Exoplanet Constellation Creator

by Shoebills in Space

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The Problem: A lack of perspective

- On Earth, we can only view the universe from **one perspective**
  - We are unable to understand the scale or scope of the universe
- On Earth, we can only see constellations in **two dimensions**
  - These beautiful 3-dimensional shapes are greatly diminished from our traditional vantage
- On Earth, we cannot understand **how far away** distant planets are
  - Even though telescopes can give us numbers, the distance to the nearest star is farther than any human has traveled

Our Solution

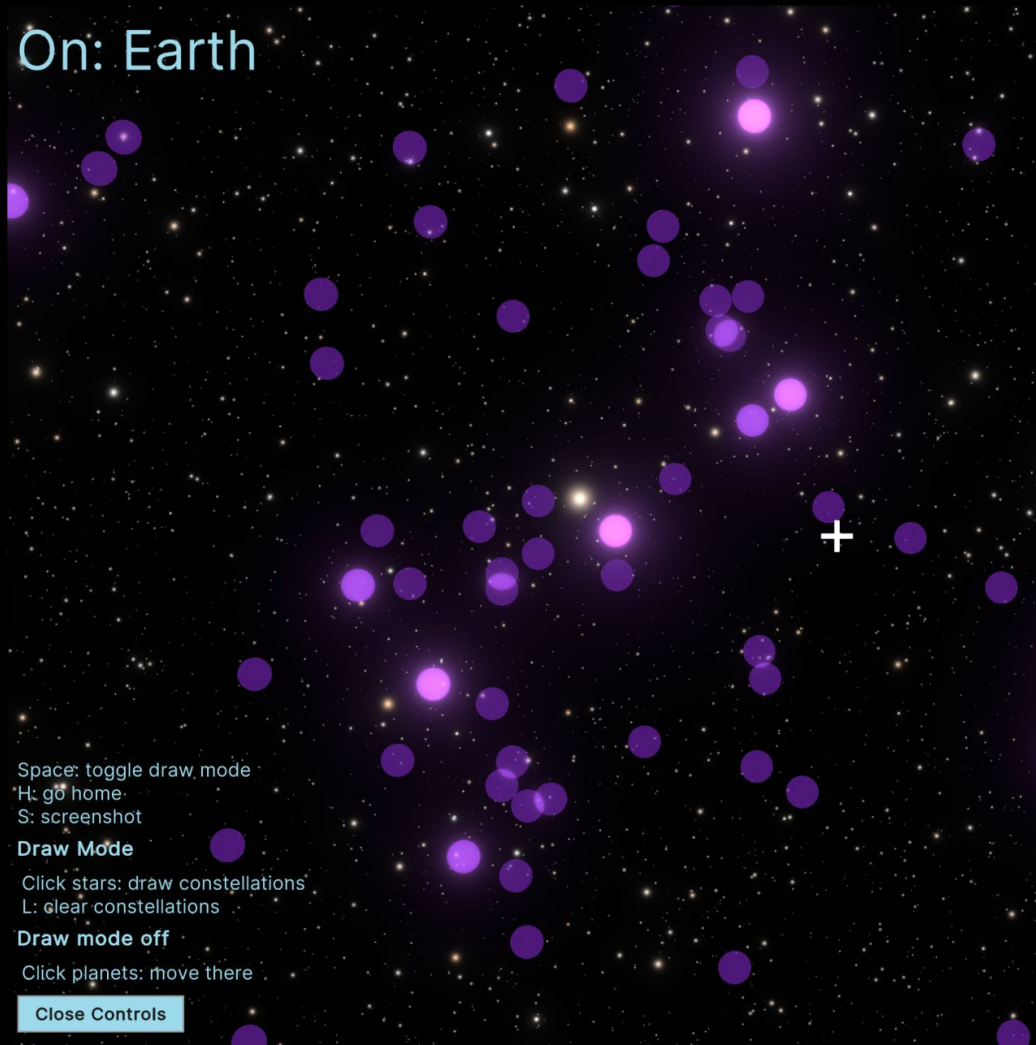
- We developed an **interactive 3D starfield** based on **5500 exoplanets and half a million stars** from NASA and ESA databases.
- A user can **draw constellations** and **travel to real-life exoplanets** to see how the stars — and their constellations — change with perspective.
- **The goal** is to provide a tool that provides this missing perspective to people all over the world and sparks interest in space exploration and exoplanets!

Step #1

Users start on Earth.

Our UI displays purple spheres on the location of all exoplanets. Closer ones are brighter.

The user can click on an exoplanet to travel there.



Step #2

Users travel through the starfield to reach the exoplanet.

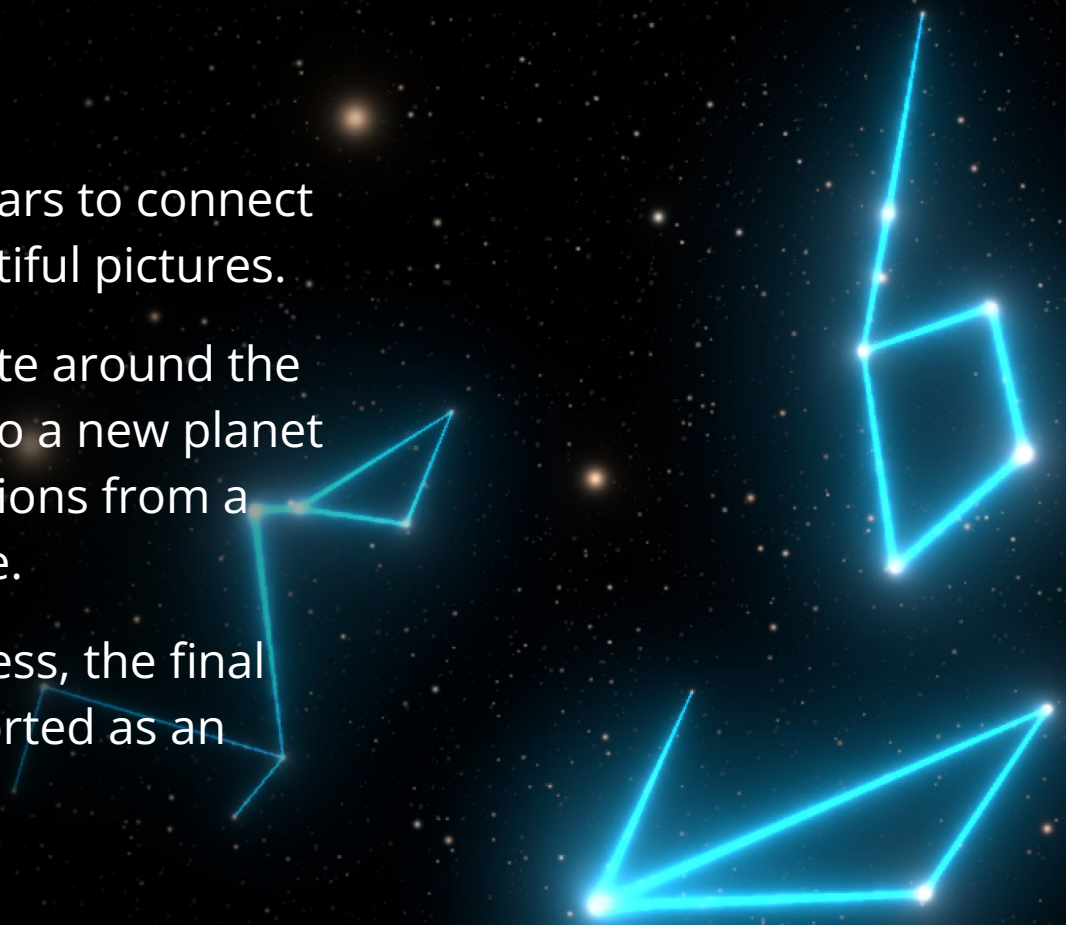
The position of all 5,500+ exoplanets and 500,000 stars are calculated using data from observatories and the ESA Gaia mission.

Step #3

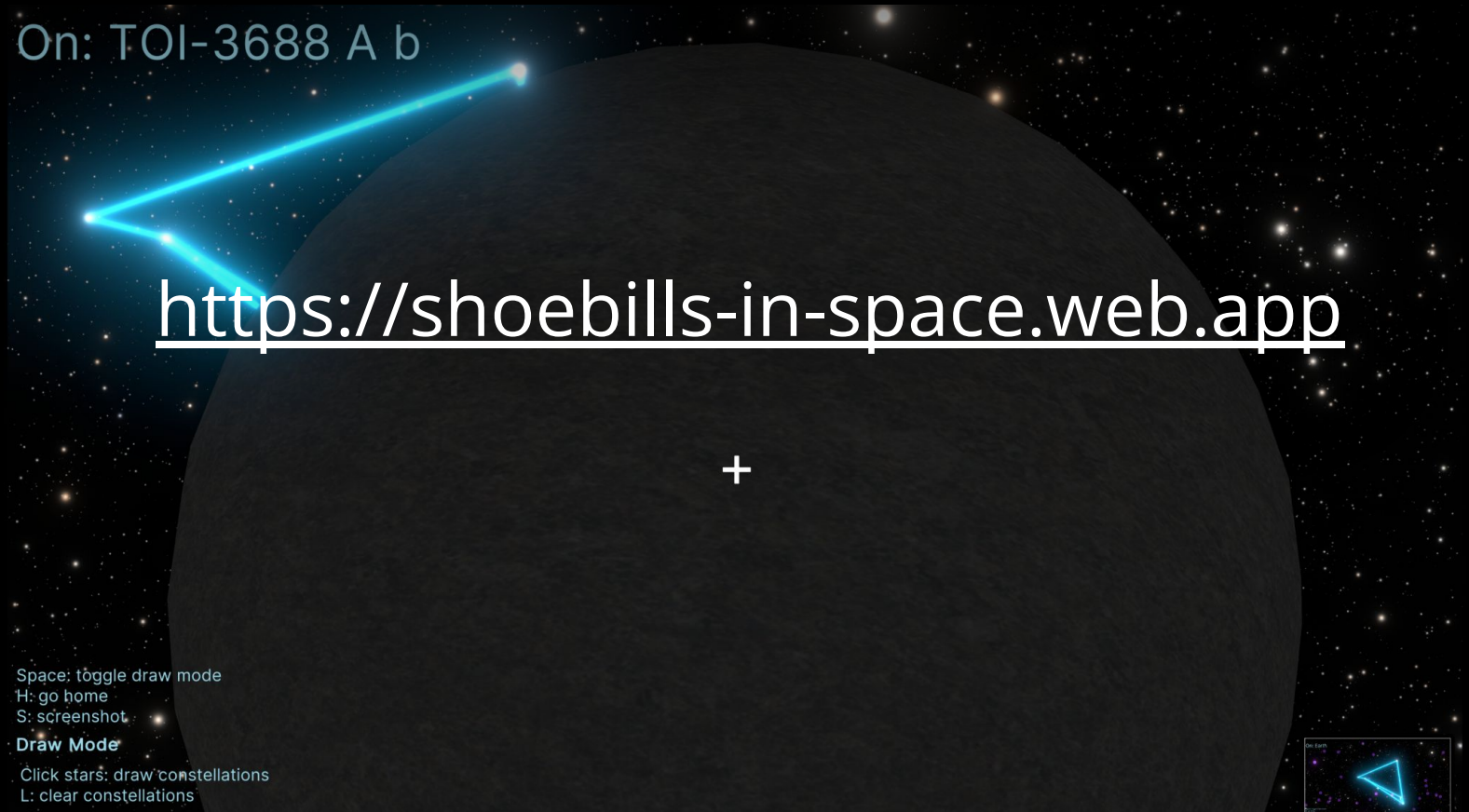
Users can click on stars to connect them, creating beautiful pictures.

You can then navigate around the exoplanet or move to a new planet to see the constellations from a different perspective.

With a simple keypress, the final constellation is exported as an image.



Try it Out!



https://shoebills-in-space.web.app

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The Science

Even though our simulation is pretty, it is highly accurate as well.

- Star brightness is determined by Gaia probe measurements.
- Star color is derived from measured temperature.
- Stars and planets are placed using their calculated position on January 1st, 2024.

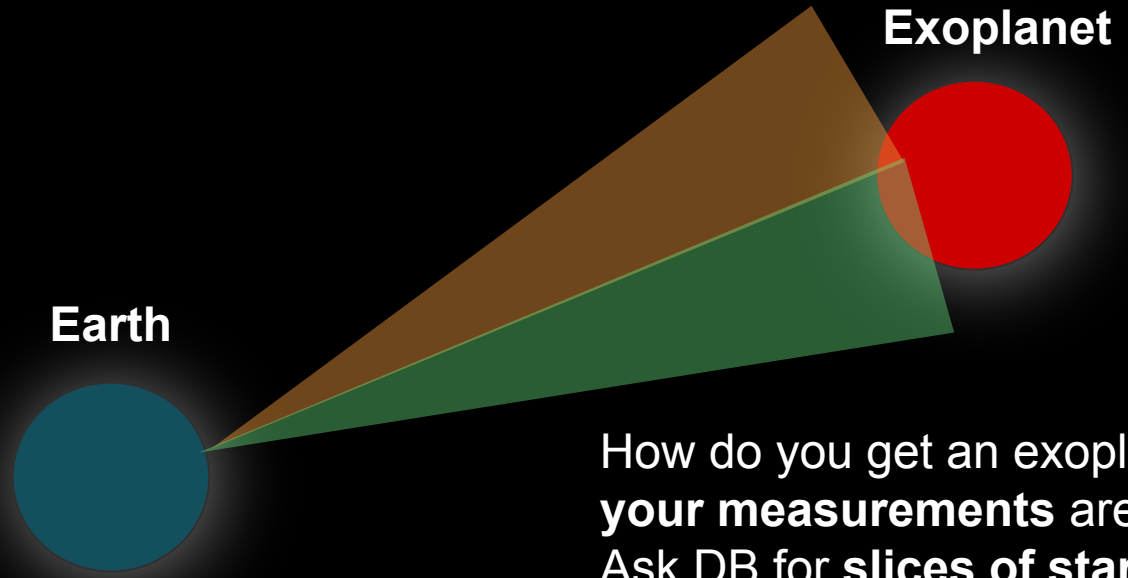
Stylistic choices include:

- Star and planet size is scaled to make the simulation more visibly appealing and easy to use.
- Out of the 2 billion stars in the Gaia archive, we only used the brightest half million to optimize performance.

Technical Challenges

- Finding the balance between accurate representations and interoperability.
- In addition, the convention for astronomical data is in relation to the Earth and in polar coordinates.
    - Our traditional observation point for the universe is from Earth.
- To display the stars as we would see them from an exoplanet, we tried various approaches...

The First Approach



How do you get an exoplanet's set of stars, if **all your measurements** are from Earth?
Ask DB for **slices of stars** overlapping with view of exoplanet?
Advantage: can display more stars
Problem: many calls to DB, computationally intensive

The Approach We Went For

So, if that approach was too computationally intensive... what should we do?

- Instead of computing the stars we needed on the fly, we used a single, smaller set of stars from the Gaia databases that were visible from all of exoplanets
    - We focused on the brightest stars that have the greatest visibility in the universe
- We preprocessed these in Python and translated them to 3D coordinates that the Unity engine can understand

Implementation Details

- Star data was sourced from the 3rd data release of ESA's Gaia probe.
- Exoplanet data was sourced from NASA's exoplanet archive.
- Calculating and formatting the data was done in Python with packages like Skyfield, Astropy, and NumPy.
    - We converted the polar coordinates of the stars into cartesian ones for our simulations.
- The simulation was created using the Unity 3D engine and C# scripts.
- The final product is hosted on Google Firebase.

Our Impact

The tool we built...

- Makes it easier to understand the scope of space from new perspectives
    - We can see see constellations from three dimensions and the space between stars - even fly through stars!
- Gives the younger generation a way to be excited about exoplanets and space exploration!
    - Highlight the importance of what NASA does and the significance of their data
    - Easily accessible to anyone at any age

Future Work

There is so much more potential...

- Create procedural generations of planet's, modeling both physical properties and appearance
    - Show what DATA impacted these generations for educational purposes
- Provide perspectives of solar systems
- Implement a Level of Detail system to dynamically load new clusters of stars