A Perspective on Clinical Deployment of AI-GMA: From Quality-Gated Video Acquisition to Robust Decision Support

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Abstract

GMA is a powerful tool for early cerebral palsy screening, but clinically useful AI-GMA systems must jointly address quality-gated acquisition, robust temporal representation, calibrated risk output, and workflow integration.

- Early identification improves developmental outcomes.
- Quality is the upstream enabler, not the result of fate.
- GMA reduces content bias in the risk.
- Prior AI-GMA work often emphasizes isolated model metrics.
- The goal is trustworthy clinical decision support.

Conventional vs. AI-GMA vs. Deployment-Centered AI-GMA

	Conventional (Heuristic / Rule-based)	Clinical / Workflow Deployment Focus	Deployment-Centered AI-GMA
Input Assumption	Standardiced clinical devices	Heterogeneous clinic/home videos with acquisition variability	Heterogeneous cline f hem with quality gating
Primary Target	Risk or AUC on curated sets	PGC / AUC on variablity, wor/low foasbiity, integration, clinicion trust	PGC/AUC on workflow ferrbity,integration
Output	Predicted label	Risk score, confidence, uncertainty, escalation path	PGC / AUC on veracity, workflow fidelity, integration, clinician trust
Compute & Privacy	BSN/Transfomer (black-bot)	3D or privacy-preserving scalable compute requirements	30 or privacy-preserving, scalable compute requirements
Follure Handling	Continue inference by defaut	Hold/flag low-quality and edge-case videos	Hold/flag low-quelty, exploin. escalate, and route to suggort team

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A call to action for the computer vision community:
build infant-adapted models, robust datasets, and privacy-preserving pipelines for trustworthy clinical decision support.

Deployment-Centered AI-GMA Pipeline

1 Data Acquisition & Validation
- Standardized protocol
- Quality-gated recording
- Anonymization

2 Infant Pose Modeling
- Multi-view 3D pose
- 20 keypoints
- Confidence scoring

3 Motion Feature Extraction
- Kinematic statistics
- Frequency features
- Spatiotemporal patterns
- Descriptors

4 Temporal Encoder & Classification
- SVM/STT
- Deep Models (3D CNN / Transformer)|
- Risk calibration

5 Clinical Output
- Normal / Abnormal / TBD
- High-risk probabiaty
- Key driving signals
- Recommendation /action

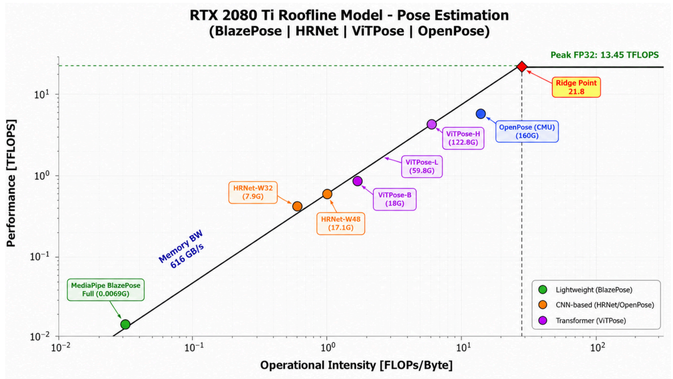
Quality-Gated Video Acquisition & QC Framework

Acquisition Protocol
- Infant awake, supine
- 3-5 min recording
- 20-24 views
- ≥ 21 FPS upgrade

Automated Quality QC
- Coverage (Score < Th)
- Duration (≥180s)
- Human Occlusion (≤ 20%)
- Keypoint Stability (< Th)
- Motion Clarity (≥2 rad/s)
- Blur / Exposure (Exclude / Correct Scoring)

Decision Outcome
- Psss
- REPROCESS
- ESCALATE

Results



Beyond AUC
- Balanced Accuracy
- Sensitivity / Specificity
- Calibration
- Rejection Behavior
- Throughput
- Cross-site Robustness

Lightweight or compute-adapted pose models achieve favorable accuracy-compute trade-offs, enabling edge deployment. Evaluation should go beyond AUC to ensure clinical reliability.

Discussion

- Quality gating before inference is essential for reliability and safety.
- Privacy-preserving compact representations enable safe cross-site collaboration.
- Risk-stratified outputs with calibration and rejection handling support clinicians.
- Seamless integration with pediatric workflows is key for adoption.

Privacy-Preserving Deployment Architecture

Raw Video (Per site) · On-Device Inference · Compact Representation (Per site) · Secure Transmission · Cloud AI / AUC Analytics · Calibrated Risk Output & Guidance

Cross-Institutional Collaboration Options

Federated Learning · Differential Privacy · Homomorphic Encryption · Trusted Execution Environment(TEE) · Audit& Accountability (Logs)

Conclusions

- Deployment is the core scientific challenge, not an afterthought.
- Quality gating and QC drive a more reliable and clinically actionable AI-GMA.
- Privacy-preserving collaboration enables broader clinical adoption.
- The goal is trustworthy clinical support systems for early CP screening.

References

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