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Heales Medical

Industry Track
Paper Number: 349-IND

OccuTriage: An AI Agent Orchestration Framework for Occupational Health Triage Prediction

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Problem Statement

Critical Challenges in Occupational Health Triage

- **Manual Process Limitations**
  - High variability in clinical decision-making (practitioners prefer judgment over algorithms)
  - Inconsistent triage outcomes, especially in borderline cases
  - Resource allocation inefficiencies
- **Existing AI System Gaps**
  - Single-agent LLMs show variable accuracy (67.6% in complex cases)
  - Most systems target emergency medicine, not occupational health
  - Limited integration of domain-specific knowledge
- **Safety-Critical Requirements**
  - Under-triage leads to inadequate care (safety risk)
  - Over-triage causes resource waste (efficiency loss)

Research Contributions

Novel AI Agent Orchestration Framework – Occupational Health

Key Innovations:

- **Multi-Agent System** with specialised clinical expertise simulation
- Retrieval Augmentation with **occupational health knowledge bases**
- **Bidirectional Decision Architecture** for comprehensive triage coverage
- Safety-Prioritised Protocols with conservative default mechanisms

Impact:

- 53% reduction in discordance rate vs. baseline (20.16% vs 43.05%)
- 20% improvement over human expert performance (25.11%)
- 66% reduction in critical under-triage rates for assessor decisions

Dataset & Problem Formulation

Real-World Clinical Data

<u>Dataset Characteristics:</u>

- 2,589 occupational health cases from Heales Medical
- 12 medical categories (Mental Health 34.1%, Musculoskeletal 29.6%)
- Referral forms + attachments (medical records, job descriptions)

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System Architecture Overview

Multi-Stage Processing Pipeline

Stage 1: Document Processing

- LLM-based anonymization (M'_i)
- Medical entity extraction
- PDF content processing (Llama 3.2 13B Vision)

Stage 2: Knowledge Augmentation

- External knowledge integration (NCI Thesaurus + O*NET)
- Dragon dual-encoder semantic retrieval
- Comprehensive summarization

Stage 3: Multi-Agent Orchestration

- Dual-crew specialized agent system
- Iterative consensus building (5 rounds)
- Safety-prioritized decision protocols

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AI Agent Orchestration Framework

Dual-Crew Architecture

Crew 1: Appointment Type Decisions ($C^1{}_m$)

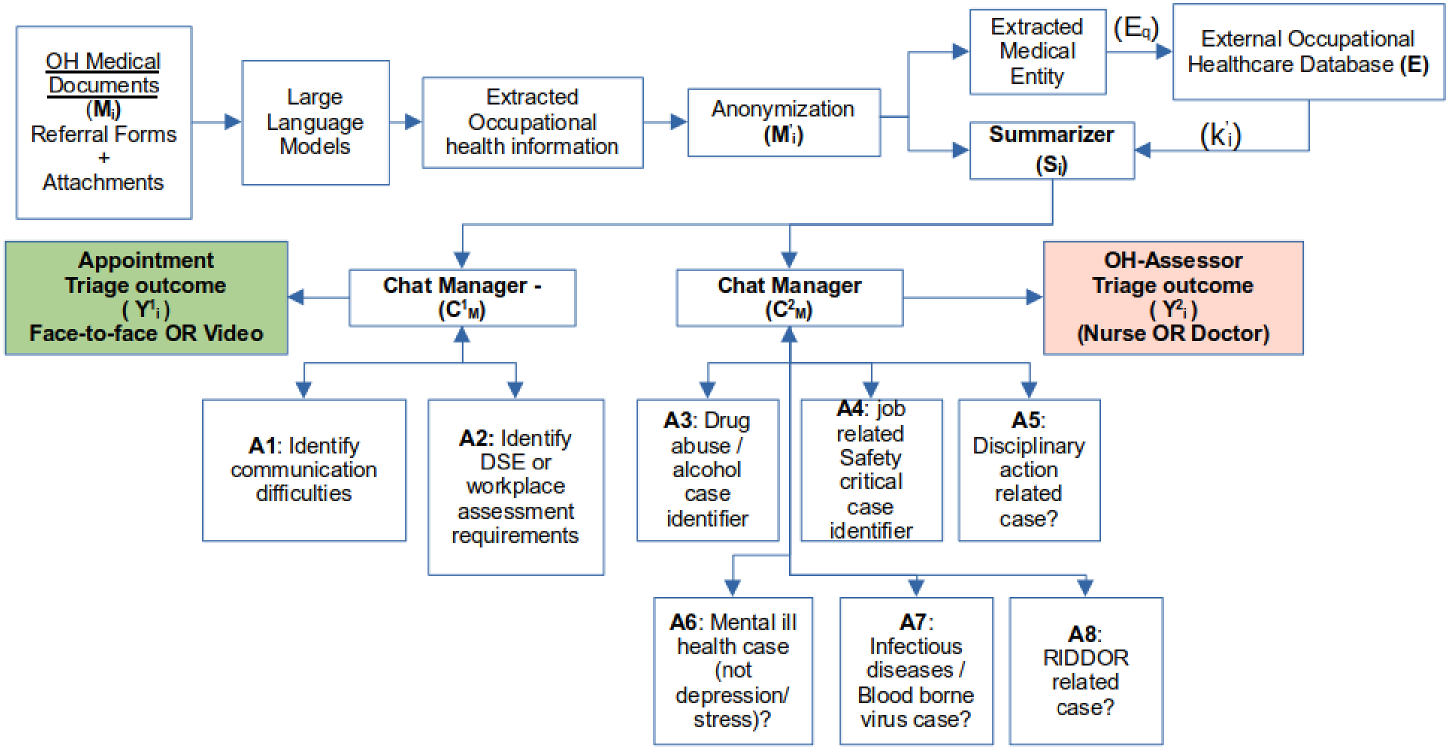
- A1: Communication difficulties assessment
- A2: Workplace assessment requirements

Crew 2: Assessor Type Decisions ($C^2{}_m$)

- A3: Substance abuse identifier
- A4: Job-related safety concerns
- A5: Disciplinary action issues
- A6: Mental health conditions
- A7: Infectious diseases
- A8: RIDDOR-related cases

Decision Protocol:

- Parallel processing → Iterative discussion → Majority voting → Safety override



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Technical Implementation

Technology Stack & Configuration

Core Models:

- Llama 3.1 8B, Llama 3.2 13B Vision
- Asclepius-Llama3-8B (domain-specific)
- Dragon dual-encoder (retrieval)

Infrastructure:

- 4x Nvidia H100 GPUs, Text Generation Inference
- Microsoft AutoGen framework
- Temperature: 0.7, Top_p: 0.95

Safety-Prioritized Rules:

- Face-to-face default: Any Crew 1 agent recommends in-person
- Physician default: Any Crew 2 agent suggests doctor consultation
- Early stopping: After 3 consistent decisions

Experimental Results

Configuration	Appointment Type	Assessor Type	Average
Single-agent Baseline	47.00%	39.1%	43.05%
+ RAG	37.50%	32.5%	35.00%
+ Chain of Thought	35.00%	30.5%	32.75%
OccuTriage	22.32%	18.0%	20.16%
Human Expert	26.22%	24.0%	25.11%

Key Findings:

- 53% reduction vs. baseline discordance
- Outperforms human experts by 20%
- Consistent improvement across both triage dimensions

Safety Analysis - Under-triage Reduction

Critical Safety Metric Improvements
Under-triage Rates (Safety-Critical):

Method	Appointment Type	Assessor Type
Baseline	19.82%	6.8%
Human Expert	11.84%	9.0%
OccuTriage	**9.84%**	**3.1%**

Safety Impact:
- 17% reduction in appointment under-triage vs. humans
- 66% reduction in assessor under-triage vs. humans
- Conservative bias ensures high-risk cases receive appropriate care

Processing Efficiency:
- ~12 seconds per case (suitable for non-emergency triage)
- Early stopping optimizes computational resources

Error Analysis & System Insights

Understanding Remaining Discordance

Residual 20.16% Error Analysis:

- Complex multi-comorbidity scenarios (traditional clinical judgment varies)
- Rare medical conditions with non-standard terminology
- Edge cases requiring knowledge base expansion

Model-Specific Findings:

- Asclepius: Superior clinical accuracy, requires sentiment analysis overhead
- Llama: Direct structured output, slightly lower domain performance
- RAG Impact: 4.93% improvement with domain-specific models

Multi-Agent Effectiveness:

- Crew 2 (6 agents) achieves 18.0% vs. 24.0% human performance
- Iterative consensus resolves borderline cases effectively
- Simple cases match human performance, complex cases show improvement

Clinical Impact & Integration

Real-World Deployment Readiness

Clinical Workflow Integration:

- JSON-formatted outputs compatible with EHR systems
- Complete audit trails for clinical governance
- Professional override capabilities preserved

Quality Assurance:

- Comprehensive reasoning chains for practitioner review
- Structured decision protocols for regulatory compliance
- Safety-prioritized design aligns with clinical practices

Scalability Considerations:

- Handles typical occupational health referral volumes
- Parallel processing architecture supports concurrent evaluation
- Knowledge base expandable for emerging medical knowledge

Conclusions & Future Work

Advancing AI-Assisted Healthcare Triage

Key Achievements:

- First specialized AI framework for occupational health triage
- Demonstrated superiority over single-agent approaches and human experts
- Safety-critical under-triage reduction (66% for assessor decisions)
- Real-world validation on 2,589 clinical cases

Clinical Significance:

- Bridges clinical judgment and algorithmic consistency
- Optimizes resource allocation while maintaining safety
- Provides structured decision support for healthcare professionals

Future Directions:

- Knowledge base expansion for rare conditions
- Integration with additional healthcare specialties
- Longitudinal outcome studies for long-term validation
- Advanced consensus mechanisms for complex edge cases

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