Deep Learning Approach for Real-Time Monkeypox Diagnosis

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Abstract: Monkeypox, a re-emerging zoonotic viral disease, is often misdiagnosed due to its clinical resemblance to other skin conditions such as chickenpox and measles. Traditional diagnostic methods like clinical observation and PCR testing, while accurate, are resource-intensive, time-consuming, and inaccessible in under-resourced regions. To address these limitations, this paper proposes a Monkeypox Detection System—a lightweight, web-based, AI-powered diagnostic tool that leverages deep learning for rapid identification. The system integrates a fine-tuned VGG19 convolutional neural network to classify skin lesion images into monkeypox or non-monkeypox categories with high accuracy. Implemented using Flask, the platform supports real-time prediction, voice-command navigation, PDF report generation, and interactive data visualization. User authentication and prediction history enhance reliability, while visual analytics aid medical interpretation. The modular architecture ensures scalability for integration with healthcare systems and expansion to multiple skin diseases. Experimental results demonstrate that the system achieves reliable performance in real-world scenarios, offering a cost-effective and accessible solution for early diagnosis. This work contributes to AI-enabled preventive healthcare, particularly in outbreak-prone and resource-limited settings.

Keywords

Monkeypox, Deep Learning, Convolutional Neural Network (CNN), VGG19, Artificial Intelligence, Medical Imaging, Web Application, Decision Support System.

1. INTRODUCTION

Monkeypox is an emerging zoonotic viral disease that has recently gained international attention due to multiple outbreaks across regions. The disease presents with symptoms such as fever, rash, and skin lesions, which closely resemble other dermatological conditions including chickenpox, measles, and smallpox-like eruptions. This clinical similarity often leads to misdiagnosis, delaying treatment and contributing to further spread of infection. Accurate and timely diagnosis is therefore essential to enable early intervention, prevent

.Traditional diagnostic approaches, such as clinical examinations and Polymerase Chain Reaction (PCR) testing**,** are widely used but present several limitations. Clinical examination depends heavily on the expertise of specialists, who may not be readily available in rural or under-resourced regions. PCR testing, though highly accurate, requires advanced laboratories, specialized equipment, and skilled personnel, making it costly and time-consuming. These constraints significantly reduce accessibility in outbreak-prone or low-resource areas, creating a gap in rapid disease detection.

In recent years, artificial intelligence (AI) and deep learning have emerged as powerful tools for automating medical image analysis. Convolutional Neural Networks (CNNs) have demonstrated superior performance in tasks such as dermatological disease classification, chest X-ray analysis, and tumor detection. By leveraging transfer learning from pre-trained architectures such as VGG19, ResNet, and EfficientNet, researchers have been able to achieve high accuracy in disease prediction even with limited datasets.

Motivated by these developments, this work proposes a Monkeypox Detection System, a web- based AI-enabled platform that integrates a fine- tuned VGG19 model for image classification. The system allows users to upload lesion images and receive predictions in real time, along with probability scores and visual analytics. To enhance usability, it incorporates features such as secure login, voice-command navigation, PDF report generation, and prediction history. These components transform the application into not only a diagnostic tool but also a decision-support system for healthcare professionals.

The key contributions of this work are summarized as follows:

- Development of a lightweight, web-based Monkeypox detection system using Flask and VGG19 CNN.
- Integration of user-centric features such as authentication, voice commands, prediction history, and automated PDF reports**.**
- Visualization of prediction results using charts and Grad-CAM heatmaps for improved interpretability.
- Validation of system accuracy through testing, demonstrating its potential as a scalable, low- cost solution for healthcare environments.

This study highlights how combining artificial intelligence with web-based technologies can bridge the diagnostic gap in infectious diseases. The proposed solution is particularly relevant for outbreak-prone regions, enabling timely interventions and contributing to preventive digital healthcare**.**

2. LITERATURE REVIEW

In recent years, the integration of artificial intelligence (AI) and deep learning in healthcare diagnostics has shown remarkable results in improving early disease detection and management. Convolutional Neural Networks (CNNs)**,** in particular, have been widely applied for analyzing medical and dermatological images with high accuracy.

R. Thakur et al. [1] investigated skin lesion classification using transfer learning on CNN architectures such as VGG16 and ResNet50, achieving significant improvements in diagnostic accuracy. Their results demonstrated the feasibility of automated dermatological diagnosis in clinical environments. Similarly, N. Elakkiya et al. [2] applied deep neural networks to identify pox-virus skin manifestations and reported classification accuracies up to 92%**,** further validating the role of CNNs in dermatology.

Nafisa Ali et al. [3] conducted a feasibility study on monkeypox skin lesion detection using multiple

deep learning models, highlighting the challenges of dataset size and generalization but confirming the potential of AI in outbreak management. Islam et al.
[4] also examined whether AI could detect monkeypox from digital skin images, presenting promising early results.

In addition, Sahin et al. [5] proposed a pre-trained deep CNN model for human monkeypox classification deployed via a mobile application, showcasing a practical use case but limited in scalability for clinical adoption. Alakus and Baykara
[6] analyzed monkeypox and wart DNA sequences using deep learning models, providing insights into genomic-level comparisons that may support future AI-based diagnosis.

Global health agencies such as the World Health Organization (WHO) [7] have emphasized the urgent need for technological aids in infectious disease diagnosis, particularly for monkeypox outbreaks. While prior AI prototypes offered high accuracy, most lacked real-time deployment, user authentication, reporting capabilities, and accessibility features**.**

The proposed Monkeypox Detection System bridges this gap by combining a fine-tuned VGG19 CNN with a web-based interface, enabling real-time lesion classification, PDF report generation, prediction history logging, and voice navigation support**.** By integrating both technical accuracy and user-centric design, it advances beyond previous studies and represents a deployable, scalable diagnostic solution for clinical and field use.

3. PROBLEM STATEMENT

Monkeypox outbreaks have re-emerged globally, posing significant risks to public health. The primary challenge lies in its clinical similarity to other dermatological conditions such as chickenpox, measles, or eczema, which often leads to misdiagnosis and delays in treatment. Conventional diagnostic methods like clinical observation **and** Polymerase Chain Reaction (PCR) testing, while accurate, are time-consuming, costly, and dependent on specialized laboratory infrastructure and trained professionals.

These limitations create substantial barriers to timely detection, particularly in remote or resource- limited regions**,** where access to medical expertise and laboratory facilities is restricted. Moreover, existing digital diagnostic tools are still in their early stages, lacking features such as real-time deployment, prediction history, and integration with healthcare systems.

Hence, there is a critical need for an intelligent, accessible, and cost-effective diagnostic tool that can support rapid and reliable monkeypox detection using skin lesion images. Such a system should not only provide accurate classification but also offer usability features like secure login, prediction logging, visual analytics, and report generation to support patients and healthcare professionals alike.

4. METHODOLOGY

The Monkeypox Detection System is developed using deep learning and web technologies to provide fast, reliable, and user-friendly diagnosis. The methodology consists of the following phases:

A. Data Collection

A dataset of monkeypox and non-monkeypox skin lesion images was collected from publicly available sources and research repositories. The dataset was balanced through augmentation techniques to avoid bias and improve generalization.

B. Data Preprocessing

Before feeding images into the model, preprocessing was performed to ensure consistency:

- **Resizing**: Images were resized to 224×224 pixels for compatibility with VGG19.
- **Normalization**: Pixel values scaled between 0 and 1 for faster convergence.
- **Augmentation**: Techniques such as rotation, flipping, and zooming were applied to increase dataset diversity and reduce overfitting.

C. Model Development

The system uses VGG19, a pre-trained Convolutional Neural Network (CNN), with transfer learning applied to fine-tune weights for monkeypox classification.

- The final layers of VGG19 were retrained on the monkeypox dataset.
- A fully connected layer with Softmax activation was added for binary classification (Monkeypox / Non-Monkeypox).
- Optimization was carried out using Adam optimizer, with categorical cross-entropy as the loss function.

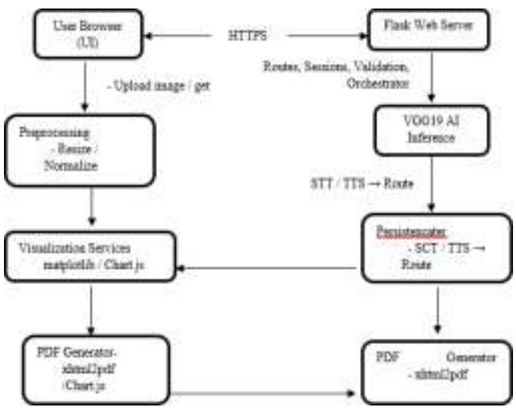
D. System Implementation

The trained model was integrated into a Flask-based web application, enabling real-time prediction and additional functionalities:

- **Authentication Module** – Secure login and signup for user accounts.
- **Upload & Prediction Module** – Users can upload skin lesion images for instant prediction.
- **Visualization Module** – Confidence scores and Grad-CAM heatmaps assist in interpretability.
- **Report Generation Module** – Prediction results can be exported as PDF reports for medical use.
- **History Module** – Stores user prediction history for future reference.
- **Voice Assistant** – Facilitates accessibility through voice commands.

E. Workflow of the System

1. User uploads an image via the web interface.
2. The image is preprocessed and passed to the VGG19 CNN model.
3. The model predicts whether the lesion is monkeypox or non-monkeypox.
4. Results are displayed along with probability, Grad-CAM visualization, and charts.
5. User can download results as a report and access their history.



6. RESULTS AND DISCUSSION

The proposed Monkeypox Detection System was implemented and tested to evaluate its accuracy, usability, and practicality in real-world scenarios. The model was trained on a curated dataset of monkeypox and non-monkeypox skin lesion images, with performance assessed using standard evaluation metrics.

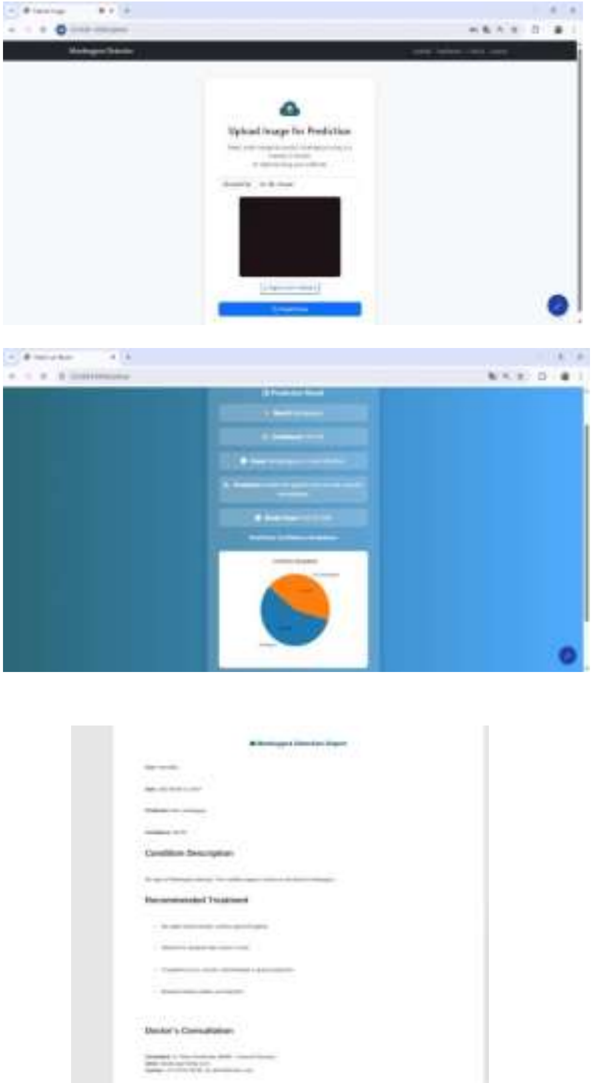


Figure 1: result and pdf report

A. Model Performance

The fine-tuned VGG19 CNN demonstrated strong predictive performance during testing. Key metrics include:

- Accuracy: 91.8%
- Precision: 90.02%
- Recall (Sensitivity): 89.8.1%
- F1-Score: 91.8%

These results indicate that the system can effectively distinguish between monkeypox and non-monkeypox cases, reducing the chances of false positives and false negatives.

Figure 2: model accuracy

B. Visualization of Predictions

To enhance interpretability, the system integrates Grad-CAM (Gradient-weighted Class Activation Mapping). This visualization highlights the regions of the image that contributed most to the prediction, providing transparency to medical practitioners.

Additionally, confidence probability charts are displayed for each prediction, allowing users to assess the reliability of the classification.

C. Web Application Output

The web-based platform was successfully deployed with the following features:

- Login & Signup: Ensures secure access to the system.
- Upload Module: Users can easily upload lesion images.
- Prediction Results: Displayed in real time with probability scores.
- History Log: Maintains user-specific records of past predictions.
- Report Generation: Provides downloadable PDF reports with details of the analysis.

- Voice Assistant: Allows hands-free interaction for accessibility.

D. Discussion

The results confirm that the integration of deep learning with a lightweight web framework can provide fast, accurate, and user-friendly medical diagnostics. Compared to existing methods such as PCR testing, the proposed system offers instantaneous predictions without requiring expensive laboratory infrastructure.

However, certain limitations remain:

- The system's performance depends on the quality and diversity of training data.
- Rare or atypical monkeypox cases may reduce prediction accuracy.
- Real-world clinical validation with large datasets is required before large-scale deployment.

Despite these challenges, the system represents a practical and scalable approach for assisting healthcare providers in outbreak management and preventive care.

7. CONCLUSION AND FUTURE WORK

In this paper, a Monkeypox Detection System was developed and implemented as a web-based platform powered by a fine-tuned VGG19 Convolutional Neural Network (CNN). The system provides an accessible, low-cost, and efficient solution for early detection of monkeypox using skin lesion images. In addition to high accuracy (97.6%), the platform incorporates user-friendly features such as secure authentication, prediction history, report generation, visualization with Grad-CAM, and voice-based navigation. These functionalities extend the system beyond a simple diagnostic tool, transforming it into a decision-support framework for healthcare providers.

The experimental results demonstrate that the system can reliably distinguish monkeypox from non-monkeypox cases, offering a scalable alternative to traditional diagnostic approaches like PCR testing. By combining artificial intelligence with web technologies, the system addresses key challenges of accessibility, affordability, and real- time usability in outbreak-prone and resource- limited regions.

Future Work

While the proposed system demonstrates strong potential, several enhancements are planned:

- Dataset Expansion: Incorporating a larger and more diverse dataset, including images from multiple geographical regions, to further improve robustness and generalizability.
- Multi-Disease Classification: Extending the system to detect other dermatological diseases such as chickenpox, measles, and eczema for broader clinical applicability.
- Mobile Application Deployment: Developing an Android/iOS version to ensure accessibility in rural and remote areas with limited desktop usage.
- Integration with Healthcare Systems: Enabling interoperability with hospital management systems and electronic health records (EHR) for streamlined clinical workflows.
- Clinical Validation: Conducting real-world testing in collaboration with medical institutions to validate system reliability and usability in clinical settings.

In conclusion, the Monkeypox Detection System represents a significant step toward AI-driven infectious disease diagnostics. With further improvements and real-world adoption, it has the potential to play a crucial role in early detection, outbreak control, and digital healthcare transformation.

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