

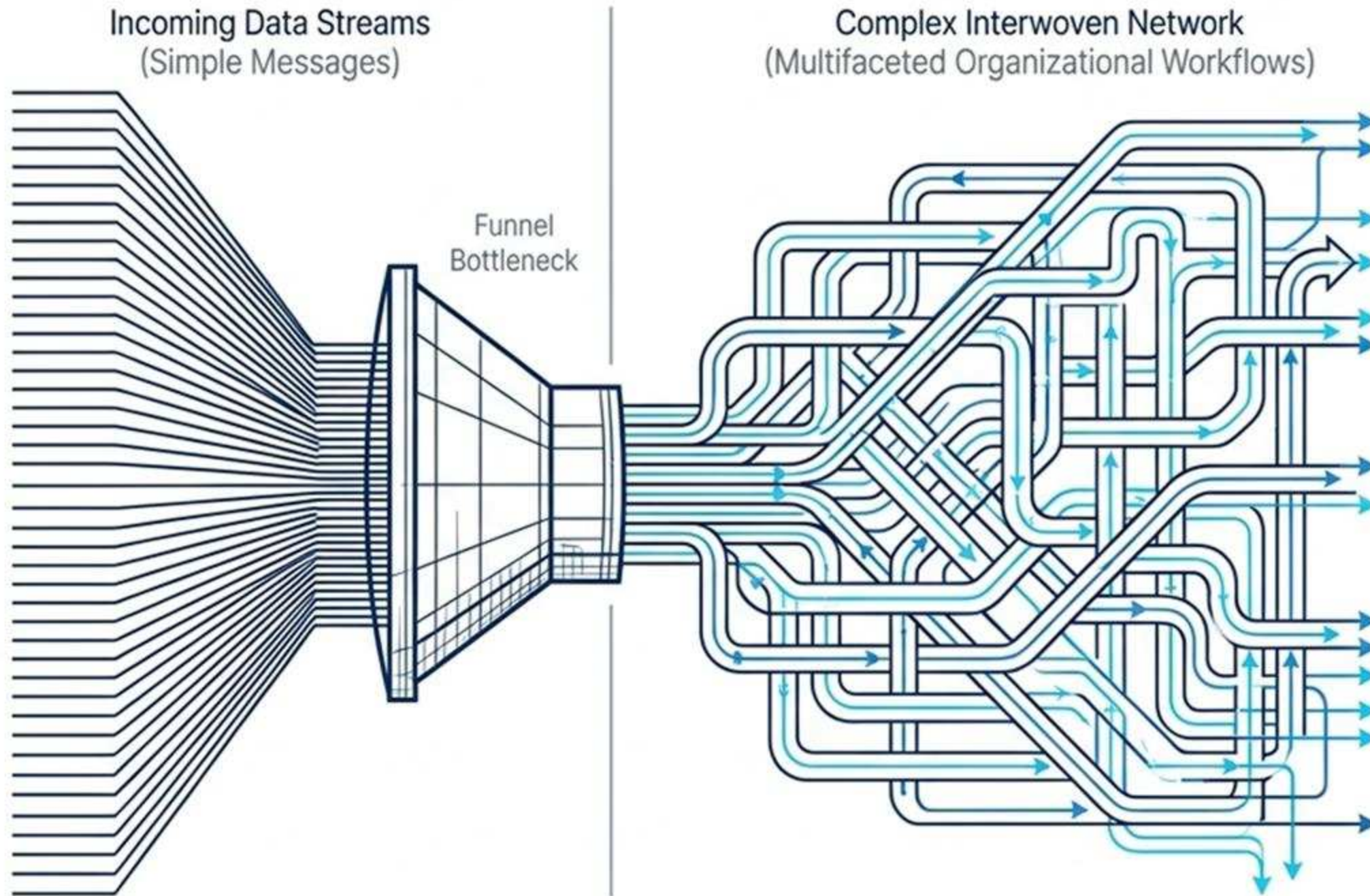
Enhancing Email Management through Machine Learning: A Multi- Label and Priority Approach

Submitted in fulfillment of the requirements for the degree
Master of Science in Artificial Intelligence

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Overview



In today's digital enterprise, the challenge of communication management has fundamentally shifted. The issue is no longer merely removing malicious or unsolicited spam. Instead, organizations face a crisis of complex workflow routing. Modern digital correspondence contains intertwined genres, varying urgencies, and multifaceted requests embedded within a single thread. Classical methods relying on manual effort or simplistic rule-based algorithms are mathematically incapable of scaling to this linguistic complexity.

Definitions

Technical Abbreviations

ANN: Artificial Neural Network

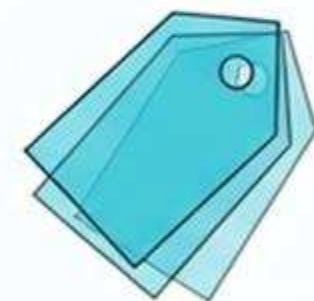
Acc: Accuracy

ANOVA: Analysis of Variance

ROC: Receiver Operating Characteristic

TF-IDF: Term Frequency-Inverse Document Frequency

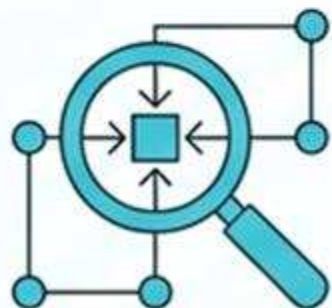
Core Thesis Concepts



Multi-Label Classification: Assigning multiple tags (e.g., Invoice + Urgent) to a single email simultaneously.



Priority Inference: Algorithmic determination of an email's urgency based on intent and content.



Explainable AI (XAI): Techniques ensuring model decisions are transparent and interpretable to human operators.

The Multifaceted Nature of Professional Emails



Core Insight: Professional communications rarely fit a single category. Effective automation demands a transition from single-intent categorization to simultaneous Multi-Label Classification paired with Urgency Assessment.

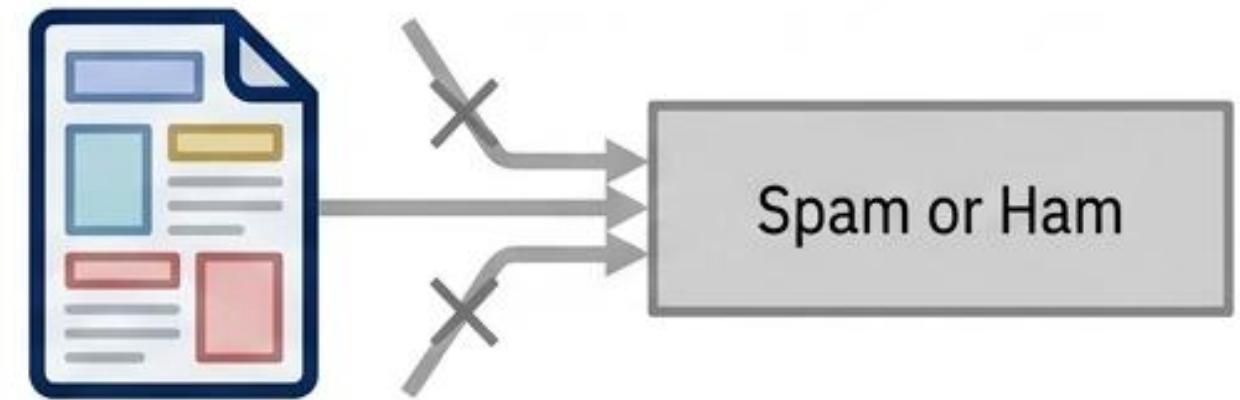
The Multi-Label Problem Definition

Professional communications inherently contain overlapping intents. A single email might simultaneously contain a financial invoice, a technical troubleshooting request, and an urgent deadline.

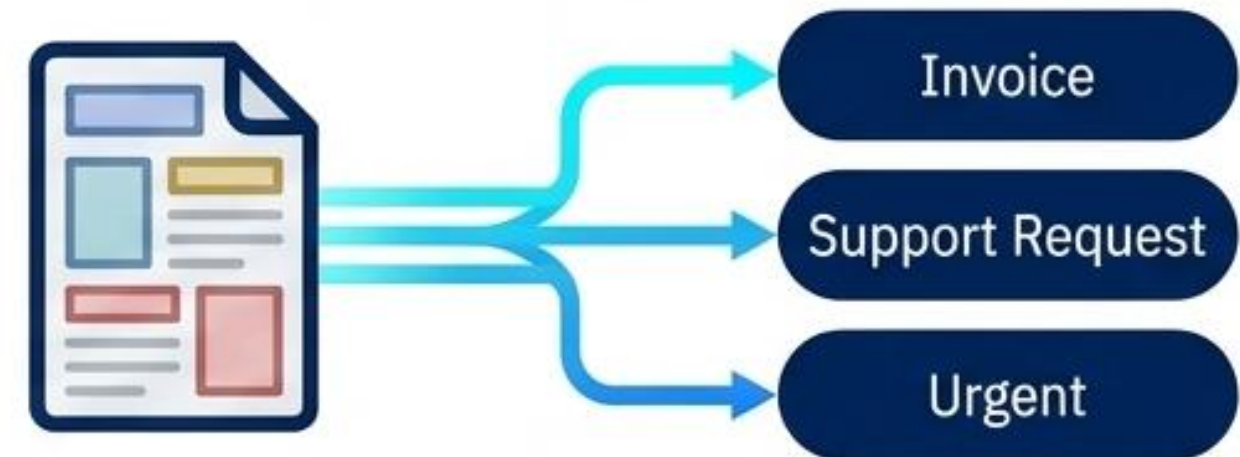
Current enterprise spam filters fail because they view data in a binary (Spam/Ham) or mutually exclusive single-label construct.

The multi-label approach bridges this specific research gap by mapping a single body of text to multiple functional categories, mimicking human comprehension and enabling accurate, multifaceted organizational routing.

Current State (Binary / Single-Label)



Proposed State (Multi-Label)



Multi-Label Classification: A predictive modeling task where a given sample of data is assigned multiple target labels concurrently, unlike multi-class classification where only one exclusive label is assigned.

Thesis Objectives



Goal 1: Algorithmic Evaluation

Systematically assess and benchmark various machine learning algorithms currently utilized in single-label email categorization and prioritization.

Goal 2: Multi-Label Architecture

Design and train a robust classification system capable of isolating and identifying multiple distinct intents from a single email message simultaneously.

Goal 3: Priority Inference

Develop a dynamic priority ranking algorithm that weights urgency based on the combined classified intents, ensuring immediate attention for critical communications.

Key Contributions

Unified Architecture (Theoretical)

Synchronizing multi-intent detection with urgency ranking into a single framework, solving the literature gap where classification and prioritization are treated as isolated, disconnected tasks.

Contextual Superiority (Empirical)

Overcoming the severe limitations of linguistic diversity. By leveraging deep contextual embeddings, the model surpasses the rigidity of keyword-based filters to understand complex professional nuance.

Methodological Efficiency (Methodological)

Guaranteeing interpretability in data-constrained environments. Advanced modeling ensures high performance even with minimal labeled datasets without becoming a 'black box'.

Functional Proof-of-Concept (Practical)

Delivering a tangible prototype that validates the mathematical models, proving real-world applicability for streamlining high-volume email workflows in industrial settings.

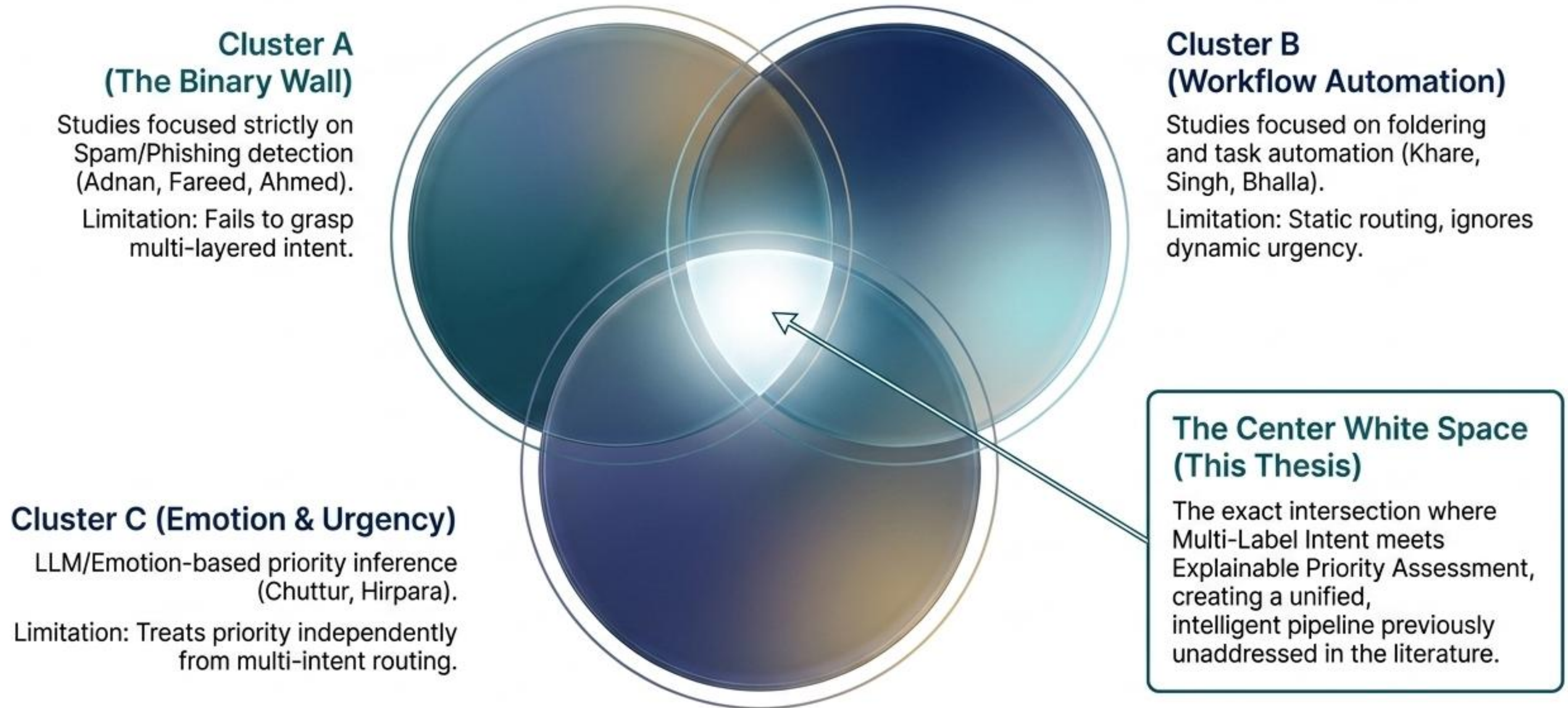
Literature Review Matrix (2025–2023)

Author/Year	Paper Title	Description	Dataset	Methodology	Results	Advantages	Disadvantages
Fareed et al. (2025)	ML-Based Email Spam Detection...	Analyzing model robustness to analytonize...	Public Ham/Spam	19 Classifiers + Robustness	Random Forest most stable	Extensive comparison	Focuses mostly on classic ML
Hirpara & Polara (2025)	InboxG...	AI system for manufacturing to detect urgency	Elecon Data	Gemma 1.1 + Decision Tree	Accurate urgency & replies	Modern LLMs	Requires high hardware specs
Duong et al. (2025)	AEEM...	System for academic emails	University Data (Vietnam)	DL + Text Summarization	93% accuracy	Combines sum & class	Localized dataset
Wang et al. (2024)	Deep active learning...	Deep AL for multi-label	Reuters, AAPD	Bayesian DL + BEAL	Reduced labeled data by 30%	Lowers manual labeling	High computational complexity
Jane et al. (2024)	Model architecture...	NER in multi-class documents	Financial/Compla ints	Transformer + Knowledge Distillation	94% multi-label accuracy	Improves NER mapping	Lacks priority-based label selection
Adnan et al. (2023)	Improving spam email...	Stacking approach	Aggregated Spam	Stacking Ensemble	98.8% accuracy	Reduces overfitting	Higher resource consumption
Singh et al. (2023)	EmFore...	Learning folder rules	Microsoft Internal	Online Learning + Rule-based	Continuous improvement	Adapts dynamically	Requires constant data stream

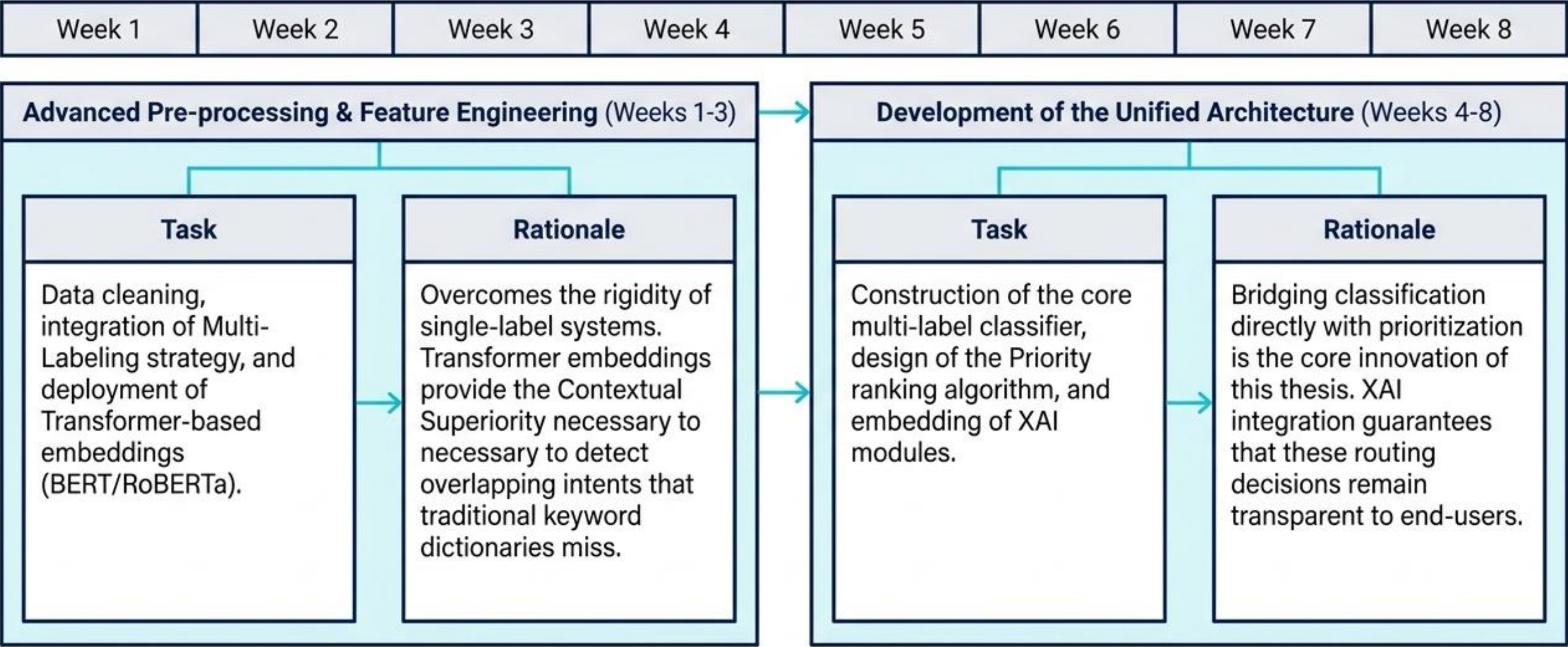
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Author/Year	Paper Title	Description	Dataset	Methodology	Results	Advantages	Disadvantages
Khare et al. (2022)	E-Mail Assistant...	Automating handling	Experimental	RPA (UiPath) + AI	Reduced human effort	Practical integration	Dependent on commercial tools
Ahmed et al. (2022)	ML Techniques...	Challenges in IoT	Analytical Review	ML Comparison	Identified gaps in IoT	Links email to IoT	Broad scope; lacks depth
Chuttur et al. (2022)	A Comparison...	Prioritizing by emotion	Customer Service	Emotion Analysis + ML	Random Forest best (84%)	Integrates emotion	Limited scope
Jáñez-Martino et al. (2022)	A review of spam...	Dataset Shift problem	SLR	SLR Methodology	Dataset Shift is main challenge	In-depth adversarial analysis	Theoretical only
Kaddoura et al. (2022)	A systematic literature...	Spam in social/email	Multi-platform	SLR	Email most targeted	Cross-platform comparison	Reduces specific technical depth
Salloum et al. (2022)	A Systematic Literature...	Phishing via NLP	SLR	SLR + NLP	DL outperforming traditional ML	High comprehensiveness	Misses latest Transformers
Bhalla et al. (2021)	Automatic Genre...	Classifying by genre	Enron	TF-IDF + SVM	Accuracy >90%	Simplicity & speed	Heavy reliance on keywords
Ali et al. (2021)	Feature Extraction...	Imperative sentences	Enron	DL + Imperative	Improved intent tracking	Focus on action	May misclassify informal emails

The Research Gap: Finding the White Space



Next Term Roadmap: System Design & Intelligence

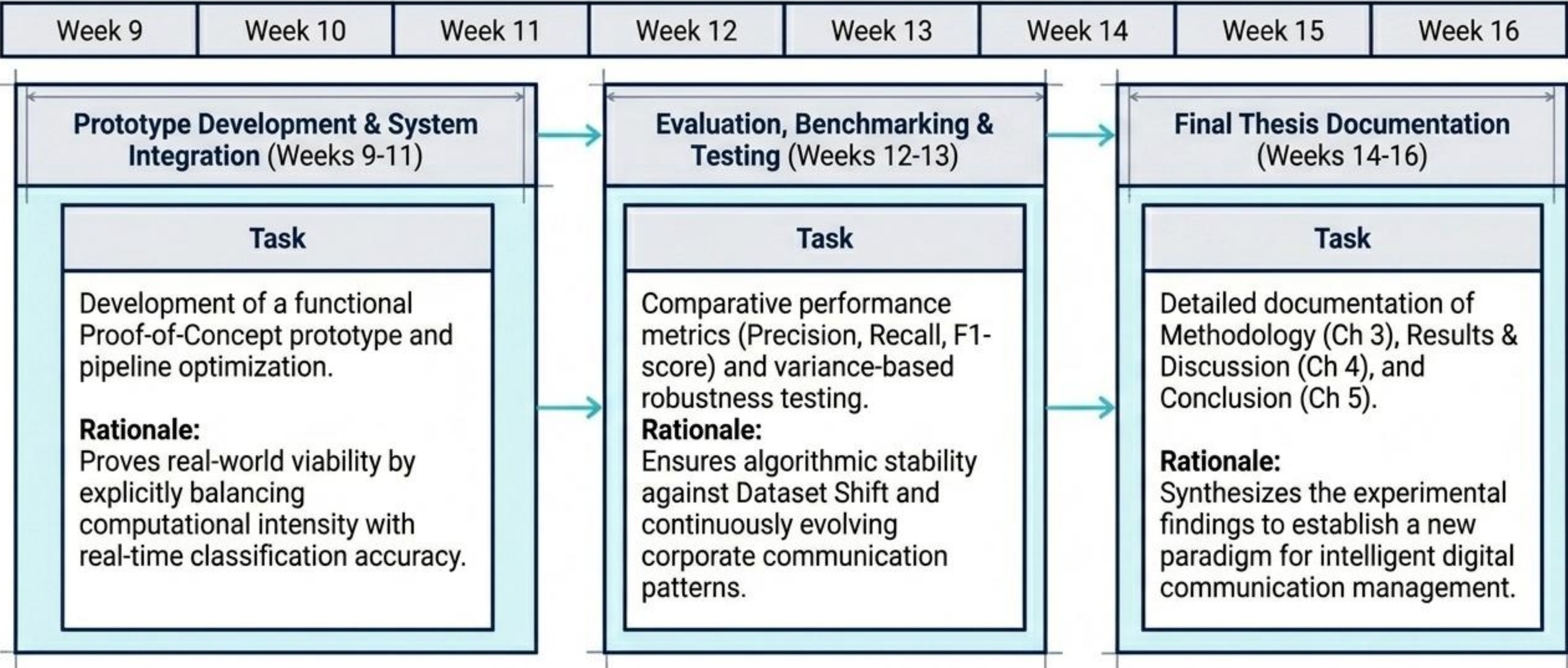


Contextual Superiority: The ability of an advanced language model to understand the nuance and multiple meanings of words based on their surrounding sentence structure, beyond simple keyword matching.

XAI (Explainable AI): Artificial intelligence algorithms and techniques that produce results that can be understood and trusted by human users, contrasting with 'black box' models.

NotebookLM

Next Term Roadmap: Validation & Finalization



Dataset Shift: A phenomenon where the distribution of data in a production environment changes significantly compared to the data used to train the machine learning model, potentially leading to performance degradation.

Ethical & Privacy Considerations

Confidentiality Firmness

Techniques focus purely on extracting linguistic patterns. Organizational data privacy rules are respected at all stages, ensuring algorithms learn structures, not secrets.

Data Source

Utilizing the Enron Email Corpus—an already public, anonymized, and standardized dataset.

Identity Protection

Strict stripping of names and unique markers; zero individual identities surface during processing.

Conclusion & Summary

The Vision

Transforming email from a chronological burden into an intelligently prioritized, multi-faceted workflow asset.

The Method

Overcoming keyword-based limitations by leveraging advanced Machine Learning, contextual embeddings, and Explainable AI.

The Value

Delivering a unified, functional system that outsmarts traditional filters, respects organizational privacy, and adapts to the complex reality of professional communication.

Q&A / Thank You

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