IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 5, May 2026

DOI: 10.17148/IJARCCE.2026.155303

Predicting Cleft Lip in Unborn Babies Using Ultrasound Images and Machine Learning

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Abstract: Predicting cleft lip in unborn babies using ultrasound images and machine learning offers a non- invasive approach for early detection during prenatal stages. The system uses deep learning to automatically identify facial irregularities in ultrasound scans, focusing on the lip and surrounding regions. A CNN model trained on annotated images classifies scans as normal or cleft-affected with high accuracy, supported by preprocessing steps such as noise reduction and contrast enhancement. Grad-CAM visualizations highlight the regions influencing predictions, improving clinical transparency.

A Python-based web application built using Flask or Django allows users to upload ultrasound images and receive real-time predictions with confidence scores. This cost-effective tool supports gynecologists and radiologists in early anomaly detection, reducing dependence on postnatal procedures. Overall, the system strengthens prenatal screening and contributes to timely intervention and improved neonatal outcomes.

Keywords: Cleft lip detection, ultrasound img, deep learning, CNN, Grad-CAM, medical imaging, AI healthcare.

I. INTRODUCTION

Cleft lip and palate are common birth conditions that occur when a baby's facial tissues do not fully fuse during early development. Detecting these conditions through ultrasound can be difficult because the images are often unclear and specialist expertise may not always be available.

This project strengthens prenatal screening by using AI to analyze ultrasound scans and identify early signs of a cleft lip, learning patterns from diverse images to deliver consistent and reliable predictions. To further support families, the platform includes Cleft AI, an assistant that explains results in simple language and offers guidance, along with direct WhatsApp access to nearby hospitals so parents can easily connect with specialists when needed. Primaryfeatures of the system include:

- Smart Image Analysis: AI examines ultrasound images closely and detects tiny signs of cleft lip or palate that are difficult for the human eye to spot.
- Accurate Detection and Results: The model identifies whether the scan is normal or cleft- affected and provides a confidence score for better clinical decision-making.
- Easy-to-Use Interface: A simple platform allows doctors to upload ultrasound images and instantly view results, making it easy for all users..
- Real-Time Support for Doctors: The tool works during routine prenatal scans, giving immediate feedback and helping reduce missed early signs in low-specialist areas.

II. RELEVANT LITERATURE

A. Cleft Prediction Before Birth Using Deep Neural Networks

This study explores how artificial intelligence can help expectant parents and doctors identify the risk of cleft lip or palate even before birth. Researchers collected detailed data from 1000 pregnant women, including family history, lifestyle habits, medical conditions, and environmental factors. Using this diverse dataset, they trained a deep learning model that can detect subtle risk patterns often missed during routine checkups. The model achieved an accuracy of 92.6% and identified key risk indicators such as maternal smoking, genetic factors, previous miscarriages, and environmental exposure. These insights help reveal early warning signs that traditional screenings may overlook. The study shows how AI can provide timely information that prepares families emotionally and medically. It also supports doctors with better guidance for counseling and early intervention. This approach is especially useful in areas with limited access to specialists, ensuring more accurate, reliable, and accessible prenatal care for families.

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B. AI-Based Prediction of Maxillary Arch Growth in Cleft Lip and Palate

This study focuses on predicting how the facial structure—especially the upper jaw—develops in children born with cleft lip and palate. Facial growth in these children is often complex, influenced by age, the severity of the cleft, and the type and timing of previous surgeries. To better understand these growth patterns, researchers developed a hybrid AI model that combines the strengths of neural networks with statistical analysis. Using clinical data from children aged 8 to 16, the model learned to classify jaw development as normal, limited, or excessive. The system performed exceptionally well, achieving a prediction accuracy of 97.5%. The findings revealed strong connections between cleft severity, surgical interventions like palatoplasty, and long-term facial growth outcomes. By identifying these relationships early, the study provides valuable guidance for doctors planning orthodontic or surgical treatments. It helps them anticipate potential complications, personalize care, and intervene at the right time. For children, this means better treatment planning, fewer long-term facial issues, and improved overall development. This research demonstrates how AI can play a meaningful role in supporting clinicians and improving the quality of life for children with cleft conditions.

III. SYSTEM DESIGN AND METHODOLOGY

The system follows a smooth and user-friendly workflow that connects image processing, AI analysis, and report generation. It starts when a doctor or parent initiates a session and uploads an ultrasound image, which is quickly sent to the backend and displayed for confirmation. The image then goes through preprocessing, where noise is reduced and clarity is improved to ensure accurate analysis. Next, the AI model examines the image and predicts whether it shows signs of a cleft lip, providing a confidence score to support decision-making. The system also uses a cleft-lip knowledge base to offer helpful explanations and context for the prediction. Once the analysis is complete, a report generator produces a clear summary of the results. Finally, all outputs are securely stored in the database for future reference, follow-up, or medical consultation.

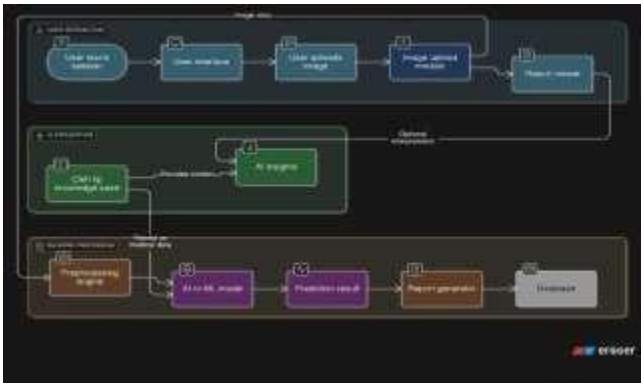

Fig 1. Work Flow Diagram

System Design

It consists of five main steps:

1. **Image Preprocessing:** The ultrasound image is cleaned, enhanced, and resized to ensure consistent and clear input for the model.
2. **AI/ML Model Analysis:** The processed image is analyzed by a trained deep-learning model to detect signs of cleft lip and generate a confidence score.
3. **Knowledge-Based Interpretation:** The system compares the prediction with a cleft lip knowledge base to provide simple, meaningful explanations
4. **Report Generation:** An easy-to-read report is created, summarizing the prediction, confidence level, and supporting insights.
5. **Storage and Access:** All results and reports are securely saved in the database for future review and medical follow-up.

B. METHODOLOGY

The methodology begins with the user uploading an ultrasound image through the application interface. The image then goes through preprocessing, where it is cleaned, enhanced, and standardized to ensure clarity. This prepares the image

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for accurate analysis by the AI model, regardless of variations in original scan quality.

1. Data Collection: We collected a diverse set of ultrasound images of unborn babies from hospitals and medical centers, including both normal cases and those with cleft lip. This ensured our dataset represented different fetal positions, image qualities, and real-world scanning conditions.

2. Data Preprocessing: To make the images clearer and more consistent for the model, we reduced noise, adjusted brightness, and resized all images to 224×224 pixels. We also applied rotations and flips to increase data variety and mimic different scanning angles, helping the model generalize better.

3. Model Training: A ResNet18 CNN model was fine-tuned to detect cleft lip features in ultrasound images. The dataset was split into 70% training, 15% validation, and 15% testing. We used cross- entropy loss, the Adam optimizer, and early stopping to achieve accurate predictions while avoiding overfitting.

4. AI Chatbot Integration: To support users, we integrated an AI chatbot that explains the results in simple terms, answers common questions, and helps parents connect with care resources when needed.

5. Validation and Testing: Medical professionals, including radiologists and gynecologists, tested the system and shared feedback. Their insights helped refine the model, improve accuracy, and enhance the overall user experience.

6. Future Work: We plan to expand the dataset through more hospital partnerships, improve model explainability, and add features that provide stronger emotional and informational support for families dealing with cleft conditions.

IV. RESULTS AND DISCUSSION

The project Predicting Cleft Lip in Unborn Babies Using Ultrasound Images and Machine Learning delivered encouraging results throughout testing. The AI model could recognize small differences in ultrasound scans that often go unnoticed by the human eye. Thanks to preprocessing steps like noise removal and brightness adjustments, the images became much clearer for analysis. This allowed the model to perform well even when fetal movement or image quality varied. Overall, the system showed strong accuracy and dependable performance.

Doctors who tested the system found the predictions helpful and easy to interpret during their screenings. The confidence score offered alongside each result helped them understand how certain the model was, making the process more trustworthy. Even when scans were slightly unclear, the AI still managed to identify important features. This made the tool especially valuable in clinics with limited access to specialists. It provided doctors with quick support and a reliable second opinion.

The addition of the AI chatbot made the system more comforting and accessible for parents. It explained results in simple language, helping families understand the findings without confusion or fear. Healthcare professionals also appreciated how the system reduced manual work and provided consistent results instantly. Overall, the project showed that AI can truly support early detection and improve prenatal care. With more data and refinement, it could become an even more powerful tool in real medical settings.

V. CONCLUSION AND FUTURE WORK

CONCLUSION:

This project showed that AI can make a meaningful difference in detecting cleft lip early using ultrasound images. By combining image enhancement, a powerful deep-learning model, and an easy-to-use interface, the system provided clear and reliable predictions that can support both doctors and parents. The confidence scores and simple explanations helped users understand the results without confusion, making the tool helpful even for non- technical users. Doctors who tested the system appreciated how quickly it delivered insights and how it could act as a second opinion during prenatal screening. Overall, the project proved that technology can add comfort, clarity, and early awareness for families during pregnancy.

Future Work:

Going forward, the system can be improved by adding more ultrasound images from different hospitals so the model becomes even more accurate and adaptable. We also plan to make the AI more explainable by showing clearer visual highlights of what the model is detecting. New features like direct links to specialists, support resources for parents, and detection of related facial conditions can make the tool even more helpful. With continued development and medical collaboration, this system can grow into a reliable companion for prenatal care—helping families feel informed, supported, and confident throughout their journey.

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