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EXPLAINABLE AI BASED NECK DIRECTION PREDICTION AND ANALYSIS USING YOLOV8

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ABSTRACT— The project focuses on detecting and analysing the neck rotation during head impacts using the YOLOv8 model, with the aim of providing preventive healthcare measures. The neck's position and orientation need to be monitored and measured to predict the direction of the neck during such impacts. This project involves simulating mild head impacts, replicating movements such as flexion and lateral rotation, based on American football scenarios, with data collected from ten subjects (five male and five female). The YOLOv8 model is employed to detect and track the neck's rotation in real-time from video footage, providing high accuracy in determining the direction of the neck during head impacts. By utilizing YOLOv8, This project aims to achieve a more efficient and precise system for detecting neck rotation compared to traditional methods. This approach, integrated with explainable AI, helps in offering meaningful interpretations of the results, which can support clinical systems in making informed decisions regarding head and neck injury prevention.

Index Terms – Neck rotation detection, YOLOv8, head impact analysis, explainable artificial intelligence (XAI), computer vision, object detection, real-time tracking, injury prevention, healthcare AI, motion analysis, sports injury monitoring, preventive healthcare.

I. INTRODUCTION

The musculoskeletal system enables movement and provides structure, style, and support for the human body. The muscles of the head and neck are responsible for the crucial functions, such as head and neck movement, chewing, swallowing, expressions on the face, and eye movement.

Musculoskeletal models are effective computational simulation tools that enable a physically precise analysis of human movement. They can provide meta data on joint contact forces, muscle forces, and musculotendon lengths. They help us to analyze athletic performance, study neuromuscular coordination, and calculate musculoskeletal loads. The models are used to estimate joint, muscle, and ligament forces that are difficult or impossible for experimental measurement. Open Sim is a free software developed at Stanford University that enables users to create dynamic simulations of musculoskeletal models for analysis and visualization. Open Sim is a scalable and dependable tool for analyzing human motion due to its integrated feature extraction capabilities and community contributions. Once a musculoskeletal model has been made, Open Sim helps to analyze at how muscle-tendon characteristics, joint kinematics, and musculoskeletal architecture affect the forces and the common movements. OpenSim tool offers additional data on muscle activation and facilitates modeling of kinetic and kinematic joint factors. Inertial measurement units (IMU) are used to collect kinematic data or information about the movement of body parts. In contrast, kinetic data provides information about the force exerted by the moving component and helps analyze muscle activation related to the moving joint. This study aims to deploy machine learning models for analyzing and identifying the different positions of the human neck to prevent and treat musculoskeletal disorders in the neck area. Machine learning (ML) is a type of artificial intelligence that is proficient of learning from data and making predictions or decisions.

II. RELATED WORK

A. Artificial Intelligence in Head and Neck Cancer: Innovations, Applications, and Future Directions

Artificial intelligence (AI) is revolutionizing head and neck cancer (HNC) care by providing innovative tools that enhance diagnostic accuracy and personalize treatment strategies. This review highlights the advancements in AI technologies, including deep learning and natural language processing, and their applications in HNC. The integration of AI with imaging techniques, genomics, and electronic health records is explored, emphasizing its role in early detection, biomarker discovery, and treatment planning. Despite noticeable progress, challenges such as data quality,

algorithmic bias, and the need for interdisciplinary collaboration remain.

B. *Analysis of artificial neural network: Architecture, types, and forecasting applications*

The artificial neural network reduces humanity and society's burden to solve complex problems highly efficiently. Artificial neural networks resemble brain activities based on the acquired training samples used for various applications such as classification, regression, prediction, smart grid, natural language processing, image processing, medical diagnosis, and so on. This paper illustrates the different artificial neural network architectures, types, merits, demerits, and applications. Therefore, this paper provides valuable information to students and researchers to enrich their knowledge about an artificial neural network and research it.

C. *Explainable artificial intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI*

In the last years, Artificial Intelligence (AI) has achieved a notable momentum that may deliver the best of expectations over many application sectors across the field. For this to occur, the entire community stands in front of the barrier of explainability, an inherent problem of AI techniques brought by sub-symbolism (e.g. ensembles or Deep Neural Networks) that were not present in the last hype of AI. Paradigms underlying this problem fall within the so-called eXplainable AI (XAI) field, which is acknowledged as a crucial feature for the practical deployment of AI models. This overview examines the existing literature in the field of XAI, including a prospect toward what is yet to be reached.

D. *Opportunities and challenges in explainable artificial intelligence (XAI): A survey*

Nowadays, deep neural networks are widely used in mission critical systems such as healthcare, self-driving vehicles, and military which have direct impact on human lives. However, the black-box nature of deep neural networks challenges its use in mission critical applications, raising ethical and judicial concerns inducing lack of trust. Explainable Artificial Intelligence (XAI) is a field of Artificial Intelligence (AI) that promotes a set of tools, techniques, and algorithms that can generate high-quality interpretable, intuitive, human understandable explanations of AI decisions. In addition to providing a holistic view of the current XAI landscape in

deep learning, this paper provides mathematical summaries of seminal work.

III. PROPOSED METHODOLOGY

YOLOv8 model for detecting and analyzing neck rotation during head impacts. In this system, the position and orientation of the neck are monitored in real-time using video footage captured during simulated head impacts. These impacts are designed to replicate flexion and lateral movements, similar to those encountered in American football scenarios. The YOLOv8 model, a state-of-the-art object detection model, is trained to detect and track the neck's position, identifying rotational movements with high accuracy. By processing video frames, YOLOv8 is able to recognize the neck's orientation during the impact, providing valuable data for predicting the direction of the neck's movement. This system is designed to support clinical decision making by providing detailed, real time predictions and explanations of neck rotation.

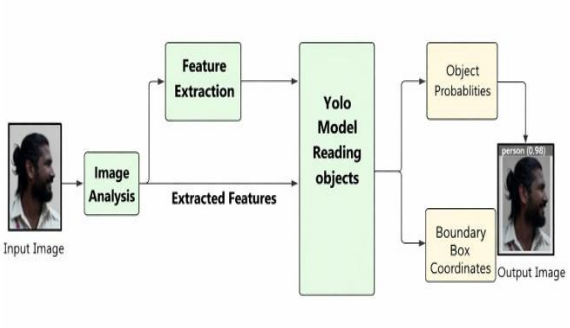


Fig. 1: System Overview

1. Data Collection and Preprocessing

Collect and label a dataset of head impact scenarios, including videos or images that show the neck's position during various head impacts (flexion, extension, and lateral movements). Ensure the dataset includes both male and female subjects to account for variability in neck movement. Preprocess the images or video frames, ensuring they are of consistent size and quality suitable for YOLOv8 input.

2. Model Selection and Configuration

Select the YOLOv8 model, which is known for its fast and accurate real-time object detection capabilities. Configure the model architecture and set parameters such as input size, batch size, and learning rate, based on the specific requirements of neck detection.

3. Labeling and Annotation

Annotate the key features in the video frames or images, marking the neck’s position and rotation direction (flexion, extension, lateral). Use appropriate annotation tools to label the regions of interest (neck and head) within the image.

4. Train YOLOv8 Model

Use the labeled dataset to train the YOLOv8 model. Set up the model with appropriate

parameters (input size, batch size, etc.). Train the model on the labeled data, adjusting the hyperparameters to optimize performance.

5. Test and Evaluate

Once the model is trained, test it on unseen images or video frames to check its accuracy. Evaluate the model's performance using metrics like precision and recall.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The experimental results show that the proposed YOLOv8-based framework accurately detects and tracks neck rotation during simulated head impacts in real time. The integration of Explainable AI (XAI) enhances the interpretability of predictions, enabling better understanding of neck movement patterns. The model demonstrates high detection accuracy and reliable performance across different head movement scenarios. Overall, the proposed system provides an efficient and effective solution for neck direction analysis and injury prevention in healthcare and sports applications.



Fig. 2: Home Page

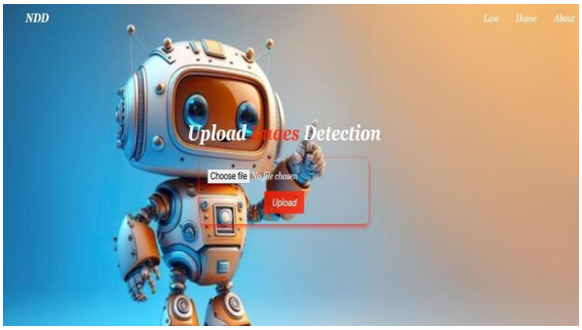


Fig. 3: Upload Images

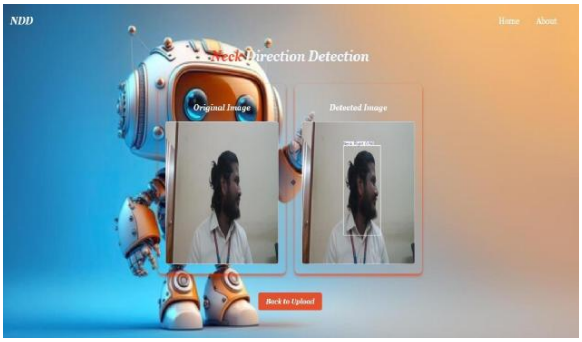


Fig. 4: Prediction Result

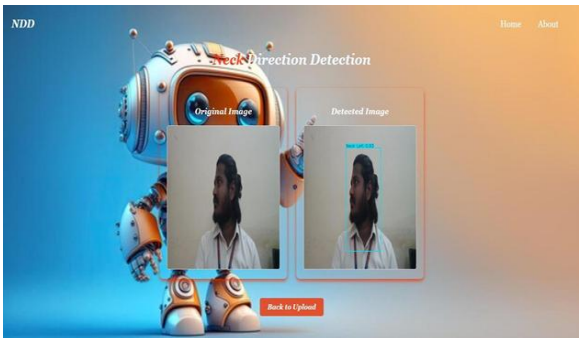


Fig. 5: Prediction Result



Fig. 6: Prediction Result

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.

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