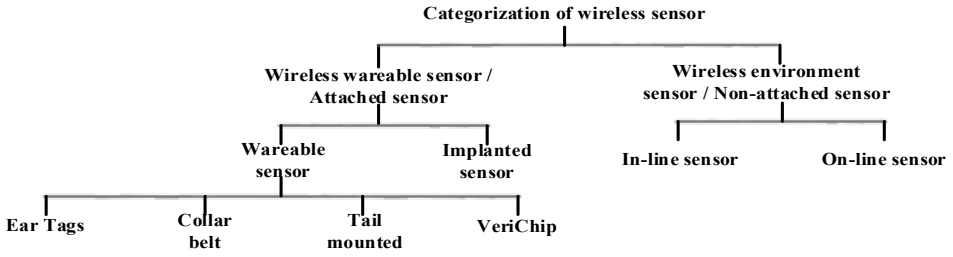

Figure 2. Categorization of Wireless Sensor by Types

Wireless Wearable Sensor / Attached Sensor:

Attached sensors can easily be attached in cattle externally or internally. It can be further divided into wearable and implanted based sensor**.** Wireless sensor technology is not only applicable in human but, it is also used for animal tracking and monitoring in a wearable form like smart ear tags, GPS collar, tail mounted, etc. Wearable sensors are those sensors which are fitted on the external of the cow's body with smart collar and watch form to measure different parameter of cattle externally. Implanted sensors are those sensors that are injected internally into the cow's body in chip form to measure different parameters of cattle and also for monitoring and tracking of cattle internally. It send appropriate information via some wireless communication medium for maintaining further record about animal basic information like ID, age, breeding, vaccination and milking process record etc.

Wireless Environmental Sensor / Non-Attached Sensor

Non-Attached sensors are fitted far away from the cow's body to measure different parameters like production flow and sampling of data. It's further divided into two categories, In-line sensor and on-line sensor. In-line sensor utilized to measure continuous flow of product from cow, farmer get. On-line sensor utilized to analyse samples of the product.

Categorization of wireless sensor by Monitoring Task

Categorization of wireless sensors according to their task can be categorized on the basis of monitoring task / function for which this technology has been designed. Figure 3 shows the categorization of wireless sensor, technologies, according to monitoring task / function.

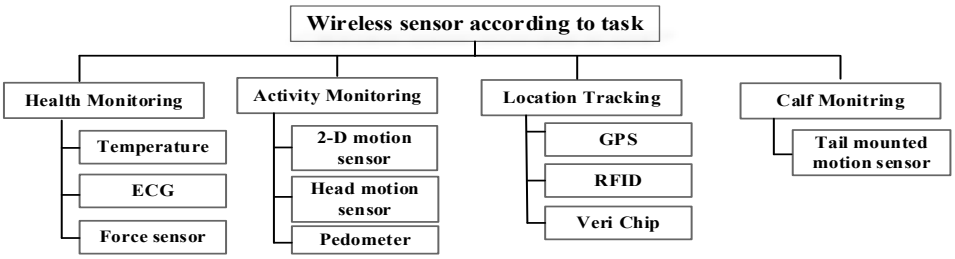

Figure 3. Categorization of Wireless Sensor based on Task

Basically, all sensors are developed for monitoring and tracking purpose, here sensors are categorized as per their monitoring task like health monitoring, location monitoring, activity monitoring and calf monitoring. In health monitoring side temperature, ECG and force sensor are utilized to sense little bit disturbance occurred in health parameters and send current status of cattle to their owners. In location monitoring side GPS, RFID, VeriChip are utilized to trace the exact location of cattle in herds in a different manner. In activity monitoring side pedometer, head motion sensor, 2-D motion sensors are utilized to sense the changing patterns of position/movement like sitting standing etc. In calf monitoring side tail mounted sensor has been introduced to measure tail movement patterns that used to predict preceding calving. The integration of these entire sensors in one unit provides proper monitoring of cattle to their farmers. Here different sensors are attached with central device which connects wirelessly to a main server where the sensor generates an appropriate message to farmers about their cattle health status as well as location. In case of any abnormal condition, farmers will take preventive action for proper treatment of their cattle.

4. EXISTING CATTLE MONITORING SYSTEM

Number of researches of WSN sensors and mobile applications in various domain for the purpose of monitoring and acquiring environmental data and location information, as previously mentioned in brief that provides real time monitoring and tracking of cattle's for its better growth and productivity. In this section our focus is on the recent application and existing systems, especially in cattle farming. Table 3 shows some existing cattle motoring systems

Table 3.

S. №	Existing System	Year	Detection	Emerging Technologies	Interface	Communication Medium	Result
1	A Sensor-Based Forage Monitoring of Grazing Cattle in Dairy Farming [22]	2018	Grazing activity (chew, bite, and chew– bite.)	Device consists of Arduino uno, Accelerometer sensor and battery for power supply	Wearable collar	Wi-Fi	Observation of grazing activity indicate good health in cattle.
2	Measuring Farm Animal Emotions—Sensor-Based Approaches [23]	2021	Emotion detection by facial feature of animals and physiological functions	Sensor, Algorithm, Big data and AI	-	Wi-Fi	Not generate results due to lack of available commercial products. Many of these projects are still in the research phase
3	Internet of Things for evaluating foraging and feeding behavior of cattle on grassland-based farming systems: concepts and review of sensor technologies [24].	2019	foraging and feeding behavior	RFID, Accelerometer, GPS, Acoustic sensor, Cloud-based data storage	Wearable collar	IoT, GIS	-
4	Combination of Multi-Agent Systems and Wireless Sensor Networks for the Monitoring of Cattle [25].	2018	Remote monitoring of a beef cattle farm to detect heat and calving time and measures the levels of feed in the feeders.	GPS sensor,solar collar for GPS sensor, food sensor (ultrasonic sensor and solar battery), motion sensor, motion sensor and vaginal thermometer. AI techniques. PANGEA platform	TV application and Mobile application	GPRS, Wi-Fi	Detected heat events has matched with the observed heat events 8/8.
5	Validation of a pressure sensor-based system for measuring eating, rumination and drinking behaviour of dairy cattle [26].	2016	Measures eating, rumination and drinking time of cattle	pressure-based system (RumiWatch noseband sensor)	Automatic equipment	Wi-Fi	RWS results were relatively free from random errors for rumination and eating, but not for drinking

After a detailed review of the state of the art, several automated cattle monitoring and tracking systems are available in which heterogeneous sensors were utilized for the measurement of different parameters of cattle. Some of these existing system utilized Cloud-based data storage platform for storing data. It allows collection of big data from sensors to be stored in the cloud.

5. CONCLUSION

The study of e-agriculture analysis, verifies that real time monitoring and tracking of cattle's is mandatory in cattle farming. This paper has reviewed the literature on several types of Wireless sensors of cattle farming and provides an overview of existing automated cattle farming systems. The review shows that the topic received a lot of attraction from the research community. Grazing activity, Emotion detection, foraging and feeding behaviour can be easily detect by these existing automated cattle farming system for commercially and pet animals too. For monitoring of pets animal several system are available with its mobile application (Pit pat,Kyon Pet Tracker App, Pit Pat Pet App , Tab Cat by Locator App etc.) in term of easy access. These apps provides real time health status and current location to the owner. It turned into concluded that greater emphasis have to receive to carry out implemented studies to enhance cattle production via robust extension offerings in delivery of veterinary offerings, automated real time-time cattle monitoring and tracking, stepped forward fodder cultivation and feed conservation, and stepped forward availability of water in extraordinary agro-ecologies of the country. The price of era may be great found out whilst incorporated with agronomic knowledge, the use of the statistics amassed with inside the development of decision support systems in order to improve cattle farming. As we know that cattle health is most important in cattle farming so, early detection of infections could be useful to avoid the financial misfortunes in the cattle farming. In this technological era, all these detection can easily be conduct by heterogeneous sensor, IoT, electronic equipment, AI and machine learning algorithms and cloud based data storage.

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Information about the authors:

Sana Irshad is Lecturer at Federal Urdu University of Arts, Science and Technology. She holds a BS and MS form Federal Urdu University of Arts, Science and Technology. Her Masters focused on research in area of Information system related to E-Swimmer. Her specific research area include information system, mobile applications in the disaster management, AI, IoT and knowledge management. She has published research paper in international journal.

Dr. Kamran Ahsan, has PhD from Stafforshire University, UK. Dr. Ahsan has one patent to his credit while 4 others are almost finishing the process. He is currently leading the department of IT as Director and as an Assistant Professor at the Department of Computer Science at Federal Urdu University of Arts, Science and Technology.

Muhammmad Abid Khan is currently Lecturer in Department of Computer Science, Federal Urdu University of Arts, Science and Technology, Karachi, Pakistan. Strong education professional with a Master of Philosophy (MPhil) in Computer Science from Federal Urdu University of Arts, Science and Technology. His principal of research interest includes, Artificial intelligence, Mobile Technology and Information System.

Dr. Sarwat Iqbal is serving Ilma University Karachi as an assistant professor and Federal Urdu University of Arts, Science and Technology as a visiting faculty member. Her current research area is Fog and Edge computing security and privacy issues.

Dr. Muhammad Azhar Hussain has research interest in exploring the potential of technology in supporting persons with disability(ies) and elderly people who face age-related problems. Dr. Hussain is currently working in ILMA University, Karachi as Assistant Professor.

Dr. Farhan Shafiq received the PhD degree in Computer Science from Federal Urdu University of Arts, Sciences and Technology (FUUAST), Karachi, Pakistan. He is currently working as an assistant professor in department of computer science and holds the position of In-Charge department of Computer Science, FUUAST. His current research interests include disaster management, information system, mobile technology and Data Science.

Shah Muhammad Emaduddin is a permanent faculty member at Karachi Institute of Economics and Technology. He is also a Ph.D. Scholar at FUUAST, Karachi. His focused area of work includes assistive technologies, artificial intelligence and machine learning. Mr. Emaduddin has received his education in Computer Science from Politecnico di Torino, Italy and Mälardalen University, Sweden and University of Karachi, Pakistan.

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