<u>Posture Guard – Gym Injury Prediction and Prevention</u>

PROJECT SYNOPSIS

OF MAJOR PROJECT

BACHELOR OF TECHNOLOGY

C.S.E

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INTRODUCTION

The concept of using technology to improve the workout experience is not new. Fitness applications, wearable devices, and other technological innovations have been developed in recent years to help individuals track their fitness progress and achieve their fitness goals.

However, these solutions do not address the issue of injuries and ineffective workouts that can occur due to incorrect form, irregular exercise schedules, and lack of personalization in workout plans.

According to a study conducted in 2014, knee injuries accounted for the highest number of gym - related injuries at 23%, followed by injuries to the ankle and foot at 16%, shoulder injuries at 14%, lower back injuries at 12%, and neck injuries at 11%.

The remaining 22% included injuries to the elbow, muscle strains, pulls and tears, and tendon ruptures.

These injuries not only cause physical discomfort but can also hinder the progress of the individual's fitness journey.

The POSTURE GUARD project aims to address these issues by leveraging machine learning and deep learning techniques to create a comprehensive workout solution that can help people reduce the risk of injuries and achieve their fitness goals.

The proposed solution will provide personalized recommendations for workouts based on the user's fitness level and injury risk, as well as real-time feedback on form and technique to prevent injuries and ensure that the workouts are effective.

Technologies used in Developing the project-

Tools and Platforms Required

- Python
- NumPy
- Media Pipe Library
- Camera
- OpenCV
- Tkinter
- HTML/CSS

FIELD OF PROJECT- MACHINE LEARNING

Problem Statement: -

The problem that the Posture Guard project aims to address is the issue of injuries during exercise, which is prevalent among both amateur and professional athletes. While there are existing solutions available to address this issue, they may not be comprehensive, personalized, or easily accessible. This can lead to individuals being at risk of injuries during exercise, which can have a significant impact on their physical health and well-being.

A gap analysis of the existing solutions reveals that while some solutions may provide guidance on proper exercise form, they may not take into account individual characteristics and fitness goals. Moreover, these solutions may not be easily accessible or affordable, limiting their reach and effectiveness. The Posture Guard project seeks to bridge this gap by providing a personalized, data-driven, and accessible solution that can be used by individuals in various settings and at different fitness levels.

By leveraging machine learning and deep learning techniques, the project can create a comprehensive workout solution that can help people reduce the risk of injuries and achieve their fitness goals. The project's focus on injury prevention is particularly relevant given the high prevalence of exercise-related injuries. The project can provide individuals with a comprehensive workout solution that is tailored to their specific needs and fitness goals, thereby promoting safe and effective exercise and reducing injuries related to physical activity.

NEED FOR POSTURE GUARD: -

Safety: One of the key gaps identified in existing solutions is the lack of advanced safety features. While some solutions may provide basic safety features, such as heart rate monitoring or exercise tracking, they do not offer advanced safety features, such as form analysis or personalized feedback, to help users perform exercises with proper form and technique. POSTURE GUARD addresses this gap by offering advanced safety features that help users reduce the risk of injury and optimize their workouts.

Personalization: Another key gap identified in existing solutions is the lack of personalization in workout plans. While some solutions may offer pre-made workout plans or general recommendations based on fitness level, they do not provide personalized workout plans that are tailored to an individual's specific needs, goals, and injury history. POSTURE GUARD addresses this gap by offering personalized workout plans that are tailored to an individual's specific needs, goals, and injury history, ensuring that users can achieve their fitness goals more effectively.

Scalability: A final key gap identified in existing solutions is scalability. While some solutions may be effective for a small group of users, they may not be scalable for a larger user base or for use in various settings. POSTURE GUARD addresses this gap by providing a scalable solution that can be used by individuals in various settings and at different fitness levels, ensuring that users can access the benefits of the solution regardless of their location or fitness level.

OBJECTIVES: -

1. The Posture Guard project aims to develop an innovative exercise monitoring system that helps reduce and prevent injuries during physical activity.

2. The primary objective of this project is to provide users with a safe and effective workout experience, regardless of their location, by constantly monitoring their exercise routine and alerting them in real-time when issues arise that could be harmful to their health.

3. To achieve this objective, the project will focus on developing a user-friendly and efficient monitoring system that can be used in different exercise settings, such as professional gyms or home workouts.

4. The system will be designed with an algorithm that analyses the user's movements and provides real-time feedback to ensure that the user is performing exercises safely and effectively.

5. The project will prioritize user safety and injury prevention by designing the system to keep the user out of danger and provide a safe and effective workout.

6. The user interface will be simple, intuitive, and accessible, allowing users to change modes and place the device in a convenient location.

7. The system will also be adaptable to different exercise routines and settings, ensuring that users can work out and exercise with peace of mind, without worrying about wasting their efforts or causing harm to themselves.

Literature review: -

Reference Number	Objective	Methodology	Conclusion
[1]	In Human-Robot Interaction, finding natural and effective communication routes is critical.	Gesture-based language allows people to connect with robots in a natural way by utilising their bodies. To train our network, we used neural networks and a specific dataset of individuals executing a series of body motions.	Gesture-based language allows people to connect with robots in a natural way by utilising their bodies. To train our network, we used neural networks and a specific dataset of individuals executing a series of body motions.

[2]	Recognizing postures without invading privacy, expensive costs, and difficult implementation procedures, as well as raising recognition rate for stationary postures, which is not achievable with acceleration sensor techniques.	A single deployed indoor location system is built by placing wearable receiving tags at strategic spots on the human body. In addition, the least square estimation (LSE) technique and the improved extended Kalman filtering (iEKF) algorithm are used.	The iEKF algorithm outperforms the LSE technique in terms of accuracy. The system's robustness and stability are also commendable. Work on developing wearable technology has the potential to increase overall process accuracy.
[3]	Convolutional neural networks are used in a vision-based method for one-person posture identification to identify and categorise several classes for the human posture.	Numerous algorithms are given, divided into groups such computer vision-based algorithms and algorithms based on wearable sensors and ambient devices.	The learned CPN's ideas increase the accuracy of the findings by employing four distinct scales and aspect ratios for each. Real-time recognition is becoming better.
[4]	Accelerometer-based fall detection that uses posture recognition to identify postures that might be the outcome of both fall detection and posture recognition.	By determining whether the posture may be the consequence of a fall, the posture recognition techniques were applied to enhance fall detection.	Using the appropriate methodologies, good accuracy was often attained in both fall detection and posture detection, and potential issues are discovered and highlighted.

[5]	Method for spotting human silhouettes in a certain walking position. include 2D silhouette sequences generated from motion capture data.	Utilize statistical learning techniques to calculate and record the significance of the many silhouette components to the job of recognition. They apply at runtime to transform Chamfer distance into useful probability estimates.	Capable of producing extremely good results for indoor and outdoor sequences when backdrop removal is impossible, under tough lighting circumstances, multiple camera views, and visible scale changes.
[6]	To develop a novel technique to gesture identification that concurrently tracks the body and hands and detects movements continuously from an unsegmented and unbounded input stream.	The system begins by collecting RGBD pictures from a single stereo camera. 1 As it receives the photos, it does background removal using a mix of a codebook technique [Kim et al., 2005] and a depth-cut method, i.e., once a likely region-of-interest (foreground item) is identified,	Presented a novel method for gesture identification that concurrently tracks the body and hands, detects gestures continuously from an unsegmented and unbounded input stream, and described our latest work on multimodal gesture recognition and deep-hierarchical sequence representation learning, which gets the best results on a number of real-world datasets.

[7]	To create technology that effectively records and understands human movement, body behaviour, and face expression.	It investigates four areas of subproblem solutions in automated facial expression analysis and classification: a database of Ekman-Hager facial action exemplars. Detecting and/or monitoring the face in a facial picture or image sequence is a vastly unexplored domain, and creating automatic facial expression analysis computes the output data expressions.	The study initially reviewed several methodologies and past work in autonomous facial expression/action analysis, gesture detection, and multimodal interfaces before offering a concept for a vision-based multimodal analyser that identifies face and body gesture.
[8]	In order to handle various analytical tasks, such as detection, tracking, action recognition, and identification, it is intended to characterise both specific body parts and the person as a whole. The technology under consideration, which uses me.	Different non-hierarchical and hierarchical techniques were investigated for this multiclass problem, and the system structure was sketched out. Experiments were conducted after the item was separated from the backdrop using contour-based shape descriptor (CBSD), one of the shape descriptors.	Present a novel way to recognising human body position. The MPEG-7 shape description and the projection histogram serve as its foundation. Based on the binary object mask obtained after the segmentation process, a mixture of them was utilised to recognise the principal posture and view of a human.
[9]	Using geometric characteristics from the Kinect for a multi-class human posture detection and identification method	The collected characteristics correspond to 11 vectors defined by 14 human skeleton points. Postures are detected by thresholding the likelihood of the stance. An SVM classifier is used for classification. The system incorporating positional characteristics has a recognition accuracy of 74.08%, emphasising the significance of the proposed method's scale.	Using Kinect-based geometrical characteristics, a person, location, and scale invariant posture detection and identification technique are suggested. The collected characteristics correspond to 11 vectors defined by 14 human skeleton points. Postures are detected by thresholding the likelihood of the stance.

[10]	To demonstrate a template-based method for recognising human silhouettes in a specified walking stance.	Short sequences of 2D silhouettes derived from motion capture data are utilised as templates. This allows it to incorporate motion information into them and distinguishes real individuals who move in regular patterns from static items whose outlines are generally similar to those of humans. Furthermore, during the training phase, statistical learning techniques are used to quantify and store the significance of various silhouette elements to the recognition task.	The research developed a template-based technique for detecting human body poses. The templates are created using a virtual figure that makes genuine human gestures that are collected by a motion capture device. Despite not using colour or texture, it has demonstrated extremely strong performance for indoor and outdoor sequences when backdrop removal is impossible, under harsh lighting circumstances, multiple camera views, and apparent size changes.
[11]	The goal of this project is to create a system that can recognise different body positions of a sitting individual. Sitting on the edge of the seat, sitting erect, slumping back, loose, leaning left, leaning right, right leg up, left leg up are all recognised positions.	The pressure sensors installed in the chair allow the system to discriminate between different positions based on the presence of imposed pressure. The data is subsequently sent into a decision engine, which determines the sitting person's condition.	We have demonstrated the Aware Chair system, which can recognise a seated person's body position using only 8 binary pressure sensors. Because the sensors in some situations require direct pressure to be activated, the readings are mismatched, thus we aim to experiment with various types of sensors whose sensitivity may be modified to fit the application's needs.
[12]	In this paper, we provide a unique method for marker less real-time posture detection in a multi-camera configuration. To enable real-time pose identification, body posture is extracted using example-based classification based on Haar wavelet-like characteristics. The Average Neighbourhood Margin Maximization (ANMM) approach for training Haar-like features is introduced.	Instead of tracking the actualized body model, example-based techniques compare observations and record matches as instances of body positions. The silhouettes and their visual hulls appear to reflect the essence of human body positions rather effectively. The 3D method seeks to categorise positions based on the user's 3D hull rather than the silhouette. The ANMM was introduced to boost the system's spe	This paper introduced ANMM as a novel and effective method for training Haarlets for human posture categorization. This method was constructed, tested, and compared to traditional AdaBoost for posture identification on 2D silhouettes. The method was expanded to categorise 3D voxel hulls, and 3D Haarlets were introduced as a result. First, this article shows how Haarlets may be taught using ANMM, with intriguing features such as being a genuine multi-class technique with almost no memory constraints on the resolution or number of candidates Haarlets to train from.

[13]	Adults' face and body perception is characterised by holistic processing, which is linked to competence. Infants perceive faces in a holistic manner, but it is uncertain if they process body information in the same manner. These findings suggest that some amount of competence in body processing emerges early in childhood. Babies aged 5 to 9 months	Numerous exams and investigations were conducted prior to the research to provide unambiguous evidence of configural information processing of faces in youngsters aged 5 and 9 months. In three scenarios, the newborns were evaluated for discriminating between body postures that differed in limb orientations: in the context of the entire body, with only the isolated limbs that changed orientation, or with the limbs. Body postures, emotions, intentions, and planned activities were also recorded.	5–9-month-old babies discriminated against changes in limb orientation within the context of a normal entire body, but not when body parts were shown in isolation or in the context of scrambled bodies. These findings suggest that newborns, like adults, interpret bodily information holistically. To the best of our knowledge, this is the first study to show this type of expert body information processing in infancy. This suggests the early development of both face and body information processing, which probably permits the developing newborn to process vital social information effectively.
[14]	Back propagation (BP) neural networks are used as a classifier in this study to recognise human body posture, with signals gathered from VG350 acceleration sensors and a posture signal collecting system based on WBAN developed.	The algorithm's practicality is validated using datasets acquired by the hardware system of human body position recognition. The BP neural network structure with the greatest recognition rate is provided.	Because of the high identification rate, the BP neural network is better suited for human body position recognition in WBAN. The rate of posture recognition can reach 91.67%.
[15]	Four long-term priming tests using static images of a human model evaluated the identification of human behaviours and body postures seen from various angles. Of course, this issue is identical to the viewpoint invariance issue with object recognition that the visual system is currently facing (as distinct from action recognition).	The model in the second set, who had been facing straight ahead in the first set, was now oriented roughly 75 degrees to the right (from the perspective of an observer or the camera). AT Vista 4M video graphics adapter and a 3 CCD colour camera were used to create the images on an IBM-compatible computer.	For the normal human actions and body postures, reliable priming was obtained mainly in the same-view prime condition. Reaction times and errors in the primed block increased rapidly with increasing orientation differences in the priming block: The priming effect dropped halfway in the 15°-different view prime condition and was nearly non-existent when view differences exceeded 30°.
[16]	We gave people still images of emotions (anger, disgust, fear, happiness, sorrow, and surprise) represented as points of light in dynamic light displays in order to test if the dynamic movement condition in a videotape would translate to a photograph.	The Kodachrome slides had been prepared via photographing a videotaped picture displayed on a black and-white tv monitor. The videotape was of a performer dressed in black garb with a hood over the head. White cotton balls, four. Zero cm in diameter, had been taped to the clothing black historical past.	More specifically, the average correct recognition varied insignificantly depending on the type of cue, with 27% for full cues, 24% for higher cues, and 26% for lower cues. As a result, the second batch of full-cue data was removed from all analyses, and an ANOVA was performed to compare subject sex and emotion.

[17]	The objective of this examination is to decide emotions using body posture. a complete of 176 laptop generated mannequin figures were created from descriptions of postural expressions of emotion in order to investigate the attribution of emotion to static body postures.	Using a mixture of methodologies such as photographs, and dynamic and static point-mild displays, walk and colleagues have verified that emotion can be recognized from static posture with varying ranges of accuracy.	The effects of this study shed light on some of questions regarding the notion of emotion from body posture. these difficulty how different feelings are attributed to body postures, the effect of anatomical variables and viewpoints on attribution, and the nature of confusion throughout emotions.

Feasibility study

The POSTURE GUARD project has a high feasibility for success due to the availability of data on workout-related injuries, as well as the availability of machine learning and deep learning techniques to analyse and process this data.

The project will involve collecting data from fitness enthusiasts, gym-goers, and personal trainers to analyse the factors that contribute to work out-related injuries. This data will be used to develop a machine learning model that can predict the likelihood of injury based on user characteristics and workout habits. The machine learning model will be trained on a dataset of historical workout injury data and tested for accuracy on a separate validation dataset.

Implementing deep learning techniques within the mobile application to analyse user movements requires significant technical considerations. The application must be capable of capturing and processing video data in real-time, applying sophisticated algorithms for movement analysis, and providing accurate and helpful feedback. The availability of suitable deep learning libraries, such as TensorFlow or PyTorch, will be crucial for implementing the necessary algorithms and models.

The mobile application should offer a seamless and intuitive user experience. It should be easy to navigate, with clear instructions and visual cues to guide users through their workouts. The feedback provided should be concise and actionable, allowing users to make immediate corrections to their form and technique. Consideration should also be given to the visual design and interface layout to ensure clarity and readability on mobile devices.

To ensure the feedback provided by the mobile application is accurate and helpful, extensive testing and refinement will be necessary. This will involve training deep learning models on large datasets of exercise movements, including diverse user scenarios. The models should be able to recognize correct form, detect deviations, and offer appropriate suggestions on posture, breathing, or alignment. Rigorous testing will be conducted to evaluate the accuracy and effectiveness of the feedback provided by the application.

Overall, the POSTURE GUARD project has a high feasibility for success due to the availability of data and techniques to analyse and process this data. The project team is highly skilled and has extensive experience in machine learning and deep learning, as well as mobile application development. With proper planning, execution, and testing, the project can provide individuals with a comprehensive workout solution that is tailored to their specific needs and fitness goals.

METHODOLOGY/PLANNING: -

Design methodology refers to the systematic process used by designers to solve problems and create innovative solutions. It involves a structured approach to identifying and defining problems, generating ideas, and testing and refining solutions.

Here is an overview of the design methodology:

1. **Define the Problem:** The first step in the design methodology is to identify and define the problem that needs to be solved. This involves understanding the user's needs and requirements, as well as any constraints or limitations that may impact the design.
2. **Research and Analysis:** Once the problem has been defined, the designer conducts research to gather information and gain a deeper understanding of the problem. This may involve studying existing solutions, conducting user surveys, and analysing data.
3. **Ideation:** In this stage, the designer generates a range of ideas and concepts to address the problem. This can involve brainstorming, sketching, and creating prototypes to explore different possibilities.
4. **Design:** Once the ideas have been generated, the designer begins to create a detailed design plan. This involves creating drawings, diagrams, and blueprints that provide a clear and concise overview of the proposed solution.
5. **Prototype:** In this stage, the designer creates a prototype or model of the proposed solution. This may involve creating a physical prototype, a 3D model, or a computer simulation.
6. **Testing and Refinement:** The prototype is tested and evaluated to determine how well it meets the user's needs and requirements. Based on the feedback, the design is refined and improved until it meets all the necessary criteria.
7. **Implementation:** Once the design has been finalized, it is ready for implementation. This involves producing the final product, creating marketing materials, and developing user manuals and documentation.
8. **Evaluation and Feedback:** Finally, the designer evaluates the effectiveness of the solution and gathers feedback from users to determine how well it meets their needs. This information is used to improve the design for future iterations or versions.

EXPECTED OUTCOMES: -

The Posture Guard project is expected to have significant outcomes in both the short term and long-term. In the short-term, the project aims to reduce and prevent injuries during physical activity by constantly monitoring the user's exercise routine and alerting them when issues arise that could be harmful to their health. This will help users to have a safe and effective workout, which can lead to immediate improvements in their physical health. In the long-term, the project aims to promote physical health and reduce the incidence of exercise related injuries among both amateur and professional athletes. By providing users with a safe and effective workout, the project can help them to maintain a healthy lifestyle and prevent long-term health problems related to physical inactivity or injury. Additionally, the project has the potential to revolutionize the fitness industry by providing a cost effective and efficient solution to injury prevention. This could lead to the development of new products and services that integrate the Posture Guard technology, as well as increased demand for similar solutions in other industries. Furthermore, the project can serve as a platform for future research in the areas of exercise monitoring and injury prevention. By collecting and analysing data on user habits and workout routines, researchers can gain insights into the factors that contribute to exercise-related injuries and develop more effective prevention strategies. Overall, the outcomes of the Posture Guard project are expected to have a significant impact on promoting physical health and reducing injuries related to exercise, both in the short-term and long-term.

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