Knowledge Extraction from Podcasts

Dataset Overview

Lex Fridman Podcast playlist on Youtube

- 75 episodes with well-defined timestamps (as on 11/22/2020), each around 2-4 hours.
- Dynamic data, with 2 to 3 new podcasts added every week.

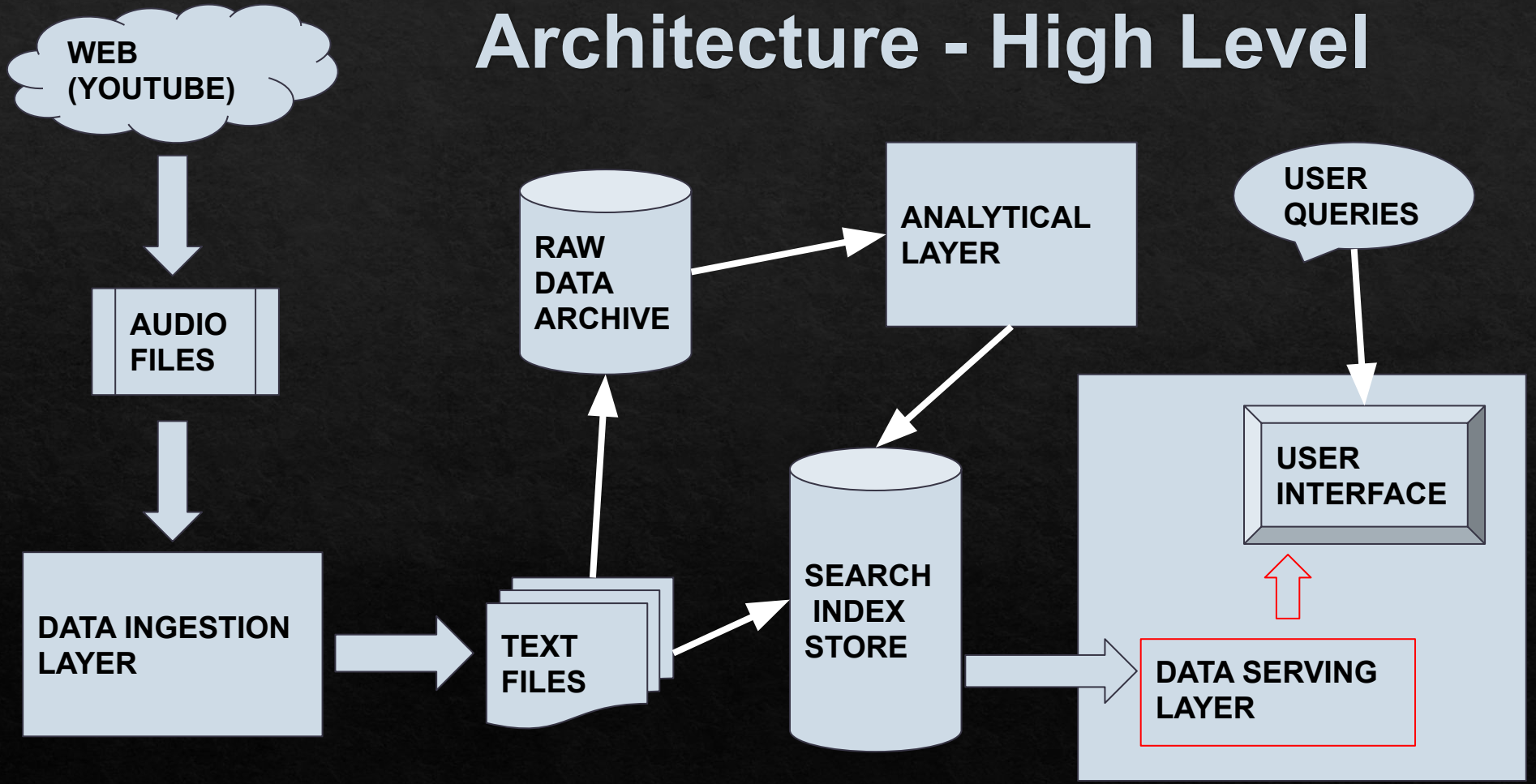
Unstructured raw data
- Audio files

Structured metadata
- Text files

Why is the problem / dataset interesting?

- As per the internet, 850,000 active podcasts and 30 million episodes on the web, impossible to listen to them all for a user
- As opposed to mainstream media, contain invaluable information, expert opinions and diverse perspectives, ranging from science, society, politics, to life and beyond
- By efficiently organizing and processing this huge data, we can create an easily explorable repository of knowledge for end-users

Architecture - High Level



Architecture - End to End

DATA INGESTION LAYER

- **EXTRACT**
  - ***Data Downloader*** **: downloads Youtube videos as .wav format audio files and metadata for videos as text files**

- **TRANSFORM**
  - ***Audio segmentation by subtopics*** **: uses timestamps in metadata to split full podcast audio into multiple shorter segments, each covering a subtopic of discussion**

  - ***Speaker Diarization*** **: identifies timestamp partitions for each subtopic segment audio stream based on speaker identity**

Architecture - End to End

DATA INGESTION LAYER

- **TRANSFORM**
  - ***Audio segmentation by speakers*** **: uses speaker diarization information to split each subtopic segment audio into multiple shorter speaker segments**

- **LOAD**
  - ***Raw Data Load*** **: transcribes audio to text for each speaker segment and writes each segment as one textual record to the raw data archive**

  - ***Index Segments*** **: summarizes each speaker segment text (transcribed utterances) and writes each summarized speaker segment as one record to the search index store**

Architecture - End to End

DATA INGESTION LAYER

- **LOAD**
  - ***Index Metadata and Speakers*** **: writes metadata to separate indices in the search index store as one record for each podcast as well as for each speaker**

ANALYTICAL LAYER

- ***Setup Knowledge Graph*** **: performs named entity recognition over each speaker segment in raw data store and defines speaker to entity relationships to realize a knowledge graph**

- ***Index Knowledge Graph*** **: writes all nodes and edges of the knowledge graph as records in two separate indices in the search index store**

Architecture - End to End

DATA SERVING LAYER

- User interface to the end-user for searching the knowledge repository built over podcasts data
- REST endpoints to query the search index store for retrieving processed data
- Knowledge graph visualization

Current scope of project

YES

NO

For example, Google

USER INTERFACE

QUERY

RESPONSE

REAL TIME PROCESS

SEARCH INDEX STORE

GOAL : enhance the search experience as much as possible

RESEARCHER

BATCH PROCESSES (run in background)

Updates for improved search results or recommendations

KNOWLEDGE GRAPH

EXPERIMENTATION ON MASSIVE KNOWLEDGE GRAPH

- Link prediction
- Community detection
- Graph decomposition
- Large graph visualization (say build graph cities)
- etc.

Tools & Libraries

- Programming Languages
  - Backend : Python and Java
  - Frontend : HTML and JavaScript
- Data Lake
  - Raw data archive : MongoDB
  - Search index store : Elasticsearch
- Distributed computing / Data wrangling
  - PySpark and Pandas
- Data Download (Data Ingestion Layer)
  - pytube + ffmpeg
- Audio Segmentation (Data Ingestion Layer)
  - pydub

Tools & Libraries

- Speaker Diarization (Data Ingestion Layer)
  - CMU Sphinx (Java)
- Audio to text transcription (Data Ingestion Layer)
  - Mozilla deepspeech
- Text summarization (Data Ingestion Layer)
  - bert-extractive-summarizer
- Named Entity Recognition (Analytical Layer)
  - spacy
- Web application (Data Serving Layer)
  - flask
- Graph visualization (Data Serving Layer)
  - D3.js (force directed graph)

Raw data schema - MongoDB

segment

- **video_id**
- **title**
- **subtopic_name**
- **subtopic_order**
- **speaker_name**
- **speaker_order**
- **start_timestamp**
- **end_timestamp**
- **raw_text**

No queries from the end-user go here. This is a hidden archive of raw data.

Processed Data Model - Elasticsearch

podcast_segment

- video_id
- title
- subtopic_name
- subtopic_order
- speaker_name
- speaker_order
- start_timestamp
- end_timestamp
- segment_summary

All search queries from the UI go here.

podcast_guest

- guest_name
- guest_description

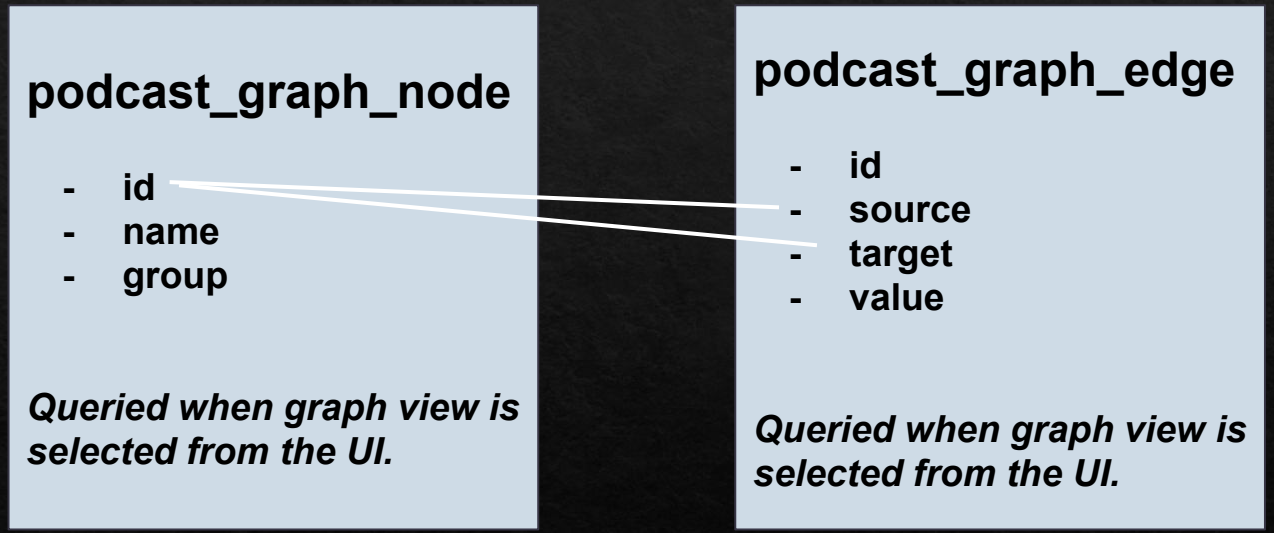
Queried when a speaker selected from the UI.

podcast_metadata

- video_id
- title
- description
- rating
- length
- views
- author
- downloaded_at

Queried when a podcast is selected from the UI.

Knowledge Graph Data Model - Elasticsearch



Challenges

CURRENT

- Highly unstructured speech to text output in terms of grammatical syntax (for example, no punctuation), leading to lots of garbage entities in knowledge graph

- Pretrained models for speaker diarization, speech to text, text summarization and named entity recognition not too accurate, need to build better models through transfer learning on specific dataset

FUTURE

- Traditional approaches to graph visualization will fail as the knowledge graph keeps growing in size with more data

- Increasing readability in UI design and improving user experience