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 = HIGH, > 0.15 = MODERATE, ≤ 0.15 = LOW

Output Example - Classical

Song: Aaron Dunn - Minuet (Classical Piano)

HIGH (> 0.3)	**MODERATE** (> 0.15)	**LOW** (≤ 0.15)
0.41 piano	**0.29** chill	**0.15** 70s
0.40 classical instrumental song with piano	**0.28** chillout	**0.14** choir
0.38 classical music	**0.27** sad	**0.14** beautiful
0.37 instrumental	**0.26** jazz	**0.14** danceable
0.33 instrumental music	**0.25** acoustic	**0.12** pop music wit bass guitar
	0.23 acoustic guitar	**0.12** funk
	0.22 pop	**0.12** bass guitar
	0.21 folk	**0.11** soul
	0.21 happy	**0.11** rock

Observation: Piano and classical-related queries score highest. Chill/mellow descriptors moderate. Rock and modern era queries score low.

Tip: Detailed, specific queries combining multiple descriptors (genre + instrument + style) yield excellent results!

Output Example - Rock

Song: SUSE Band - Paint it Green (Rock)

HIGH (> 0.3)	**MODERATE** (> 0.15)	**LOW** (≤ 0.15)
0.42 indie rock	**0.28** hard rock	**0.14** heavy metal
0.41 alternative rock	**0.28** folk	**0.14** dance
0.40 classic rock	**0.26** punk	**0.13** soul
0.37 Progressive rock	**0.25** 80s	**0.13** instrumental
0.37 indie pop	**0.25** funk	**0.13** acoustic guitar
0.36 rock	**0.25**90s	**0.13** singing
0.33 female vocalist	**0.24**60s	**0.12** bass guitar
0.32 rock music	**0.24** metal	**0.12** guitar
0.31 blues	**0.23** Mellow	**0.06** female voice

Observation: Rock subgenres (indie, alternative, classic) score highest. Generic instrument queries score low.

Query Wording Matters: Notice "female vocalist" (0.33, HIGH) vs "female voice" (0.06, LOW) - 5× difference! 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.

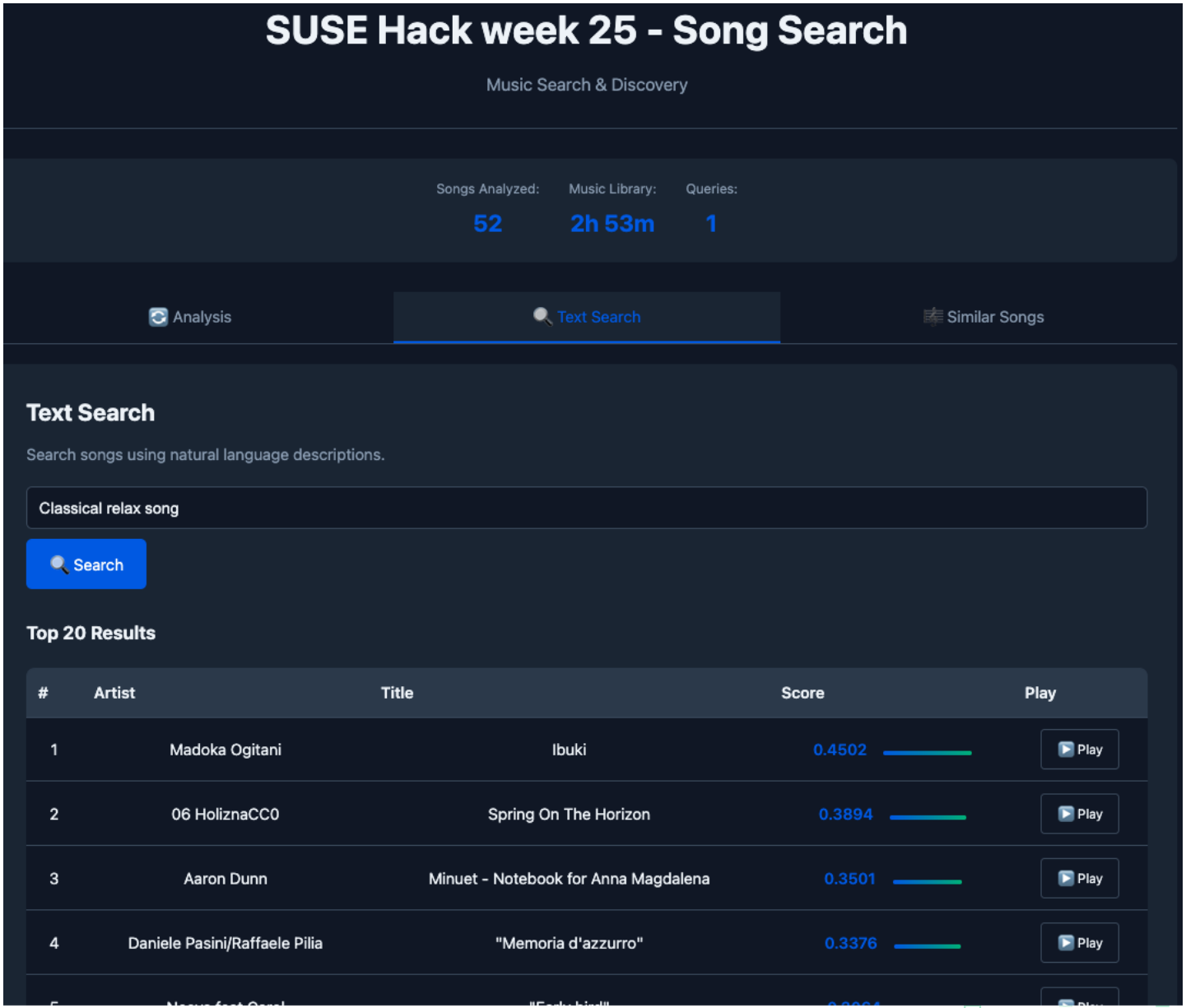
Example: Finding songs similar to SUSE Band - Paint it Green (Rock)

Song	Similarity
HoliznaCC0 - Dreams Of Lilith (Rock)	0.72
Jenna Jay - Someone Real (Pop)	0.56
Zane Little - Always and Forever (Pop)	0.47
SUSE Band - SUSE Yes Please (Pop)	0.43
SUSE Band - Can't Stop The SUSE (Pop)	0.39
Aaron Dunn - Minuet (Classical Piano)	0.18

Use Cases:

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

Containerized Web App



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

AI Support in Development - What Needs Improvement

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` - 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