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Optimizing Swim Pose Estimation and Performance Analysis Using AI and Predictive Analytics

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Abstract: ***Swim position estimation and performance analysis are critical for improving training outcomes and minimizing injury rates among swimmers of all skill levels. Traditional approaches rely heavily on manual video processing, which is time-consuming and prone to human error, as well as biomechanical evaluations. Recent advances in artificial intelligence (AI) and predictive analytics have created new prospects for automating and improving these operations. The goal of this project is to create an artificial intelligence-powered swim position evaluation system that utilizes machine learning and computer vision techniques. The device monitors swimmers' activities in real time and gives exact feedback on technique, posture, and stroke efficiency. Predictive analytics improves this technique by predicting future trends and potential areas for development based on performance indicators and historical data. To provide precise, non-invasive human movement tracking in water, the proposed system employs biomechanical studies, deep learning models, and 3D pose estimation techniques.***
Keywords: Swim Pose Estimation, Artificial Intelligence, Machine Learning, Pose Estimation

I. INTRODUCTION

Proper posture assessment is strongly dependent on precisely modeling human body kye-points. A computer vision algorithm can recognize human attitudes, physical movements, and motion in a variety of ways. The majority of past research employed this method to determine accuracy or efficiency in terms of speed[1].To address the lack of objective quantitative evaluation in long jump training, this study proposes a normative analytic approach based on human pose estimate and similarity metrics. This method employs a lightweight human pose estimation model that may be run on embedded devices with minimal delay[2].

Calculating inner-cyclic time intervals in the motion sequences of top swimmers in a swimming channel. Key poses, or distinct bodily positions, develop throughout time, defining interval boundaries[3]. In this study, we look with the problem of predicting human positions in real-world swimming films. These recordings can provide quantifiable feedback on an athlete's performance. Currently, quantitative evaluation involves manually categorizing body parts in each video frame[4].

Three-dimensional object identification is a popular research topic in computer vision and robotics. To successfully carry out autonomous intervention missions, robots must incorporate spatial and semantic knowledge. This study describes a method for identifying submerged objects and calculating their placements in man-made structures, which enables autonomous intervention. The methods apply to 3D colorless point clouds gathered with a rapid laser scanner[5]. Human pose estimate has a variety of applications, including healthcare, sports, fitness, and criminal investigation. This technology has a wide range of applications, including activity identification, motion capture, augmented reality, and motion tracking. Artificial intelligence is introducing new and innovative technology to the fitness industry. Fitness and technology are rapidly growing industries[6].

To overcome the limits of human technique assessment, artificial intelligence and predictive analytics are being used to improve swim position estimation and performance analysis. Swimmers may improve their performance, lower their risk of injury, and fine-tune their technique by leveraging AI to provide precise, real-time feedback and predictive data to adapt their training. This will increase their efficiency and performance in competition swimming. Swim position estimation and performance analysis rely on subjective judgments, making them time-consuming and prone to human error. Traditional methodologies lack real-time feedback, technical problem diagnosis, and customized training insights. AI and predictive analytics can automate analysis, provide real-time feedback, and enhance swimming performance at all levels.

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II. LITERATURE SURVEY

1) Normative Evaluation Method of Long Jump Action Based on Human Pose Estimation

Addressing the issue of the lack of objective quantitative evaluation in training long jump events, this study presents a normative analysis method based on human pose estimation and similarity measures. By training a lightweight human pose estimation model, this method can run on low-delay embedded devices. In line with key movements, the proposed method designs a normative analysis for long jump actions, which yields a measurement of the movements' adherence to the standard and provides corrective suggestions. Experimental results indicate that the accuracy of this approach in analyzing the standardization of long jump action reaches 91.3%. As a result, it holds significant application value in various scenarios, including students' long jump training and correction of long jump techniques. Furthermore, it can be extended to other practical applications beyond sports. This method involved recording pitch angle and side angle features extracted from acceleration to identify the posture and basic motion index of the human body, culminating in the development of a system to detect swimming performance, thus facilitating training guidance.

2) Improvement of Human Pose Estimation and Processing With the Intensive Feature Consistency Network

Computer vision algorithm identifies human pose, body-movement, and action in many ways. Most of the previous works taken advantage for finding accuracy or efficiency in terms of speed. However, many techniques suffer for intensive computational demands with low-latency or higher proceeding speed. We have designed a unique approach for single-person pose estimation and action recognition which is well suited for fitness application and mobility activities. The proposed framework has been developed with a base network that provides an initial pose to further refinement through Intensive Feature Consistency (IFC) network. The IFC network enforces high-level constraints on the global body intensity correction and local body part adjustments. The proposed module reduces the impact of body joint movement diversity by interpreting long-term consistent view. We have illustrated the effectiveness of proposed framework through pose estimation accuracy improvement with two benchmark datasets. Which is specified state-of the- art performance of IFC network under the required real-time processing speed on the CPU platform. The IFC network has improved 99.1% of PCK body and 94.7% of PCK torso accuracy under 31 FPS, which is comparatively higher than the existing work.

3) Key-Pose Prediction in Cyclic Human Motion

In this paper we study the problem of estimating inner cyclic time intervals within repetitive motion sequences of top-class swimmers in a swimming channel. Interval limits are given by temporal occurrences of key-poses, i.e. distinctive postures of the body. A key-pose is defined by means of only one or two specific features of the complete posture. It is often difficult to detect such subtle features directly. We therefore propose the following method: Given that we ob serve the swimmer from the side, we build a pictorial structure of poselets to robustly identify random support poses within the regular motion of a swimmer. We formulate a maximum likelihood model which predicts a key-pose given the occurrences of multiple support poses within one stroke. The maximum likelihood can be extended with prior knowledge about the temporal location of a key-pose in order to improve the prediction recall. We experimentally show that our models reliably and robustly detect key-poses with a high precision and that their performance can be improved by extending the framework with additional camera views.

4) Object Recognition and Pose Estimation using Laser scans For Advanced Underwater Manipulation

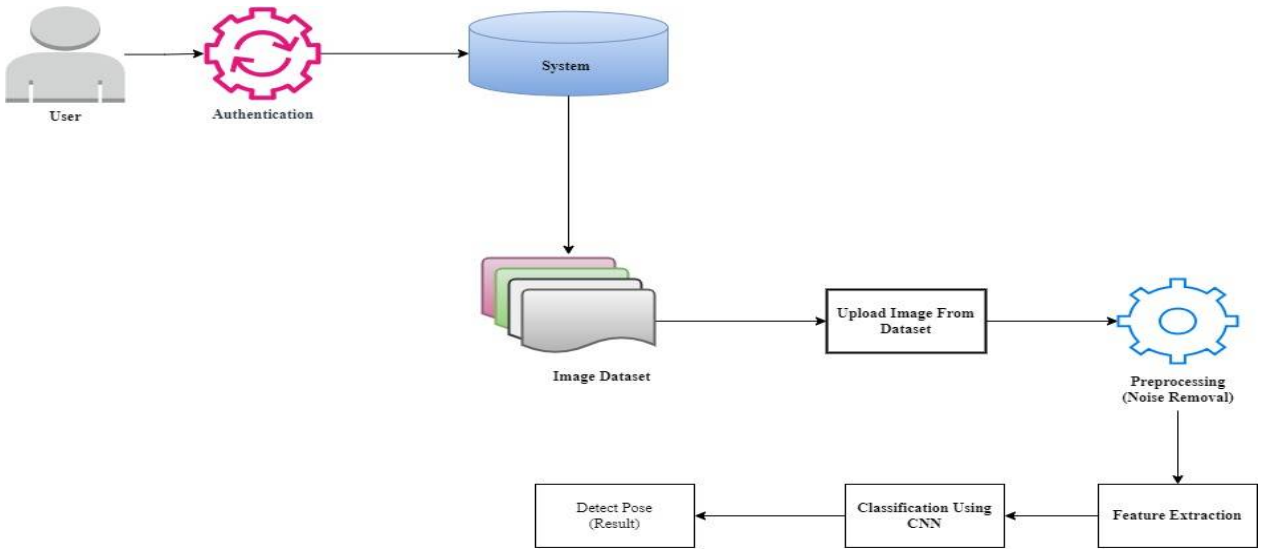
This paper presents an approach for the recognition and pose estimation of underwater objects, with the goal of enabling autonomous underwater intervention in man made structures. The methods are developed to be used with raw data consisting of 3D colorless point clouds collected by a fast laser scanner. The proposed approach contains two main phases: Object recognition from range data, and feature-based semantic SLAM. The first goal consists of recognizing different objects present in the scene. For this purpose, a recognition and pose estimation pipeline was developed enclosing different steps such as segmentation, identification, and estimation of the position and orientation for each targeted object. The second goal aims at improving the AUV navigation in an underwater environment by using the result of the recognition and pose estimation pipeline to feed a feature based SLAM algorithm. As the AUV moves along the trajectory, the SLAM algorithm builds a map, recognizes targeted objects and integrates them into this map, and localizes its position with respect to it. Compared to previous experimental results performed in a water tank, this paper emphasizes the importance of estimating the pose of the objects (namely the orientation), as a way of promoting the accuracy of the robot localization.

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5) Human Pose Detection and Estimation

In an era of booming technology, the application of Artificial Intelligence and Machine Learning in day to day activities is increasing rapidly. In recent years, there has been a significant increase in the implementation of Artificial Intelligence in Human Pose Detection and Estimation, particularly pose tracking. This paper primarily focuses and summarizes the recent progress made in this field. The methodologies used, datasets encountered, and future research scope in pose estimation applications have also been presented. a method for estimating Human pose using Deep Neural Networks (DNNs), the formulation of their approach was based on a regression problem on the body joints of a human being. They carried out a delineated empirical analysis and procedure on the eclectic real-world images obtained from two large datasets, namely FLIC (Frames Labelled In Cinema) and LSP (Leeds Sports Pose) Dataset. A comparative study of different approaches to the metrics was presented by them and further demonstrated that a generic convolutional neural network applies to various tasks of localization.

III. SYSTEM ARCHITECTURE



The system ensures that only authorized users can access and use its functionalities.

1) *Image Dataset:* A collection of images representing various swimming poses is stored in the dataset.
2) *Upload Image From Dataset:* Users can select and upload images from the dataset for analysis.
3) *Preprocessing:* The input images undergo preprocessing to enhance their quality and remove noise, improving the accuracy of the pose estimation process.
4) *Feature Extraction:* The preprocessed images are analyzed to extract relevant features, such as body landmarks and joint angles.
5) *Classification:* A convolutional neural network (CNN) is used to classify the extracted features and determine the swimmer's pose.
6) *Output:* The final result of the pose estimation process is displayed to the user, indicating the detected swimming pose.

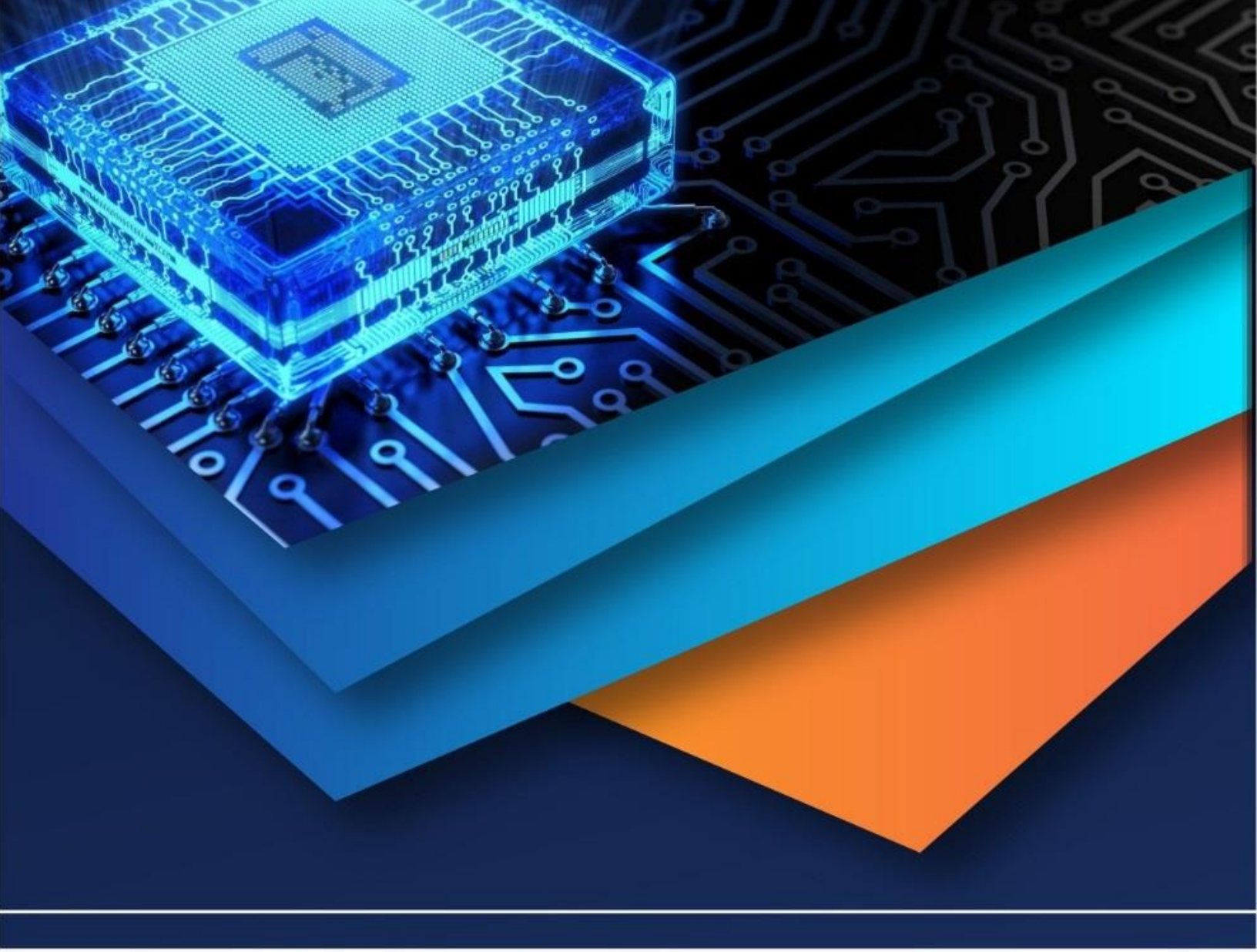
IV. CONCLUSION

The use of artificial intelligence and predictive analytics to improve swim posture estimation and performance analysis is a significant advancement in swimming training and development. AI-powered solutions give swimmers objective, real-time feedback that boosts their performance and efficiency while lowering their risk of injury. Predictive analytics can be used to develop customized training plans that incorporate targeted improvements and data-driven forecasts of future performance. Swimmers of all skill levels benefit from these technologies because the advantages of Acknowledgment improved accuracy and performance outweigh the drawbacks, which include cost and complexity. Artificial intelligence (AI) will continue to revolutionize sports training and performance monitoring as it becomes more generally available, with far-reaching implications for the swimming industry.

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