

Machine Learning for Physics and Astronomy: Exercises

David Sergio

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Problem 3.4

Based on your knowledge of the laws of physics (in particular, the scaling of stellar luminosity as a function of mass for main sequence stars and the scaling of flux from a point source with distance), engineer a new feature (a combination of two or more features you already have) that might correlate strongly with planet habitability. Explain why you think this feature would work. [1]

– extra points if you include a special reference to Battlestar Galactica and their ability to live on a planet but not one like earth. . . . that might not even make sense but something like that lol

Background

The mass-luminosity relationship for main sequence stars is given by the equation:

$$L \propto M^{3.5} \quad (1)$$

where L (watts) is the luminosity and M (kg) is the mass of the star. [3]

The flux F from a point source at a distance d is given by:

$$F = \frac{L}{4\pi d^2} \quad (2)$$

where F (watts per square meter) is the flux and d (meters) is the distance from the source. [4]

Tylium and Battlestar Galactica

In the universe of Battlestar Galactica, Tylium is a valuable resource used to fuel spacecraft. [2] A star system with a high concentration of Tylium will support advanced technology and space travel, critical for the survival of humanity and winning the Cylon War. Because Tylium is a natural resource with a very high energy density, it follows that planets in massive star systems would have a higher concentration of Tylium, either on the planet or on a nearby moon, asteroid, or neighboring planet. Taking this into account, we will need to limit our search to stars with a mass greater than 2 solar masses, as these stars are more likely to have planets with Tylium deposits. This also means the distance from the star to the planet must be very large, as the habitable zone for such massive stars is much farther out than for smaller stars.

Feature Engineering

The features used will be a combination of the mass of the planet's star and the distance of the star to the planet. The new feature will be defined as:

$$(4\pi d^2)F \propto M^{3.5} \quad (3)$$

Now, since the surface temperature can be used as a zero-order proxy for habitability, we can correlate the flux will be a suitable feature.

$$F_{\text{habitability}} = \frac{M^{3.5}}{d^2} \quad \text{where } M > 2M_{\odot} \quad (4)$$

Code

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1
2 // comment
3
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References

- [1] V. Acquaviva. *Machine Learning for Physics and Astronomy*. Cambridge University Press, 2025.
- [2] Battlestar Galactica Wiki. Tylium, 2025. URL <https://galactica.fandom.com/wiki/Tylium>. Accessed: 2025-07-15.
- [3] D. L. Moche. *Astronomy A Self-Teaching Guide*. Wiley, 2015.
- [4] S. Weinberg. Lecture 2: Stellar structure and evolution, 2021. URL <https://www.astronomy.ohio-state.edu/weinberg.21/Intro/lec2.html>. Accessed: 2025-07-14.