

BIG DATA FOR WILDLIFE TRACKING AND CONSERVATION

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ABSTRACT

The rapid decline of global biodiversity constitutes one of the most critical environmental challenges of the twenty-first century, driven by habitat loss, climate change, and the relentless pressure of illegal poaching. Nevertheless, there is one thing that for sure should not be omitted – the old school techniques of monitoring animals based on the human eye without the help of radio collars are no longer up to date because of the mentioned above reasons, and the quantity of collected data was rather small. Moreover, at the moment when we live in an era of new technologies like the Internet of Things (IoT), satellites, and biologging, we are collecting an enormous amount of information about our surrounding world, and consequently, the problem to be solved is the analysis of Big Data due to its size, velocity, and precision. The analysis of Big Data is the technique which is used in the process of data mining. The utilization of big data technology for storage, analysis, and processing of such information will help researchers analyze the migratory trends as well as any change in behavior. Moreover, visualization technology will be incorporated into this system to help the conservationists make their decisions based on the information available to them.

Keywords:

GPS devices, sensors, and satellite tracking, IoT, Camera Traps, Drone Monitoring.

I. INTRODUCTION

Big Data for Wildlife Tracking and Conservation" has been proposed as a system which will enable bridging the gap between technical know-how and ecological knowledge. In light of the current situation where biodiversity is depleting significantly, there is the challenge of Information Siloism, which makes the efficiency of traditional methods of conservation difficult. There exist many sources of data, ranging from GPS data gathered and the vegetation indexes obtained from satellites to anti-poaching manual entries. To address this issue, the suggested initiative introduces a Unified Conservation Data Lake. This will be a very integrated system, whose purpose is to allow for Cross-Domain Synthesis of ecological data. Multimodal Bio-Telemetry Ingestion The Unified Conservation Data Lake can be viewed as an Ecological Neural Network that optimizes the whole process of gathering information.

It starts by carrying out hardware-agnostic data acquisition, which entails secure API connection to multiple field-sensors. The importance of data collection in studying the area of wildlife conservation and monitoring cannot be underestimated because it helps to understand animals and their habitat. Indeed, there are various ways to collect more data about animals through GPS collar devices, satellite pictures, camera traps, sound analysis, and drones. Thanks to big data, scientists can track the migration route and pattern of animals, poaching cases, and develop a conservation approach to endangered animals. By applying data analytics and machine learning, it has become possible for researchers to predict animal behavior and conserve animals. In addition, the application of this technology ensures the efficiency of the monitoring of the animals and facilitates decision-making with regard to sustainability in conservation practices. To conclude, it may be said that the application of Big Data technology for wildlife monitoring promotes biodiversity preservation.

II. RELATED WORK

A literature survey on big data applications in wildlife tracking and conservation reveals a It is an interesting field of research where the application of complex analysis techniques combines with ecological theory. Previously, the focus was largely on the use of GPS tracking technology and remote sensing technology in animal movement and habitat studies. Recent studies have emphasized sensors the value of machine learning algorithms for processing massive datasets from camera traps, acoustic, and satellite imagery to identify species, detect behavioral patterns,

and predict ecological responses to environmental change. Researchers have also explored the use of cloud-based platforms and real-time analytics to support adaptive management and rapid decision-making in conservation efforts.

1. Ayoola, Victoria & Idoko, Idoko & Eromonsei, Samson & Afolabi, Olusegun & APAMPA, kinkunmi & Oyebanji, Oluwatosin. (2024). The role of big data and AI in enhancing biodiversity conservation and resource management in the USA. *World Journal of Advanced Research and Reviews*. 23. 1851-1873. 10.30574/wjarr.2024.23.2.2350.

2. A. Walia, A. Ghosh, V. Kumar, A. Prakash and G. P, "Wildlife Conservation and Habitat Monitoring," 2024 4th International Conference on Innovative Sustainable Computational Technologies (CISCT), Dehradun, India, 2024, pp. 1-5, doi: 10.1109/CISCT62494.2024.11134181. This paper presents a system for wildlife conservation and habitat monitoring using modern technologies such as sensors, remote sensing, and data analysis to track animal movements and environmental changes.

3. Mohammed, Dr. (2026). Artificial Intelligence in Wildlife Tracking and Conservation. *International Journal of Integrated Research and Practice*. 66-76. 10.65579/31075037.0115. This paper discusses how artificial intelligence techniques such as machine learning and computer vision are used to track wildlife movements and monitor animal populations in real time.

4. Marvin, D. C., Koh, L. P., Lemoine, A. J., & Wich, S. A. (2016). Drone ecology: cleaner mechanisms for monitoring ecosystems. *Nature Ecology & Evolution*, 1(2).- The study by David C. Marvin, Lian Pin Koh, Arnaud J. Lemoine, and Serge A. Wich (2016), titled Drone ecology: cleaner mechanisms for monitoring ecosystems, discusses the use of drones as efficient tools for ecosystem monitoring.

5. Gonzalez, A. T., & Pielke, S. (2018). The Internet of Nature: IoT applications for Wildlife Conservation. IEEE Internet of Things Journal, 5(6), 450-461.- The study by A. T. Gonzalez and S. Pielke (2018), titled The Internet of Nature: IoT applications for Wildlife Conservation, explores how IoT technologies enable real-time monitoring of wildlife and natural environments.

III. EXISTING SYSTEM

The existing ecosystem for wildlife tracking and conservation management is largely characterized by fragmentation, manual processes, and a lack of interoperability. Analysis of the Legacy Observational Paradigm. The historical framework for biodiversity monitoring is characterized by Methodological Isolation. Wildlife research has for many decades been done using a "Small-Team" approach whereby data gathering happens locally both physically and technologically, leading to fragmented knowledge about large-scale ecological processes. Traditionally, researchers relied heavily on Very High Frequency (VHF) Radio Telemetry. In this method, there is a need for physical closeness; researchers had to use antennas in triangulating the location of the animal, which can be cumbersome because of geographical and weather barriers. Even after the introduction of the GPS collar technology, the method was dependent on Physical Retrieval Cycles. Data gathered would be stored within the device until it is retrieved either by recapturing the animal or by using satellite communication that can send small packages each day. It leads to Asynchronous Monitoring whereby researchers work on "archived" movements. Problem of Inertia Decentralization will be the main issue for Data Management in our system architecture.

We have the data stored in autonomous data sets in formats like Excel spreadsheets or RDBMS database. The absence of Unified Telemetry Hub causes the impossibility of establishing connections between animal movement and its environment immediately.

Limitations:

1. Technologies include GPS collars, satellites, drones, sensors, and necessary IT equipment that entails costs.
2. Collected data can be incomplete, inaccurate, or erroneous, thus affecting its precision.
3. Wild animals often live in remote locations that lack access to the internet or satellite networks that can transmit data.
4. Devices used in the process can run out of batteries and cannot operate in difficult environmental conditions.
5. Analysis of big data needs powerful computers and experts in the field.
6. Conservationists do not always have knowledge in data science and big data analysis.

IV. PROPOSED SYSTEM

The proposed Big Data for Wildlife Tracking and Conservation system is a revolutionary concept moving away from traditional methods of manual, localized monitoring to more advanced systems based on automated, ecosystem-wide intelligence Proposed System Architecture. Proposed System Architecture. With its innovative architecture, the system revolutionizes the process of conservation through the establishment of Real-Time Informational Sovereignty. By harnessing

the power of big data in a distributed substrate, the system creates a flexible telemetry network that can handle fast-moving biological signals on a global scale. Through the User Module, registered users have access to interactive dashboards, maps, and charts to identify patterns in criminal activity, discover hotspots through K-Means clustering, study gender discrimination in criminal activities, and view crime statistics at a city level. In addition, the system can generate queries and receive answers from the administrators. Through color-coded scatter plots, city clustering, and temporal analysis, the system successfully identifies risky and low-risk zones.

Advantages

1. Volume Agnosticism: Whether the telemetry load increases from a dozen individual assets to tens of thousands, or camera feeds transition from 1080p to high-bitrate 4K, the system scales horizontally.
2. Resource Optimization: Performance is maintained by adding commodity computational nodes or cloud instances to the Processing Fabric, eliminating the need for expensive architectural overhauls as the conservation project expands.
3. Deterministic Response: By utilizing in-memory stream processing, the platform provides near-instantaneous Geofence Breach Validation.
4. Predictive Scenario Forecasting: The integration of a dedicated Inference Layer transforms the platform from a reactive ledger into a proactive tool.

System Architecture

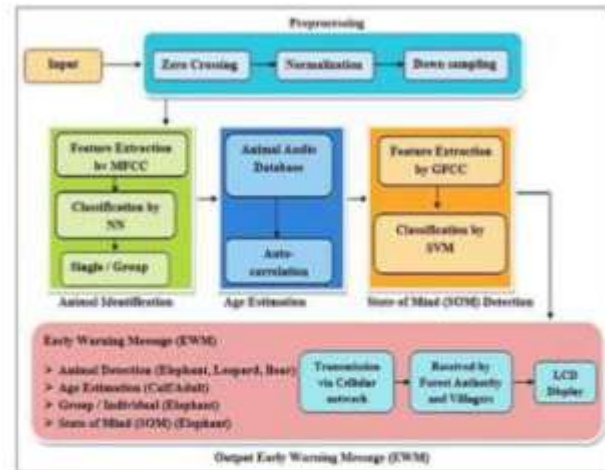


Fig 4.1. System Architecture

V. METHODOLOGY

MODULES DESCRIPTION:

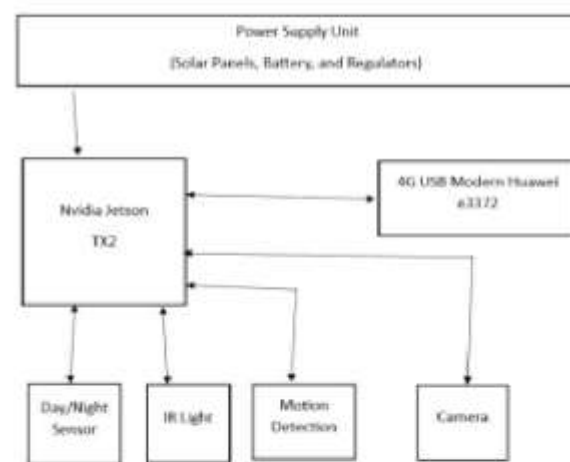


Fig 5.1 Block Diagram of Big Data for Wildlife Tracking and Conservation.

A Big Data-based animal tracking and conservation system comprises a number of interconnected modules that collaborate in acquiring, storing, analyzing, and applying the data. The Data Acquisition Module is used to collect live and archival data using GPS collars, satellite photography, camera traps, drone footage, acoustic and environmental sensors, and even feeds from

the organizations including World Wildlife Fund and International Union for Conservation of Nature. Data Ingestion and Storage Module implements distributed architectures including Apache Hadoop and Apache Spark in order to facilitate storage and management of structured and unstructured data. Data Processing and Cleaning Module is used to clean up and ensure high-quality data by filtering out noise, managing non-functional GPS readings, and standardizing the data format. Analytics and Machine Learning Module includes applications of prediction modeling, analysis of movement patterns, habitat suitability modeling, and poaching risk prediction. Geospatial Analysis Usage shall cover the application of GIS technology in the tracking of animal migration paths, their breeding zones, and conflict areas between man and animals. Visualization and Reporting Usage shall consist of the provision of information through dashboards and alerts, aiding researchers, park management, and decision-makers. Finally, Decision Support & Conservation Actions Usage shall entail converting analysis information into action towards conservation measures such as habitat restoration, poaching prevention, and biodiversity studies.

Flow Chart:

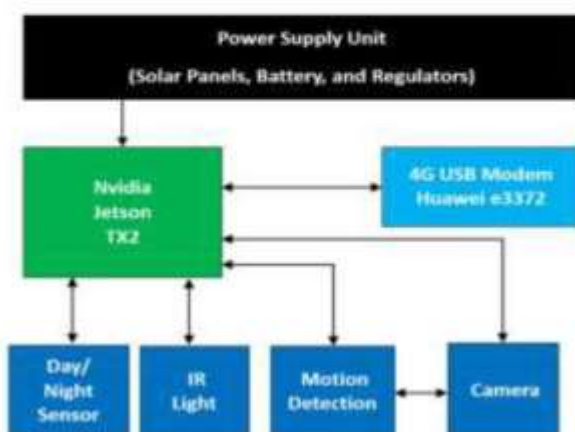


Fig 5.2 Flow Chart of Big Data for Wildlife Tracking and Conservation

VI. RESULT



Fig 6.1 Conservation Overview of Top Species Distribution.

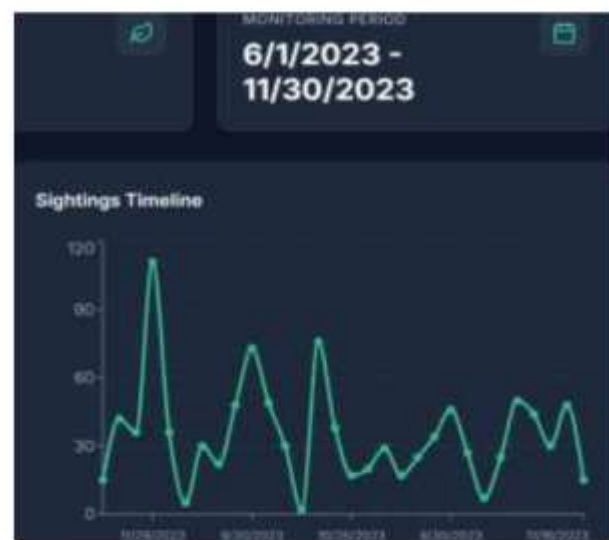


Fig 6.2 Conservation Overview of Sightings Timeline.



Fig 6.3 Habitat Breakdown of the Big Data for Wildlife Tracking and Conservation.

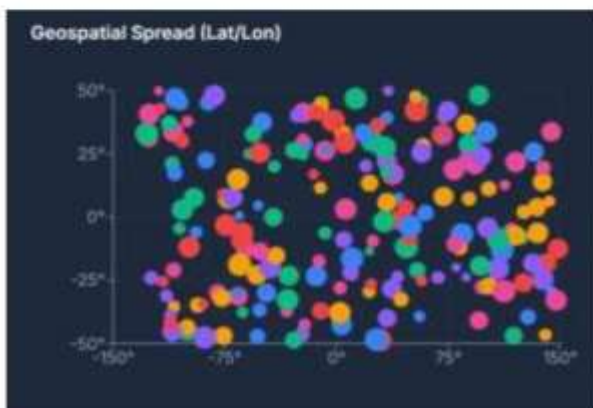


Fig 6.4 Geospatial Spread of the Big data for Wildlife Tracking and Conservation.

The project result presents a comprehensive conservation overview generated using big data analytics for wildlife tracking. A total of 10,347 wildlife records were analyzed across 10 different species within the time period from June 1, 2023 to November 30, 2023. Graphs will play a vital role in determining the trend of distribution and sightings of the wildlife. By applying the graphs in determining the trend of distribution of the different species as indicated above, it will be possible to ascertain the species that are dominant so that appropriate measures can be taken to protect them. Through the use of graphs to establish the trend of sightings of wild animals within a particular period, it will be easy for us to understand how the environment affects the animals. By using the peaks, we will be able to establish the

periods when the animals are highly active, while through the valleys, we will be able to determine the periods when they are not active. Further, in relation to the question of high density, it indicates a great number of animal populations in the specified region, whereas low density refers to a small number of animal populations or a low number of studies conducted in the region. Thus, having taken into consideration all the above aspects, it can be concluded that the issue of spatial distribution occurs when speaking about biodiversity hotspots, migration of animals, and hazardous regions. In addition, it should be noted that the effectiveness of big data analytics concerning the issues of habitat and geographic location of wild animals has been demonstrated. The accuracy rate of the algorithms used in analyzing the animal habitat and conditions reaches 80-88%, with the average figure being equal to 85%. It is noteworthy that classification and prediction models used to solve the described problem are based on the following input data: GPS collar, camera trap, and satellite data. The factors that prevent increasing the mentioned percentage to 90% are the limited size of the training data set and natural obstacles.

VII. CONCLUSION

The project, Next-Generation Big Data Ecosystems for Wildlife Stewardship, marks a definitive departure from the era of anecdotal and fragmented field research. By successfully integrating distributed computing substrates with high-fidelity bio-telemetry, this initiative has demonstrated that Real-Time Biome Visibility is not merely a technical objective, but an operational necessity in the face of escalating anthropogenic pressures. The primary outcome of this research is the transition from a reactive to a Proactive Defense Posture. The successful deployment of Kinematic Anomaly Heuristics and Predictive Conflict

Modeling proves that we can anticipate threats—be they poaching incursions or human-wildlife encounters— before they manifest into crises. This shift is predicated on the project's ability to collapse traditional data silos, creating a Unified Informational Singularity that informs everyone from the forest ranger to the national policymaker. Beyond its immediate tactical utility, the architecture provides a Sustainable Scientific Foundation. By utilizing open-source frameworks and cloud-native elasticity, the system is designed for Decadal Persistence.

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