ORALCARE-X

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Introduction:

Oral health is a critical aspect of overall well-being, yet it is often overlooked, especially in underserved and remote communities. With over 2.3 billion people worldwide affected by untreated dental caries and other oral conditions, timely and accurate diagnosis has become a pressing global need. Traditional diagnostic methods heavily rely on the visual inspection skills of dental professionals, which may not always yield consistent or early detection results. The increasing elderly population and lack of accessible dental care in many regions further exacerbate this challenge.

To bridge this gap, the OralCareX project proposes an AI-enhanced dental diagnostic system powered by Convolutional Neural Networks (CNN). This system automates the analysis of dental images, enabling rapid, reliable identification of conditions such as caries, calculus, hypodontia, and tooth discoloration. By leveraging deep learning and mobile health technology, the project aims to revolutionize the way dental care is delivered—making diagnostics faster, more accurate, and more inclusive, especially for visually impaired users and those without immediate access to a dentist. The system has been designed as a mobile application integrated with a Django backend and MySQL database, facilitating real-time interaction and feedback.

Objectives:

This project aims to develop an AI-powered tool for accurate and accessible dental diagnostics. The key objectives are:

1. Develop an AI-powered dental diagnostic tool using CNN algorithms.
2. Provide accessible and user-friendly diagnostics for visually impaired individuals.
3. Promote early detection of dental disorders for better health outcomes.
4. Create a portable and affordable device to reach underserved populations.
5. Empower users with real-time feedback and actionable oral health insights.

Methodology:

The development of OralCareX followed a three-phase approach: Data Collection, Analysis, and Implementation. In the data collection phase, primary dental image datasets and diagnostic records were gathered, alongside secondary resources such as dental research papers and clinical guidelines to ensure medical relevance.

The analysis phase focused on image preprocessing and model training. Images were resized (150x150), denoised, and normalized using OpenCV. Feature extraction was carried out using contour detection, and the Region of Interest (ROI) was isolated to train the model more accurately.A CNN (Convolutional Neural Network) model was designed using Keras and TensorFlow. Data labeling was done with LabelEncoder and converted into one-hot encoded formats for classification. The dataset was split using train_test_split into training and validation sets to avoid overfitting and ensure model reliability. ImageDataGenerator was applied to augment the training set using transformations like rotation, zoom, and shifts, improving the model's generalization. The model was trained using callbacks like ModelCheckpoint and EarlyStopping to optimize training time and retain the best performing weights. The trained CNN was then integrated into the backend, and a prediction function was created to process uploaded dental images. This function included grayscale conversion, Gaussian blurring, binary thresholding, contour detection, ROI extraction, and normalization.

Images were passed through the trained model, which returned a probability distribution across five classes: Calculus, Caries, Healthy, Hypodontia, and Tooth Discoloration. Based on the highest probability index, the application provided the disease name as the final output, which was sent back to the mobile app frontend. Finally, the model's performance was validated using evaluation metrics like accuracy and loss graphs to confirm its diagnostic efficiency in real-time scenarios. This structured methodology enabled OralCareX to deliver accurate, fast, and accessible dental diagnostics on a mobile platform.

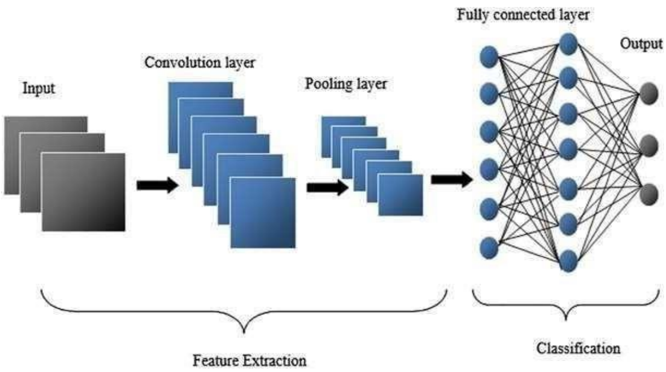

Figure 1.0: Architecture of the CNN Model

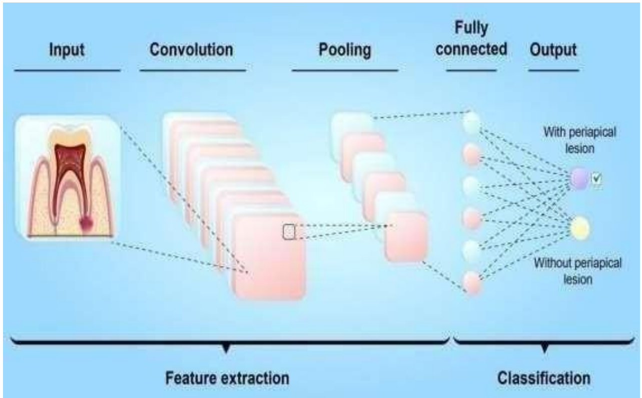

Figure 1.2 : Working of the CNN

Result and Conclusion:

The OralCareX system was rigorously trained and tested using a labeled dataset of dental images. The CNN model achieved a classification accuracy of over 90%, demonstrating strong capability in detecting five major dental conditions: Calculus, Caries, Healthy, Hypodontia, and Tooth Discoloration.

During the evaluation phase, the model showed low loss values, indicating minimal error in predictions. This was visually confirmed through accuracy and loss graphs, which reflected stable learning curves and effective training.A significant outcome was the reduction in diagnostic time. What traditionally took several minutes of manual observation could now be completed in seconds, with reliable and repeatable predictions. User testing was conducted through the integrated mobile application. The application allowed users to upload images, receive predictions, and view personalized feedback. Screenshots from the dashboard, prediction results, and registration pages showcased a clean, intuitive interface.Initial user feedback, particularly from testers with medical and dental backgrounds, praised the system's ease of use and potential clinical value. The app was responsive and provided real-time predictions with high confidence.

The tool's ability to process complex dental images and extract meaningful patterns confirmed the suitability of CNNs in dental diagnostics. The prediction function successfully handled various input image qualities, proving the robustness of the pre-processing pipeline.

Graphical outputs, such as the accuracy vs. loss plots, provided further validation of the system's learning efficiency and generalization ability.OralCareX demonstrates that artificial intelligence, especially deep learning, can significantly enhance dental diagnostics. The system can serve as a valuable support tool for dental practitioners and as an accessible diagnostic alternative in rural or underserved areas.

It not only improves early disease detection but also promotes preventive care, reducing long-term complications and healthcare costs. With continued refinement, OralCareX has the potential to reshape how dental care is delivered and accessed in the future.

Figure 1.3 : Results

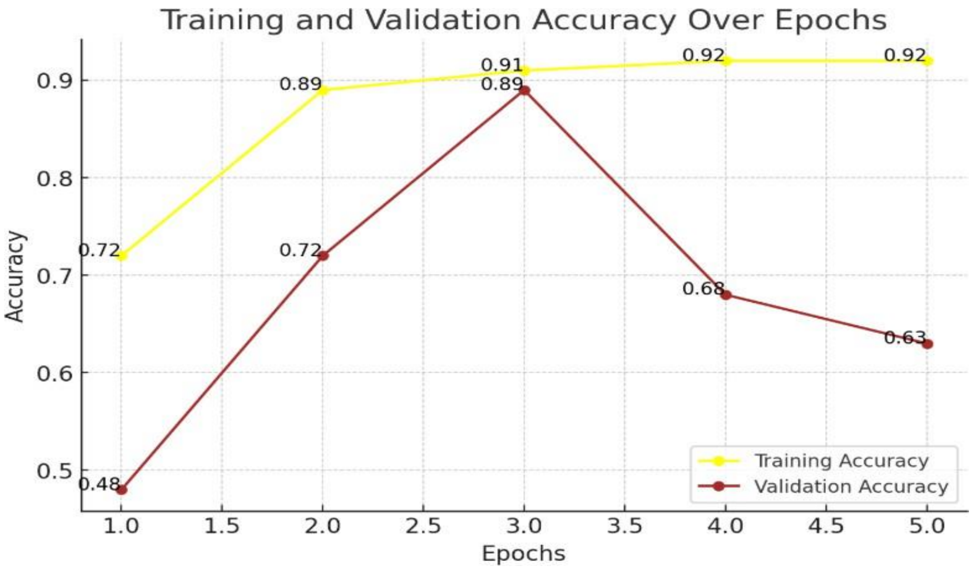

Figure 1.4: Training and Validation Accuracy over Epochs

Project Outcome & Industry Relevance:

OralCareX successfully delivers a smart, AI-powered dental diagnostic system that simplifies disease detection using CNNs. It provides fast, reliable analysis of dental images through a user-friendly mobile interface. The project demonstrates how machine learning can enhance healthcare accessibility and accuracy. Its real-time prediction feature reduces dependency on in-person consultations, supporting early diagnosis. This is especially useful for remote areas where dental professionals are scarce. The system aligns with the industry's growing shift toward AI in medical imaging and mHealth applications. It can serve as a pre-screening tool in clinics, streamlining patient flow and saving time for dentists .The technology is scalable and adaptable for tele-dentistry, mobile clinics, and public health initiatives. By promoting preventive care and timely intervention, it can lower treatment costs and improve patient outcomes. Overall, OralCareX bridges the gap between healthcare innovation and accessibility, making it highly relevant for the dental tech industry.

Working Model vs. Simulation/Study:

The project resulted in a fully functional working model—a mobile application backed by a real-time AI-based diagnostic system. The model accepts image uploads and returns disease predictions, making it suitable for practical use.

Project Outcomes and Learnings:

1. Successfully developed an end-to-end AI-powered diagnostic tool using CNN and integrated it with a mobile interface.

2. Gained experience in machine learning, image preprocessing, backend API development, and Android UI design.

3. Learned to handle real-world challenges in dataset labeling, model tuning, and deployment.

4. Understood the significance of inclusive design and healthcare accessibility.

5. Strengthened team collaboration, project planning, and software lifecycle management skills.

Future Scope:

The OralCareX system has significant potential for future expansion. Upcoming improvements can include:

1. **Dataset Expansion**: Collecting more diverse images across demographics to improve model generalization.
2. **Multilingual Support**: Adding multiple languages in the app interface to cater to users across regions.
3. **Broader Diagnosis**: Including more oral diseases such as oral cancer, gingivitis, or fractured teeth.

4. **Real-Time Expert Connect**: Integrating with telemedicine platforms for live consultations based on diagnostic outputs.
5. **Cloud Integration**: Storing diagnostic records in cloud-based EHRs for long-term patient tracking.
6. **IoT Integration**: Developing smart dental kits with cameras for automatic capture and real-time analysis.
7. **Accessibility Enhancements**: Adding audio-based navigation and voice output for visually impaired users.