Agentic AI for Exploring and Analyzing Omics Metadata at Scale

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Introduction

Large, dense, and highly multi-dimensional biomedical datasets are increasingly common, making manual exploration slow and inefficient.

- Identifying consistent patterns across large datasets is not scalable through manual review and the data spans multiple formats: numeric, categorical, and free-text requiring complex programmatic queries .
- We present a chatbot-based interface powered by LLMs and Agentic AI to enable fast, intuitive, and scalable exploration and analysis of such datasets.
- The system interprets user requests and maps them to structured analytical operations on underlying metadata.

Strand's scRNA Portal: Snapshot

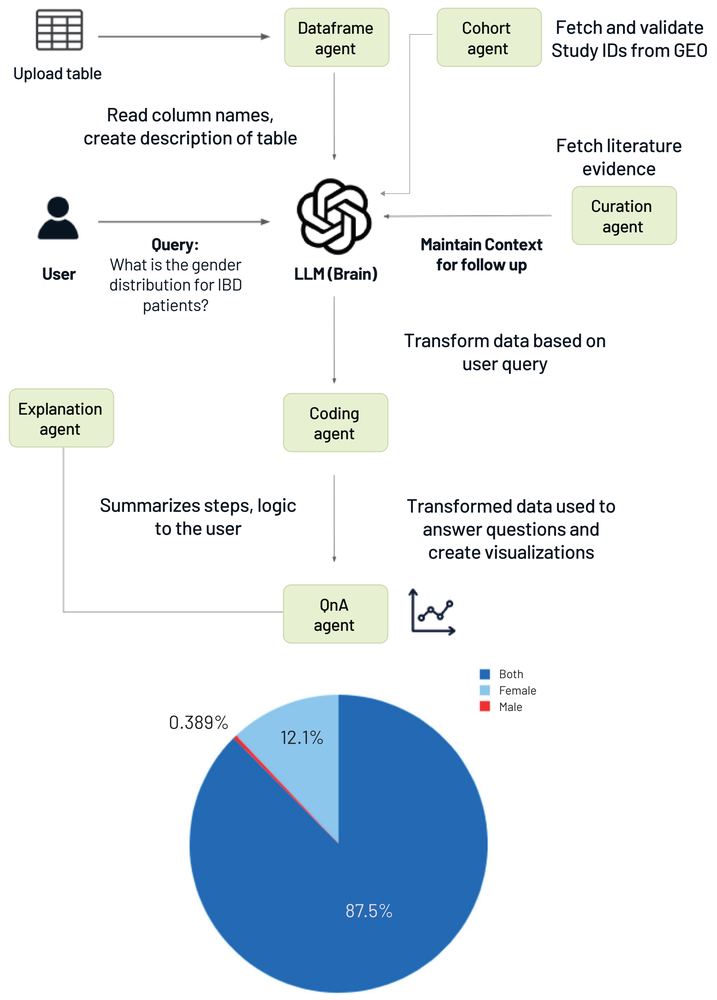
A Disease-Specific Repository

- Our portal hosts deep, curated metadata from specific disease areas like IBD and Neurodegenerative disorders.
- Datasets span a wide range of modalities across single-cell RNA sequencing, bulk RNA and LC-MS/MS proteomics.
- We curated 100+ metadata fields, with 35+ fields involving either ontology mapping or formatting to maintain homogeneity across datasets.

Business value

- Reduce time-to-insight from days to minutes.
- Enable non-technical users to explore complex datasets, curate cohorts for their research goals, fetch relevant literature.
- Support interactive and iterative analysis.
- Ensure data security with local/on-prem deployment.
- Scale across diverse datasets and domains.

Methods



Simple, conversational interface designed for domain scientists without programming or data expertise

LLM + Agentic AI Framework

- LLM interprets user intent and maps it to appropriate analytical operations
- Agent layer selects and executes the appropriate tools based on the interpreted request:
  - Database querying with multi-step reasoning
  - Tool usage (e.g., QnA, visualization,
  - cohort building)

Key Capabilities

- Query and analyze structured experimental metadata (e.g., sample attributes, QC status, study parameters)
- Grounded Responses
  - Outputs are derived directly from the under lying database.
  - Each answer is traceable and verifiable.

  Cohort building based on research goals

Validation Process

- Curated benchmark questions for each dataset.
- Manual validation with Subject Matter Experts (SMEs)
- Evaluation across:
  - Textual responses (25 questions with curated ground truth)
  - Visual outputs (25 questions visually validated by user)
- Cohort agent validated with gold standard manually curated cohorts from GEO.
  - Internal benchmarks: 5 research goals ~30 Study IDs
  - External benchmarks: 1 research goal ~250 Study IDs

Conclusion

- Agentic AI driven exploration transforms how users interact with complex biomedical datasets
- Eliminates the need for manual querying and scripting.
- Maintains accuracy through database-grounded responses.
- A hybrid approach combining LLMs, Agentic AI, and structured databases enables scalable, secure, and efficient data exploration.

Key highlights

- Context-aware, multi-step reasoning via Agentic AI
- Integrated visualization for faster decision-making
- Supports multiple LLM providers: Gemini, OpenAI, Ollama, and OpenRouter for flexible deployment and model choice.
- Support for expanding Cohorts sourced from GEO
- Extensible tool-based framework for integrating additional analysis capabilities

Results

- Accuracy across ~50 questions (textual + visual) ~90%
- Average Latency of the tool is 5.54 secs
- Average Cost with gpt-5.4 is ~$ 0.2
- The estimated reduction is turn around time for getting queries answered is around ~7x
- Cohort agent's precision on internal, external benchmarks: 100%, 92.9%
- Curation agent's TAT reduction in target extraction and mapping to Mechanism of action for a neurological disorder ~2x.

Example Use Cases:

Cohort Discovery Tool

- Gender-based stratification
- Age-based stratification
- Cell/tissue based selection

Biological Insights Assistant

- Summarizing most studied tissue/cell types in different disease states, most commonly used gene markers, cell types involved in treatment response/resistance