Skin Cancer Classification Using CNN

Submitted for

Statistical Machine Learning CSET211

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July-Dec 2024

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Abstract

This project develops a machine learning model for classifying skin lesions using the HAM10000 dataset, comprising 10,015 dermatoscopic images of pigmented lesions. The model leverages transfer learning with MobileNetV2, a pre-trained convolutional neural network, to categorize lesions into seven classes: actinic keratosis (akiec), basal cell carcinoma (bcc), benign keratosis-like lesions (bkl), dermatofibroma (df), melanoma (mel), melanocytic nevi (nv), and vascular lesions (vasc). Data augmentation techniques enhance model generalization, and the trained model is deployed via a FastAPI application for real-time image predictions. The approach aims to support early skin cancer detection, potentially improving diagnostic accuracy and patient outcomes. Due to limited repository access, performance metrics are inferred from standard practices in similar studies.

Introduction

Skin cancer is the most prevalent cancer in the United States, with over 9,500 daily diagnoses and an estimated one in five Americans developing it by age 70 Skin Cancer Facts. Globally, 331,722 new cases were reported in 2022, with melanoma being the deadliest form Skin Cancer Statistics. Early detection significantly improves survival rates, with melanoma's 5-year survival rate reaching 99% when caught early. However, accurate diagnosis is challenging due to the visual similarity between lesion types and variability in image quality.

Machine learning, particularly deep learning, has emerged as a powerful tool for medical image analysis. Convolutional Neural Networks (CNNs) can learn complex patterns from dermatoscopic images, potentially matching or surpassing dermatologist accuracy Dermatologist-level Classification. The HAM10000 dataset, a collection of 10,015 dermatoscopic images from diverse populations, provides a robust foundation for training such models HAM10000 Dataset.

This project utilizes transfer learning with MobileNetV2, a lightweight CNN pre-trained on ImageNet, to classify skin lesions. Data augmentation enhances model robustness, and a FastAPI application enables real-time predictions, making the system accessible for clinical use. The project aims to assist dermatologists in early skin cancer detection, potentially reducing diagnostic errors and improving patient outcomes.

Related Works

Numerous studies have explored machine learning for skin cancer classification, particularly using the HAM10000 dataset. Esteva et al. (2017) demonstrated that a CNN could achieve dermatologist-level accuracy in classifying skin lesions, including those from HAM10000 Dermatologist-level Classification. Haenssle et al. (2018) showed that a CNN outperformed 58 dermatologists in melanoma detection, highlighting the potential of automated systems Man Against Machine.

Recent work has focused on efficiency and applicability. Rajabi et al. (2021) proposed a lightweight CNN for mobile devices, achieving high accuracy on HAM10000 while minimizing

computational demands Lightweight CNN. Transfer learning with models like VGG16, ResNet, and MobileNetV2 is common due to their effectiveness in image classification Seven-point Checklist. Data augmentation and techniques like k-fold cross-validation have been used to address class imbalance and improve model robustness Skin Lesion Classification.

This project builds on these efforts by using MobileNetV2 for its computational efficiency, implementing data augmentation, and deploying the model via FastAPI, which enhances its practical utility in clinical settings.

Problem Statement

The project addresses the challenge of classifying skin lesions into seven categories (akiec, bcc, bkl, df, mel, nv, vasc) using dermatoscopic images. Accurate classification is critical for early skin cancer detection, particularly for melanoma, which has a high mortality rate if untreated. The visual similarity between lesion types, variability in image quality, and class imbalance in datasets like HAM10000 pose significant challenges for both human experts and automated systems. The goal is to develop a reliable machine learning model that assists dermatologists in diagnosing skin lesions, improving accuracy and reducing unnecessary biopsies.

Contribution

This project advances medical image analysis by developing a skin lesion classification model using transfer learning with MobileNetV2 on the HAM10000 dataset. The key contributions are:

1. **Model Development**: Fine-tuning MobileNetV2, a pre-trained CNN, for skin lesion classification. MobileNetV2's lightweight architecture balances accuracy and computational efficiency, making it suitable for resource-constrained environments.

2. **Data Augmentation**: Applying techniques like random flips, brightness adjustments, contrast changes, and 90-degree rotations to increase training data diversity. This mitigates overfitting and improves generalization, especially for underrepresented classes.

3. **Training Process**: Using a stratified 80-20 train-validation split to ensure representative class distribution. Training incorporates early stopping (patience=5) and model checkpointing to save the best model based on validation loss, optimizing performance.

4. **Deployment**: Integrating the model into a FastAPI application with a `/predict` endpoint, enabling real-time predictions from uploaded images. This RESTful API enhances accessibility for clinical use.

5. **Evaluation**: Likely generating a classification report with metrics like accuracy, precision, recall, and F1-score, though specific results are unavailable due to limited

repository access. Evaluation on the validation set assesses performance across all classes.

These contributions provide a practical tool for skin lesion classification, potentially enhancing diagnostic accuracy and supporting clinical decision-making.

Model Architecture

Component	Description
Base Model	MobileNetV2, pre-trained on ImageNet, input shape (224, 224, 3)
Frozen Layers	All but the last 30 layers to retain pre-trained features
Custom Layers	Global Average Pooling, Dense (128, ReLU), Dense (7, softmax)
Optimizer	Adam
Loss Function	Sparse categorical crossentropy
Metrics	Accuracy

Training Details

Parameter	Value
Dataset Split	80% training, 20% validation, stratified by class
Batch Size	32
Epochs	Up to 20, with early stopping (patience=5)
Callbacks	ModelCheckpoint (save best model), EarlyStopping (restore best weights)
Augmentation	Random flips, brightness (20%), contrast (80-120%), 90-degree rotations

Conclusion

This project demonstrates the potential of transfer learning with MobileNetV2 for skin lesion classification, addressing a critical need in dermatology. By leveraging the HAM10000 dataset, the model learns to distinguish seven lesion types, supporting early skin cancer detection. The FastAPI deployment enables real-time predictions, enhancing its clinical applicability.

Future work could include:

- **Model Optimization**: Testing other architectures (e.g., EfficientNet) or hyperparameter tuning.
- **Class Imbalance**: Applying oversampling or synthetic data generation for rare classes.
- **Clinical Validation**: Conducting trials to assess real-world performance.
- **Integration**: Combining with other diagnostic tools for comprehensive analysis.

Expanding the dataset and validating the model in diverse clinical settings could further establish its role in dermatological practice, potentially reducing diagnostic errors and improving patient outcomes.

Key Citations

- Skin Cancer Facts & Statistics
- Skin Cancer Statistics Worldwide
- HAM10000 Dataset Description
- Dermatologist-level Classification of Skin Cancer
- Man Against Machine: CNN vs. Dermatologists
- Lightweight CNN for Skin Lesion Classification
- Seven-point Checklist for Skin Lesion Classification
- Skin Lesion Classification Using CNN