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Performance Assessment Methodology and End-to-End Framework for Tactical Combat Casualty Care Autonomous Documentation Algorithms

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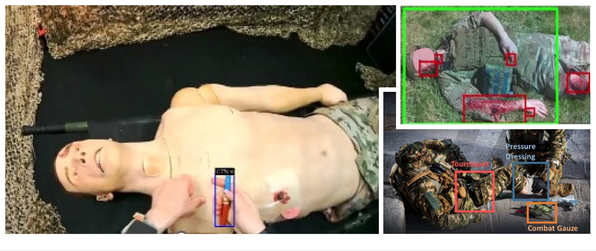
Background

- Tactical Combat Casualty Care (TCCC) requires rapid, high-intensity medical interventions where documentation is often delayed or incomplete [1]
- Human Machine Teaming (HMT) with autonomous documentation improves continuity of care and operational efficiency [2]
- Conventional artificial intelligence (AI) evaluation methods do not capture the workflow-dependent nature of TCCC care



Objective

- Develop a standardized evaluation framework for autonomous TCCC documentation algorithms in realistic field care workflows
- Assess integrated system-level algorithm performance under edge-device resource constraints
- Identify strengths, limitations, and areas requiring model refinement to support iterative performance improvement

Approach

- Evaluated three detection tasks: treatment procedures, medical objects, and injury locations
- Assessed representative algorithms within an orchestration framework for edge-device deployment using detection metrics and latency analysis
- Evaluated system-level computational efficiency using CPU, GPU, memory utilization, and throughput metrics

References:

[1] Joint Trauma System (JTS), Committee on Tactical Combat Casualty Care (CoTCCC). "Tactical Combat Casualty Care (TCCC) Guidelines for All Service Members" 2024.

[2] U.S. Army Futures Command (2022) Army Futures Command Concept for Medical 2028, AFC Pamphlet 71-20-12. U.S. Army Medical Center of Excellence.

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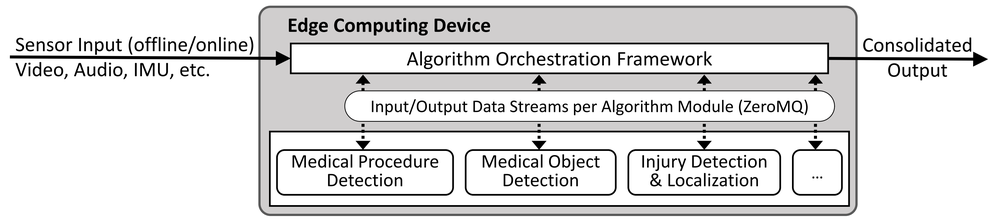
Methods

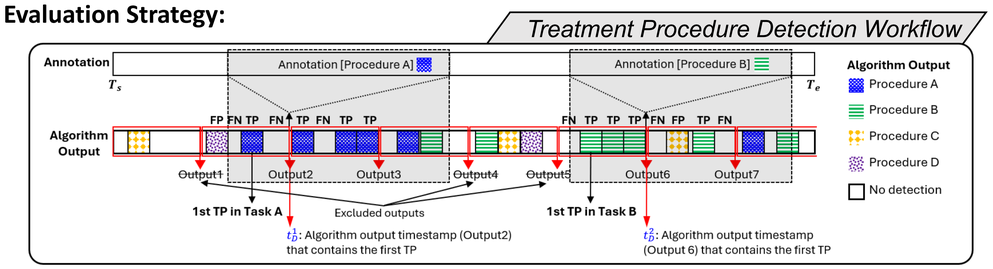
Algorithm Orchestration Process:

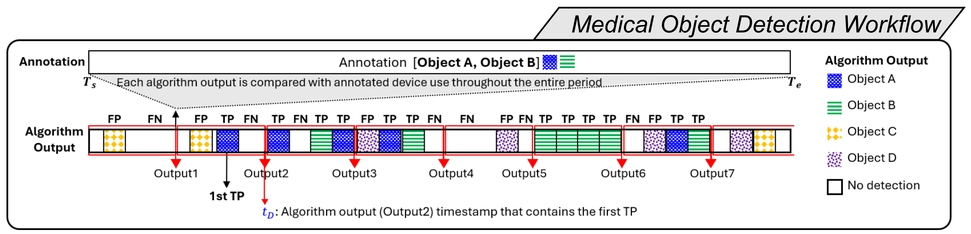


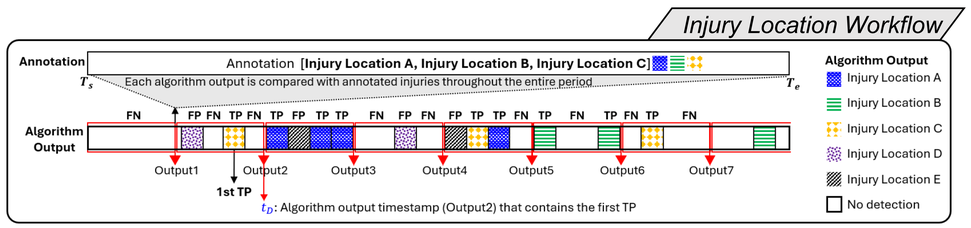
Ground-Truth Annotations:

- Expert combat medics generated event-level TCCC annotations
- Procedure intervals and anatomical regions without frame-level or bounding-box labels

Evaluation Strategy:







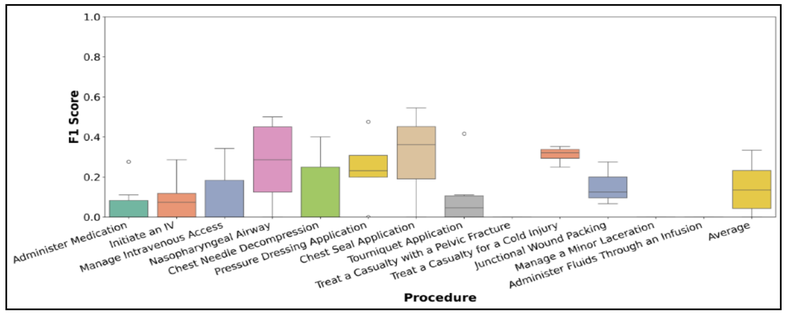
Evaluation Metrics:

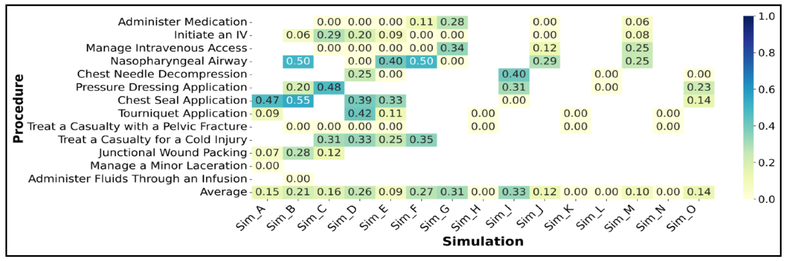
Detection Effectiveness		Processing Efficiency
Modified accuracy (No TN)	Recall	Lag-time analysis
Precision	F1-score	

Computational Efficiency
CPU/GPU utilization
Memory usage
Throughput

Results

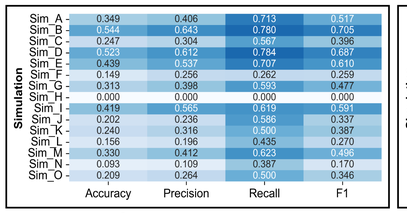
Treatment Procedure Detection:



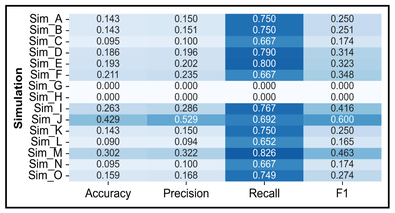


- Treatment detection varied across procedures and simulations

Medical object detection & injury location:



Object Detection



Injury Location

- Object detection: higher recall and F1 with variability
- Injury location: recall consistently exceeded precision

Conclusion

- Enabled standardized, workflow-aware evaluation of autonomous TCCC documentation algorithms
- Provided a repeatable framework for objective assessment across diverse TCCC documentation tasks
- Identified algorithm limitations and priorities for future refinement

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