



Original Research Paper

Deep Learning Analysis of Exploratory Behaviour in Environmentally Enriched Mammals

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Key Words	Abstract
Environmental enrichment, Mammal behaviour, Exploratory activity, Deep learning, Behaviour recognition, Wildlife monitoring.	Exploratory enrichment is a vital strategy towards improving the wellbeing of mammals through stimulation of their natural behaviors such as exploring, moving around, object manipulation and environmental inspection. Understanding the behavior of animals in captivity and managed environments is key in evaluating their psychological state of mind, adaptability and quality of habitat. Unfortunately, the existing methods of behavioral analysis largely rely on manual observation and annotation and are labor-intensive, non-scalable and are associated with observation bias. To address the above limitations, this work introduces a deep learning-based framework for behavioral monitoring in exploratory enriched mammals. The framework relies on animal video data sets under enriched environments and employs deep learning models in behavioral detection and classification. The model learns to detect complex visual cues related to exploratory behaviors, making it possible to detect various behavioral states and motions. It was demonstrated through experiments that the suggested method makes it possible to detect behavioral differences and automate the process of monitoring more effectively than traditional observation. The suggested framework allows for the continuous monitoring of behavioral patterns without involving many manual actions, thus providing more efficient analysis. Moreover, the suggested method is helpful for assessing the enrichment efforts, improving animal welfare, and conducting behavioral ecology studies. The combination of deep learning and animal monitoring tools can be a breakthrough in the field of wildlife intelligent observation and conservation planning.

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Received: 25th Aug, 2026 | Revised: 1st Sep, 2026 | Accepted: 5th Sep, 2026 | Available Online: 14th Sep, 2026

(DOI): 10.70102/AEJ.2026.18.5s.60

Introduction

Influence of Environmental Enrichment on Mammal Behaviour

Enrichment positively influences the welfare of mammals through the provision of stimulating environments that encourage natural behaviors such as exploration, locomotion, and interaction. Exploration is an adaptive behavior indicating welfare and adaptation of animals to their environment. It has been demonstrated that enrichment helps in reducing aberrant behavior and increasing behavioral diversity (Wood-Gush and Vestergaard, 1989; Poole, 1992; Swaisgood and Shepherdson, 2006). Modern studies emphasize the effects of both food and sensory enrichment on the activity of animals kept in captivity (Puehringer-Sturmayer et al., 2023; Göbel et al., 2024).

Challenges in Traditional Exploratory Behaviour Monitoring

Classic behavioural monitoring involves observation and annotation by humans, which is time-consuming and requires human labor. This approach suffers from limitations such as observer's bias, massive video data volume, and difficulties in constant monitoring. The automation of processes is required for enhancing behavioral analysis efficiency. Machine learning platforms have already proved their applicability in lowering manual annotation and enabling explainable behaviour recognition (Goodwin et al., 2024).

Role of Deep Learning in Animal Behaviour Analysis

Deep learning technology facilitates automated analyses of animal behavior via computer vision and feature recognition technology. CNN models can recognize the presence of an animal, identify the behavioral features, and analyze the pattern of the activity within video frames. Machine learning technologies have successfully conducted real-time behavioral analysis using visual sensor technologies (De Chaumont et al., 2019). Deep learning-based animal sensing technologies also aid in habitat monitoring and ecological studies (Yashaswini et al., 2025).

Research Motivation and Objectives

There is a need to have efficient animal welfare evaluation tools, which is why there is a need to create intelligent systems that will help in assessing behavioral change due to environmental enrichment. This paper explores the creation of an intelligent system using deep learning for detecting exploratory behavior in environmentally enriched animals.

Review of Literature

Environmental Enrichment and Mammalian Behaviour Studies

Environmental enrichment is a critical component in the enhancement of well-being among mammals due to the promotion of natural behavior, exploration, and behavioral diversification. Enrichment has been found to minimize the incidence of abnormal behaviors and facilitate positive behavioral performance in

various animal models (Wood-Gush and Vestergaard, 1989; Swaisgood and Shepherdson, 2006; Orihuela et al., 2019).

Vision-Based Animal Behaviour Monitoring

Visual monitoring methods offer an automated system of analyzing animal behavior via video observation. Visual methods allow tracking of the movement, interaction, and behavioral state of the animals with decreased restrictions of manual observation. The machine-learning-based vision systems have shown efficiency in real-time behavioral analysis through the use of camera-based methods (De Chaumont et al., 2019). Explainable behavioral analysis systems make it even easier to recognize the behavior of animals automatically (Goodwin et al., 2024; Nielsen et al., 2026).

Deep Learning Approaches for Behaviour Recognition

Animal behavior recognition techniques have evolved owing to deep learning algorithms that are capable of capturing high-level features from images and video data. Deep learning models like CNN help in automatic feature extraction and behavior recognition tasks, whereas sophisticated techniques make it possible to recognize temporal behavior patterns of animals. Deep learning-based animal sensing systems have been found effective for efficient ecological monitoring and behavioral analysis of mammals (Yashaswini et al., 2025).

Research Gap

Despite many previous studies addressing the area of detection and behavior recognition in

animals, there is a lack of studies concerning analysis of enrichment-induced exploratory behaviors through the application of deep learning algorithms. A lot of existing solutions imply the necessity for manual labeling or provide the capability for detecting the behavior in general. Thus, there is a need for development of an automatic recognition system.

Methodology

Dataset Collection and Behaviour Annotation

The dataset comprises video clips and images that are collected from enriched environments where mammals are kept. The collected data includes various behaviors of exploration, such as motion, manipulation, investigation, and exploration. The samples are manually labeled with respect to behavioral classes so that deep learning models can be trained using the labeled data. This will help the deep learning model understand the visual features of various behaviors of exploration.

Deep Learning Behaviour Recognition Model

In the proposed framework, a machine learning model is used that makes use of deep learning principles for the analysis of the behavior patterns in mammals. The convolutional layers of this machine learning model are employed for the extraction of features of movements and body posture from images and video frames. Such features include behavioral characteristics of the mammalian exploratory actions.

Behaviour Analysis Framework

This comprehensive framework of behavior analysis comprises various processing steps such as input data acquisition, animal detection, feature extraction, behavior classification, and

behavior exploration. Firstly, the video data is fed as input and then the deep learning algorithm detects the animals. Behavioral features are identified through classification in order to analyze the exploratory behaviors.

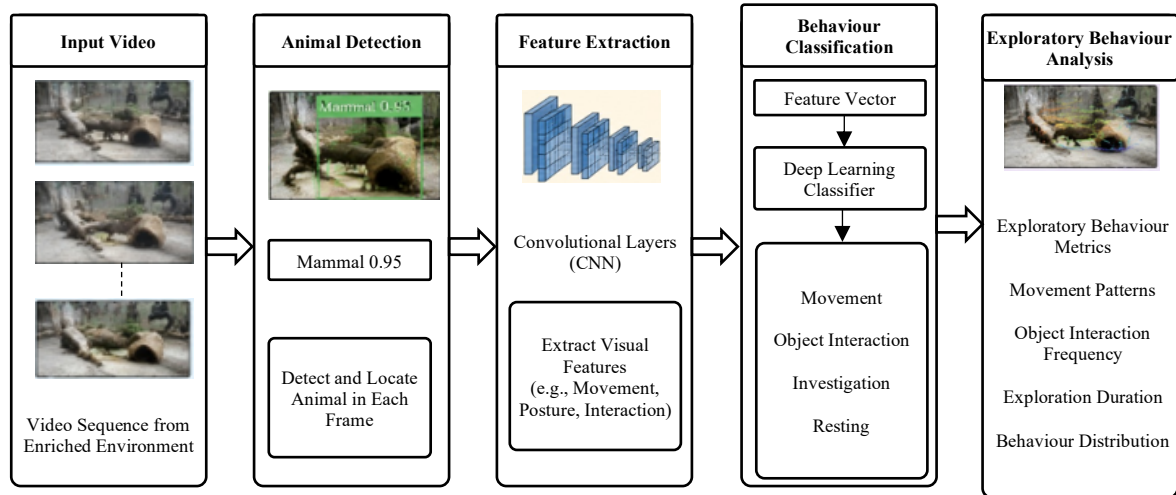


Figure 1: Deep Learning-Based Exploratory Behaviour Analysis Workflow

The deep learning process flow to analyse exploratory behaviour in environmental enrichment for mammals is shown in figure 1. It starts from input video data processing by using animal detection, convolutional feature extraction, and deep learning process in order to classify behaviours such as moving, interacting with objects, investigating, and resting.

Results and Discussion

Performance Evaluation of Deep Learning Model

Table 1: Classification Performance of Different Deep Learning Models

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-score (%)
CNN	89.5	88.7	87.9	88.3
ResNet	92.4	91.8	92.0	91.9
YOLO-based Model	94.1	93.5	93.8	93.6
Proposed Deep Learning Model	97.2	96.8	97.0	96.9

Performance analysis of the developed deep learning framework was done by evaluating its exploratory behaviour recognition performance compared to other deep learning models. The analysis was done using conventional classification metrics such as accuracy, precision, recall and F1-score. The use of these metrics gives a general idea of how effectively the model identifies different exploratory behaviors in enriched environment animals.

The performance of various deep learning models for exploratory behavior recognition is presented in table 1. From the evaluation results, it can be seen that the proposed deep learning model has performed the best by attaining an accuracy rate of 97.2%, precision rate of 96.8%,

recall rate of 97.0%, and F1-score rate of 96.9%. The improved performance demonstrates the efficiency of the proposed model in detecting behavioral patterns in enriched mammal environments.

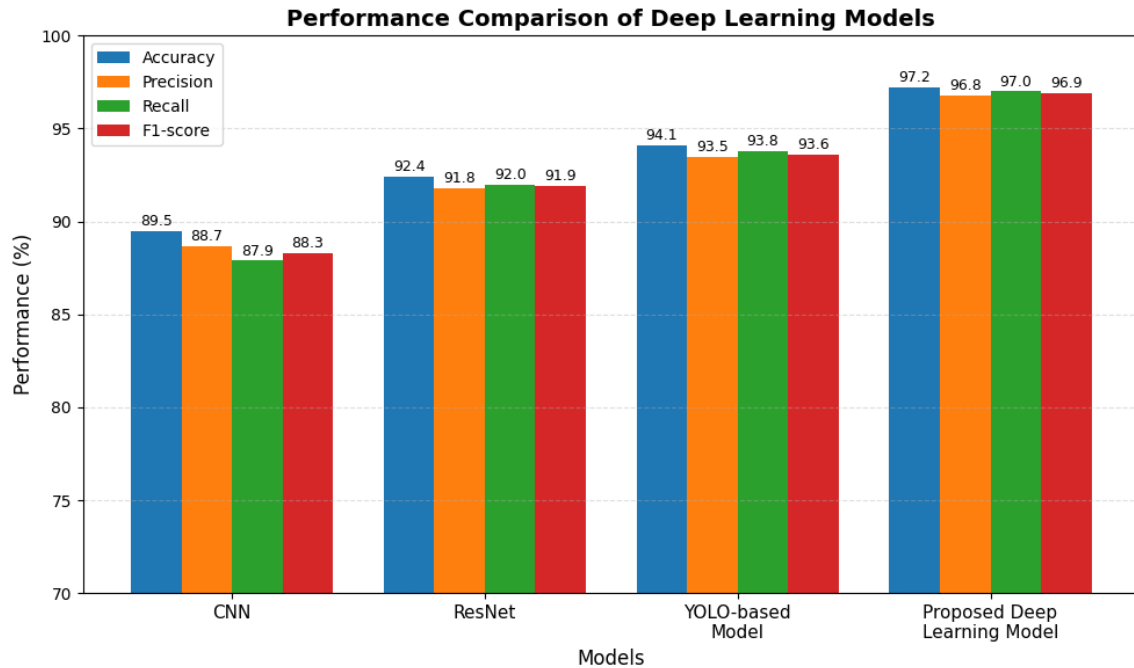


Figure 2: Performance Comparison of Deep Learning Models

Figure 2 provides a comparison of performance of various deep learning models used for the detection of mammalian exploratory behavior in terms of accuracy, precision, recall, and F1 score. The performance of the proposed deep learning model is much better than that of CNN, ResNet, and YOLO models.

Conclusion

This study has presented a deep learning-based system for automatic behavioral pattern recognition in mammals living under environmental enrichment. The methodology proposed in this study is quite efficient in recognizing behavioral patterns by processing

video recordings of animals and discovering crucial features associated with movement, interaction, and exploration. The findings have proved that deep learning algorithms can be efficiently used for behavioral recognition and monitoring as an alternative to manual observation techniques. This system helps reduce the need for manual work and provides continuous evaluation of behavior of animals and has applications in animal welfare and ecology research. Future research will concentrate on real-time behavioral monitoring and further development of deep learning models for different types of animals.

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