# 3D POINT CLOUDS ON EMBEDDED PLATFORMS

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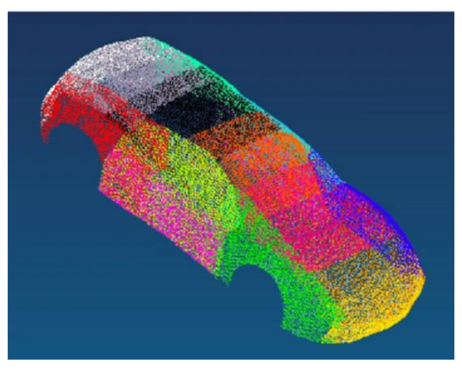
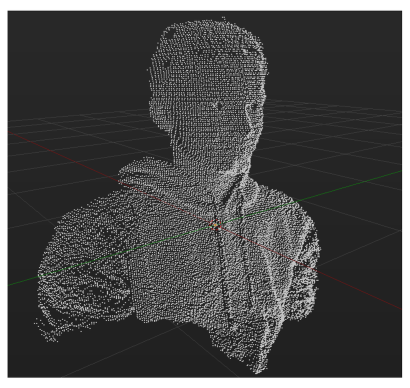
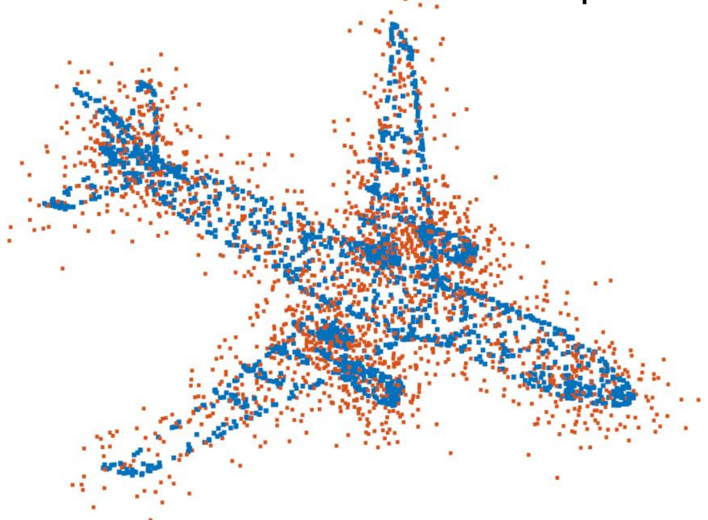
## Introduction

AI accelerators via FPGA are fueling deep learning on 3D point clouds, revolutionizing LIDAR-powered autonomous vehicles and emerging AR/VR fields. This project focuses on:

- Building a framework for implementing 3D point cloud DL models on FPGAs
- Building a high-level synthesis library with the supported algorithms
- Demonstrating novel hardware results with SOTA 3D point cloud model PointMLPElite

## Methodology

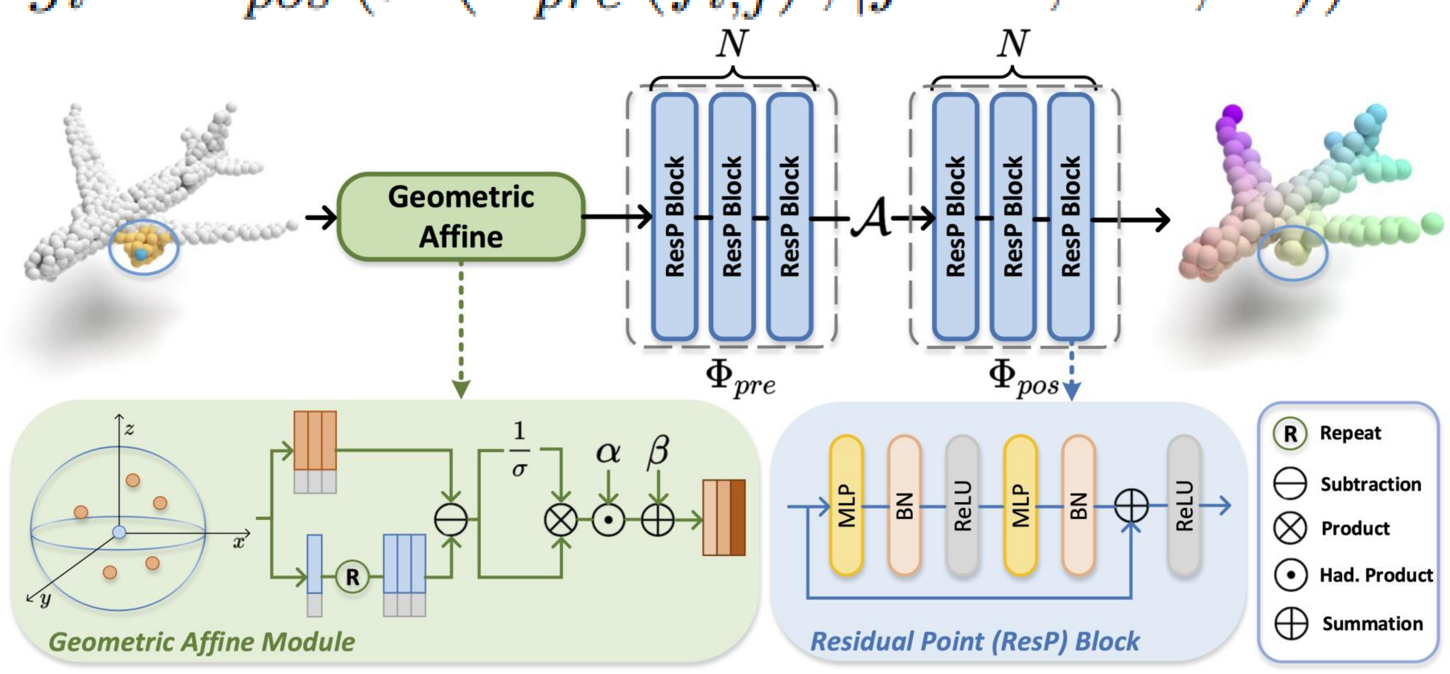
**PointMLPElite**

PointMLP is the state of the art 3D point cloud deep learning model. Some of its features are:

- Lightweight geometric affine module
- Novel normalization layer with learnable parameters that improve performance drastically
- Simple MLP structure with reconfigurable depth

PointMLP has the following kernel function:

$$g_i = \Phi_{pos}\left(\mathcal{A}\left(\Phi_{pre}\left(f_{i,j}\right), |j = 1, \cdots, K\right)\right)$$




**Software Optimization**

Next, we compress & optimize the model at software level by:

- Quantizing its weights, biases, activations, & geometric parameters
- Fusing CONV-BN layers, reducing number of input points

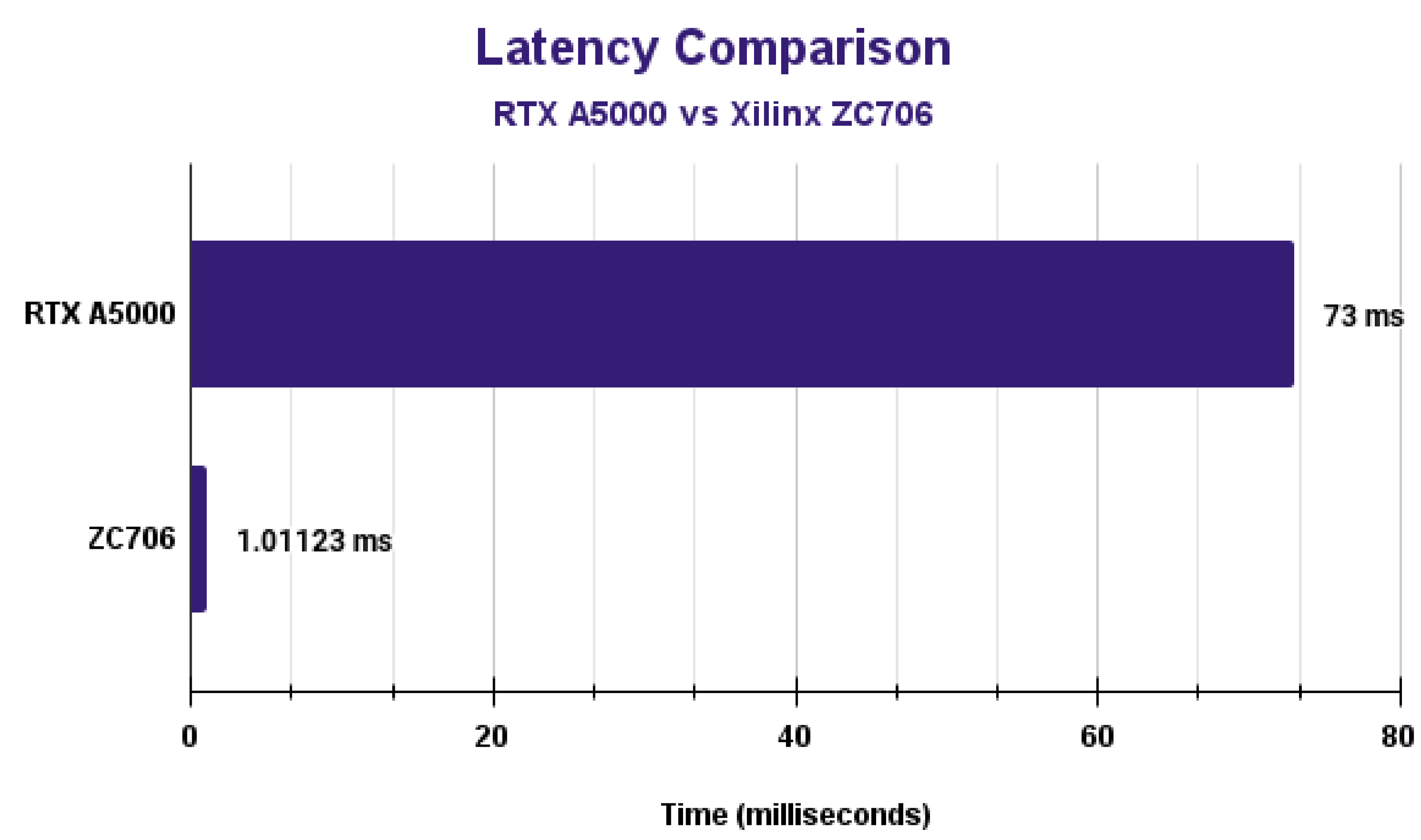
**Hardware Implementation**

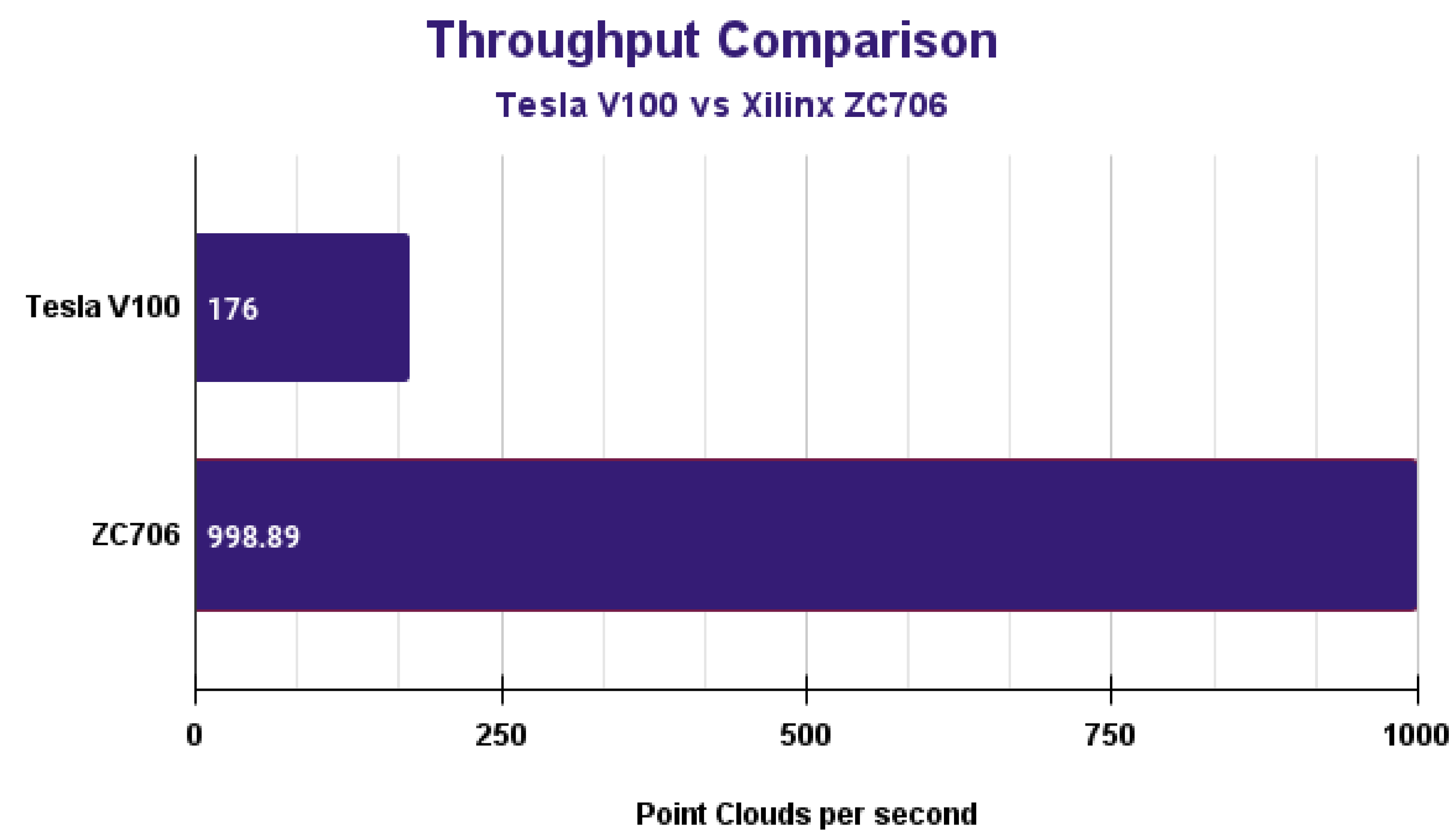
We use high-level synthesis to create the RTL for our mod el. For this purpose, the optimized algorithms are written in HLS C++ using Xilinx Vivado HLS 2018.3. This implementation includes:

- Linear Feedback Shift Registers (LFSRs)
- Streaming k-Nearest Neighbors, Normalization

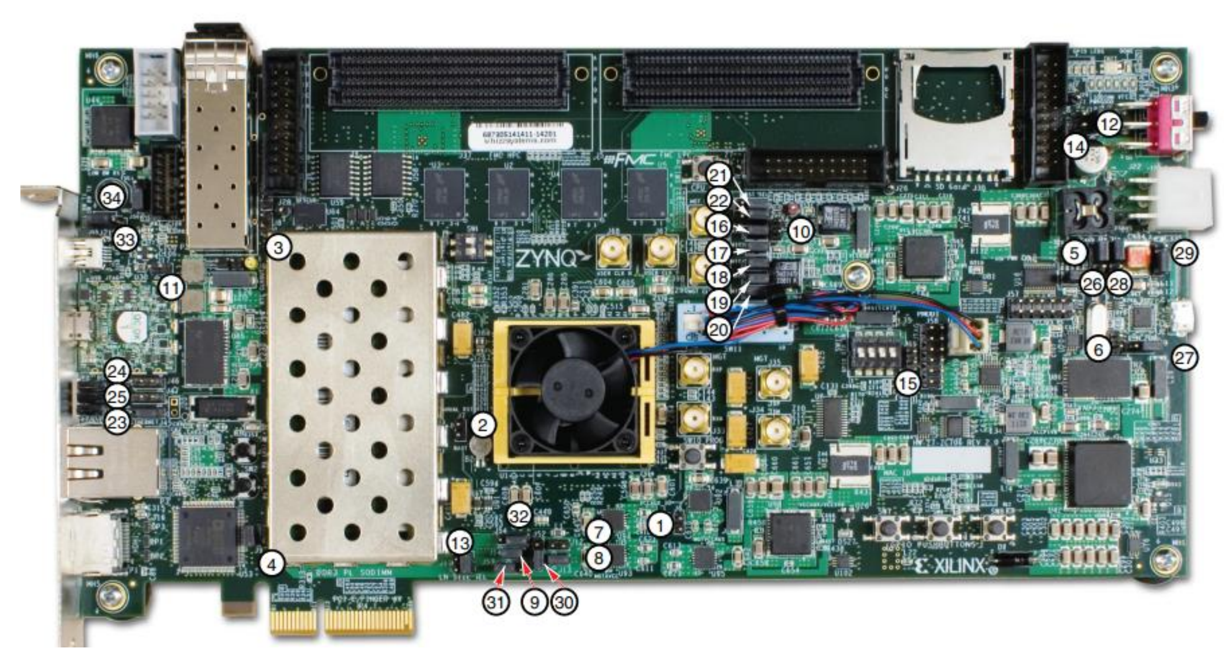
## Results & Discussion

**Xilinx ZC706** is used to accelerate **PointMLPElite** on **ModelNet40** dataset. Significant performance gain is observed:




- ***73x improvement in latency vs. NVIDIA RTX A5000***
- ***5.61x increase in throughput vs. NVIDIA Tesla V100***



- Low power consumption of **0.575W**