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Conceptual Design and Prototyping of an IoT-Based Camel Tracking and Perimeter Monitoring System

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Abstract

The main aim of this study is to provide conceptual design elements for tracking and monitoring animals, specifically camels, for the purpose of complete prototyping, considering ensuring precise location tracking and enhancing security. The primary innovative monitoring approaches in our system implementation are the utilization of GSM and GPS technologies. The laser sensor, which is integrated with farm gates, is a critical component of the system that ensures the protection of camels and real-time surveillance through a mobile platform. The Internet of Things (IoT) successfully receive the information concerning physical environments of the camels via an integrated security gate alarm sensor, then transmit it to a cloud network using a GSM network. The purpose of the security system allocation is to implement real-time monitoring and access control measures. Various components have been utilized in the design consideration process throughout the deployment of the system. The robust components of this technology (geographical location using Arduino and SIM800L GSM and Global Positioning System (GPS) modules, aside from geographical capabilities) have been specifically chosen for the purpose of efficiently and effectively tracking animals in diverse environments. The tracking devices will be made to be worn for a long period of time because of these devices which also provide accurate and updated position data. The proposed prototyping has several features to provide a unique, reliable performance over long-life usage in terms of user-friendliness and sustainability through economic and cost considerations. In short, the system that was installed in place gives a latitude and longitude that is closely with the real location in Google Maps. The latest IOT technologies have enabled the camels' real-time monitoring and safety management.

***Keywords**:* GSM; IOT ; GPS; Arduino uno; Camel tracking

1. Introduction

Animal telemetry and tracking have great potential to inform our knowledge of animals and their environments, and to aid in the development of conservation strategies. In recent years, our planet's natural resources at wildlife dependencies managers have utilized latest IOT technologies and methodologies for striving towards the achievement of suitability [1-4]. In theory, other technological means including radio telemetry, accelerometers and monitoring via satellite have been commercially utilized to achieve successful animal tracking methods. Kappes and Poorman [1] show that of Radio telemetry in which transmitters are mounted on animals to track multiple circumstances such as the movement of harp seals. The accelerometers used by Plimm, J., et al., provide information regarding the behavior and habitat use of wildlife as well, such as recording dung beetle choice in a South African savannah [2]. Satellite tracking systems, used by Rozier and Morin to relocate beavers in France, are essential in understanding the movements of animals and are vital in conservation practices [3]. The use of GPS systems, demonstrated in Koel et al. and Blanchet et al., is an essential tool in understanding the distribution of wild animals and their preference to their habitats [4-5]. Emerging technologies such as GPS systems, satellite telemetry systems, RFID systems, and accelerometers have made it possible to track the movements of animals over vast ranges, an aspect that has presented new frontiers in understanding migration patterns, feeding habits, and reaction to different changes in the environment. Factors to be taken into consideration in designing such systems include size, weight, battery life, data capacity, and attachments to avoid interfering with the lives of the targeted animals.

Recently, a car accident report in Oman, which has been published by the National Center for Statistics and Information, stated that there were 57 accidents involving stray camels in 2022. This represents a 39% increase compared to the number reported in 2021 [6].There is a need for a reliable and efficient tracking and monitoring system for animals, particularly in wild or large-scale farming settings. Existing methods based on desert environment case studies are shown in Table 1 for tracking and monitoring animals and have several limitations, such as being invasive, requiring manual observation, or providing limited data [7-10]. This problem becomes a challenge in terms of the design and implementation of a non-invasive, automated, and accurate tracking and monitoring system for animals that can provide real-time data and insights into their behavior, health, and well-being [11].

Table 1: Previous case studies based on desert environments

Author(s)	Year	Technology Used	Focus Area	Key Findings/Contributions
Ungar et al.[12]	2005	GPS	Wildlife tracking	Demonstrated the effectiveness of GPS collars in tracking large mammals.
Tomkiewicz et al.[13]	2010	GPS	Spatiotemporal tracking	Highlighted GPS accuracy and challenges like battery life and signal loss.
Aqeel-ur-Rehman et al.[14].	2012	GPS + GSM (SMS, GPRS)	Livestock monitoring	Developed GSM-based real-time monitoring system for cattle using SMS location updates.
Ben Salah et al.[15].	2016	GPS + GSM + Solar Power	Power management in tracking devices	Designed solar-powered tracking collars to extend operational life in desert conditions.
Al-Habsi et al.[16]	2019	GPS + GSM	Camel-specific tracking system	Proposed a camel collar with periodic GPS data transmission via GSM; focused on durability.
Yahya et al.[17]	2021	GPS + GSM + Motion Sensors	Theft prevention and health monitoring	Used motion sensors to detect abnormal behavior and implemented geofencing for security.

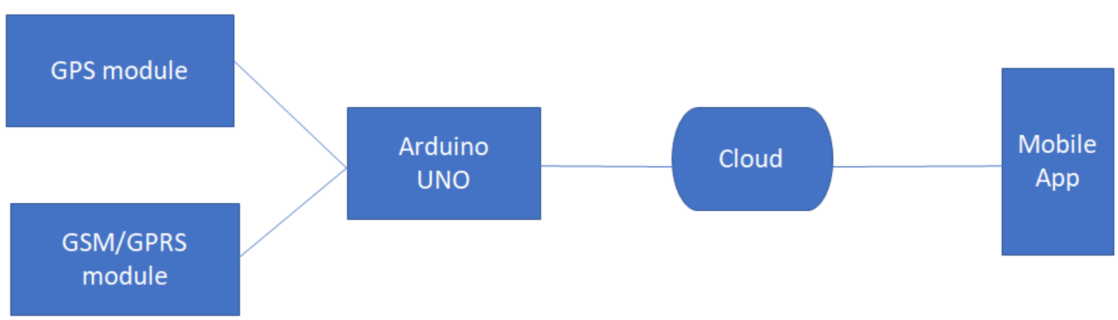
None of the previous case studies have examined the integration of GPS with cloud technology for live mapping and pasture decision support using an IoT platform. Our system based on IoT sensors is embedded in devices that collect information about them and sent to the cloud via GSM network. Nonetheless, it should also alert and notify when an animal is showing significant behavior or health changes to prompt intervention and action. The intention of this paper is twofold: first, to design and integrate laser protection systems for perimeter security, access control integration, and real-time intrusion detection and response; and secondly, to implement animal tracking through a cheap and low-intrusive GSM system and high-precision GPS tracking technology in order to keep animals visible all year round. This paper is organized as follows. Section II outlines the design process for validation of the proposed approach. Section III describes results and a discussion of the performance of the proposed system model. Finally, Section V illustrates the results of this study.

2. System Design

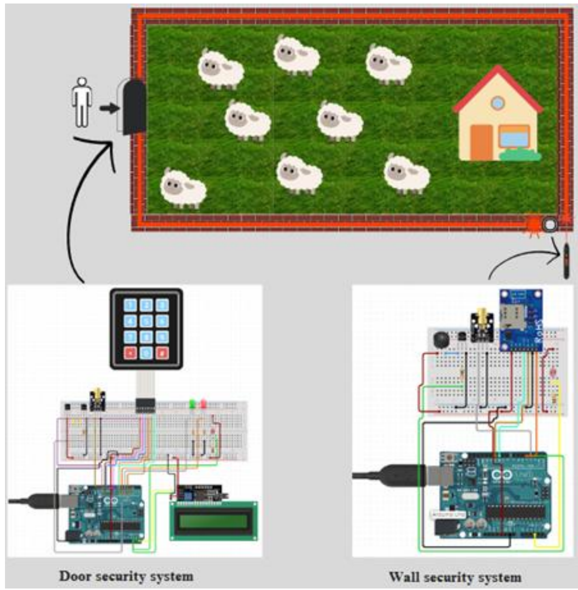
2.1 System Components

The Camel tracking and monitoring system can be implemented by using camel identification, which will include a GPS connected tracking device for each camel. This will enable individual animals to be identified and monitored in real time. In addition, monitoring software via a central monitoring software will be used to see where and how all the camels are marked on the digital map. It can also be programmed to send alerts if it detects unusual behavior or if camels try and cross the threshold.

Figure shows a complete camel farm security system that performs two functions, the laser protection and perimeter security, is shown in this section. The laser sensors will be mounted on the perimeter wall of the farm. These sensors will sound an alarm if they detect any unauthorized intrusion or exit of the animal. Meanwhile, the main gate security, which has a separate laser system, is implemented at the main gate of the farm. This system can be integrated with an access control mechanism to ensure authorized entry and exit. The proposed real-time system implementation is based on the following steps. Firstly, the GPS sensor is used for real-time location tracking by collecting the signal form the equipped camel wearable IOT tracking module. next, the signal is sent to microcontroller (Arduino) for data processing, next, the communication GSM module is used to transfer the long-rage data transmission. Finally, the received signal is periodically collected info rated to location are, time zone, data and transmits it to the cloud server.



(a)



(b)

Figure 1:(a) IOT-based GSM/GPS Block diagram; (b) Implemented module via Laser sensor wall and gate protection system

The proposed system is designed for the principle of operating a laser protection system for farm walls, which in turn deters intruders, such as camels, from entering or leaving protected areas. The system includes a laser beam that, when interrupted, triggers an alarm or sends a message to the sponsor. Table 2 shows a list of components used in the circuit of the laser protection system; some components have already been adopted in the studies [18-20].

Table 2: system components

No.	Items	Quantities
1	650nm Red Laser Diode Module	2
2	SIM900 GPRS/GSM Shield	2
3	Buzzer	2
4	LDR - Mini Photocell	3
5	10K Ohm Resistor	3
6	Transistor - NPN BC337	2
7	DC battery 9v	2

2.2 system flowchart

The detailed flowchart presented in Figure 2 shows how these components work together to form a security system that can detect intrusions and promptly alert the necessary parties. A door security system typically includes a combination of hardware and software components to monitor and control access to a door or building gate.

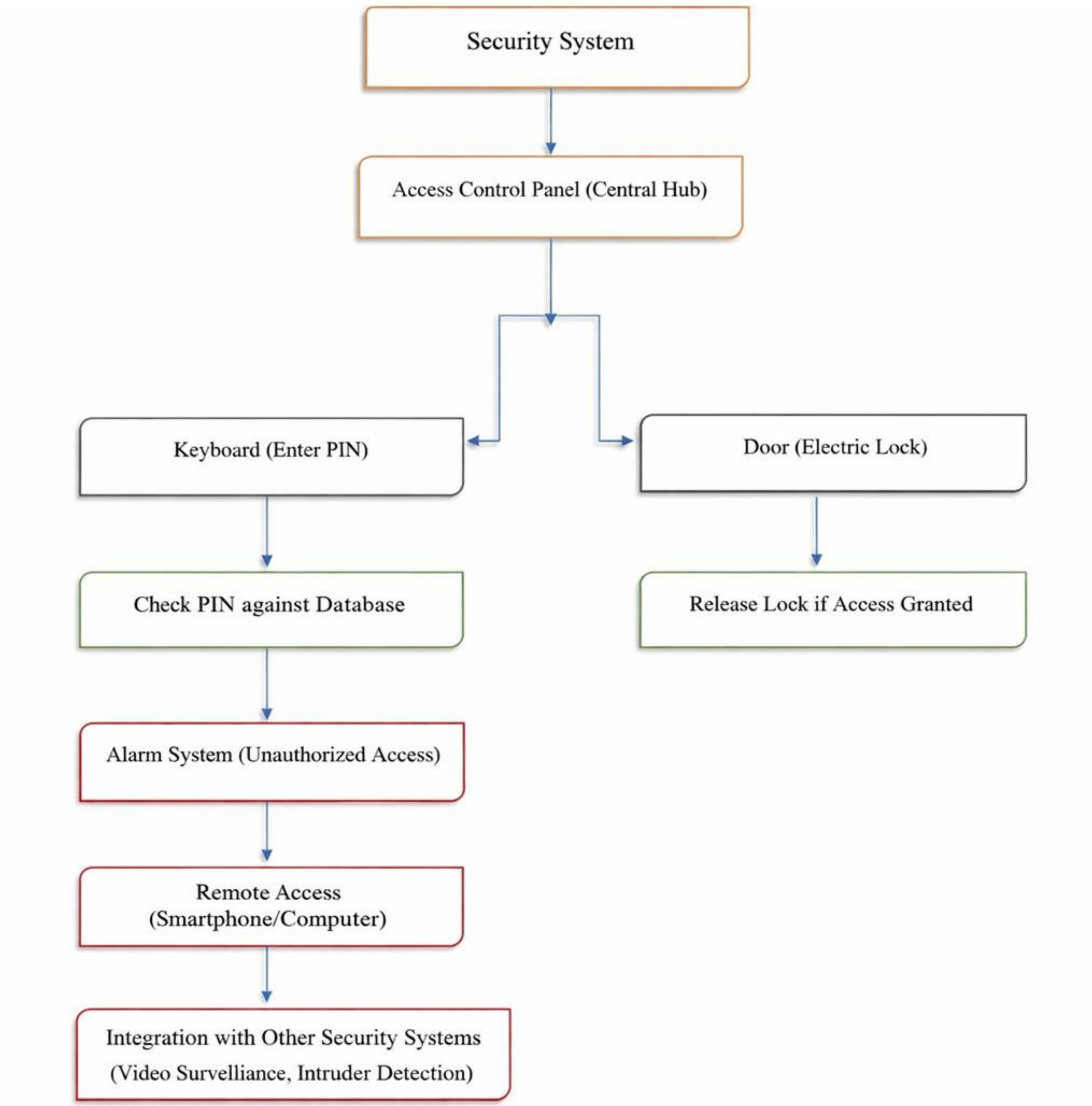


Figure 2: Proposed flowchart-based door Security System

The security system operates correctly and efficiently based on the component selection which plays a crucial role in implementation. The tracking device is responsible for monitoring the location of the camel. It offers an accurate determination of its location using various technologies such as GPS, radio frequency (RF), or satellite communication. It periodically stores data on the location and speed of the camel and environmental conditions. The tracking device periodically collects data about the animal's location, speed, and sometimes environmental conditions. This data is stored on the device or transmitted in real-time to a base station or satellite. Data transmission for tracking is done in real- time, as the tracking device sends data to a base station or satellite using radio frequencies, satellite communications, or cellular networks.

2.3 Basic Operation Principe

Laser protection systems generally work by using a laser to create an invisible boundary that, when breached, triggers an alarm. A laser emitter is a device that emits an invisible laser beam. Then, a series of mirrors placed at the corners of the wall onto which a laser beam is projected directs the beam across the protected area. Also, the detector, which in turn receives the beam, and as long as the beam continues without interruption, the system remains in standby mode. Finally, the photo-detector plays an important role, as this system recognizes intrusion if something obstructs the beam from reaching the detector. At this stage, the alarm activation comes into play, as the interruption of the beam triggers an alarm. This could be a loud sound, a silent alert to the authorities, or any other form of notification, such as a text or call via the GSM system. Finally, all parts are connected to the control panel, to which the sensors are connected and which can be operated via a wired or wireless connection. Modern systems often allow remote control through an app. Figure 3 shows the proposed circuit-based integrated laser protection system.

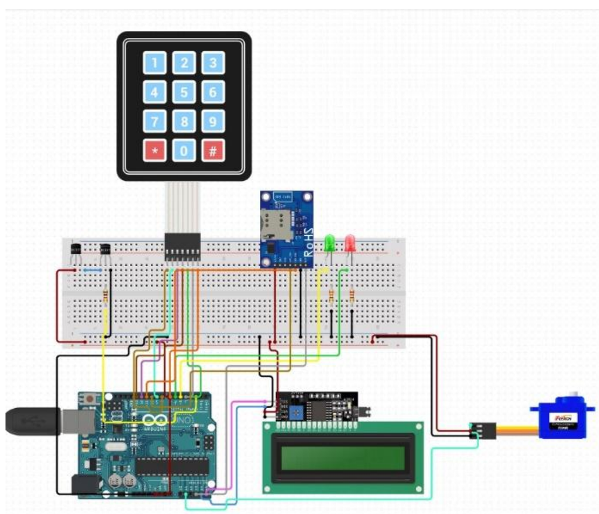


Figure 3: Gate security circuit schematic diagram

Figure 4 shows the Arduino Uno processes the sensor data, the GPS module provides location data, the GSM shield transmits the data, and the LCD screen displays the information. The LEDs and buzzers act as user interfaces, indicating system status or alerts. Resistors and transistors ensure that the circuit operates within safe electrical parameters. Figure 5 shows the programming setup.

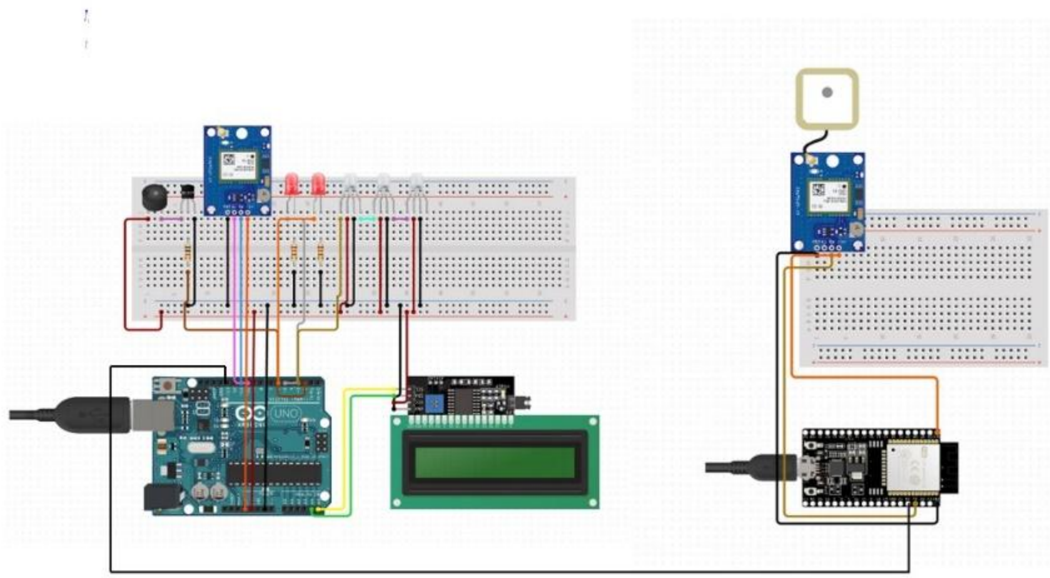


Figure 4: Camel's GPS tracking systems

Animal_tracking_systems.ino

```
  dist_calc = (sin(diflat / 2.0) * sin(diflat / 2.0));
  dist_calc2 = cos(flat1);
  dist_calc2 *= cos(flat2);
  dist_calc2 *= sin(diflon / 2.0);
  dist_calc2 *= sin(diflon / 2.0);
  dist_calc += dist_calc2;

  dist_calc = (2 * atan2(sqrt(dist_calc), sqrt(1.0 - dist_calc)));

  dist_calc *= 6371000.0;

  return dist_calc;
}




void getGps(float& latitude, float& longitude) {

  boolean newData = false;
  for (unsigned long start = millis(); millis() - start < 2000;) {
    while (neogps.available()) {
      if (gps.encode(neogps.read())) {
        newData = true;
        break;
      }
    }
  }


  if (newData) {
    latitude = gps.location.lat();
    longitude = gps.location.lng();
    newData = false;
  } else {
    Serial.println("No GPS data is available");
    latitude = 0;
    longitude = 0;
  }
}
```

Figure 5: Programming setup of animal tracking system.

3. Results and Discussion

Our approach takes the form of using geolocation technology, which is integral to modern tracking systems and serves to build virtual boundaries in real world locations. This approach has been particularly successful in the field of livestock management, as it was demonstrated in a project monitoring camel movement. A combination of the Arduino module with a SIM800L GSM module and a GPS module allows for the animal to easily distance itself from a starting position and to a desired maximum distance. If the camel is caught outside these areas, the system will display an alert as in Figure 6-8 that alerts the sponsor via SMS or urgent calls. This proactive alert mechanism is used to anticipate any possible deviation. The circular geolocation system monitors the position of the camel relative to its original position. When a violation occurs within the geophone radius, the system initiates the communication protocol via the SIM800L GSM module and alerts are immediately sent to the address provided.

Figure 6: proposed APPs software via message/ urgent call

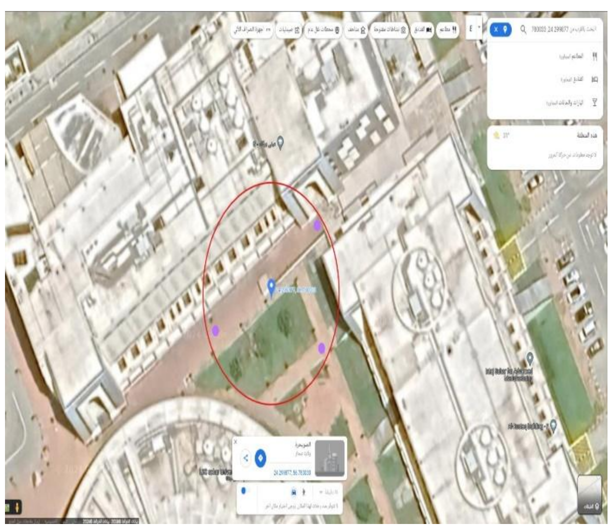


Figure 7: Camel Within Specified Path

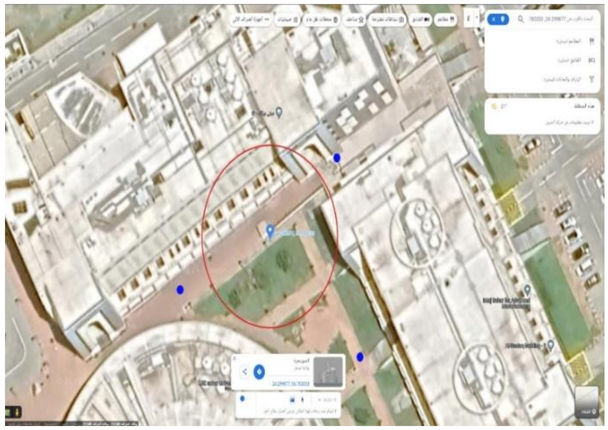


Figure 8: Camel Exits Specified Path.

Measurement of the difference between the positions of moving objects in the Google map and the coordinates of moving objects in the system enables the assessed accuracy of the implemented system to set the right direction and track the moving units. Table 3 provides a summary of measured movement units at various locations; there are several factors that can result in the difference between the GPS coordinates and the true location coordinate. These discrepancies usually range in size from a few centimeters to several meters, depending on technology and situation.

Table 3: The location via GPS versus original location coordinate's

Location		Actual location in Google Maps		Location by free GPS service		Difference distance (m)
		Latitude	Longitude	Latitude	Longitude	
Sohar	Technical college nearby,	24.2567	56.8645°	24.2560°	56.8450°	1.95
	University road	24.23458°	56.3256°	24.23478°	56.3147°	1.09
	Sohar Univ.	24.2978° N,	56.7803° E	24.2954°	56.7844°	0.41

Conclusion

The proposed system essentially eliminates the limitations of existing approaches by providing a solution that is effective and reliable while also respecting the animal welfare. The proposed project explained high quality systems include advanced features such as geolocation with Arduino and SIM800L GSM and GPS modules, as well as geolocation to ensure accurate and reliable tracking of animals in different locations. This integration of laser security systems allows for enhanced security measures for perimeter security, access control, and instantiated intrusion detection and response. This extended approach not only ensures the safety and security of the animals being monitored, but provides valuable information and insights into their behavior, health, and welfare. Further, animal tracking has gained speed by developing a comfortable, non-intrusive collar with high precision tracking. This is a long-term wearable technology and offers a high battery life, making it an economical option for continuous monitoring. So, the successful operation of the tracking and monitoring system represents a great improvement in animal conservation and management, and provides opportunities for studying and protecting wildlife populations across the globe.

Author contribution: All authors have contributed, read, and agreed to the published version of the manuscript results.

Conflict of interest: The authors declare no conflict of interest.

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