SYNOPSIS

Report on

AI-POWERED SELF-DEFENSE TRAINING PLATFORM

by

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ABSTRACT

This project focuses on the development of an **AI-Powered Self-Defense Training Platform** that enables individuals to learn and practice defensive techniques interactively from the comfort of their homes. Unlike traditional video tutorials, the proposed system leverages **machine learning and computer vision technologies** to provide **real-time pose detection and corrective feedback**, ensuring that techniques are practiced accurately and safely.

The platform uses a **webcam-enabled device** to capture user movements and compares them with expert demonstrations through **pose estimation algorithms** such as MediaPipe and OpenPose. Users are guided through **step-by-step tutorials**, while the system evaluates their performance and suggests improvements in posture, stance, and technique execution.

Key highlights of the project include:

- **Interactive Guided Training**: Structured modules ranging from beginner to advanced levels.
- **Pose Detection & Feedback**: Real-time analysis and correction of user movements.
- **Accessibility & Scalability**: Requires no special hardware, only a standard webcam and internet connection.
- **Safety & Confidence Building**: Empowers individuals, especially women and vulnerable groups, with practical self-defense skills.
- **Research Contribution**: Demonstrates the application of AI and computer vision beyond fitness into personal safety.

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INTRODUCTION

In today's society, personal safety has become a critical concern, particularly for vulnerable groups such as women, children, and senior citizens. Traditional self-defense training requires physical classes, instructors, and practice sessions, which are not always accessible due to factors like cost, location, and time constraints.

This project introduces an **AI-Powered Self-Defense Training Platform** that combines **artificial intelligence and computer vision** to make self-defense training widely available. Unlike video tutorials, our system uses **pose detection and machine learning algorithms** to provide **real-time interactive training**.

Key Points:

1. Need for Accessible Training

- Rising concerns over personal safety, particularly for women, children, and vulnerable groups.
- Demand for practical solutions that build confidence and safety awareness.

2. Limitations of Traditional Methods

- Physical classes are costly, time-bound, and geographically limited.
- Video tutorials lack personalized correction, which can lead to improper learning.

3. Role of Technology

- Advancements in **pose estimation frameworks** (like OpenPose, MediaPipe, and PoseNet) make it possible to track human movements accurately.
- Machine learning algorithms can compare a learner's movements with expert demonstrations and provide corrective feedback instantly

4. Purpose of the Platform

- To democratize self-defense training by making it **affordable, scalable, and interactive**.
- To empower individuals with **life-saving skills** without requiring physical attendance at training centers.

LITERATURE REVIEW

The field of **AI-assisted human movement analysis** has gained significant attention in recent years, particularly in domains such as **fitness training, sports coaching, physiotherapy, and healthcare**. Researchers and developers have experimented with **pose estimation algorithms, deep learning models, and real-time feedback systems** to improve accuracy and enhance user experience. While many applications exist for **fitness and exercise correction**, the specific use of these technologies in **self-defense training** is relatively unexplored.

Key Points:

1. **Traditional Self-Defense Training Approaches**
   Historically, self-defense training has been imparted through **physical classes** conducted by professional trainers in martial arts schools, workshops, or defense academies. While highly effective, such training methods face challenges:
   - **Accessibility Issues** – Limited to those who can physically attend.
   - **Cost Factor** – Professional instructors and structured programs are often expensive.
   - **Time Constraints** – Regular practice requires dedicated schedules, which many individuals cannot manage.
   - **Lack of Scalability** – Training is localized and cannot reach mass audiences simultaneously.

2. **Early Applications of AI in Fitness and Movement**
   Several AI-powered fitness platforms have emerged in recent years. For example:
   - **AI Yoga Trainers** – Applications use pose estimation to ensure correct posture during yoga exercises.
   - **Fitness Coaching Systems** – Platforms like Freeletics and FitOn provide real-time feedback during workout sessions.
   - **Physiotherapy and Rehabilitation** – AI systems monitor patient recovery exercises and ensure that movements are executed correctly to prevent re-injury.

These applications have demonstrated that **AI-driven pose detection can significantly improve learning outcomes** by providing immediate feedback to users.

3. Pose Estimation Frameworks

The core technology enabling real-time movement analysis is **pose estimation**. Popular frameworks include:

- **OpenPose** – Detects skeletal key points for multiple persons in real-time.
- **MediaPipe Pose** – Lightweight, efficient, and suitable for web/mobile deployment.
- **PoseNet** – Provides pose estimation with lower computational requirements.

These frameworks have been widely used in research and practical applications such as dance training, sports performance monitoring, and gesture recognition.

4. Deep Learning and Frameworks in Human Movement

Modern deep learning frameworks such as **PyTorch** have become standard for implementing action recognition and pose classification models due to their flexibility and GPU optimization. Studies show that **PyTorch-based CNN and LSTM models** can effectively classify human actions and track sequential movements. Combining **YOLO for fast detection** with **PyTorch-based models for classification** creates a powerful pipeline for real-time self-defense training.

5. Research in Martial Arts and Self-Defense Applications

While research on **AI in martial arts/self-defense** is limited compared to fitness applications, some studies highlight the potential:

- AI-based systems for **punch and kick recognition** in martial arts training.
- Use of pose estimation in **boxing or karate** for motion analysis and scoring.
- Prototype self-defense simulators combining **VR/AR with AI pose correction**.

However, these studies remain experimental and lack real-world, scalable implementation

6. Research Gap and Opportunity

Existing literature shows strong applications of **AI in fitness and rehabilitation**, but self-defense training systems are underdeveloped. Most available solutions either provide video tutorials without feedback or require physical trainers for corrections.

This project fills the gap by:

- Applying **pose detection algorithms** specifically to self-defense techniques.
- Providing **real-time corrective feedback** to ensure safe and effective learning.
- Delivering the platform as a **scalable web-based system**, accessible to anyone with a webcam.

RESEARCH OBJECTIVE

The main aim of this project is to design and implement an **AI-powered interactive self-defense training platform** that provides real-time guidance and feedback to users while they practice defensive techniques. The project focuses on making **self-defense training accessible, affordable, and accurate**, ensuring that users not only learn techniques but also perform them correctly.

Key Objectives:

1. Pose Detection & Similarity Check

- Implement a computer vision-based **pose estimation model** to track the skeletal structure of the user in real time.

2. Guided Training Modules

- Design **step-by-step tutorials** led by expert demonstrations.
- Divide lessons into **beginner, intermediate, and advanced levels** to ensure progressive learning.

3. Real-Time Feedback Mechanism

- Compare user poses with expert models and calculate accuracy scores.

4. Accessibility & Scalability

- Ensure that the platform requires **no specialized hardware** beyond a standard webcam-enabled device.
- Design the system to handle multiple users simultaneously, making it scalable for public adoption.

5. Safety and Confidence Building

- Empower individuals, especially women and vulnerable groups, to feel **more confident in their ability to defend themselves**.
- Promote **safe practice methods**, reducing the risk of injuries caused by incorrect execution.

HARDWARE AND SOFTWARE REQUIREMENTS

For the successful design and implementation of the AI-Powered Self-Defense Training Platform, both hardware and software resources are essential. The requirements are kept minimal to ensure accessibility and scalability, so that users can practice self-defense techniques using commonly available devices like laptops, smartphones, or desktops**.**

Hardware Requirements:

- **Webcam-enabled Laptop/Desktop/Smartphone**: Minimum 720p resolution camera.
- **Processor**: Intel i5 / AMD Ryzen 5 or above.
- **RAM**: Minimum 8 GB.
- **Storage**: 256 GB SSD or higher.
- **Internet Connection**: Stable broadband or 4G/5G for real-time feedback.

Software Requirements:

- Programming Languages: Python 3.10+.
- Frontend: HTML, CSS, Bootstrap
- Backend: Flask.
- Database: Firebase.
- AI/ML Frameworks: PyTorch, Yolo / mediapipe.
- Tools/IDE: Visual Studio Code.

RESEARCH METHODOLOGY

The **research methodology** for the AI-Powered Self-Defense Training Platform is designed to ensure a structured, step-by-step development process that results in an accurate, user-friendly, and scalable system. The methodology integrates **requirement analysis, data preparation, model development, system integration, and evaluation**, ensuring that the platform meets both technical and user needs.

Step 1: Requirement Analysis

- Identify the key problems faced by learners in traditional self-defense training.
- Define system goals, such as real-time pose correction, guided tutorials, and user progress tracking.
- Finalize technical requirements (hardware/software) and functional requirements (modules like training, practice, feedback).

Step 2: Data Collection & Preprocessing

- Collect a dataset of expert demonstrations of self-defense techniques, recorded as videos.
- Extract skeletal keypoints from these videos using pose estimation frameworks.
- Preprocess the data:
    - Normalize keypoint coordinates.
    - Remove noise and irrelevant frames.
    - Annotate movements into categories such as block, escape, strike, counterattack.

Step 3: Feature Extraction & Model Development

- Use pose estimation outputs (keypoints/joints) as features for training ML/DL models.
- Implement algorithms such as:
    - Similarity Matching – Compare user poses with expert poses in real time.
    - Classification Models – Train models to recognize specific moves.
- Develop a scoring mechanism to calculate the accuracy of user performance.

Step 4: System Design & Integration

- Build the frontend interface where users can:
    - Select training modules (beginner to advanced).

    - Watch expert demonstrations.
    - Practice live with feedback.
- Backend functionalities:
    - Store user data and progress in a database.
    - Handle pose detection and ML model integration.
    - Provide personalized feedback messages.

Step 5: Real-Time Feedback Mechanism

- The system analyses user input from the webcam in real time and give similarity percentage.
- It compares the user's movements with expert pose data.

Step 6: Testing & Evaluation

- Test with sample users to measure system accuracy and responsiveness.
- Evaluation Metrics:
    - Pose Detection Accuracy – Percentage match between expert and user.
    - Latency – Speed of feedback delivery.
    - User Satisfaction – Measured through surveys and interaction.
- Debug errors and optimize the system for different devices (laptops, mobiles).

Step 7: Deployment & User Access

- Deploy the system on cloud platform.
- Ensure cross-platform compatibility so that users can access via web browsers.
- Integrate a dashboard for tracking user progress and session history.

RESEARCH OUTCOME

The AI-Powered Self-Defense Training Platform is expected to produce multiple technical, social, and academic outcomes. The outcomes will not only demonstrate the functionality of the system but also highlight its practical significance in the real world.

- Development of a functional web-based platform that provides guided tutorials, real-time pose detection.
- Improved accessibility of self-defense training, requiring only a webcam-enabled device.
- Contribution to user confidence and safety awareness, especially among women and vulnerable groups.
- Academic value through integration of AI and computer vision in personal safety applications, with scope for further research and publication.

Additionally, the platform will help users adopt safe and correct training methods, minimizing the risk of injuries due to improper practice. It will also promote wider awareness of self-defense by making training convenient and scalable. The project thus creates a practical, innovative, and socially impactful system that bridges the gap between technology and personal safety.

PROPOSED TIME DURATION

PHASE	TIME DURATION
Requirement Analysis	2 Weeks
Design Phase	4 Weeks
Development Phase	7 Weeks
Testing phase	3 Weeks
Deployment Phase	2 Weeks
Total Duration	18 Weeks

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