AI IN ASTRONOMY

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Prepared By: Dhanesh Verma(12105129)
Sai Kumar(12105147),
Jatin Tanwar 12108153

Submitted To: Akshara Rana

About Project

Project Breakdown

NAME	RESPONSIBILITY
DHANEHS VERMA	CODING & RESEARCH
SAHIL KUMAR	MODULE MAKING
JATIN TANWAR	RESEARCH & APPLICATION

What is **AI**?

AI, or artificial intelligence, refers to the development of computer systems that can perform tasks that typically require human intelligence, such as learning, reasoning, and problem-solving. AI systems use algorithms and data to recognize patterns and make predictions, often improving their accuracy over time as they learn from more data. Machine learning is a subset of AI that involves training algorithms on large amounts of data to make predictions or take actions without being explicitly programmed. Deep learning is a type of machine learning that uses neural networks, which are modeled on the structure of the human brain, to perform complex tasks like image and speech recognition. Natural language processing is another subset of AI that focuses on enabling machines to understand and process human language, both spoken and written. AI has many real-world applications, including in fields like healthcare, finance, transportation, and entertainment.

Use of AI in Astronomy

Artificial intelligence (AI) has become an increasingly important tool in astronomy over the last few years. Here are some of the different applications of AI in astronomy:

1.Image analysis: AI can help analyze images taken by telescopes to identify patterns and structures that might be difficult for humans to detect. For example, AI algorithms can be trained to identify gravitational lenses, which are often difficult to spot in astronomical images.

2.Data processing: Astronomy produces vast amounts of data that need to be processed and analyzed. AI can help automate this process by identifying and categorizing data, reducing noise, and enhancing signal-to-noise ratios.

3.Exoplanet discovery: AI algorithms can be used to search for exoplanets by analyzing the data from telescopes. These algorithms can detect subtle changes in a star's brightness or position that might indicate the presence of an orbiting planet.

Use of AI in Astronomy

4.Galaxy classification: AI can help classify galaxies based on their shape, size, and other properties. This can help astronomers better understand the structure and evolution of galaxies.

5.Astronomical simulations: AI can be used to create simulations of astronomical phenomena, such as the formation of galaxies, the evolution of stars, and the behavior of black holes.

6.Prediction of astronomical events: AI can be used to predict astronomical events such as supernovae or solar flares, which can be helpful in planning observations or in preparing for potential space weather events.

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Our Evaluation Plan

We Are Planning of Making a Software That will Predict the Type of Star Using The AI. It will do so based on the data base it have from past few years to increase its accuracy for the same.

Predicting astronomical events such as meteor showers, lunar and solar eclipses, and planetary alignments can be very challenging, but AI algorithms can certainly help improve accuracy.

We shall conduct evaluation activities and use success or performance indicators to measure the progress of the project plan.

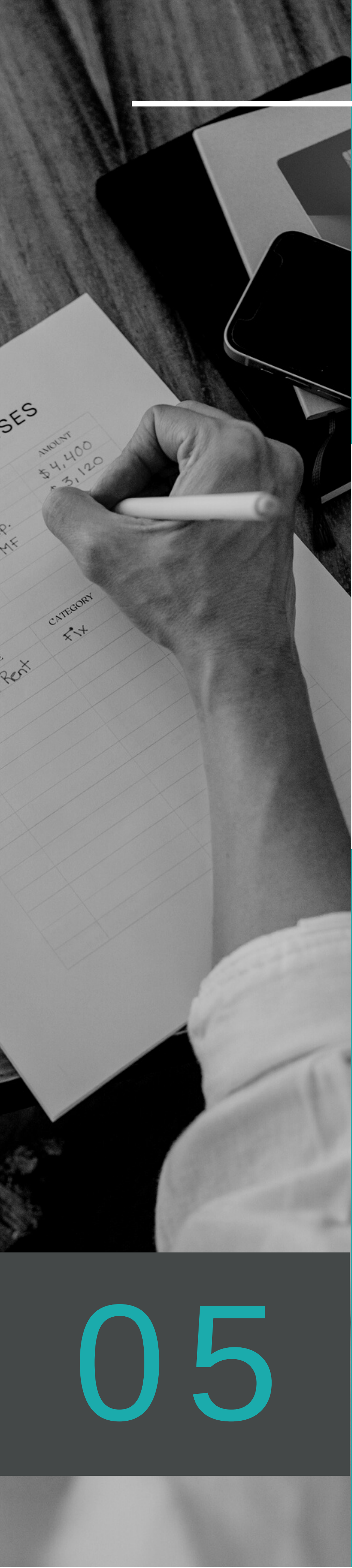
Our Evaluation Plan

- To start with, we will need to gather a large dataset of star and their corresponding dates and times over the past few years. we can use this data to train the AI model to identify patterns and make predictions about its type.

- Next, we'll need to determine which AI algorithms will work best for your project. We may want to consider machine learning algorithms such as decision trees, random forests, or neural networks. These algorithms can analyze the data and identify patterns, making predictions based on that analysis.

- Once our AI model has been trained and tested, We can begin using it to make predictions about the type of star.

- It's important to note that while AI algorithms can be very accurate, they are not perfect. There will always be some degree of uncertainty in predicting astronomical data, and it's important to communicate that to your users. You may also want to include a disclaimer that your software is for informational purposes only and should not be relied upon for safety-critical decisions.



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Project Execution

We use 2-3 data sets for this project

```
hipparcos = pd.read_csv("/content/hipparcos-voidmain.csv")
star_df = pd.read_csv("/content/hipparcos-voidmain.csv")
star_df2 = pd.read_csv("/content/6class.csv")
```

Which Contain some of the information about the star like their magnitude, emissions wavelength, etc.

We used all this information to draw some graphs

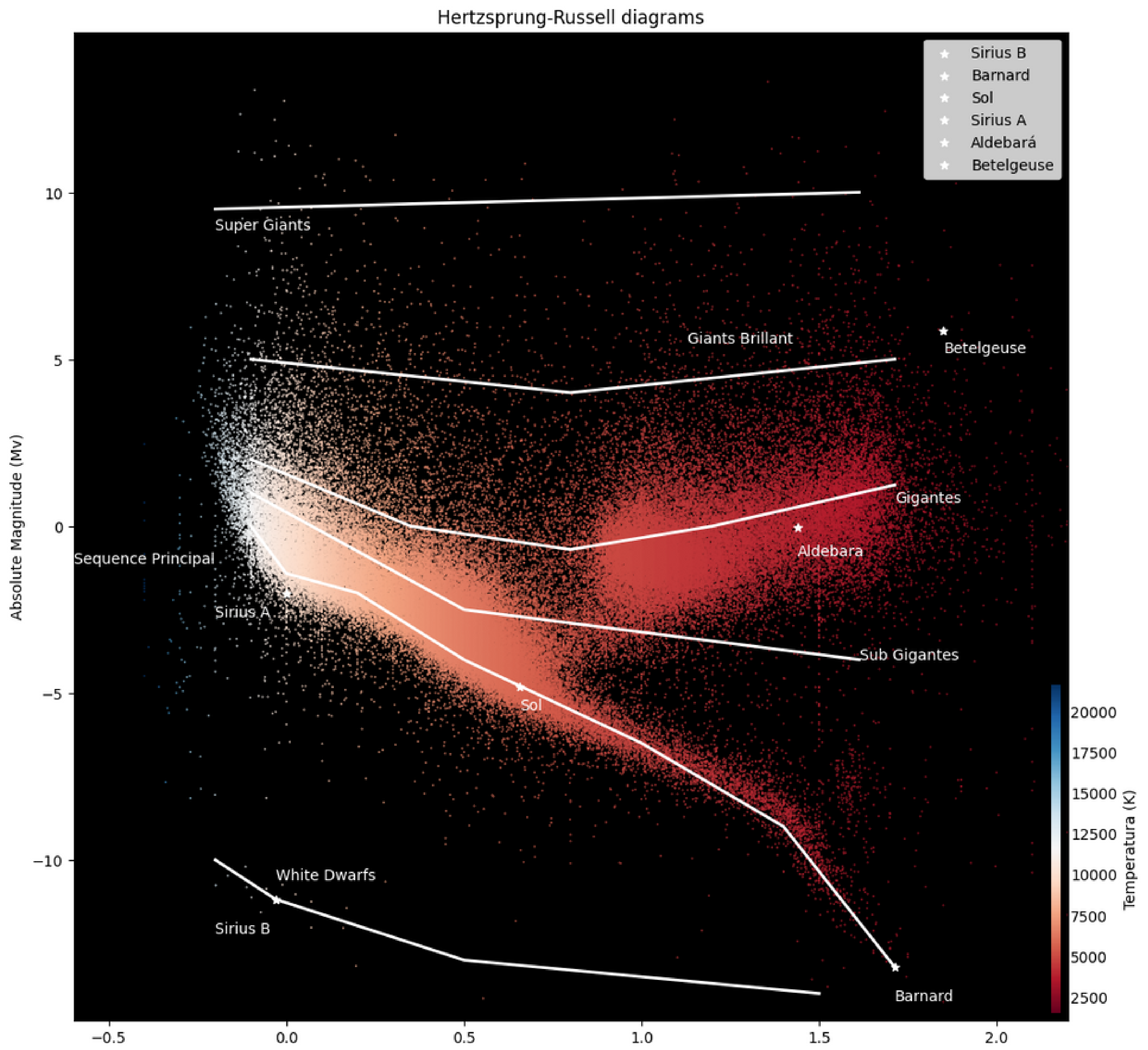
```python
# Calculate the temperature
# Calculate the absolute magnitude

d = 1/p*1000
t = np.array(4600 * (1/(0.92 * bmv + 1.7) + 1/(0.92 * bmv + 0.62)))
M = m - 5 * np.log10(d/10)

print(d, t, M, sep="\n")
```

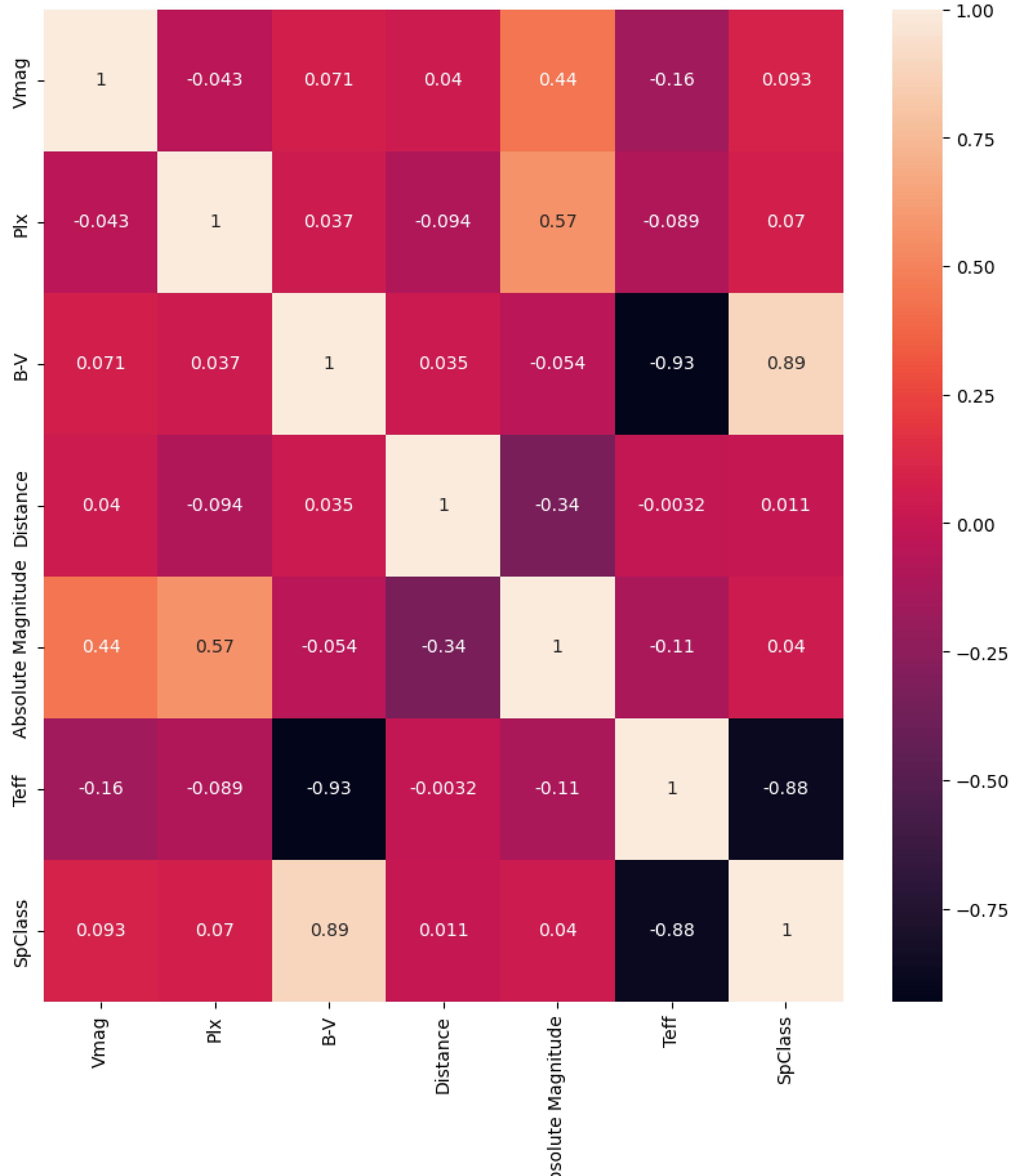
```
[282.48587571  45.66210046 355.87188612 ... 200.          52.02913632
 114.81056257]
[ 6471.66782641  4745.14042459 10368.59558776 ...  4745.14042459
  5608.54490151 11168.81296033]
[ 1.84501631  5.97222057 -1.1464684  ...  1.08485002  5.61876692
 -0.80990922]
```

```python
# Line that shows the flow of movement in the graph of the stars throughout their live
sequence_principal_x = [-0.1,0, .2,0.5, 1, 1.4, 1.713]
sequence_principal_y = [0,-1.42, -2, -4, -6.5, -9, -13.21]

whiteDwarfs_x = [-0.2, -0.03, 0.5,1.5]
whiteDwarfs_y = [-10, -11.18,-13, -14]

SubGiants_x = [-0.1, .5 ,1.613]
SubGiants_y = [1, -2.5 , -4]

SuperGiants_x = [-0.2, 1.613]
SuperGiants_y = [9.5, 10]

giants_x = [-0.1,0.35 ,0.8 ,1.2 ,1.713]
giants_y = [2,0 ,-0.7, 0,1.231]

giantsBrillant_x = [-0.1,0.8 ,1.713]
giantsBrillant_y = [5, 4 ,5]
```

```python
# Plot the graph
fig, ax = plt.subplots(figsize=(12, 12))
scatter = ax.scatter(bmv, -M, c=t, cmap="RdBu", marker='.', s=.5)

ax.scatter(x=-0.03, y=-11.18, c="white", s=30, label="Sirius B", marker="*")
ax.scatter(x=1.713, y=-13.21, c="white", s=30, label="Barnard", marker="*")
ax.scatter(x=0.656, y=-4.83, c="white", s=30, label="Sol", marker="*")
ax.scatter(x=0, y=-2.02, c="white", s=30, label="Sirius A", marker="*")
ax.scatter(x=1.44, y=-0.031, c="white", s=30, label="Aldebará", marker="*")
ax.scatter(x=1.85, y=5.85, c="white", s=30, label="Betelgeuse", marker="*")

# Set xlabel, ylabel and title
plt.xlabel("Color Index (B-V)")
plt.ylabel("Absolute Magnitude (Mv)")
plt.title("Hertzsprung-Russell diagrams")
plt.legend()
```

```
# Set x and y limit
plt.xlim(-0.6, 2.2)
plt.ylim(-14.8, 14.8)

# Plot the stars
plt.plot(sequence_principal_x, sequence_principal_y, c="white", linewidth=2)
plt.plot(whiteDwarfs_x, whiteDwarfs_y, c="white", linewidth=2)
plt.plot(SubGiants_x, SubGiants_y, c="white", linewidth=2)
plt.plot(giants_x, giants_y, c="white", linewidth=2)
plt.plot(SuperGiants_x, SuperGiants_y, c="white", linewidth=2)
plt.plot(giantsBrillant_x, giantsBrillant_y, c="white", linewidth=2)

# Write the name of stars
plt.annotate("Super Giants", (-0.2, 8.9), c="white")
plt.annotate("Giants Brillant", (1.13, 5.5), c="white")
plt.annotate("Sequence Principal", (-0.6, -1.1), color="white")
plt.annotate("White Dwarfs", (-0.02, -10.6), color="white")
```






```
[ ] # Add column name
    features = pd.DataFrame(hipparcos_t, columns=hipparcos.columns[:7])
```

```
# Show coorelation
fig = plt.figure(figsize=(10, 10))
matrizC = sns.heatmap(features.corr(), annot=True)
```

Theory Part

Star Rating

Stars are celestial bodies of great importance in the universe, since they emit light and heat that is essential for life on our planet. They are the result of the nuclear fusion of hydrogen in their nuclei, which generates a large amount of energy. The classification of stars is based on their surface temperature and their luminosity. This is reflected in its color and size. One way to classify stars is by the Hertzsprung-Russell stellar sequence, also known as the "Hertzprung-Russell diagram". In this diagram, stars are classified based on their surface temperature and luminosity, which allows their position in the stellar sequence to be determined.

1.1 Absolute magnitude

The absolute magnitude of a star is a measure of its intrinsic brightness, that is, its true brightness regardless of its distance from us. It is used to compare the luminosity of different stars. Absolute magnitude is measured on an inverse logarithmic scale, such that a star of absolute magnitude -1 is 100 times more luminous than a star of absolute magnitude 1. This means that as the absolute magnitude number increases, the star it becomes less bright. For example, a star with an absolute magnitude of -1 is brighter than a star with an absolute magnitude of 1.

The absolute magnitude scale is based on the idea that the difference of one magnitude is equal to 2,512 times the difference in luminosity, that is, a star with an absolute magnitude of -1 is 2,512 times brighter than a star with a magnitude absolute of 0.

The absolute magnitude is calculated from the apparent magnitude (the measure of a star's brightness as observed from Earth) and the distance from the star. This makes it possible to compare the luminosity of stars that are at different distances from Earth.

As the absolute magnitude increases, the star becomes less luminous. The brightest known star, Sirius, has an absolute magnitude of -1.46. It is important to mention that the apparent magnitude is the measure of the light that reaches us from a star, and this can vary depending on the distance to the star.

A star with an absolute magnitude of -2 is not necessarily 2512*2 times more luminous than a star with an absolute magnitude of 0. It is important to remember that absolute magnitude is a logarithmic measure, which means that a difference of 5 absolute magnitudes represents a factor of 100 in lightness.

The apparent magnitude (m) is related to the absolute magnitude (M) through the formula:

$$M = m - 5log_{10}(\frac{d}{10})$$

The term 5x(log10(dpc)+1) is known as the modulus of distance and is denoted by μ. Therefore, the absolute magnitude of an object could be written as

$$M = m - \mu$$

1.2 Color Index (B-V)

The color index (B-V) is a measure of the difference in magnitude between two bands of the electromagnetic spectrum: blue (B) and green (V). It is mainly used in astronomy to measure the color of stars and determine their effective temperature. A lower B-V value indicates a hotter (white or bluish) star while a higher value indicates a cooler (red) star.

1.3 Plotting the model

1. Calculate the distance to a celestial object.

to calculate the distance to a celestial object using trigonometric parallax measured in milliarcseconds (mass). Parallax is expressed in arcseconds (seconds) and to convert to milliarcseconds, divide by 1000. Arcseconds are a unit of angle measurement used in astronomy. An arc second is 1/3600 of a degree. Arcseconds are used to measure the angular separations between objects in the sky, such as the angular distance between two nearby stars or the angular size of a planet or star.

In relation to the mass of stars, seconds of arc are used to measure the angular size of stars in binary stars, stars that orbit around each other. The angular size of a star in a binary system, together with the star's radial velocity, allows the star's mass to be calculated.

In addition, arc seconds are also used in the measurement of stellar parallax, which allows the distance to nearby stars to be calculated. Stellar parallax is the change in the apparent position of a star due to the oscillation of the observing position, caused by the orbital motion of the Earth around the Sun. Stellar parallax is measured in seconds of arc, and its magnitude is used to calculate the distance to the star.

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Stellar parallax is used to calculate the distance of a star from Earth. Stellar parallax is the change in the apparent position of a star due to the oscillation of the observing position, caused by the orbital motion of the Earth around the Sun. Stellar parallax is measured in seconds of arc, and its magnitude is used to calculate the distance to the star.

For example, if the stellar parallax of a star is 1 arcsecond, the star can be calculated to be at a distance of approximately 3.26 light-years from Earth. This technique is very accurate and is used to measure the distance to nearby stars, but its accuracy decreases as the distance increases.

The distance between nearby stars is measured in a different way, you can use techniques such as trigonometric measurements, based on stellar parallax, the method of star clusters, which is based on the relationship between the mass, luminosity and color of the stars. in a star cluster, or the type star method, which is based on the relationship between the absolute magnitude and the apparent magnitude of a star.

$$p = \frac{d}{pc} \times \frac{\pi}{180} \times 3600$$

where: parallax is the stellar parallax measured in seconds of arc d is the distance to the star in units of parsec (pc) pi is the value of pi

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(3.14159)

The formula to calculate the apparent magnitude of a star is:

$$m = m_0 + 5\log_{10}(d) - 5$$

where: m is the apparent magnitude of the star m0 is the absolute magnitude of the star d is the distance to the star in units of parsec (pc)

Absolute magnitude is a measure of the total luminosity of a star, independent of its distance. The apparent magnitude, on the other hand, is a measure of the amount of light reaching Earth from a star, and it depends on both the total luminosity of the star and its distance.

It is important to mention that these formulas are approximations, since to calculate these values accurately, a large number of measurements and adjustments are required, and even then, there may be uncertainties in the calculations.

According to this, the formula to Calculate the distance of a Star is:

$$d = \frac{1}{1000p}$$

2. Calculate the absolute magnitude (M) of a celestial object from its apparent magnitude (m) and its distance (d). Absolute magnitude is a measure of an object's intrinsic brightness, that is, how bright it would be if it were 10 astronomical units (parsecs) away.

The formula is:

$$M = m - 5\log_{10}\left(\frac{d}{10}\right)$$

where "m" is the apparent magnitude of the object, "d" is the distance to the object in units of parsecs, and "log10" is the base 10 logarithm function.

Apparent magnitude is a measure of the brightness of a celestial object as observed from Earth and can vary due to distance from the object and atmospheric conditions. Absolute magnitude is a distance-independent measure and is useful for comparing the brightness of different celestial objects.

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The formula is based on the fact that the apparent magnitude of an object is inversely proportional to its distance. As the distance increases, the apparent magnitude decreases. Therefore, subtracting the logarithm of the distance in parsecs divided by 10 from the apparent magnitude, gives the absolute magnitude.

temperature of a star:

Algorithm Used To Train our AI

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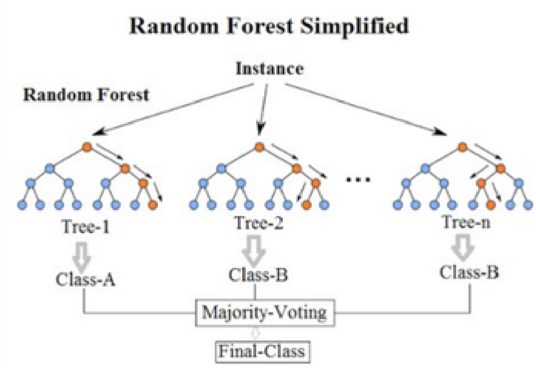
Random Forest Classifier

Random forest classifier is a supervised learning algorithm that can be used for both classification and regression tasks. It works by creating a set of decision trees from randomly selected subsets of the training set and then averaging their predictions to improve accuracy and prevent overfitting.

Here's how it works:

1. The algorithm selects random samples from the dataset provided.
2. The algorithm creates a decision tree for each sample selected. Then it gets a prediction result from each decision tree created.
3. Voting will then be performed for every predicted result.
4. Finally, the algorithm selects the most voted prediction result as the final prediction



Conclusion

Overall, AI has the potential to revolutionize the field of astronomy by enabling astronomers to analyze vast amounts of data more efficiently, and by enabling the discovery of new phenomena that might be difficult to detect using traditional methods.