Prediction of Centroid Pixel Values in Image Triangulations Using a Graph Neural Network

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- PhD candidate dealing with:
  - Artificial Intelligence,
  - Data Compression,
  - Big Data Analysis

Motivation

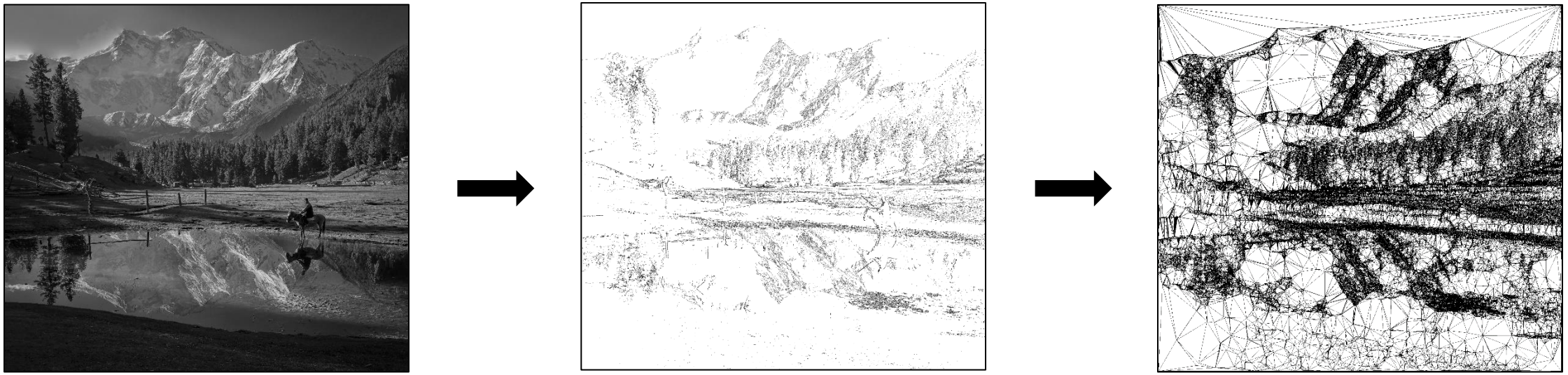
- Prediction → Better compression ratios
- Most predictions operate on ordered data
- Image triangulations not ordered
- Conventional prediction methods not directly applicable

Graph Neural Network (GNN)

- Machine learning method, operating on a graph domain
- Well-suited for unstructured data
- Modern & popular architecture used for:
  - materials science,
  - recommendation systems,
  - natural phenomena forecasting,
  - image classification,
  - image clustering,
  - etc.

Method

- Three major parts:
  - detection of key pixels,
  - graph construction,
  - centroid pixel values' prediction



Detection of Key Pixels

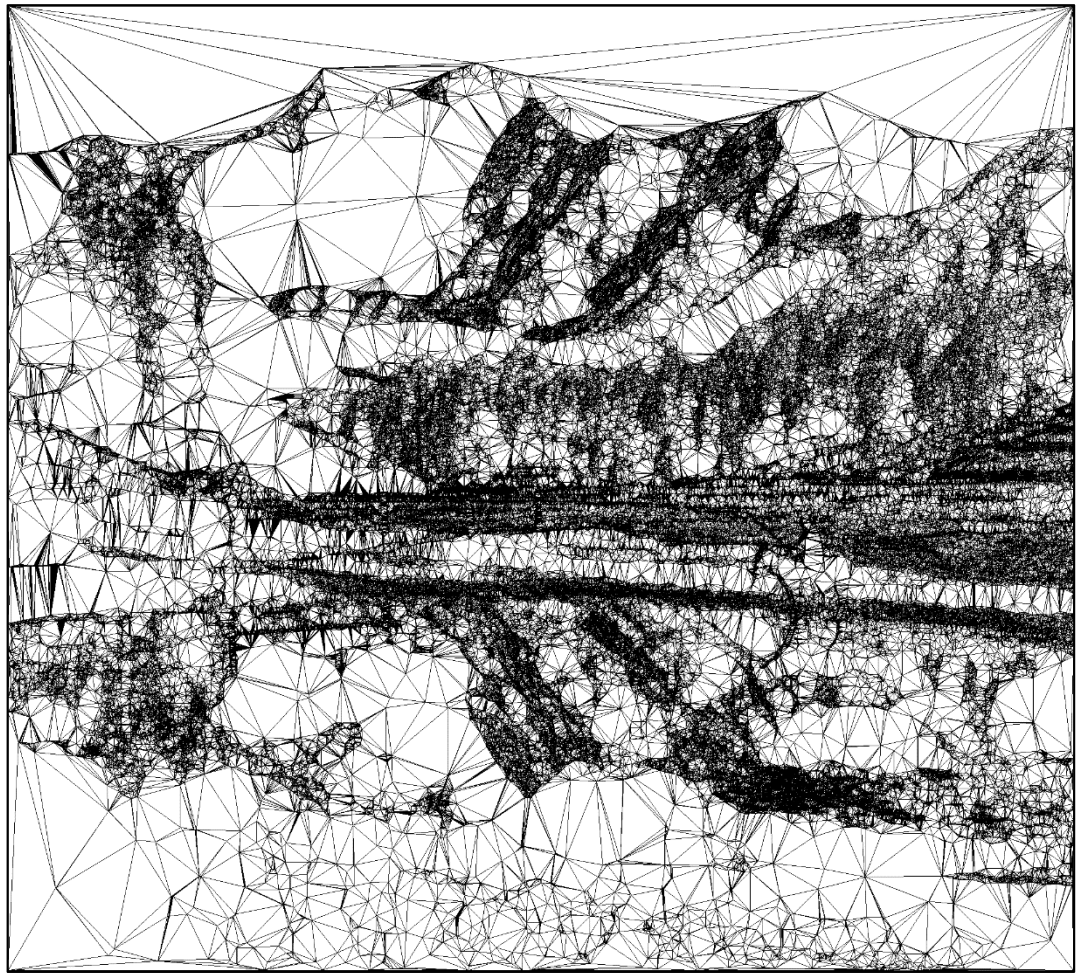
- Key pixels → Important image features
- Largest gradients (e. g., edges and corners)
- Edge and corner detectors
- User-given rate of key pixels

Graph Construction

- Delaunay triangulation:
  - Vertices → Key pixels
  - Edges → Triangles' sides
- Calculation of edge weights:

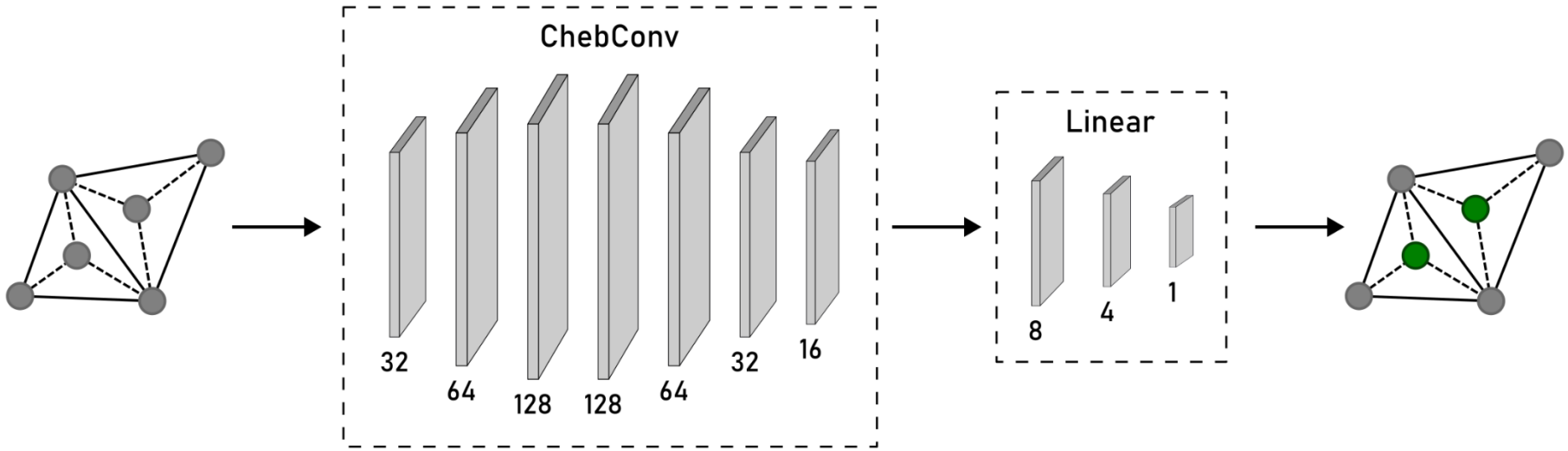
$$w_{i,j} = \begin{cases} 1 & d(v_i, v_j) = 0 \\ \frac{1}{d(v_i, v_j)} & \text{otherwise} \end{cases}$$

- Centroid pixel with an unknown value added to each triangle



Centroid Pixel Values' Prediction

- GNN
- Initial centroid pixel values set to average value of their corresponding triangles
- Regression task → Prediction of centroid pixel values



GNN Training

- DIV2K dataset (1,000 images) split into:
  - training dataset (800 images),
  - validation dataset (100 images),
  - testing dataset (100 images)
- Rate of key pixels varied from 2% to 10% (9 samples from 1 image)
- Min-max normalization of pixel values

Hyperparameter	Value
Number of epochs	10
Learning rate	0.001
Batch size	1
Optimisation algorithm	Adam
Loss function	Mean squared error (MSE)

Results (I.)

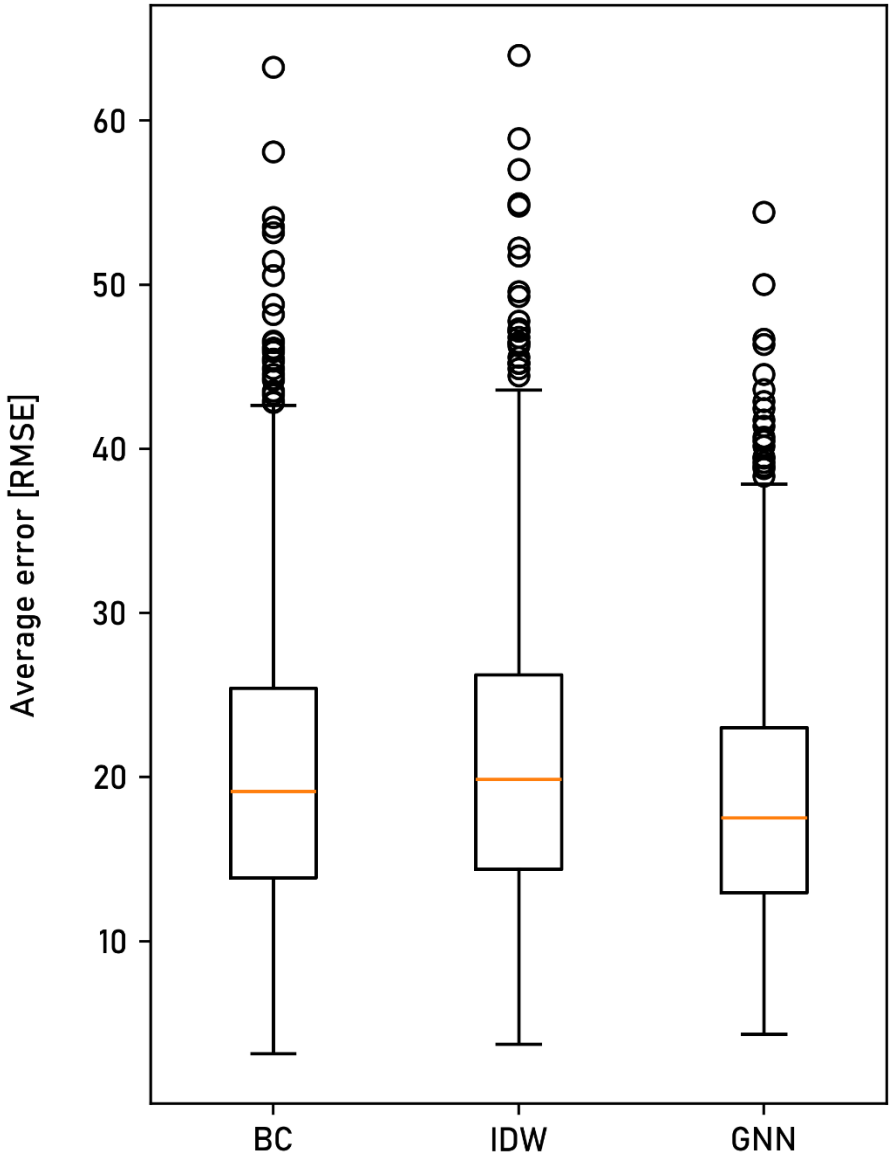
- Compared with barycentric coordinates (BC) and inverse-distance weighting (IDW)
- Evaluation metric → Root-mean-square error (RMSE)
- GNN outperformed BC and IDW in 839 of 900 test samples

Method	Value
BC	22.54
IDW	23.23
GNN	20.26

Results (II.)

- GNN better than BC by 10.11%
- GNN better than IDW by 12.79%

Method	Value
BC	22.54
IDW	23.23
GNN	20.26



Conclusion

- New method for prediction of centroid pixel values in image triangulations
- GNN trained on a large dataset of diverse greyscale images
- GNN better than conventional interpolation methods such as BC and IDW

- Future work:
  - integration into data compression algorithms,
  - prediction of all pixel values inside triangulations

Thank you for your attention!