Exo Planets Visual Analytics tool

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Introduction

The Software is a visual analytics tool for exoplanet data.
It has been built using the exoplanet catalog directly scraped from the nasa website:
https://science.nasa.gov/exoplanets/exoplanet-catalog/
Using this tool the user can:

- look for insights about the discovered planets
- look for insight about the discoverying methods used
- look for insights about the stars these planets orbit around

Data preprocessing

Scraping Script

json file

Features considered

Planet Radius (Jupiter Radius)

Planet Mass (Jupiter Mass)

Discovery Date

Distance from own star (Astronomical Units)

Planet Type

Discovery Method

Distance from Earth (Parsec)

Star Type

Solar System's Number of Planets

Removing data with missing features (223 exoplanets)

Removing data previous to 2011 (421 exoplanets)

Planet Mass normalized according to Jupiter mass, Planet Radius normalized according to Jupiter Radius

Legends

Planet Type (Qualitative color rapresentation)

Gas Giant · Neptune-like · Super Earth · Terrestrial

Star Type (Sequential color rapresentation)

(Y) 80–500 K · (T) 500–1,500 K · (M) 2,400–3,700 K · (K) 3,700–5,200 K · (G) 5,200–6,000 K · (F) 6,000–7,500 K
(A) 7,500–10,000 K · (B) 10,000–30,000 K · (O) 30,000–50,000 K

Discoverying Method (Qualitative color rapresentation)

Transit · Radial Velocity · Transit Timing Variations · Microlensing · Imaging · Eclipse Timing Variations · Disk Kinematics
Orbital Brightness Modulation · Astrometry

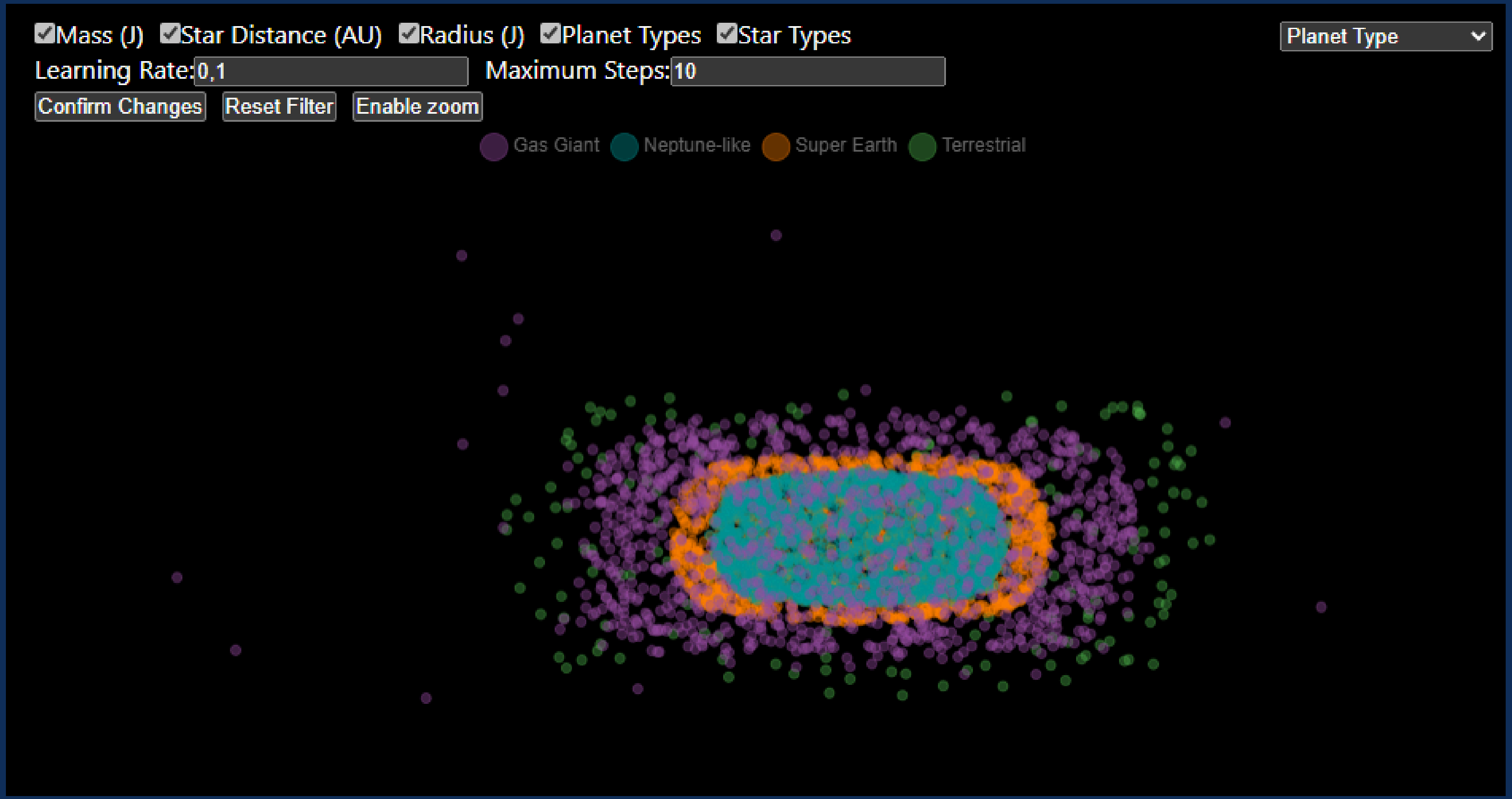
https://colorbrewer2.org/

Scatter Plot

- MDS applied.
- planet type, radius, mass, star distance, star type .
- Force direct approach, Stress Loss (Squared Loss)
- Computation possible on the Front-end
- Customizable settings for MDS
- Zoom
- Filter on Click
- Legend Switch
- Legend Label Removal

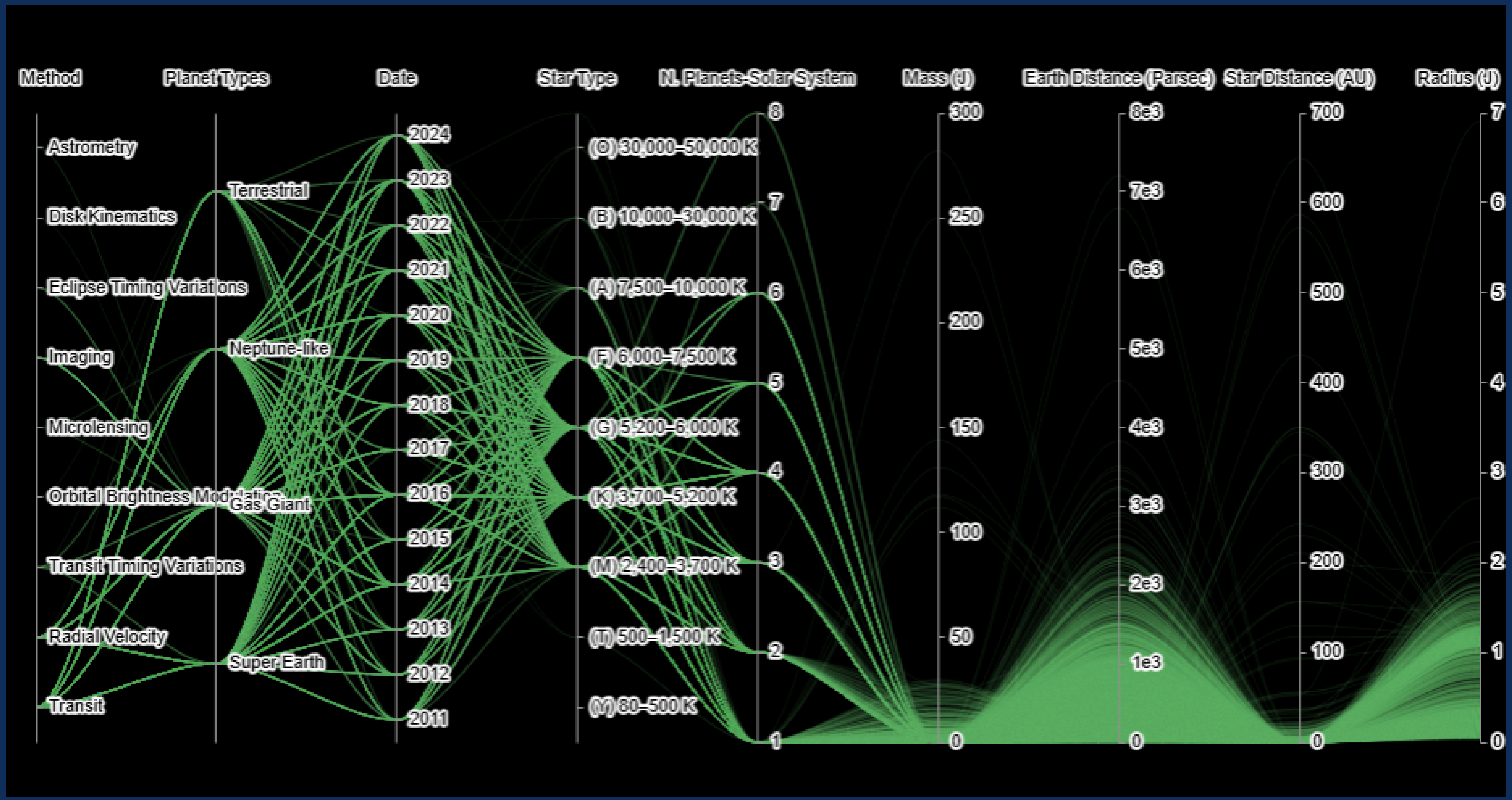
Type 1	Type 2	Distance
Gas Giant	Gas Giant	0
Gas Giant	Neptune-Like	0.33
Gas Giant	Super-Earth	0.66
Gas Giant	Terrestrial	1
Neptune-Like	Neptune-Like	0
Neptune-Like	Super-Earth	0.33
Neptune-Like	Terrestrial	0.66
Super-Earth	Super-Earth	0
Super-Earth	Terrestrial	0.33
Terrestrial	Terrestrial	0

Type 1	Type 2	Distance
(Y) 80–500 K	(Y) 80–500 K	0
(Y) 80–500 K	(T) 500–1,500 K	0.125
(Y) 80–500 K	(M) 2,400–3,700 K	0.250
(Y) 80–500 K	(K) 3,700–5,200 K	0.375
(Y) 80–500 K	(G) 5,200–6,000 K	0.5
(Y) 80–500 K	(F) 6,000–7,500 K	0.625
(Y) 80–500 K	(A) 7,500–10,000 K	0.75
(Y) 80–500 K	(B) 10,000–30,000 K	0.875
(Y) 80–500 K	(O) 30,000–50,000 K	1
(T) 500–1,500 K	(T) 500–1,500 K	0
(T) 500–1,500 K	(M) 2,400–3,700 K	0.125
(T) 500–1,500 K	(K) 3,700–5,200 K	0.250
(T) 500–1,500 K	(G) 5,200–6,000 K	0.375
(T) 500–1,500 K	(F) 6,000–7,500 K	0.5
(T) 500–1,500 K	(A) 7,500–10,000 K	0.625
(T) 500–1,500 K	(B) 10,000–30,000 K	0.75
(T) 500–1,500 K	(O) 30,000–50,000 K	0.875
(M) 2,400–3,700 K	(M) 2,400–3,700 K	0
(M) 2,400–3,700 K	(K) 3,700–5,200 K	0.125
(M) 2,400–3,700 K	(G) 5,200–6,000 K	0.25
(M) 2,400–3,700 K	(F) 6,000–7,500 K	0.375
(M) 2,400–3,700 K	(A) 7,500–10,000 K	0.5
(M) 2,400–3,700 K	(B) 10,000–30,000 K	0.625
(M) 2,400–3,700 K	(O) 30,000–50,000 K	0.75
(K) 3,700–5,200 K	(K) 3,700–5,200 K	0
(K) 3,700–5,200 K	(G) 5,200–6,000 K	0.125
(K) 3,700–5,200 K	(F) 6,000–7,500 K	0.25
(K) 3,700–5,200 K	(A) 7,500–10,000 K	0.375
(K) 3,700–5,200 K	(B) 10,000–30,000 K	0.5
(K) 3,700–5,200 K	(O) 30,000–50,000 K	0.625
(G) 5,200–6,000 K	(G) 5,200–6,000 K	0
(G) 5,200–6,000 K	(F) 6,000–7,500 K	0.125
(G) 5,200–6,000 K	(A) 7,500–10,000 K	0.25
(G) 5,200–6,000 K	(B) 10,000–30,000 K	0.375
(G) 5,200–6,000 K	(O) 30,000–50,000 K	0.5
(F) 6,000–7,500 K	(F) 6,000–7,500 K	0
(F) 6,000–7,500 K	(A) 7,500–10,000 K	0.125
(F) 6,000–7,500 K	(B) 10,000–30,000 K	0.25
(F) 6,000–7,500 K	(O) 30,000–50,000 K	0.375
(A) 7,500–10,000 K	(A) 7,500–10,000 K	0
(A) 7,500–10,000 K	(B) 10,000–30,000 K	0.125
(A) 7,500–10,000 K	(O) 30,000–50,000 K	0.25
(B) 10,000–30,000 K	(B) 10,000–30,000 K	0
(B) 10,000–30,000 K	(O) 30,000–50,000 K	0.125
(O) 30,000–50,000 K	(O) 30,000–50,000 K	0



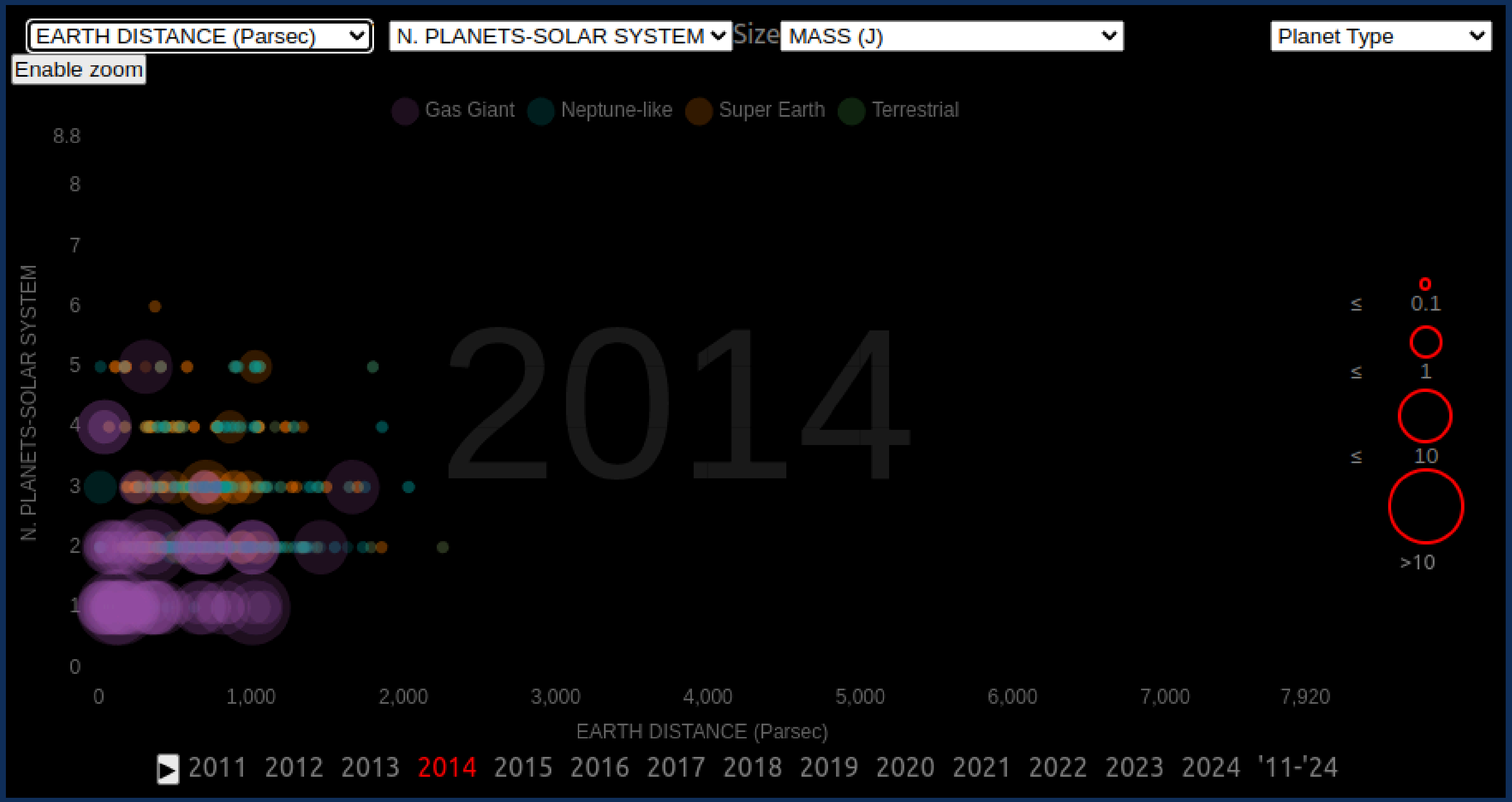
Parallel Coordinates

- Discoverying Method, Planet Type, Date, Star Type, N. Planets - Solar System, Mass, Earth Distance, Star Distance, Radius
- Filter is possible



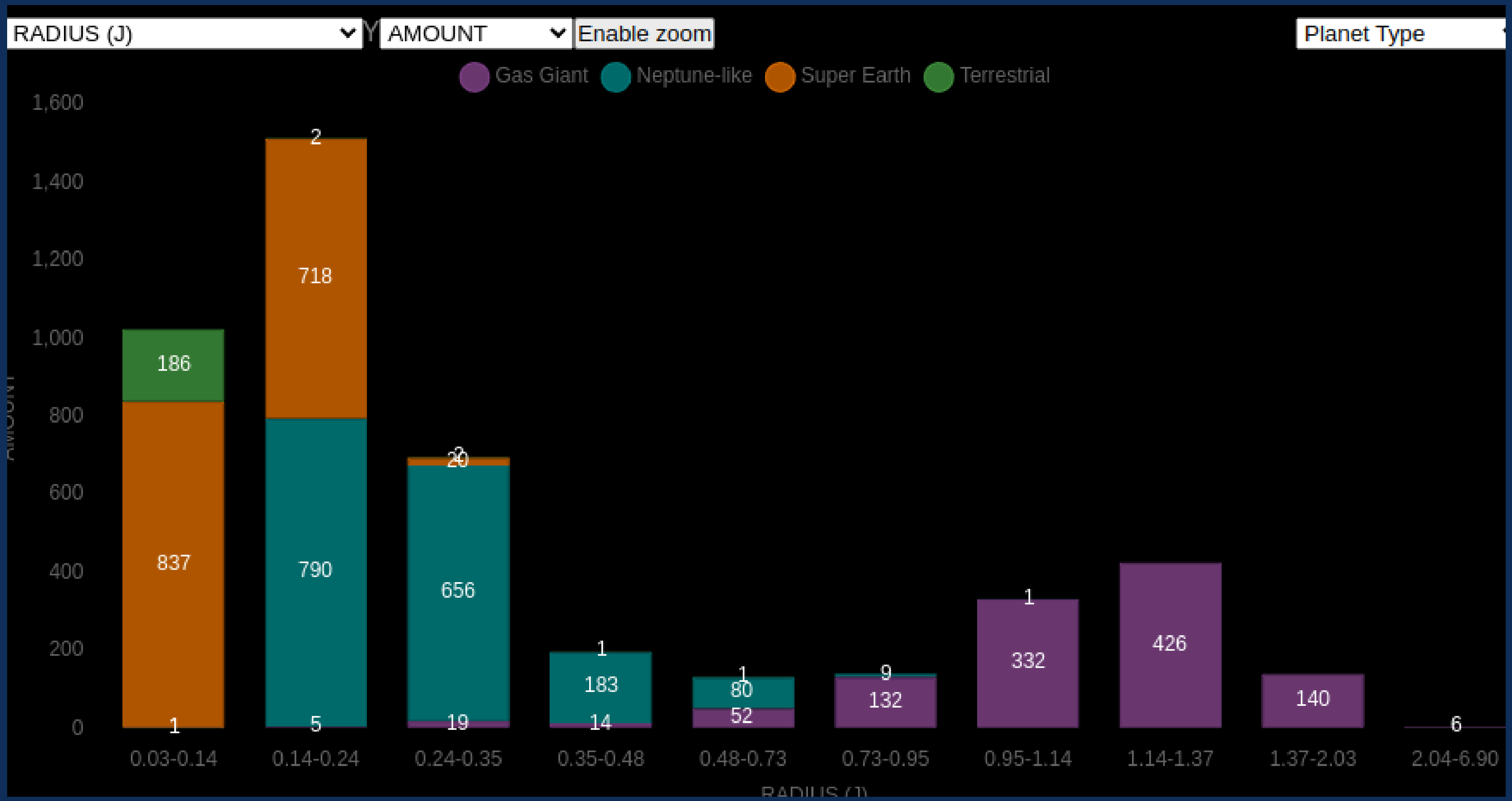
Bubble Plot

- X axis, Y Axis, Dimension Size
- Zoom
- Editable Size
- Time Laps Play
- Time On Date Clicking
- Filters with region selection
- Filter out with empty region selection
- Legend Switch
- Legend Label Removal

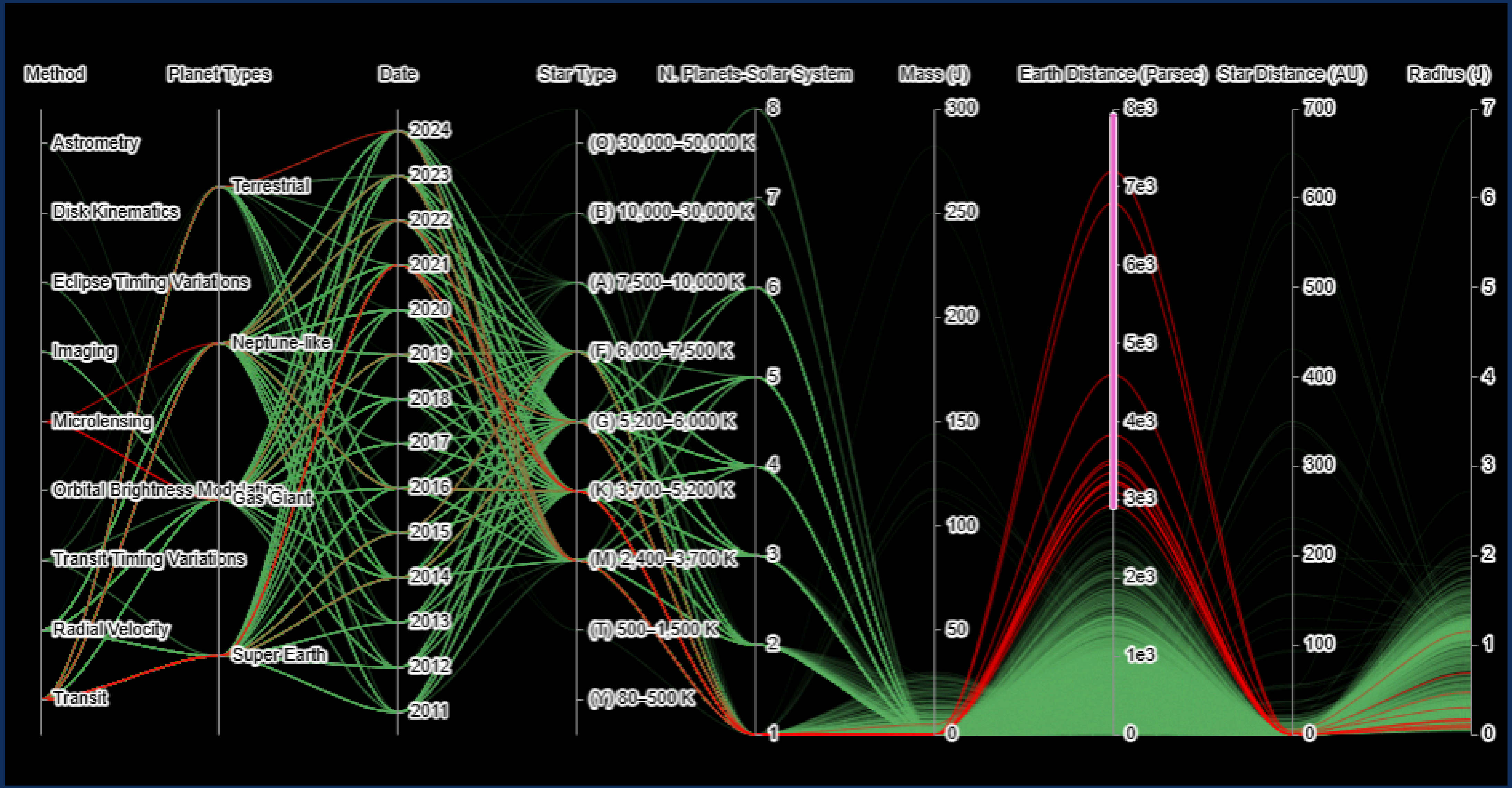


Histogram

- Features on X Axis
- Amount and Percentage On Y Axis
- Zoom
- Legend Switch
- Legend Label Removal

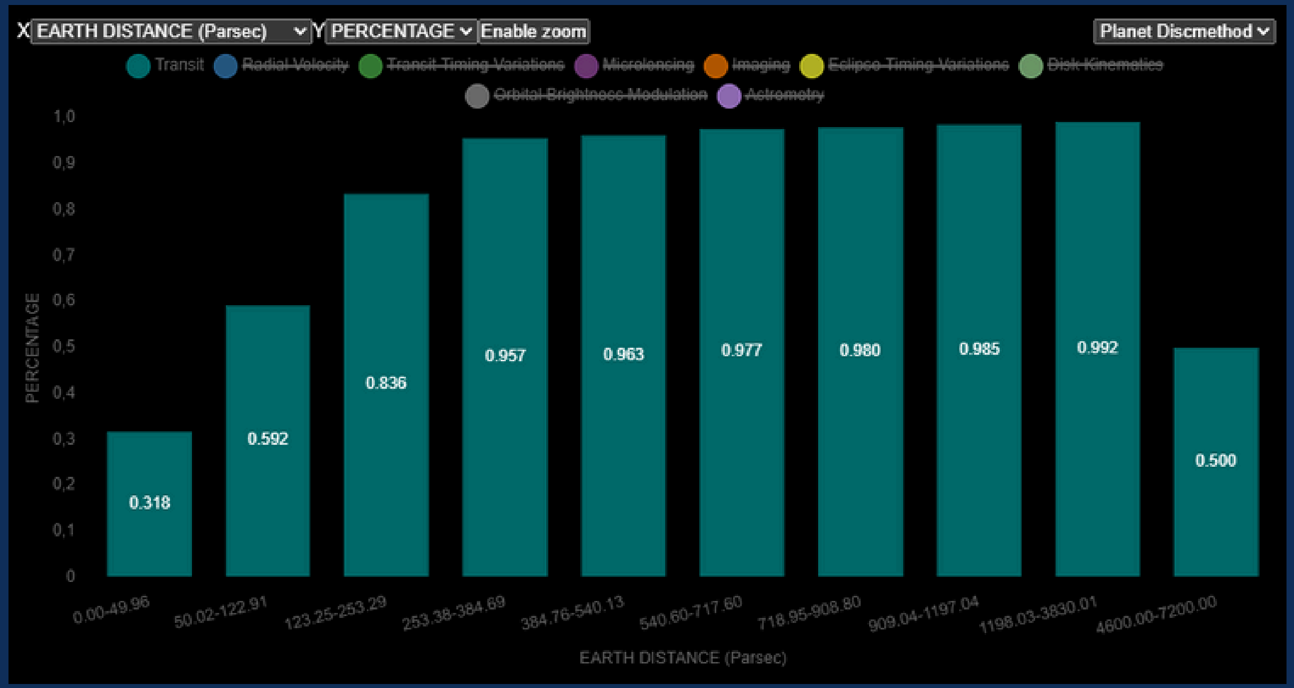


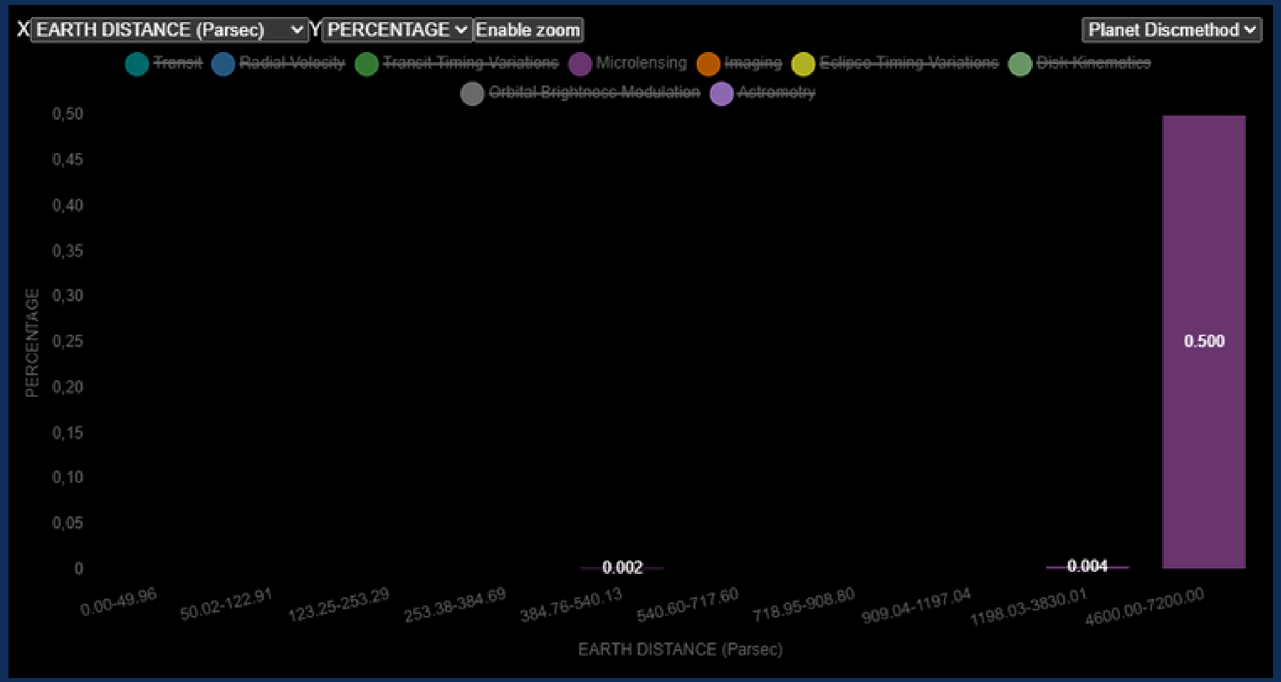
Use Case



Let's assume our target user wants to know what type of discoverying method is the most adequate to spot the planets with some specific features (For example high Earth Distance). In this case the first thing that the user can do is to highlight with a filter the datapoints with the highest earth distance on the parallel coordinates. The user could select a filter that goes from 3e3 to 8e3 Parsecs as showed in the figure

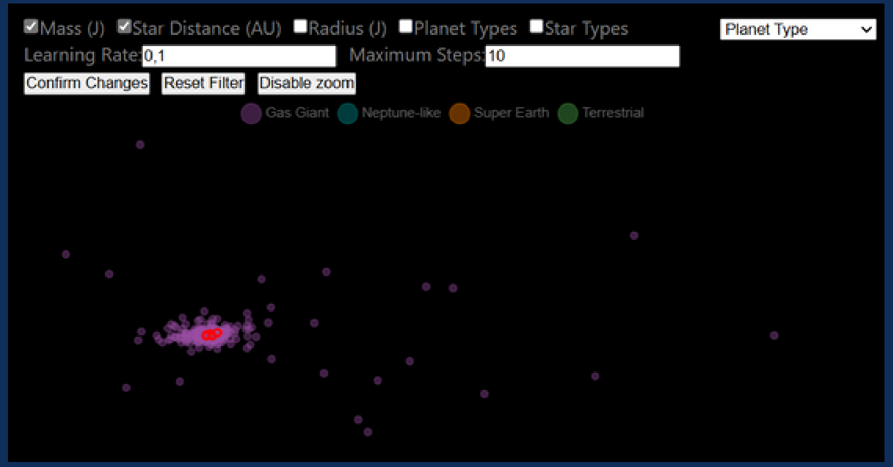
Use Case

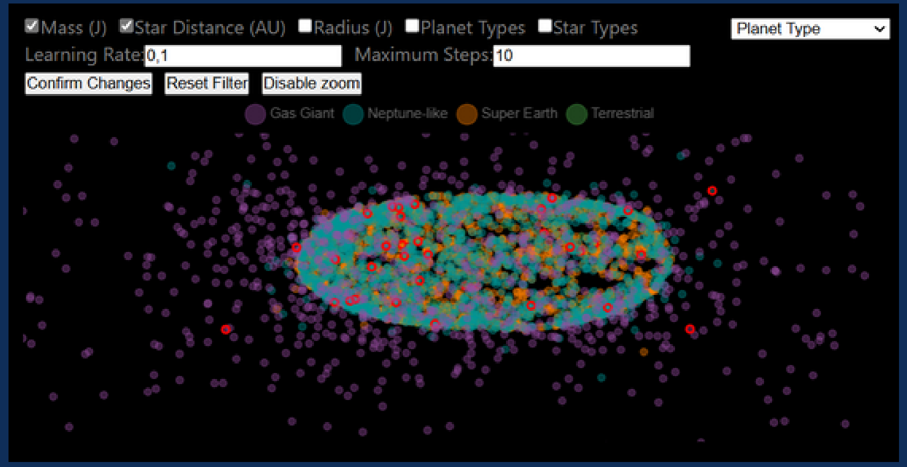


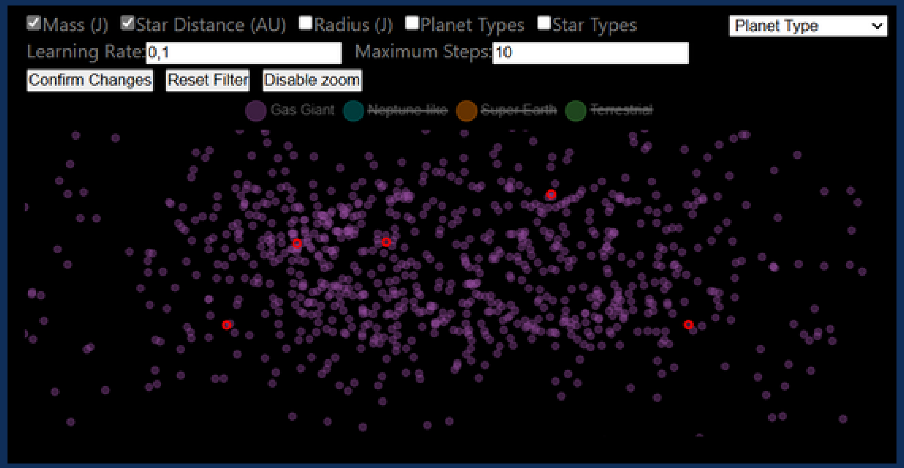


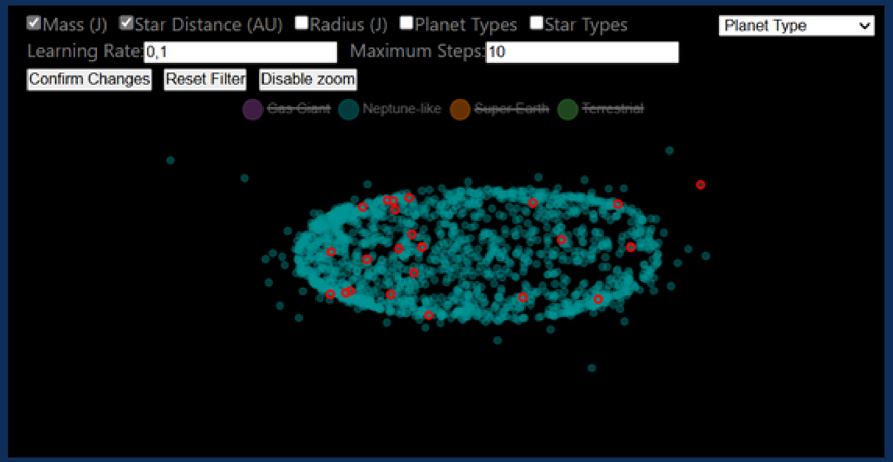
According to the data highlighted seems that the discoverying methods of these distant planets are only Microseling and Transit. The user then can decide to go to the histogram chart and see how many exoplanets the Microlensing and the Transit method have discovered as showed in the images

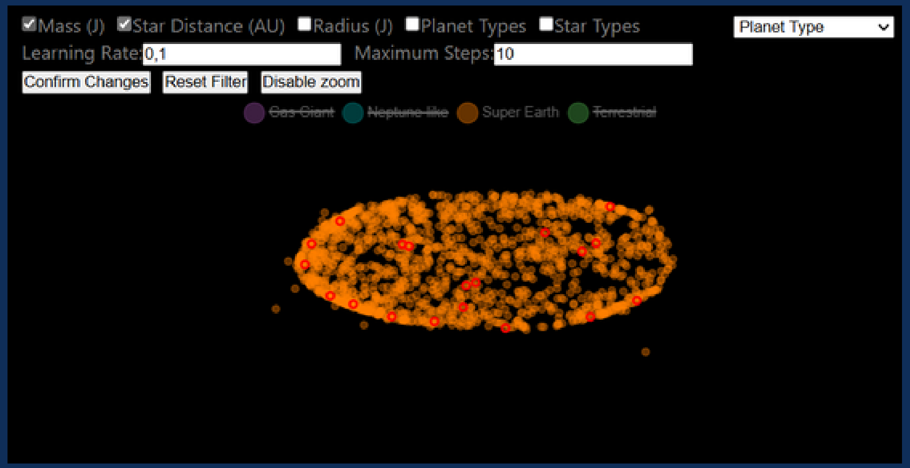
Use Case

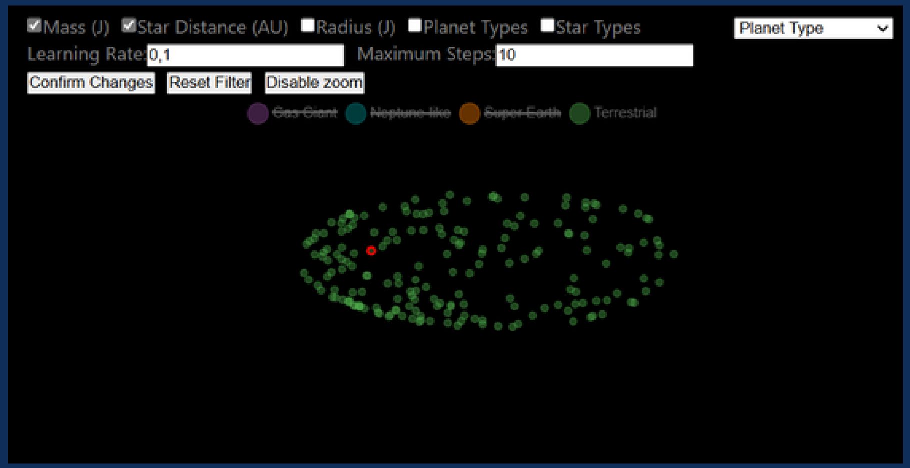






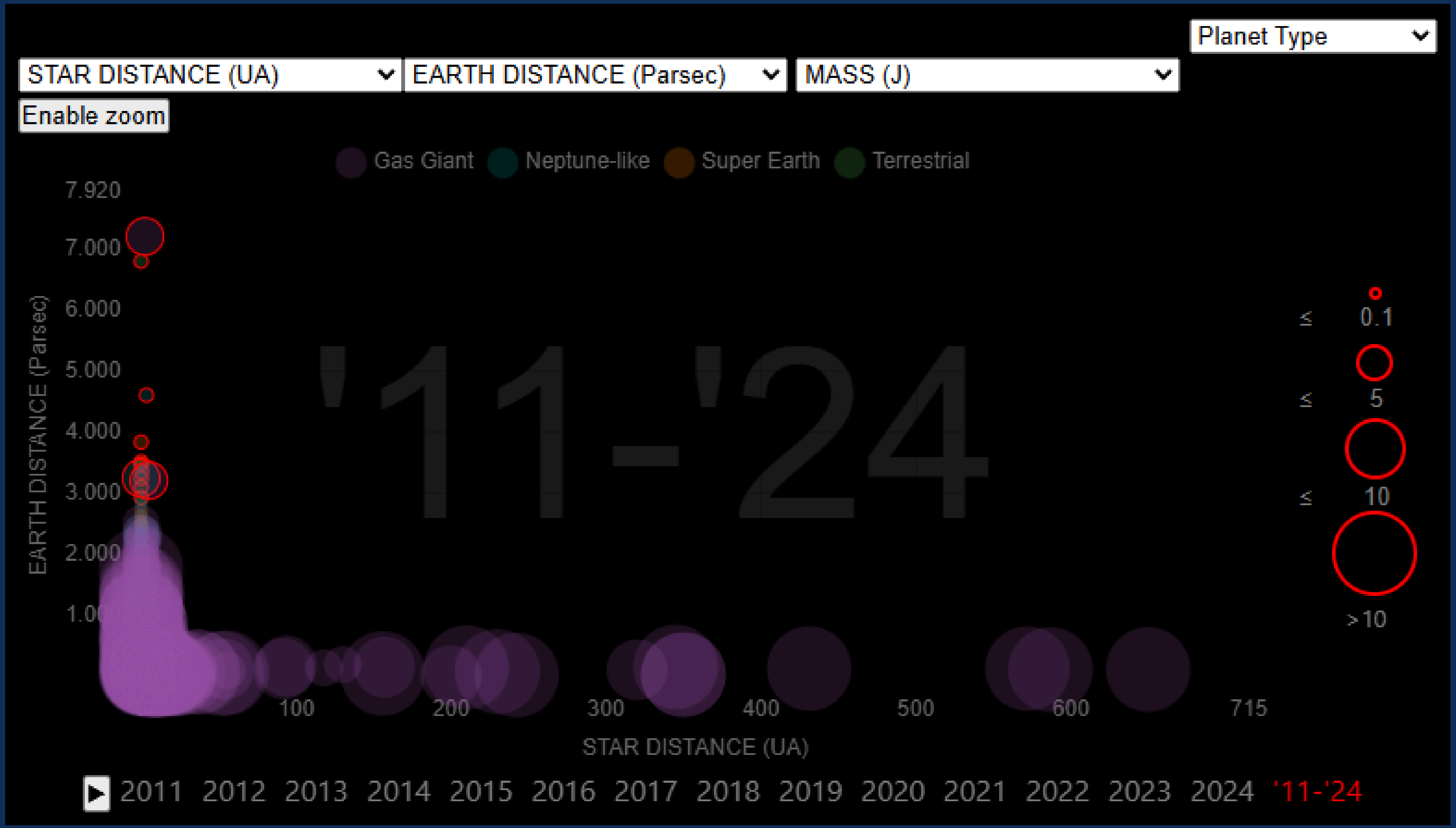






Also from the parallel coordinates seems that the only stars with these type of planets so far from Earth are those regarding the Stars in the temperature range 2400-7500, and seems also that these planets could have in common similar star distances and masses. The user can use the Scatter Plot to confirm or disprove this claim. In the general plot we can see that, filtering the scatter plot according to the filters set on the parallel coordinates and setting the distance computation according to only the mass and the star distance, the points are really close togheter. Also zooming in and filtering according to the planet type we can see that these type of planets are common among Terrestrial, Neptune-Like and Super-Earth, but not among Gas-Giant planets

Use Case



The user can check this also in the bubble plot setting the 2011-2024 data and filtering by Earth Distance, Star Distance and Mass on the X,Y axis and on the size parameter. Since among the exoplanets with huge mass and huge distance no one has a huge distance from Earth the user can conclude that the methods used for discoverying distant exoplanets around a star will tend to have also these characteristics

Final Thoughts

The user can assert:

- For distant exoplanets the best discoverying method is Microlensing: the 50% of the most distant planets (in the range of 4600-7600 parsecs from the Earth) have been discovered through the Microlensing method while other planets discovered with this method are in the half above the average for the earth distance. The user can see indeed that the transit method can discover planets in every Earth Distance range, however even if the majority of discoveries have been done with the Transit method with an average of 89% of all discovered exoplanet considered ,the amount of planets discovered in the highest range (4600-7600 parsecs) is shared with the microlensing method with only a 50%. And this agree with [1]
- Distant planets discovered with these methods around the star will tend to be close to its own star. This agrees with the common literature: since some of these distant planets are discovered with the transit method, for example, a planet that orbits close to its star blocks a larger percentage of the star's light (because its angular size compared to the star is larger), making the transit more detectable [1] (there is an increase in the dip, which is the decrease in the brightness of a star when a planet passes) and as the star's distance from us increases, the overall brightness we observe decreases. As a result, the small dip in brightness caused by a transit becomes harder to detect, since the light reaching us is more diffused and weaker overall. This means that with the transit method is harder to find distant planets, but as the planet is closer to its star it becomes esier.

[1] Ziqi Dai, Dong Ni, Lizhuang Pan, and Yiheng Zhu. Five methods of exoplanet detection. Journal of Physics: Conference Series, 2012:012135, 09 2021.

Links

Code: https://github.com/VivianoRiccardo/VA-project

Demo: www.visual-analytics.netlify.app