Detecting and Predicting Clusters of Evolving Binary Stars

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Introduction

Problem

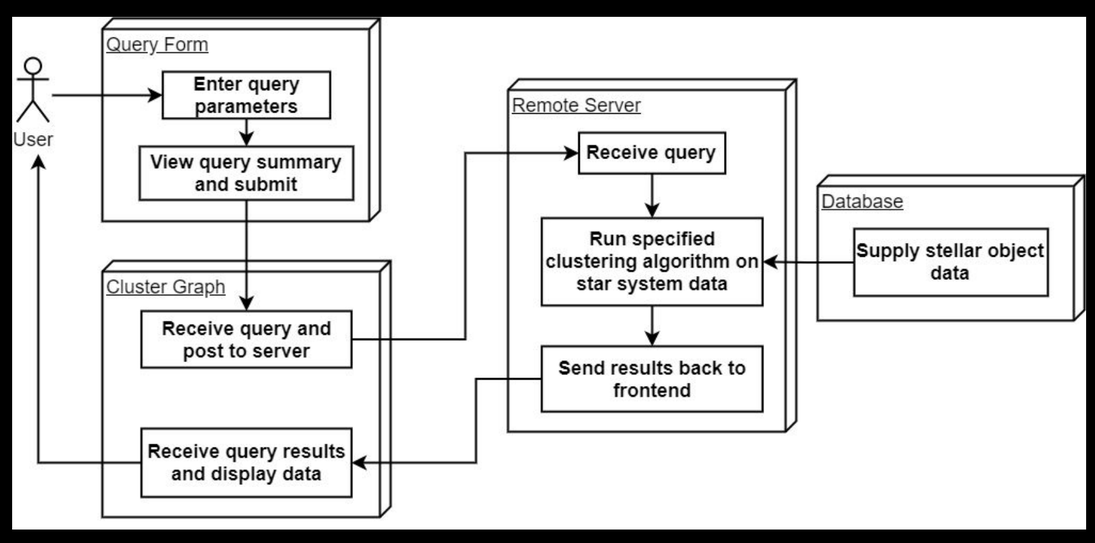
- Astrophysicists manage numerous databases of generated stellar evolutions.
- Generated stellar evolutions include attributes to describe each star (i.e. Mass, Luminosity, Helium abundance)
- Each star has multiple timesteps. As these timesteps increment, attributes gradually change.
- Methods are needed to organize and analyze data

time_id	tphys	kstar_1	mass0_1	mass_1	lumin_1	rad_1	teff_1
1	0.1	1	12.26615	12.26615	10612.93	3.386865	31976.4
2	0.2	1	12.26613	12.26613	10637.99	3.394414	31959.66
3	0.3	1	12.2661	12.2661	10663.46	3.401981	31943.18
4	0.4	1	12.26608	12.26608	10689.33	3.409569	31926.95
5	0.5	1	12.26606	12.26606	10715.61	3.417177	31910.98
6	0.6	1	12.26603	12.26603	10742.31	3.424808	31895.24

Solution

- One method is clustering: grouping together similar data points into clusters.
- Multiple algorithms to cluster
  - K-Means
  - DBScan
- Visualizing clusters with 2D and 3D graphs

Concept Sketch



Core Functional Modules

Frontend Modules
- Query Form, Cluster Graph Page

Backend Modules
- Remote Server, Database

Testing

Backend (the APIs)
- Unit testing
- Algorithm interaction testing
- API request testing

Frontend (the UI)
- Cypress Automated tests
  - End-to-end tests
  - Robustness testing

Operating Environment

- Linux Server
- Ubuntu 2004 LTS

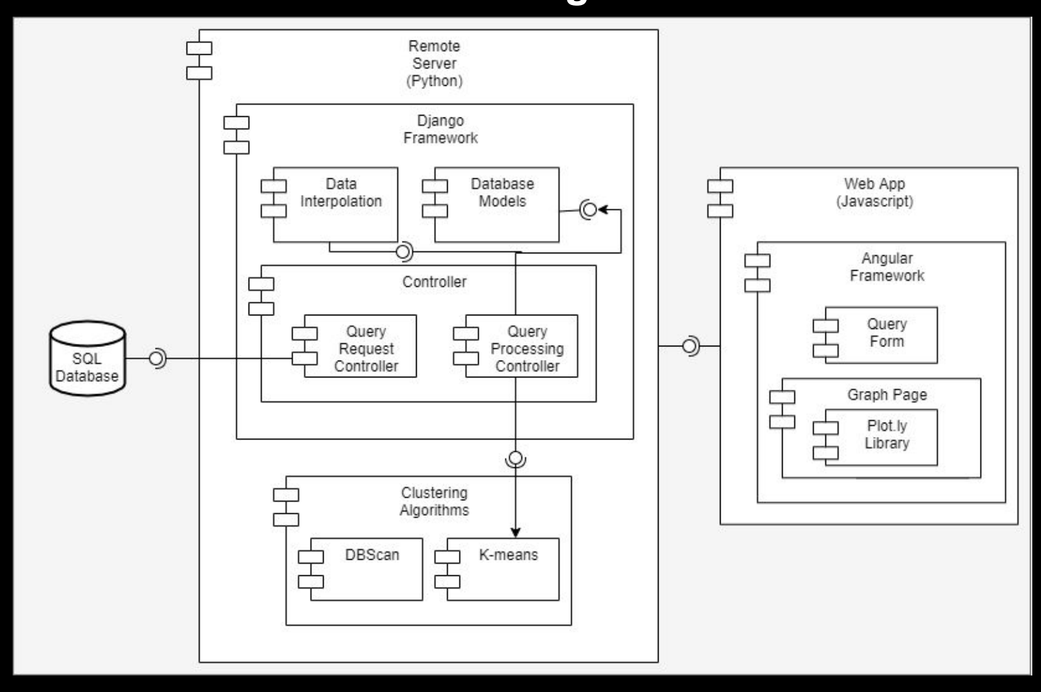
Engineering Constraints

- Existing Dataset(s)
- Internet Access
- Server Size

Relevant Standards

- 24765-2010 - ISO/IEC/IEEE International Standard
  - Software Engineering Vocabulary Standard
- Modules for Experiments in Stellar Astrophysics (MESA)
  - Simulation standard for astrophysical data

Block Diagram



Intended Users and Uses

- Astrophysicists
- Researchers using stellar data

Stellar Data Providers

- Sloan Digital Sky Survey
- Gaia Archive

Functional Requirements

- Accept User Specified Input
  - Clustering Method
  - Attributes of Interest
  - Attribute Weight
  - Time Intervals
- Display Results to End Users
  - 2D and 3D Graphs

Non-Functional Requirements

- Request time ~ 1 min per time step
- 24/7 Server up time
- User Interaction with graph

Technical Details (Technologies Used)

Frontend

- Angular
- Angular-plotly

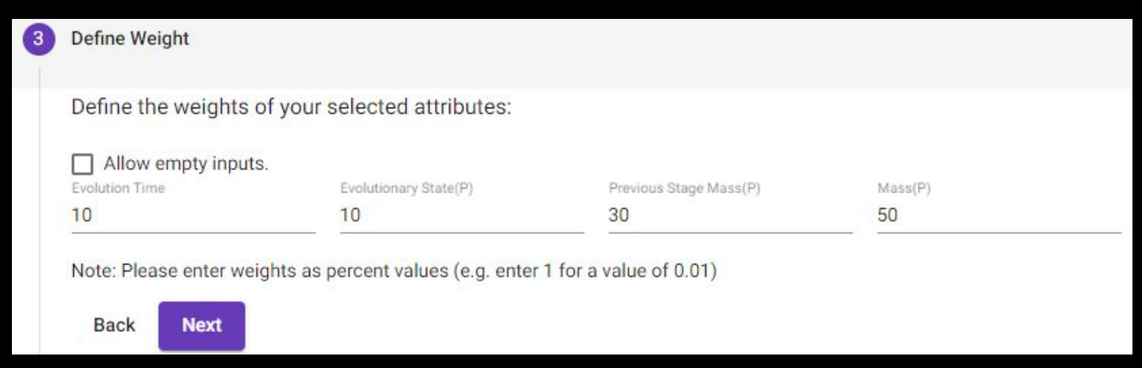
Backend

- Postgresql (Database)
- Django (Web Framework)
- Clustering and Interpolation
  - sklearn.cluster
  - Numpy.interp

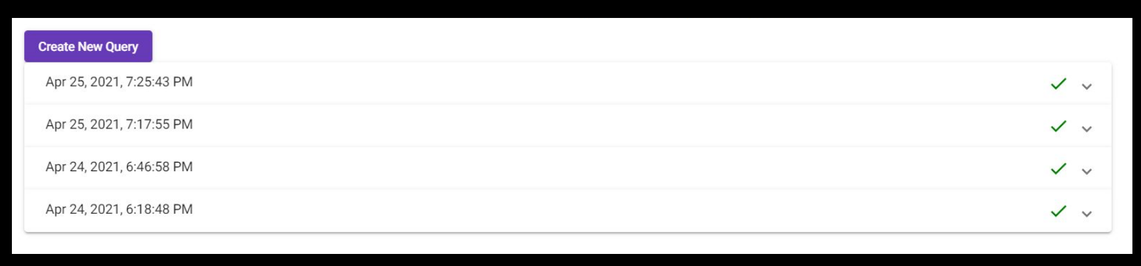
DevOps

- Gitlab CI/CD
- Docker

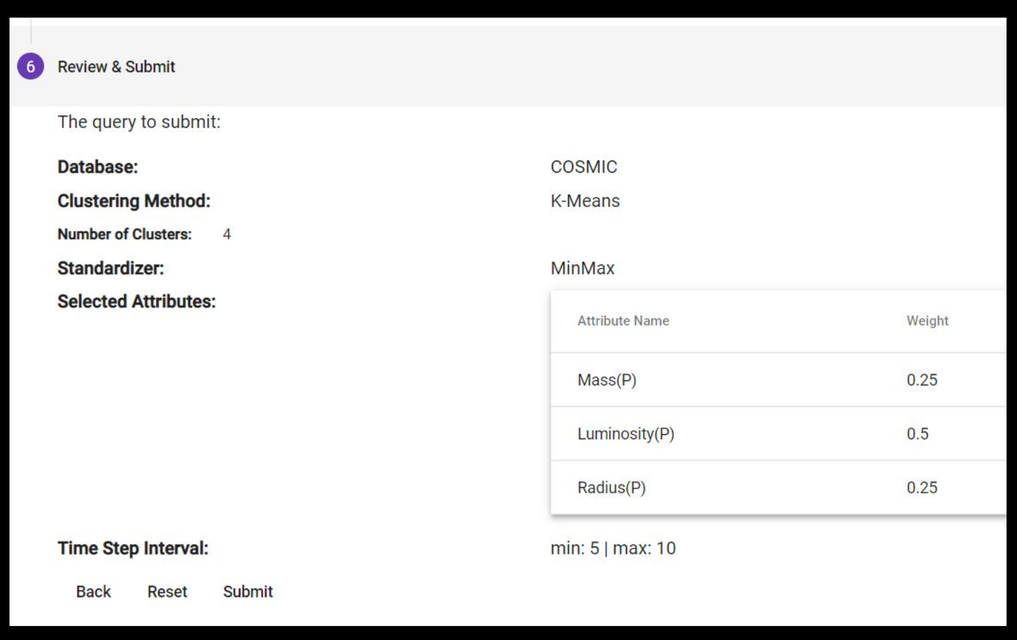
Attribute Weight Input



Query Queue System



Query Submission



Cluster Visualization