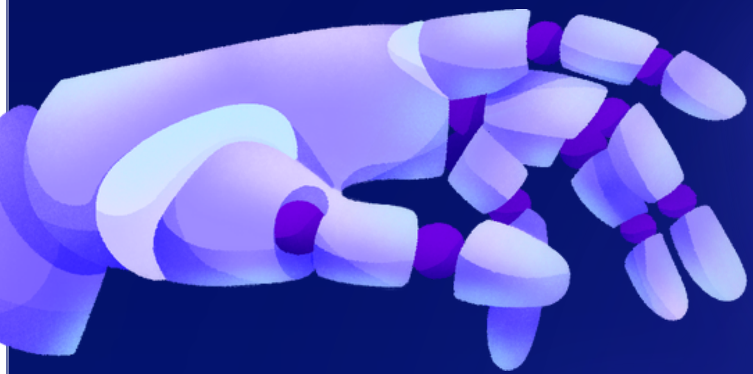
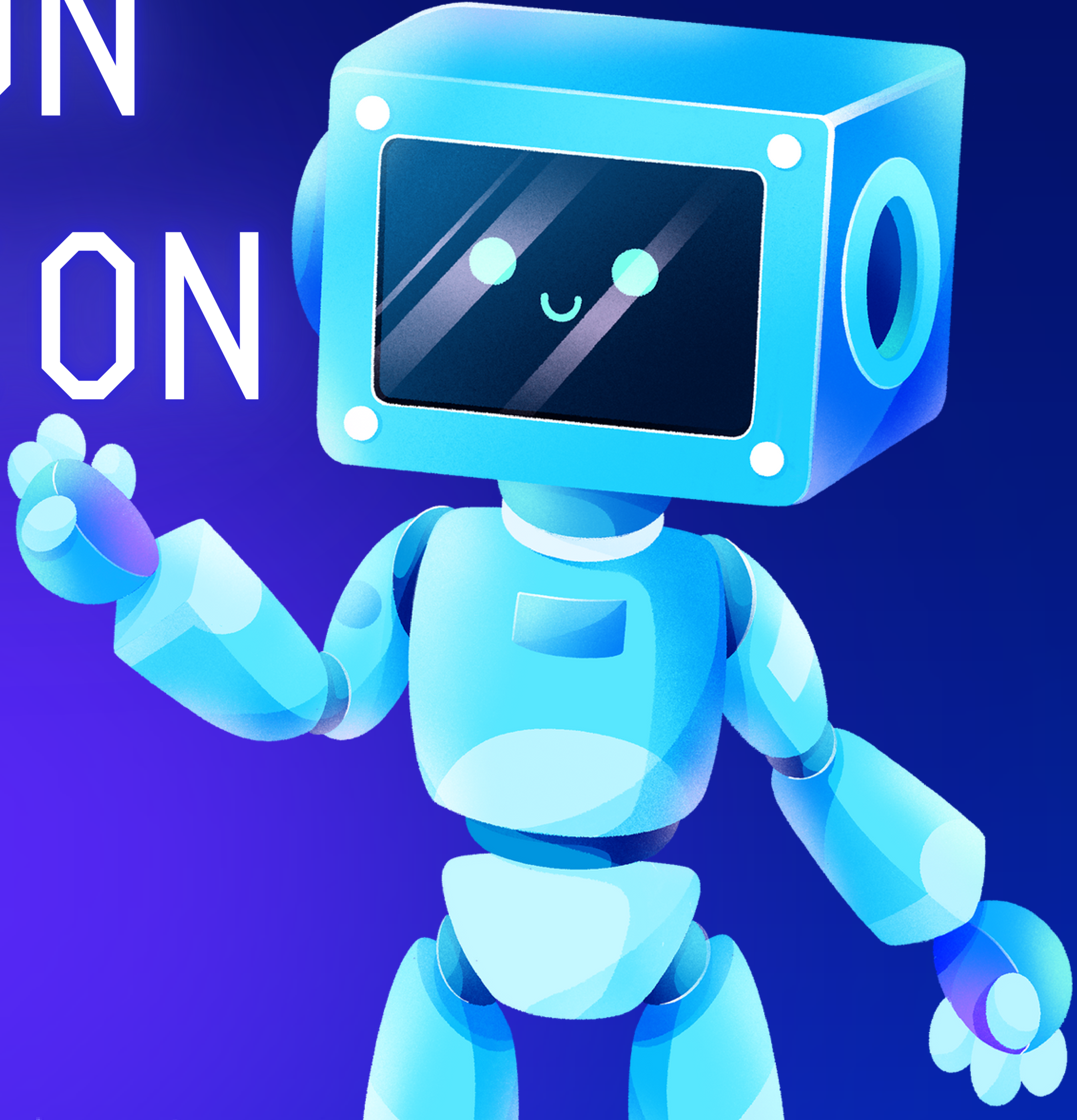


SOLUTION DISCUSSION

By Nitin Kumar

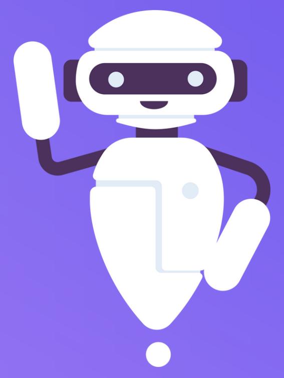
IIT ROPAR



THE CHALLENGE

The question was very closely related to the arena of physics but still did not require much knowledge of the same. My first impression on seeing the question was not at all trivial. I approached the question in a way such that it could be done using a the most basic of all Data science models, Linear Regression. I have used a Bayesian approach(which was recommended in the problem statement), and combined it with the Linear model to get as precise output as possible.

PROJECT OBJECTIVES



OBJECTIVE 01

- To find the set of constants given in the formula by using the data given

OBJECTIVE 02

- To keep the error in the answer as low as possible

OBJECTIVE 03

- To analyze the values of the parameters and to check how accurate they are.

PROPOSED SOLUTION

- Here, I observed that the formula need can be reconstructed into a linear relation between input and output.

$$H(z) = H_0 \left[\Omega_m (1 + z)^3 + \Omega_k (1 + z)^2 + \Omega_\Lambda \right]^{1/2}$$

$$\left(\frac{H(z)}{H_0}\right)^2 = \Omega_m (1 + z)^3 + \Omega_k (1 + z)^2 + \Omega_\Lambda$$

$$y = \Omega_m x_1 + \Omega_k x_2 + \Omega_\Lambda$$

where, $x_1 = (1 + z)^3$, $x_2 = (1 + z)^2$, $y = \left(\frac{H(z)}{H_0}\right)^2$

- Now, one can easily observe that if we construct our feature vector so it contains the required powers of 1+z, and also reconstruct our output such that it is now the square of ratio of H and H0, we will be able to apply a simple linear regression and find the values of the parameters which is exactly what we need to find.

PARAMETER RECONSTRUCTION

Here I had to calculate the parameters and their errors seperately from each other rather than together.

So, I used the concept of errors from physics-

$$Z=\left(\frac{H}{H_0}\right)^2$$

$$\Delta Z = Z\left(\frac{\Delta H}{H}+\frac{\Delta H_0}{H_0}\right) = \left(\frac{H}{H_0}\right)^2\left(\frac{\Delta H}{H}+\frac{\Delta H_0}{H_0}\right)$$

I used these set of values for finding the parameters.

RESULT

- So, the final answer reaches to:
- Wm= 0.1646535 +- 0.0313167
- WK= 0.35964872 +- 0.01680515
- W= 0.2827349977938409 +- 0.5604636445724958

```
[7]
print(model1.coef_,model1.intercept_)
✓ 0.0s
... [0.1646535  0.35964872] 0.2827349977938409

[8]
print(model2d.coef_,model2d.intercept_)
✓ 0.0s
... [0.03131676 0.01680515] 0.5604636445724958

[9]
pred1=model1.predict(x.T)
pred2=model2d.predict(x.T)
✓ 0.0s

[10]
from sklearn.metrics import mean_absolute_error
error1=mean_absolute_error(y,pred1)
print(error1)
✓ 0.0s
... 0.43539831225997006

[11]
error2=mean_absolute_error(dely,pred2)
print(error2)
✓ 0.0s
... 0.4348458268086364
```

- I have reached these conclusions and have then verified the result by calculating the mean absolute for each term. And the error observed is fairly small indicating that the values of the parameters are very precise.

THANK YOU!