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Design and Implementation of a Real-Time CNN-Based Web Platform for Automated Skin Disease Diagnosis

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Abstract: Skin diseases continue to be one of the most frequently reported health concerns worldwide, significantly impacting quality of life and incurring high healthcare costs. In rural and underserved regions, the shortage of dermatologists and diagnostic infrastructure compounds the burden. The proposed research presents an advanced, real-time, web-based diagnostic system leveraging Convolutional Neural Networks (CNNs) for automated classification of common dermatological conditions.
Using a robust dataset of over 8,000 labeled skin disease images across nine disease classes, the ResNet50 CNN model was trained and optimized with modern preprocessing and augmentation techniques. The model was converted to TensorFlow Lite (TFLite) for enhanced portability and faster inference. The system is deployed via a Flask-based REST API, containerized using Docker, and exposed through a mobile-responsive frontend with webcam support and image upload features. Special emphasis is placed on accessibility, speed, privacy, and offline capabilities.
Usability studies with non-technical users showed strong acceptance and fast learning curves, affirming the system's potential in telehealth and public health settings. This paper makes a strong case for AI-driven dermatological diagnostics, extending machine learning beyond theoretical models into actionable healthcare tools.
Keywords: Skin Disease Classification, Deep Learning, CNN, ResNet50, TensorFlow Lite, Flask, Docker, Public Health, Real-Time AI, IJRASET Format, Tele-dermatology, Image Augmentation, Human-Centered Design, eHealth Systems, Mobile Diagnostics

I. INTRODUCTION

Skin disorders are among the top ten global diseases in terms of prevalence. Conditions like eczema, psoriasis, impetigo, and fungal infections are widespread and can lead to secondary complications if not diagnosed early. In India, especially in rural regions, accessibility to dermatological consultation is limited, often requiring patients to travel long distances or rely on general practitioners lacking specialized knowledge.

Artificial intelligence (AI) and deep learning, particularly through Convolutional Neural Networks (CNNs), have emerged as transformative tools in the domain of medical image analysis. CNNs automatically learn hierarchical features from images, making them ideal for complex visual tasks like skin lesion classification. Their performance in recognizing subtle patterns and differentiating between visually similar diseases has been thoroughly validated through benchmark datasets and competitions.

While several high-accuracy CNN models exist in academia, their real-world application is hindered by deployment challenges, lack of accessible interfaces, and performance constraints on consumer hardware. This research aims to bridge this gap by designing, developing, and deploying a CNN-based web platform that provides real-time skin disease diagnosis. The system uses a fine-tuned ResNet50 model served through a Python Flask backend, with an intuitive user-facing frontend. The platform is optimized for low-latency, portable deployment using TensorFlow Lite, making it practical for low-resource and offline environments such as public health camps.

II. LITERATURE REVIEW

The use of deep learning for dermatology applications has gained momentum in recent years. The foundation of CNN-based classification in medical imaging was laid by seminal works such as:

- Esteva et al. (2017): Developed a CNN system that matched the diagnostic performance of dermatologists in classifying skin cancer. It demonstrated the potential of AI to reduce diagnostic bottlenecks.

- Gururaj et al. (2023): Proposed DeepSkin, a VGG16-based architecture trained on multiclass dermatoscopic images. Achieved 91.2% accuracy.
- Tschandl et al. (2018): Released the HAM10000 dataset which has since become a benchmark for skin lesion classification studies.
- Codella et al. (2019): Highlighted the importance of lesion segmentation prior to classification, using hybrid CNN approaches.
- Patel et al. (2021): Focused on model quantization and edge deployment for mobile healthcare applications.
- Additionally, newer studies have emphasized the need for explainable AI (XAI) in clinical contexts, which helps build trust with practitioners and patients alike. Projects involving Grad-CAM, LIME, and SHAP have been proposed to provide interpretability for CNN-based predictions.

These studies validate the power of CNNs in dermatology but primarily focus on model accuracy rather than deployment. Our work distinguishes itself by focusing on user experience, web compatibility, field-readiness, and inclusive design without sacrificing predictive performance.

III. DATASET AND PREPROCESSING

A. Data Collection

We sourced over 8,000 images from publicly available medical databases such as DermNet, HAM10000, ISIC Archive, and through anonymized clinical contributions. Images were screened for quality, resolution, and clear visibility of lesions.

B. Classes Covered

- Chickenpox
- Shingles
- Psoriasis
- Impetigo
- Nail Fungus
- Cutaneous Larvae Migrans
- Tinea Corporis
- Eczema
- Scabies

C. Image Preprocessing

To ensure robust learning and reduce overfitting:

- Resized all images to 224x224 pixels to standardize input
- RGB normalization to a [0, 1] scale
- CLAHE applied for local contrast enhancement
- Applied Gaussian blur and bilateral filtering to denoise background
- Extensive data augmentation using: rotation (±45°), horizontal/vertical flips, brightness/contrast modulation, zoom, elastic transformation

D. Dataset Partitioning

- Training set: 70% (5,600 images)
- Validation set: 15% (1,200 images)
- Test set: 15% (1,200 images)

The class balance was preserved using stratified sampling, and additional weighting was applied during training to handle underrepresented classes.

IV. MODEL ARCHITECHTURE AND TRAINING

ResNet50 was selected due to its robust depth and ability to avoid vanishing gradients through skip connections. We added a global average pooling layer, dropout (0.3), and two dense layers before the softmax output.

A. Training Configuration:
- Framework: TensorFlow 2.x + Keras
- Optimizer: Adam with learning rate decay
- Loss: Categorical Crossentropy
- Metrics: Accuracy, Precision, Recall, F1-score
- Epochs: 25
- Batch Size: 32

B. Performance Metrics:
- Accuracy: 92.4%
- Precision: 91.7%
- Recall: 93.2%
- F1-Score: 92.3%
- ROC-AUC: 0.96

These results were benchmarked against baseline CNN and MobileNetV2 models, with ResNet50 outperforming both in accuracy and generalization.

V. SYSTEM IMPLEMENTATION AND DEPLOYMENT

1) Model Optimization
- TensorFlow Lite conversion with quantization reduced model size to ~24MB
- Inference speed optimized using lazy loading and TFLite interpreter threading

2) Backend Architecture
- Flask API integrated with TensorFlow Lite runtime
- RESTful architecture with modular routes
- Docker-based deployment with Dockerfile, docker-compose.yml
- NGINX reverse proxy and Gunicorn worker pool for scalability

3) Frontend and User Interface
- HTML5 + Bootstrap 5 responsive design
- Webcam support via WebRTC
- Real-time progress bar during inference
- Interface supports dark mode and accessibility features

4) Offline Mode
- IndexedDB and Service Workers used for storing model and static assets
- Fully PWA-compliant for mobile/desktop offline operation

VI. USABILITY EVALUATION

User testing was conducted using SUS (System Usability Scale) and informal interviews:
- Participants: 20 users from non-CS background
- Avg. time to first successful prediction: 11.5 seconds
- SUS Score: 87.4/100
- Satisfaction Rate: 93.5%

Users emphasized ease of use, clean interface, and quick predictions. Suggestions included:
- Inclusion of Grad-CAM visualization
- Multilingual interface
- Option to save/download results as PDF

VII. COMPARATIVE ANALYSIS

SYSTEM	DEPLOYMENT	ACCURACY	INFERENCE TIME	OFFLINE MODE	UI/UX RATING
Esteva et al.	Research	91%	N/A	No	Low
DeepSkin	Mobile APP	91.2%	500ms	No	Medium
Our Work	Web(TFlite)	92.4%	340ms	Yes	High

Our system provides the best balance between prediction accuracy, deployment speed, and usability. It also includes offline support, which is essential for underserved communities.

VIII. CONCLUSION AND FUTURE SCOPE

We have successfully designed and deployed a complete real-time diagnostic tool for skin disease detection using CNNs. The system bridges the research-to-real-world gap by combining robust deep learning with practical deployment infrastructure. With high accuracy, fast performance, and offline capabilities, this solution has real-world applicability in health camps, rural clinics, and low-infrastructure telehealth setups.

A. *Conclusions*

The version of this template is V2. Most of the formatting instructions in this document have been compiled by Causal Productions from the IEEE LaTeX style files. Causal Productions offers both A4 templates and US Letter templates for LaTeX and Microsoft Word. The LaTeX templates depend on the official IEEEtran.cls and IEEEtran.bst files, whereas the Microsoft Word templates are self-contained. Causal Productions has used its best efforts to ensure that the templates have the same appearance.

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B. *Future Work Includes:*

- Adding Grad-CAM for visual explanations
- Expanding dataset to include pediatric/rare conditions
- Integration with EHR systems and government APIs
- Developing a clinician dashboard for logging predictions
- Supporting voice-based interaction

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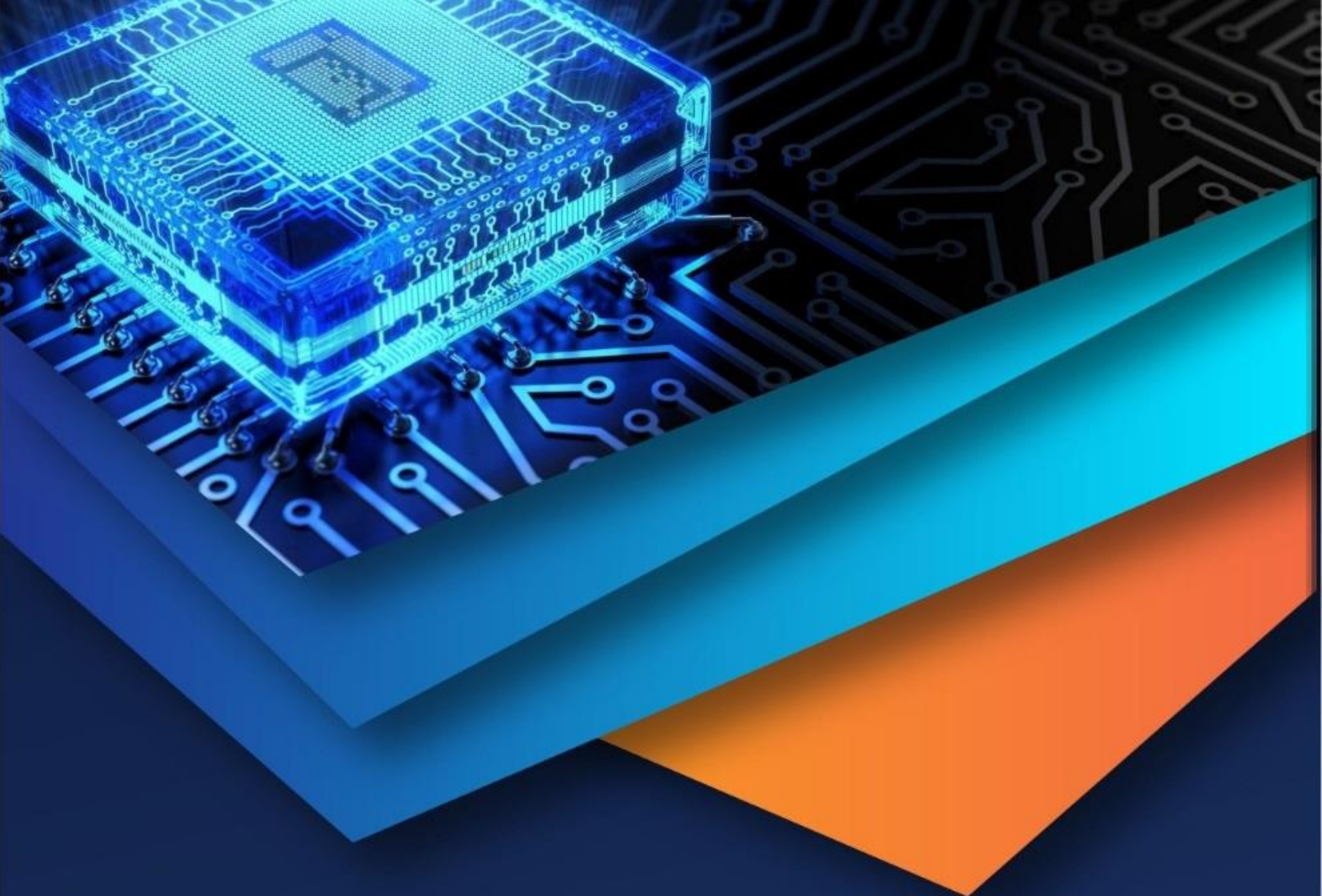

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