AI based behavior analysis of Birds using UAV

Venugopal E[1], Saghana T[2], Shakunthala S[3], Varnika S[4], Sathana S[5]

{Venug2285@gmail.com, saghanasaghana979@gmail.com, shakunthalasingaram@gmail.com}

Assistant professor, Sri Eshwar College of Engineering, Student,Sri Eshwar College of Engineering, Student, Sri Eshwar College of Engineering

Abstract. Analyzing avian reactions to Unmanned Aerial Vehicles (UAVs) using Artificial Intelligence (AI) provides valuable insights into their response to such technology. Gathering data on avian behavior and population dynamics in a specific area deepens understanding of UAV effects on behavior of birds, identifying zones where drones can operate without disturbing natural avian conduct. Drones act as unobtrusive tools for capturing bird imagery in their habitats, while avian tagging aids in monitoring individual bird movements. Remote sensors facilitate the observation of avian vocalizations and behavior indicators. Designating safe drone corridors enables researchers and professionals to operate drones without disrupting avian habitats, protecting vulnerable bird populations and reducing bird-drone collision risks. Leveraging AI-driven analysis of avian responses to UAVs enhances understanding of their impact on behavior of birds and aids in safeguarding bird populations. Establishing designated drone zones ensures coexistence between drones and birds.

Keywords: Unmanned Aerial Vehicle (UAV), Artificial Intelligence (AI), Avian, Bird Behaviour, Remote Sensor, Drone Corridor.

1 Introduction

Unmanned aerial vehicles, also known as drones, come with cameras and sensors that capture detailed images and data. UAV’s are programmable to follow specific routes, cover large areas, and observe behavior of birds from different perspectives and heights. Advanced drones with stability controls ensure smooth flights, minimizing bird disruption. AI algorithms analyze the collected data, including images and videos, to automatically identify and track bird species. Techniques like object detection, classification, and tracking help researchers identify birds, track the movements, and

[1]Corresponding author. Email:venug2285@gmail.com

ICAMDMS 2024, February 23-24, Coimbatore, India

DOI 10.4108/eai.23-2-2024.2346975

study the behaviors. Machine learning can classify behaviors like feeding, mating, nesting, and social interactions

2 AI-based system for bird behavior analysis using UAV

The **Figure 1. [1]** illustrates the key components of an AI-based system for behavior of bird analysis using UAVs.

UAV: An unmanned aerial vehicle outfitted with a camera to capture footage of birds in natural surroundings.

Pre-processing: This module entails cleaning, filtering, and enhancing the captured footage to optimize data quality before feeding it into AI algorithms. Object detection: Using computer vision algorithms, this module identifies and tracks birds within the UAV footage.

Feature extraction: Extracting pertinent features from bird tracking data, such as movement patterns and behavior, characterizes this module.

Machine learning: Training AI algorithms on these extracted features to discern and categorize various behaviors of birds constitutes this module. Behavior analysis: Analyzing the output of machine learning algorithms to pinpoint various bird behaviors, including feeding, mating, and flocking, characterizes this module.

Visualization and reporting: This module presents the results of behavior analysis lucidly through graphs, charts, and maps, facilitating data interpretation and decision-making. Overall, an AI-based system for analyzing behavior of birds using UAVs synergizes hardware (UAV and camera) with software (pre-processing, object detection, feature extraction, machine learning, behavior analysis, and visualization/reporting) components, thereby providing precise and insightful analysis of behavior of birds in natural habitat.

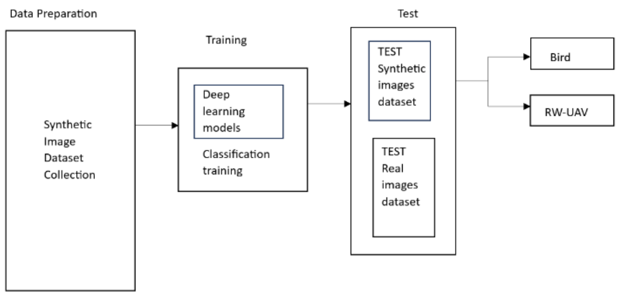

Fig. 1. Block Diagram

2.1 Birds

Birds, especially larger species, often initiate aggressive interactions with unmanned aerial vehicles (UAVs), leading to numerous incidents of drone collisions worldwide. These confrontations typically arise from birds misinterpreting drones as either a threat or potential prey. Upon detecting a drone within the established territorial boundaries, where birds nest and search for food, birds perceive it as an intruder. Responding to natural instincts to defend habitat, birds instinctively engage in defensive behaviors, including launching attacks against perceived threats. Regardless of the size of birds, nesting birds exhibit intolerance towards drones encroaching upon the vicinity, reacting promptly with defensive measures. It has been noted that urban areas, densely populated and featuring prominent landmarks such as beaches and harbors, bear the brunt of drone strikes more frequently. This phenomenon is attributable to urban-dwelling birds displaying heightened vigilance towards unfamiliar airborne objects. Predatory avian species, notably eagles and hawks, adopt strategic aerial tactics by either approaching from above or trailing behind the drone before accelerating to deliver precise strikes. Hungry birds of prey often employ talons to target drones as potential prey items. Across continents such as Australia, Africa, Europe, and America, eagles have exhibited consistent patterns of behavior in treating drones as primary threats. Similarly, in the UK, 3 seagulls have been identified as posing significant dangers to drones. Additionally, other avian species including hawks, owls, geese, and crows have been observed to respond in a similar manner. When drones encroach upon nesting sites, birds often react with fear due to the unfamiliarity and disruptive noise emitted by these devices. Consequently, birds may vacate the nests in haste, leaving behind vulnerable eggs or nestlings. Some maternal birds may resort to attacking drones as a protective measure to safeguard progeny. However, in instances where birds are of smaller stature, may lack the physical prowess required to effectively counter drones. Consequently, birds themselves may become inadvertent casualties of drone encounters, sustaining injuries or succumbing to fatal consequences

2.2 Drones

Drones have garnered escalating significance across a myriad of domains owing to adaptability, accessibility, and technological breakthroughs. Herein lies an exposition on several consequential domains where drones have exerted a notable impact

(i) Aerial Photography and Videography: Equipped with high-fidelity cameras, drones have ushered in a transformative era in aerial photography and videography. Drones afford an unparalleled vantage point for capturing breathtaking aerial imagery and cinematic sequences, serving as indispensable assets across diverse sectors including filmmaking, real estate, tourism, and advertising.

(ii) Agriculture: In agriculture, drones serve as indispensable tools for crop surveillance, irrigation assessment, and pest detection. Leveraging specialized sensors, drones facilitate the collection of granular data pertaining to crop vitality, soil composition, and land mapping, thereby empowering agricultural stakeholders with actionable insights to optimize crop productivity.

(iii) Infrastructure Inspection: Drones find increasing utility in infrastructure inspection endeavors, facilitating the meticulous evaluation of critical assets such as bridges, power lines, and pipelines. Drones adapt manoeuvrability enables access to remote or hazardous locales, enabling the capture of high-resolution imagery for structural analysis, thereby streamlining inspection processes and bolstering operational efficiency.

(iv) Search and Rescue Operations: Drones equipped with thermal imaging capabilities play a pivotal role in search and rescue operations, swiftly scanning vast expanses to pinpoint missing individuals or survivors amidst disaster-stricken regions.The real-time aerial perspectives furnish emergency responders with invaluable situational awareness, facilitating judicious decision-making and resource allocation.

(v) Environmental Conservation: In environmental conservation initiatives, drones assume a pivotal role in wildlife surveillance, anti-poaching campaigns, and the monitoring of endangered species. These aerial platforms furnish researchers with invaluable data pertaining to animal behavior, habitat delineation, and ecosystem surveillance, whilst minimizing disturbance to wildlife.

(vi) Disaster Response and Relief: Drones lend vital assistance in disaster management endeavors, expediting damage assessment, area mapping, and search and rescue endeavors. Furnishing emergency responders with realtime aerial insights, drones facilitate informed decision-making and efficient resource allocation amidst crisis situations.

(vii) Delivery and Logistics: Enterprises are increasingly exploring the deployment of drones for delivery and logistics operations. These aerial couriers swiftly transport small parcels across challenging terrain or areas with limited infrastructure, potentially slashing delivery times and operational costs.

(viii) Mapping and Surveying: Drones, equipped with cutting-edge sensors and imaging technologies, are indispensable assets in mapping and surveying applications.Drones adeptly generate high-resolution maps, three-dimensional models, and topographic data, catering to sectors such as construction, urban planning, and land surveying.

(ix) Scientific Research: Across scientific research endeavors, drones are progressively harnessed for data collection in remote or inaccessible locales. Drones facilitate environmental research, atmospheric studies, wildlife monitoring, and geological surveys, thereby furnishing researchers with invaluable insights whilst mitigating risks associated with traditional fieldwork. In culmination, the significance of drones continues to burgeon as technological innovation advances and novel applications unfurl. The unparalleled capacity to access inaccessible locales, capture data from unique perspectives, and automate diverse tasks renders them indispensable across a gamut of industries.

3 Drone Vs Birds:

Drones and birds are both capable of flying, but have distinct differences in terms of design, behavior, and purpose. Here are some points to consider when comparing drones and birds:

3.1 Design and Construction:

3.1.1 Drones: Drones are autonomously controlled airborne apparatuses engineered by human intervention. Drones are commonly constructed utilizing materials like carbon fibre or plastic and are propelled by either electric motors or combustion engines.

3.1.2 Birds: Birds are living creatures with a unique biological structure adapted for flight. Birds have feathers, hollow bones, and strong.

3.2 Flight Characteristics:

3.2.1 Drones: Drones are operated remotely by humans or autonomously through onboard sensors and computer systems. Drones exhibit capabilities such as hovering, directed flight, and executing intricate manoeuvres. The flight can be stabilized, altitude altered, and velocity increased, contingent upon the specific engineering and design attributes.

3.2.2 Birds: Birds demonstrate flight control through wing flapping, body adjustments, and tail feather manipulation. The flight of birds repertoire encompasses soaring, gliding, and hovering. Birds exhibit exceptional agility, enabling precise navigation across diverse terrains.

3.3 Purpose and Functionality:

3.3.1 Drones: UAVs have been engineered for various intentions, such as aerial photography and cinematography, parcel transportation, search and rescue expeditions, agricultural surveillance, scientific inquiry, and recreational utilization

4 Crow behavior towards drones

Crows, known for intelligence and adaptability, exhibit intriguing behavior when encountering flying objects like drones. The reactions are multifaceted, encompassing curiosity, vocalizations, aerial manoeuvres, and even defensive and playful interactions. Understanding these behaviors provides insights into the complex social dynamics and adaptability of these intelligent birds

Curiosity and Exploration: Crows' natural curiosity prompts them to investigate novel objects in the environment, including drones. This curiosity often manifests in close approaches, with the birds examining the unfamiliar flying object to understand its nature. The cognitive exploration is a testament to the intelligence and ability to adapt to changes in the surroundings.

Vocalizations as Communication: One of the defining features of crows is the rich repertoire of vocalizations. When faced with a drone, crows may express the curiosity or alert others to the potential threat through various calls. This vocal communication is an essential aspect of the social behavior and serves to coordinate actions within the group.

Aerial Maneuvers and Agility: Crows are renowned for the agile flight. When confronted with a drone, birds may engage in intricate aerial manoeuvres, showcasing the ability to navigate the surroundings with precision. Flying alongside, above, or below the drone, these maneuvers reflect a combination of curiosity and an adaptive response to the unfamiliar object in the airspace.

Mobbing Behavior as a Defensive Strategy: In situations where crows perceive a drone as a threat, may exhibit mobbing behavior. This collective response involves multiple crows actively harassing the drone, possibly with dive-bombing or physical contact. Mobbing is a defensive strategy aims at driving away potential dangers from the territory or nesting sites.

Playful Interaction: Ravens are not exclusively motivated by protective instincts; certain individuals or collectives might interact with drones in a recreational fashion. This can involve chasing the drone, mimicking its movements, or displaying behaviors reminiscent of play. Such interactions highlight the adaptability and sometimes whimsical nature of crows.

Defensive Measures and Adaptation: Crows are territorial birds, and the encounters with drones may trigger defensive behaviors, particularly if the drone poses a perceived threat to the nesting sites or territory. Over time, however, crows in areas with frequent drone activity may adapt to the presence of these flying objects. Initially defensive responses may diminish as the birds become accustomed to the technology in the environment.

Responsibilities of Drone Operators: When flying drones in areas inhabited by crows, responsible drone operation is crucial. Maintaining a safe distance, minimizing disturbances, and adhering to local regulations help mitigate potential stress on the birds. Respecting the natural behaviors of crows ensures a harmonious coexistence between these intelligent avians and modern technology. In conclusion, the detailed examination of crow behavior towards drones provides a nuanced understanding of the intelligence, adaptability, and the intricate interplay between natural instincts and responses to contemporary elements in the environment. Crows are known for the high intelligence and complex social behavior. When it comes to drones, the behavior can vary. Here are some general observations:

Curiosity: Crows are naturally curious birds and may investigate drones in the environment.Birds might approach the drone to get a closer look, especially if it's making noise or moving in an unusual way.

Cautiousness: Although crows exhibit curiosity, a cautious nature is also characteristic of crow. If a drone gets too close or behaves in a threatening manner, crows may become wary and attempt to keep a safe distance.

Aggression: Some crows may display aggressive behavior towards drones, particularly if crows perceive the drone as a threat. This aggression can manifest in vocalizations, dive-bombing, or even attempts to chase the drone away.

Playful Interactions: In some cases, crows might engage with drones in a playful manner. Crows may fly alongside or above the drone, perhaps viewing it as an interesting and interactive object.

Alarm Calls: Crows are known for the alarm calls, which also use to alert others in the group about potential threats. If crows perceive a drone as a threat, may emit loud alarm calls to warn others. Important to note that individual crow behavior can vary, and some crows may not show much interest in drones at all. Additionally, local factors, such as the presence of nesting sites or the level of human interaction, caninfluence crow behavior towards drones

5 Algorithm to detect bird behavior

Convolutional Neural Architectures (CNAs) and Region-based Convolutional Neural Architectures (R-CNAs) are pivotal in the analysis of avian behavior, particularly when handling visual information like images or video frames.

5.1 CNNs (Convolutional Neural Networks):

5.1.1 Feature Extraction: CNNs are powerful for extracting hierarchical features from images. In the context of bird behavior analysis, CNNs can learn to identify important visual patterns, textures, and structures that characterize different behaviors.

5.1.2 Behavior Classification: Once trained on a labelled dataset, a CNN can be used for behavior classification. For instance, a CNN can learn to distinguish between various bird behaviors, such as perching, flying, feeding, or interacting, based on the visual features has extracted.

5.2 R-CNNs (Region-based Convolutional Neural Networks):

5.2.1 Object Localization: designed to address object localization tasks. In the context of bird behavior analysis, an R-CNN can be used to detect and localize birds within an image or video frame. This is crucial for understanding where specific behaviors are occurring.

5.2.2 Behavior Localization: By localizing objects (birds) within an image or video, R-CNNs contribute to behavior localization. This means identifying which part of the image contains the behavior of interest. For example, an R-CNN can help pinpoint the location of a feeding bird within a larger scene.

5.3 Efficient Algorithm

The fusion of Convolutional Neural Networks (CNNs) and Region-based Convolutional Neural Networks (R-CNNs) presents a highly effective methodology in the examination of avian behavior. CNNs exhibit proficiency in feature extraction, adept at discerning intricate patterns embedded within images, whereas R-CNNs specialize in precise object localization, enabling the identification of specific objects within the image space. Through the amalgamation of these models, a comprehensive framework is established for the nuanced understanding of avian behavior. CNNs capture generic features and facilitate behavior classification, while R-CNNs augment localization capabilities, pinpointing the precise locations where distinct behaviors manifest. This dual-stage process facilitates an in-depth analysis of bird activities. In the realm of video data analysis, temporal dynamics are addressed 1 4 through the utilization of 3D CNNs, which capture spatiotemporal patterns inherent in avian behaviors. The synergy between CNNs and R-CNNs facilitates robust object tracking, an essential aspect for accurately monitoring the dynamic movements of birds. Architectures like Faster R-CNN and Mask R-CNN further enhance the accuracy of object detection and segmentation tasks. In essence, the integration of CNNs and R-CNNs forms a potent toolkit for behavior analysis, offering a holistic perspective on avian activities across both image and video datasets.

6 Conclusion

In summation, the exploration of AI-based behavior analysis of avian species through the utilization of Unmanned Aerial Vehicles (UAVs) presents an auspicious avenue with the potential to yield invaluable insights into the intricate nuances of avian behavior and ecological dynamics. Employing sophisticated computer vision algorithms and advanced machine learning methodologies, proficiently discern and monitor avian entities within UAV-captured, pristine video footage, subsequently extracting pertinent features and categorizing avian behaviors with unparalleled precision. This technological prowess harbors the capacity to facilitate comprehensive studies encompassing diverse avian taxa inhabiting disparate ecosystems, including but not limited to elucidating migratory patterns, discerning feeding and mating rituals, deciphering intricate social dynamics, and scrutinizing avian responses to environmental vicissitudes. Moreover, the application of this innovative technology extends to conservation and management imperatives, encompassing the meticulous surveillance of avian populations and the identification of potential threats encroaching upon habitats. However, the inception and fruition of such an endeavour necessitate an amalgamation of specialized expertise in fields such as computer vision, machine learning, and data analytics. Furthermore, the acquisition of requisite hardware, encompassing cutting-edge UAVs and high-fidelity cameras, is imperative to ensure the acquisition of pristine video footage conducive to meticulous analysis. Armed with the requisite tools and acumen, this pioneering technology holds the promise of engendering profound impacts upon our comprehension of avian behavioral intricacies and ecological dynamics, ultimately fostering concerted endeavors toward the conservation and preservation of avian species on a global scale.

References

[1] Horizon2020. The SafeShore project. In http://safeshore.eu, funded by the European Commission under the “Horizon 2020” program, grant agreement No 700643.
[2] G. De Cubber, R. Shalom, A. Coluccia, O. Borcan, R. Chamrad, T. Radulescu, E. Izquierdo, and Z. Gagov. The ´ SafeShore system for the detection of threat agents in a maritime border environment. In IARP Workshop on Risky Interventions and Environmental Surveillance, Les Bons Villers, Belgium, May 2017.
[3] Cemal Aker and Sinan Kalkan. Using deep networks f
or drone detection. In IEEE International Workshop on Small Drone Surveillance, Detection and Counteraction Techniques, Lecce, Italy, Aug. 2017.
[4] Muhammad Saqib, Nabin Sharma, Sultan Daud Khan Makkah, and Michael Blumenstein. A study on detecting drones using deep convolutional neural networks. In IEEE International Workshop on Small-Drone Surveillance, Detection and Counteraction Techniques, Lecce, Italy, Aug. 2017.
[5] S. Ren, K. He, R. Girshick, and J. Sun. Faster r-cnn: towards real-time object detection with region proposal networks: Towards real-time object detection with region proposal networks. In Advances in neural information processing systems, 2015.
[6] Coluccia, A.; Fascista, A.; Schumann, A.; Sommer, L.; Ghenescu, M.; Piatrik, T.; De Cubber, G.; Nalamati, M.; Kapoor, A.; Saqib,M.; et al. Drone vs. Bird Detection Challenge at IEEE AVSS2019. In Proceedings of the 16th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS), Taipei, Taiwan, 18–21 September 2019.
[7] Aksoy, M.C.; Orak, A.S.; Özkan, H.M.; Selimoglu, B. Drone Dataset: Amateur Unmanned Air Vehicle Detection. 2019,doi:10.17632/zcsj2g2m4c.4.
[8] Bosquet, B.; Mucientes, M.; Brea, V. STDnet: A ConvNet for Small Target Detection. In Proceedings of the 29th British Machine Vision Conference, Newcastle, UK, 3–6 September 2018.Pawełczyk, M.Ł.; Wojtyra, M. Real World Object Detection Dataset for Quadcopter Unmanned Aerial Vehicle Detection. IEEE Access 2020, 8, 174394–174409.
[9] Li, J.; Ye, D.H.; Chung, T.; Kolsch, M.; Wachs, J.; Bouman, C. Multi-target detection and tracking from a single camera in Unmanned Aerial Vehicles (UAVs). In Proceedings of the 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Daejeon, South Korea, 9–14 October 2016; pp. 4992–4997.