Camel Detection on Traffic Roads Using Sensor Technology

Eiman Galaleldin Ahmed Kalil

Shaqra University, Saudi Arabia
College of Science and Humanities-Afif

Abstract
Traffic accidents on desert roads are a major cause of concern for society, and have been considered as one of the most difficult challenges that incur huge losses on material and human resources. Here, the Internet of Things (IoT) can play a crucial role in ensuring the safety of vehicles and sensors, since it can manage data flow of the obtained predictions from different sensors and devices including their respective complex automated detection programs. The main aim of this research project is to develop a method for detecting the presence of camels in close proximity to traffic highways over a three-kilometer distance range. This can be achieved by using an electronic application that emits a loud noise alert as it detects camels outfitted with smart chips. These chips also holds valuable data regarding these animals such as (camel ID , owner name , place . weight) The application reads the chips remotely using sensor technology, which helps reduce traffic accidents.

Keywords:
Geographic Information Systems (GIS); Remote Sensing (RS); Management Information Systems (MIS).

1. INTRODUCTION

Traffic accidents caused by the collision of motor vehicles with wildlife are a global phenomenon. These incidents frequently involve various animal species, including but not limited to moose, deer, kangaroos, and camels. Such occurrences are particularly prevalent in Europe, the Middle East, the United States, Canada, and Australia [1]. Due to the size of these creatures, accidents often result in high rates of injury and fatality. In the specific case of Saudi Arabia, the frequency of camel-vehicle collisions has escalated to an alarming level [2]. It is imperative to implement effective measures to mitigate the risk of such accidents and ensure the safety of both drivers and animals. In Saudi Arabia, camels hold a prominent position within the sociocultural structure, with a population exceeding 500,000. These majestic creatures, known for their impressive weight of up to 726 kg, contribute significantly to the local way of life. Saudi Arabia serves as a prominent illustration of habitat fragmentation, particularly in rural regions where rich road networks coexist with domesticated camels [1]. Owing to this cohabitation environment, collisions between camels and vehicles are inevitable. A staggering 200 such incidents being officially recorded in 2004 alone. The dimensions of the camel, velocity of the vehicle, passenger's adherence to seat belts practice, and the implementation of defensive reflex actions to avert contact all significantly influence to the severity of injuries sustained [3]. Predominantly reported injuries encompass head and chest trauma, fractures in the cervical and dorsal spine, and fractured discs, resulting in a fatality rate four times higher than that of other traffic accidents [4]. To address this issue, a range of mitigating measures have been undertaken, including the construction of highway barriers, the establishment of camel-friendly underpasses and overpasses that facilitates unobstructed passage for camels, the installation of reflective warning signs, the implementation of awareness campaigns, and initiatives for wildlife road crossing awareness campaigns [5].

Every year, hundreds of Camel-Vehicle incidents are recorded, resulting in countless fatalities and property losses totaling billions of Saudi Riyals. According to a comprehensive analysis of traffic accident data, the frequency of camel-vehicle collisions exceeds 600 per annum [6]. The presence of domestic camels in close proximity to highways is a common occurrence, as owners prefer to live in close proximity to highway for transportation purposes. These animals often cross roads in search of sustenance, such as water and food, particularly during the breeding season. The visibility of camels poses a significant challenge for drivers, particularly during nighttime, leading to severe accidents. Regrettably, there is currently no established mechanism in Saudi Arabia to notify vehicles to reduce their speed when encountering or approaching a camel on or near the highway causing high accidents and fatality rates [7]. Currently, fencing is utilized as a preventive measure to impede the entry of camels onto highways.

Manuscript received January 5, 2025
Manuscript revised January 20, 2025
https://doi.org/10.22937/IJCSNS.2025.25.1.2

However, the installation and upkeep of such fencing incur substantial costs. Moreover, these barriers have the unintended consequence of segregating and isolating camel herds within their natural habitat. Furthermore, it is widely acknowledged that camel owners often create openings in the fences to allow their animals to pass through, leading to potential accidents. Consequently, the efficacy of the fences is rendered futile [8]. To effectively address this issue and mitigate accidents, it is imperative to implement a comprehensive warning system that promptly alerts drivers when a camel is present or in close proximity to the road, thereby enabling vehicle drivers to react by reducing speed and preventing accidents [6].

Dromedaries, also known as Arabian camels, are the common animals found in the desert. They can weigh up to 726 kg and reach a height of over 2.1 m at the hump. Their ability to traverse vast distances of up to 161 kilometers across the desert without access to water is attributed to their humps, which possess the capacity to store approximately 36 kg of fat. Remarkably, camels can endure a weight loss of up to 40% without experiencing agitation, and they can sustain themselves for a period of five to seven days without consuming any water [9]. Camels have a strong sense of smell that allows them to find water from 2.5 km away and spot another camel from 11 km away. They can travel up to 60 km in search of food. When they need to return to their original location, they can journey for up to 20 days. Female camels feel a strong desire to go back to their birthplace with their calves. Camels possess the ability to maintain consistent velocities of up to 40 km/h, while also exhibiting momentary velocities reaching 65 km/h. Research conducted in Australia indicates that camels tend to engage in racing activities with automobiles upon encountering them. As a creature of the desert, the camel population continues to expand steadily. Notably, within the past four decades, the United Arab Emirates has witnessed a substantial increase in camel population, escalating from 100,000 to 250,000 [10]. In Saudi Arabia, more than 500,000 camels roam freely [6]. According to the Food and Agriculture Organization (FAO) in 2004, the density of camels in the vicinity of Riyadh and Qassim was recorded at 0.4 and 0.6 per square kilometer respectively. Along Saudi Arabia's western roadways, the density increases significantly to 12 camels per kilometer. Camels have a natural instinct to traverse extensive distances in search of food and water, which leads them to cross various rural routes. Consequently, the occurrence of camel-related accidents is higher. These accidents are particularly prevalent during nighttime when camels, predominantly unattended, roam in herds across highways without warning [11]. It is worth noting that there are currently no designated camel crossing sites, and as a result, camel owners often damage fences placed in different locations to allow their animals to pass through. A study conducted at the Riyadh Armed Forces Hospital examined 140 patients with low cervical spinal cord injuries, finding that 119 (85%) of these injuries were caused by automobile accidents, while 39 (33%) were primarily caused by collisions with camels. This suggests that the presence of camels in groups during movement can limit the space and options available for vehicles to avoid collisions [12].

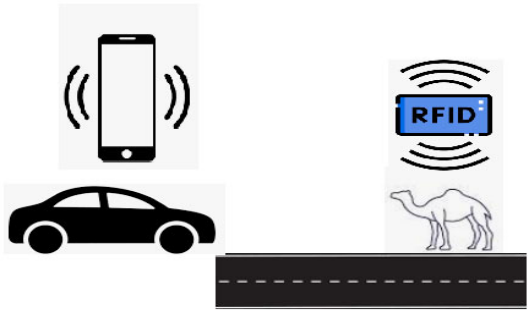

Figure (1). Illustrates Camel Detection System Components Using GIS

2. PREVIOUS STUDIES

There have been a substantial number of accidents as a result of camels being present on roads and highways in Middle East, which has grown into urgent concern for its development. These incidents involving wildlife animals have proven to be fatal, which has caused severe injuries to passengers involved in collisions with larger animals [13]. Consequently, numerous researchers, in collaboration with the Saudi Arabian government, have developed potential solutions to address the concerns surrounding animal-vehicle collisions (AVC) or specifically camel-vehicle collisions (CVC) [6]. Additionally, various preventive measures have been introduced to minimize the likelihood of motor vehicle collisions (MVC) involving larger animals [14].

AVCs can be mitigated through a range of approaches encompassing road-based, animal-based, and vehicle-based technologies. These innovative solutions aim to minimize traffic accidents and safeguard the lives of both humans and animals. Additionally, this study explores several other technologies such as sensor-based technology, mobile technology and wireless radio frequency (RF) [15].

A. Road-based Technologies

The methods used on roads are divided into two groups: traditional methods and detection systems.

- **Traditional Methods:**

AVC's are prevented through the installation of fences, which act as a deterrent to keep animals from crossing roads and highways. The barrier has to be at least 2 meters tall in order to adequately prevent any potential leaping [16]. It is important to ensure that this approach necessitates periodic maintenance and inspections to guarantee that the fences are secure and undamaged, especially in situations when large groups of animals could aggressively crash into the fence structures. Strategically placed warning signs are used to alert commuters regarding the presence of animals in the vicinity. These signs use a variety of symbols, indicators, and brief warnings messages to notify drivers and prompt them to drive cautiously and carefully, which ultimately leads to a reduction in vehicle speed [15]. Additionally, from dark till morning, highway lighting is used to improve traveler's vision, enabling them to navigate the highway with convenience alongside providing visible instructions at important crossings. This is additionally assisted by the presence of informative signboards [17].

- **Detection Systems:**

Various technologies, including sensing equipment and technology-based equipment, may be used to identify animals crossing highways. There are certain types of vehicle detection systems on the market that can only identify cars based on the information they have stored in their databases [18]. These tools are unable to recognize animals. Long-range audio and visual signals from the specified spots on the roadways or highways are used in such situations to inform the animals. The likelihood of animals disregarding warning signs is high in this technique.

Additional instances using sensors as a detection method involves, a 30- to 100-meter detection range of infrared sensors that is used to find animals on the highways. When an animal is found, a signal is sent out to warn oncoming traffic that the animal is present near the highway [15]. In the other situations, infrared sensors are set up to detect animals on highways within a 30-100 m radius, and when an animal is detected, a signal is triggered to notify vehicles of the presence of an animal on the road [15]. This system is more susceptible to errors in detection owing to damaged sensors, power loss from solar panels that have stopped working properly, broken lights, etc. caused by strong winds and fog at night and extremely cold conditions. Corresponding to this, some sites have microwave radar sensors placed to detect the movement of bigger animals as far as 50m away with 600 horizontal angles.

When animal is detected, LED with animal symbols are switched on as a warning signal for the driver [15]. Wintertime false detection possibilities are increased by heavy snowfall and fog in some of the colder areas for such sensors.

In addition to the methods listed above, certain regions of Washington, USA, have installed laser sensors with two lasers placed on each side of roads and highways. The purpose of these sensors is to identify non-rectangular objects, such as animals, and to trigger warning lights for drivers. The warning signals, nevertheless, may be turned off when a deer stays in the laser's line of sight for more than a minute. It should be mentioned that this technology can only go a small distance and has high maintenance expenses. A network of transmitters and receivers is used to emit continuous microwave RF signals in order to identify animals [19]. Using different noise or light indicators, this technique warns animals when a car is about to cross the road. This method, however, is not appropriate for roads with large traffic densities owing to the noise that goes off continuously as vehicles move along the road [15].

B. Animal-based Technologies

This specific technique uses several kinds of collars to reduce AVC by providing a flashing signal system. Radio collars and luminous collars are the two categories under which these collars fall. Both kind of collars may be found simply on the market and don't

need a lot of equipment. However, collars could also be attached to the animal's neck or other body regions, depending on the GPS systems. These systems are able to cover a vast area of ground and a wide variety of species [15].

- **Reflective Collars:**

Leveraging modern technological gadgets and sensor-based devices, there are numerous methods for detecting animals crossing the road. There are other types of vehicles detecting systems available, that don't use electronic devices. For instance, fluorescent tape that are wrapped around animal's neck allows drivers to distinguish the animals from an extended distance. Although it is sometimes hard to avoid a collision if the distance is too vast, these collars must be well-maintained by the animal's owners in order to be seen from a distance else it becomes useless [20].

- **Radio Collars:**

They were originally made available in Olympic Peninsula, Washington, in 1999. The animals were fitted with radio collars, and during the day, receivers were used to verify the frequencies of various radio collars. The flashing beacons are activated when a signal is present at a certain radio-collar within 400 meters of the highway. However, since these radio collars operate continuously for many years, the batteries eventually run out and need to be changed, which is a serious concern when applying these radio collars to animal [21].

- **GPS Collars:**

This approach has the ability to monitor the movement of a large population of wildlife and may be useful in gathering a significant amount of data to examine animal mobility in different situations and conditions [22].

C. Vehicle-based Technologies

These devices calculate the distance between your vehicle and the object in front using sensors while other devices perform just alert actions. The integrated infrared detection system and warning whistles were both used in earlier generations of the device to stop AVC. However, in order to minimize collisions, future automobiles have been equipped with systems that automatically reduce speed when they get close to other cars or objects. However, these systems are not designed to avoid camels that stand by the side of the road and suddenly cross it [23].

- **Warning Whistles:**

It should be emphasized that the warning whistles do not need any special installations or equipment to function properly which can remove the uncertainty of not working at any given moment.
The concept first came up in the late 1970s [24]. On the front side of the vehicles, air-activated warning whistles were placed at an ideal position. These whistles respond to the flowing wind by emitting ultrasonic frequency vibrations. These whistles are used to shock animals, frighten them away from the road, and encourage them to get away. It has been argued, nonetheless, that the auditory indications that the whistles transmit don't significantly affect animal behavior [25].

- **Infrared Detection System (IDS):**

Through infrared sensors that are put on the vehicle, drivers are alerted when animals are seen within a certain range of distances. The range of these sensors must, however, be both animal-friendly and sufficiently wide to enable drivers to respond swiftly by applying the brakes [26]. In the images taken using this technology, heated objects are seen as white and cold objects as black due to the monochromatic display used. Although some drivers reported success with this strategy, many others had problems. IDS (Infrared Detection System) adoption also comes with a number of technical and maintenance issues. Additionally, using this approach often results in both false positives and false negatives problems, as previously pointed out in recent studies [27].

D. Future Prospects

Many new innovations have entered the market, and they have an immense amount of potential for improving safe travel practices among Saudi Arabian drivers by reducing accidents with animals. There are seven innovative options that stand out as being especially useful for location monitoring among the others. Beacons, Wi-Fi, QR, LoRa, RFID, GPS, and Near-Field Communication (NFC) are all included in this group of technologies [28].
It is essential to fully evaluate the aforementioned technologies reach, cost, accuracy, precision, and security before planning to apply them. These

elements are crucial in deciding if a technology is suitable for the application in question. It's important to remember that no one monitoring method can be rated as better or worse than another [28]. Recent developments have seen a substantial improvement in GPS precision, while Bluetooth beacons have shown they can handle greater data loads. The widespread use of mobile phones, driven by intense manufacturer rivalry, has also considerably increased the use of these technologies. Most of these tools have shown to be quite effective in tracking people within enclosed environments. The use of mobile phones as sensing devices has rapidly increased as a result of the incorporation of numerous types of sensors, including gyroscope, temperature and GPS etc. This combination has grown into an effective tool for a number of applications, notably real-time tracking and navigation [29]. This combination has been further reinforced by the internet and mobile technologies also referred to as internet of things (IoT) [30]. To efficiently monitor animals a specifically made device is needed to deal with the present situation as mentioned above where many sensors fail. It's also important to consider limitations of sensors since some of the sensors used in modern mobile devices may not be appropriate for the intense heat in Saudi Arabia [31]. As a result, prior to selecting any devices or sensors, thoughtful consideration must be made to the selection of such components.

1. PROPOSED METHODOLOGY:

Different methods are proposed for using remote device applications in this field and in this paper, an additional model system is proposed including the development stage, requirements, design stage until the final stage. It is shown in Figure 3. The design stage is the testing and implementation stage.

The paper mainly aims at how to sense camels on public roads and alert the user (driver) with an audio warning message from a distance of 3 km using GIS technology. In order to apply this proposed methodology, design, implement and test all components of the system, the programmer needs to develop a system that controls a robot connected to the sensing technology.

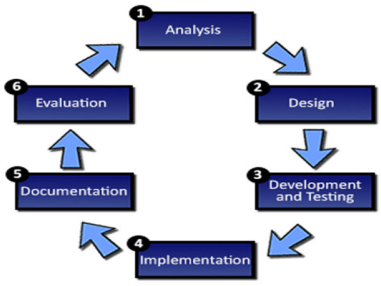

Figure (2). Schematic Representation of an Incremental Build Model

Use Case

Figure (2) shows the use case diagram of the proposed system. In Figure (2), the first actor represents the system supervisor who registers on the site, opens the application and runs the site on the mobile phone to sense the smart chip remotely. The second actor is the system that enters and updates the camel data on the smart chip.

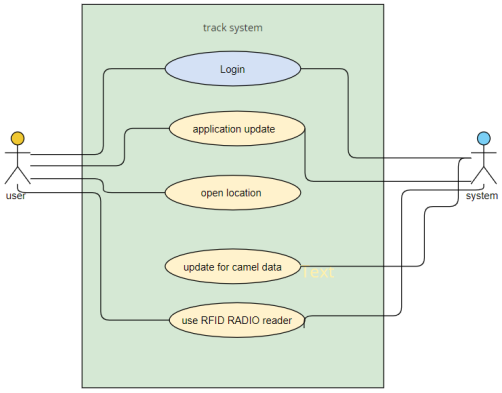

Figure (3): Use Case Diagram for the Proposed System

2. COMPONENT

The proposed RFID system in this paper consists of different components integrated into a system and described in Section 4. RFID components enable the implementation of RFID solution [15]. The components of RFID system are as follows:

- Transceiver (tag that can be attached to the camel and contains information about the camel

such as chip number, owner name, location and weight).).

- RFID antenna (to detect the transceiver).
- RFID reader (used to receive data from the transceiver).
- Communication (enables the transceiver, antenna and reader to work together using IT infrastructure).
- Web-based system (database/user interfaces)

3. FINDINGS AND DISCUSSION

Figure (4): A screen showing how to enter the application, which requires opening the site first before entering

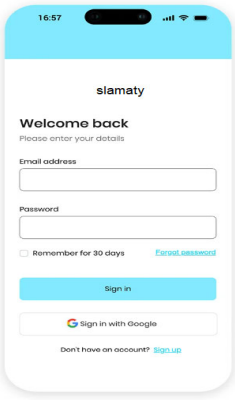

Figure 4. System login screen

Figure (5): A screen showing the operation of the remote sensing technology, the audio alert to the user, and the distance determination.

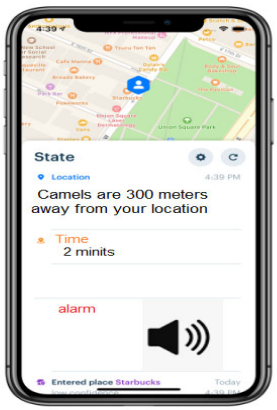

Figure (5) :Warning and audio message to the user

Figure (6): A screen showing complete information about location camels and the owner**.**

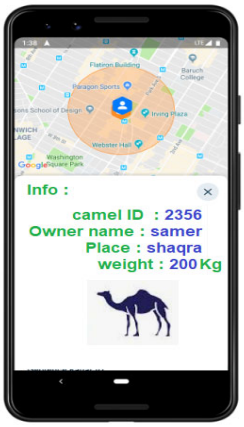

Figure (6). Info about location camel and owner screen

4. CONCLUSION AND FUTURE ENHANCEMENT

Remote sensing and geographic information systems (GIS) are two technologies that have radically changed the way we perceive and interpret our surroundings. These technologies are increasingly important in a variety of industries, including urban planning, disaster response, and natural resource management. GIS and remote sensing technology have been combined to develop a method for detecting camels near highways up to three kilometers away. This can be achieved using an electronic application that emits a loud noise alert when camels equipped with smart sensors are detected.

5. REFERENCES

[1] A. Al Shimemeri and Y. Arabi, “A review of large animal vehicle accidents with special focus on Arabian camels,” *Journal of Emergency Medicine, Trauma and Acute Care*, vol. 2012, no. 1, May 2012, doi: 10.5339/jemtac.2012.21.

[2] E. DeNicola, O. S. Aburizaize, A. Siddique, H. Khwaja, and D. O. Carpenter, “Road Traffic Injury as a Major Public Health Issue in the Kingdom of Saudi Arabia: A Review,” *Front Public Health*, vol. 4, Sep. 2016, doi: 10.3389/fpubh.2016.00215.

[3] M. S. Zahrani, K. Ragab, and A. U. Haque, "Design of GPS-Based System to Avoid Camel-Vehicle Collisions: A Review," *Asian Journal of Applied Sciences*, vol. 4, no. 4, pp. 362–377, May 2011, doi: 10.3923/ajaps.2011.362.377.

[4] M. A. Al-Ali, H. M. Mousa, I. Nibelle, and A. F. Hefny, "Camel-Related Facial Injuries: A Seven-Year Retrospective Study," *Clin Pract*, vol. 13, no. 4, pp. 889–897, Aug. 2023, doi: 10.3390/clinpract13040081.

[5] A. Al Shimemeri and Y. Arabi, "A review of large animal vehicle accidents with special focus on Arabian camels," *Journal of Emergency Medicine, Trauma and Acute Care*, vol. 2012, no. 1, May 2012, doi: 10.5339/jemtac.2012.21.

[6] A. S. Al-Ghamdi and S. A. AlGadhi, "Warning signs as countermeasures to camel–vehicle collisions in Saudi Arabia," *Accid Anal Prev*, vol. 36, no. 5, pp. 749–760, Sep. 2004, doi: 10.1016/j.aap.2003.05.006.

[7] A. Jamal, M. T. Rahman, H. M. Al-Ahmadi, and U. Mansoor, "The Dilemma of Road Safety in the Eastern Province of Saudi Arabia: Consequences and Prevention Strategies," *Int J Environ Res Public Health*, vol. 17, no. 1, p. 157, Dec. 2019, doi: 10.3390/ijerph17010157.

[8] R. Pagany and W. Dorner, "Do Crash Barriers and Fences Have an Impact on Wildlife–Vehicle Collisions?—An Artificial Intelligence and GIS-Based Analysis," *ISPRS Int J Geoinf*, vol. 8, no. 2, p. 66, Jan. 2019, doi: 10.3390/ijgi8020066.

[9] C. C. Harris, "Egypt: Creature of the Desert, Camel." [Online]. Available: http://www.touregypt.net/featurestories/camel.htm

[10] David Gallacher, "Overgrazing Their Welcome." Accessed: Oct. 06, 2023. [Online]. Available: https://www.zu.ac.ae/zawaya/0101/0109.pdf

[11] N. K. Al-Shammari and C. Neal-Sturgess, "Simulation of a Typical Camel–Vehicle Collisions (CVCs) in Saudi Arabia," *Arab Gulf Journal of Scientific Research*, pp. 43–56, Mar. 2016, doi: 10.51758/AGJSR-1/2-2016-0006.

[12] S. Ansari and K. A. Ali, "Camel collision as a major cause of low cervical spinal cord injury," *Spinal Cord*, vol. 36, no. 6, pp. 415–417, Jun. 1998, doi: 10.1038/sj.sc.3100530.

[13] T. P. Pynn and B. R. Pynn, "Moose and Other Large Animal Wildlife Vehicle Collisions: Implications for Prevention and Emergency Care," *J Emerg Nurs*, vol. 30, no. 6, pp. 542–547, Dec. 2004, doi: 10.1016/j.jen.2004.07.084.

[14] M. O. Bashir and F. M. Abu-Zidan, "Motor vehicle collisions with large animals.," *Saudi Med J*, vol. 27, no. 8, pp. 1116–20, Aug. 2006.

[15] K. Ragab, "Simulating Camel-Vehicle Accidents Avoidance System," *Asian Journal of Information Technology*, vol. 10, no. 7, pp. 306–314, Jul. 2011, doi: 10.3923/ajit.2011.306.314.

[16] A. L. Ward, "Mule Deer Behavior in Relation to Fencing and Underpasses on Interstate," 1982, Accessed: Oct. 07, 2023. [Online]. Available: http://onlinepubs.trb.org/Onlinepubs/trr/1982/859/859-002.pdf

[17] Hosseini SMR and Khorasani-Zavareh Davoud, "Challenges and strategies for preventing vehicle collisions with camels in South Khorasan Province: a qualitative study," *Safety promotion and injury prevention (Tehran)*, vol. 6, no. 1, pp. 43–48, 2018.

[18] W. Saad and A. Alsayyari, "Loose Animal-Vehicle Accidents Mitigation: Vision and Challenges," in *2019 International Conference on Innovative Trends in Computer Engineering (ITCE)*, IEEE, Feb. 2019, pp. 359–364. doi: 10.1109/ITCE.2019.8646591.

[19] K. Finkenzeller, *RFID Handbook*. Wiley, 2010. doi: 10.1002/9780470665121.

[20] Inc. Nite Glow Industries, "Retractable flat belt reflective pet leash," 20100212601, 2016

[21] S. Alasaad, J. E. Granados, P. Fandos, F.-J. Cano-Manuel, R. C. Soriguer, and J. M. Pérez, "The use of radio-collars for monitoring wildlife diseases: a case study from Iberian ibex affected by Sarcoptes scabiei in Sierra Nevada, Spain," *Parasit Vectors*, vol. 6, no. 1, p. 242, Dec. 2013, doi: 10.1186/1756-3305-6-242.

[22] J. A. Stabach *et al.*, "Short-term effects of GPS collars on the activity, behavior, and adrenal response of scimitar-horned oryx (Oryx dammah)," *PLoS One*, vol. 15, no. 2, p. e0221843, Feb. 2020, doi: 10.1371/journal.pone.0221843.

[23] Alastair Bland, "Will Driverless Cars Mean Less Roadkill?" Accessed: Oct. 07, 2023. [Online]. Available: https://www.smithsonianmag.com/innovation/will-driverless-cars-mean-less-roadkill-180957103/

[24] K. K. Knapp, X. Yi, T. Oakasa, W. Thimm, E. Hudson, and C. Rathmann, "DEER-VEHICLE CRASH COUNTERMEASURE TOOLBOX: A DECISION AND CHOICE RESOURCE," 2004. [Online]. Available: https://api.semanticscholar.org/CorpusID:18953129

[25] M. Huijser, M. E. Wagner, A. Hardy, A. Clevenger, and J. A. Fuller, *Animal–Vehicle Collision Data Collection. A Synthesis of Highway Practice.* 2007.

[26] H. Bender, "Deterrence of kangaroos from roadways using ultrasonic frequencies- efficacy of the Shu Roo," Jan. 2001.

[27] C. Druta and A. S. Alden, "Preventing Animal-Vehicle Crashes using a Smart Detection Technology and Warning System," *Transp Res Rec*, vol. 2674, no. 10, pp. 680–689, Jul. 2020, doi: 10.1177/0361198120936651.

[28] Lighthouse.io, "6 Technologies That Can be Used to Track Location." Accessed: Oct. 07, 2023. [Online]. Available: https://feedreader.com/observe/blog.lighthouse.io/6-technologies-that-can-be-used-to-track-location%2F%3F+itemId=6161055008

[29] S. Plangi, A. Hadachi, A. Lind, and A. Bensrhair, "Real-Time Vehicles Tracking Based on Mobile Multi-Sensor Fusion," *IEEE Sens J*, vol. 18, no. 24, pp. 10077–10084, Dec. 2018, doi: 10.1109/JSEN.2018.2873050.

[30] W. Saad and A. S. Alsayyari, "Real Time IoT Based Camel-Vehicle Collision Avoidance System for KSA," in *2020 3rd International Conference on Computer Applications & Information Security (ICCAIS)*, IEEE, Mar. 2020, pp. 1–4. doi: 10.1109/ICCAIS48893.2020.9096714.

[31] J. Nazdrowicz and A. Napieralski, "An Analysis of Temperature Variation Effect on Response and Performance of Capacitive Microaccelerometer Inertial Sensors," in *2021 37th Semiconductor Thermal Measurement, Modeling & Management Symposium (SEMI-THERM)*, 2021, pp. 10–15.

Eman J. Ahmed, received Ph.D. Degree in 2020. She is a currently working as an Assistant Professor at the College of Science and Humanities-Afif Shaqra University, in the Kingdom of Saudi Arabia. She is a research interests include software engineering, information retrieval and computer networks.