Constraining stellar population parameters from narrow band photometric surveys using convolutional neural networks

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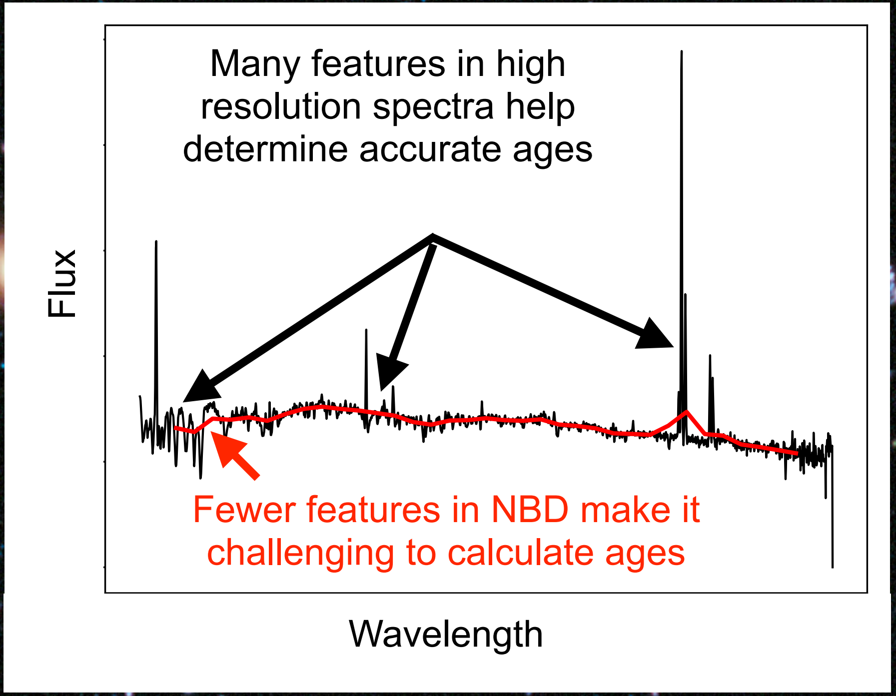
1. The Challenge

Can we recover the average age and metallicity (Z) of stars in a galaxy from narrow-band data (NBD, red) as accurately as from high-resolution spectra (black)?
Measuring the age and Z of stellar populations within galaxies helps us to understand their evolutionary history. Upcoming large-area narrow band photometric surveys, such as J-PAS, will enable us to observe a large number of galaxies simultaneously and efficiently. However, it will be challenging to analyse the spatially-resolved stellar populations of galaxies from over 1 trillion data points. The resolution of J-PAS NBD is 50x worse than CALIFA high resolution spectral data, and the lack of spectral lines in NBD make it much harder to determine stellar population properties. With J-PAS and J-PLUS expected to gather 1.5TB of data per night, we need to have a quick & efficient method of data analysis.



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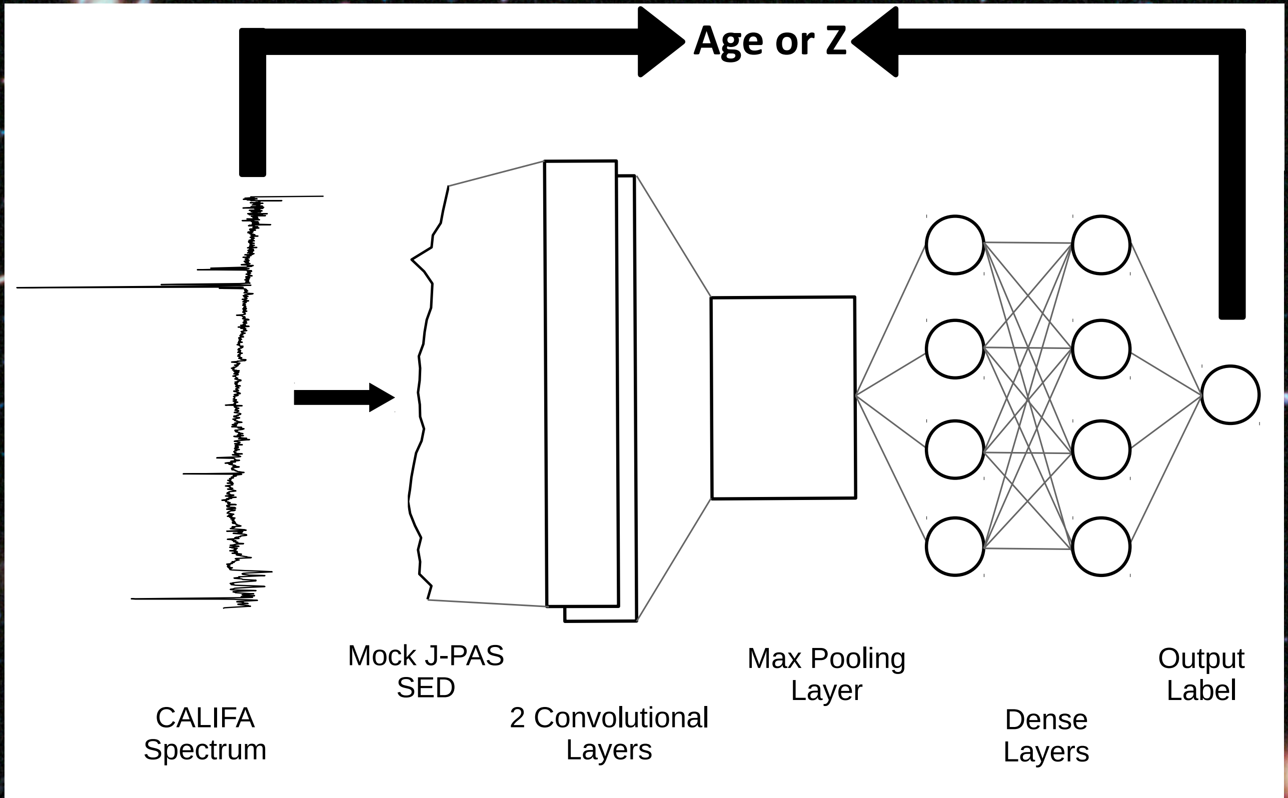
2.1 Method: Neural Networks

We use a convolutional neural network (**CNN)** to analyse our data as the application of trained CNNs to new data is very quick. A schematic representation of our CNN is shown to the right. We trained the CNN with the synthetic J-PAS-like NBD created from CALIFA spectra (input features) and the accurate age or Z derived from CALIFA spectral data (output label), and tested the CNN with the unseen data.



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2.2 Method: Splitting the Data Set

Our dataset is formed of 19,727 CALIFA spectra from 190 galaxies. We use two methods for splitting the dataset into training and testing:

Set A: We take 25% of the data from each galaxy to test (light blue), and train with the rest (red). This is the ideal case, where the histories of the galaxies in the training and testing sets are similar.

Set B: The training and testing sets come from different galaxies. This is the realistic case, where we know nothing about a galaxy before we observe it.

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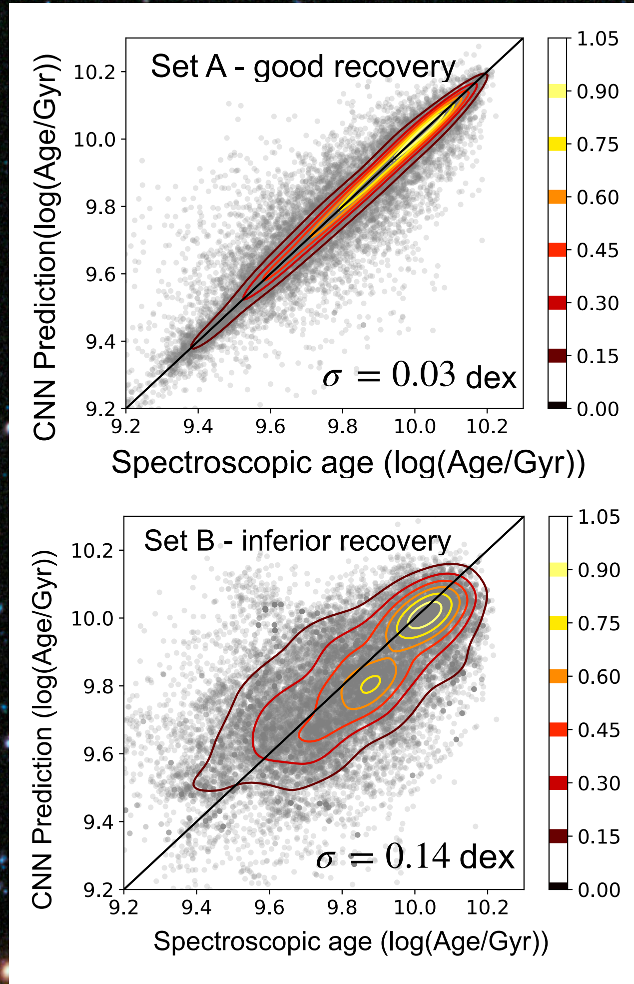
3. Results

The recovery of age from the CNN for Set A (top) and Set B (bottom). The spectroscopically determined ages are plotted against the CNN age predictions. Each grey dot shows the prediction for a single spectrum. The black diagonal shows the location of points that are predicted with perfect accuracy. The coloured contours show the normalised distribution of data points. Results for Z were similar to those for age.



4. Conclusions

- This proof of concept study shows for the first time that convolutional neural networks are able to reproduce ages and metallicities from narrow-band photometric data
- Increased accuracy in predictions from Set A implies that galactic evolutionary histories can be very different for galaxies of the same age
- For better convolutional neural network predictions, we need more high resolution spectral data from a variety of stellar populations for our training dataset

For more information, see Liew-Cain et al. 2021,
https://academic.oup.com/mnras/article/502/1/1355/6070644
https://github.com/ChoongLing/SimulatedJ-PAS