AI-Based Pediatric Pneumonia Detection Using Chest X-Ray Image on FPGA Board

Presented by: Anshika Naik, Aditi Padhy, Debanjan Deb, Rayan Qamar
Electronics & Computer science Engineering
Guided by: Prof.Amit Bakshi
School of Electronics Engineering
Kalinga Institute of Industrial Technology (Deemed to be University), Bhubaneswar

GROUP CODE
OLM_33

Introduction

- Urgent need for fast, reliable, and accessible pneumonia diagnosis, particularly in pediatric cases where early detection plays a critical role in saving lives.
- Manual interpretation of chest X-ray images is time-consuming and susceptible to human error, highlighting the importance of automated AI-driven diagnostic solutions.
- A convolutional neural network (CNN) is trained in MATLAB to perform accurate pneumonia detection from chest X-ray images.
- Deployment of the trained model on an Artix-7 FPGA enables real-time hardware acceleration with low latency, improved energy efficiency, and suitability for practical healthcare environments.

Objectives

- To develop and validate a CNN-based pneumonia detection system using pediatric chest X-ray images in MATLAB.
- To deploy the trained model on an Artix-7 FPGA for real-time, low-latency, and energy-efficient medical diagnosis.

Societal Impact

- Enables early pneumonia detection in children, supporting faster clinical intervention and reduced mortality rates.
- Contributes to the development of portable, low-power medical technology and advances research in AI-driven healthcare diagnostics.

Methodology

- Training and validation of the CNN model using MATLAB Deep Learning Toolbox on chest X-ray images.
- Freezing of the finalized CNN architecture and learned weights after performance verification.
- Implementation of the trained model in Vivado for deployment on the Artix-7 FPGA board.
- Overall system flow: chest X-ray input → image preprocessing → CNN inference → FPGA-based real-time pneumonia detection.

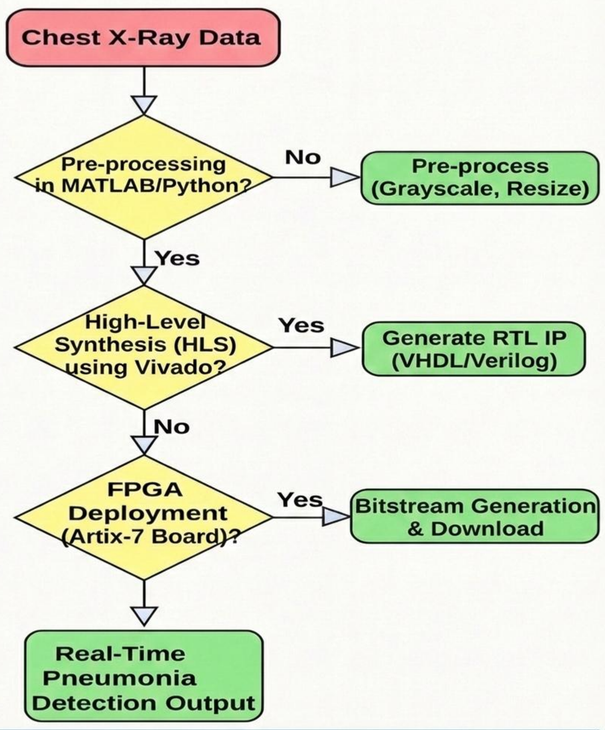


Fig. 1: Pneumonia Detection System on FPGA Artix-7

Experimental/Simulation Outcome

- CNN trained and validated in MATLAB using pediatric chest X-ray images, achieving reliable classification accuracy.
- Final CNN architecture and trained weights were frozen for hardware translation.
- Vivado simulations confirmed successful mapping of the CNN onto the Artix-7 FPGA with efficient resource utilization and low latency.

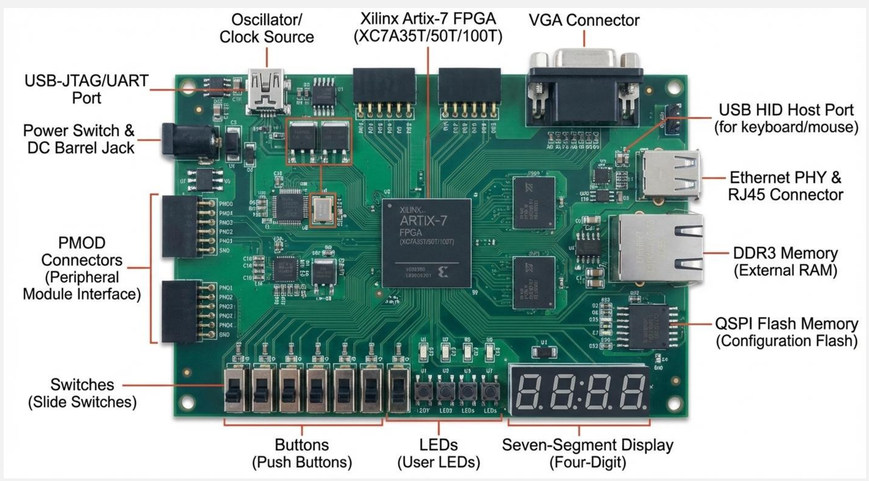
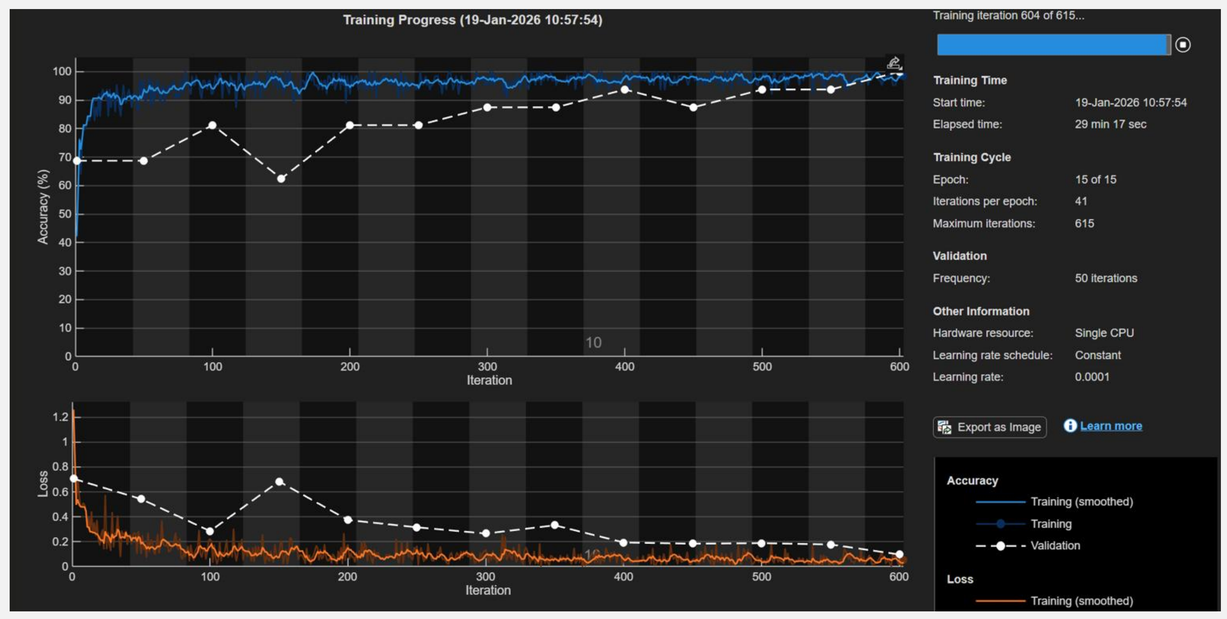


Fig. 2: Xilinx Artix-7 FPGA Development Board with On-Board Peripherals

Fig.3: CNN Training and Validation Performance for Pneumonia Detection.



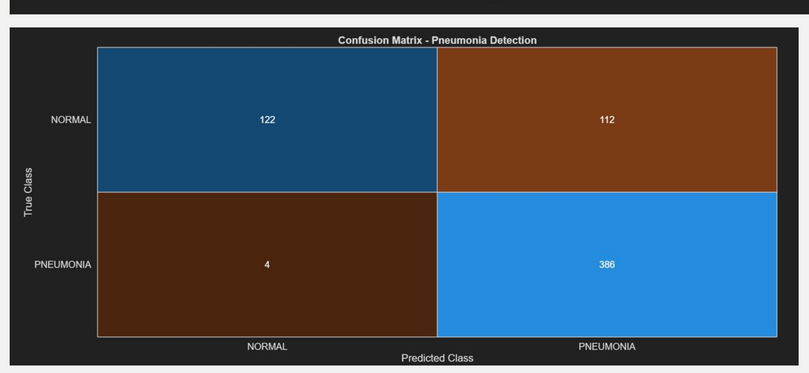


Fig.4 : Confusion Matrix of CNN-Based Pneumonia Detection Model.

Conclusions

- Successful demonstration of a CNN-based pneumonia detection system deployed on an Artix-7 FPGA with real-time, low-latency, and energy-efficient performance.
- Effective integration of MATLAB-based CNN training with hardware implementation using Vivado for practical deployment.
- Scope includes improved accessibility to automated medical diagnosis through portable AI-driven systems.
- Constraints involve FPGA resource limitations and dependency on the size and diversity of the dataset.

Future Work

- Optimization of CNN architecture for efficient FPGA resource utilization and improved hardware performance.
- Extension of the system to support multi-disease detection using chest X-ray images.
- Integration of larger, diverse datasets and wireless connectivity for enhanced robustness and remote healthcare monitoring.

References

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