Teeth Disease Classification Utilizing InceptionResNetV2

Introduction

The increasing prevalence of teeth and dental diseases, such as cavities, gum disorders, and teeth cancer, presents
significant health risks, including potential links to cardiovascular diseases. Traditional diagnostic methods face
challenges in accuracy and efficiency, underscoring the need for AI-driven solutions. Deep learning techniques,
particularly convolutional neural networks (CNNs), have shown promise in medical image analysis for identifying
dental conditions. However, previous research has been constrained by limited datasets and an inability to classify
multiple teeth diseases comprehensively. This study addresses these gaps by employing InceptionResNetV2 to
categorize seven distinct teeth diseases. A newly developed dataset, known as the Mouth and Teeth Disease (MOD)
dataset, enhances classification accuracy, surpassing earlier approaches.

MOD Dataset

Source and Composition

The MOD dataset was compiled from images acquired in dental clinics located in Okara, Punjab, Pakistan, along
with additional data sourced from online dental resources. The dataset contains 517 labeled images, each
corresponding to one of seven categories of teeth and dental diseases.

Categories and Sample Allocation:

- Teeth Thrush (OT) - 62 images
- Canker Sores (CaS) - 78 images
- Cold Sores (CoS) - 79 images
- Gingivostomatitis (Gum) - 61 images
- Teeth Lichen Planus (OLP) - 93 images
- Mouth Cancer (MC) - 90 images
- Teeth Cancer (OC) - 54 images

Labeling and Challenges

Expert dental professionals meticulously annotated the dataset to ensure labeling accuracy. However, certain challenges persisted:

- A relatively small number of samples per category, making classification more complex.
- Lack of demographic data, such as patient age, gender, or other identifiers, during data collection.

Data Preprocessing

Image Resizing and Augmentation

Images were standardized to a resolution of 224×224 pixels. Data augmentation techniques were applied using the Keras Image Data Generator to mitigate overfitting and enhance dataset variability. The following transformations were incorporated:

- Pixel Normalization: Values rescaled to the [0,1] range.
- Rotations: Images rotated by up to 25 degrees.
- Shifts: Applied horizontal and vertical shifts of 0.1.
- Shearing: Shear transformations with an angle of 0.2.

- Zooming: Random size alterations within a defined range.

- Horizontal Flipping: Introduced symmetry variations.

- Brightness Adjustments: Ranges set between 0.5 and 1.0.

- Channel Shifts: Applied modifications of 0.05 to pixel intensity.

These adjustments significantly contributed to model performance improvements by diversifying the training dataset.

Dataset Partitioning

The dataset was divided into:

- 60% Training Data

- 20% Validation Data

- 20% Testing Data

Following augmentation, the total number of images increased to 5,143, distributed as 3,087 training images,

1,028 validation images, and 1,028 testing images.

Model Architecture

This study utilizes InceptionResNetV2, a hybrid deep learning framework integrating Inception and ResNet

structures. This architecture enables multi-scale feature extraction while ensuring effective gradient flow.

Key Features of InceptionResNetV2:

- Parallel Convolutional Processing: Incorporates 1×1, 3×3, and 5×5 filters to capture intricate details at varying resolutions.

- Residual Connections: Addresses vanishing gradient issues, optimizing learning efficiency.

- Stem Block and Reduction Blocks: Reduce spatial dimensions while enhancing high-level feature

extraction.

- Auxiliary Classifiers: Improve learning efficiency.

- Global Average Pooling: Minimizes model complexity while ensuring spatial invariance before final classification.

- Softmax Activation: Utilized for final disease classification.

Model Training

Experiments were conducted on Google Colab Pro using high-performance GPUs. The training employed transfer

learning, leveraging pre-trained weights on ImageNet for feature extraction.

Training Configurations:

- Loss Function: Categorical Cross-Entropy

- Optimizer: Adam

- Learning Rate: 0.0001

- Early Stopping: Implemented based on lowest validation loss

- Batch Size: 4

- Epochs: 50

The model was assessed using the MOD dataset with and without augmentation, and results were compared with

other existing approaches to evaluate effectiveness.

Results

The InceptionResNetV2 model demonstrated a classification accuracy of 99.51%, surpassing prior methods.

Key Findings:

- Confusion Matrix and ROC Curves: Displayed near-perfect classification across most disease categories.

- Ablation Study: When trained without augmentation, accuracy significantly dropped to 74.07%, underscoring the

importance of data augmentation in improving generalization.

Conclusion

The implementation of InceptionResNetV2 for teeth disease classification yielded highly accurate results,

demonstrating its potential in assisting early diagnosis and medical decision-making. The incorporation of data

augmentation played a crucial role in enhancing the model's predictive capabilities. Future work could explore

larger datasets and additional deep learning architectures to further optimize performance.