Estimating photometric redshifts using Deep Learning

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Why photo-z ?

Spectroscopic Redshifts	Photometric Redshifts
More accurate	Comparatively less accurate
More expensive	Way less expensive
Far more telescopic time	Way less telescopic time

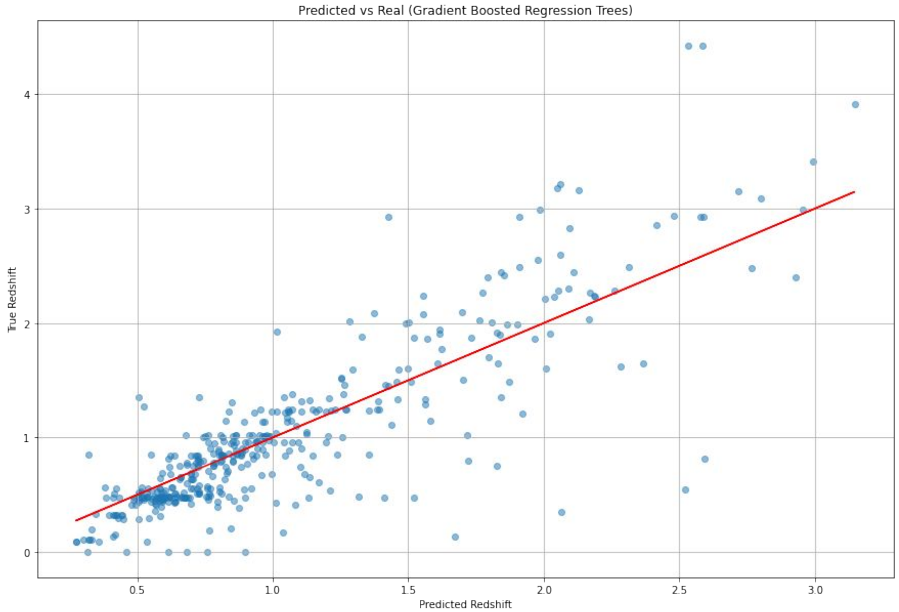
Photo-z measurement techniques

1. Direct Shift Measurement: Baum(1962)
2. Color-color diagrams: Koo (1985)
3. Template Fitting: Loh & Spiller (1986)
4. Machine Learning (using regression)

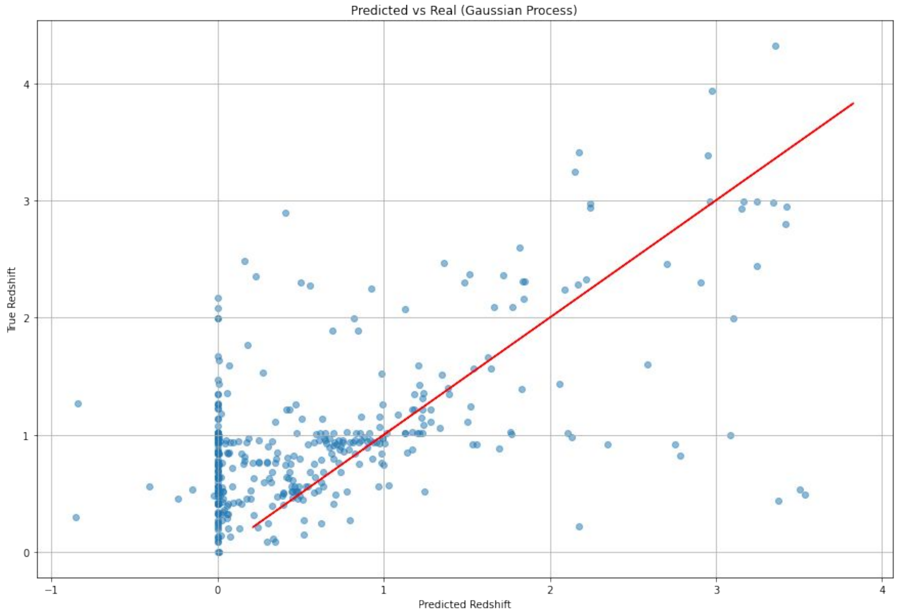
Machine Learning

- **Dataset:** Hubble Deep Survey (GOODS- North) from Barro(2019)
- **Input:** Multiband fluxes from 500 nm to 941 nm
- **Output:** Photometric redshifts
- **Comparison Metric:** Mean-squared error

Classical ML Algorithms

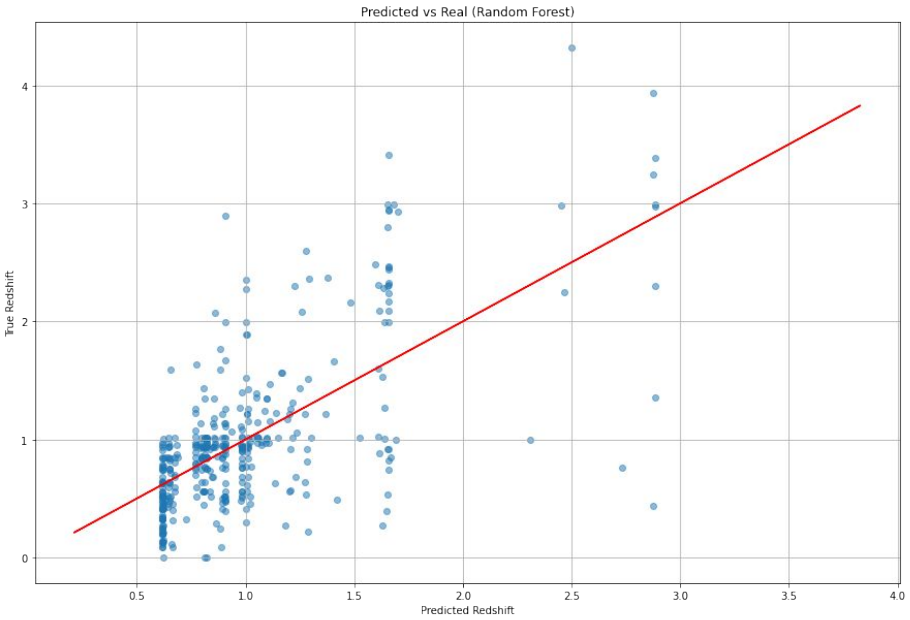


Gradient Boosted Regression Trees
(MSE = 0.154)

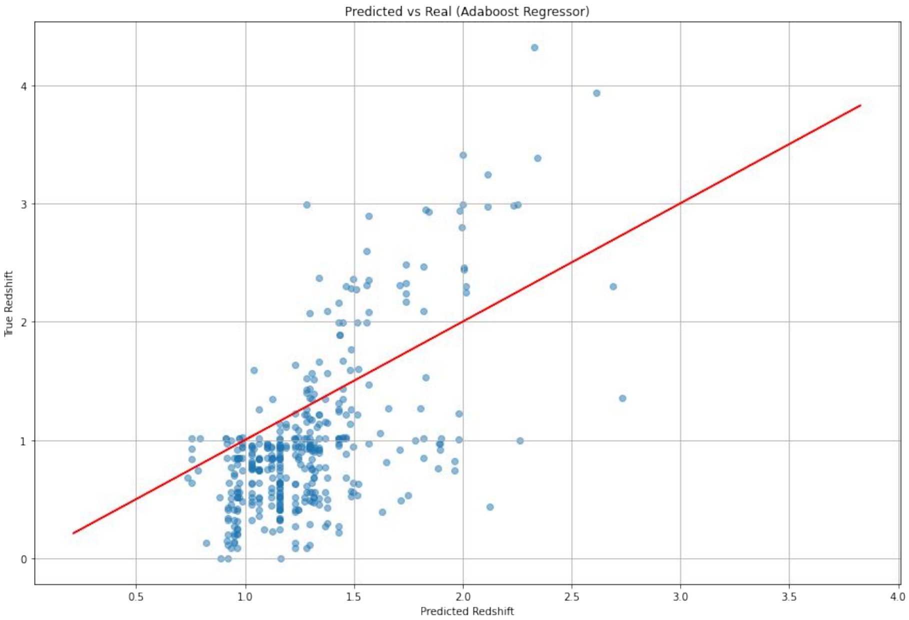


Gaussian Processes
(MSE = 0.584)

Classic ML Algorithms

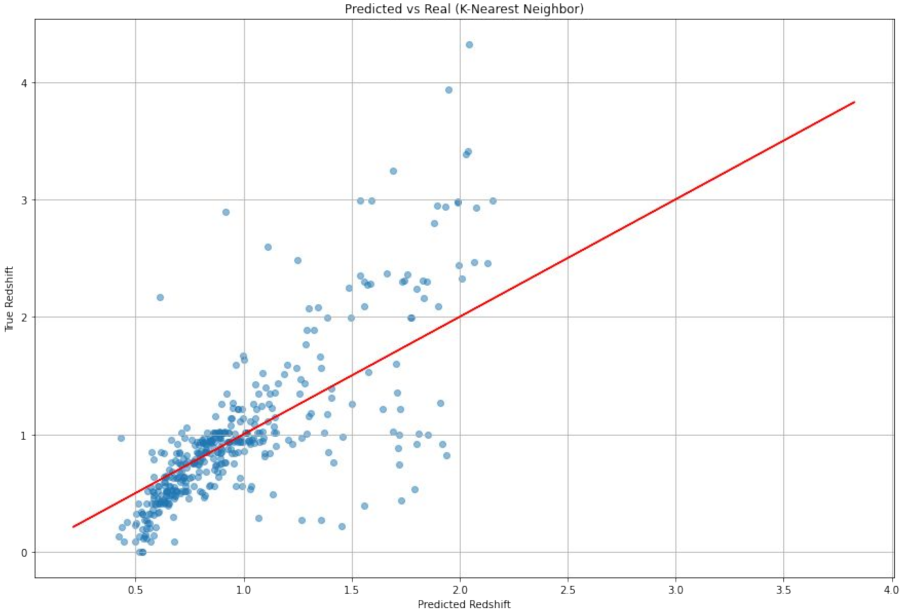


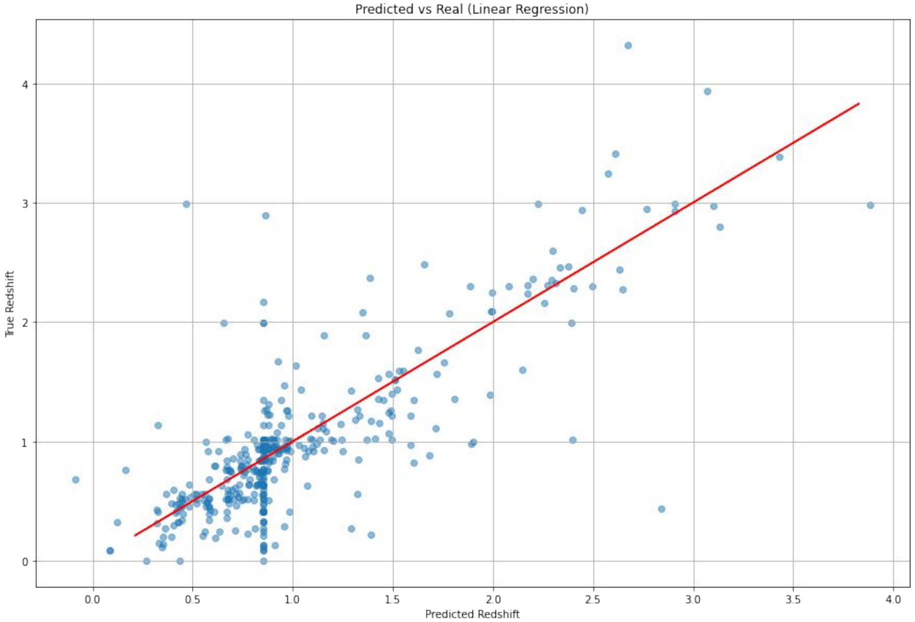
Random Forests
(MSE = 0.242)



Adaboost Regressor
(MSE = 0.359)

Classic ML Algorithms

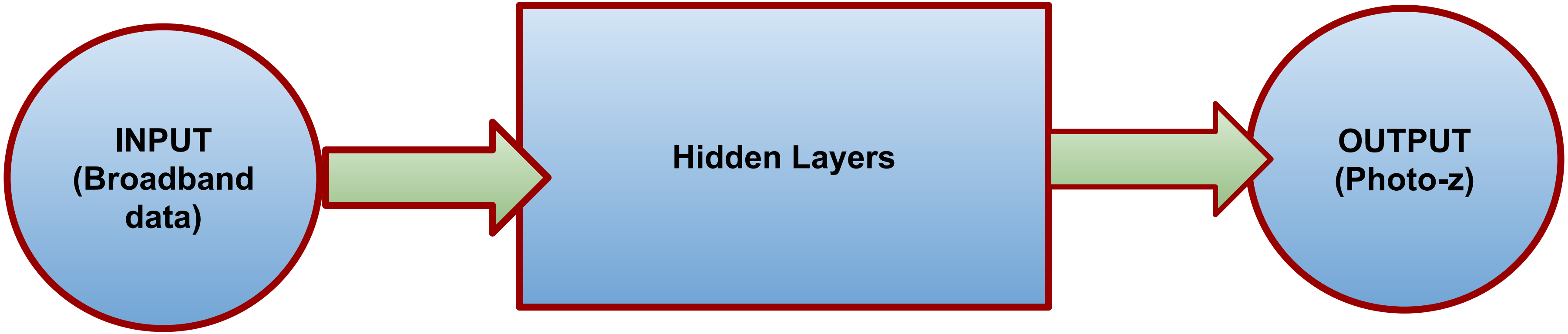




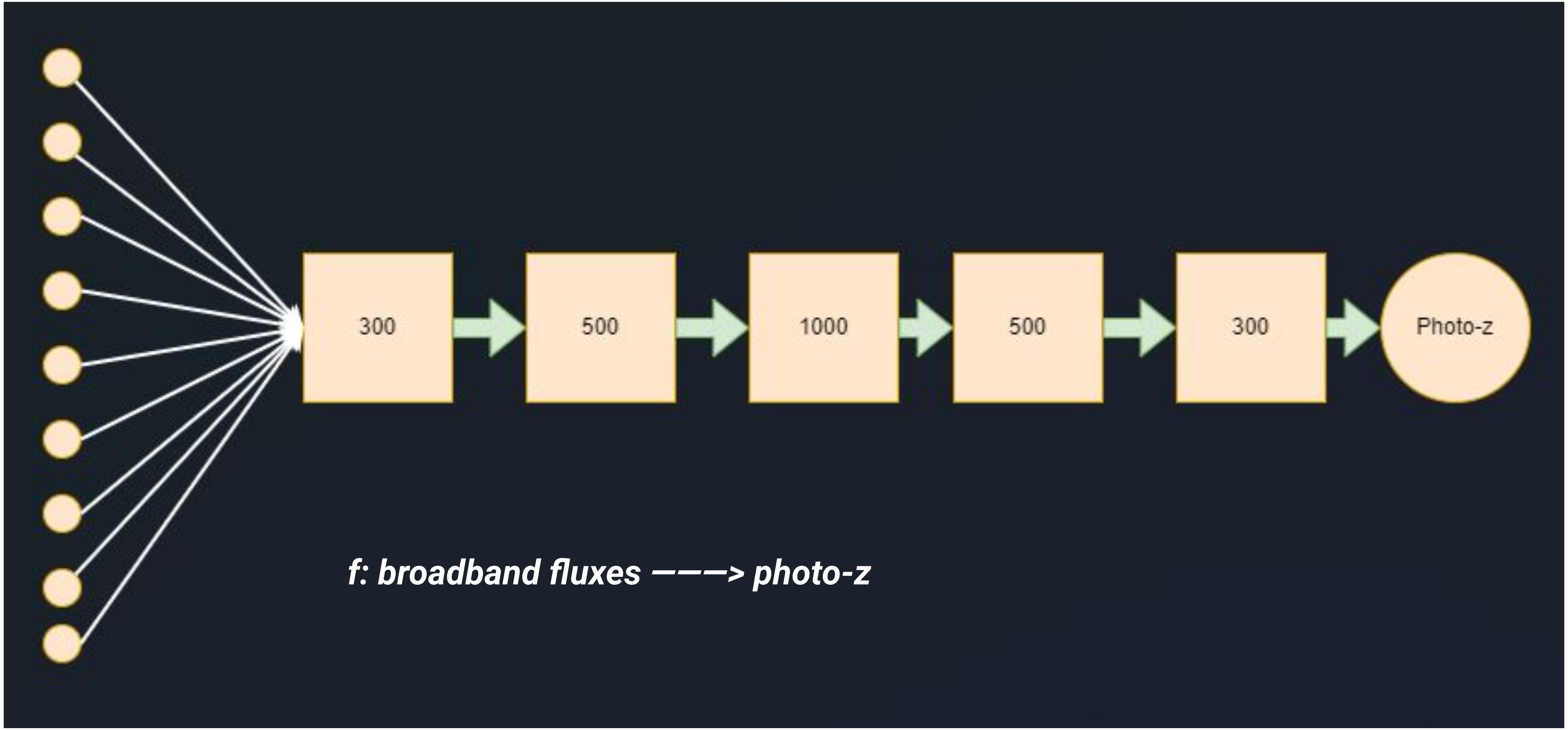
K-Nearest Neighbor
(MSE = 0.189)

Support Vector Machines
(MSE = 0.156)

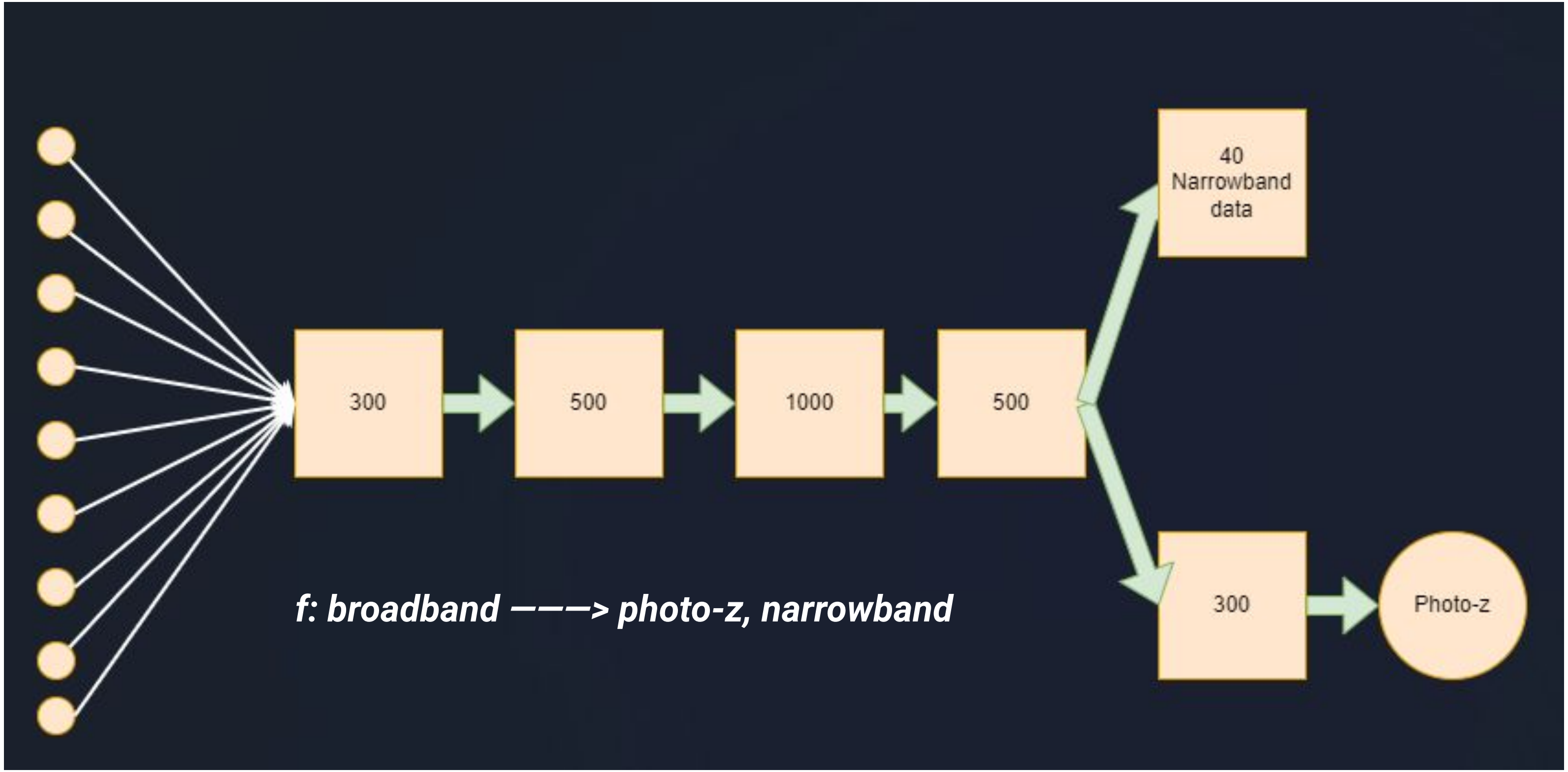
Neural Networks



Baseline network



Multitask Network



Network features

- **Dataset:** PAU Survey Catalogue
- **Broadband data:** 9 bands from u,b,v,g,r,z,i,j,k bands (fluxes in Janskys)
- **Narrowband data:** 40 bands from 455 nm to 845 nm
- **Redshift output**

Comparison Metrics

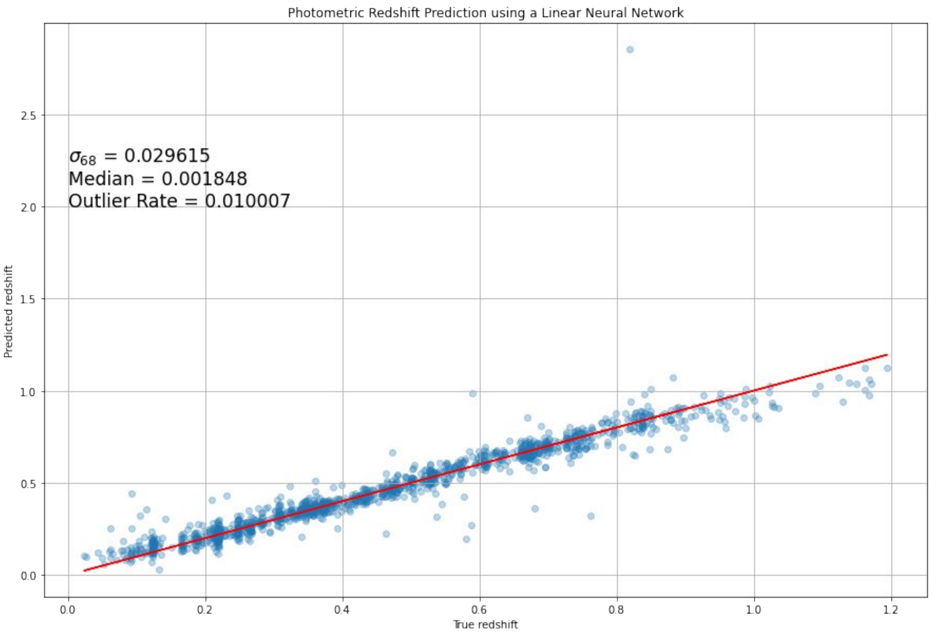
- **Dispersion:** $$\sigma_{68} := \frac{1}{2}\left[Q_{84}(\Delta z) - Q_{16}(\Delta z)\right]$$

  where,

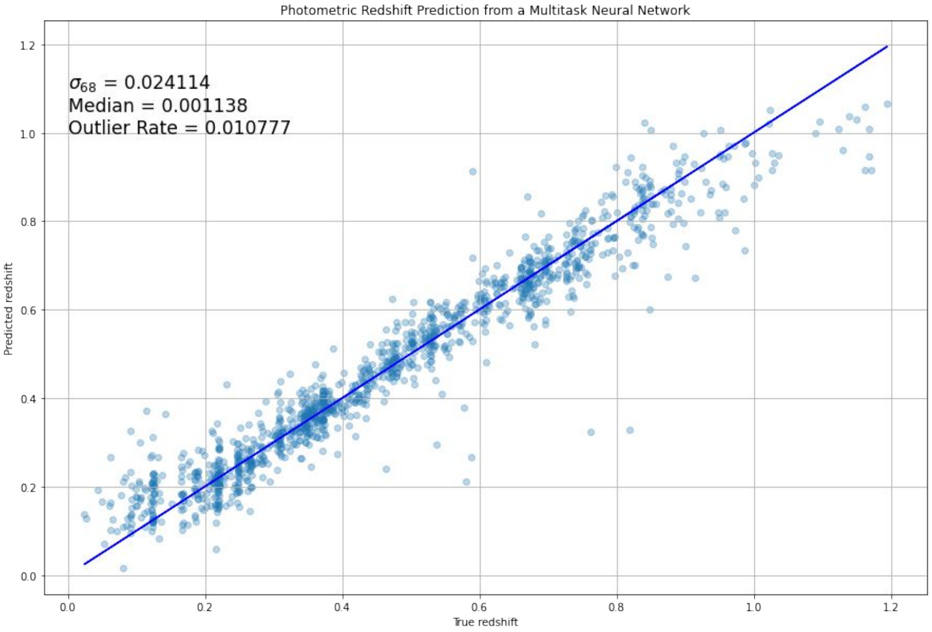
  $$\Delta z := (z_\mathrm{p} - z_\mathrm{t}) \;/\; (1 + z_\mathrm{t})$$

- **Outlier:** $|z_\mathrm{p} - z_\mathrm{t}| \;/\; (1 + z_\mathrm{t}) > 0.15$

Results



Photometric Redshift Prediction using a Linear Neural Network
σ_{68} = 0.029615
Median = 0.001848
Outlier Rate = 0.010007
Predicted redshift
True redshift
0.0
0.5
1.0
1.5
2.0
2.5
0.0
0.2
0.4
0.6
0.8
1.0
1.2



Photometric Redshift Prediction from a Multitask Neural Network
σ_{68} = 0.024114
Median = 0.001138
Outlier Rate = 0.010777
Predicted redshift
True redshift
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2

CONCLUSION