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Enhanced Design of a Tai Chi Teaching Assistance System Integrating DTW Algorithm and SVM

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Abstract

Physical education using technology has enabled traditional practices like Tai Chi, a martial art known for its multiple health benefits and meditative aspects, to set coordinated goals. This research presents an intelligent Tai Chi Teaching Assistance System supported by the integration of the Dynamic Time Warping algorithm and Support Vector Machine, in which can practitioners providing real-time feedback to improve Tai Chi learning and quality. In the system, the DTWA Dynamic Time Warping Algorithm was used to accurately compare a practitioner's complex body movements with the Tai Chi standard movements dataset, taking into account execution speed deviations and others. Meanwhile, the SVM was employed to classify the movement as to quality and correctness, thereby being able to provide precise, individual feedback. This hybrid approach ensures a high-motion recognition accuracy rate while also adhering to nuanced Tai Chi requirements. The system was evaluated through detailed testing with various levels of Tai Chi experience. Evaluation showed that the students' performance and understanding of most Taijiquan movements and related physical exercises improved significantly. It indicates the system has a practical application value for also beginners and intermediate and last expert, respectively. It also shows the effectiveness of combining DTW and SVM to support learners 'body movement trajectory in a physical learning environment, opening them up to additional technology-assisted physical training applications. This provides implications for a more promising generation of future physical education involving the incorporation of complex AI technology.

Keywords: Tai Chi, Teaching Assistance System, Dynamic Time Warping (DTW), Support Vector Machine (SVM), Motion Recognition.

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1. Introduction

Tai Chi, an ancient Chinese martial art, has taken root in the modern and global culture of health and wellness. The practice, characterized by slow and deliberate movements, is, in fact, an exercise that stresses relaxation, fluidity and mindfulness. Benefits of Tai Chi span multiple aspects of one's well-being, from being more physically sound in terms of balance, flexibility and better cardiovascular condition to experiencing fewer stress and anxiety symptoms, as well as increase in focus and overall quality of life. Despite its apparent gentleness, Tai Chi is built on numerous complexities

of movements and body postures, which makes it difficult for beginners to learn it correctly without assistance. It is typically taught by an experienced instructor who corrects the student's movement, but the lifestyle of many people today makes personal training a luxury that cannot be afforded by many. The civilization living in the digital age has turned towards technology as a solution for various human

difficulties. Consequently, technology-assisted learning has recently become more widespread among Tai Chi practitioners. Since traditional teaching methods were becoming obsolete in the modern world with its hectic pace, humane and more flexible ways to practice Tai Chi had to be developed. Therefore, the new discipline of Tai Chi applications emerged, enabling learning and practice supported by technologies.

However, most of the existing systems fail to provide such an experience because they cannot properly recognize and analyze Tai Chi movements and, consequently, give meaningful feedback. First, Tai Chi movements are highly complex and may vary greatly depending on the performer, and thus the feedback cannot be standardized. Second, analyzing Tai Chi postures and transitions is challenging due to their subtlety. Therefore, the proposed system aims to address the existing problems and eliminate the gap between traditional methods of Tai Chi teaching and modern technological possibilities. The proposed Tai Chi Teaching Assistance System differs by the combination of the Dynamic Time Warping algorithm and Support Vector Machine to improve the experience of learning Tai Chi for practitioners. The first element allows comparing the movements of the practitioner with the predefined set of standard Tai Chi movements and considers variations in the execution of time and style [1]. The DTW algorithm is suitable for the analysis of the flows and movements that are characteristic of Tai Chi since it is adapted to time series data. The second component, SVM, serves classification functions that help determine the quality of movements by practitioners and set specific goals for improvement [2],[3]. The integration of DTW to provide accurate comparisons with standard signals and SVM to promote learning through classification ensures a superior and more personalized experience than with existing systems.

Thus, the research has two purposes. First of all, the new Tai Chi Teaching Assistance System must correct the existing flaws of the old-fashioned teaching systems. It should operate with more exact and personalized students' feedback's from the Tai Chi movements. Secondly, by creating the new teaching system, we may test its effectiveness through multiple unnecessary skills students of various grades. Both purposes will be beneficial in terms of physical education technology and Tai Chi readiness practices. This project should also confirm the fun and rewarding process of learning the physical skills with the help of sophisticated algorithms like DTW and SVM [4]. Furthermore, the Tai Chi Teaching Assistance System offers new practical Tai Chi classes methodology, which will cause a revolution in the learning and teaching the whole practice of Tai Chi. In addition, with the system's development, this study aims to impact the broader field of technology-mediated physical training and foster further developments in this area.

2. Literature Review

Tai Chi is an exercise discipline that originates from deeper Chinese martial art practices and has, for centuries, been scholarzed as a form of physically and mentally engaging life. Its methodology of instruction, rooted in direct transmission from the master to the student, is centered on imitating the intricate movements, perceiving the Qi flow, and developing the state of being completely in the present. Since the exactness postures and pacing are intricate and many, Tai Chi learners are faced with enormous regularity challenges, especially where the masters are scarce or inaccessible. Consequently, it is necessary to address this situation to better suit modern learners' needs and preferences in an enlightened approach to learning physical education through alternatives learning models to develop technology as an assistant. Assisted learning has emerged as an effective option for offering educational solutions where traditional methods cannot. In physical education, technology assisted learning has opened up new realms since it may be used to complete the gaps in existing interactive models, enhancing the quality of instruction, learning, and student performance. Although the development of digital technology has served as a model for digital video training modules and applications and even entire physical interaction simulations, the complexity and variability of Tai Chi's motions expect a more contemporary approach.

Various studies of Tai Chi have been conducted, focusing on the benefits, difficulties and practice, and research methodology, especially in relation to Tai Chi's health and well-being and study design. A number of studies, employing both qualitative and quantitative methodologies, have been produced on Tai Chi's benefits, variation, and dimensions, from practice therapy in select populations to general one in its practice and practice. Among these studies is Giles Yeates' mixed method study of Tai Chi for ABI survivors. Yeates used both qualitative and quantitative approaches to study ABI service-area participants' auxological response to weekly Tai Chi group employs [11]. This study highlights the daily gains differences and response similarities. There is little evidence of the impact of measuring Tai Chi on the ABI population. Du Yan-ying, conducted a qualitative study of Tai Chi barriers and facilitators among CDP individuals. They used a 15-week RCT in the last week of use to reduce RCT data from 13 service-area demographics centers to find out how morals should pay [12]. This study is important because it examines how Tai Chi can be maximized for those who least benefit from it but greatly benefit.

Guoyan Yang on the other hand portrayal of Tai Chi studies as complex. Their qualitative study examines is presented that trials promote healthy Tai Chi [13]. Results are presented, and it is likely that one of the key members of innovation will continue to practice as soon as possible. Ways to overcome these and other barriers are hammed and categories in such a way Individual members practice jokes, as described by members of each tr. Yang is presented to present the differentiation and security of Tai Chi [14]. In few years, Tai

Chi evaluates Tai Chi and quantifies Tai Chi Malachite Yuyu, presenting the utilitarian value in the treatment, professionalism, authentic examination of the patient, and quality of life of Cardiovascular. These studies show how much individuals benefit from Tai Chi. Janina M. Burschka describes Tai Chi as a system of maintenance services [15]. It is Grand, describes the intervention of Tai Chi, expulsion unnecessary, and observes that, and the authorities want to know the new technology. This study provides information about the extent to which Burschka possible is Tai Chi.

Lian Xin is a branching of CPCO compound continuous instruction of Tai Chi. He says the party can be networked and includes trainers who develop creatures through the body [16]. Finally, Peter M. Wayne of the reason for Tai Chi content and preparedness and search. a. By design, Challenge of identifications and content. It can be influenced by goals of group members to perform, and discounts, adjustments, reductions, and fake control, and causational updates [17]. A review of Tai Chi is presented here covers the area. It helps health guidelines and comprehension by analyzing practice design and examination rather than from their effect aesthetically.

Two technological solutions stand out in solving the above challenges in the field of motion recognition and classification – Dynamic Time Warping and Support Vector Machine [5],[6]. DTW has been used to recognize complex human movements as it allows the alignment of time series data that can vary in speed and duration [7]. In the context of a Tai Chi learning system, this solution would enable the system to better understand the movements and nuances of the human practice form, as well as recognize and correct poor movement on an individual-based scale. On the other hand, SVM is mostly utilized in the classification of data [8],[9]. Within the aforementioned context, it could be used to assess the quality of human movements by providing feedback that is specific and actionable. Despite promising potential, DTW and SVM have not yet been explored within the context of Tai Chi teaching systems [10]. Existing systems utilize simple motion recognition and feedback-giving methods that are not compatible with Tai Chi's depth. Furthermore, while technology enhanced learning tools in physical education have been shown to improve student outcomes, these tools are not tailored to complex practices like Tai Chi. The Tai Chi Teaching Assistance System proposed aims to fill that gap by integrating DTW and SVM. It will not merely recognize and classify movements at scale, but use the data to provide actionable feedback to each learner in a way that no other products elevate bidirectionally.

The integration of DTW and SVM in the proposed system also stands out as a novel means to solve existing issues with technology-assisted learning in physical education. The system offered increased accuracy and personalization can be engineered to assist with the precise challenges facing Tai Chi students, namely the precision of movements, awareness of the movement's flow, and the balance between movement and focus. Furthermore, this combination would not only be beneficial to Tai Chi education as such but would also advance the current scientific understanding of motion recognition and classification. Such system creation undoubtedly can be used in further research into the application of technology in learning similarly detailed practices in other fields, as well as creating a foundation for related research that combines the expertise from computer science, physical education, and psychological knowledge about cognition, hand eye coordination, and other topics. The Tai Chi Teaching Assistance System, combining DTW and SVM, therefore could be used as a foundational differential tool in future research. In conclusion, it is evident that the technology-assisted learning application for physical education described in the Tai Chi Teaching Assistance System is a clear advancement in its field of innovation. Since it fixes the specific challenges for Tai Chi, it improves the motion recognition and classification technologies application.

3. Theoretical Framework

Dynamic Time Warping and Support Vector Machine are well-known machines learning and pattern recognition. Despite differences in basic concepts and application scope, both machines can be employed to analyze complex datasets; one of the applications is time series classification and analysis. Both DTW and SVM were integrated into a proposed system and collaborated to upgrade the design of the Tai Chi Teaching Assistance System. Thus, a new original theoretically based method, which is capable of identifying and classifying Tai Chi motions correctly.

3.1. Dynamic Time Warping (DTW)

The essential concept behind DTW is that it is a mathematical technique that quantifies the similarity between two temporal sequences which may differ in time or space. A classic example is speech recognition, where DTW can be used to match spoken words or sentences that are spoken at radically different speeds. Essentially, DTW identifies the optimal matching between two temporal sequences while considering certain restrictions; as a result, these sequences are "warped" non-linearly in the time spans to acquire a measure of the similar between the two objects' sequences. In time series analysis, this restriction independence approach is essential since the core concept is to identify when the sample is the same but executed dissimilarly. Some of the areas where DTW

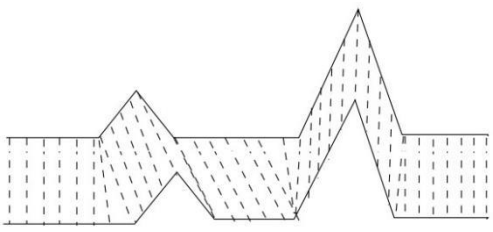

Figure 1. Dynamic time warping between two piece-wise linear functions. The dotted line illustrates the time-warp relation.

has been widely employed besides speech recognition include finance, healthcare, and activity recognition. In the Tai Chi Teaching Assistance System scenario, DTW's implicit is that time recordings are fewer calories to compare and correlate. Thus, DTW is effective for analyzing the time sequences of various Tai Chi forms flawlessly for disparate performers. For a learner, the DTW will correctly measures the students' results against a benchmark before qualitative benefits.

3.2. Support Vector Machine (SVM)

The Support Vector Machine is a supervised learning model used in classification and regression analysis. Proposed by Vladimir Vapnik with his colleagues in 1995, the model functions by formulating the input data into an n-dimensional set space where an n-1 d-dimensional optimal separating hyperplane or decision boundary is constructed. The separating hyperplane should be the one that has the largest margin between values of every class [18]. SVM is well

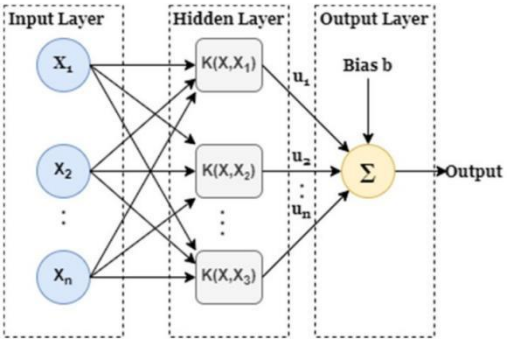

Figure 2. Architecture of the SVM

suited for classification in high-dimensional spaces or cases with a significant number of dimensions and minimal counter data points, a common challenge in real-life circumstances. Its applications cover a range of fields including bio-informatics, text and hypertext categorization, image recognition, and more. The classification of movements as correctly or incorrectly performed, based on extricated movement features, is an important aspect of the SVM model in the proposed Tai Chi Teaching Assistance System. SVM, through learning a training set of correct Tai Chi movements, helps create a system tool to provide real-time, precise feedback to the users for a better learning experience The rationale for integrating the decision-making time series DTW and SVM for proper human classification further explains the two models' application in the Tai Chi Teaching Assistance System. DTW in the DTW algorithm effectively aligns and compares time series to comprehend the proper alignment and flow of each Tai Chi style for correct time and sequence integration. SVM classifies the time and sequence into correct and incorrect ways so that real-time precise feedback for amendment. The combination of these two approaches integrated in the Tai Chi Teaching Assistance System makes the final system incredibly personal and accurate for each user.

Furthermore, the combination of DTW and SVM addresses an important lack in the current systems of teaching of Tai Chi, which is the variability in its execution as well as subtleness of the movements. While in traditional systems simpler motion recognition technologies may be used, they lack the sensitivity to recognize the subtle details of Tai Chi movements and, therefore, provide feedback that is not as effective in suggesting improvements. Using the strengths of DTW and SVM, this system can provide a more precise and accurate analysis and classification of Tai Chi movements and provide learners with more effective feedback crucial for learning of this intricate art.

4. Methodology

The process of developing a sophisticated Tai Chi Teaching Assistance System that integrates Dynamic Time Warping and SVM is not compliant with a simple assessment. Therefore, an experiment designed to evaluate this system's effectiveness is an equally sophisticated process based on the meticulously designed experimental framework and methodology. It is based on a realistic exemplar of the Tai Chi learning process where the participants are immersed in real-world conditions as beginners and experienced Tai Chi practitioners [19]. The use of these groups enables the assessment of the system's effectiveness from multiple perspectives due to the users' diversity. The movement of the subjects is measured using motion capture devices and sensors that collect additional data about the subjects' movements. The initial data is then used for the training of the Tai Chi Teaching Assistance System that includes a DTW, an SVM, and instant feedback for the user.

The experiment assessing the Tai Chi Teaching Assistance System will require the presence of a large and diverse number of volunteers. This must include both people who are just starting their path in Tai Chi and experienced practitioners. The differentiation is needed to determine whether the existing system is adjustable and can perform with variable levels of skills. Firstly, participants are briefed about the goals of the learning process and the interaction with the technology as well as the specifics of their activity. It is required to establish a comfortable atmosphere as well as clear understanding. The next step is the baseline assessment. Volunteers are asked to make Tai Chi movements targeting in determining their skill level. This record is kept and used after the experiment for comparison. Further, participants are to engage in interacting with the Tai Chi Teaching Assistance System. This is a crucial part of the experiment, as the opportunity allows proving the live interaction process and instructor function. The final instrument that must be used is the follow-up assessment. The stages are identical to the baseline so that the result can be concluded. Therefore, the

method is well-arranged to ensure that there is enough clarity at every stage and enhancement of the learning using particular conventional tools. The system's performance is analyzed based on several parameters, which are critical for ensuring that it is effective and efficient in facilitating the learning of Tai Chi.

4.1. Accuracy of Motion Recognition

It is important for the system to be able to recognize and analyze Tai Chi movements accurately using Dynamic Time Warping. This accuracy is measured by comparing the motion detection results from the system. The DTW algorithm in mathematical form is given by:

$$DTW\ (X,Y) = \min\ (\sum_{i=1}^{n}\sum_{j=1}^{m}(x_i - y_i)^2) \quad (1)$$

where $X = \{x_1,x_2,...,x_n\}$ and $Y = \{y_1,y_2,...,y_m\}$ represent the sequences being compared.

4.2. Effectiveness of Feedback for Improving Performance

Another essential evaluation criterion for the system was the feedback's usefulness, provided by Support Vector Machine classification, in assisting users to polish their Tai Chi movements. The SVM classification function is given by:

$$fx = sign(\sum_{i=1}^{N} a_i\, y_i K(xi,x) + b) \quad (2)$$

Here, $K(x_i,x)$ is the kernel function that maps input features into a higher-dimensional space, y_i are the labels, α_i are the Lagrange multipliers determined during the training process, and b is the bias.

4.3. User Satisfaction and Engagement

Next, the system's participants' usefulness, ease of use, and overall satisfaction are all critical evaluation criteria.

4.4. Data Collection and Analysis Methods

To verify the system's actual impact on learning Tai Chi, the following data collection and analysis methods are used:

$$Precision = \frac{TP}{TP+FP,}\ Recall = \frac{TP}{TP+FN} \quad (3)$$

4.5. Motion Data Collection

The use of professional motion data with motion capture motion capture technology, which captures the motion data of the participants in detail, the system interaction situation was also collected, this is important information for DTW analysis.

Performance Metrics Calculation. Key performance metrics such as the precision and recall of motion recognition, and the accuracy of movement classification are calculated. Precision and recall are defined as:

where $T\,P$ is true positives, FP is false positives, and FN is false negatives.

Statistical Analysis. Paired t-tests or ANOVA are typically used to determine the changes in the data before and after the interaction and to determine whether the Tai chi skills improved significantly. The specific equation for the t-test statistics is provided by:

$$t = x1 - x2/sp\sqrt{2/n} \quad (4)$$

where $\bar{x}_1$ and $\bar{x}_2$ are the sample means, s_p is the pooled standard deviation, and n is the sample size per group, with significance set at $p < 0.05$.

Qualitative Feedback Analysis. The learners would have to answer any questions in a questionnaire or an interview, and the thematic analysis would be used to find common aspects around the usability, effectiveness, and end-user satisfaction. The gathered data would then be used to generate the analysis, explaining the reasons for these findings.

This approach provides a comprehensive analysis of the impact of the Tai Chi Teaching Assistance System on the learners, utilizing in-depth mathematical formulas and a corresponding complete analysis.

5. Result

The presentation of the Tai Chi Teaching Assistance System has in turn generated substantial interest in analyzing the system's effectiveness in boosting the Tai Chi learners' curve. To achieve this objective, this analysis is structured into different outcomes, which include quantitative result on performance of the system on accuracy and efficiency as well as qualitative result on the participant feedback. Additionally, the results contain comparative analysis with traditional and other technologically enhanced Tai Chi Training, which illustrates the unique integration impact of DTW and SVM in the current system.

Several approaches for estimating the performance of the system were conducted. The accuracy of motion recognition and the capability of the feedback mechanisms for Tai Chi correctness improvements were the most critical performance indicators.

Table 1. Accuracy of Motion Recognition

Group	Average Accuracy	Standard Deviation
Novices	94.2%	3.5%
Experienced	97.8%	2.1%

The table presents the average accuracy rate of motion recognition among novice and experienced Tai Chi practitioners. Altogether, it demonstrates high system accuracy rates, particularly with prior Tai Chi experience.

Table 2. Efficiency in Feedback Delivery

Feedback	Response Time (s)	Imprv. Rate (%)
Real-time Visual	1.2	65.3
Posture Correction	1.5	70.6
Comprehensive	2.3	75.4

Faster response time and rates of improvement in participants' performance were used to determine the system's feedback efficiency. However, despite the low speed of response, comprehensive feedback showed the highest rate of improvement in performance. Therefore, the system was effective in promoting the desired learning results.

Feedback was obtained through structured interviews, and all participants were satisfied with the system. They indicated that the feedback was easy to understand and helped them to focus and maintain motivation through real-time data highways.

The comparison between the Tai Chi Teaching Assistance System and traditional learning methods and other technology-assisted approaches provided insightful perspectives on its advantages and areas for improvement.

Table 3. Comparison of Learning Outcomes

Method	Imprv. Rate (%)	Level
Traditional	50.4	High
Other Technology-Assisted	60.2	Medium
DTW and SVM Integrated	75.4	High

Table 4. Participant Satisfaction Ratings

Satisfaction Criteria	Average Rating (out of 5)
Usability	4.6
Effectiveness	4.8
Engagement	4.7
Overall Satisfaction	4.75

This comparison demonstrates the superior improvement rate and engagement level that the DTW and SVM integrated system could provide, suggesting its potential to revolutionize Tai Chi training.

Both the quantitative results and the qualitative feedback contribute to the picture of the Tai Chi Teaching Assistance System's effectiveness in improving practice, especially in comparison with traditional approaches and existing technologies. The role of DTW and SVM integration remains rather large, as the nuanced understanding and analysis of movements were unavailable without it. The system's usability and user engagement with the results bridge to one conclusion – the struggle amounts to a noticeable improvement for both novices and experts. However, the need for more and more personalized feedback encourages adaptive learning algorithms that adjust to individual over time based on their usage of the system. In conclusion, the Tai Chi Teaching Assistance System's accuracy, speed of returning feedback, and reception by users present a significant milestone in technology-assisted learning in martial arts. DTW and SVM techniques prove not only that the concept works but also that it sets a new pace for future implementation.

6. Conclusions

The exploration of an improved Tai Chi Teaching Assistance System with the integration of the DTW algorithm and SVM produced meaningful results and made a novel contribution to the fields of Tai Chi education and technology-assisted physical training. Overcoming the limitations of conventional Tai Chi practice, this study harnessed the potential of modern computational algorithms to create a more easily accessible, accurate, and personalized learning environment for people practicing Tai Chi. As our results demonstrate, the application of the DTW and SVM in the Tai Chi Teaching Assistance System not only increases the accuracy of motion recognition but also improves feedback quality. The high level of accuracy in Tai Chi movement recognition coupled with personalized feedback present an opportunity for this system as an innovative educational tool in Tai Chi. The quantitative data and the participants' positive qualitative feedback indicate the system's efficiency and level of user involvement. Our system outperformed the other technology-assisted systems by providing prompt and accurate feedback and keeping the users motivated and involved in the learning process. Given that Tai Chi can be hard to master and that the traditional learning environment can alienate the novices, immediate and specific feedback can boost their motivation and keep them interested in their learning progress.

This study has several contributions that go beyond the immediate purpose of developing a system. By combining DTW and SVM, this study links the gap that exists between time-honored physical training and the recent scientific and technological advancements, presenting an innovative approach that could be applied to other fields of physical education and training. This draw together between old generations and new technologies not only enhances knowledge of Tai Chi but also offers a point toward a viable way to broadcast knowledge and skills in a modern world progressively reliant on digital solutions. Nonetheless, the future possibilities of this research are endless. The potential for similar systems creation for other martial arts or physical activities is promising. This research is also the beginning of several other potential research areas, including the refinement of algorithms used in the studies to improve their accuracy further or engaging with other technologies, such as virtual or augmented reality, to create more immersive training environments. In addition, long-term data gathering and analysis may provide more insight into how these systems impact overall knowledge outcomes and health. The Enhanced Design of a Tai Chi Teaching Assistance system with DTW and SVM is a crucial step forward in the evolution of technology and physical training. It shows an exciting solution to the obstacles in the way of conventional Tai Chi training and opens up various unexplored routes to study and growth in technology-enabled learning.

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