# AlphaNet: Architecture, Models, and Applications

Final Presentation, June 2020
Major Project (CSE–419 and CSE–429)
MANIT, Bhopal (India) – 462003

# Outline

- About Project
- About Team
- Proposed Work
- Novelties in the project
- Methodology and Architecture (Dataset and Loss function)
- Results
- Conclusion
- Further Readings

# About Project

- So called “major” project; it is actually huge!
- Innovation expected; Novelty in the elements of research required
- Hands-on theoritical and practical contributions
- *Delieverables:* Application, Report, Presentation, Code, etc.
- Preparation of a thesis/paper based on the project
- No. of credits: 2 for CSE-429 and 1 for CSE-419
- Open Source wherever seems appropriate :)

# About Team

- Team members:
  - Adya Sharma (161112102) CSE-1
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  - Ankit Chouhan (161112051) CSE-1
  - Avinash Mahawar (161112048) CSE-1
- Supervisor:
  - Prof. Bholanath Roy (Dept. of CSE, MANIT Bhopal)
  - Prof. Sweta Jain (Dept. of CSE, MANIT Bhopal)
- Reviewers and Coordinators:
  - Prof. Saritha Khetawat (Dept. of CSE, MANIT Bhopal)
  - Prof. Sanyam Shukla (Dept. of CSE, MANIT Bhopal)

# Proposed Work

- Theoritical works
  - Alpha-net: Framework, Design Architecture
    - Improvements over traditional RESNETs (RESNET-32, etc.)
    - For plain networks and block networks
  - Analysis and Modeling with novelties
- Practical works
  - Implementation of Alpha-Net v1, v2, v3, and v4
  - Quantitative analysis over previous architectures and different techniques

# Novelties in the project

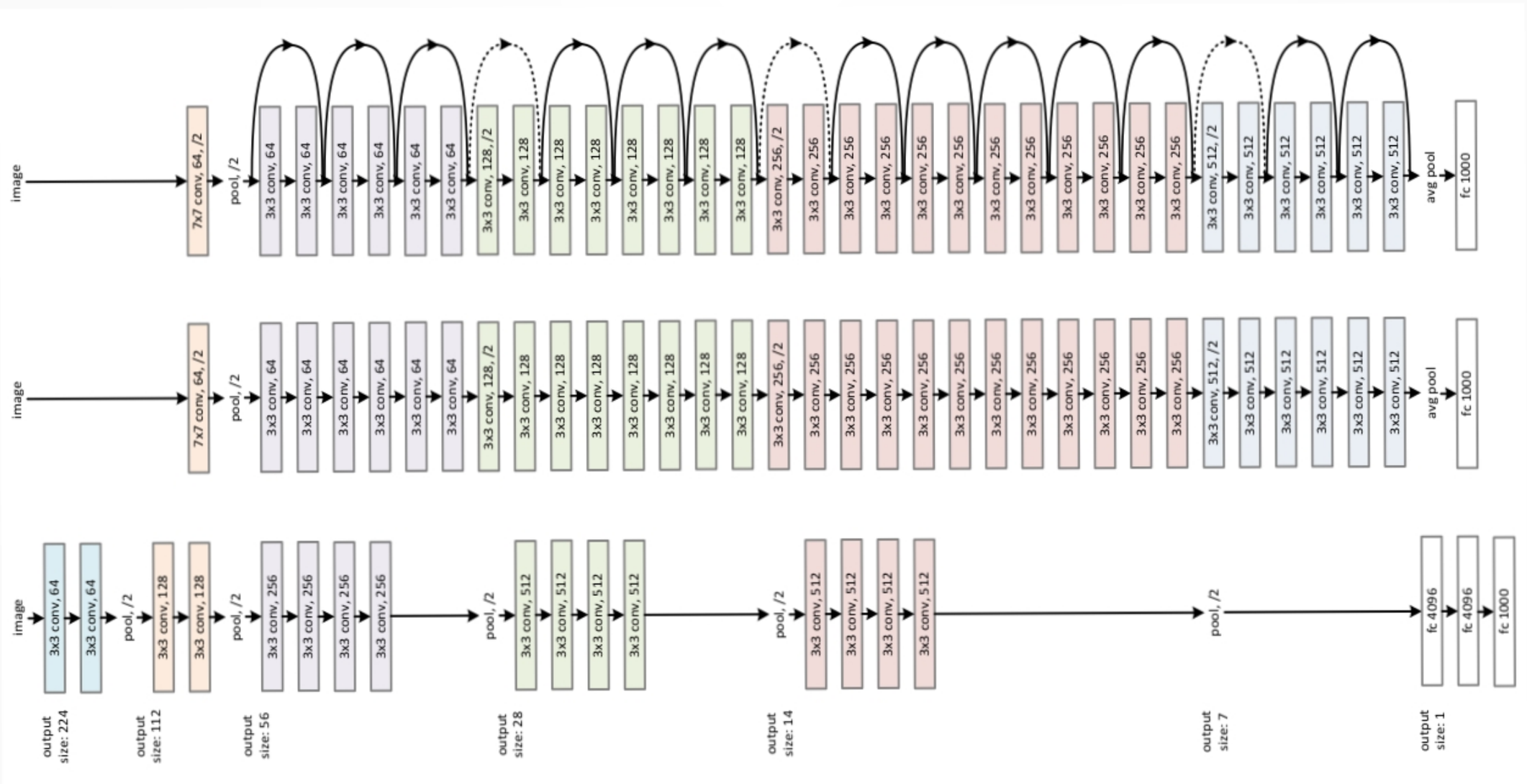
- Normalization function – Alpha-encoding
  - Better than log-scaling and z-score normalization in accuracy
- Loss function – Additive Margin Softmax + Linear weights
  - Better than Softmax and AM Softmax in accuracy
- Layer interconnection – Stochastic Manner
  - Better than linear interconnection in data per layer complexity
- Dataset – Hybrid benchmark similar to that of ImageNet
  - Better training complexity because of simple and small representation (Alpha-blocks and convolutions)

# Alpha-Net: Architecture

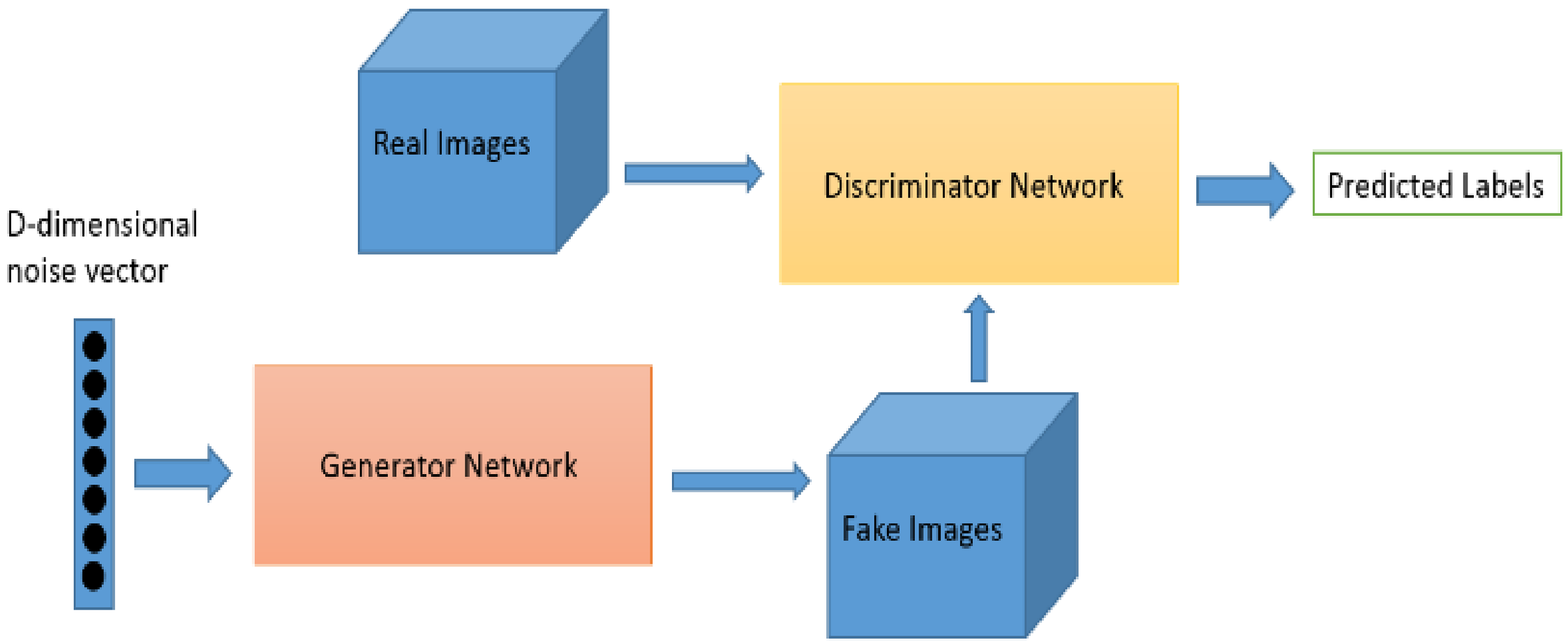
## Alpha transforms (over convoluted layers)

- For normalization of data for lesser feature vector size
  - Stochastic Interconnection between layers
  - Data flow according to Alpha blocks
- Architecture
  - Novel loss function (AM Softmax + Linear weights)
  - Alpha-encoding in preprocessing
  - Diagram (...continued)

# 34-layer linear plain structure



# Alpha-Net: GAN Dataset



# Alpha-Net: Novel loss function

$$\Lambda_{AMS} = -\frac{1}{n}\sum_{i=1}^{n} \frac{e^{s(cos\theta_{y_i}-m)}}{e^{s(\cos\theta_{y_i}-m)} + \sum_{j=1,j\neq y}^{c} e^{s\cos\theta_j}}$$

For linear weights ($y = ax_1 + c$), we can add a piece-wise division of it to make AM Softmax function with linear weights trained on ImagNet benchmark, as follows:

$$\Lambda_{AMS} = \begin{cases} -\frac{1}{n}\sum_{i=1}^{n} \frac{e^{s(cos\theta_{y_i}-m)}}{e^{s(\cos\theta_{y_i}-m)} + \sum_{j=1,j\neq y}^{c} e^{s\cos\theta_j}} & \theta - m > 0 \\ ax_i + c & \theta - m <= 0 \end{cases}$$

Where:

$\Lambda_{AMS}$ = Calculated Loss

$n$ = Training instances

$\theta$ = Angle with the origin

$m$ = Gradient for the instance

$s$ = Sample value of the current instance

$a$ and $c$ = Linear weight coefficients

**Excerpt from report**

# Results (1 of 4)

| Architecture | No. of Layers | Layer structure (Top 1 Accuracy) | | |
|---|---|---|---|---|
| | | Plain | Residual Blocks | Alpha Blocks |
| Alpha-Net v1 | 128 | 75.1% | 78.2% | 79.0% |
| Alpha-Net v2 | 256 | 76.2% | 76.3% | 79.2% |
| Alpha-Net v3 | 512 | 76.3% | 76.5% | 79.5% |
| Alpha-Net v4 | 1024 | 72.1% | 76.1% | 77.5% |

Table 6.1: Accuracy comparison of Alpha-Net models vs Layer structure.

# Results (2 of 4)

| Architecture | No. of Layers | Loss Function (Top 1 Accuracy) | | |
|---|---|---|---|---|
| | | Softmax | AM Softmax | AM Softmax + Linear Weights |
| Alpha-Net v1 | 128 | 72.1% | 74.3% | 76.2% |
| Alpha-Net v2 | 256 | 71.3% | 74.3% | 77.1% |
| Alpha-Net v3 | 512 | 72.1% | 74.3% | 77.2% |
| Alpha-Net v4 | 1024 | 71.2% | 73.1% | 75.1% |

Table 6.2: Accuracy comparison of Alpha-Net models vs Loss function.

# Results (3 of 4)

| Architecture | No. of Layers | Normalization (Top 1 Accuracy) | | |
|---|---|---|---|---|
| | | log-scaling | z-score | Alpha-encoding |
| Alpha-Net v1 | 128 | 69.2% | 71.2% | 71.0% |
| Alpha-Net v2 | 256 | 69.5% | 70.1% | 71.2% |
| Alpha-Net v3 | 512 | 70.1% | 70.1% | 71.5% |
| Alpha-Net v4 | 1024 | 71.2% | 69.5% | 70.5% |

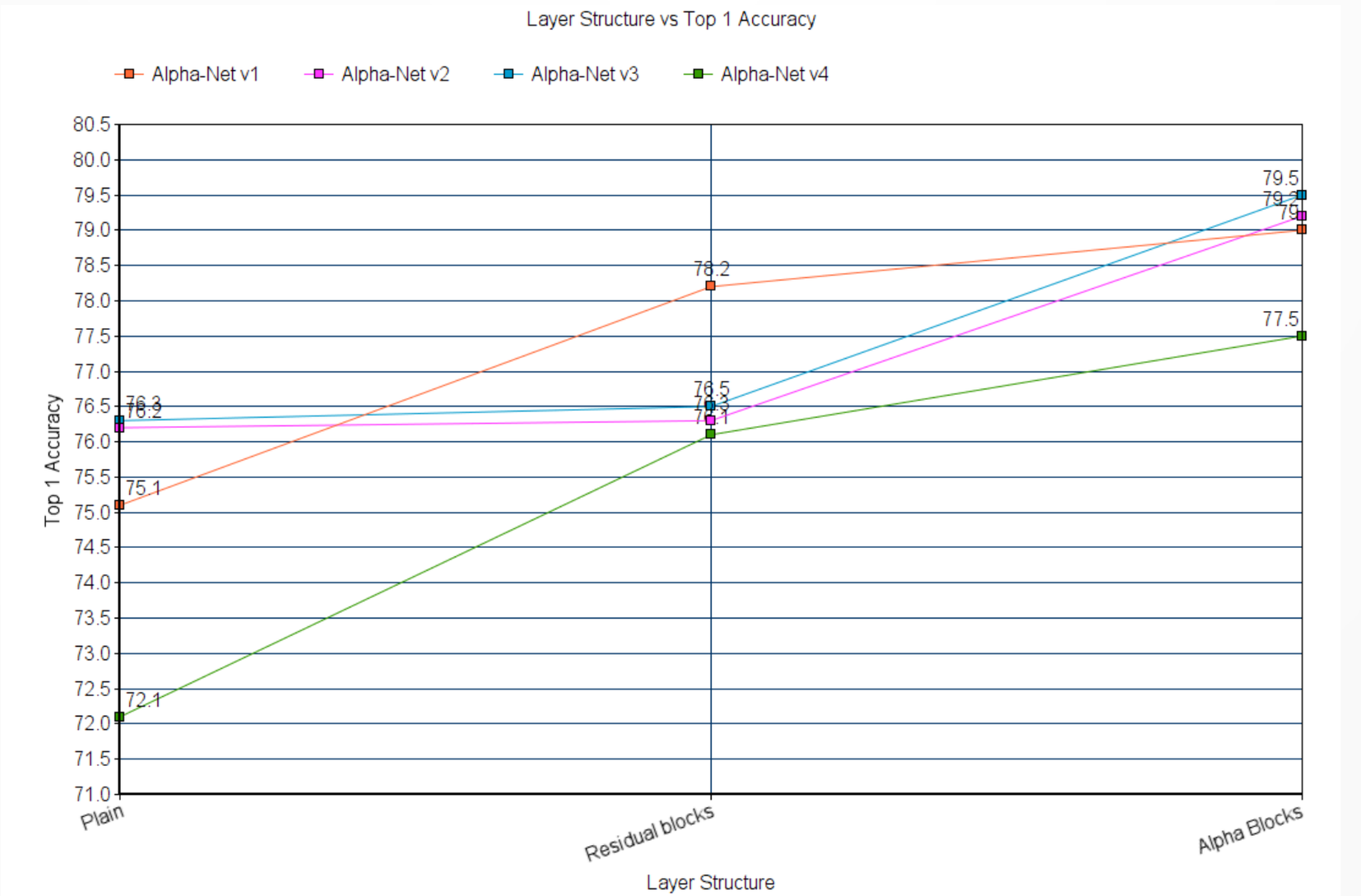
Table 6.3: Accuracy comparison of Alpha-Net models vs Normalization function.

# Results (4 of 4)

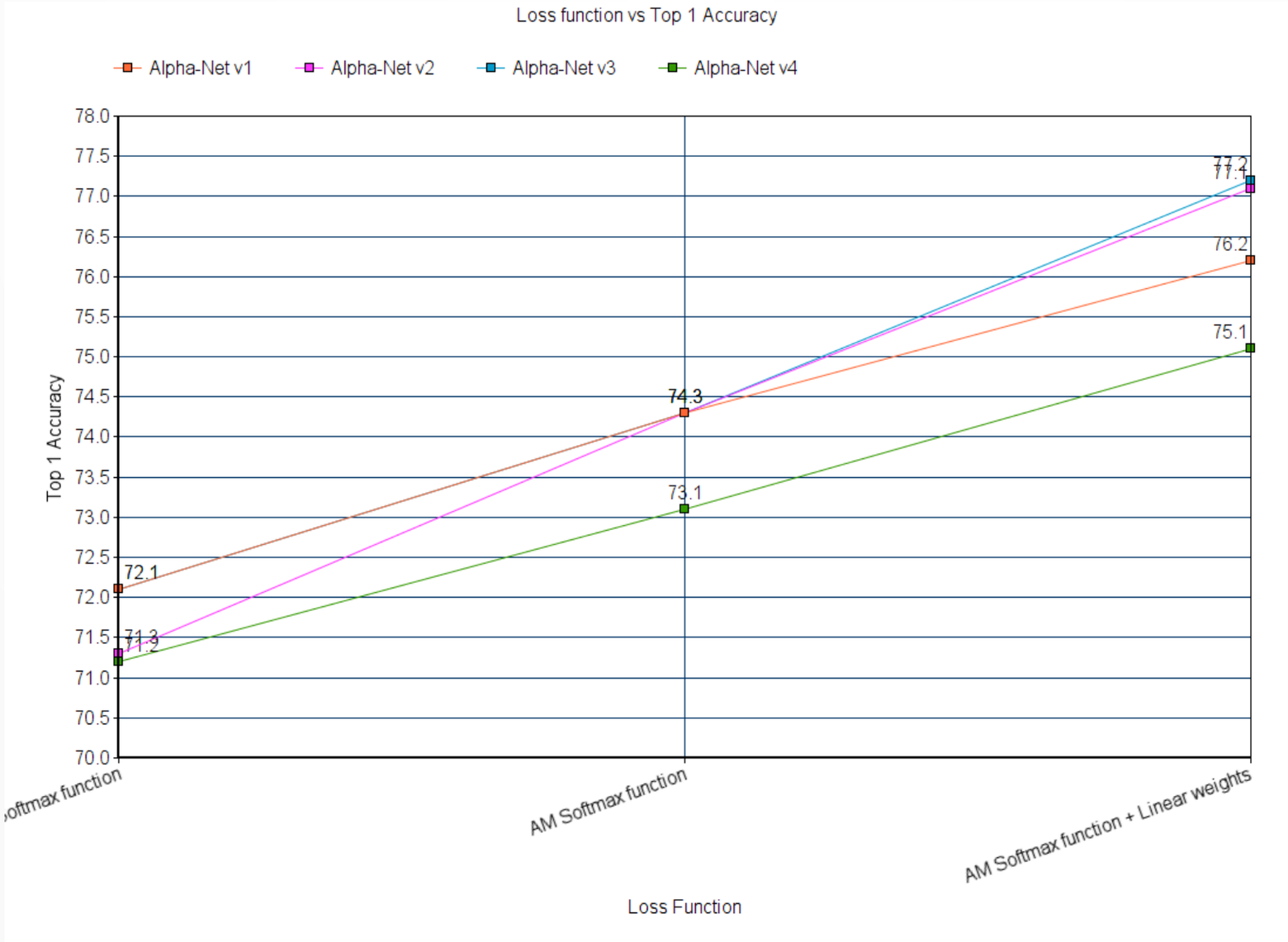
| Architecture | Top 1 Accuracy |
|---|---|
| Xception | 79.0% |
| Inception v3 | 78.8% |
| ResNet 50 | 75.9% |
| VGG 19 | 72.7 |
| VGG 16 | 71.5 |
| InceptionResNet v2 | 80.4% |
| Alpha-Net v1 | 78.2% |
| Alpha-Net v2 | 79.1% |
| Alpha-Net v3 | 79.5% |
| Alpha-Net v4 | 78.3% |

Table 6.4: Accuracy comparison of various architectures

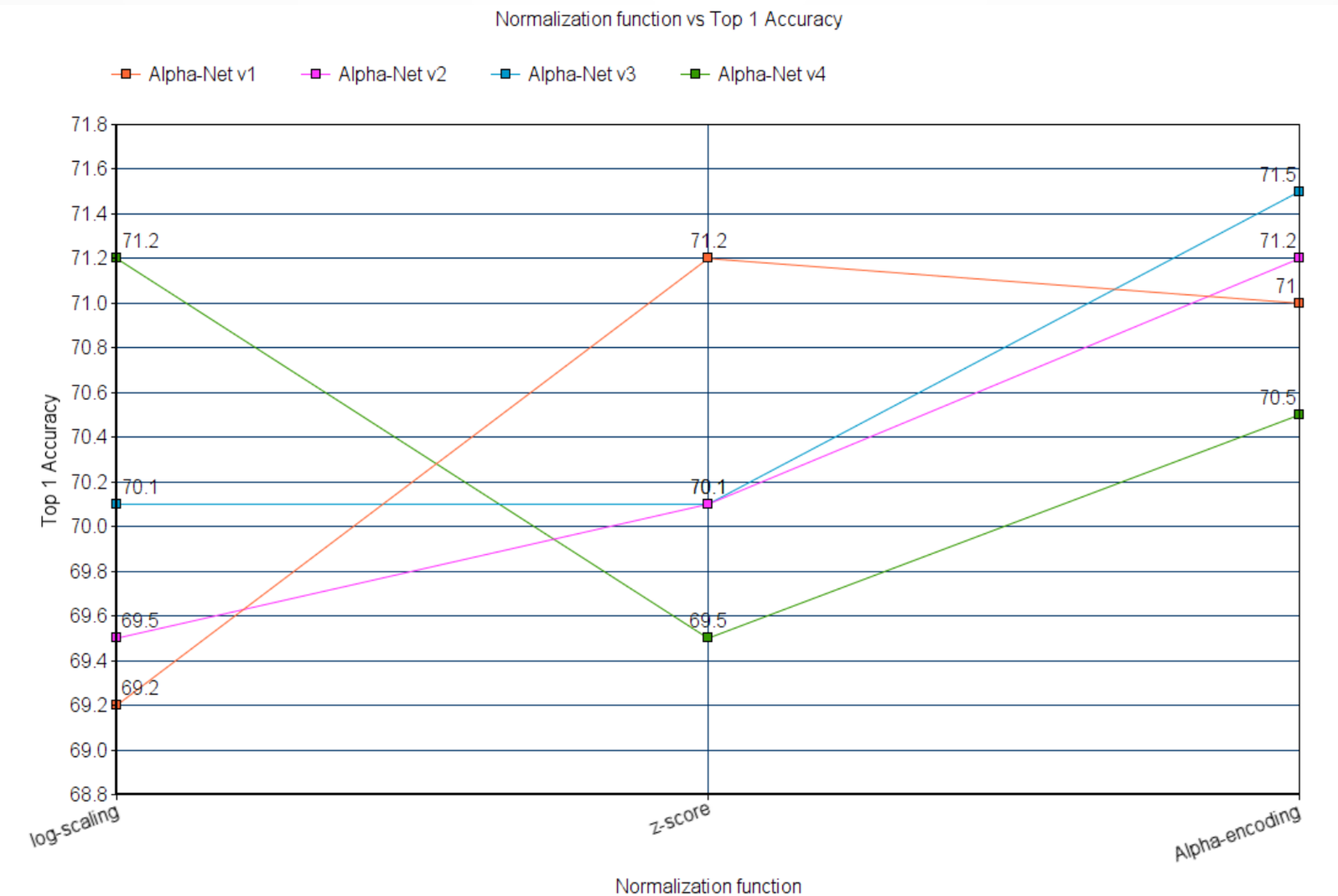
# Graphs (1 of 4)


Layer Structure vs Top 1 Accuracy
Alpha-Net v1
Alpha-Net v2
Alpha-Net v3
Alpha-Net v4
Top 1 Accuracy
80.5
80.0
79.5
79.0
78.5
78.0
77.5
77.0
76.5
76.0
75.5
75.0
74.5
74.0
73.5
73.0
72.5
72.0
71.5
71.0
78.2
79.5
77.5
76.5
76.3
76.2
75.1
72.1
Plain
Residual blocks
Alpha Blocks
Layer Structure

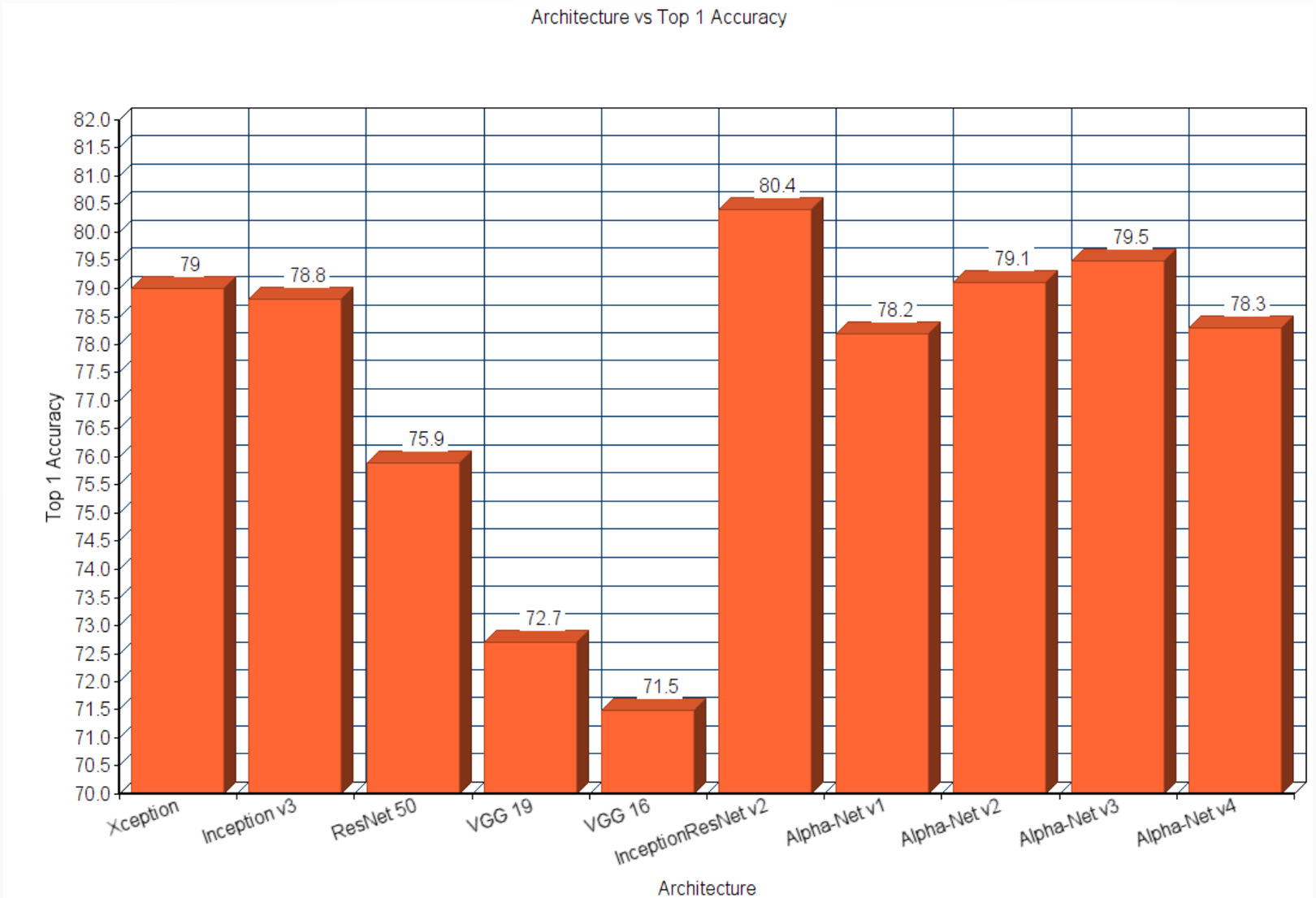
# Graphs (2 of 4)


Loss function vs Top 1 Accuracy
Alpha-Net v1
Alpha-Net v2
Alpha-Net v3
Alpha-Net v4
Top 1 Accuracy
78.0
77.5
77.0
76.5
76.0
75.5
75.0
74.5
74.0
73.5
73.0
72.5
72.0
71.5
71.0
70.5
70.0
72.1
71.3
71.2
74.3
73.1
77.2
77.1
76.2
75.1
oftmax function
AM Softmax function
AM Softmax function + Linear weights
Loss Function

# Graphs (3 of 4)


Normalization function vs Top 1 Accuracy
Alpha-Net v1
Alpha-Net v2
Alpha-Net v3
Alpha-Net v4
71.8
71.6
71.4
71.2
71.0
70.8
70.6
70.4
70.2
70.0
69.8
69.6
69.4
69.2
69.0
68.8
Top 1 Accuracy
71.2
71.2
71.5
71.2
71
70.5
70.1
70.1
69.5
69.5
69.2
log-scaling
z-score
Alpha-encoding
Normalization function

# Graphs (4 of 4)


Architecture vs Top 1 Accuracy
Top 1 Accuracy
82.0
81.5
81.0
80.5
80.0
79.5
79.0
78.5
78.0
77.5
77.0
76.5
76.0
75.5
75.0
74.5
74.0
73.5
73.0
72.5
72.0
71.5
71.0
70.5
70.0
79
78.8
75.9
72.7
71.5
80.4
78.2
79.1
79.5
78.3
Xception
Inception v3
ResNet 50
VGG 19
VGG 16
InceptionResNet v2
Alpha-Net v1
Alpha-Net v2
Alpha-Net v3
Alpha-Net v4
Architecture

# Conclusion

- Designed Alpha-Net: Architecture with novel loss function, layer arrangements, normalization function, etc.
- Implemented 4 models – Alpha-Net v1, v2, v3, and v4 based on Alpha-Net architecture with 128, 256, 512, and 1024 layers.
- Novel loss function: Additive margin Softmax + Linear weights.
- Quantitative analysis of Top 1 Accuracy with different layer structures, different normalization functions, and differnt loss functions.
- Comparisons with different architectures previously proposed.
- Custom dataset with ImageNet benchmark as an inspiration + large size
- Application of network ranges to a broad set of training tasks.

# Thank you.

# Questions?