ETH zürich

Data Analytics Lab
Cosmology Research Group

Cosmology from Galaxy Redshift Surveys with PointNet

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Abstract

General setting

- The ΛCDM model of cosmology: free parameters
- Galaxy redshift surveys: positions of millions of galaxies

→ Parameter constraints

Goals of this work

- Comparison between
  - Hand crafted features (standard approach)
  - Learned features
- Higher precision constraints

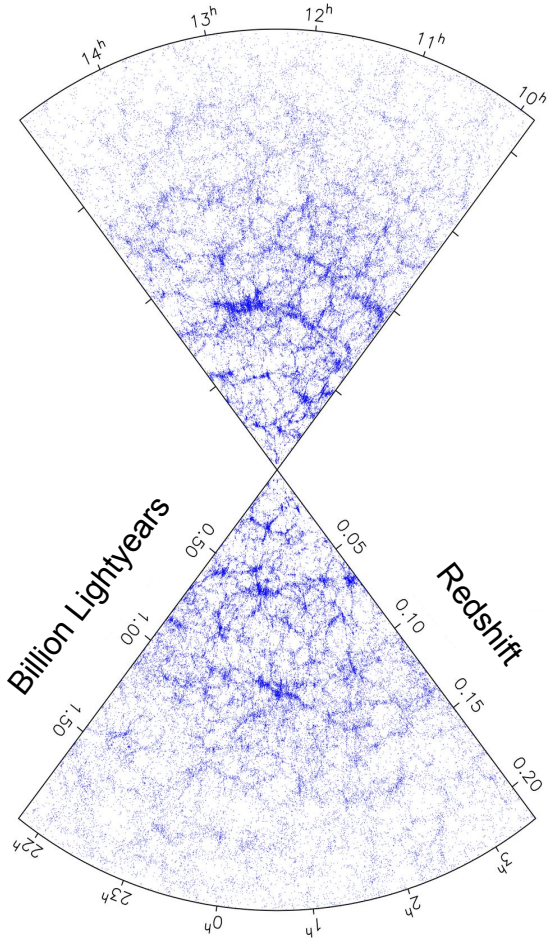


Image credit: 2dF Galaxy Redshift Survey

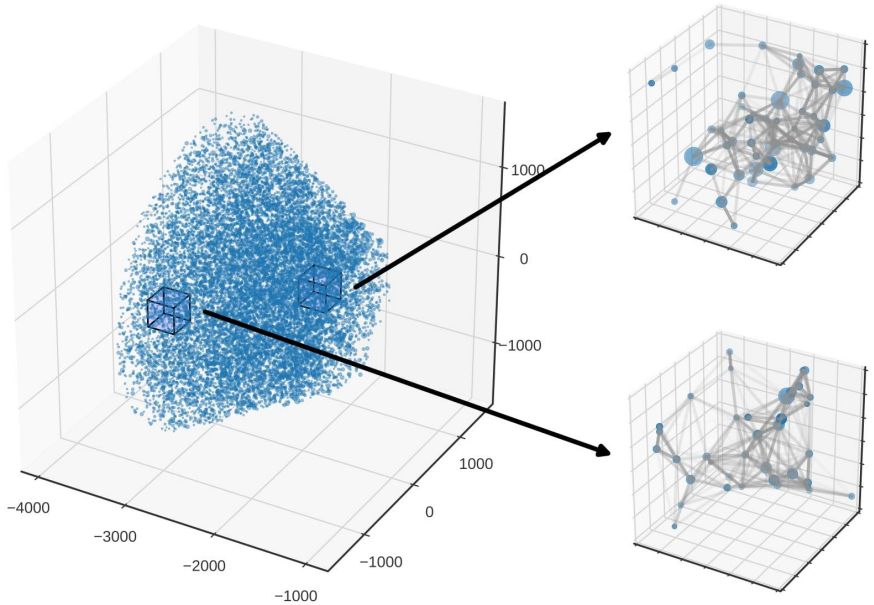
Dataset

Cosmological aspects

- Dark matter only N-body simulations
  → Halo catalogs
- Parameters
  - Ω_M Present-day matter fraction
  - σ_8 Clumpiness of the matter distribution

Format

- Point clouds
- Features
  - Positions only (x,y,z)
  - Positions and masses (x,y,z,M)



Features

Two-point statistics *(hand crafted)*

- Standard summary statistic
  - Real space: *correlation function*
  - Fourier space: *power spectrum*
- Sufficient for Gaussian random fields

Point cloud networks *(learned)*

- PointNeXt architecture
- Automatic extraction of relevant features
- Hierarchical
- Can easily include additional features

Both cases

- Input to multilayer perceptrons (MLPs)
- Direct regression of the cosmological parameters (MSE loss)

Results

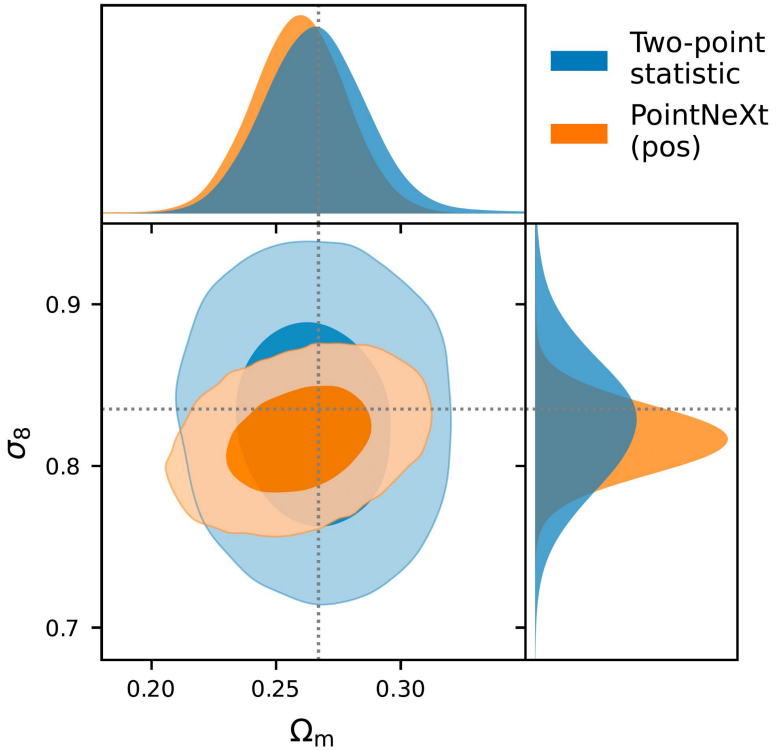
Equal numbers of points

- MSE on test set
- Posterior conditioned on a mock observation

→ **The networks outperform the correlators**

# points	PointNeXt (pos)	PointNeXt (pos+M)	Two-point
8 000	3.6	1.3	8.3
16 000	2.4	0.67	3.3
32 000	1.3	0.58	1.8

MSE in multiples of 10^-3



Promising application of Deep Learning