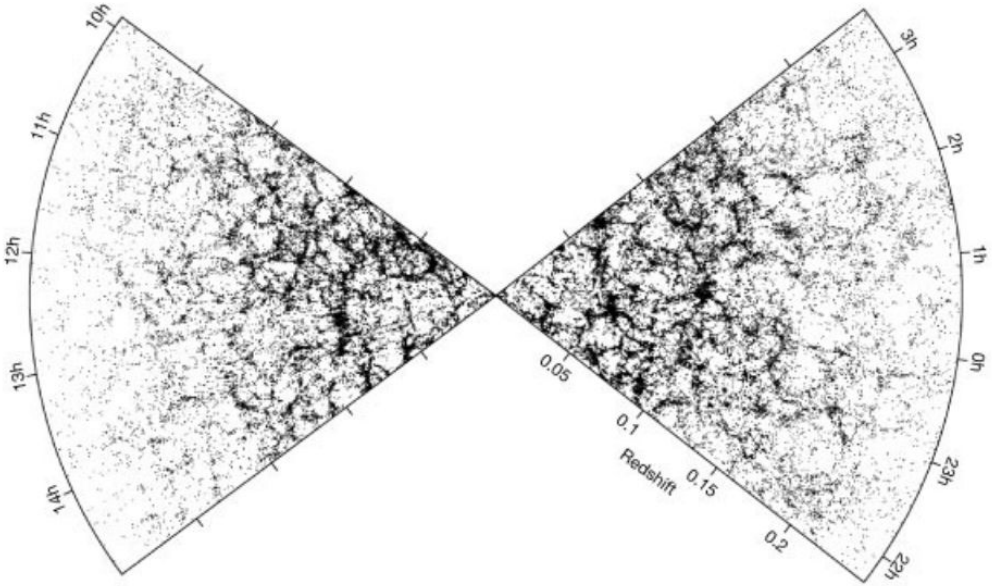
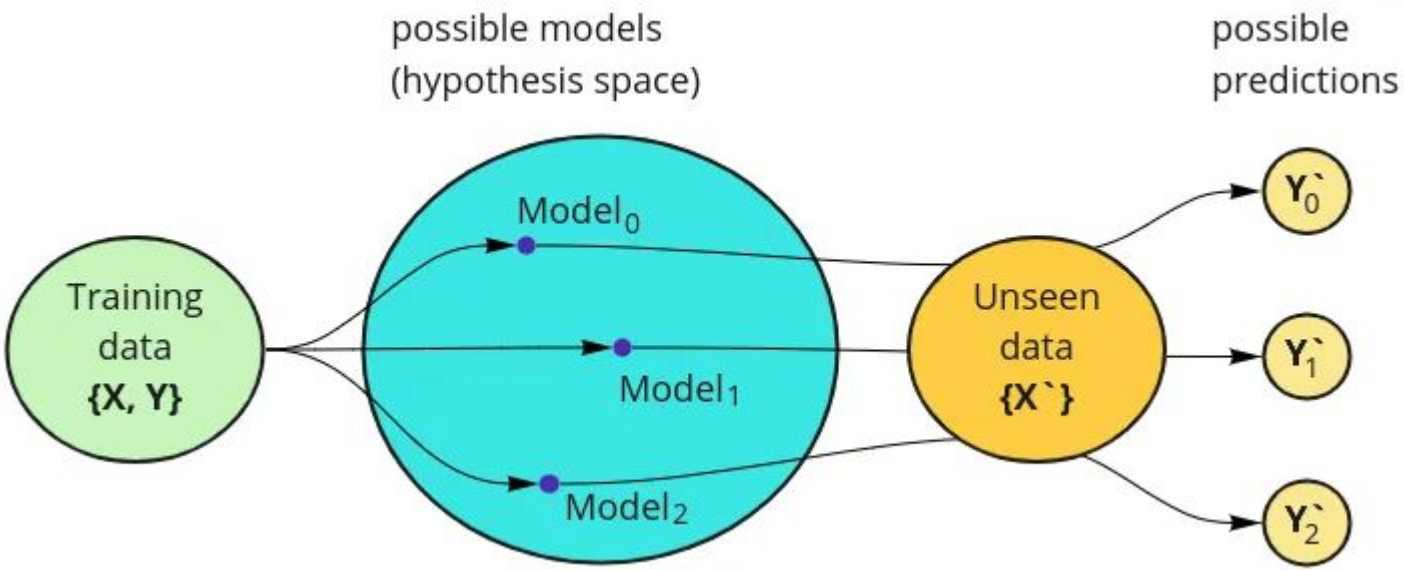
PointNet for Galaxy Redshift Surveys

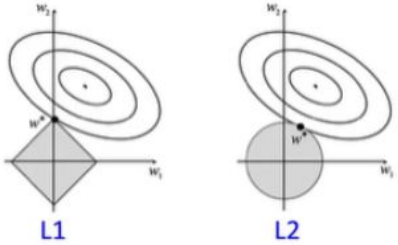


Sotiris Anagnostidis, ETH Zurich

Inductive Bias



Inductive bias encodes our knowledge about the structure in the world

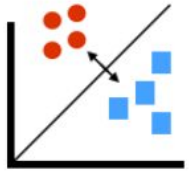


Regularization
Occam's Razor

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

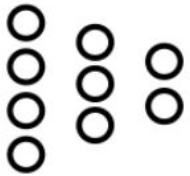
Bayesian Models
Prior Belief

k-Nearest Neighbors
Smoothness



Max-Margin Methods
Inter-class distance

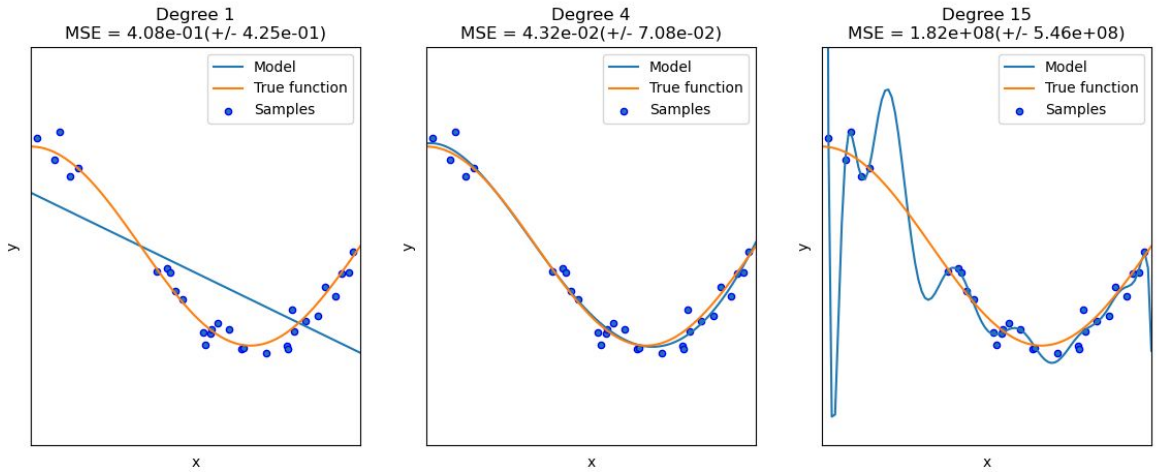
Low-Dimensional Representations
Manifold Hypothesis



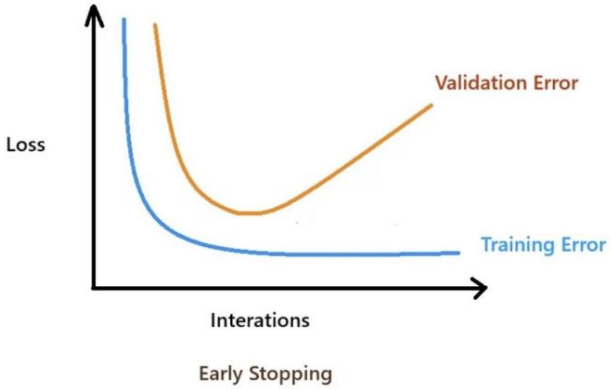
Hierarchical Models
Abstraction

No Free Lunch

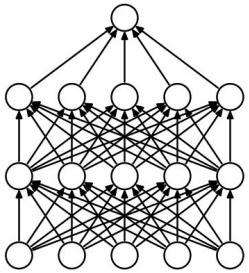
- Any inductive bias will have equal accuracy compared to any other bias over **all** set of functions/tasks, assuming that all functions are **equally** likely.
- Are all functions equally likely in the real world?



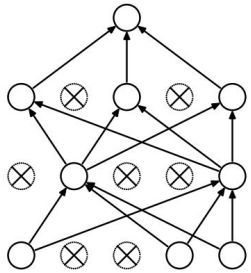
Inductive Bias in Deep Learning (1)



$$L(x,y) \equiv \sum_{i=1}^{n}(y_i - h_\theta(x_i))^2 + \lambda \sum_{i=1}^{n} \theta_i^2$$



(a) Standard Neural Net



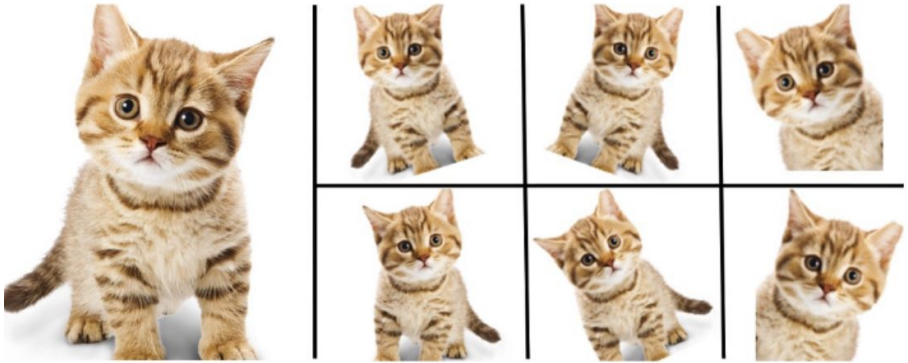
(b) After applying dropout.

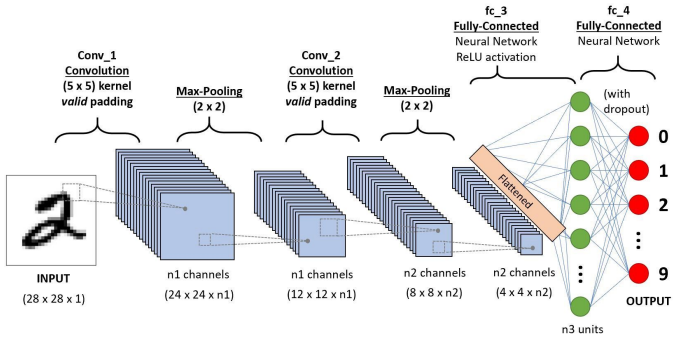
$$\mu_{\mathcal{B}} \leftarrow \frac{1}{m}\sum_{i=1}^{m} x_i$$

$$\sigma_{\mathcal{B}}^2 \leftarrow \frac{1}{m}\sum_{i=1}^{m}(x_i - \mu_{\mathcal{B}})^2$$

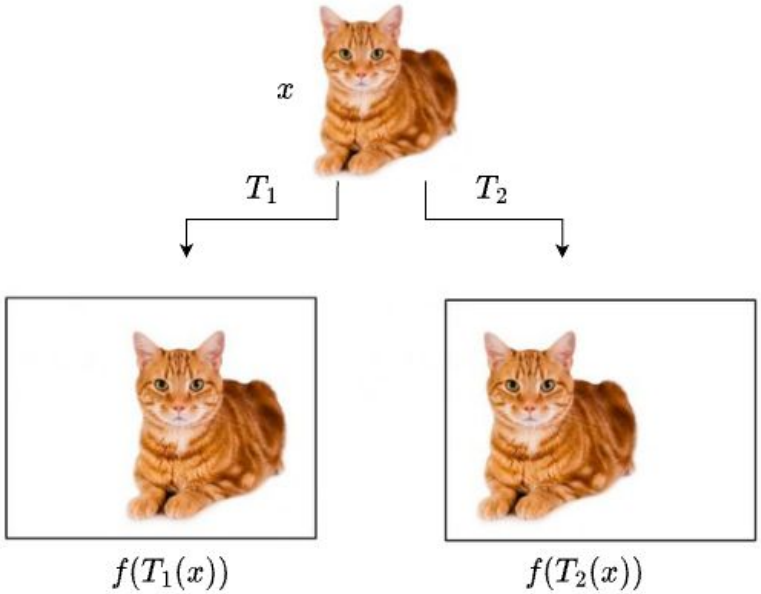
$$\widehat{x}_i \leftarrow \frac{x_i - \mu_{\mathcal{B}}}{\sqrt{\sigma_{\mathcal{B}}^2 + \epsilon}}$$

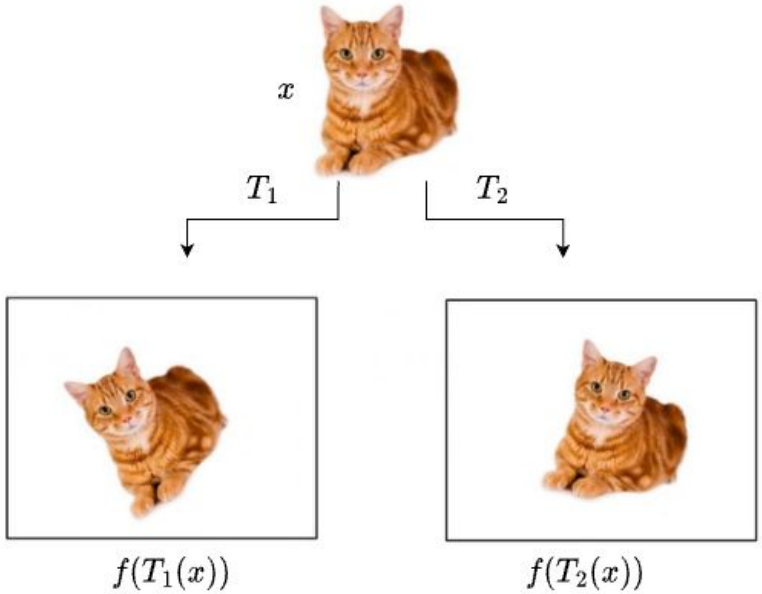
$$y_i \leftarrow \gamma \widehat{x}_i + \beta \equiv \mathrm{BN}_{\gamma,\beta}(x_i)$$



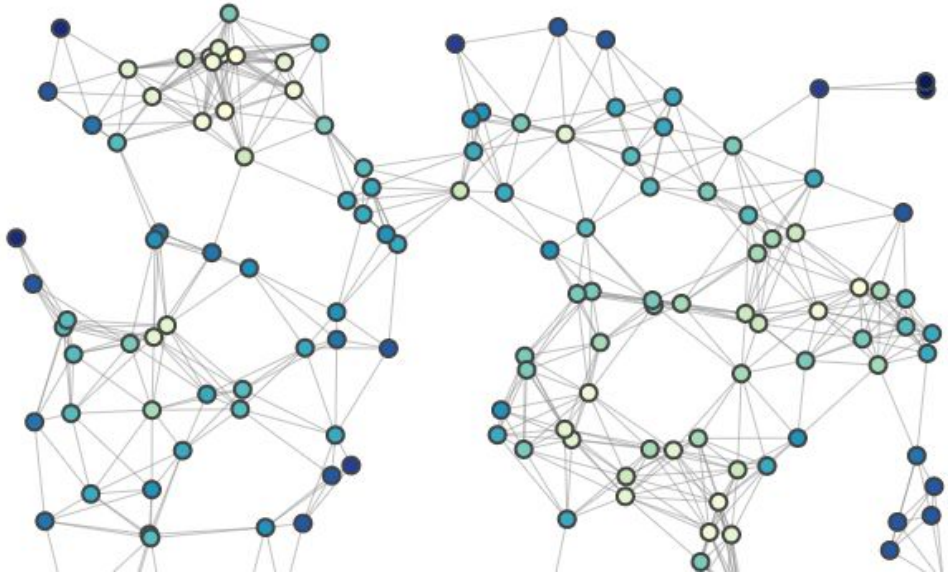


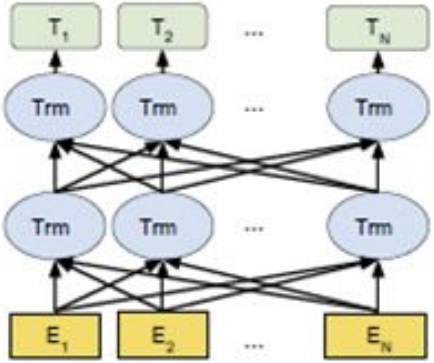
Inductive Bias in Deep Learning (2)



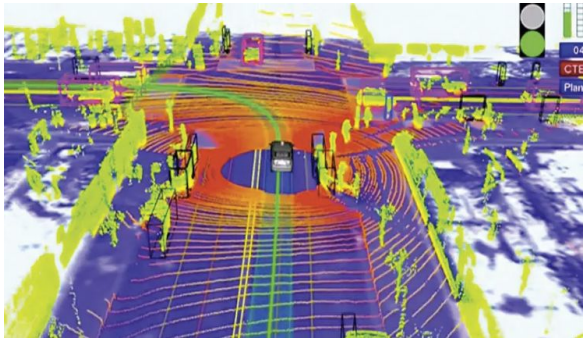


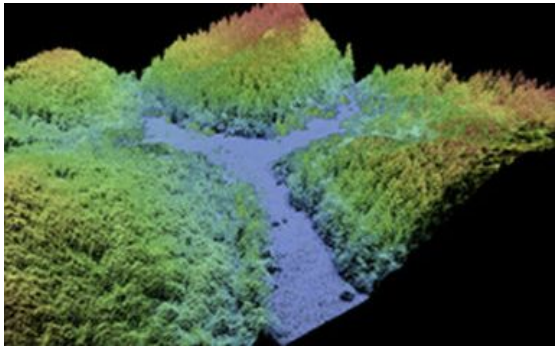
Inductive Bias in Deep Learning (3)

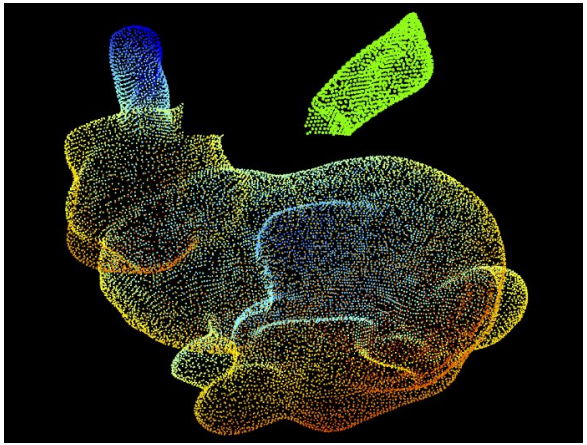


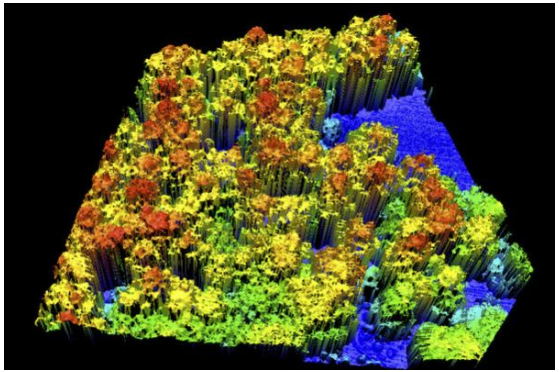


Point Clouds

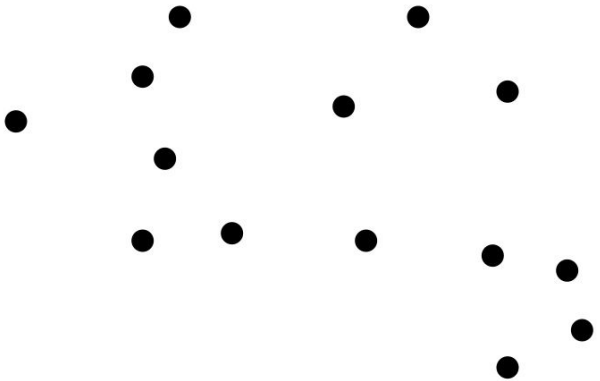


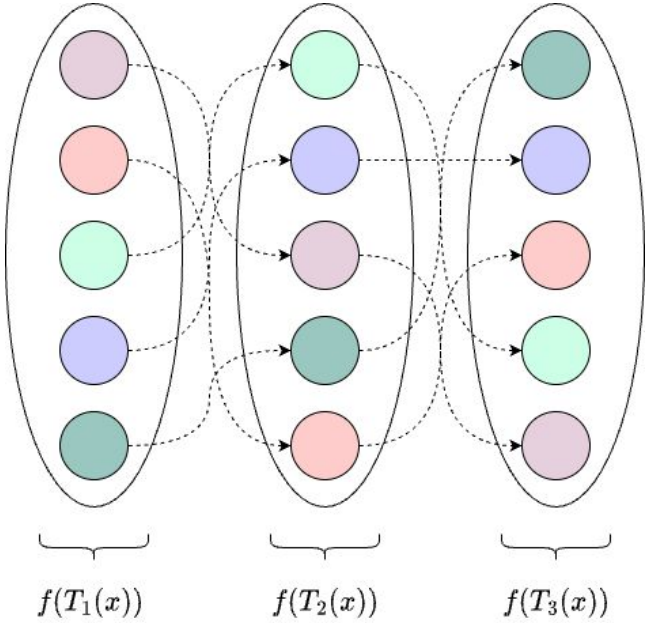






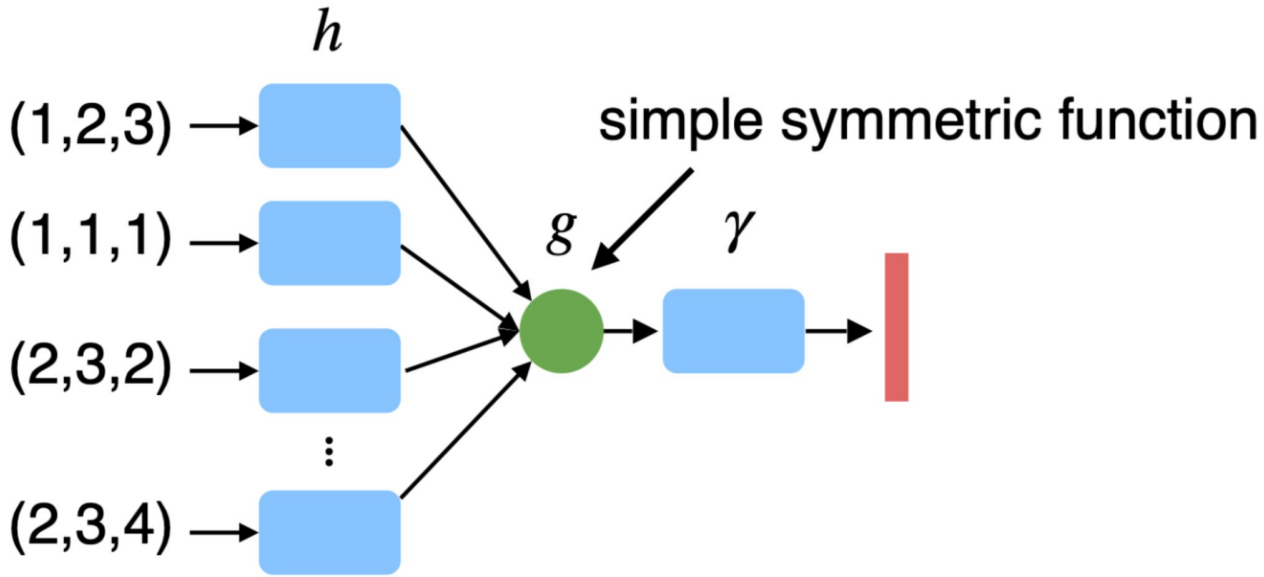
Inductive Bias in Point Clouds



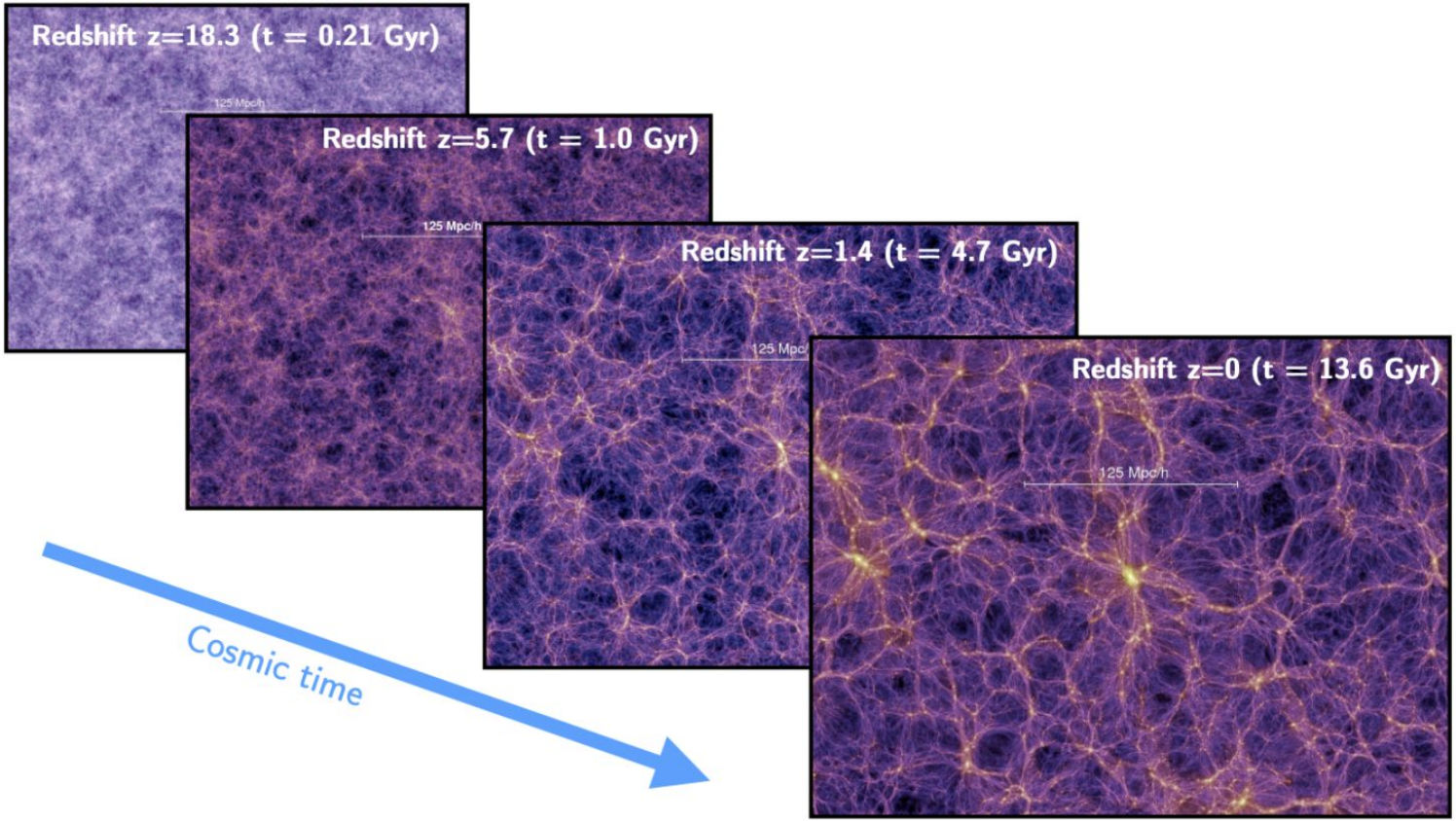


PointNet

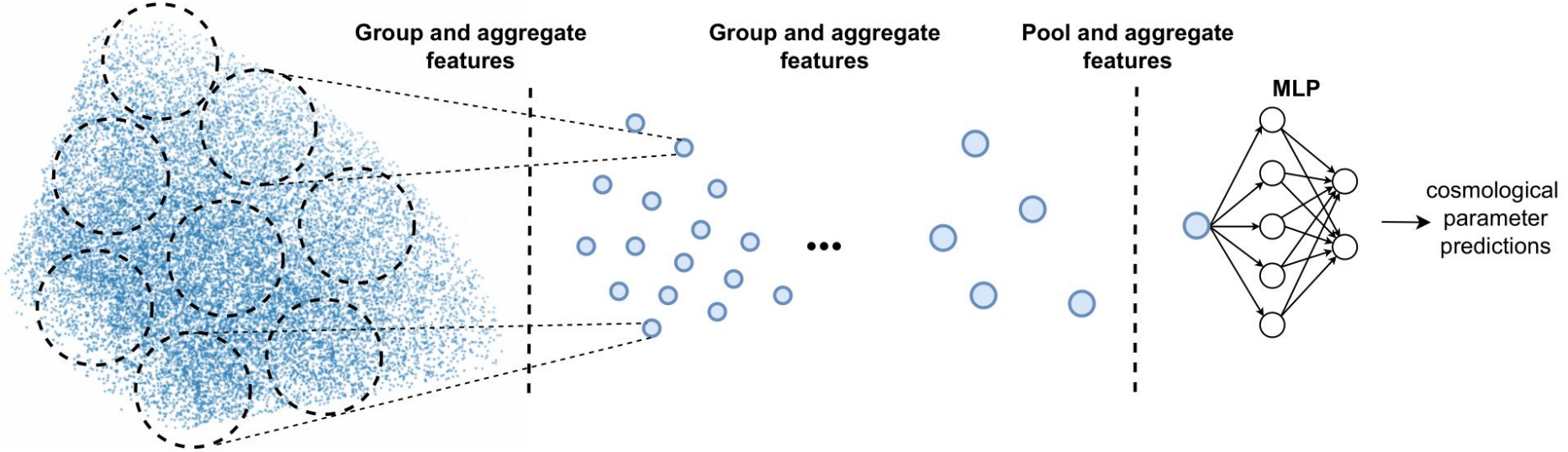
$$f(x_1, x_2, \ldots, x_n) = \gamma \circ g(h(x_1), \ldots, h(x_n))$$



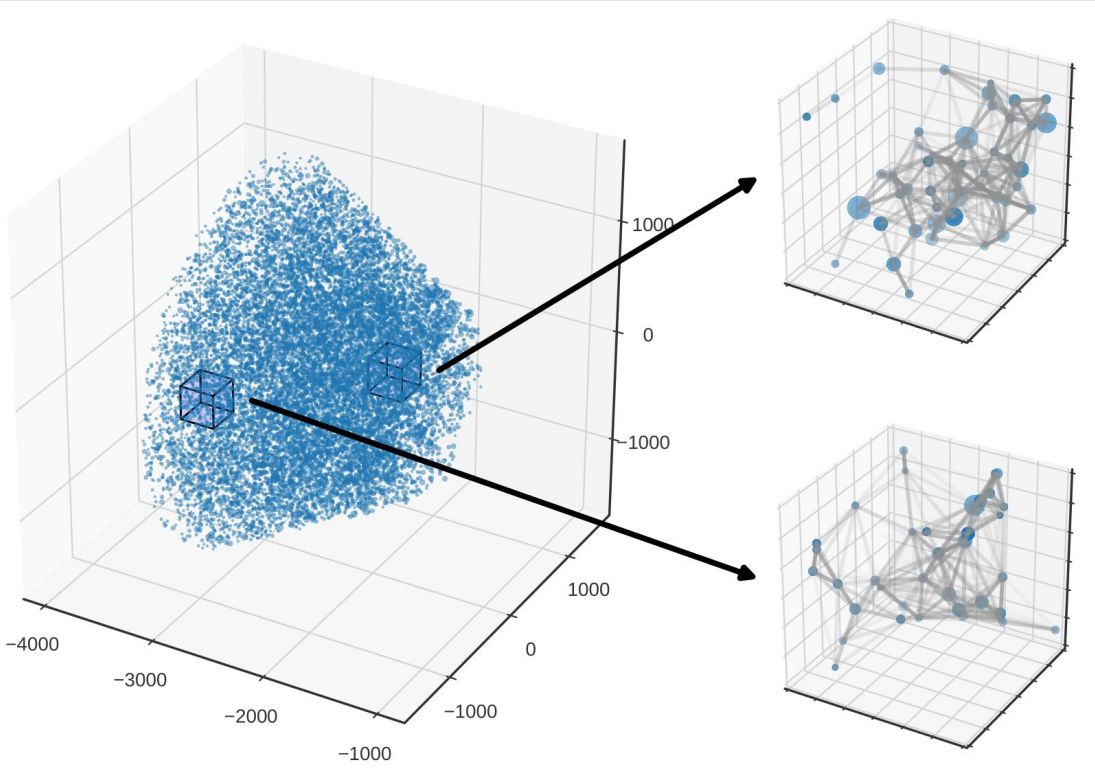
Redshift Surveys



Extract Hierarchical Features



Scaling to bigger Point Clouds



Better Predictions

# points	PointNeXt (pos)	PointNeXt (pos+M)	Two-point statistic
0.8×10^4	3.6×10^{-3}	1.3×10^{-3}	8.3×10^{-3}
1.6×10^4	2.4×10^{-3}	6.7×10^{-4}	3.4×10^{-3}
3.2×10^4	1.3×10^{-3}	5.8×10^{-4}	1.8×10^{-3}