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Explainable AI Based Neck Direction Prediction and Analysis Using YOLOV8

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***Abstract*—**This research focuses on the detection and analysis of neck rotation during head impacts using the YOLOv8 model, with the goal of enhancing preventive healthcare measures. Accurately monitoring the neck's position and orientation is crucial for predicting its movement direction during such impacts. The study simulates mild head impacts by replicating neck movements like flexion and lateral rotation, inspired by scenarios commonly seen in American football. Data is collected from ten subjects—five male and five female. The YOLOv8 model is employed to detect and track neck rotation in real-time using video footage, offering high accuracy in determining directional movement

I. INTRODUCTION

The musculoskeletal system supports and enables body movement, with the head and neck muscles playing vital roles in motion, expression, and sensory functions. Musculoskeletal models, like those created using OpenSim, provide detailed insights into muscle and joint dynamics, aiding in the study of human motion, performance, and disorders. Kinematic data from IMUs and kinetic data related to muscle forces help in analyzing neck movement. This study applies machine learning and deep learning models to detect and predict neck positions under load impacts, aiming to prevent musculoskeletal disorders.

By integrating Explainable AI, the system offers interpretable results to support clinical decision- making. The proposed model demonstrates higher efficiency and accuracy, making it a valuable tool for musculoskeletal healthcare and personalized biomechanics.

II. EASE OF USE

The integration of YOLOv8 with Explainable AI (XAI) offers a user-friendly and efficient system for real- time neck direction prediction during head impacts. YOLOv8's fast and accurate object detection enables seamless video-based tracking of neck movements, while musculoskeletal healthcare.

III. EXISTING SYSTEM

- **XGB Classifier for Neck Direction Prediction:**

The XGBoost (Extreme Gradient Boosting) classifier is used to predict neck direction based on biomechanical data such as tendon and muscle forces. Known for its high accuracy (98%) and efficiency with structured data, XGBoost builds sequential decision trees to capture complex patterns. However, it operates offline, lacks real-time detection, and does not handle spatial or visual context— limiting its effectiveness for dynamic scenarios like continuous neck movement monitoring.

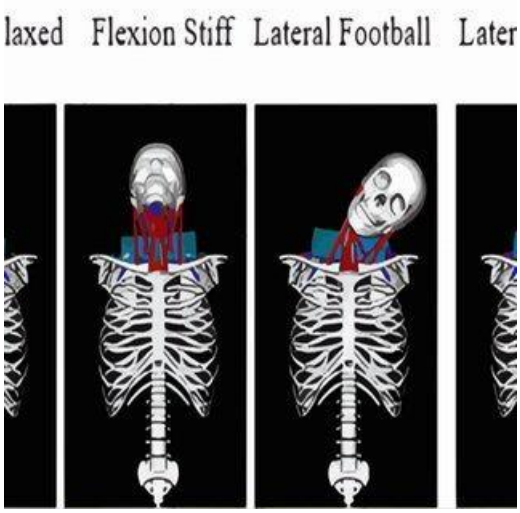
B. LIMITATIONS

- Longer training time compared to simpler models
- Risk of overfitting
- Low interpretability without additional tools
- High memory consumption on large datasets or limited hardware

IV. TECHNIQUES/ALGORITHMS USED

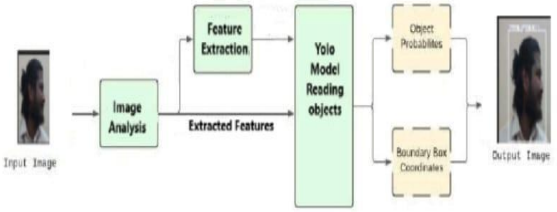
XGBoost for Neck Direction Prediction:

XGBoost is a gradient-boosted decision tree algorithm used to predict neck direction during head impacts based on structured data like impact forces, accelerations, and neck angles. Trained on labeled datasets, it captures complex patterns and delivers high accuracy while minimizing overfitting. However, the model lacks built-in explainability, making it difficult to interpret which features drive predictions—limiting its usefulness for safety analysis and design optimization.



A. *ADVANTAGES*

- High Accuracy
- Handles Complex Features
- Efficient Training
- Customizable



YOLOv8 for Neck Rotation Detection:

YOLOv8 is a real-time object detection model used to track neck rotation during head impacts. It processes annotated video frames by resizing and normalizing them, then uses a deep neural network to predict bounding boxes and class probabilities. The model divides each frame into grids, detects head and neck positions, and applies Non-Maximum Suppression (NMS) to refine results.

YOLOv8 enables accurate, continuous tracking of neck movements such as flexion and lateral shifts. Integrated with Explainable AI, it offers interpretable insights, supporting injury prevention and clinical decision-making in healthcare applications.

FUTURE ENHANCEMENTS

Future improvements include integrating YOLOv8 into real-time systems like wearables and motion capture for continuous neck rotation monitoring. Expanding datasets to cover diverse populations and scenarios will boost model robustness. Combining neck rotation data with other physiological metrics can offer deeper impact insights. Enhanced explainability will improve clinician trust. Deploying on cloud and edge devices will enable remote and real-time analysis. The system could also expand to applications like driver safety and workplace ergonomics, broadening its impact across healthcare, sports, and safety sectors.

V. CONCLUSION

The use of YOLOv8 for detecting neck rotation during head impacts highlights its potential as a powerful tool in preventive healthcare. This system provides accurate and efficient monitoring of neck movements, ensuring timely identification of risky positions during impacts. By incorporating Explainable AI, the approach ensures transparency and reliability, making it highly suitable for clinical decision-making. This innovative method not only advances the field of biomechanical analysis but also opens new avenues for real-time injury prevention and improved patient care.

VI. REFERENCES

[1] C. Kuo, J. Sheffels, M. Fanton, I. B. Yu, R. Hamalainen, and D. Camarillo, ‘‘Passive cervical
spine ligaments provide stability during head impacts,’’ J. Roy. Soc. Interface, vol. 16, no. 154,
May 2019, Art. no. 20190086.

[2] K. V. R. Kumar and S. Elias, ‘‘Predictive analysis for detection of human neck postures
using a robust integration of kinetics and kinematics,’’ Healthcare, vol. 9, no. 12, p. 1755, 2021,
Dec. 2019.

[3] X. Zhang, F. K. Chan, T. Parthasarathy, and M. Gazzola, ‘‘Modeling and simulation of
complex dynamic musculoskeletal architectures,’’ Nature Commun., vol. 10, no. 1, p. 1755, Oct.
2019.

[4] J. D. Mortensen, A. N. Vasavada, and A. S. Merryweather, ‘‘The inclusion of hyoid muscles
improve moment generating capacity and dynamic simulations in musculoskeletal models of the
head and neck,’’ PLoS ONE, vol. 13, no. 6, Jun. 2018, Art. no. e0199912.
[5] F. Li, N. Liu, H. Li, B. Zhang, S. Tian, M. Tan, and B. Sandoz, ‘‘A review of neck injury and
protection in vehicle accidents,’’ Transp. Saf. Environ., vol. 1, no. 2, pp. 89–105, 2019.
[6] P. Puchaud, C. Sauret, A. Muller, N. Bideau, G. Dumont, H. Pillet, and C. Pontonnier,
‘‘Accuracy and kinematics consistency of marker-based scaling approaches on a lower limb
model: A comparative study with imagery data,’’ Comput. Methods Biomech. Biomed. Eng.,
vol. 23, no. 3, pp. 114–125, Feb. 2020.
[7] G. Du, Y. Li, Q. Liu, and Z. Lian, ‘‘OpenSim-based neck musculoskeletal model and
analysis of isometric resistance motion,’’ in Proc. China Autom. Congr. (CAC), 2022, pp.
3465–3470.
[8] C. Pizzolato, M. Reggiani, L. Modenese, and D. G. Lloyd, ‘‘Real-time inverse kinematics
and inverse dynamics for lower limb applications using OpenSim,’’ Comput. Methods
Biomechanics Biomed. Eng., vol. 20, no. 4, pp. 436–445, Mar. 2017.
[9] I. Wechsler, A. Wolf, S. Fleischmann, J. Waibel, C. Molz, D. Scherb, J. Shanbhag, M. Franz,
S. Wartzack, and J. Miehling, ‘‘Method for using IMU-based experimental motion data in BVH
format for musculoskeletal simulations via OpenSim,’’ Sensors, vol. 23, no. 12, p. 5423, Jun.
2023.

[10] S. Paldauf, W. Potthast, and I. Kommik, ‘‘A methodological approach for simulating musculoskeletal loading in the head and neck region following boxing punches to the head,’’
ISBS Proc. Arch., vol. 40, no. 1, p. 535, 2022.
[11] F. Deng, J. Huang, X. Yuan, C. Cheng, and L. Zhang, ‘‘Performance and efficiency of
machine learning algorithms for analyzing rectangular biomedical data,’’ Lab. Invest., vol. 101,
no. 4, pp. 430–441, Apr. 2021.
[12] M. Leitheiser, D. Capper, P. Seegerer, A. Lehmann, U. Schüller, K. Müller, F. Klauschen,
P. Jurmeister, and M. Bockmayr, ‘‘Machine learning models predict the primary sites of head
and neck squamous cell carcinoma metastases based on DNA methylation,’’ J. Pathol., vol. 256,
no. 4, pp. 378–387, Apr. 2022.
[13] D. Jaiswal, J. Daftari, and S. Shridevi, ‘‘Explainable ai framework for multi-label
classification using supervised machine learning models,’’ in Proc. Workshop Adv. Comput.
Intell., Concepts Appl., 2022, pp. 10–22.
[14] B. X. W. Liew, F. M. Kovacs, D. Rügamer, and A. Royuela, ‘‘Machine learning versus
logistic regression for prognostic modelling in individuals with non-specific neck pain,’’ Eur.
Spine J., vol. 31, no. 8, pp. 2082–2091, 2022.
[15] Y. Smirnov, D. Smirnov, A. Popov, and S. Yakovenko, ‘‘Solving musculoskeletal
biomechanics with machine learning,’’ PeerJ Comput. Sci., vol. 7, p. e663, Aug. 2021.
[16] D. Jiménez-Grande, S. Farokh Atashzar, V. Devecchi, E. Martinez-Valdes, and D. Falla, ‘‘A machine learning approach for the identification of kinematic biomarkers of chronic neck
pain during single- and dual-task gait,’’ Gait Posture, vol. 96,
pp. 81–86, Jul. 2022.
[17] K. V. R. Kumar and S. Elias, ‘‘Real-time tracking of human neck postures and
movements,’’ Healthcare, vol. 9, no. 12, p. 1755, Dec. 2021.
[18] F. Paskali, J. Simantzik, A. Dieterich, and M. Kohl, ‘‘Specification of neck muscle
dysfunction through digital image analysis using machine learning,’’ Diagnostics, vol. 13, no. 1,
p. 7, Dec. 2022.
[19] Y. Jiang, A. Sadeqi, E. L. Miller, and S. Sonkusale, ‘‘Head motion classification using
thread-based sensor and machine learning algorithm,’’ Sci. Rep., vol. 11, no. 1, p. 2646, Jan.
2021.
[20] J. Sheffels and C. Kuo, ‘‘Simtk: Role of the neck during impact loading: Project home,’’ J.
Roy. Soc. Interface, 2019. [Online]. Available: https://simtk.org/projects/kuo-head-neck .

[21] T. K. Kim and J. H. Park, ‘‘More about the basic assumptions of ttest: Normality and
sample size,’’ Korean J. Anesthesiol., vol. 72, no. 4, pp. 331– 335, Aug. 2019.
[22] R. Mera and R H. W. Thompson, ‘‘A description of the appropriate use of student’s t-test,’’
Sci. Rep., vol. 1, no. 2, pp. 72–165, 1998.
[23] C. Ringwalt, M. J. Paschall, D. Gorman, J. Derzon, and A. Kinlaw, ‘‘The use of one-versus
two-tailed tests to evaluate prevention programs,’’ Eval. Health Professions, vol. 34, no. 2, pp.
135–150, Jun. 2011.
[24] M. Kumar, S. Ali Khan, A. Bhatia, V. Sharma, and P. Jain, ‘‘Machine learning algorithms:
A conceptual review,’’ in Proc. 1st Int. Conf. Intell. Comput. Res. Trends (ICRT), Roorkee,

India, Feb. 2023, pp. 1–7.
[25] J. G. Greener, S. M. Kandathil, L. Moffat, and D. T. Jones, ‘‘A guide to machine learning for biologists,’’ Nature Reviews Mol. Cell Biol., vol. 23, no. 1, pp. 40–55, 2022.
[26] Z.-H. Zhou, ‘‘Open-environment machine learning,’’ Nat. Sci. Rev., vol. 9, no. 8, Aug. 2022.
[27] R. Tr, U. K. Lilhore, S. Simaiya, A. Kaur, and M. Hamdi, ‘‘Predictive analysis of heart diseases with machine learning approaches,’’ Malaysian J. Comput. Sci., vol. 10, pp. 132–148, Mar. 2022.
[28] T. D’Angelo, D. Caudo, A. Blandino, M. H. Albrecht, T. J. Vogl, L. D. Gruenewald, M. Gaeta, I. Yel, V. Koch, S. S. Martin, and L. Lenga, ‘‘Artificial intelligence, machine learning and deep learning in musculoskeletal imaging: Current applications,’’ J. Clin. Ultrasound, vol. 50, no. 9, pp. 1414–1431, 2022.
[29] I. H. Sarker, ‘‘Machine learning: Algorithms, real-world applications and research directions,’’ Social Netw. Comput. Sci., vol. 2, no. 3, p. 160, May 2021.
[30] A. K. Paul, A. Prasad, and A. Kumar, ‘‘Review on artificial neural network and its application in the field of engineering,’’ J. Mech. Eng., Prakash, vol. 1, no. 1, pp. 53–61, 2022.