NEXCEPTA

Artificial Intelligence and Machine Learning (AI/ML)

HIGH QUALITY DATA GENERATION

- **Availability of high-quality synthetic data** to develop AI/ML algorithms is **vital**.
- **Representative datasets** for tactical and mission-critical operations are **limited**.
  - Images of red-force drones, ships or tanks or wireless signals in different domains.
  - Different angles or daylight/seasonal change for image data.
  - Variation in channel and interference characteristics for the RF signal data.

Diffusion model

Vector-Quantized Variational Autoencoder (VQ-VAE)

Embedding Space · Encoder · Decoder · Image data · RF signal data · Augmented data

- **Diffusion models** for augmenting data for object detection in a guided and principled way.

- VQ-VAE-based synthetic data generation for RF waveforms provides high-fidelity and diverse data samples for RF signal waveforms.

AI-DRIVEN THRAT DETECTION AND MITIGATION

- Deep learning is vulnerable to catastrophic forgetting (forgets old tasks when learning new ones).
- Continual deep reinforcement learning (DRL) to prevent catastrophic forgetting in jamming mitigation for Electronic Warfare (EW) applications.
- Retain knowledge of old jammer patterns while learning to handle new ones.
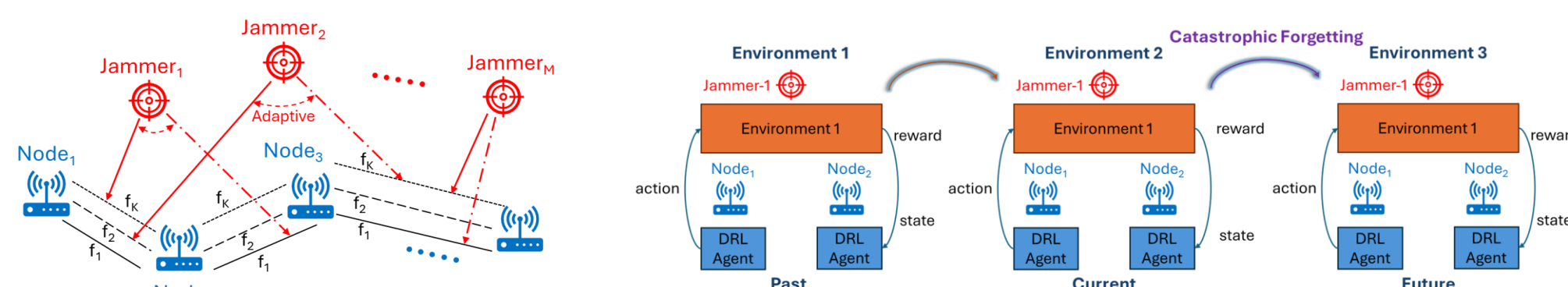
Multi-agent Reinforcement Learning (MARL)

- Explainable AI.
  - Explain decisions of DRL:

RF SIGNAL CLASSIFICATION
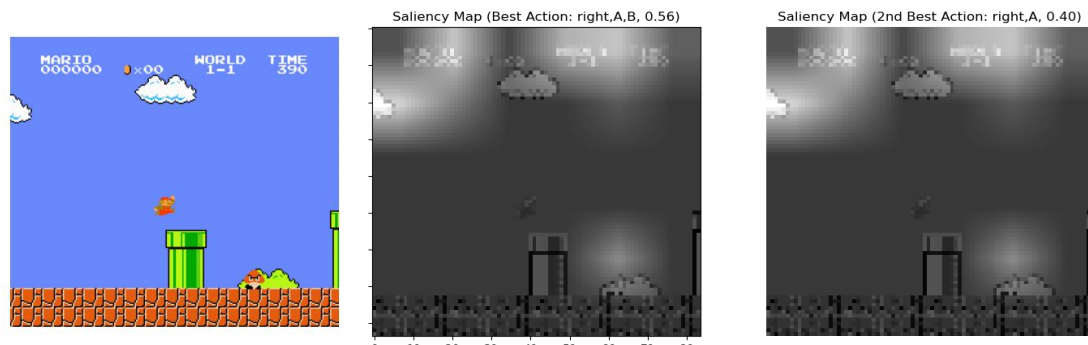
- Detection and classification of **multiple Signals of Interest (SOIs)**.
- Large database of SOIs and AI/ML models for different applications.
  - Signal classification for **4G/5G, and V2X protocols**.
  - Signal classification for **HF protocols**.
  - **Waveform and protocol classification.**
  - **Multifunction radar** cognitive state estimation and next state prediction.
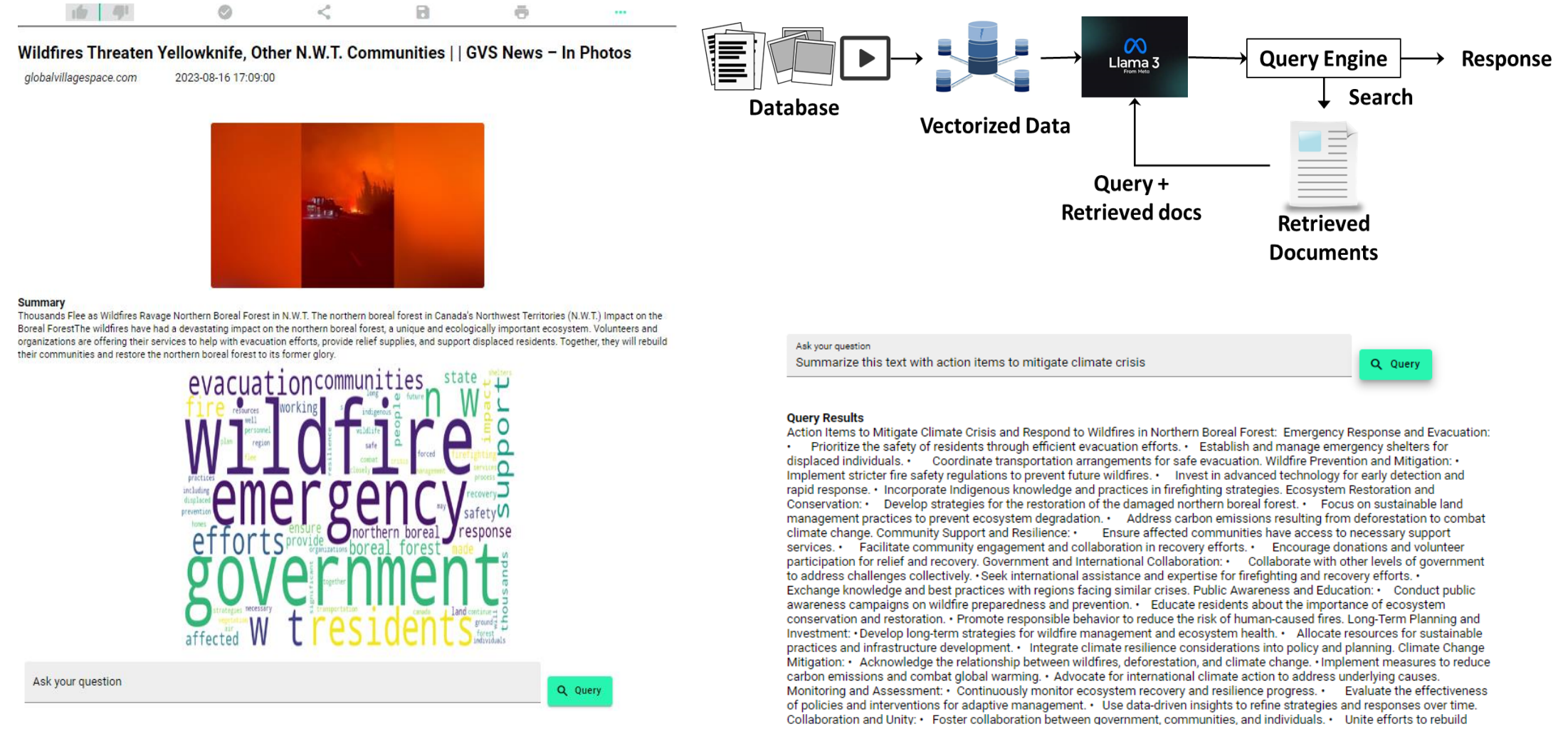

LARGE LANGUAGE MODELS
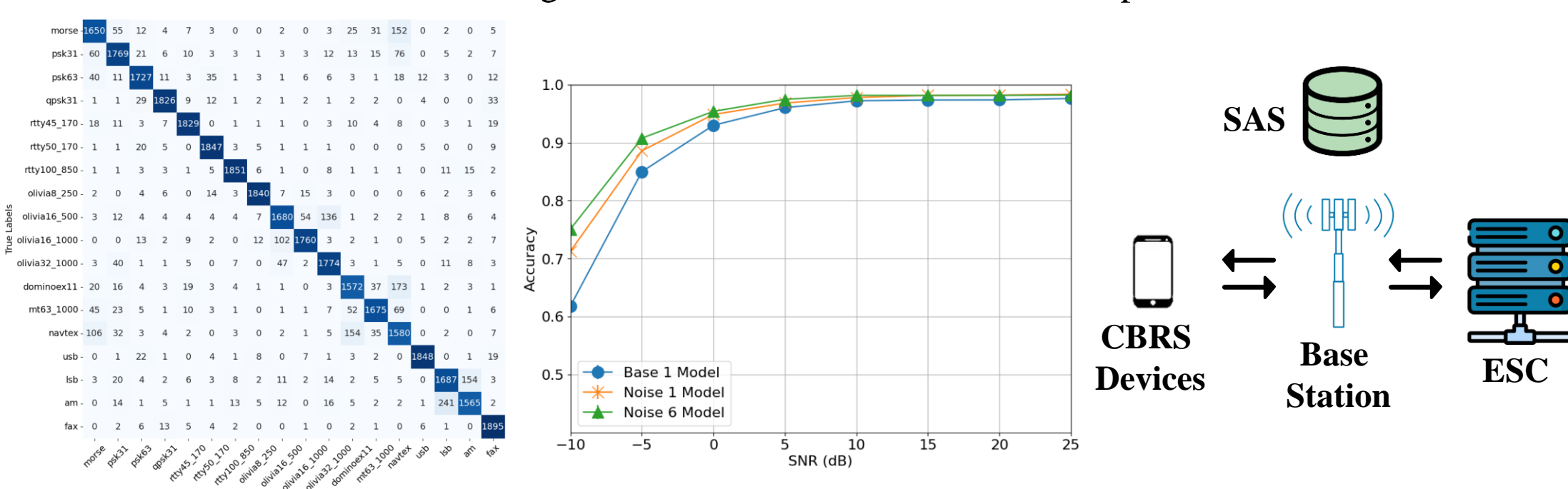
- **Multilingual LLM-based context search and LLM-based advanced text analytics.**
- Processes **+60K data sources** from **+140 countries** in **+40 languages**.
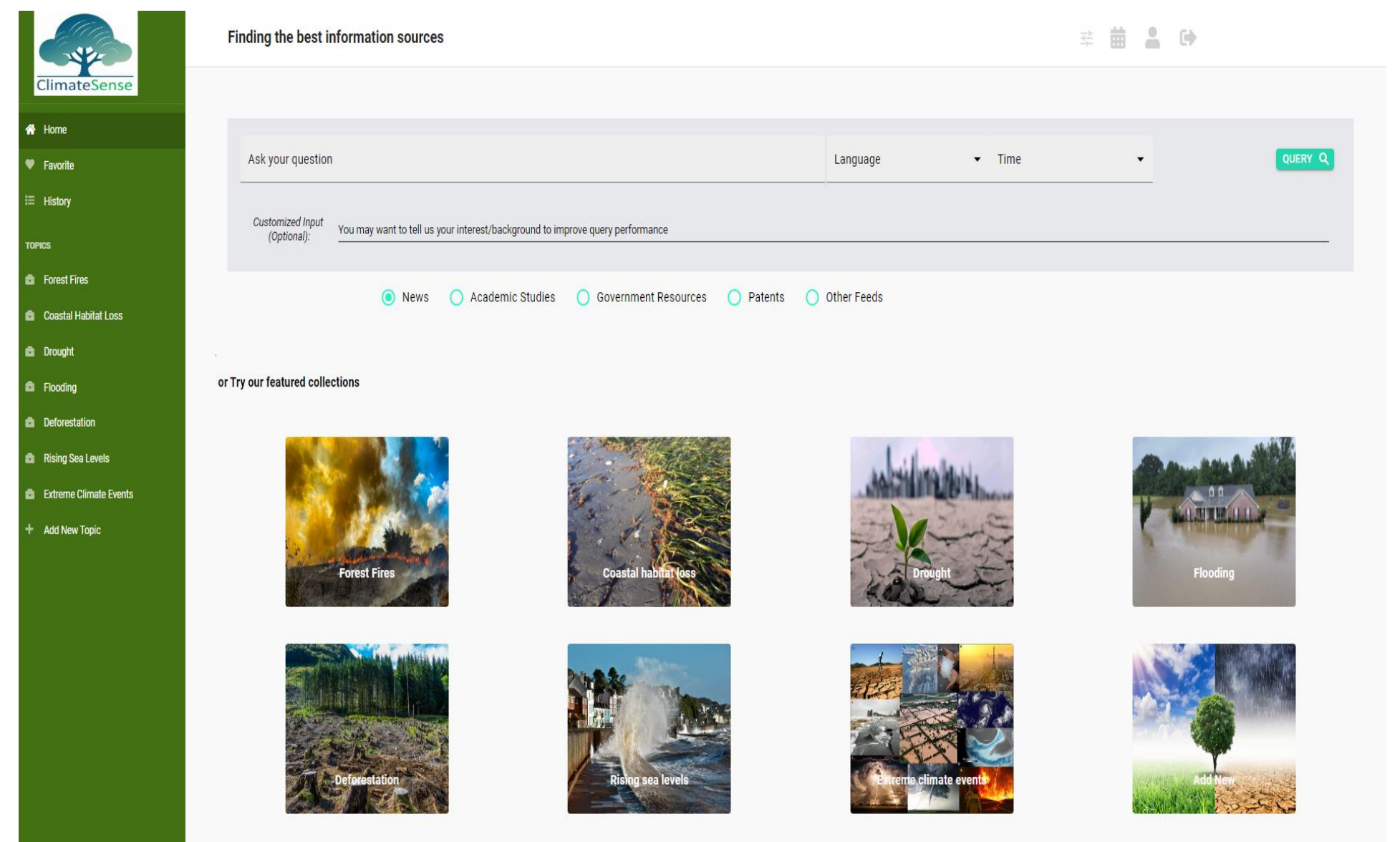

- Recommender system for Model-based Systems Engineering (MBSE) artifacts.
- Multimodal Retrieval Augmented Generation (RAG) for text, image, audio, video.
- Personalized and sequential-time recommendations.

Retrieval Augmented Generation (RAG)

Database · Vectorized Data · Llama 3 · Query Engine · Response · Search · Query + Retrieved docs · Retrieved Documents

OBJECT DETECTION AND TRACKING

- **Need:** Most real-world datasets are typically imbalanced.
  - Imbalance in **class distribution** (instance count).
  - Imbalance in **spatial distribution** (pixels squared).
- State-of-the-art AI/ML models for **object detection** and **multi-target tracking (MTT)**.

LOGISTICS & SUPPLY CHAIN MANAGEMENT
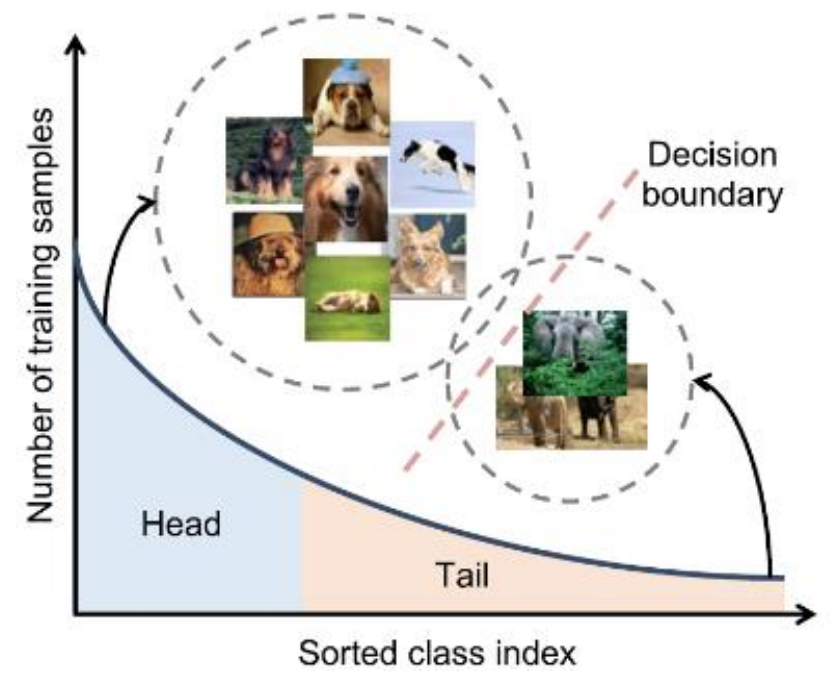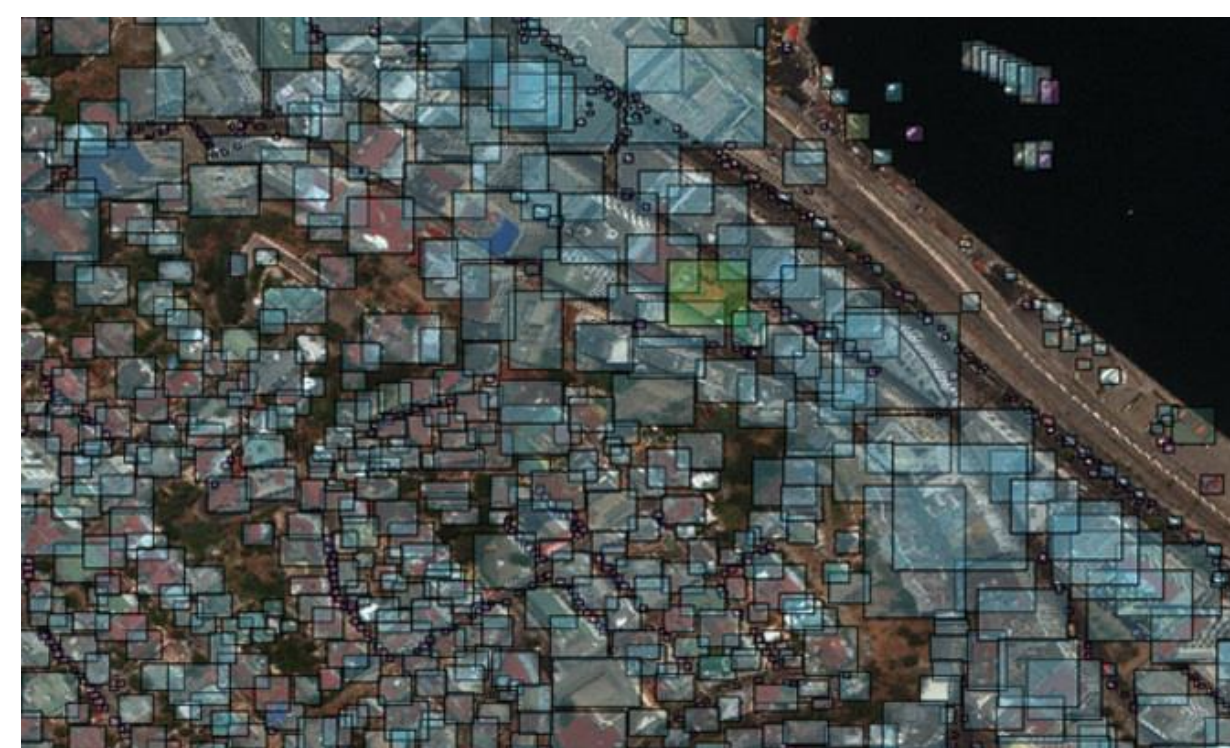
- Track logistical supplies and personnel movements across multiple transport modes.
- Monitor military logistics supply movements.
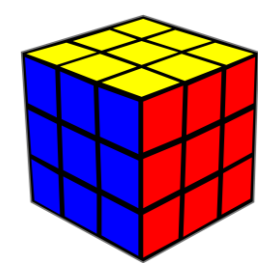
Risk Management · Manufacturer · Distributors · Asset Tracking · End User

GRAPH ANALYTICS

Graph representation for Text
- Knowledge representation and extraction.
- LLM-based Knowledge graph generation.

Graphs Embeddings
- Graph Reinforcement Learning for network resource allocation.
- Community/subcommunity detection.
- Influential node identification.
- Attribute/feature prediction.
- Predictive analysis.
  - Communication link states.
  - Traffic flow prediction.