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# Image Recognition and AI in Sports: A Survey on Technology Adoption and Consumer Behavior

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## Abstract

This survey provides a comprehensive examination of the integration of advanced technologies, such as image recognition and artificial intelligence (AI), in the sports and fitness industry. It explores how these technologies enhance training methodologies, boost customer engagement, and influence consumer behavior, ultimately aiming to improve athletic performance and foster customer loyalty. The survey systematically delves into key areas, including the role of image recognition in sports training, the factors influencing AI adoption, and the impact of technology on customer participation and repurchase intention. It highlights successful case studies of AI adoption, underscoring the transformative potential of these innovations in performance analysis and consumer interaction. Despite the promising advancements, the survey identifies significant challenges, such as data security, privacy concerns, and technological limitations, that must be addressed to optimize the applicability of AI models in diverse sports contexts. It emphasizes the need for continued research to enhance model robustness, computational efficiency, and user engagement. By addressing these challenges and pursuing innovative research directions, the sports industry can fully leverage the potential of AI and image recognition technologies, driving innovation and enhancing both athletic performance and consumer satisfaction.

## 1 Introduction

### 1.1 Structure of the Survey

This survey systematically examines the integration of advanced technologies, particularly image recognition and artificial intelligence (AI), within the sports and fitness industry. The structure is designed to facilitate a comprehensive exploration of the topic. The introduction establishes the relevance and impact of these technologies on training methodologies and consumer behavior. Following this, the Background and Definitions section elucidates core concepts—such as image recognition, AI in sports, technology adoption, consumer behavior, customer participation, and repurchase intention—while exploring their interrelations in the context of sports and fitness.

Subsequent sections delve into specific aspects of the survey. The section on Image Recognition in Sports Fitness Training discusses the enhancement of training methodologies and athletic performance through image recognition technology, providing current examples and potential future developments. The AI in Sports and Technology Adoption section analyzes factors influencing AI adoption in the sports industry, supported by successful case studies.

Further, the survey investigates Customer Participation and Consumer Behavior, focusing on how technology influences customer engagement, motivation, and satisfaction. The section on Repurchase Intention and Customer Loyalty examines the relationship between technology use and repurchase intentions, illustrating how improved customer experiences can foster loyalty and encourage repeat purchases.

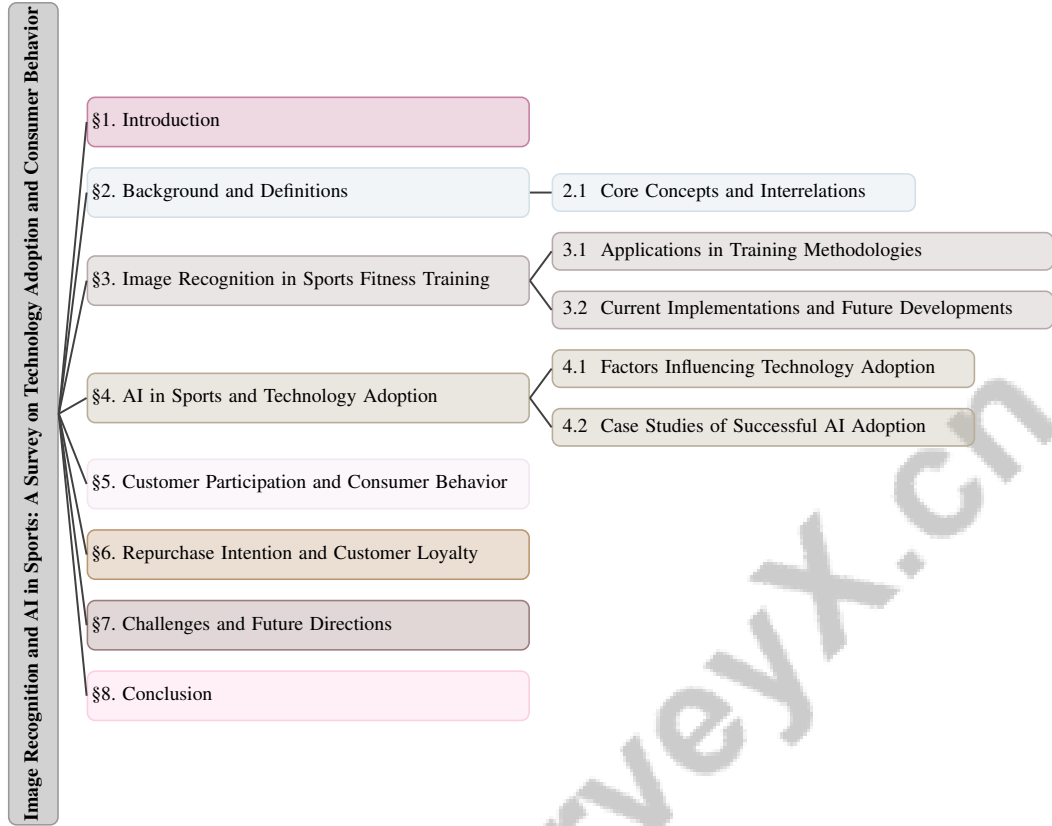


Figure 1: chapter structure

The survey concludes with an analysis of Challenges and Future Directions, addressing privacy concerns, data security, and technological limitations, while proposing future research avenues and potential advancements in this interdisciplinary field. The conclusion synthesizes key findings regarding the transformative effects of image recognition and AI on sports fitness training, customer engagement, and consumer behavior. It emphasizes the enhancement of brand loyalty and purchasing intentions, supported by research indicating that over 33

## 2 Background and Definitions

### 2.1 Core Concepts and Interrelations

The integration of image recognition and artificial intelligence (AI) in sports and fitness is driven by several interconnected concepts that enhance training methodologies, consumer engagement, and technology adoption. Image recognition technology is crucial, enabling precise object identification within images. This is significantly improved through collaborative feature learning, which uses user behavior data to derive latent image representations without category labels, thus enhancing system accuracy and efficiency [1]. Advancements in person re-identification (re-id) models further improve the reliability of image recognition in dynamic sports contexts by adapting to varying test environments [2].

To capture accurate spatial information under challenging conditions, mmWave radar technology offers a cost-effective solution, although its use in static gesture recognition remains underexplored [3]. Edge AI accelerators also provide high-performance solutions within strict area and power constraints, facilitating real-time AI deployment in sports environments [4]. Achieving a balance between informativeness and representativeness in sample selection is critical for AI model generalization, yet existing methods often fall short, leading to suboptimal outcomes [5].

Recent deep learning advancements, notably the CPC-R algorithm, enhance the representation of non-image data by using pair values mapping instead of traditional single value mapping [6]. The

integration of convolution and self-attention mechanisms, which rely on 1×1 convolution operations, shows promise in improving computational efficiency and model performance [7]. Addressing perspective distortion in images, especially in tasks like object detection and crowd counting, remains challenging, as benchmarks aimed at mitigating these issues indicate [8].

The inadequate representation of motion by 3D CNNs in activity recognition is a critical concern, with current methods failing to effectively separate motion from spatial context [9]. Recognizing human behaviors is further complicated by the inability of current methods to integrate and utilize multimodal data, such as depth and skeletal information [10]. Robust adverse pre-training and its aggressive variant generalize conventional unsupervised pre-training and data augmentation methods, improving resilience in visual recognition under adverse conditions [11]. Additionally, the Temporal Contrastive Learning (TCL) framework enhances action recognition by maximizing similarity between representations of the same video at different speeds [12].

These concepts collectively illuminate the complex interrelations between image recognition, AI, and consumer behavior in sports and fitness, highlighting both challenges and opportunities in leveraging technology to enhance athletic performance, customer satisfaction, and brand loyalty. The proposed S-ConvNet, a shallow convolutional neural network, exemplifies this by recognizing neuromuscular activities from instantaneous HD-sEMG images without pre-training [13]. Moreover, incorporating image-to-text translation in interactive machine learning (IML) systems allows users to define tasks using text outputs rather than predefined categories, enhancing flexibility and user engagement [14]. The challenges of performance variability in meta-learning algorithms and data deficiency in few-shot learning underscore the need for robust data representation and decision boundary learning. Revisiting multinomial logistic regression through Gaussian distributions, RGC methods provide a foundation for initializing deep neural networks, enhancing AI’s applicability in sports contexts [15].

### 3 Image Recognition in Sports Fitness Training

Category	Feature	Method
Applications in Training Methodologies	Model Enhancement Techniques	DynTTA[16], D-ISP[17], E2E-3M[18], ODCA[19]
	Vision and Spatial Processing	AG-Net[20], VEDM[21], SRM[9]
Current Implementations and Future Developments	Augmentation Strategies	SITTA[22]
	Adaptive Techniques	TEMP[2]
	Real-Time Performance	DI[23]
	AI Enhancement	AOF[24]

Table 1: The table presents a comprehensive overview of image recognition technologies employed in sports fitness training, categorized into applications in training methodologies and current implementations with future developments. It details specific features and methods, including model enhancement techniques, vision and spatial processing, augmentation strategies, adaptive techniques, real-time performance, and AI enhancement, highlighting their roles in optimizing athletic training experiences.

In sports fitness training, image recognition technologies have significantly advanced performance analysis and athlete development methodologies. This section examines these technologies’ applications within training frameworks, emphasizing their role in enhancing training precision and adaptability. Table 1 provides a detailed summary of the image recognition technologies and methods applied in sports fitness training, emphasizing their applications in training methodologies and current implementations as well as future developments. Additionally, Table 2 offers a comprehensive comparison of distinct image recognition technologies utilized in sports fitness training, elucidating their unique features and applications in refining training methodologies. As illustrated in Figure 2, the hierarchical structure of image recognition technologies categorizes applications into advanced models and techniques, data augmentation and model adaptation, current implementations, and future developments. This categorization highlights the transformative impact of these technologies on athletic performance, focusing on their practical implications and effectiveness in optimizing athlete training experiences.

#### 3.1 Applications in Training Methodologies

Image recognition technologies have revolutionized sports training methodologies by improving the precision, efficiency, and adaptability of performance analysis. Integrating advanced models like

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Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) into real-time environments facilitates complex recognition tasks, offering instantaneous feedback and dynamic training adjustments [18]. Moreover, Vision Transformer models paired with GPT-2 enhance interaction and decision-making during training [21].

DynamicISP offers state-of-the-art accuracy in image recognition with low computational costs, refining training methodologies by providing high-quality image processing [17]. Similarly, DistInference optimizes training by distributing Deep Neural Network (DNN) layers across multiple UAVs, crucial for maintaining high accuracy in dynamic sports settings [23].

The Single Image Texture Translation and Augmentation (SITTA) technique augments data by translating textures from a single image, enhancing model adaptability [22]. AG-Net refines training methodologies by capturing spatial structures and focusing on critical performance areas [20]. Dynamic Test-Time Augmentation (DynTTA) improves athlete movement analysis by blending augmented images based on learned parameters [16].

Optimal Data-Driven Convolutional Architecture (ODCA) ensures effective model selection and tuning based on dataset characteristics [19]. Selective relevance maps highlight significant temporal changes in motion, focusing analysis on activity patterns [9]. Enhancing reflex models with reinforcement learning extends adaptability to environmental variations, improving training robustness [24]. These advancements underscore image recognition technologies' transformative impact on sports training, enabling precise, efficient, and adaptive performance analysis.

In Figure 3, the hierarchical categorization of advanced image recognition technologies and methodologies applied in sports training is illustrated. This figure highlights the integration of various neural network models, optimization techniques, and performance enhancement strategies that collectively contribute to refining sports training methodologies. Specifically, it showcases the performance of transfer and meta-learning algorithms against VTAB and Meta datasets, providing insights into their capabilities in processing sports data. Furthermore, the deployment of Recurrent Neural Networks (RNN) with Long Short-Term Memory (LSTM) architecture exemplifies the sophistication of current training technologies, adept at handling sequential data for analyzing and predicting athletic performance over time. These examples underscore the transformative impact of image recognition and machine learning on refining training methodologies within the sports fitness domain [25, 26].

### 3.2 Current Implementations and Future Developments

Current implementations of image recognition in sports fitness training leverage advanced models to enhance performance analysis and efficiency. Models like MobileNetV2, ResNet101V2, DenseNet121, and InceptionV3 have been evaluated for sensitivity to variations in deep learning frameworks, emphasizing framework stability's importance for consistent recognition performance [27]. The TEMP method exemplifies test-time adaptation for person re-identification, enhancing performance by minimizing prediction uncertainty and adapting pre-trained features to dynamic environments [2].

SITTA has improved image classification tasks by augmenting data with translated textures [22]. DistInference maintains low latency in image classification, even with increased request complexity, valuable for real-time sports applications [23].

Future developments focus on AI-driven filtering agents to enhance image quality and recognition performance. Q-Learning and LinUCB-based agents have shown promise in improving image quality, suggesting future research avenues [24]. Exploring novel architectures and integrating technologies like edge computing and mmWave radar are expected to drive advancements in image recognition, offering efficient and scalable solutions for sports training. These developments highlight the potential for continued innovation, aiming to refine training methodologies and enhance athletic performance.

## 4 AI in Sports and Technology Adoption

### 4.1 Factors Influencing Technology Adoption

The adoption of AI technologies in sports is shaped by perceived benefits, ease of use, and external pressures. As illustrated in Figure 4, the key factors influencing this adoption are categorized into perceived benefits, challenges, and external pressures, with each category highlighting specific

Feature	DynamicISP	DistInference	SITTA
<b>Model Type</b>	Image Processing	Dnn Distribution	Texture Translation
<b>Key Feature</b>	Low Computational Costs	Layer Distribution	Data Augmentation
<b>Application Focus</b>	Training Refinement	Dynamic Sports Settings	Model Adaptability

Table 2: This table provides a comparative analysis of three image recognition methods applied in sports fitness training: DynamicISP, DistInference, and SITTA. It highlights their model types, key features, and specific application focuses, emphasizing their roles in enhancing training methodologies through low computational costs, layer distribution, and data augmentation.

examples and challenges drawn from the referenced literature. AI’s perceived effectiveness, such as Vision Transformer models with GPT-2 that provide immediate feedback from visual inputs, enhances consumer engagement and brand loyalty by enriching coaching experiences [21]. However, challenges like the subjective nature and high computational demands of current image synthesis methods can hinder practical applications [22]. Additionally, the lack of tailored AI explanations limits the utility of insights [28].

Neural network architectures and regularization techniques reflect the need for adaptable, user-friendly AI solutions [29]. FoodAI exemplifies user-friendly applications, automating food logging to promote consistent dietary tracking, with implications for other sports applications [30]. External pressures also drive technology adoption, as seen in AG-Net’s development, which eliminates manual annotations and improves accuracy and usability [20].

Challenges in generalizing models to real-world conditions, such as noise or poor lighting, remain significant [24]. The need for adaptable AI is underscored by the complexities of adopting test-time adaptation methods for person re-identification in open-set tasks [2]. Innovations like wall time penalties for fitness evaluation demonstrate potential for accelerating convergence without losing accuracy [31].

These factors highlight the interplay of technological, environmental, and user-centric considerations in AI adoption in sports. Continuous research and innovation must enhance AI usability, accessibility, and efficiency, particularly for non-experts. Addressing data preparation, application modeling, and deployment barriers is crucial for mass adoption across sectors like healthcare and autonomous driving. Collaboration between AI researchers and practitioners, incorporating insights from domain experts, is essential to ensure AI technologies remain effective and user-friendly [32, 33, 34].

## 4.2 Case Studies of Successful AI Adoption

Case studies illustrate AI’s transformative impact on sports, enhancing performance analysis and training methodologies. AI-driven image recognition systems using architectures like MobileNetV2 and DenseNet[21] improve performance analysis accuracy and efficiency in dynamic sports, recognizing complex motion patterns and enabling precise training regimens [27].

AI’s role in automating dietary tracking is highlighted by the FoodAI system, which uses image recognition to log food items, streamlining processes and increasing adherence to dietary plans [30]. This enhances nutritional assessment accuracy and provides real-time feedback for informed dietary choices, boosting performance outcomes.

In sports training, AI systems like AG-Net refine methodologies by targeting key performance areas. By identifying semantic regions through keypoints, AG-Net supports targeted training interventions, offering nuanced insights into athlete movements and facilitating effective training strategies [20].

AI-driven test-time adaptation methods, such as TEMP, enhance robustness and accuracy in person re-identification by modifying similarity between query and gallery features to reduce prediction uncertainty [2].

These case studies showcase AI’s diverse applications and benefits in sports, driving precision, efficiency, and adaptability in performance analysis and training. This technological integration marks a transformative phase in sports, optimizing training regimens tailored to individual athletes and enhancing athletic performance. AI also fosters brand loyalty and influences consumer behaviors

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in the sports market, as recent studies on emerging technologies in sports sponsorship and advertising reveal [34, 35, 21, 36, 33].

## **5 Customer Participation and Consumer Behavior**

### **5.1 Influence of Technology on Customer Participation**

Technology integration in the sports and fitness sector has significantly transformed customer engagement by facilitating personalized and interactive experiences. Advanced technologies, such as image recognition and artificial intelligence, promote diverse and frequent usage patterns among fitness enthusiasts, thereby increasing revisit intentions due to the innovative and effective fitness solutions offered [37]. Moreover, digital tools enhance trust and emotional connections between fitness coaches and clients through consistent communication and personalized feedback, strengthening relationships and boosting customer satisfaction [38]. This emotional connection is crucial for customer retention and ongoing participation in fitness activities. Additionally, the concepts of Customer-Company Identification (CCI) and Customer-Brand Identification (CBI) highlight technology's role in enhancing Customer-Brand Engagement (CBE), as digital platforms strengthen consumer-brand connections and positively influence loyalty and advocacy behaviors [39]. Consequently, technology not only enhances initial customer participation but also fosters sustained engagement and brand loyalty in the sports and fitness sector.

### **5.2 Consumer Motivation and Satisfaction**

Technology plays a pivotal role in influencing consumer motivation and satisfaction in the sports and fitness sector by enriching user experiences and meeting expectations for personalized service. Innovative technologies, especially in sports sponsorship advertising, significantly impact brand loyalty and purchase intentions, with loyalty accounting for over 33% of purchasing behavior. Strategic technological applications, such as innovative fitness solutions and effective training partners, enhance user engagement and revisit intentions, thereby deepening consumer allegiance and promoting sustained purchasing behaviors [37, 36]. Advanced technologies, including artificial intelligence and image recognition, enable personalized training programs and interactive fitness platforms, motivating consumers through engaging and dynamic workout experiences, with real-time feedback and progress tracking being essential for maintaining motivation and achieving fitness goals. The relationship between service quality and customer loyalty is critical to understanding consumer satisfaction. Technological advancements that enhance service quality lead to increased customer loyalty and repurchase intentions, as demonstrated by comparative studies on various methods and their effectiveness [40]. This underscores the importance of continuous service delivery improvement through technology to meet and exceed consumer expectations. Furthermore, technology's ability to foster community and connection among users significantly enhances consumer satisfaction by facilitating meaningful interactions between consumers and brands, as well as among consumers themselves. This dynamic engagement fosters emotional and cognitive ties, driving repurchase intentions and ongoing search behaviors, ultimately leading to greater consumer loyalty and satisfaction [33, 38, 36, 39]. Digital platforms encourage social interaction and support among fitness enthusiasts, creating an environment where users feel motivated and valued. This sense of community, combined with the convenience and accessibility of technology-driven fitness solutions, contributes to heightened consumer satisfaction, resulting in increased engagement and loyalty in the sports and fitness industry.

## **6 Repurchase Intention and Customer Loyalty**

### **6.1 Impact of Technology on Repurchase Intention**

In the sports and fitness sector, technology significantly influences repurchase intentions by aligning customer expectations with perceived service quality. AI-driven applications and image recognition systems enhance personalization, bridging the gap between consumer expectations and service delivery, which is essential for fostering loyalty and repeat purchases [40]. Leisure involvement, facilitated by interactive fitness platforms and virtual coaching, enhances user engagement and

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positively impacts repurchase intentions, with commercial friendships strengthening consumer-brand connections [38].

Cognitive, emotional, and behavioral engagements are crucial for determining repurchase intentions. Interactive platforms that promote cognitive engagement drive ongoing search behavior, while immersive experiences foster emotional and behavioral engagement, essential for encouraging repeat purchases [39]. Studies emphasize the role of innovative technologies in sports sponsorship, highlighting their influence on brand loyalty and purchase intentions, accounting for over 33

## 6.2 Service Quality and Customer Loyalty

Technology-driven innovations are critical for enhancing service quality and fostering customer loyalty in the sports and fitness sector. This survey categorizes research into service quality, customer loyalty, and repurchase intention, highlighting their interrelations [40]. AI and image recognition systems improve service quality by offering personalized solutions that align with consumer expectations, facilitating seamless interactions and real-time feedback essential for user satisfaction.

The integration of technology in service delivery elevates perceived service value and strengthens emotional and cognitive consumer-brand connections, vital for loyalty cultivation. Advanced technologies in marketing customize consumer experiences and foster a robust user community, enhancing loyalty by creating an environment where consumers feel valued and understood. Personalized interactions, especially via social media, enhance consumer engagement and encourage ongoing brand participation, influencing repurchase intentions and loyalty [33, 36, 39, 40].

Continuous service quality improvement through technological advancements encourages repeat purchases by ensuring positive consumer experiences. This enhancement is crucial for maintaining a loyal customer base, reinforcing consumers' brand choices. Technology-driven service quality improvements are essential for fostering loyalty within the competitive sports and fitness industry. Emerging technologies strengthen brand loyalty and influence purchasing intentions, with brand loyalty serving as a vital mediator in this relationship. Research on health and fitness clubs underscores the positive correlation between improved service quality, customer loyalty, and repurchase intentions, emphasizing the need for managers to align service delivery with customer expectations to enhance competitive advantage [36, 40].

## 7 Challenges and Future Directions

### 7.1 Challenges and Limitations

The integration of advanced technologies such as image recognition and artificial intelligence (AI) into sports and fitness is fraught with challenges that impede their full potential. Deep learning models, while successful in fields like image and speech recognition, require extensive datasets and struggle with generalization across diverse tasks, exacerbated by issues like catastrophic forgetting, where sequential task training overwrites previously learned information. This limitation necessitates complementary techniques to enhance model robustness and generalization, particularly in real-time sports applications [29, 32, 41, 5]. The computational demands of Convolutional Neural Networks (CNNs) during training and evaluation, coupled with the incompatibility of essential image processing libraries across platforms, further complicate their application. Additionally, the robustness and consistency of AI systems require improved benchmarking methods, especially in real-time scenarios, where hardware compatibility issues add complexity to system design.

Privacy and data security concerns further complicate AI deployment, particularly in resource-intensive environments like IoT devices. Ensuring model performance while mitigating backdoor behaviors presents a significant security challenge. High-quality, diverse datasets are crucial for effective and generalizable AI models, with active learning strategies enhancing dataset representativeness and informativeness. However, backward compatibility and the complexities of causal relationships in data must be addressed to reduce errors and bolster user trust [5, 42, 43, 34]. Technological limitations, like execution cycles for specific filter sizes in convolution engines, present additional challenges. Methods such as TEMP may underperform when distribution shifts occur, resulting in knowledge loss, while reliance on UAVs for communication introduces challenges in real-time image recognition due to resource exhaustion.

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The use of single texture sources in methods like SITTA may limit pattern diversity and accuracy, and extensive user interaction required by methods such as CX-ToM can be impractical in real-time scenarios. The statistical heterogeneity of data from different UAVs complicates federated learning model convergence, particularly when labeled data is scarce due to high annotation costs. Current methods' reliance on predefined filters may not adequately address all image quality issues [24]. Addressing these challenges requires enhancing model robustness, optimizing computational efficiency, and ensuring data security to successfully integrate AI and image recognition technologies in sports and fitness.

## 7.2 Future Research Directions and Opportunities

The integration of image recognition and AI in sports presents numerous research opportunities to advance the field. Enhancing meta-learning algorithms to improve robustness and explore alternative strategies for support data selection and evaluation can optimize AI model adaptability in dynamic sports environments, improving performance analysis [44]. Extending AI systems' action space to include sophisticated image quality correction filters and developing realistic reward schemes can enhance AI technologies' practical utility in sports, ensuring they meet diverse user needs [24].

Improving user interaction with text-based machine learning algorithms is essential for enhancing task definition efficiency and accuracy, facilitating effective communication and task execution in sports settings [14]. Developing robust feature representations and optimizing training methodologies in few-shot learning tasks can address challenges like dataset bias and limited labeled data utilization. By examining relationships between base and novel categories, enhancing feature extraction through sophisticated network architectures, and employing strategies such as continual local replacement and active learning frameworks, researchers can improve classification performance while minimizing computational costs. These advancements ensure few-shot learning models can adapt to new categories with minimal data, leading to more efficient and accurate image recognition systems [44, 45, 46, 47, 5].

In sports nutrition, enhancing model adaptability to recognize new food items and exploring lifelong learning techniques will improve user experience. Validating and adapting innovative performance improvement methods to diverse datasets will ensure effectiveness in real-world scenarios. Incorporating advanced techniques like vision encoder-decoder models for AI coaching facilitates seamless interactions between visual inputs and textual guidance. Active learning strategies combining representativeness and informativeness refine training sets, improving classification performance across applications. Exploring transfer and meta-learning approaches can address challenges related to limited data and out-of-distribution performance, leading to versatile AI solutions in sports and beyond [5, 21, 25].

Enhancing AI systems' interpretability and usability in sports offers significant opportunities for advancing AI integration. Developing accessible explanations for non-experts and exploring causal reasoning within knowledge graphs can mitigate AI's black-box nature, fostering trust and understanding among domain experts. This focus promotes user-friendly AI applications leveraging professional sports expertise. By emphasizing causal analysis and employing techniques like Concept Localization Maps and active learning frameworks, AI decision support systems' reliability and practicality improve, fostering greater acceptance and utilization of AI technologies in sports [42, 34, 48, 5, 21]. Pursuing these research directions enables the sports industry to fully harness image recognition and AI technologies' potential, enhancing athletic performance, improving customer satisfaction, and fostering innovation in this dynamic field.

## 8 Conclusion

This survey underscores the significant impact of image recognition and AI technologies on the sports and fitness industry, with a focus on refining training methodologies, enhancing consumer engagement, and shaping behavior. The integration of advanced image recognition and AI solutions has revolutionized performance analysis, enabling the creation of precise, adaptive training regimens that significantly enhance athletic performance. Moreover, AI's capabilities in automating dietary tracking and optimizing training strategies demonstrate its potential to streamline processes and boost user engagement.



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Technology's influence on consumer behavior is evident in increased customer satisfaction and loyalty, achieved through personalized and efficient service. AI-driven fitness applications and image recognition systems have effectively aligned customer expectations with their experiences, strengthening loyalty and promoting repeat purchases. Additionally, technology's role in enhancing leisure activities and building emotional connections between consumers and brands highlights its importance in influencing repurchase intentions.

However, challenges such as dataset bias, privacy concerns, and technological constraints persist. Addressing these issues is crucial for maximizing AI model effectiveness in varied and dynamic sports contexts. Continued research and development are essential to improve model robustness, computational efficiency, and data security, thereby facilitating the seamless integration of AI and image recognition technologies in the sports and fitness sectors. By exploring innovative research pathways and overcoming existing obstacles, the sports industry can fully harness these technologies, ultimately driving innovation and enhancing both athletic performance and customer satisfaction.

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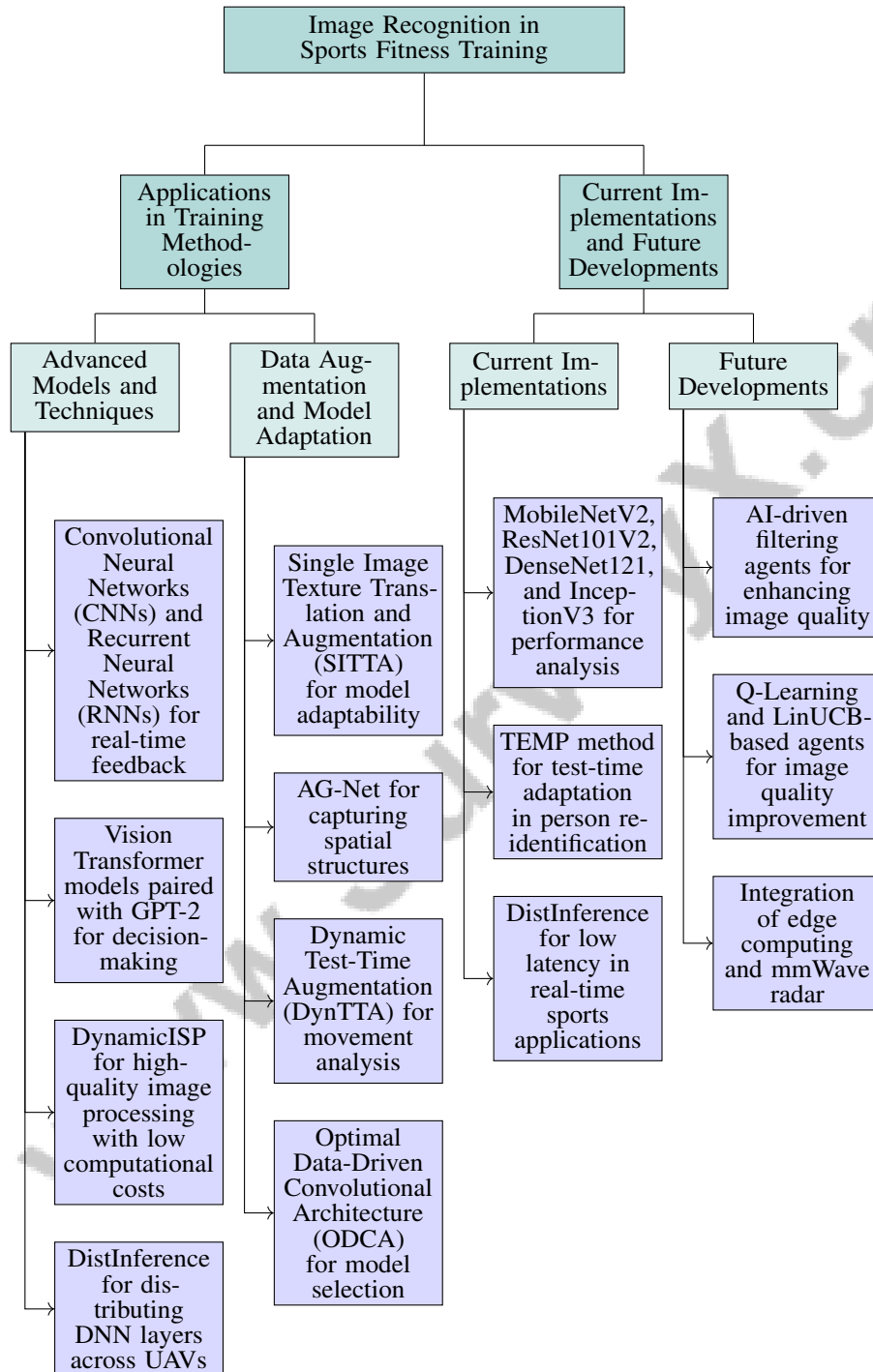


Figure 2: This figure illustrates the hierarchical structure of image recognition technologies in sports fitness training. It categorizes the applications into advanced models and techniques, data augmentation and model adaptation, current implementations, and future developments, highlighting their roles in enhancing training methodologies and performance analysis.

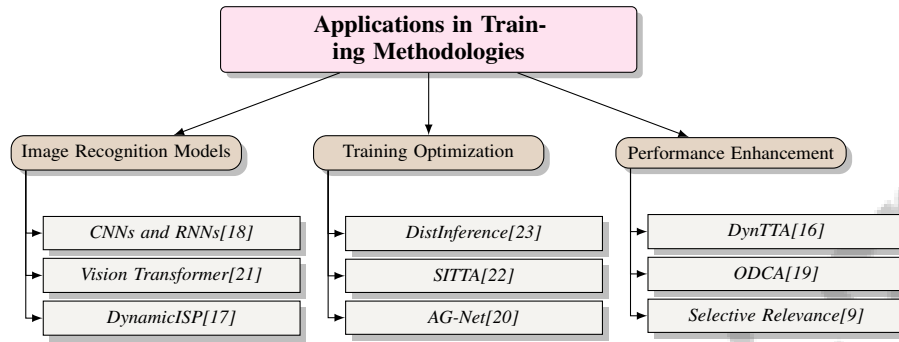


Figure 3: This figure illustrates the hierarchical categorization of advanced image recognition technologies and methodologies applied in sports training. It highlights the integration of various neural network models, optimization techniques, and performance enhancement strategies that collectively contribute to refining sports training methodologies.

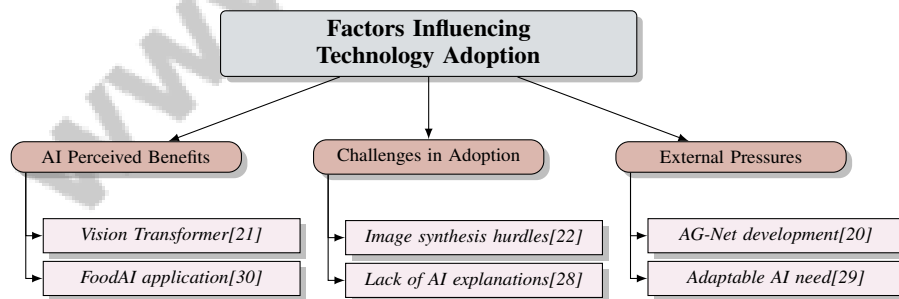


Figure 4: This figure illustrates the key factors influencing the adoption of AI technologies in sports, categorized into perceived benefits, challenges, and external pressures. Each category highlights specific examples and challenges from the referenced literature.