

# Fox ML Infrastructure – System Architecture Diagram

This document provides a visual and textual representation of the Fox ML Infrastructure system architecture. This architecture diagram is essential for enterprise technical reviews and integration planning.

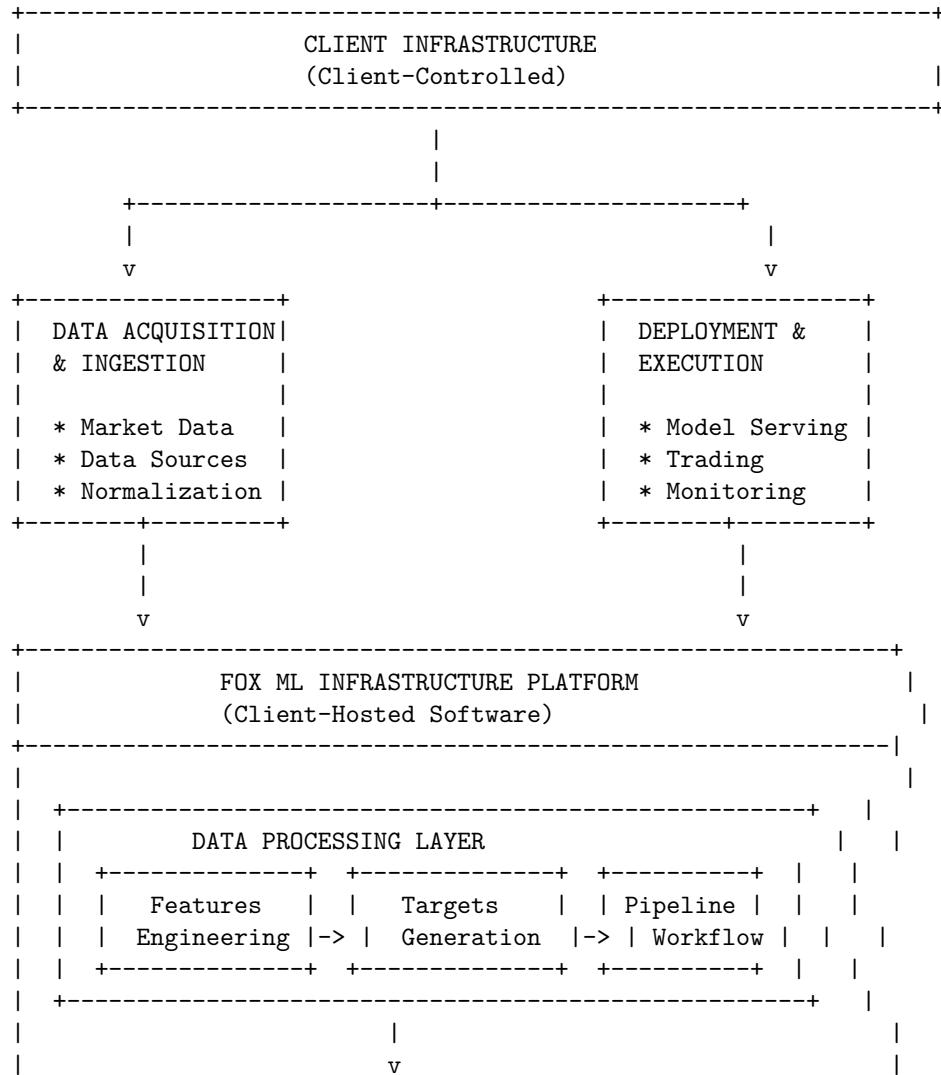
## 1. Executive Summary

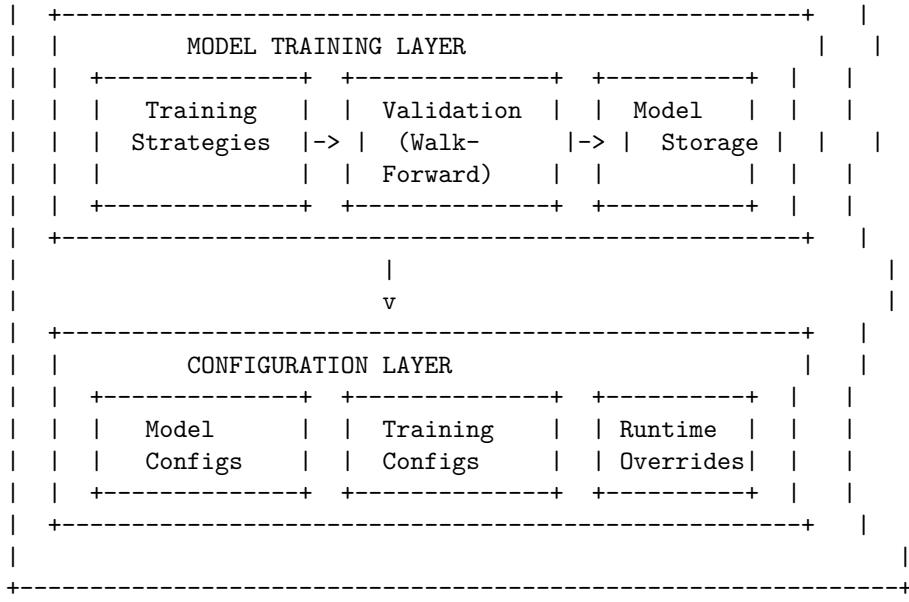
**Fox ML Infrastructure** is a client-hosted, modular ML research infrastructure platform.

**Key architectural principles:** - **Client-hosted** – Software runs entirely on client infrastructure - **Modular design** – Clear separation of concerns across modules - **Configuration-driven** – All runtime parameters from centralized configs - **Pipeline-based** – Data flows through well-defined pipeline stages - **Extensible** – Easy to add new models, features, and strategies

## 2. High-Level Architecture

### 2.1 System Overview





### 3. Component Architecture

#### 3.1 Data Processing Layer

**Purpose:** Transform raw market data into ML-ready features and targets.

**Components:**

```

DATA_PROCESSING/
+-- features/
|   +-- SimpleFeatureComputer      # Basic technical indicators
|   +-- ComprehensiveFeatureBuilder # 200+ feature engineering
|   +-- StreamingFeatureBuilder    # Streaming/online features
+-- targets/
|   +-- BarrierTargetBuilder      # Barrier-based targets
|   +-- ExcessReturnsBuilder       # Excess return targets
|   +-- HFTForwardReturnsBuilder  # High-frequency targets
+-- pipeline/
|   +-- DataNormalization         # RTH alignment, grid correction
|   +-- FeaturePipeline          # End-to-end feature workflow
|   +-- TargetPipeline            # End-to-end target workflow
+-- utils/
    +-- MemoryManagement          # Efficient memory handling
    +-- Logging                   # Structured logging
    +-- Validation                # Data sanity checks

```

**Data Flow:**

```

Raw Market Data
  v
Normalization (RTH alignment, grid correction)
  v
Feature Engineering (200+ technical features)
  v
Target Generation (barrier, excess returns, HFT)

```

```
v  
Labeled Dataset (features + targets)
```

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### 3.2 Model Training Layer

**Purpose:** Train and validate ML models using walk-forward validation.

**Components:**

```
TRAINING/  
+-- model_fun/  
|   +-- LightGBMTrainer      # Gradient boosting  
|   +-- XGBoostTrainer       # Gradient boosting  
|   +-- MLPTrainer          # Deep learning  
|   +-- TransformerTrainer  # Transformer models  
|   +-- EnsembleTrainer     # Model ensembles  
|   +-- MultiTaskTrainer    # Multi-task learning  
|   +-- [13+ additional trainers] # Probabilistic, advanced models  
+-- strategies/  
|   +-- SingleTaskStrategy   # One model per target  
|   +-- MultiTaskStrategy    # Shared model for targets  
|   +-- CascadeStrategy      # Sequential dependencies  
+-- walkforward/  
|   +-- WalkForwardValidator # Time-series validation  
|   +-- PurgedTimeSeriesSplit # Leakage-safe splitting  
+-- memory/  
    +-- MemoryManager         # Memory optimization  
    +-- BatchProcessing        # Efficient batch handling
```

**Training Flow:**

```
Labeled Dataset  
v  
Walk-Forward Validation (time-series split)  
v  
Model Training (17+ model types)  
v  
Model Validation (performance metrics)  
v  
Trained Models (serialized)
```

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### 3.3 Configuration Layer

**Purpose:** Centralized, version-controlled configuration management.

**Components:**

```
CONFIG/  
+-- model_config/  
|   +-- lightgbm.yaml        # LightGBM configs (3 variants)  
|   +-- xgboost.yaml         # XGBoost configs (3 variants)  
|   +-- mlp.yaml             # MLP configs (3 variants)  
|   +-- [14+ additional configs] # All model types  
+-- training_config/  
|   +-- walkforward.yaml     # Walk-forward parameters
```

```

|   +-- feature_selection.yaml      # Feature selection configs
|   +-- first_batch_specs.yaml    # Training specifications
+-- config_loader.py
    +-- load_model_config()        # Load model configs
    +-- list_available_configs()  # List available configs
    +-- apply_overrides()         # Runtime overrides

```

#### Configuration Flow:

```

Base Config (YAML)
  v
Variant Selection (conservative/balanced/aggressive)
  v
Runtime Overrides (environment variables, CLI args)
  v
Final Configuration (validated, applied)

```

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#### 3.4 Model Output & Artifacts Layer

**Purpose:** Generation and storage of trained models, predictions, and performance metrics.

##### Components:

```

outputs/                                # Model artifacts and outputs
+-- models/                               # Serialized trained models
|   +-- lightgbm/                         # LightGBM model artifacts
|   +-- xgboost/                           # XGBoost model artifacts
|   +-- [other model families]            # Additional model types
+-- predictions/                          # Model predictions
|   +-- validation/                       # Validation set predictions
|   +-- test/                             # Test set predictions
+-- reports/                             # Performance reports
    +-- metrics/                           # Performance metrics
    +-- diagnostics/                      # Model diagnostics

```

##### Output Flow:

```

Trained Models
  v
Model Serialization (standard formats)
  v
Signal Generation (trading signals)
  v
Risk Management (safety guards, position sizing)
  v
Order Execution (broker integration)
  v
Performance Tracking (PnL, metrics)

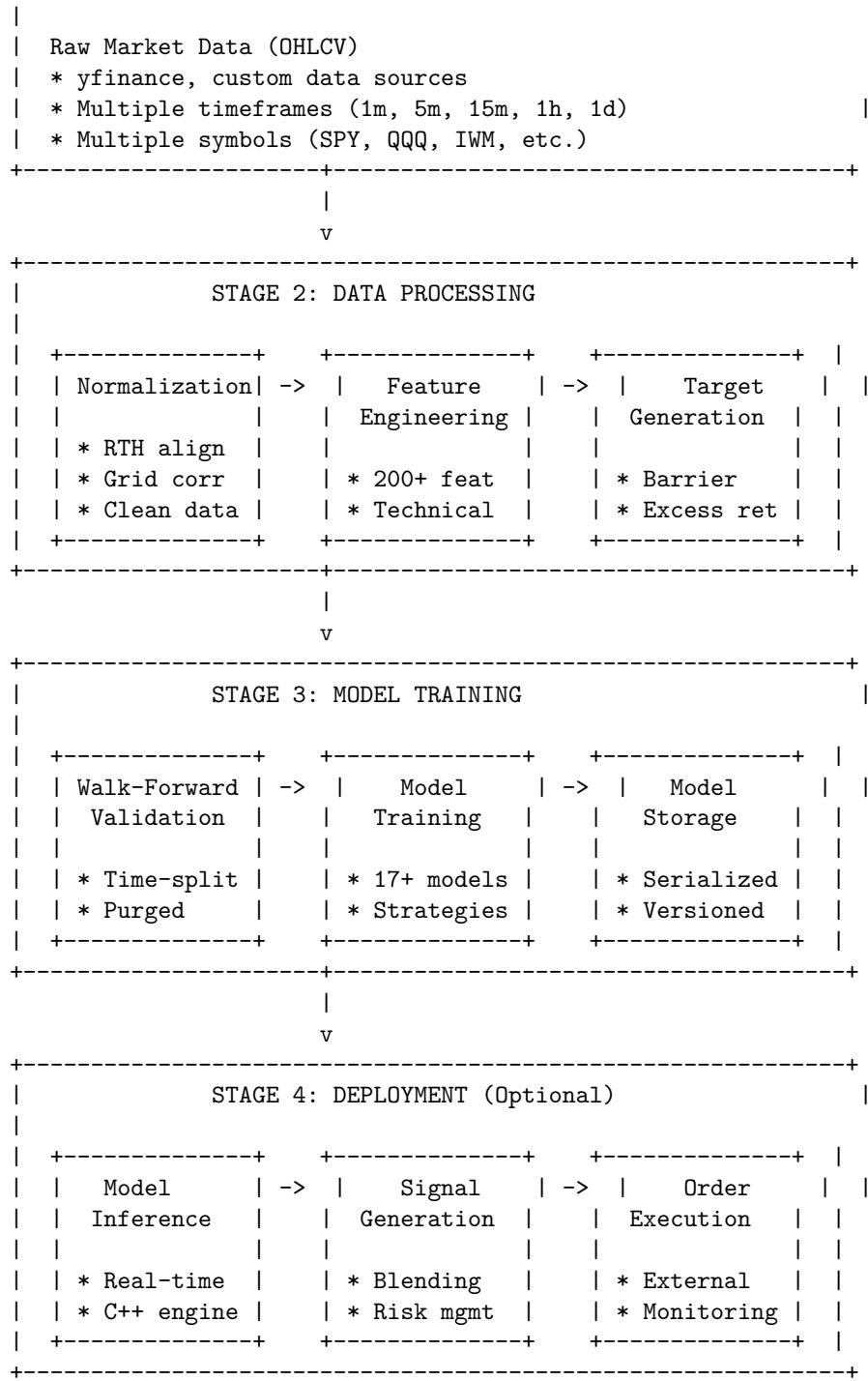
```

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## 4. Data Flow Architecture

### 4.1 End-to-End Pipeline

```
+-----+
|           STAGE 1: DATA INGESTION           |
+-----+
```



## 5. Module Dependencies

### 5.1 Dependency Graph

CONFIG (Configuration Management)

$\wedge$

| (used by)

```

|
DATA_PROCESSING (Feature Engineering)
^
| (produces)
|
TRAINING (Model Training)
^
| (uses)
|
CONFIG (Model Configs)
^
| (optional)
|
External Trading Systems (Optional Integration)

```

## 5.2 External Dependencies

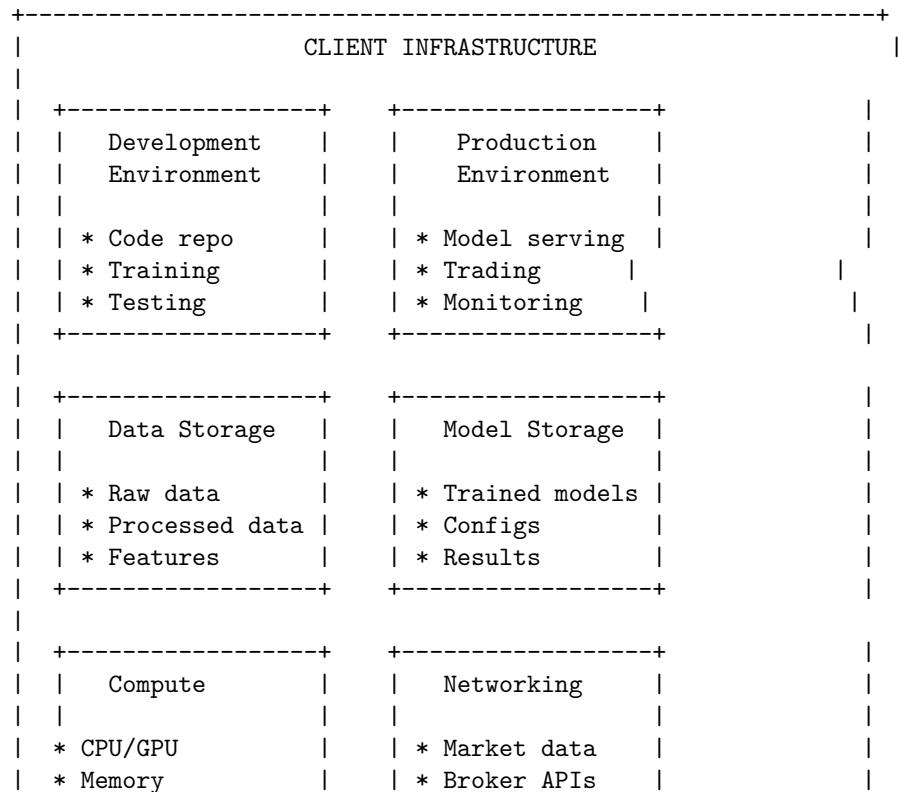
**Core Dependencies:** - Python 3.9+ – Core runtime - NumPy, Pandas – Data processing - Scikit-learn – ML utilities - LightGBM, XGBoost – Gradient boosting models - PyTorch – Deep learning models (optional)

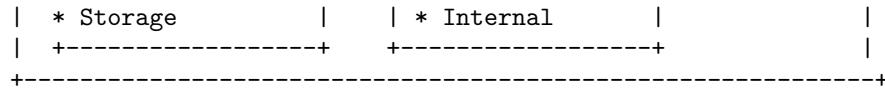
**Trading Dependencies:** - ib\_insync – Interactive Brokers API - alpaca-trade-api – Alpaca API

**Infrastructure:** - Git – Version control - GitHub – Repository hosting - YAML – Configuration format

## 6. Deployment Architecture

### 6.1 Client-Hosted Deployment





## 6.2 No Vendor Infrastructure

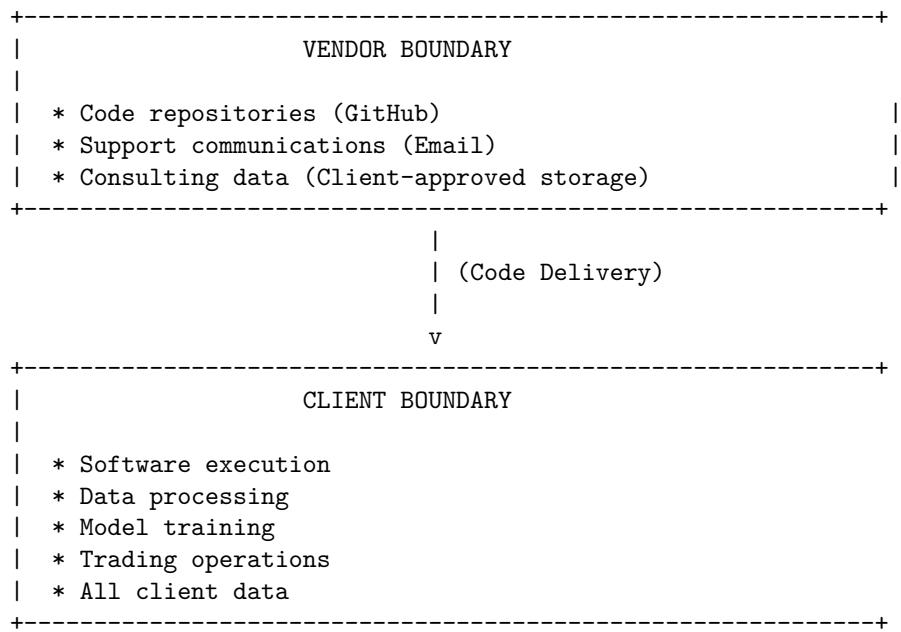
**Important:** Fox ML Infrastructure does not operate: - [X] Vendor-hosted servers - [X] Vendor-hosted databases - [X] Vendor cloud services - [X] Vendor network infrastructure

All infrastructure is client-controlled and client-managed.

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## 7. Security Architecture

### 7.1 Security Boundaries



### 7.2 Security Controls

**Vendor-side:** - Repository access controls (2FA, SSH keys) - Code integrity (version control, signed commits)  
- Supply chain integrity (no telemetry, explicit dependencies)

**Client-side:** - Infrastructure security (client-managed) - Data security (client-managed) - Network security (client-managed) - Access control (client-managed)

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## 8. Scalability Architecture

### 8.1 Horizontal Scalability

**Scalable components:** - **Data processing** – Parallel processing of multiple symbols/timeframes - **Model training** – Distributed training (if configured) - **Feature engineering** – Batch processing for large datasets - **Inference** – Parallel inference for multiple models

## 8.2 Vertical Scalability

**Resource requirements:** - **CPU** – Multi-core processors (8+ cores recommended) - **RAM** – 16GB+ (32GB+ for large datasets) - **GPU** – Optional but recommended for deep learning - **Storage** – Sufficient for datasets and models

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## 9. Integration Points

### 9.1 Data Integration

**Data sources:** - **yfinance** – Equity market data (default) - **Custom adapters** – Client-specific data sources - **File-based** – CSV, Parquet, HDF5 files

### 9.2 Model Integration

**Model deployment:** - **Serialized models** – Pickle, joblib, PyTorch formats - **REST API** – Model serving via REST API (if configured)

### 9.3 Model Integration

**Integration points:** - Models can be integrated with external trading systems - Standard formats for model serialization - Performance tracking and monitoring interfaces

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## 10. Configuration Architecture

### 10.1 Configuration Hierarchy

```
Base Config (YAML)
  v
Variant Selection (conservative/balanced/aggressive)
  v
Environment Overrides (environment variables)
  v
Runtime Overrides (CLI arguments)
  v
Final Configuration (validated, applied)
```

### 10.2 Configuration Sources

**Configuration sources:** - **YAML files** – CONFIG/model\_config/\*.yaml - **Environment variables** – Runtime overrides - **CLI arguments** – Command-line overrides - **Code defaults** – Fallback defaults

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## 11. Monitoring and Observability

### 11.1 Logging

**Logging components:** - **Structured logging** – JSON-structured logs - **Log levels** – DEBUG, INFO, WARNING, ERROR - **Contextual information** – Run IDs, symbols, fold numbers - **Client-managed** – Logs stored and managed by client

## 11.2 Metrics

**Metrics tracked:** - **Performance metrics** – Training time, inference latency - **Model metrics** – Accuracy, loss, validation scores - **Pipeline metrics** – Data processing throughput - **Client-managed** – Metrics collected and stored by client

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## 12. Contact

**For architecture questions or integration planning:**

**Jennifer Lewis**

Fox ML Infrastructure LLC

Email: [jenn.lewis5789@gmail.com](mailto:jenn.lewis5789@gmail.com)

Subject: *Architecture Inquiry – Fox ML Infrastructure*

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## 13. Related Documents

- docs/00\_executive/ARCHITECTURE\_OVERVIEW.md – Detailed architecture overview
  - docs/03\_technical/design/ARCHITECTURE\_DEEP\_DIVE.md – Deep technical dive
  - LEGAL/ENTERPRISE\_DELIVERY.md – Repository structure and delivery model
  - LEGAL/CLIENT\_ONBOARDING.md – Client onboarding and integration guide
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## 14. Summary

**Key Architectural Principles:**

1. **Client-hosted** – Software runs entirely on client infrastructure
2. **Modular** – Clear separation of concerns across modules
3. **Configuration-driven** – All runtime parameters from configs
4. **Pipeline-based** – Data flows through well-defined stages
5. **Extensible** – Easy to add new models, features, strategies
6. **Scalable** – Horizontal and vertical scalability
7. **Secure** – Security boundaries and controls clearly defined

This architecture provides a comprehensive foundation for ML research and quantitative workflows.