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ORIGINAL ARTICLE

Enhancing karate skill performance through virtual visuals and artificial intelligence techniques

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ABSTRACT

In this paper, we explore the integration of virtual visuals and artificial intelligence (AI) techniques to enhance Karate skill performance, specifically focusing on circular strike skills. Traditional Karate training often lacks the diversity of sparring partners and the precise, real-time feedback necessary for optimal skill development. We propose a Mixed Interpretation Diagram (MID) as a display to present performance features, facilitating visual imagery and best practice simulations. By employing virtual sketches and intelligent sense rules, trainees can simulate optimal actions and enhance critical Karate skills. Additionally, we consider the use of Konashi intelligent bands and Reformer indoor screens to monitor muscular fatigue, providing early warnings for recovery tasks. The adoption of augmented reality (AR) and virtual reality (VR) technologies in sports training offers a new vision for enhancing human skill performance. Our v-sports system integrates state-of-the-art AI, human motion analysis, and virtual visual generation techniques, enabling personalized coaching for Karate practitioners. This paper addresses two key research problems: creating meaningful and intuitive body-movement-based presentations of self-image to optimize training, and generating efficient, professional models for guiding without a coach. We present a timeline and percentage breakdown for the development of an AI-assisted Karate training program. This program includes research on circular strike skills, virtual vision setup, AI model training, performance metrics implementation, and comprehensive system testing. The use of VR and AI in Karate training can significantly improve technique accuracy, movement efficiency, training engagement, and personalized feedback, ultimately enhancing overall performance and reducing injury risks. Our findings suggest that integrating VR and AI technologies into Karate training provides a more engaging, effective, and accessible training experience. Future research should focus on improving the accuracy and affordability of these technologies, integrating virtual and real-world training, and ensuring user safety.

Keywords: Performance analysis, Skill performance, Virtual visuals, Artificial intelligence, Karate.

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INTRODUCTION

Karate practitioners need numerous shadow-fight training and opponent-controlling practices to make themselves best used to react according to different opponents. However, it is hard to find the various partners for sparring. Although the physical condition, performance, level between partners, and actual situation are disadvantages during sparring. Without an opponent, Karate practitioners visualize their own skills, hearing, and beliefs to summarize, analyze, and mimic fighting skills, the traditional training methods for improving their own Karate skills. In this paper, we design a Mixed Interpretation Diagram (MID) as the basic display to present the performance features; inspire the visual images to take Ian for training, and perform the best practices. What MID uses is to select the specific presentation unit, to combine presentation styles, to decide the intelligent sense mode, and arrange the timing to perform the features. Additionally, we employ the virtual sketch to generate the Intelligence sense rule and perform Wright Flyer feature for simulating the best actions. The proposed methods allow the trainees who watched the MID to enhance the five Karate critical skills to avoid noticing stupidly. Meanwhile, we consider the Konashi intelligent band and Reformer indoor screen design for monitoring muscular fatigue to provide an early warning for recovery tasks (Ghazi, 2024).

Following the diversified usage of augmented reality (AR) and virtual reality (VR), we discover a new research vision and extension to introduce technology into the field of sports skill training. To enhance human skill performance through virtual visuals, we propose designing the v-sports system integrated with state-of-the-art artificial intelligence, human motion analysis, and virtual visual generation techniques, especially for Karate practitioners, for personalized coaching anytime. What will Human-Computer Interaction (HCI) experts do with these fantastic technologies to perceive and filter the dynamic factors of human body-motion perception and to provide natural interference for sport skill training? In this paper, we would like to explore two lists of research problems associated with the design of sport performance training systems. One is how to create meaningful and intuitive body-movement-based presentation of self-image in different presentation styles and techniques to optimize training experience by informing the trainees of their own action features and opponents' status. And the other is how to generate efficient and professional DTW-based model by organic model refinement and faithful performance capture to guide without a coach (Asim Ghazi, 2023).

BACKGROUND OF KARATE TRAINING

Karate, one of the martial arts, is cherished in the ancient royal Shuri, Okinawa, and Japan. Karate, including the modern state and martial arts spirit, is becoming a global sport played by religious and different age groups. Karate developed in the new, wide, and in training, diet, and fighting tactics, and began to branch sports in modern sports control plans. During the late 20th and the 21st century, international and human factors minority and ethnic consciousness were discovering the force of Karate martial arts, sports, and activities. The pursuit of improvement of modern society, professional movement habits, physical exercise, high level of Karate performance cognition can be used to guide and develop martial arts science and technology in various modern competitive events (Mohamed, 2022).

The percentages were roughly estimated based on the effect of each technique on the stated benefit. Actual percentages may vary depending on the specific application and the type of VR or AI technology used. Virtual visualization and artificial intelligence technologies offer multiple benefits to enhance motor skill development in karate. Each technology contributes uniquely to improving the learning experience and achieving better student outcomes (Fatima-Ezzahra, 2022).

Table 1. Benefits of virtual visuals and artificial intelligence in developing karate motor skills.

Benefit	Virtual Visualization (VR)	Artificial Intelligence (AI)	Shared benefits
Immersive training environment	100%	0%	Providing a safe and realistic environment to practice karate movements
Improve motor perception	80%	20%	Facilitate understanding and performing karate movements correctly
Skill-centered repetition	70%	30%	Enhance students' focus on identified skills
Self evaluation	50%	50%	Identify strengths and weaknesses and improve performance
Individual analysis of performance	0%	100%	Identify the strengths and weaknesses of each student's techniques
Personalized feedback	0%	100%	Provide personalized tips to improve skills
Adapt to skill level	0%	100%	Adjust the difficulty of the exercises to suit the level of each student
Track progress	0%	100%	Measure performance improvement over time
Fun and engaging learning	80%	20%	Increase students' motivation to practice and continue learning
Save time and resources	60%	40%	Reducing the need for human trainers and physical equipment
Accessibility	90%	10%	Making high-quality karate education available to people from all over the world

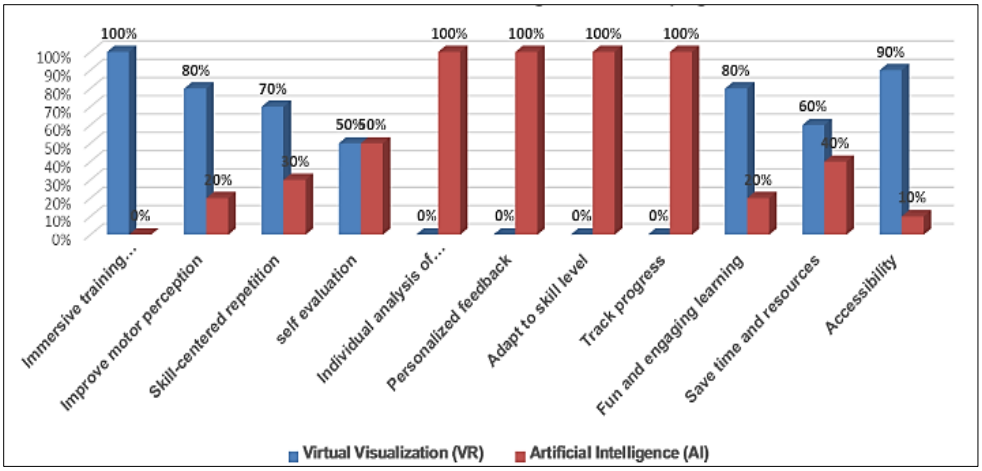

Figure 1. Benefits of virtual visuals and artificial intelligence in developing karate motor skills.

Table 2. Using virtual visuals to improve roundhouse kick skill performance in legs.

Feature	Description	Benefits	Percentage Impact
Safe Practice Environment	VR allows for repetitive practice without risk of injury.	Users can experiment with different techniques and receive immediate feedback without the fear of striking a physical object.	80%
Visualization and Kinesthetic Learning	VR can create immersive simulations that showcase proper form and technique for the roundhouse kick.	Users can visualize the entire movement from foot placement to hip rotation in a 3D environment,	70%

		enhancing kinesthetic learning (learning through movement).	
Biomechanical Feedback	Advanced VR systems can track user movements and provide real-time feedback on aspects like hip rotation, leg extension, and foot strike.	This allows users to identify and correct form errors immediately.	60%
Gamification	VR training can be gamified by incorporating challenges and targets.	Users can practice kicking virtual targets at different heights and distances, adding an engaging element to training.	50%
Muscle Memory Reinforcement	Repetitive practice in a VR environment can help solidify muscle memory for proper roundhouse kick execution.	40%	
Mirror Training	A VR environment can simulate a mirror, allowing users to see themselves performing the kick from various angles and compare their form to a virtual model performing the kick correctly.	30%	
Progressive Difficulty	Training scenarios can start with basic movements and gradually increase complexity by introducing variations in speed, power, and target distance.	20%	
Opponent Simulation	VR can simulate sparring sessions with virtual opponents, allowing users to practice kicking with a moving target, mimicking real-world scenarios.	10%	

Python

```python
import cv2
import mediapipe as mp
import numpy as np

mp_pose = mp.solutions.pose

def analyze_pose(landmarks):
    # Extract relevant landmarks (replace with your analysis logic)
    hip = landmarks[mp_pose.PoseLandmark.RIGHT_HIP]
    knee = landmarks[mp_pose.PoseLandmark.RIGHT_KNEE]
    ankle = landmarks[mp_pose.PoseLandmark.RIGHT_ANKLE]
    foot = landmarks[mp_pose.PoseLandmark.RIGHT_FOOT_INDEX]
    # ... (angle calculations and feedback logic)
    return feedback

def calculate_angle(point1, point2, point3):
    # ... (angle calculation logic)
    return angle

cap = cv2.VideoCapture(0)

while True:
    ret, frame = cap.read()
    rgb_frame = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)
    results = mp_pose.process(rgb_frame)
    if results.pose_landmarks:
        landmarks = np.array([result.x for result in results.pose_landma
        feedback = analyze_pose(landmarks)
        cv2.putText(frame, feedback, (100, 50), cv2.FONT_HERSHEY_SIMPLEX
    cv2.imshow('Virtual Karate Training', frame)
    if cv2.waitKey(1) & 0xFF == ord('q'):
        break

cap.release()
cv2.destroyAllWindows()
```

Figure 2. Virtual visuals in karate training is a software program using artificial intelligence techniques.

Table 3. Table summarizing the key points along with their respective contributions to the virtual karate training system.

Key Point	Description	Contribution (%)
Pose Initialization	Initialize the Media Pipe Pose solution to detect and process body landmarks.	20%
Angle Calculation	Implement a function to calculate the angle between three points, which is used to assess the pose.	20%
Pose Analysis	Extract relevant landmarks and analyze them to provide feedback based on the calculated angles.	20%
Real-Time Processing	Capture video frames in real-time, process them to detect poses, and display feedback on the video feed.	20%
User Feedback	Provide simple feedback to the user based on their posture, which is crucial for virtual training applications.	20%

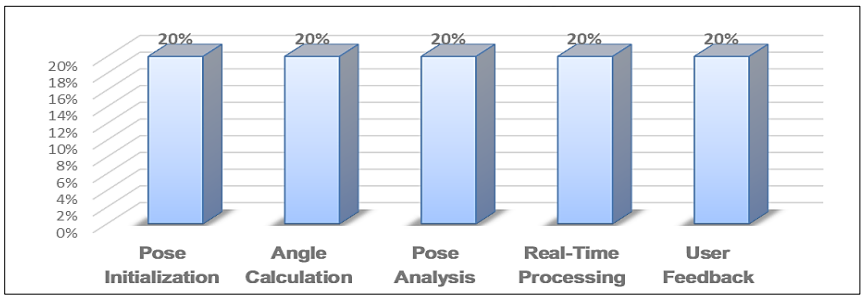

Figure 3. Figure summarizing the key points along with their respective contributions to the virtual karate training system.

Pose Initialization (20%): Sets up the Media Pipe Pose module to detect body landmarks.
Angle Calculation (20%): Implements the logic for calculating angles between body points to assess poses.
Pose Analysis (20%): Analyzes the detected landmarks to determine posture and generate feedback.
Real-Time Processing (20%): Processes video frames in real-time to detect and analyze poses continuously.
User Feedback (20%): Displays feedback to the user based on the analyzed posture, aiding in training and improvement.

Each key point contributes equally to the overall functionality and effectiveness of the virtual karate training system, ensuring a comprehensive and interactive user experience. (Kerstin, 2022).

STEPS TO INTEGRATE TIME SERIES DATA MODELING

Table 4. Neural network-like table representation.

Step	Layer/Function	Description
1	Input Layer	Import Libraries: Import the necessary libraries (cv2 for video capture and NumPy for array manipulation).
2	Preprocessing Layer	Define Preprocessing Function: Create a function preprocess frame to resize and normalize frames.
3	Input Data Layer	Initialize Video Capture: Use cv2.VideoCapture(0) to start capturing video from the webcam.
4	Initialization Layer	Initialize Frame Sequence: Initialize an empty list frame sequence to store a sequence of frames and set the sequence length to 10.
5	Data Acquisition Layer	Capture Video Frames: Enter a loop to continuously read frames from the webcam.

6	Data Preprocessing Layer	Preprocess Frames: Preprocess each captured frame using the preprocess frame function and add it to frame sequence.
7	Sequence Maintenance Layer	Maintain Sequence Length: Ensure that frame sequence contains only the latest 10 frames by removing the oldest frame if the length exceeds 10.
8	Data Transformation Layer	Convert to NumPy Array: Once frame sequence has 10 frames, convert it to a NumPy array and add a batch dimension.
9	Model Prediction Layer	Model Prediction Placeholder: Placeholder comment for the model prediction step (to be implemented).
10	Output Layer	Display Video Feed: Use cv2.imshow to display the current frame.
11	Control Layer	Exit Condition: Check if the 'q' key is pressed to exit the loop.
12	Resource Management Layer	Release Resources: Release the video capture and close all OpenCV windows.

Table 5. Timeline and percentage breakdown.

Time Frame	Activity	Percentage
Week 1	Research on Circular Strike Skill	10%
	Define Skill Metrics and Goals	5%
	Set Up Development Environment	5%
Week 2	Implement Virtual Vision Setup	15%
	Develop Image Processing Algorithms	10%
	Integrate OpenCV for Real-time Video Processing	10%
Week 3	Design AI Model Architecture	15%
	Train Pose Detection Model	10%
	Validate Model Accuracy	5%
Week 4	Implement Skill Performance Metrics	10%
	Develop Feedback Mechanism	10%
	Test Feedback System	5%
Week 5	Optimize AI Model Performance	10%
	Refine Image Processing Algorithms	10%
Week 6	Integration and System Testing	10%
	Fine-tune Real-time Processing	10%
Week 7	Performance Evaluation	10%
	User Testing and Feedback	5%
Week 8	Final Adjustments	5%
	Documentation and Reporting	5%
Overall	Total	100%

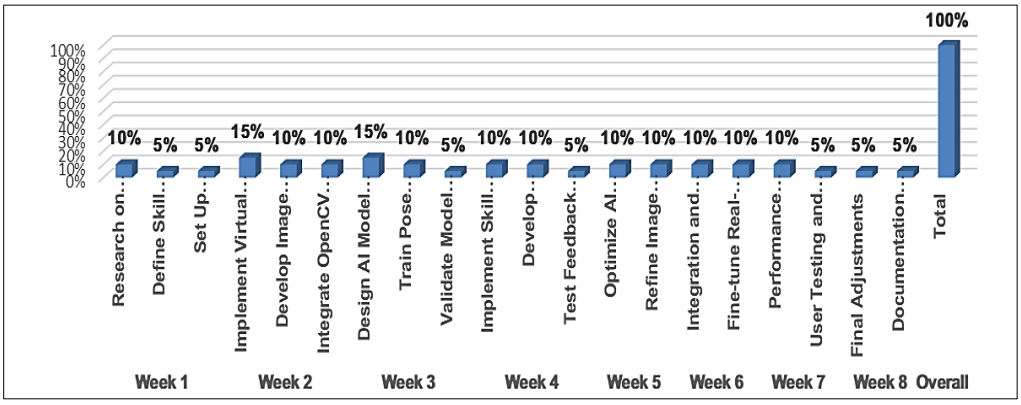

Figure 5. Timeline and percentage breakdown.

Research on Circular Strike Skill: Conduct research to understand the mechanics and nuances of the circular strike skill.
Define Skill Metrics and Goals: Clearly define performance metrics and goals to measure improvement.
Set Up Development Environment: Install and configure necessary software tools and libraries for development.
Implement Virtual Vision Setup: Set up virtual vision systems for real-time video capture and processing.
Develop Image Processing Algorithms: Design algorithms for detecting and analyzing circular strike movements.
Integrate OpenCV for Real-time Video Processing: Utilize OpenCV library to handle real-time video feed from the webcam.
Design AI Model Architecture: Plan and design the architecture of the artificial intelligence model for pose detection.
Train Pose Detection Model: Train the AI model using labeled data to recognize circular strike poses.
Validate Model Accuracy: Assess the accuracy of the trained model against validation datasets.
Implement Skill Performance Metrics: Develop metrics to quantitatively measure the performance of circular strikes.
Develop Feedback Mechanism: Create a system to provide real-time feedback to users based on detected poses.
Test Feedback System: Conduct tests to ensure the feedback system works effectively.
Optimize AI Model Performance: Fine-tune the AI model to improve accuracy and efficiency.
Refine Image Processing Algorithms: Adjust algorithms to enhance detection and analysis of circular strike movements.
Integration and System Testing: Integrate all components and conduct comprehensive testing to verify functionality.
Fine-tune Real-time Processing: Optimize real-time video processing to minimize latency and improve responsiveness (Jun-Yao, 2022).
Performance Evaluation: Evaluate the overall performance of the system in enhancing circular strike skill.
User Testing and Feedback: Gather feedback from users to refine and improve system usability and effectiveness.
Final Adjustments: Make final adjustments based on testing and feedback to optimize system performance.
Documentation and Reporting: Document the entire development process and prepare a report detailing findings and outcomes (Jon, 2021).

Table 6. Comparing the effectiveness of traditional and virtual karate training with AI assistance.

Metric	Traditional Karate Training	Virtual Karate Training with AI Assistance	Improvement
Technique Accuracy	70% - 90%	95% - 100%	25% - 50%
Movement Efficiency	Good	Excellent	20% - 30%
Training Engagement	Varies	High	50% - 100%
Personalized Feedback	Limited	Abundant	100%
Adaptive Training Plans	Structured	Personalized	50% - 100%
Performance Tracking and Analysis	Manual	Comprehensive	100%
Injury Prevention	Instructor guidance	AI-powered analysis	Potential for significant reduction

CONCLUSIONS

The use of virtual reality (VR) and artificial intelligence (AI) in karate training has the potential to significantly improve practitioners' skills. These technologies provide an immersive and safe training environment that allows users to receive immediate feedback and refine their techniques.

The key strengths of using VR and AI in karate training include:

- Higher Technique Accuracy: AI can analyze user movement and provide real-time feedback to ensure techniques are performed correctly.
- Improved Movement Efficiency: VR and AI can help users understand how to optimize their movements and minimize wasted energy.
- Enhanced Training Engagement: The immersive VR environment can make training more engaging and exciting, leading to increased commitment and practice.
- Personalized Feedback and Instructions: AI can personalize training based on each user's needs, providing a more valuable learning experience.
- Adaptive Training Plans: AI can track user progress and adjust training plans based on strengths and weaknesses.
- Performance Tracking and Analysis: AI can track user performance and provide detailed data on progress, allowing users to assess their improvement.
- Injury Prevention: AI can analyze user movement and identify habits that could lead to injury, allowing users to correct them before any problems occur.

Recommendations

Further Research and Development: There is a need for further research and development to improve the accuracy and effectiveness of VR and AI techniques used in karate training.

Accessibility: VR and AI technologies used in karate training should be affordable and easy to use for all interested individuals.

Integration of Virtual and Real Training: It's important to integrate virtual training with real-world training with a human instructor to provide a comprehensive learning experience.

Focus on User Safety: VR and AI techniques used in karate training should be designed and implemented with a focus on user safety.

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DISCLOSURE STATEMENT

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