OSAC RESEARCH NEEDS ASSESSMENT FORM

Title of research need:	Advancing Forensic Anthropology Through Machine Learning and Artificial Intelligence: Identifying Research Needs for Trauma Analysis
Describe the need:	Machine learning (ML) and artificial intelligence (AI) methods have the potential to advance trauma analysis in forensic anthropology. These methods are well-suited to identify patterning to classify trauma mechanisms and timing with higher accuracy and greater speed than traditional anthroposcopic approaches. ML/AI also has the potential to standardize trauma assessment and reduce subjectivity, while constructing comprehensive predictive models. These tools will help forensic anthropologists distinguish between trauma mechanisms and injury timing and provide crucial insights for automated collection, analysis, and interpretation of trauma data. ML/AI models in trauma analysis would also necessitate bias mitigation in these models (e.g., sex and population-specific criteria without doubling down on or reinforcing historical biases). Research into these models may consider ethical and legal considerations, sampling strategies for data hungry ML/AI methods, 3D reconstructions and visualizations, and training. The power of ML/AI for unsupervised learning without predefined categories (e.g., fracture propagation without *a priori* known mechanism) is also important to explore.
Keyword(s):	Machine Learning, Artificial Intelligence, Evidentiary Basis for Trauma Analysis; Bias Mitigation

Submitting subcommittee(s):	Anthropology	**Date Approved:**	9/19/2025

Background Information:

1. Does this research need address a gap(s) in a current or planned standard? (ex.: Field identification system for on scene opioid detection and confirmation)

AAFS Academy Standards Board Standard 147, *Standard for Skeletal Trauma Analysis in Forensic Anthropology,* provides to practitioners minimum requirements for describing, documenting, interpreting, and reporting skeletal trauma. It stresses the importance of basing trauma interpretations on empirical evidence. This is particularly important in at least three areas of trauma analysis: 1) using principles of bone fracture biomechanics to identify trauma mechanism; 2) using principles related to the anatomical basis for bone healing to assess the timing of antemortem trauma; and 3) evaluation of error, bias, and limitations associated with trauma interpretations. This includes both a quantitative and qualitative assessment of trauma methodology error, when possible. Current methods in skeletal trauma analysis are inadequate to meet these goals. ML and AI methods have only just begun to be used in skeletal trauma analysis—early applications (e.g., by Dempsey and Blau 2022) have identified challenges related to data sampling and overfitting, and have led to a recognized need for greater research in this area.

2. Are you aware of any ongoing research that may address this research need that has not yet been published (e.g., research presented in conference proceedings, studies that you or a colleague have participated in but have yet to be published)? ML and AI methodology has not routinely been used in skeletal trauma analysis and represents a fairly new application with much potential; however, current research by Isaac et al. (2024) and Brink and Messer (2025) addresses the use of Ml in improving the accuracy of Time-Since-Injury (TSI) estimates for antemortem fractures.

ISAAC, C. V., SONY, R., DEVOTA, C. J., VANBAARLE, A. L., ROSS, A. Deep Learning Models For Fracture Detection And Segmentation In Bone Histology. American Academy Of Forensic Sciences, 2024 Denver CO.

BRINK, F., MESSER, D. Using Machine Learning To Estimate Time-Since-Injury Of Healing Fractures. American Academy Of Forensic Sciences, 2025 Baltimore, MD (Pediatric Non-Accidental Injury Workshop #1).

3. Key bibliographic references relating to this research need: (ex.: Toll, L., Standifer, K. M., Massotte, D., eds. (2019). Current Topics in Opioid Research. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88963-180-3)

Dempsey, N., Bassed, R., Blau, S. 2021. Analyzing The Outcomes Of Skeletal Trauma Within A Forensic Population: Potential Issues And Implications In Inferential Modeling Of Blunt Force Trauma. Journal Of Forensic Sciences, 66, 1627-1636.

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Lekovic, A., Vukicevic, A., Nikolic, S. 2024. Assessing The Knot In A Noose Position By Thyrohyoid And Cervical Spine Fracture Patterns In Suicidal Hangings Using Machine Learning Algorithms: A New Insight Into Old Dilemmas. Forensic Science International, 357.

Atkinson K, Bench-Capon T, Bollegala D. Explanation In Ai And Law: Past, Present And Future. Artificial Intelligence 2020;289: 103387.

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Steiger, G. S., Borrini. M. 2024. A Proposal For Cut Marks Classification Using Machine Learning: Serrated Vs. Non-Serrated, Single Vs. Double-Beveled Knives. Journal Of Forensic Sciences.

Galante N, Cotroneo R, Furci D, Lodetti G, Casali Mb. Applications Of Artificial Intelligence In Forensic Sciences: Current Potential Benefits, Limitations And Perspectives. International Journal Of Legal Medicine 2023;137(2):445–458.

Jabbar H, Khan Rz. Methods To Avoid Over-Fitting And Under-Fitting In Supervised Machine Learning (Comparative Study). Computer Science, Communication And Instrumentation Devices 2015;70(10.3850):978–981.

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Machine Learning Models. Artificial Intelligence 2021;295:103458.

Spiros M, Nakhaeizadeh, S. We Think There's Been A Glitch: Artificial Intelligence And Machine Learning In Forensic Anthropology. Forensic Anthropology 2024; 7(2-3): 164-176.

4. Review the annual operational/research needs published by the National Institute of Justice (NIJ) at https://nij.ojp.gov/topics/articles/forensic-science-research-and-development-technology-working-group-operational#latest? Is your research need identified by NIJ?

Not directly. However, other forensic disciplines have identified similar operational requirements (c.f. **Fire Investigation**: Use of AI for identification of important information, hypothesis development and testing, bias mitigation, and repeatability for fire scene analysis of origin and cause determination.

5. In what ways would the research results improve current laboratory capabilities?

Current skeletal trauma casework is centered around the interpretation of bone fracture mechanism for acute ("perimortem") fractures and determination of timing of injury for antemortem fractures. Adjudication of non-accidental pediatric injury (NAI) cases, for example, is often dependent upon both. ML and AI modeling of bone fracture and repair would greatly enhance these interpretations, while reducing subjectivity, mitigating bias, and standardizing data collection and data analysis protocols.

6. In what ways would the research results improve understanding of the scientific basis for the subcommittee(s)?

Trauma analysis remains an inherently subjective component of forensic anthropological analysis, despite being the predominant aspect requiring expert witness testimony. Dempsey and Blau (2020), in their review of the past 30 years of Blunt Force Trauma research, note the absence of any current method to objectively quantify and accurately interpret fracture mechanism from bone fracture patterning. These authors note that while computer-based Finite Element models have produced intriguing results, they have not been complex enough to incorporate the myriad number of variables involved in bone fracture biomechanics. In addition, bone fracture modeling is non-linear and there is often a stochastic relationship between bone fracture mechanism and outcome (Dempsey and Blau 2022). These authors note that ML holds much promise for improving the evidentiary basis for skeletal trauma interpretations from bone fracture patterns by incorporating a more objective and nuanced approach to understanding bone trauma patterning. ML and AI studies have the potential to greatly improve our understanding of fracture mechanics and bone repair through large-scale data mining and data sharing.

7. In what ways would the research results improve services to the criminal justice system?

The criminal justice process is dependent upon accurate forensic science methodology and intepretations. ML and AI method applications in skeletal trauma analysis offer an opportunity to increase our confidence in the validity of these methods and interpetations.

8. Status assessment (I, II, III, or IV): II

	Major gap in current knowledge	Minor gap in current knowledge
No or limited current research is being conducted	I	III
Existing current research is being conducted	II	IV

This research need has been identified by one or more subcommittees of OSAC and is being provided as an informational resource to the community.