

# Song Search using CLAP

## SUSE Hack Week 25



# Goals

## Search music using natural language descriptions

- Find songs by describing what you hear: "piano melody", "female vocalist"
- Compare songs to find similar tracks
- Experiment AI with Copilot Code Assistant

# CLAP Overview

**CLAP** (Contrastive Language-Audio Pretraining) - Bridging audio and language

## Core Concept:

CLAP can represent both songs and text descriptions as **512-dimensional vectors** in the same mathematical space. This enables searching for music using natural language queries.

## How it works:

- A song becomes a 512-number vector capturing its audio characteristics
- A text query like "piano music" also becomes a 512-number vector
- Vectors that point in similar directions represent similar content
- We measure similarity to find songs matching the description

**Model:** music\_audioset\_epoch\_15\_esc\_90.14.pt - Specialized for music (71% genre accuracy, trained on ~4M samples)



# Implementation

## Two Modes:

- **Single Analysis:** `single_analysis.py` - One song vs one query
- **Batch Analysis:** `multiple_analysis.py` - All songs vs all queries

## Architecture:

- `clap_analysis.py` - Core library (shared)
- Automatic model download & caching
- Parallel processing across CPU cores
- CSV output with detailed metrics

## Cosine Similarity Scores:

- Range:  $-1$  (opposite) to  $+1$  (identical)
- Thresholds:  $> 0.3 = \text{HIGH}$ ,  $> 0.15 = \text{MODERATE}$ ,  $\leq 0.15 = \text{LOW}$

# Query Wording Matters

**Discovery:** Small word changes can dramatically affect results!

**Example - "Paint it Green" by SUSE Band (female vocalist rock):**

Query	Score	Match
"female vocalist"	0.328	HIGH
"female voice"	0.062	LOW
Difference	-0.267	5x worse!

**Why?** The model was trained on music descriptions. Professional terminology like "vocalist" appeared more frequently than casual words like "voice".

**Tip:** Use music industry vocabulary for better results.

# Finding Similar Songs

**Bonus Feature:** Beyond text search, we can find which songs sound similar to each other.

## How It Works:

- Each song gets its own 512-dimensional vector representation
- We compare these vectors between all song pairs
- Songs with similar vectors have similar audio characteristics
- Same similarity metric as text queries

**Advantage:** No additional processing needed!

- Song vectors are already computed during text query analysis
- Comparison is instant (~0.001 seconds for 10 songs)
- Can help discover related songs in your collection

## Use Cases:

- Find songs with similar instrumentation or mood
- Discover patterns in your music collection
- Create automatic playlists based on audio similarity

# AI Support in Development - What Went Well

## Project developed with GitHub Copilot (Claude Sonnet 4.5)

### 1. Research & Model Selection

- Compared CLAP models → selected music\_audioset (71% GTZAN accuracy)
- Read CLAP paper, explained architecture accessibly

### 2. Code Analysis & Technical Discovery

- Examined checkpoint: model lacks fusion, max 10s segments
- Designed overlapping segment solution

### 3. Data Analysis & Documentation

- Found "vocalist" vs "voice" pattern (5x difference in results)
- Generated all technical docs with examples

## 1. Unrequested Code Changes

- Single-file CLI disappeared, score icons changed without asking
- **Problem:** Full file rewrites hide unintended changes
- **Lesson:** Always review diffs carefully

## 2. First Solution $\neq$ Best Solution

- **Performance:** Song analyzed per query  $\rightarrow$  challenged  $\rightarrow$  **15x faster**
- **Threading:** Single-threaded  $\rightarrow$  asked "faster?"  $\rightarrow$  multiprocessing

**Key Lesson:** Working  $\neq$  optimal. Challenge AI with domain knowledge.

# Best Practices for AI-Assisted Development

## Do's:

- Ask AI to research and compare options (models, approaches)
- Request code analysis to understand existing implementations
- Share actual data/errors for pattern recognition
- Challenge solutions: "Can this be faster?" "Is there a better way?"
- Request documentation with examples from your project

## Don'ts:

- Don't accept first working solution as optimal
- Don't let AI rewrite entire files without showing diffs
- Don't assume AI made only requested changes - review carefully
- Don't trust performance without testing alternatives

**Bottom line:** AI is a powerful assistant for research, analysis, and documentation. For code: it provides a working starting point, but optimization requires your expertise and critical thinking.

# References

- **CLAP:** <https://github.com/LAION-AI/CLAP> - The main model being researched
- **Hugging Face:**  
[https://huggingface.co/docs/transformers/model\\_doc/clap](https://huggingface.co/docs/transformers/model_doc/clap)
  - Pre-trained models for CLAP
- **Free Music Archive:** <https://freemusicarchive.org/> - Creative Commons songs for testing
- **SUSE Hack Week 25 Project:**  
<https://hackweek.opensuse.org/25/projects/clap-machine-learning-to-search-song-starting-from-text>
  - Project page
- **Project Repository:**  
<https://github.com/gcolangiulisuse/hw25-song-search> - GitHub repo of the project