Use of Advanced Technologies for Personalized Training in Fitness

Lah Luka, Mirjana Kljajić Borštnar

University of Maribor, Faculty of organizational sciences, Kranj, Slovenia
luka1.lah@gmail.com, mirjana.kljajic@um.si

In the paper we address utilization of advanced technologies for supporting physical exercises backed by sports theory. Despite the availability of digital technologies, wearable sensor devices and AI methods for monitoring heart rates and planning training sessions, there is currently no all-encompassing solution for customizing fitness routines based on individual health and capabilities. For this purpose, we propose to develop a comprehensive framework that utilizes information from personal trainers to personalize workout programs at fitness centres. This proposed framework aims to address this gap by analysing user data to tailor exercises according to specific requirements, including age, abilities, and injury history. The objective is to make exercise more accessible and safer, reducing reliance on often costly personal trainers. In this paper we present an initial proposal rather than a finished product. Future work involves creating a prototype, assessing its efficiency, and integrating measures for preventing injuries, ultimately improving quality of life through healthier lifestyles and accessible fitness training.

Keywords: artificial intelligence, fitness, training program, neural networks, expert systems

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1 Introduction

To effectively address the challenge of limited availability of comprehensive sports theory on the internet and the resulting difficulty in finding trustworthy sources for effective training routines, we must also consider the important issue of data utility. The extensive amount of data gathered through wearable technology and other fitness tracking devices loses much of its value without a strong foundation in sports theory. This lack of theoretical knowledge makes it challenging for individuals, including personal trainers who may not have formal qualifications in sports science, to interpret the data accurately. Therefore, even with advanced technologies at our disposal, we are unable to fully optimize training routines based on collected health metrics. The absence of accurate understanding in sports theory leads to a reliance on potentially ineffective or harmful training methods, underscoring the critical need for accessible and reliable sports theory resources.

The progress of physical fitness training in this context is increasingly influenced by technological innovations (M. Xu et al., 2022), specifically in the fields of artificial intelligence (AI) and wearable technology (Omarov et al., n.d.). These advancements, such as AI-based virtual fitness coaches that provide instant feedback and personalized workout plans, along with wearable devices that monitor health metrics, signify a significant shift towards more efficient fitness routines. However, achieving a genuine transformation in physical fitness training requires integrating these technological solutions with a thorough comprehension of sports theory. By investigating the potential of these technologies alongside a strong foundation in sports theory, we can fully harness their capabilities to revolutionize physical fitness training. This will result in not just an abundance of collected data but also truly valuable insights for improving training outcomes.

2 Literature review

A variety of approaches and systems have been proposed to enhance the quality of training and rehabilitation while minimizing injuries and optimizing performance.

One innovative approach is seen in the utilization of AI algorithms for special movements in sports. Studies have explored how floating-point numbers in AI algorithms can optimize fitness functions and simulate training scenarios (Li &

Zhao, 2014). This work demonstrates how AI can be meticulously applied to track and improve the quality of sports training, ensuring that athletes reach their peak performance levels.

In parallel, the MOPET system exemplifies a context-aware, user-adaptive wearable system for fitness training (Buttussi & Chittaro, 2008). This system stands out for its focus on real-time data coming from sensors and its use of an embodied agent to provide interactive guidance, which can significantly benefit untrained individuals by providing motivation and safety advice tailored to personal fitness levels and environmental context.

Moreover, the development of pervasive mobile assistance systems in health and fitness scenarios (Emrich et al., 2014) shows the potential of mobile apps in personal fitness training, by considering users' health constraints and personal interests. Such systems exemplify how personalization and context-awareness can be effectively incorporated into training regimes.

Similarly, the design of a cable-driven interactive rehabilitation device with 3D trajectory tracking and force feedback (H. Xu et al., 2022) reflects an advance in rehabilitation equipment. This device allows for a more interactive and engaging form of physical therapy, which could be particularly beneficial for upper limb rehabilitation.

Further research has been conducted on the application of AI in sports training through case study approaches (Wei et al., 2021). These studies explore the intersection of AI technology with sports training, revealing the potential of AI to provide analytical support in physical education.

In addition, the use of recurrent neural models in sports training has been examined (Dhanke et al., 2022). Such models have been developed to analyse the effect of physical training and to aid in the treatment and prevention of sports injuries, which is essential for the long-term health and performance of athletes.

Another noteworthy development is the artificial intelligence-based tracking model for functional sports training goals in competitive sports (Zhao et al., 2021). This model focuses on functional physical training, showcasing the gradual shift from

elite athletes to grassroots level and highlighting the importance of advanced training concepts in sports injury prevention and performance enhancement.

Lastly, the realization of wireless sensors and intelligent computer-aided teaching in physical education (Wu & Zhang, 2022) demonstrates the integration of high-tech sensors and AI to facilitate improvements in teaching methods and the overall quality of physical education.

Collectively, these studies underscore a transformative shift in physical education and sports training. Through the lens of AI and advanced technology, researchers and practitioners are crafting innovative solutions that promise to enhance the way we train, rehabilitate, and understand the human body in motion. These advancements in digital technology, especially in wearable devices and AI, are establishing new standards in fitness training methods. The progress is leading us towards a future where personalized approaches and efficiency take centre stage in fitness and athletic training methodologies.

3 Methodology

In recent years the use of digital technology in training is gaining a lot of attention. To address the problem of comprehensive support in physical training, we aim to develop a conceptual model based on existing theories and practice. For this purpose, we first conducted a literature review to determine what is known, what we don't know and what are the functionalities and guidelines for the new model development. We followed the PRISMA model for literature review (Page et al., 2021) and searched the key words "sports", "fitness training", "physical training", "artificial intelligence" in the bibliographical databases Web of Science and Scopus for the past 20 years.

Physical AND training = 262057
Fitness AND training = 28588
"fitness training" = 926
"physical training" = 7932
"physical training" AND "artificial intelligence" = 43
"fitness training" AND "artificial intelligence" = 9
…

3.1 Proposing a personalized fitness model using advanced technologies

The integration of Artificial Intelligence (AI) and its subset Machine Learning (ML) in fitness training is fundamentally changing the way personalized fitness programs are created. Azlina & Mokmin (2020)exemplify how platforms like IVFIT employ AI to effectively engage individuals in physical activities without constant supervision, thus demonstrating its potential for enhancing independent fitness routines. However, Dergaa et al. (2023) argue that AI-generated fitness plans may lack specificity for long-term health improvement, underscoring the necessity for more interactive AI solutions in the realm of fitness.

Simultaneously, ML technologies are adapting exercise plans according to individual fitness levels and objectives. The research conducted by Iyer & Debang (2024), Nguyen et al. (2022), and Scheinker (2021) illustrates how ML can address evolving fitness needs, thereby augmenting the efficacy of workout regimens.

Wearable technology also plays a crucial role in the world of fitness by providing vital health data such as heart rates and movement patterns. Ryu et al. (2023) and Steedman (2023) showcase the profound impact wearables have on monitoring exercise routines and tailoring them to individual needs, ensuring accurate and up-to-date fitness guidance.

Our envisioned fitness model proposes the integration of Artificial Intelligence (AI), including its subset Machine Learning (ML) and wearable technology, to establish a framework for personalized fitness objectives. The model's architecture, featuring a GPT API (application programming interface) for the personalization of exercises, a Recurrent Neural Network (RNN) for the intelligent selection of exercises, and an expert system for tailored injury prevention advice, suggests a highly adaptive and user-specific fitness experience.

In this proposed model, a user-centric frontend would interact with sensor devices to collect real-time fitness data, which would then be processed by the backend to adaptively modify fitness routines based on immediate feedback. Anticipated to incorporate strong privacy protections, the proposed model aims to address health data concerns while offering customized training programs.

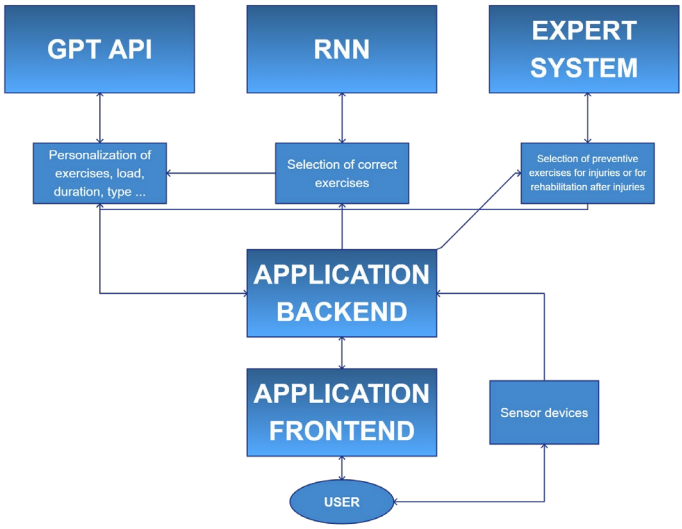

Figure 1: The proposed conceptual architecture of an AI-driven personalized fitness application

(Source: Own - diagram was made using pencil.evolus.vn)

While currently in the conceptual stage, this model has the potential to redefine personal fitness by extending its reach to professional athletic training and healthcare services. Its scalability and adaptability are indicative of its capacity for broader application, potentially leading to significant advancements in physical training and health optimization.

4 Utilizing GPT API for enhanced fitness experience

By incorporating the GPT API into our fitness model, we can explore new possibilities for customizing fitness plans. Building on Alao (2023) research, our model will feature an advanced AI assistant that dynamically adjusts diet and exercise recommendations in real time, providing a highly interactive and personalized training experience. The integration of Large Language Models (LLMs), as studied by Tesfagiorgis & Monteiro Silva (2023), will transform user interaction by simplifying access to complex fitness and nutritional information.

Additionally, we will prioritize ethical considerations in the implementation of AI, as emphasized by Chaudhary et al. (2023). This means safeguarding user privacy and data security within our fitness application. Our aim is not only to drive technological innovation, but also to ensure a trustworthy and user-centric fitness journey that aligns with individual needs and preferences. We aspire to seamlessly merge advanced AI capabilities with ethical practices, establishing a new benchmark for personalized, technology-driven fitness training.

5 Expert systems in injury management and exercise selection

Our system incorporates the insights of Valle et al. (2017) to establish a detailed method for classifying muscle injuries. By considering various aspects, this model facilitates precise diagnosis and treatment. The design of our system is further informed by Molloy et al. (2020) work on risk reduction strategies, specifically in relation to musculoskeletal injuries. Their emphasis on early injury identification and standardized exercise programming is crucial to our approach. Additionally, we have incorporated Padua et al. (2018) recommendations on injury prevention training, which include incorporating diverse exercise regimes. These comprehensive strategies aim to minimize injuries and optimize fitness training, thus influencing the selection of key features in our proposed system:

1. **Customizable Training Programs:** These programs are tailored to meet individual needs and encompass a variety of exercises for well-rounded fitness.
2. **Feedback and Adaptation:** A real-time feedback mechanism allows for program adjustments based on user input, enhancing safety and efficacy.
3. **Injury-Specific Advice:** Specialized exercises and recovery tips are provided for individuals recovering from injuries.
4. **Educational Content:** Information about common injuries and prevention strategies is included to empower users with knowledge.
5. **Long-term Tracking:** Progress tracking over time enables assessment of the impact of training on injury prevention as well as overall fitness.

This comprehensive approach ensures that our system addresses individual requirements while being supported by empirical evidence.

6 Performance coefficient as a new metric for exercise selection

Drawing upon the findings of Çakiroğlu (2021) research concerning the influence of athletic self-confidence and perfectionism on athletic achievement, our proposed performance coefficient measure will possess a distinctive framework. The measure will encompass three separate coefficients which specifically examine the lower body, core region, and upper limbs - each symbolizing significant muscle groups. This segmentation enables a thorough evaluation of an individual's athletic aptitude in these essential domains.

Exercises can be designed to address each specific muscle group during the execution phase. The quantification of an individual's performance in these exercises will enable the calculation of corresponding coefficients. To illustrate, leg strength and functionality can be assessed through exercises such as squats or lunges, core stability can be evaluated through exercises that target the trunk, and arm strength can be measured with bench press or push-ups. The outcomes derived from these exercise sessions will serve as the basis for determining the coefficients that reflect an individual's comprehensive physical capacity.

The incorporation of self-efficacy, as emphasized by Çakiroğlu (2021), will be of great importance. We can integrate a self-evaluation element wherein individuals evaluate their level of assurance in executing each physical activity. This self-evaluation will play a vital role in determining the coefficient, ensuring that the metric not only captures physical capability but also the individual's self-perception of their athletic proficiency.

Overall, the proposed approach for performance assessment is designed to deliver a nuanced view of an individual's fitness capabilities, capturing not just the physical performance through the calculation of specific upper body, lower body, and trunk coefficients, but also integrating the psychological aspect of self-efficacy to reflect an individual's confidence and self-perceived competence in their athletic pursuits.

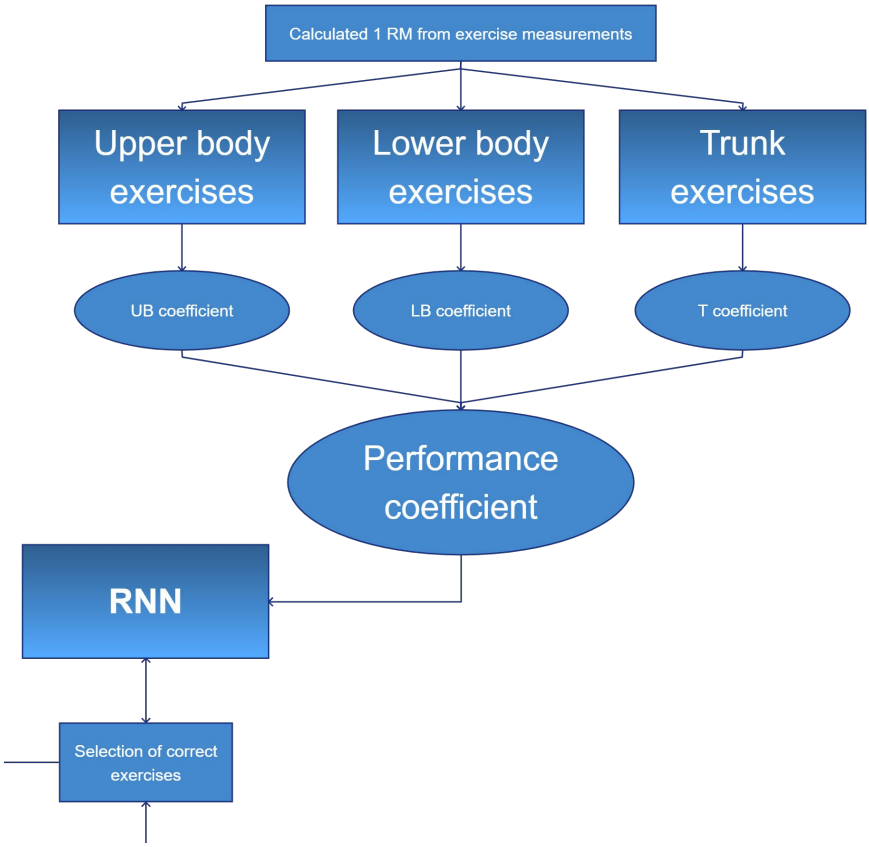

Figure 2: Performance coefficient calculation model and its connection to RNN framework
(Source: Own - diagram was made using pencil.evolus.vn)

7 Addressing diverse needs such as age, muscular symmetry and training background

Designing efficient resistance training programs necessitates a thorough comprehension of individual requirements, particularly considering variables such as age, muscular balance, and training history. Personalization is essential, as specified by Kraemer & Fragala (2006), with each program specifically customized to suit individual objectives and closely monitored to ensure both effectiveness and safety. Implementing progressive resistance training, which is fundamental for physiological enhancements, entails altering the intensity and number of exercises

over time. This methodology is critical for consistent improvements in strength and physiological functions, acknowledging that progress rates may vary depending on the specific exercise protocol employed.

It is important to tailor exercises to suit different age groups. Younger individuals should concentrate on activities that build strength and endurance, while older adults should prioritize exercises that improve balance, flexibility, and joint health. To prevent injuries and enhance performance, it is crucial to work on achieving muscular symmetry by targeting both primary and opposing muscle groups. The complexity of the training program varies depending on an individual's experience level. Beginners can begin with foundational exercises, whereas experienced athletes may engage in more specialized training.

The principles of our system will be implemented by evaluating the individual requirements of each user and adjusting programs accordingly. The user's age, muscular equilibrium, and training background will be taken into consideration to create a tailored training plan that progresses over time, prioritizing safety and optimizing its efficiency.

8 Challenges and future directions in tech-driven fitness training

In the domain of technology-based fitness training, the focus lies on the fusion of cutting-edge technology with conventional training methods. Key obstacles and areas for development in this field involve making sure that tech-centric solutions are accessible and affordable to a wider demographic, sustaining user interest over an extended period, and consistently enhancing the technology to align with current scientific research and fitness trends.

An important domain for further investigation pertains to the advancement of more intricate artificial intelligence (AI)-powered customization tactics, capable of adjusting to individual requirements using up-to-date information. Furthermore, there is an increasing necessity to tackle the disparity in digital access, guaranteeing fair availability of these fitness technologies, particularly within disadvantaged communities.

Advancements in wearable technologies and their incorporation into fitness programs indicate a notable prospective avenue. These devices have the potential to offer more accurate information on individual performance, health measurements, and conceivably even psychological conditions, thereby enhancing the comprehensiveness and efficacy of training programs.

As technology continues to advance, ethical concerns surrounding data privacy and the psychological effects of continuous monitoring will grow in significance. Consequently, there will be a need to establish stringent safeguards for privacy and develop ethical principles governing the utilization of personal information in fitness training.

9 Conclusion

In conclusion, this paper has highlighted a crucial gap in the fitness industry: the underutilization of the extensive data generated by digital health technologies. Despite advancements in devices and artificial intelligence capable of monitoring health metrics, the development of personalized fitness programs that fully capitalize on this data remains incomplete. Our proposed framework seeks to integrate the expertise of personal trainers with sophisticated AI algorithms to tailor fitness programs that consider individual characteristics such as age, ability, and medical history. By doing so, we aim to increase the accessibility and safety of exercise regimens, reducing the need for costly personal training services.

The outlined concept lays the groundwork for a technology-driven system that does more than collect data; it applies intelligent analysis to create personalized fitness solutions. Our future work includes the development of a prototype that will be rigorously tested for its efficiency in generating bespoke exercise programs and its ability to incorporate injury prevention methodologies.

Our goal is to harness the transformative potential of AI and wearable technology to redefine personalized fitness. By doing so, we aspire not only to improve the quality of life for individuals through more accessible and healthier lifestyle choices but also to set a new standard for technology-enhanced fitness solutions. Through continued research and development, we envision a fitness industry that is both

informed by data and grounded in the principles of sports science, offering long-term health benefits to users worldwide.

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