MICHIGAN STATE UNIVERSITY

Project Plan Presentation
LLM 3D Model Interpretation & Decomposition

The Capstone Experience

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From Students…
…to Professionals

Project Sponsor Overview

- Founded in 1957 in Canada.
- Provides complete vehicle engineering.
- Designs and manufactures powertrains, electronics, body, seating, etc.
- Driving innovation in electrification, autonomous driving and sustainable mobility.
- 164,000+ employees across 28 countries and 300+ facilities.
- Serves virtually every major automaker.

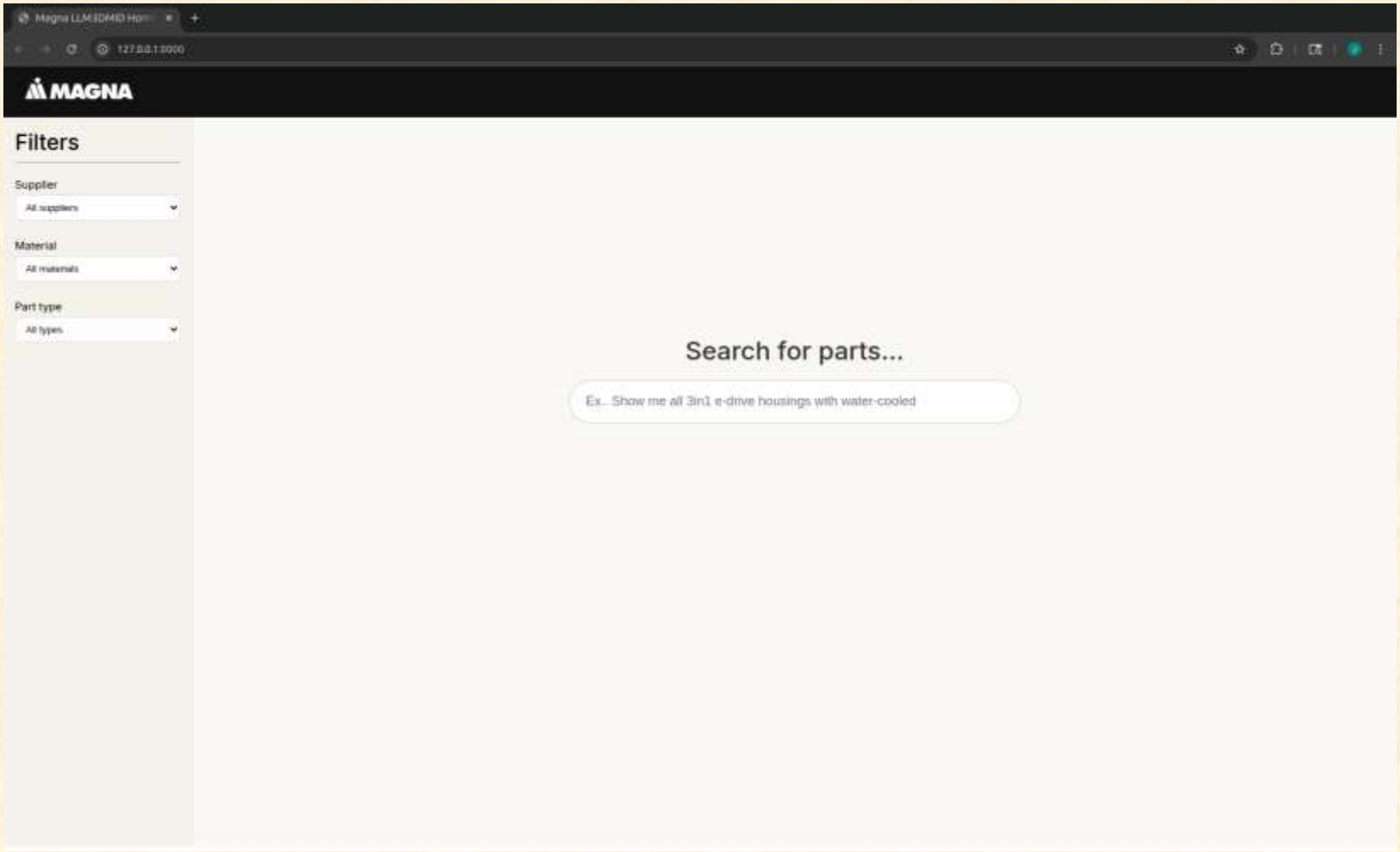
Project Functional Specifications

- Automatic model interpretation
  - Extract key features from 3D models for automated analysis.
- Holistic part comparison
  - Evaluate part variants based on geometry, materials, and manufacturing data.
- Semantic Search
  - Understand natural language queries to find parts.
- AI similarity analysis
  - Uses AI (LLMs & GNNs) to determine part similarity.

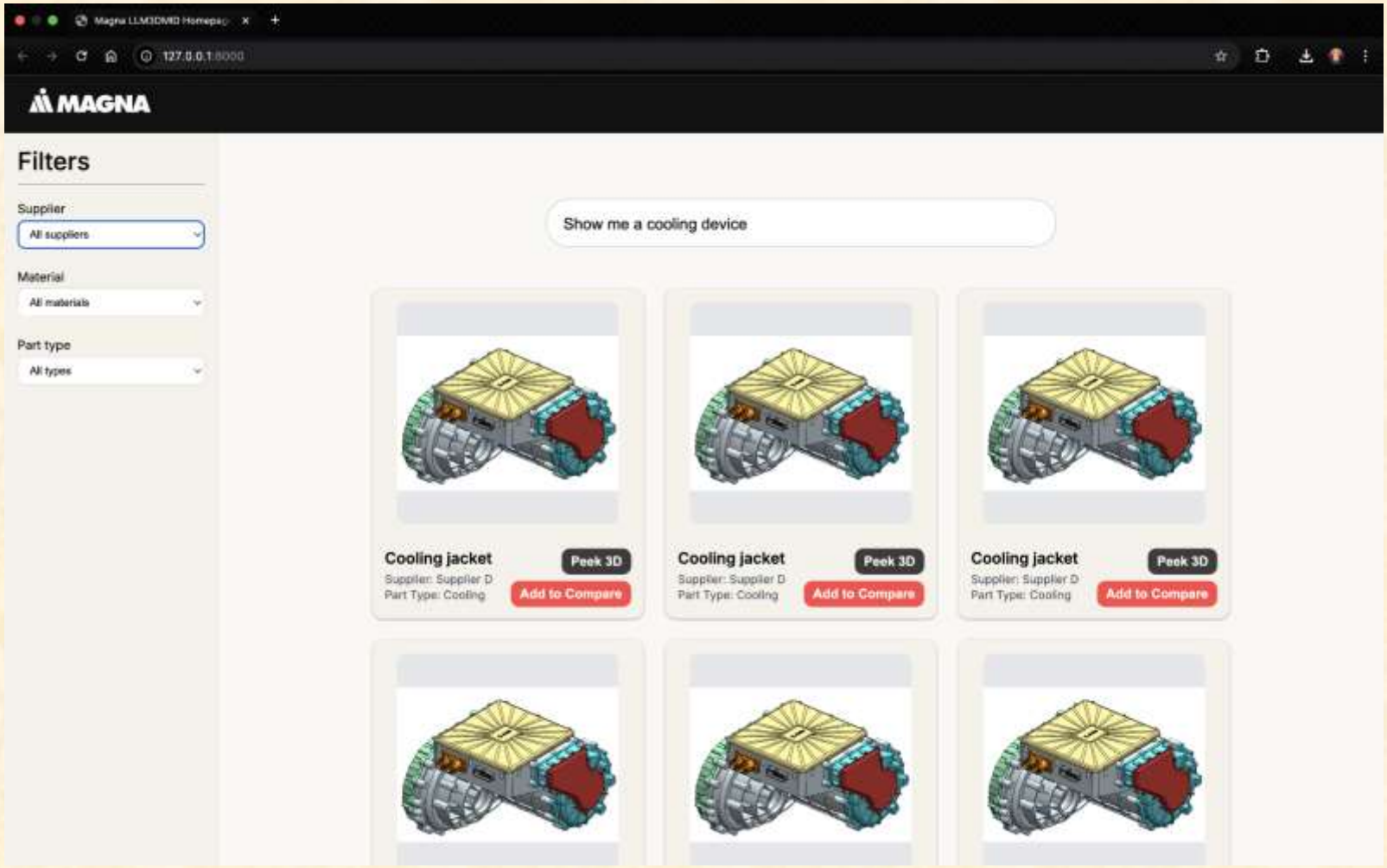
Project Design Specifications

- Homepage
  - Central parts database with search and filters.
- Semantic search
  - Natural language queries to find relevant parts.
- Metadata comparison
  - Side-by-side spec comparison with highlighted differences.
- 3D model comparison
  - Visual inspection of two models with highlighted changes.
- Exploded view
  - Interactive 3D breakdown of assemblies into component parts.

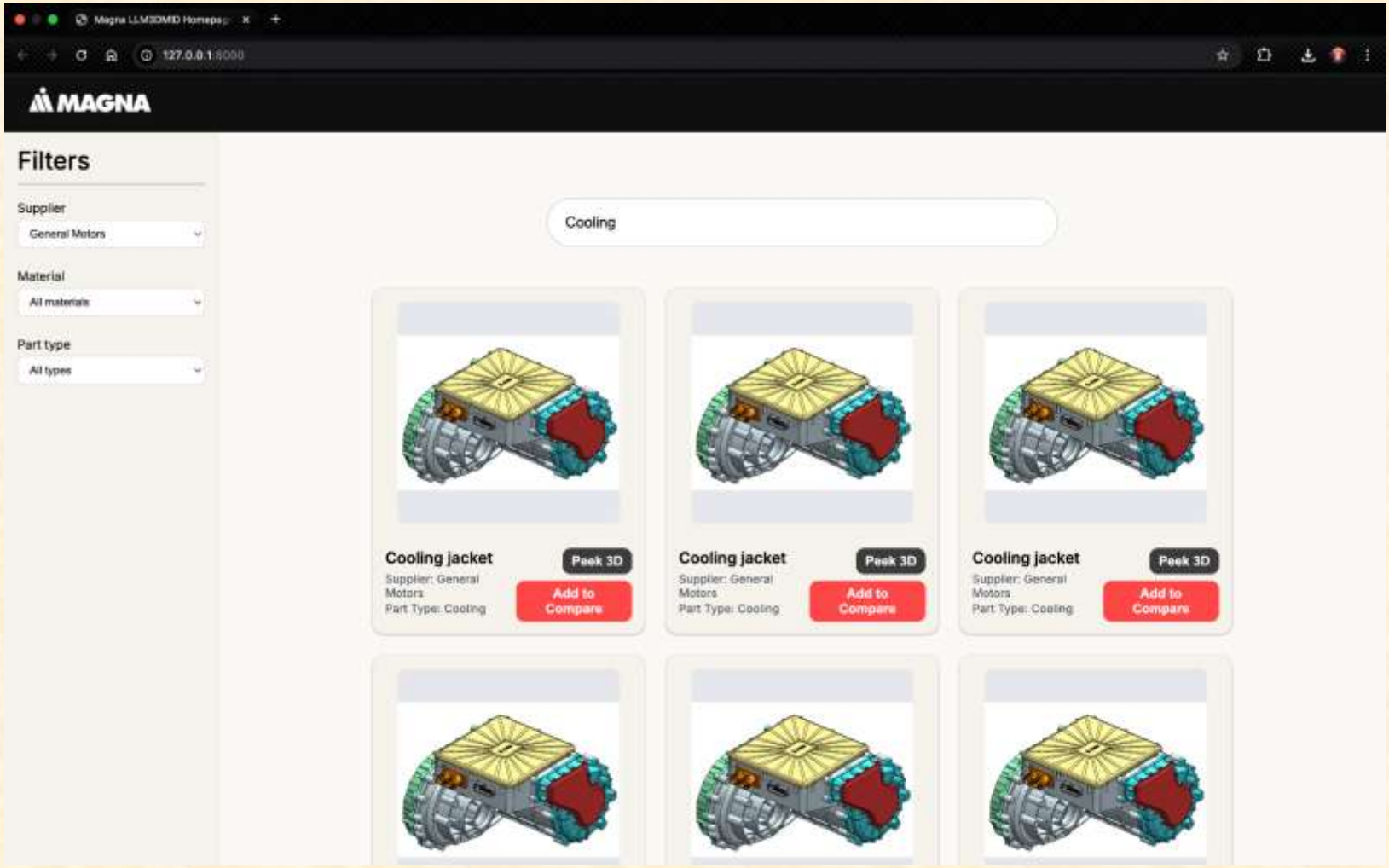
Screen Mockup: Homepage



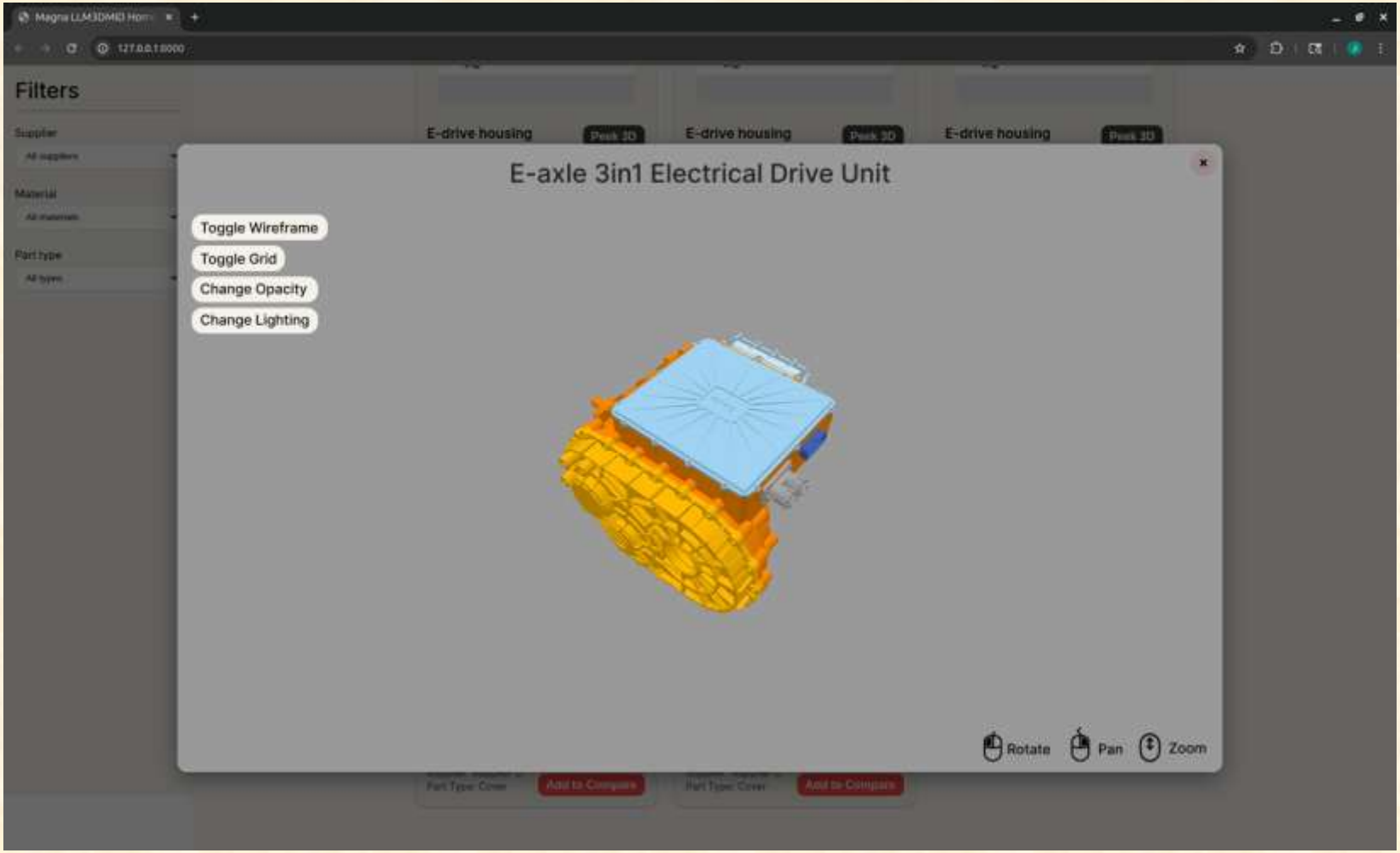
Screen Mockup: Semantic Search



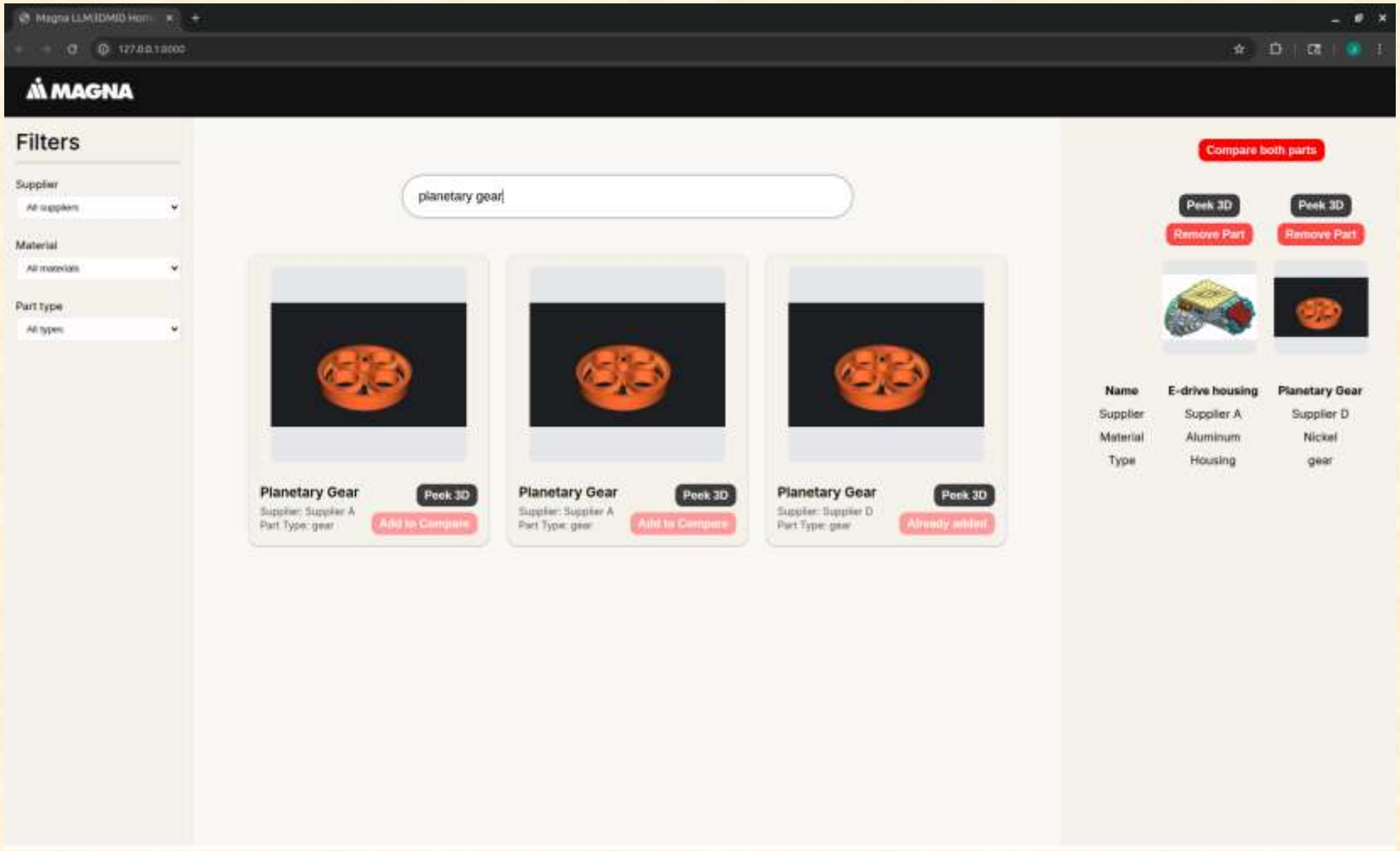
Screen Mockup: Filtered Search



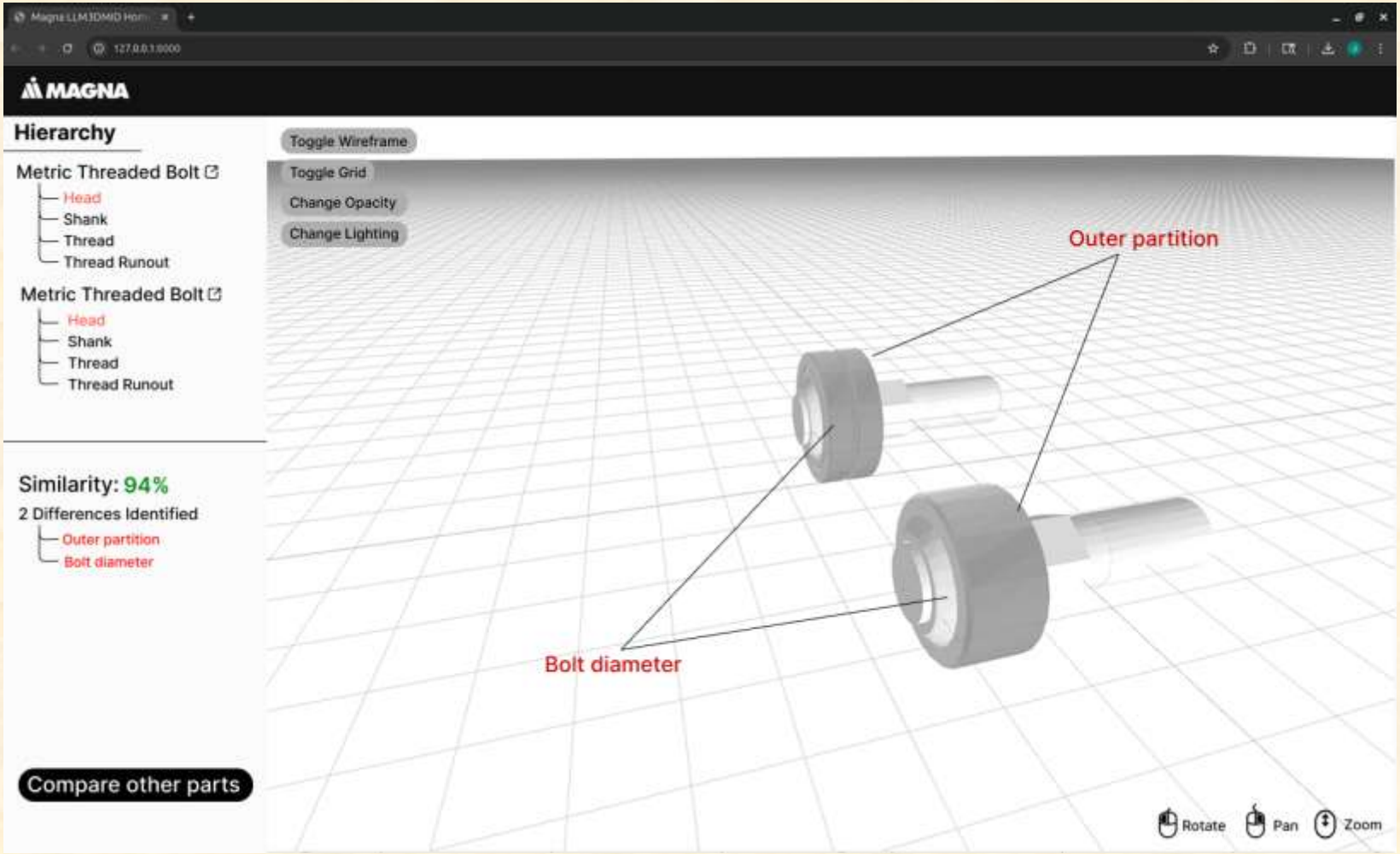
Screen Mockup: 3D Peek



Screen Mockup: Compare Metadata



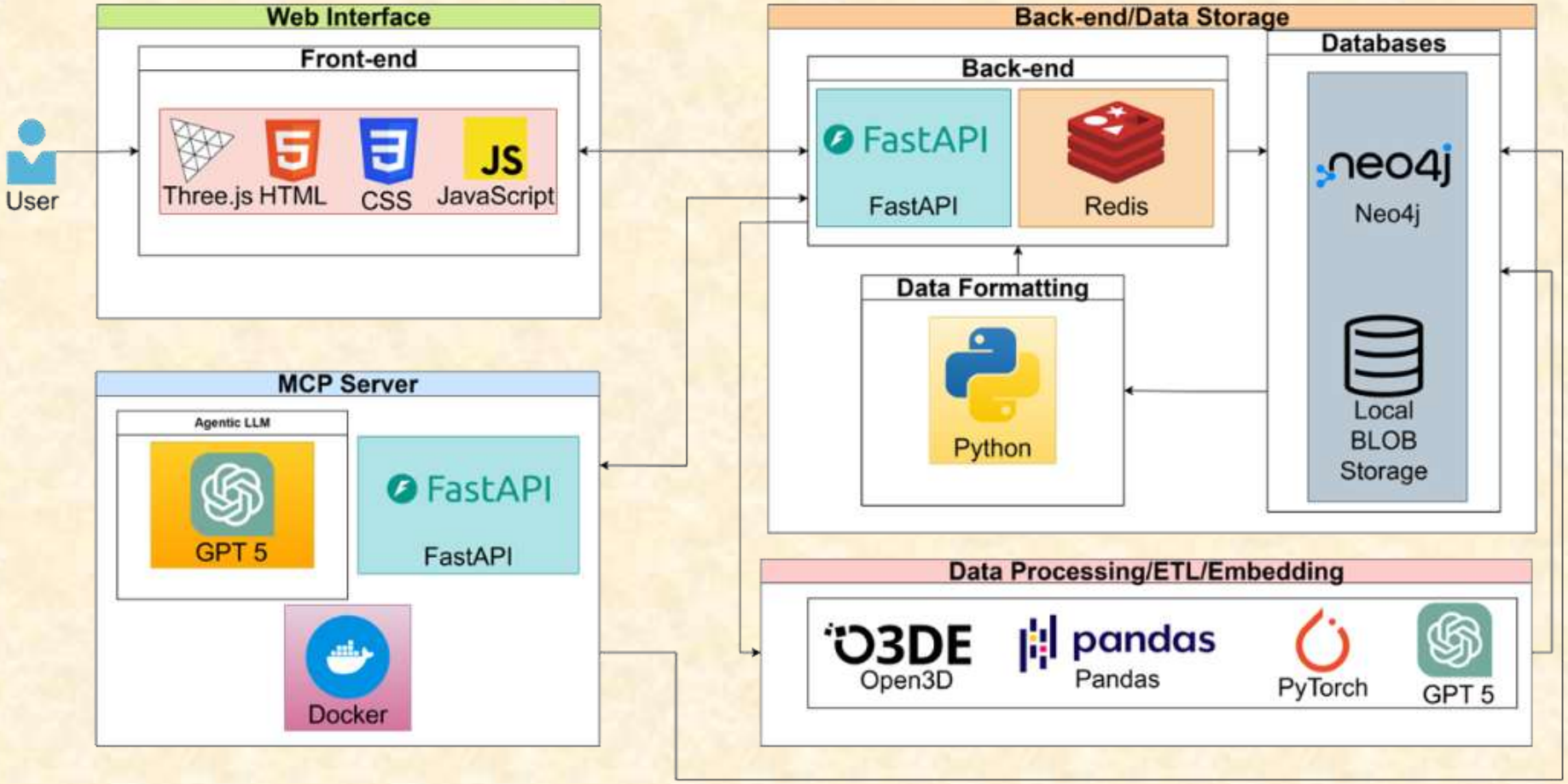
Screen Mockup: Compare 3D Part



Project Technical Specifications

- Frontend
  - Web interface with HTML5, CSS, JavaScript for interactive dashboards and 3D model viewing.
- Backend
  - FastAPI service for REST endpoints and efficient data exchange to users.
  - Redis for session and job queue.
- Data Storage:
  - Neo4j vector database for semantic search, similarity identification, and structured part metadata.
  - Local BLOB storage for STL and image files.
- ETL & Processing:
  - Python with Open3D and Pandas for formatting and embedding 3D models.
- AI/ML Stack:
  - GPT for model interpretation and PyTorch GNN for geometric similarity analysis.
- MCP Server:
  - Docker hosting a service that makes GPT calls while communicating with the main application.

Project System Architecture



Project System Components

- Hardware Platforms
  - One MSU Capstone lab iMac will be dockerized to run MCP server, databases and all backend services and host the website.
- Software Platforms / Technologies
  - Frontend: HTML5, CSS, JavaScript.
  - Backend: Flask, FastAPI.
  - Database: Neo4j, BLOB storage (STL/PNG files).
  - AI/ML: GPT (LLM), PyTorch (GNN), Open3D, Pandas.
  - DevOps: Docker, GitLab.

Project Risks

- Semantic Search
  - Difficult to determine user intent, normalize searches, and map to parts.
  - Implement multiple agentic models to generate “tags” for each user query.
- Embedding Model Accuracy
  - Creating an embedding of a CAD part that describes features is difficult.
  - Connect with sponsor, iteratively build list of features to model, track, and compare.
  - Develop tests with our 10,000 model dataset.
- Object Metadata Labeling
  - Determine part type, and relevant “tags” for uploaded CAD files.
  - Find datasets with labeled parts, and compute ”similarity scores” for each tag.
- Object Supply Sources
  - Display “real parts” similar to user uploaded CAD files.
  - Incorporate datasets from mechanical part suppliers (MiSUMi, McMaster-Carr, etc.)