Neural networks in cosmological data analysis

Isidro Gómez-Vargas[1]♠ **and José Alberto Vázquez**[1]

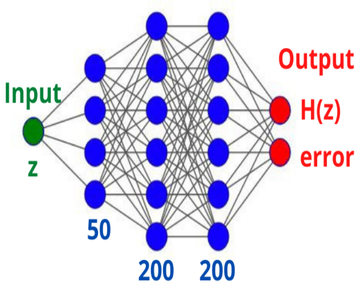
[1]**Instituto de Ciencias Físicas, UNAM.** ♠ **igomez@icf.unam.mx.** `GitHub: igomezv`

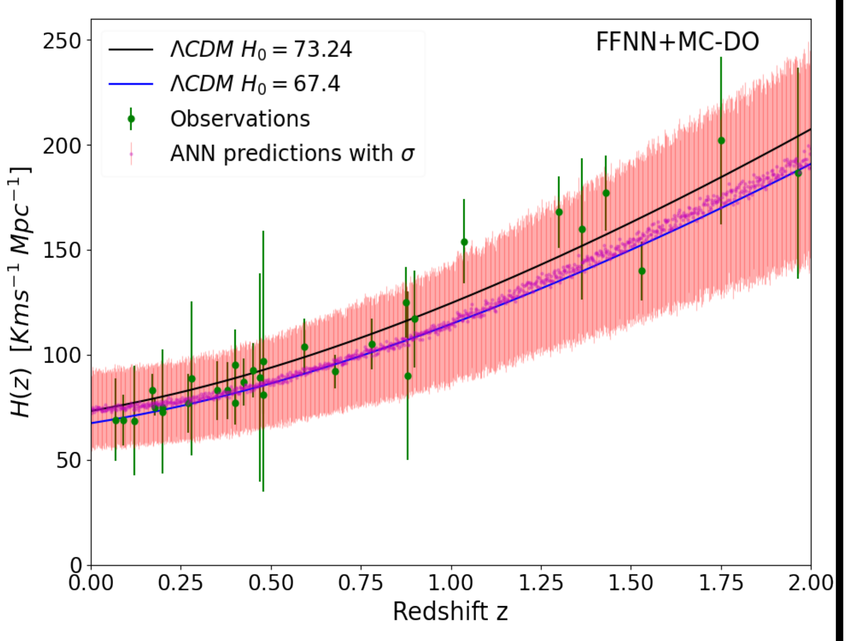
Introduction

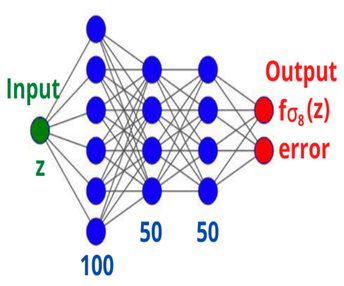
Artificial neural networks are powerful tools for data modeling due to their great ability to learn complex relationships and nonlinear functions, for this reason they have had great achievements in various industrial and scientific areas. In this poster we present our recent insights in different cosmological contexts.

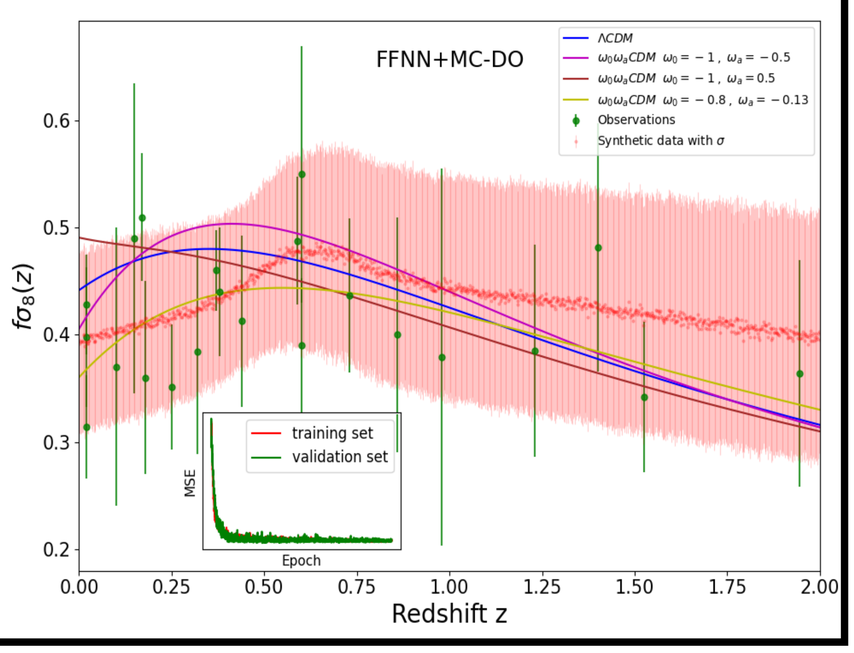
Neural reconstructions

Cosmological function reconstructions with neural networks and Monte Carlo Dropout for small observational datasets, without any statistical or theoretical assumptions. We can use these reconstructions to make interpolation and to compare their predictions with cosmological models.



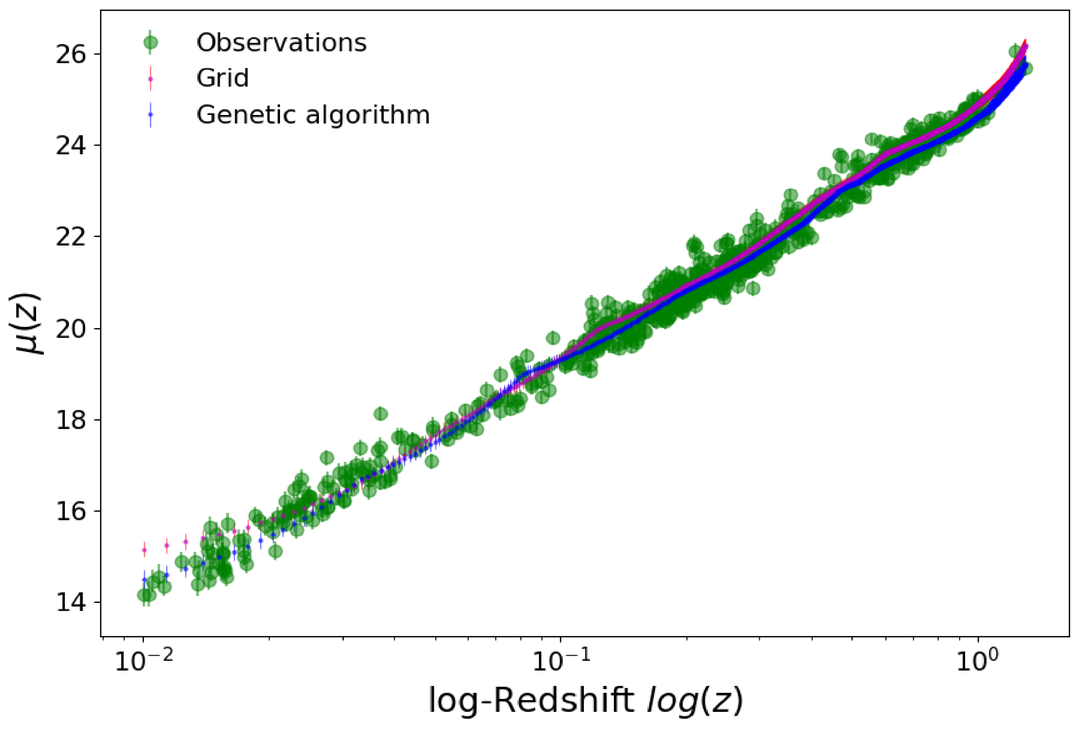






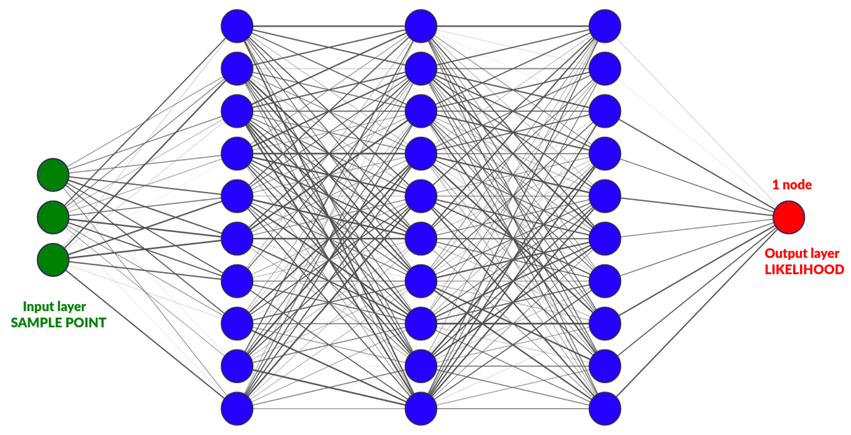
Tunning with genetic algorithms

A correct selection of the hyperparameters in a neural network is crucial. In particular, when dealing with a regression problem, a bad neural network model could suggest meaningless physical interpretations.



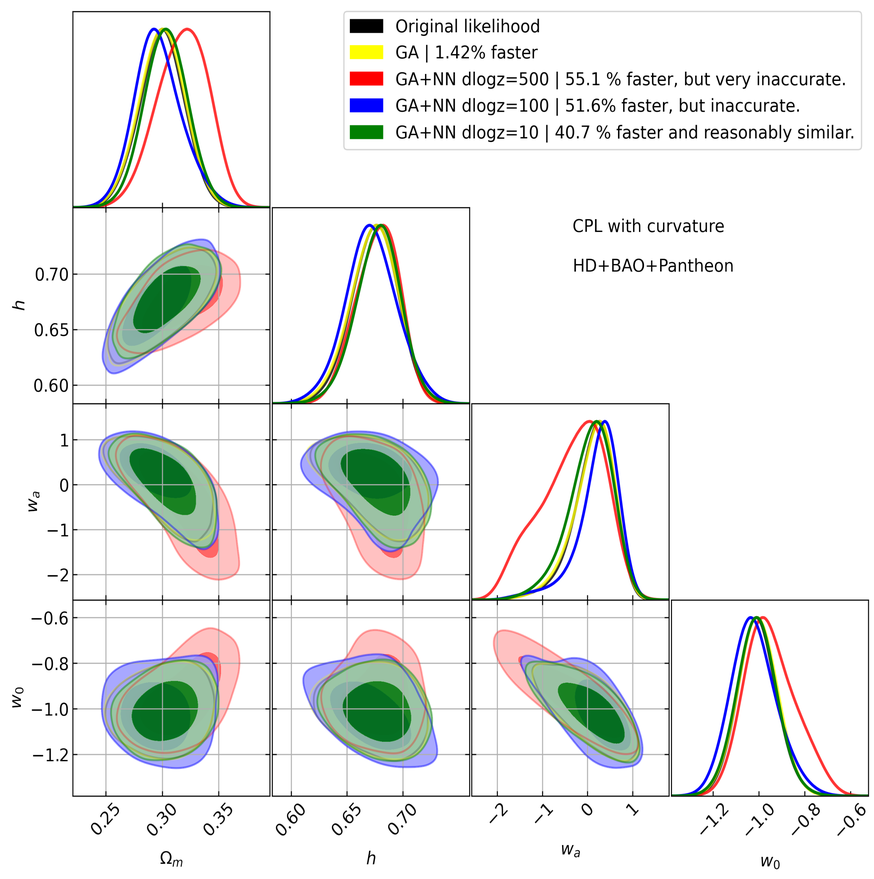
Accelerating Bayesian Inference

We use neural networks and genetic algorithms to speed up the execution of real-time nested sampling. Genetic algorithms generate the first live points to ensure an idea of the maximum likelihood value, and then neural networks are used to learn the likelihood function and replace its, sometimes computationally expensive, analytical evaluation.



Generate the initial live points with GA
for *i in range*(iteration) **do**
  if $dlogz_i < dlogz$ **then**
    Train ANN with live points
    if *loss function* <*criterion* **then**
      $\mathcal{L} = \mathcal{L}_{ANN}$
      if $i\,\%neval == 0$ **then**
        Sampling samples with original.
        if *Originals are similar to neuronals* **then**
          Continue
        else
          $\mathcal{L} = \mathcal{L}_{original}$
          Break
  else
    continue with NS
end

Example: Around 120,000 likelihood evaluations with 1000 live points.



Conclusion

ANNs can be a good complement in the cosmological data analysis, whether to model data or to optimize computational times. One must be careful with the selection of its hyperparameters. They are not substitutes for traditional methods, but they can be an interesting alternative.

References

- `https://ssrn.com/abstract=3990646`
- `https://arxiv.org/abs/2112.12645`
- `https://arxiv.org/abs/2104.00595v1`