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APPLICATION OF MACHINE LEARNING IN HIGH-CONTRAST IMAGING OF EXOPLANETS & MODELLING THE ATMOSPHERIC ESCAPE PHENOMENON

Abstract

Application of machine learning in high-contrast imaging of exoplanets

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Modelling the atmospheric escape phenomenon

Exoplanets are planets belonging to a different solar system. Detection of exoplanets has been on the rise in recent times. There are several ways to detect them of which the in-direct methods have been most successful. These methods however, fall short in detailed characterization of the exoplanets.

In 2004, for the first time an exoplanet was directly imaged. It was around a brown dwarf 2M1207. Later in 2008 an exoplanet (Fomalhaut b) was imaged around a star Fomalhaut. From then on a total of 22 exoplanets have been directly imaged.

For directly imaging, the difference in contrast between the parent star and exoplanet poses the greatest challenge. But if we observe in the infrared region the contrast ratio is lower thereby increasing the probability of detection. The probability further increases for an exoplanet around a brown dwarf in comparison to a main sequence star.

Adding to the challenge is the atmospheric abbreviations. Ground based telescopes utilize adaptive optics to correct for atmospheric effects. This is followed by high level of data processing. Few of the processing techniques that have found success are angular differential imaging and locally optimized combination of images.

For implementing angular differential imaging several algorithms are applied. In recent times machine learning technique of Principal Component Analysis (PCA) has found popularity. The PCA algorithm serves in constructing a point spread function that is subtracted from the science data to improve the probability of detecting an exoplanet. The algorithm however is sensitive to non-Gaussian noise. But further advances in machine learning promises to improve the possibilities for future direct imagine surveys. We in our work would like to explore this lead.

Once an exoplanet has been dircetly imaged the atmospheric radiance data collected will help in developing atmospheric models. The modelling can be achieved using 1D or 3D modelling similar to the ones developed for planets with earth like atmospheres. Thus enabling us to understand the atmospheric escape phenomenon (the escape of gases to outer space). The phenomenon on extrapolation can predict future atmospheric conditions on the exoplanet. Thus providing vital clues on the current and future probability of life elsewhere in the universe.