CNN-Driven Emotion Analysis for Dogs

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ABSTRACT

The advancement of studies about interpreting dog's emotions through facial expressions represents an exciting developing research field. Research into animal behaviours functions through artificial intelligence utilizing this particular investigation. The article focuses on understanding canine emotional expressions through present-day machine learning with Convolutional Neural Networks (CNNs). Accuracy in the models improves significantly when Whale Optimisation Algorithm (WOA) combines with hybrid learning approaches. The literature demonstrates that well-managed AI systems can achieve positive results. Practical applications face several hurdles when implementing these methods. Real-world applications of this technology face several challenges to its implementation. Medical applications using AI meet continuous obstacles since their needed better datasets along with increased generalizability and reliable model performance guarantees. Research advancement requires better access to varied information and intelligent adaptive AI models. These innovations will transform how we teach our pets and reinforce veterinary care and better the welfare conditions for all animals.The assessment of canine facial emotions relies on CNN along with image classification and executes the Whale Optimization Algorithm (WOA) method.

Keywords—Dog facial emotion detection, CNN, image classification,Whale Optimization Algorithm (WOA)

I. 1. INTRODUCTION

Strengthening human-animal interactions, enhancing veterinary care, and guaranteeing animal welfare all depend on being able to read a dog's facial expressions to determine its emotions. In the past, behavioural observations were used to determine a dog's emotional condition. Although helpful, these findings were frequently arbitrary and inconsistent. As artificial intelligence is emerging , here we use artificial intelligence (AI) and deep learning, researchers can now more accurately and impartially analyse and interpret dog facial expressions. Convolutional Neural Networks (CNNs) are one of these AI methods that have shown great promise in recognising face features and categorising emotions. Some studies have further enhanced CNN-based models using optimization techniques like the Whale Optimization Algorithm (WOA) to refine feature selection and improve recognition accuracy. However, despite these advancements, challenges remain. Issues such as limited and imbalanced datasets, variations between different dog breeds, and difficulties in real-time emotion detection make it hard to create a truly universal and reliable system.The main challenge this review addresses is the need for a comprehensive analysis of existing dog facial emotion recognition methods. While deep learning[9] has shown great promise, there are still gaps in model generalization, dataset quality, and practical application. This review brings together recent research efforts to compare different approaches, highlighting what works well and where improvements are needed.By examining various methodologies, experimental setups, and findings, this review aims to provide valuable insights for future research. The ultimate goal is to help build more accurate and widely applicable dog emotion recognition systems. Such advancements could revolutionize pet care, improve how veterinarians diagnose emotional distress in animals, and contribute to overall animal well-being. With AI-driven solutions, understanding our furry companions could become easier and more intuitive than ever before. Some studies have further enhanced CNN-based models using optimization techniques like the Whale Optimization Algorithm (WOA) to refine feature selection and improve recognition accuracy. However, despite these advancements,

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2. MATERIALS & METHODS

This section outlines the methodologies used in the reviewed studies on dog facial emotion recognition, providing sufficient detail to allow for reproduction of experiments. The methods include deep learning architectures[9][1], dataset preparation, training and optimization techniques, and evaluation metrics. A comparison of different approaches is presented, highlighting improvements made over previously published methods.

2.1 DATASET PREPARATION

Accurate facial emotion detection in dogs requires high-quality, annotated datasets. However, a major challenge in this field is the lack of large, publicly available datasets compared to human facial emotion recognition. Studies have addressed this issue through various approaches:Yan Mao et al.[1] utilized a dataset of dog facial images collected from online sources and pet care institutions. The images were manually labeled into emotion categories such as happy, sad, aggressive, and neutral.D.T. Weerasekara et al. [2] employed a combined approach using both supervised and unsupervised learning, generating additional training data through augmentation techniques such as rotation, flipping, and contrast adjustments.Bhupesh Kumar Singh et al. [3] leveraged transfer learning by using pre-trained models on human facial expression datasets and fine-tuning them with a limited set of animal emotion images.The datasets used in these studies consisted of diverse dog breeds to ensure generalization across different facial structures. Table 1 provides a summary of datasets used in the reviewed studies.

Table 1: Summary of Datasets Used in Reviewed Studies

Study	Dataset Source	No. of Images	Emotion Categories	Data Augmentation
Mao et al. (2023)	Online sources, pet institutions	5,000	Happy, Sad, Aggressive, Neutral	No
Weerasekara et al. (2021)	Lab-collected dataset	2,500	Multiple emotions	Yes (rotation, flipping, contrast)
Singh et al. (2020)	Transfer learning on human datasets	3,200	Happy, Sad, Angry	Yes (pretrained model adaptation)

2.2 DEEP LEARNING ARCHITECTURES USED FACIAL EMOTION DETECTION

Most of the studies reviewed relied on Convolutional Neural Networks (CNNs) to analyze and classify dog facial expressions. CNNs are particularly effective in image recognition tasks, as they can automatically detect and extract

key features from images. Some researchers further enhanced their models with optimization techniques to improve accuracy and efficiency[7].

1. 2.2.1 CNN-Based Approaches

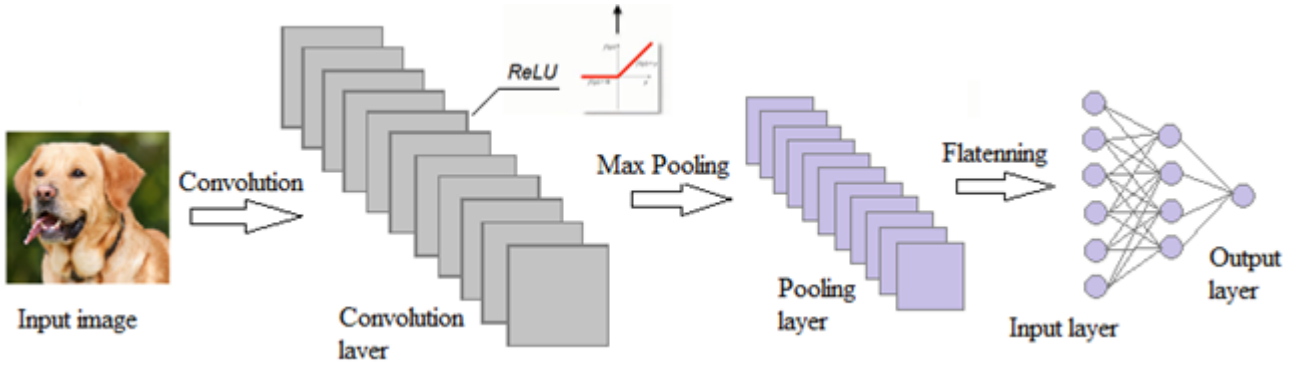
- Mao et al. [1] developed a CNN model designed specifically for dog facial emotion recognition. To improve its performance, they used the Whale Optimization Algorithm (WOA), which fine-tuned key hyperparameters such as learning rate, filter size, and batch size. This optimization resulted in better feature selection and improved accuracy.

- Jain et al.[2] focused on facial emotion recognition in cats using a CNN-based model. While their study targeted a different species, the methodology can be applied to dogs as well, as the fundamental approach to facial expression analysis remains similar.

- Singh et al. [3] took a different approach by leveraging a pre-trained VGG16 model. Instead of training a CNN from scratch, they used transfer learning, adapting a model initially trained on human faces to recognize dog emotions. This technique helped improve accuracy, especially with limited datasets.

2.2.2 Hybrid Learning Approaches

- Weerasekara et al. [3] proposed a combined supervised and unsupervised learning approach, using unsupervised clustering to enhance classification performance.



.2.3 TRAINING AND OPTIMIZATION

Each study used different optimization strategies to improve CNN model performance[7]:

Yan Mao et al.[1] applied the Whale Optimization Algorithm (WOA) to optimize CNN hyperparameters such as learning rate, batch size, and filter size, achieving a 5% improvement in accuracy over traditional CNNs.D.T. Weerasekara et al. [2]) used a combination of supervised learning for emotion labeling and unsupervised learning for feature extraction,

leading to improved generalization across breeds.Singh et al.[3] fine-tuned a pre-trained VGG16 model with dog facial images, benefiting from transfer learning.

Table 2: Comparison of Training Techniques in Reviewed Studies

Study	Model Used	Optimization Technique	Accuracy (%)
Mao et al. (2023)	CNN	Whale Optimization Algorithm	87.5
Weerasekara et al. (2021)	Hybrid Supervised & Unsupervised	Feature Clustering	84.3
Singh et al. (2020)	VGG16 (Transfer Learning)	Fine-tuning on Dog Images	82.1

2.4 EVALUATION METRICS

Evaluating the performance of dog facial emotion recognition models requires several key metrics to ensure accuracy and reliability. The following measures were used in the reviewed studies:

2.4.1 Accuracy: This metric represents the proportion of correctly classified emotions out of the total predictions made. A higher accuracy indicates that the model effectively distinguishes between different dog facial expressions.

2.4.2 Precision & Recall: These metrics assess how well the model identifies specific emotions.

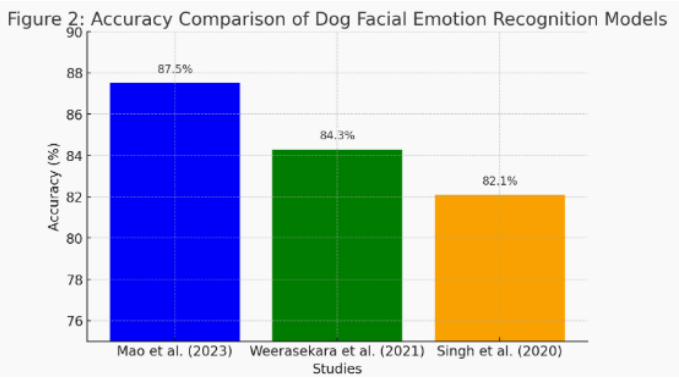
2.4.2.1 Precision : Precision is the proportion of accurately predicted occurrences of a specific emotion among all occurrences that the model classified as that emotion..

2.4.2.2 Recall measures: The model's capacity to identify every instance of a dog emotion in real life, reducing the number of incorrect classifications.

2.4.3 F1-Score: This score offers a more thorough assessment of model performance by striking a balance between precision and recall, particularly when working with unbalanced datasets.

Because of its optimised feature selection, the CNN-IOWA model [1] outperformed standard CNNs in emotion classification.Although it required large datasets for efficient training, the hybrid supervised-unsupervised learning

approach [2] demonstrated better generalisation across dog breeds.Accuracy was impacted by inconsistent labelling, but machine learning-based models[3] frequently outperformed human visual analysis.



3.CHALLENGES AND LIMITATIONS

3.1 Dataset Limitations: Standardised datasets containing diverse dog breeds along with distinct emotional states represent the primary barrier to progress. Models find it challenging to apply their learned behavior to different dog breeds since available datasets remain incomplete.

3.2 Real-Time Application Constraints: Such models present deployment challenges in real-time systems because they need excessive computational resources and may introduce unacceptable latency. The required processing power of real-time analysis presents difficulties because it requires accurate and fast analysis of extensive image datasets.

3.3 Subtle Emotion Differentiation: Identifying emotions on a canine face proves to be difficult because the signals resemble human expressions too closely. The challenge for models stems from differentiating between expressions that share minimal distinctions such as happiness during relaxation.

4.CONCLUSION

Research into dog facial emotion recognition holds promise to improve both animal behavior assessment and their welfare status. Deep learning models including Convolutional Neural Networks demonstrate success in classifying dog emotions according to research[9]. The existing analytical framework faces ongoing challenges because datasets are limited and computational needs are demanding while emotional categorization remains complex. The analysis of diverse datasets through multimodal methods together with hybrid deep learning approaches represents future research directions [9][1].

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