IceCube - Neutrinos in Deep Ice Final Presentation

Group 13

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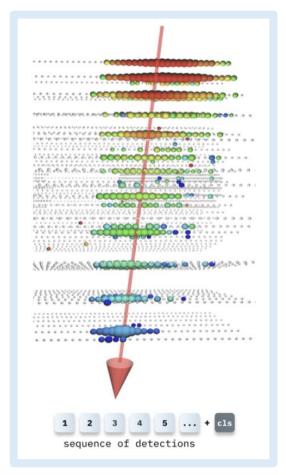
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Machine Learning Operations FS 2025

Purpose/Task of the ML System

- Neutrinos are abundant particles in our universe emitted by violent astrophysical events
- Hard to dected since they rarely interact with matter
- The <u>IceCube Neutrino Observatory</u>
 - A detector array spanning a cubic kilometer of Antarctic ice
 - Detects the directions of neutrino traces using photon detections (3D Unit Vector)
 - Enables determination of the neutrinos' origin, thereby helping locate astrophysical events
- Disclaimer: Our aim is NOT to optimize ML performance, but to explore how the IceCube data processing might be structured



3D Unit Vector

Overview of Components/Pipeline/System Setup

Data Emitter

[Raw IceCube Dataset]

Emitter Container

- Batches and Serialized Events
- Pushes to Redis Queue
- Send Heartbeat

Redis Container (Message Broker)

Stored Serialized Event Batches

Processing / Model / Monitoring

Consumer Container

- Pops from Redis
- Preprocesses
- Calls Model
- Sends Heartbeat

MLflow Tracker

Model Server Container

- REST API (/predict)
- Model Inference
- Health Check (/health)
- Sends Hearbeat



Inference Logging (Consumer)

Prometheus Container

- Scrapes/Metrics Endpoints on all Containers

Grafana Container

- Visualizes Heartbeat, Throughput, inference Metrics
- Alerts if Heartbeat is missing or high latency

Key Features of the MLOps Pipeline [1/2]

Tool	Raison d'être
GiHub Actions	Automatic Checks of Code Quality
Docker	 Easy to deploy Ensures reproducibility Allows containerization of each component
Redis Community Edition	 Easy to use and performant que system Relatively fast deployment
MongoDB	Used to track Events
Promotheus	 Scrapes metrics (total requests, latency, etc.) from the different containers (including heartbeat) Can define alert rules
Grafana	 Dashboard build upon Promotheus Displays Real Time Metrics
Flask	Server used to serve the model via REST API

Key Features of the MLOps Pipeline [2/2]



GitHub Actions



MongoDB for tracking Evenents



Grafana Dashboard with Real Time Insights



Promotheus (Eg. Automatic Alerts



«Behind the Scenes» Info Flow

Sources

- <u>Title Slide Picture</u> [Slide 1]
- 3D Unit Vector [Slide 3]
- Ice Pattern [Slide 3]