Machine learning as a tool to determine exoplanet properties

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Characterization of exoplanetary atmospheres and interiors requires information on planetary properties such as **mass, radius, and density**. However, precise measurements of these fundamental properties are not always possible, as a result of which the masses and radii of these planets are often unknown. We therefore propose an estimation method using machine learning.

- ➔ **Data-driven** machine learning method to estimate missing exoplanet properties by applying **clustering algorithms**
- ➔ Most complete data set by combining the *NASA exoplanet archive* and *exoplanet.eu* database
- ➔ Utilizing **Gaussian Mixture Models**, **K-means** and **HDBSCAN** for planet classification
- ➔ Inverting the Uniform Manifold Approximation Projection (**UMAP**, McInnes et al., 2018) to estimate planetary properties (radii, masses) for Hot Jupiters

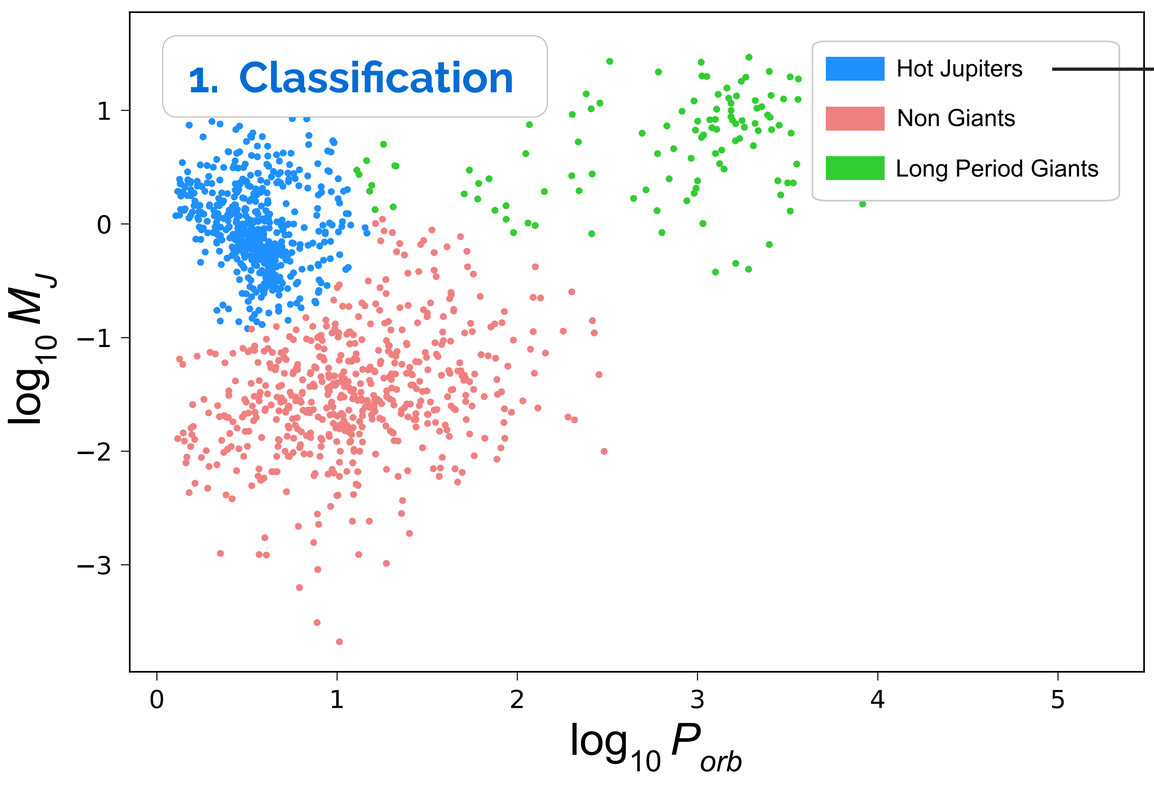

Fig.1:. Classifying exoplanets in a diagram of orbital period and mass by applying Gaussian Mixture Models to the training set. The three resulting subgroups (*blue:* Hot Jupiters, *green:* Long Period Giants, *red:* Non Giants) permit tracking of planets after the UMAP projection.

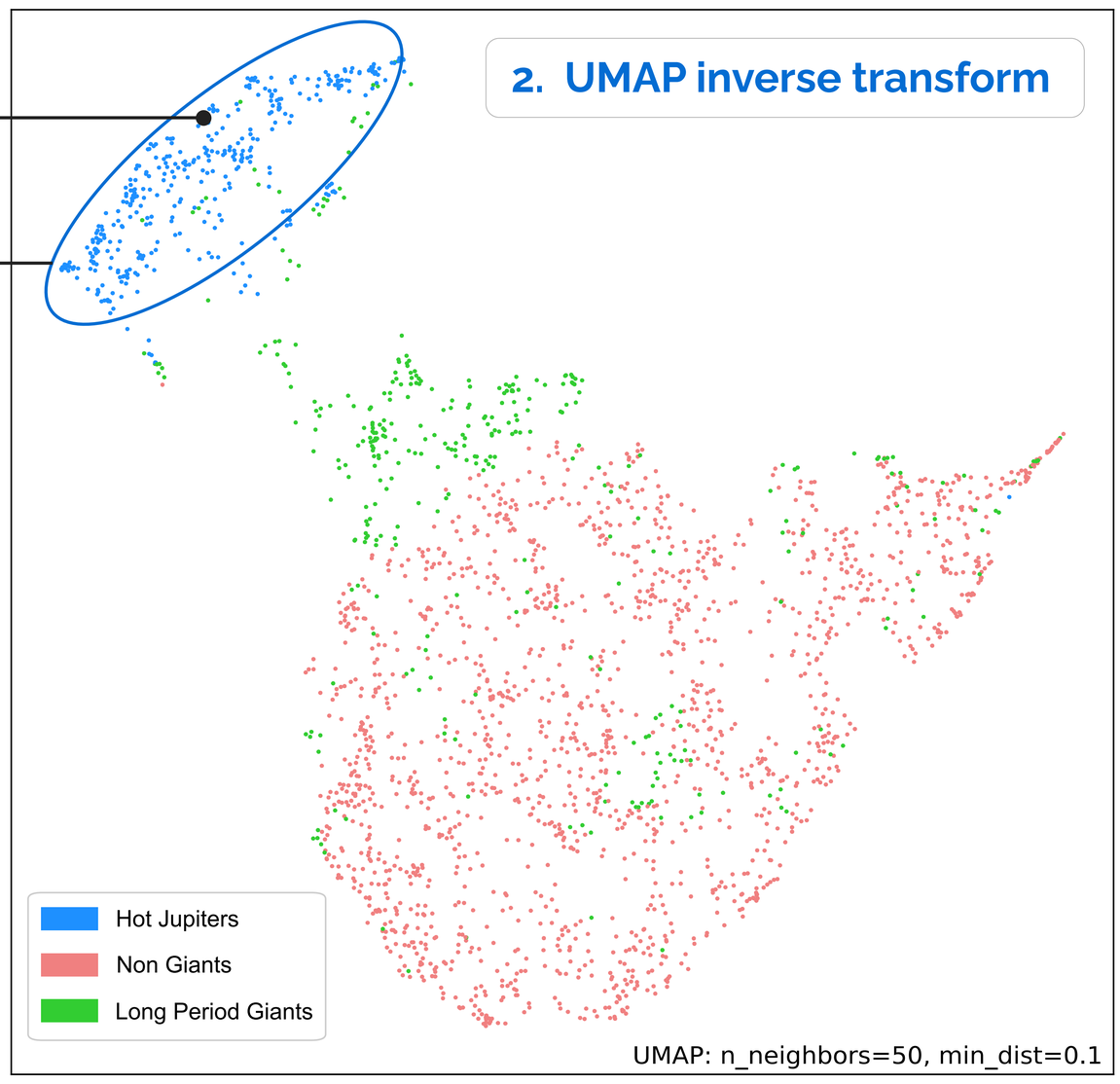

Fig.2: In this particular UMAP embedding the model was trained on the following parameters:
stellar: mass, radius & effective temperature
planetary: orbital period & radius.

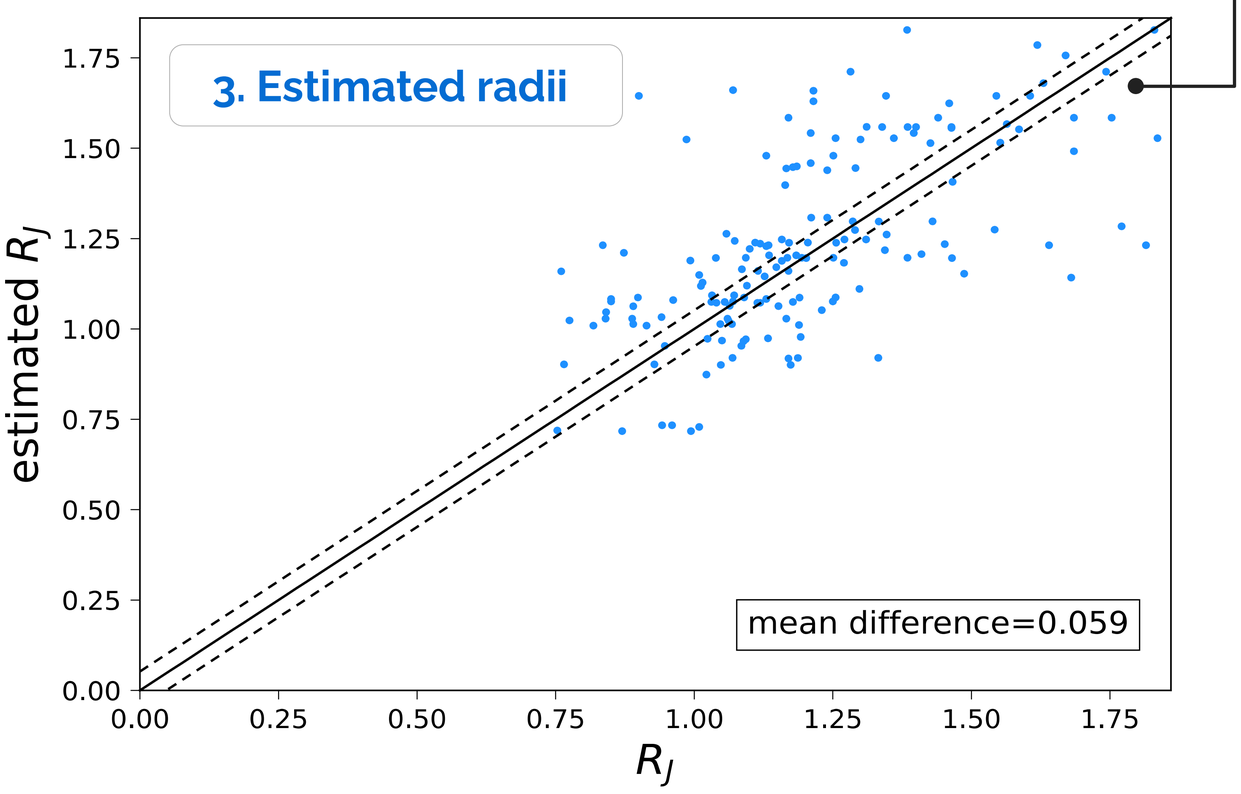

Fig.3: Known radii versus their estimated values after the UMAP inverse transformation. The solid black line corresponds to the equality of the true and estimated values. Dashed lines represent the average error in radius for Hot Jupiters between 0.5 and 2.0 R_J.

Results deviate on average by **0.06 R_J** and **0.23 M_J**

- Needs only 3 host star parameters & orbital period of the planet
- Promising for parameter estimation in exoplanets
- Useful tool in the target characterization of upcoming missions such as PLATO and Ariel.

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References: McInnes, L., Healy, J., and Melville, J., "UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction", *arXiv e-prints*, 2018. doi:10.48550/arXiv.1802.03426.
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