DATA+AI SUMMIT
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Layered Intelligence: Generative AI Meets Classical Decision Sciences

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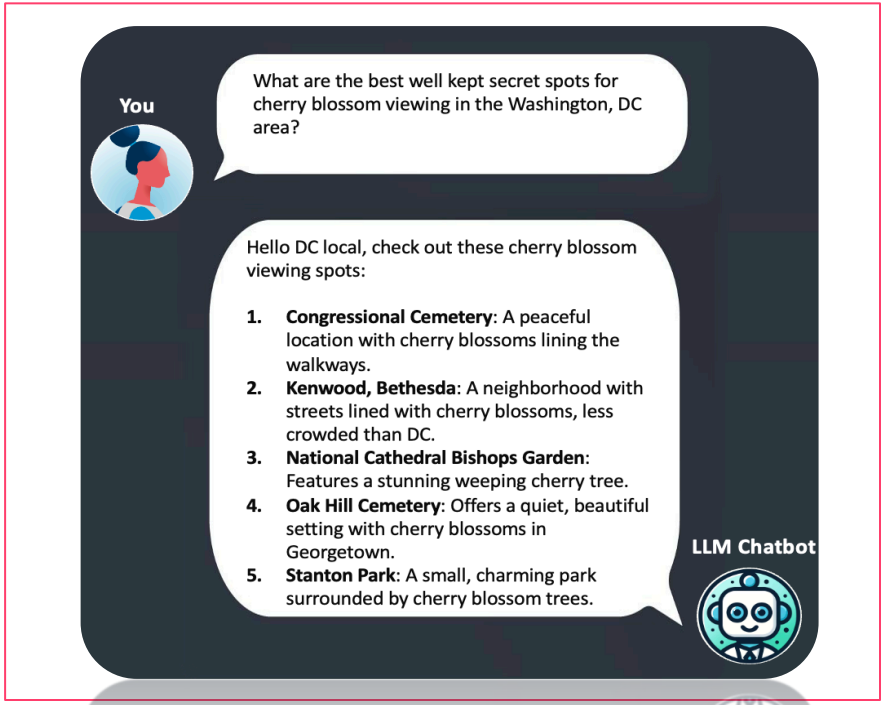
INTRODUCTION

The Evolution Beyond Chat

While LLM-based chatbots have been revolutionary in changing how we interact with information daily, their true potential is far beyond.

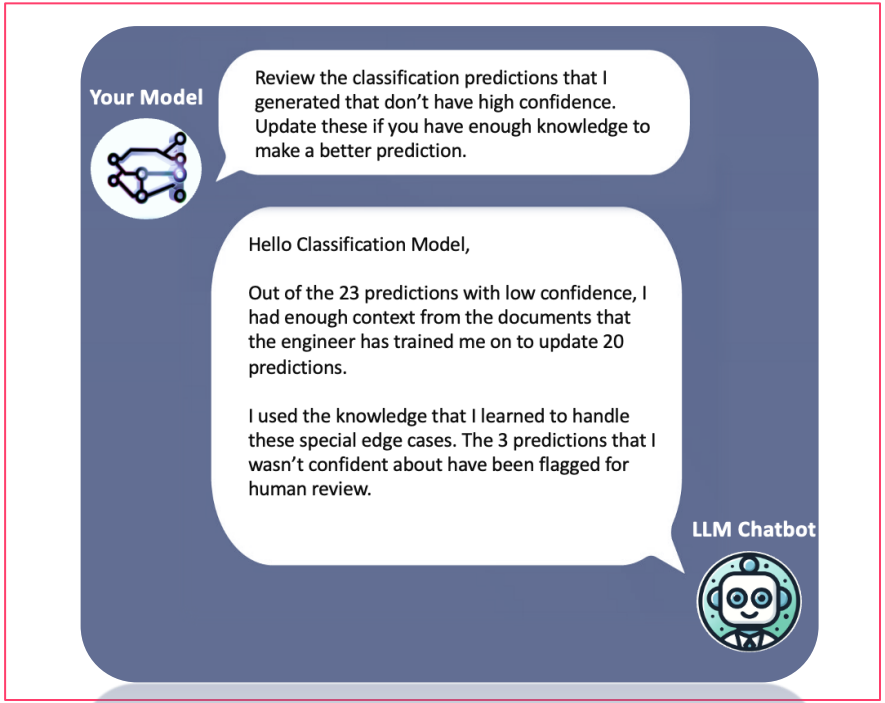
In decision sciences and analytics, generative AI agents can go beyond answering questions; they can process data, predict trends, and develop into sophisticated analytical engines



INTRODUCTION

Why AI Agents are Essential in Modern Analytics

- Dissect complex data
- Reveal underlying patterns and forecast future scenarios
- Transform language to logic
- Scale ability to interpret vast datasets
- Handle challenging edge cases
- Provide review and quality assurance (QA)



GEN AI: OVERCOMING ANALYTICS BOTTLENECKS

We will explore how generative AI can address these common bottlenecks

Volume

Overwhelmed by volume of data and required preprocessing and cleaning

Surface Insights

Conventional analytics usually provide insights that lack depth in data interpretation and context

Rigidity

Inflexibility in adapting to new or changing data and system logic

Time

From data processing to evaluation and review, the traditional pipeline is timely

The role of Generative AI

Streamline data handling, enhancing speed and efficiency	Delve deeper to uncover more challenging patterns and discoveries	Dynamically help with adjustments and evolving	Accelerate processing time and conduct QA

GENERATIVE AI IN LDA TOPIC MODELING

Demo with NIH RePORTER Data

How can we uncover hidden themes within NIH RePORTER's data and generate coherent, descriptive labels for each theme?

TOPIC MODELING

Enhanced by Large Language Models

Topic modeling uses natural language processing methods to uncover hidden patterns and insights in data

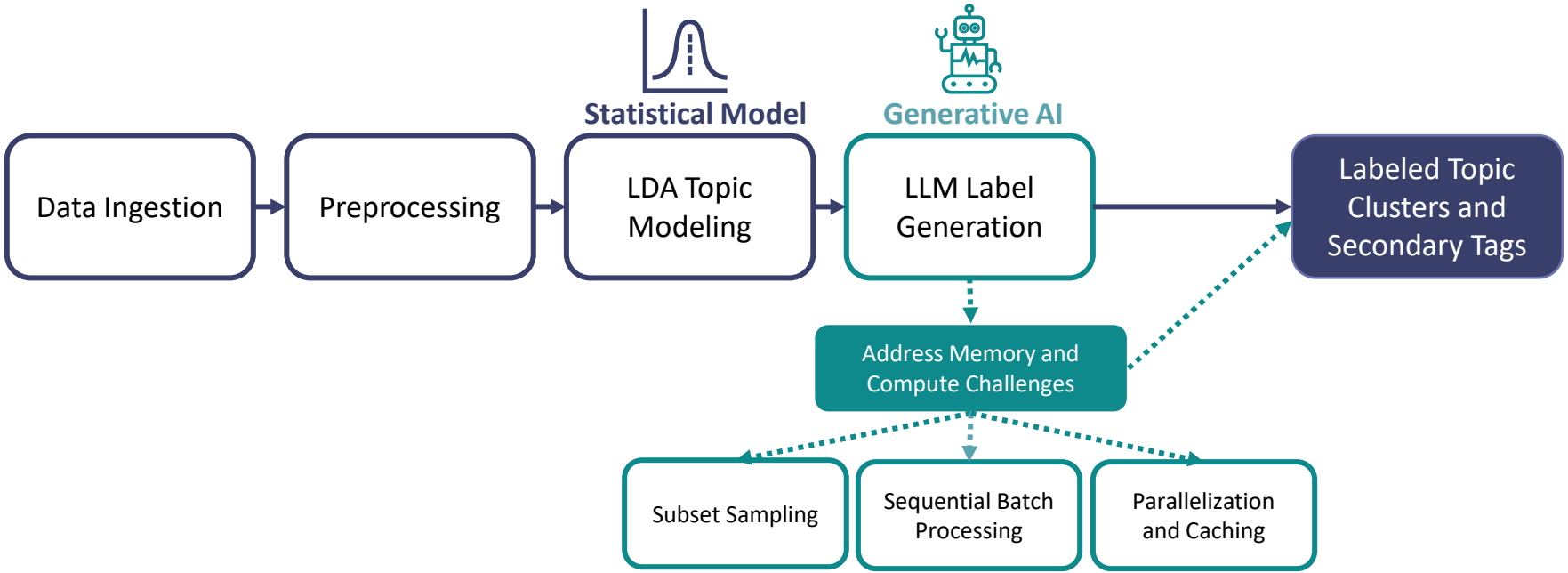
Techniques like Latent Dirichlet Allocation (LDA), a probabilistic method, can be used to identify clusters within datasets,
but often leave these clusters unlabeled

By integrating Generative AI, particularly Large Language Models (LLMs), we can enhance this process. A Gen AI agent can generate meaningful labels for the identified clusters, adding the missing context and clarity

A Gen AI agent transforms the traditional LDA results, turning clusters with no topic labels into actionable insights. This is just one way to enhance descriptive modeling techniques with a Gen AI integration

TOPIC MODELING WITH LDA AND LLMS

A Framework

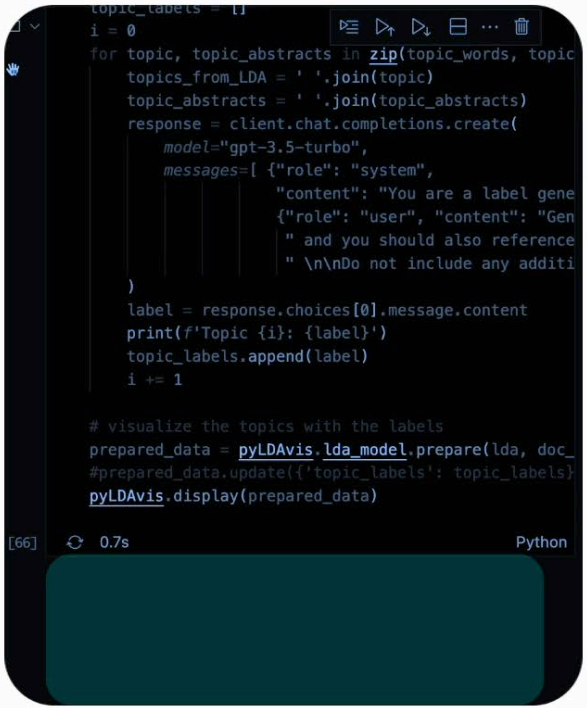


DEMO

Topic Modeling with LDA and LLMs

Dataset: NIH Reporter abstracts from National Institutes of Health (NIH) funded projects.
Source: https://reporter.nih.gov/search/NU7NRcgedUO4EMr8itHS1A/projects
Search Constraints: Fiscal Year: Active Projects; Admin: Yes; Agency/Institute/Center: NICHD; Activity Code: R01 Equivalents; Project Start Date: On or After: 4/1/2023 (until 4/1/2024)"

DEMO



RANDOM FOREST CLASSIFICATION MODEL PROTOTYPE

CLASSIFYING SCIENTIFIC BRANCHES OF GRANT APPLICATIONS AT NIH NICHD

NICHD RPAB Use Case

How can an NIH Institute be more efficient in referring >3000 applications annually while maintaining accuracy?

GRANT APPLICATION REFERRAL PROCESS OVERVIEW

NIH National Institute of Child Health and Human Development (NICHD)

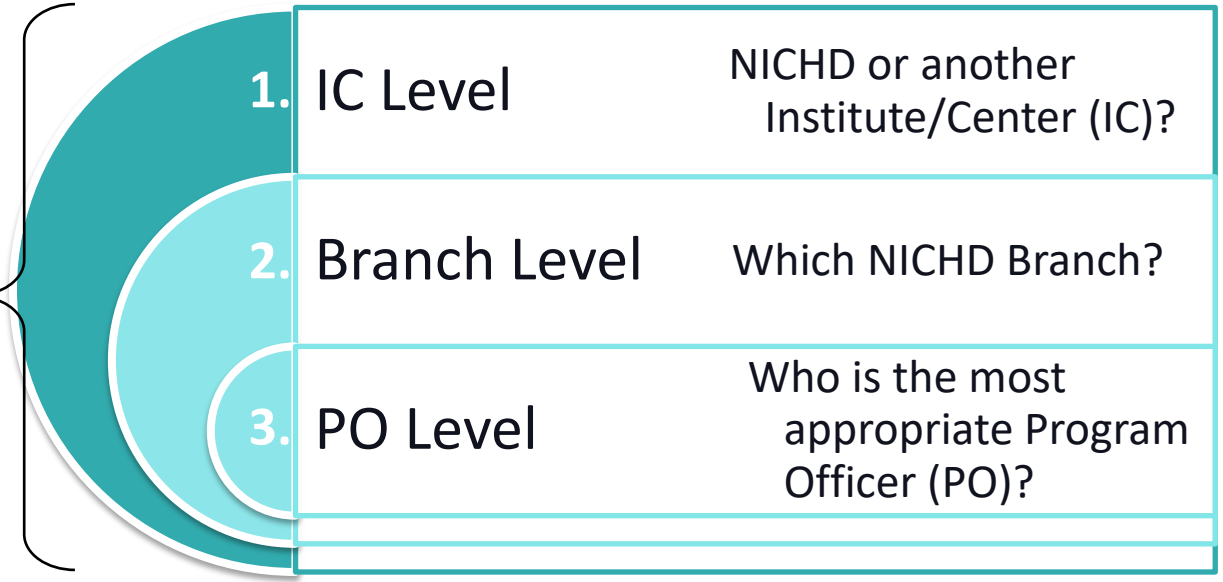
Grant Applications

4,000+ NICHD applications per fiscal year

Referral and Program Analysis Branch (RPAB)

RPAB SMEs are *responsible for internal referral of NICHD applications*

Where does the application belong?
Application Referral



NICHD APPLICATION REFERRAL CHALLENGES

At NIH NICHD, our Referral and Program Analysis Branch (RPAB) AI/ML application referral system project is modernizing the grant application referral process.

The primary aim is to develop a semi-automated referral system to reduce the burden associated with the existing manual referral process. For example, this involves empowering our system to generate initial recommendations regarding the best match between an application and a branch along with more specific branch and program codes.

The Challenge

Time

Application referral is a time-consuming process for a high volume of applications.

In FY 2023, RPAB manually referred **4415** new applications

Expertise

Requires considerable scientific expertise to accurately match applications to **one of 13 appropriate scientific branches and center**

Complexity

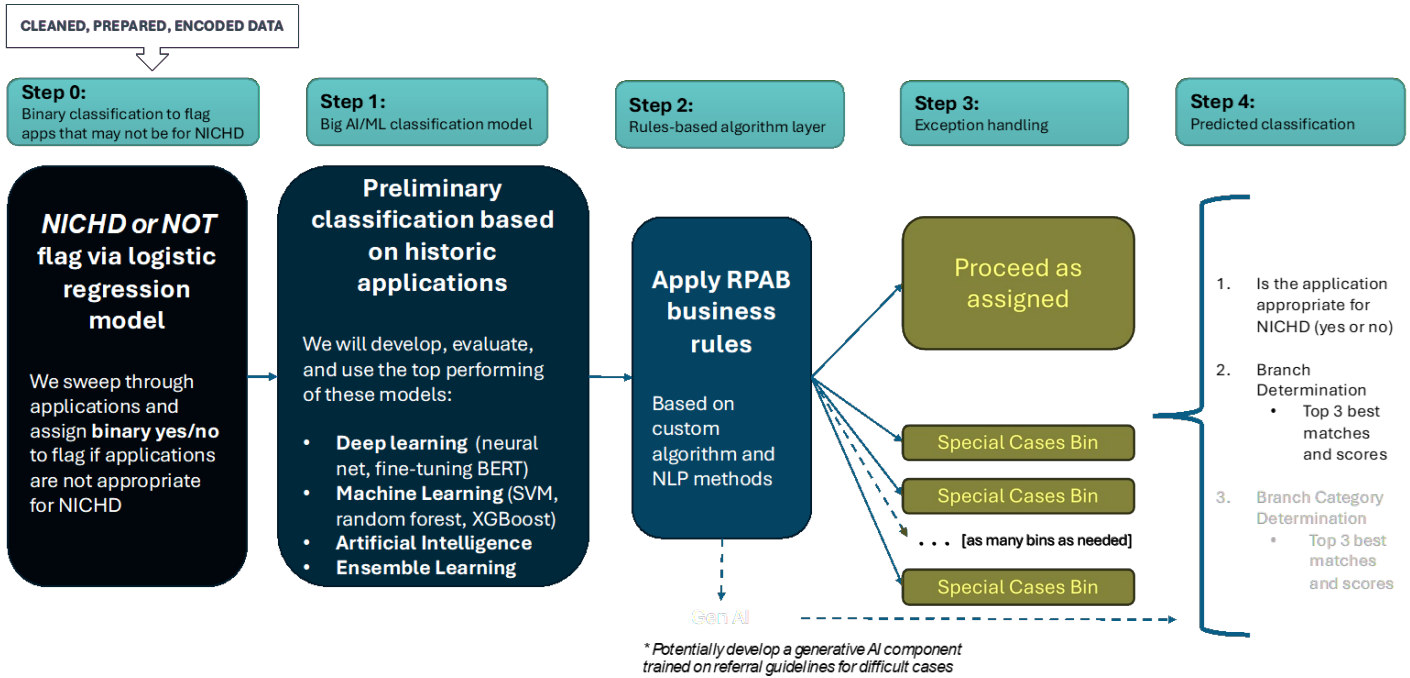
Complex overlapping of scientific domains and policy-related considerations within the extramural branches.

AI/ML APPROACH FOR NICHD REFERRALS

Solution Overview	Developing an RPAB AI/ML Referral System prototype to streamline NICHD referral processes. This approach involves developing and refining advanced algorithms and NLP techniques to semi-automate decision making and enhance data-driven insights.
Key Components	Data preprocessing, feature engineering, development of high performing classification models, analysis of evaluation metrics, user acceptance testing and review
Benefits	Our AI/ML solution can deliver tangible benefits, including faster referral, enhanced accuracy, reduction in manual errors and administrative burden, real-time insights for improved decision-making
Scalability and Adaptability	Designed to adapt to evolving scientific landscapes and changing NICHD research priorities, our solution ensures flexibility and scalability to meet future requirements and expand as needed.

MODEL DEVELOPMENT AND INTEGRATION

RPAB AI/ML Referral System: a multilayered system design



PREDICTING GRANT APPLICATION CLASSIFICATION

At NICHD RPAB

Prototype Model Overview

- Random forest classification algorithm with notable success to predict a grant application's scientific branch within NICHD
- Aimed at enhancing RPAB decision-making processes

Model Confidence and Future Development

- High initial success rates
  - Achieved accuracies ranging from 64-95% for the various branches
  - Average accuracy of approximately 85%
- Future Development: System refinement by incorporating RPAB SME business rule logic to enhance performance; exploration of neural network classification model with Generative AI QA Bot

Expected ROI

- If the AI/ML system saved just 20% of the time, this is estimated to be 4/20 minutes of time saved for manual application referral. With ~4400 applications per year, this adds up to **~37 workdays per fiscal year.**

13
NICHD Branches and Center

~85%
Average Accuracy

22788
Applications in 5-year dataset

~37
Workdays saved (expected)

Prototype Model Evaluation Score by Branch

The evaluation metric illustrated is the F1 score, which is the harmonic mean of precision and recall. It is a measure of the model accuracy.

NEURAL NETWORK CLASSIFICATION WITH GENERATIVE AI QA BOT

A FRAMEWORK AND PROTOTYPE DEMO

Demo with NIH RePORTER Data

How can we boost production-ready accuracy and confidence in classification of complex NIH RePORTER data?

REFINING UNCERTAINTY IN MACHINE LEARNING

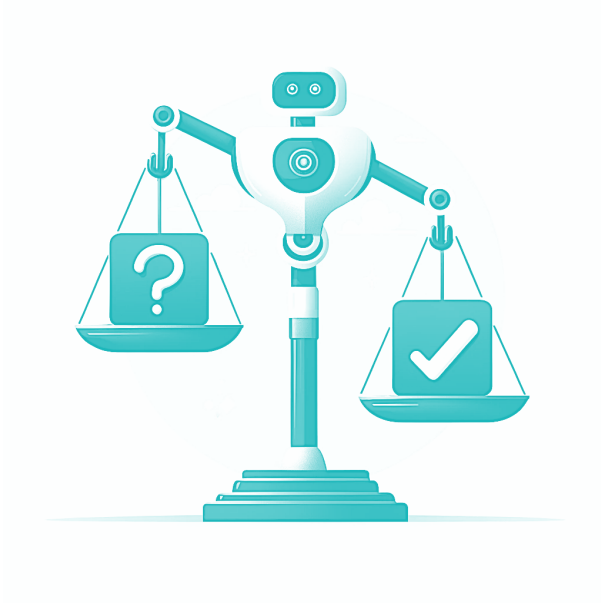
Building on Machine Learning Foundations

Whether using neural networks or random forest, every classifier encounters predictions with low confidence.

The Generative AI QA Bot

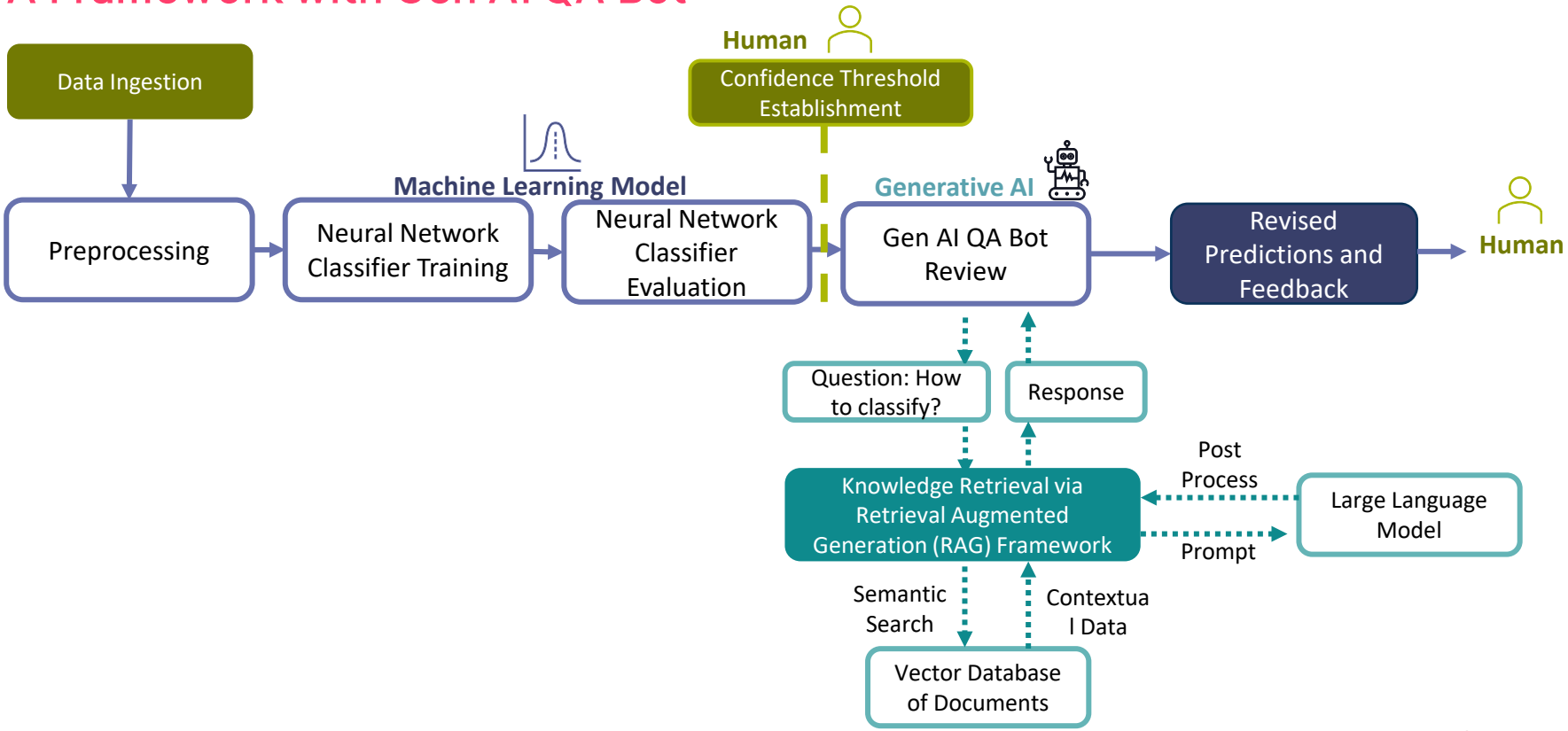
By embedding a Generative AI QA Bot in a model system, it is possible to:

- Review and refine uncertain outcomes at scale
- Improve the model's reliability and trust
- Provide the system with access to external context for larger knowledge base
- Provide additional notes for feedback to human-in-the-loop



NEURAL NETWORK CLASSIFICATION + GEN AI

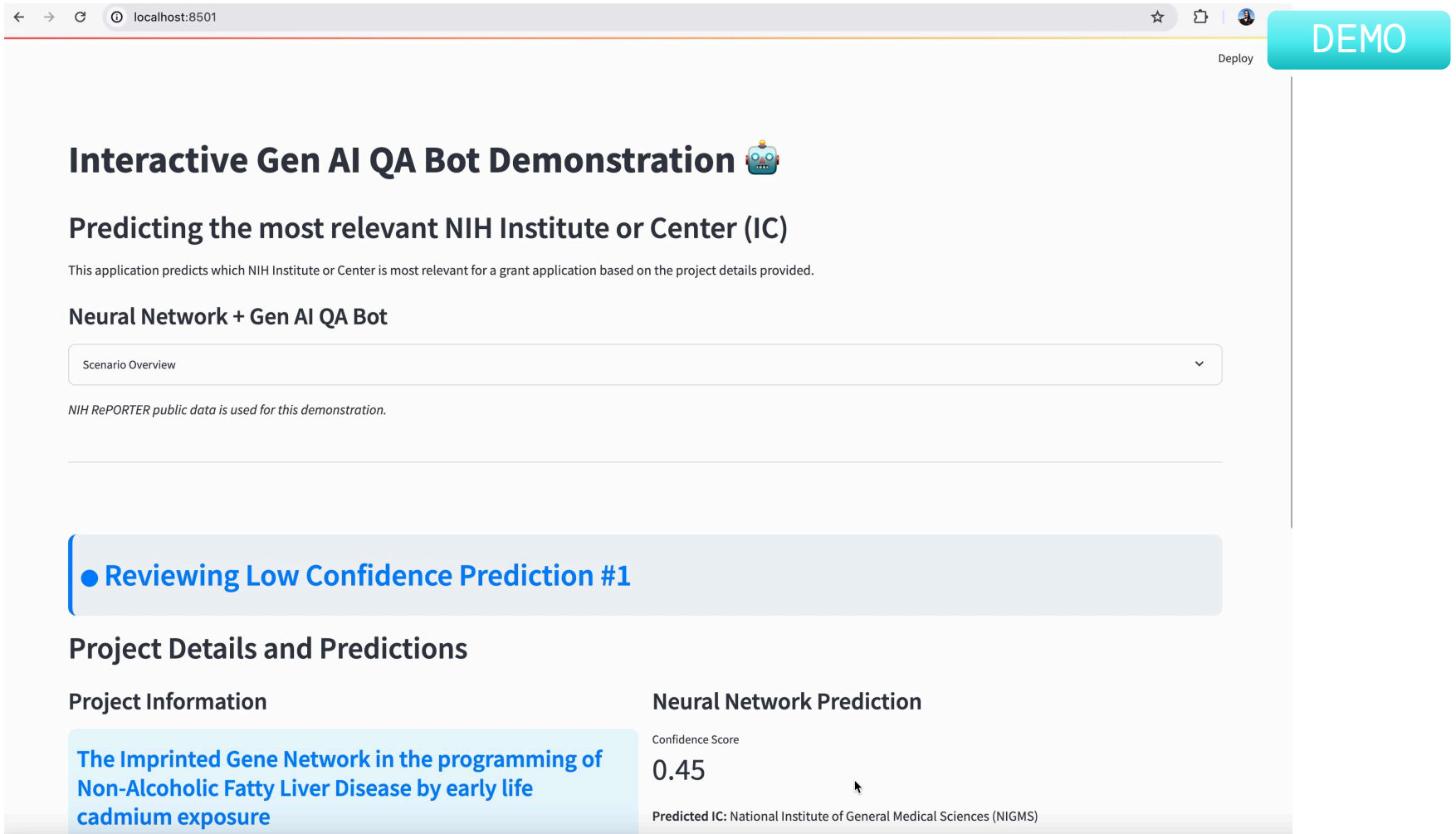
A Framework with Gen AI QA Bot



DEMO

Neural Network Classification with Gen AI QA Bot

Dataset: NIH Reporter abstracts from National Institutes of Health (NIH) funded research projects during 2024. The most recent 15000 funded projects are used.
Source: https://reporter.nih.gov/search/p8bbCVIgUEqsYZwl9yRufg/projects
Search Constraints: Search Criteria Fiscal Year: 2024Activity Code: Research Projects



CONCLUSION

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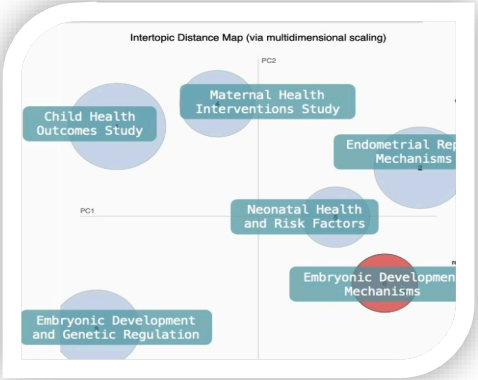
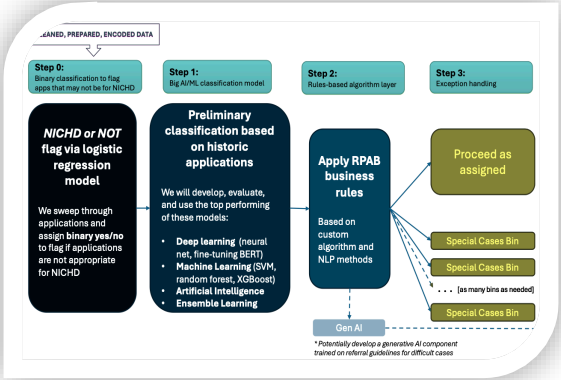
We've explored the application of generative AI in topic modeling, the NIH RPAB AI/ML referral prototype, and neural network classification with a QA bot

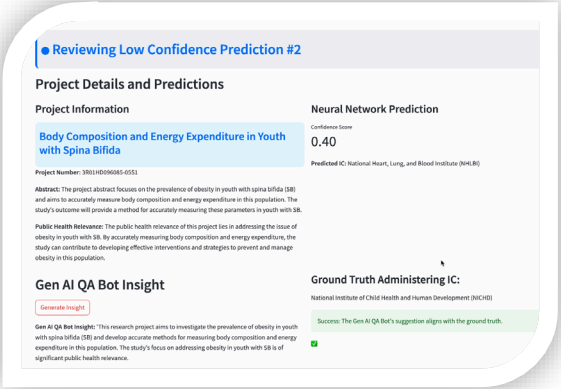
Generative AI in Topic Modeling



RPAB AI/ML Application Referral Prototype



Neural Network Model with Gen AI QA Bot



REFERENCES AND RESOURCES

Software, Images, Data

- Software and packages used in prototypes and demos
  - Data preprocessing: pandas, numpy, re, nltk
  - Topic modeling: gensim, pyLDAvis
  - Generative AI: Hugging Face Transformers, OpenAI GPT-3.5, LlamaIndex
  - Model training: TensorFlow, Keras, scikit-learn
  - Web app development: Streamlit
- Images generated by DALL-E 3
- Data from NIH RePORTER

THANK YOU!

QUESTIONS AND DISCUSSION

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