KUMITRON: Learning in Pairs Karate related skills with Artificial Intelligence support

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Summary of KUMITRON system

There are already several scientific articles that discuss the **need for intelligent tools applied to the teaching of psychomotor skills** ([1], [2]). The most recent and exhaustive search [3] on intelligent psychomotor tutoring systems shows the lack of this type of tools as only 9 systems were found to address this field. Two important challenges [1] related to technology and the acquisition of motor skills are pointed out: 1) modeling psychomotor interaction and 2) providing adequate personalized psychomotor support. Following the steps in [1] we have proposed the system KUMITRON to support learning Karate in pairs, as summarized in Fig. 1.



b. Synchronises all signals in real time to allow for a multimodal processing

2. Modelling the movement

- a. Apply computer vision (i.e. OpenCV algorithms) to model the parts of the image that have changed since the previous frame, so that it can be used to show in real time the anticipation of the movement. Computer vision algorithms identify the body parts that initiate movement, which allows to identify the type of attack of the opponent.
- b. Process the data collected by the Arduino board in real time. At this point, the inertial data collected is used to build a diagram directional vector. We are also training classification algorithms using the WEKA data mining suite to infer performance indicators.
- . For the physiological study, the evolution of the pulse rate is shown in a screen during the combat.

3. Designing the feedback

- a. At this point (and to complement the information collected when surveying practitioners and masters) we are using the Wizard of Oz technique to identify the rules to apply as feedback. That is, a sensei (karate teacher) who is watching the information processed and delivered by the system gives feedback to the learner by voice (using microphone and headphones). The system records the instructions given as well as the values of the parameters at that point, so they can be reviewed later using elicitation methodologies as TORMES (which combine user centred design and data mining techniques) to define the rules to be implemented in the system.
- b. In the future, the system will launch the predefined rules when the information sensed and modelled matches the rules. Moreover, these rules might also be adapted dynamically by learning from the data (e.g., rules applied that make the student win the combat will be given more priority than those that make the student loose).

Delivering the feedback

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- Multisensorial feedback is offered by the system.
 - On the one hand, auditory feedback can be provided by the system to the practitioner through the microphone with instructions on
 combat strategy and movement anticipation. By the moment they are provided directly by the sensei, but in the future, they will be
 delivered automatically by the system using natural language processing on the system predefined rules. For instance, this is one of the
 rules that we have already identified: "raise your guard" when it is identified that the opponent attacks on screen.
 - On the other hand, visual feedback that can be watched in real time during practice by the sensei and after practice by the own
 practitioners. It consists of: i) the kumite on video, ii) the kumite video with OpenCV algorithms, iii) the data collected by the sensors in
 real time, and iv) the movement data in a diagram directional vector. Fig. 2 shows a snapshot of the current user interface. In the future, we
 plan to present the sensors' information in a visual way, as the direct values of the indicators are not much helpful.

Figure 1: Description of KUMITRON in the four-stage framework to build intelligent psychomotor systems [1].

KUMITRON uses Artificial Intelligence (AI) techniques (mainly machine learning and computer vision) to teach psychomotor skills when two karatekas interact to each other in a karate combat (called kumite). The learning scenario in a karate combat offers additional challenges to other psychomotor learning scenarios since movements are not predefined and depend of the dynamic interaction of two practitioners moving around the tatami (space where the karate combat takes place). As described in [4], both learners and experts were surveyed to understand their needs and interest which are related to movements, technique, activity parameters and kumite strategy. In addition, the development of the system was inspired by state of the art: sensors to collect motion related data [5], existing karate systems ([6] and [7]) and sports ([8] and [9]), drones for dynamic video gathering ([10],[11] and [12]), and computer vision algorithms ([13] and [14]).

In this way, KUMITRON aims to support learning in pairs karate related skills with AI support in several way. In particular, this infrastructure can serve to analyze:

- **Psychomotor skills and physical condition**: the video, inertial and physiological sensors connected to AI algorithms (predictive and computer vision) can be used to improve motor skills, art technique, physical condition, attitude to stress situations, fatigue management avoid injuries...
- **Game strategy**: the monitoring of data combined with predictive algorithms can allow obtaining expert recommendations to win the game. For this purpose, KUMITRON connects to Machine Learning applications, exchanging data (respecting the GRPD [15]) in real time, to obtain expert advice that can be transmitted to the learner during training. As mentioned in Fig. 1, currently the delivery of feedback to the learner is performed with the "Wizard of Oz" to identify the personalized support required and train the intelligence of the system.
- **Motivation through innovation:** KUMITRON brings innovative capabilities and features that aim to enhance psychomotor education, turning the Dojo (martial arts gym) into a smart learning environment.

The system's potential impact

To understand the impact of Karate on the individual there is a fundamental reading by its founder [16]. There are also academic works (e.g. [17] and [18]) where the benefits of karate for people are explained. In this sense, KUMITRON can help in:

- Improving perception skills, specifically in terms of punch anticipation, so this extra time allows to better react to the punch, as suggested in [19].
- Placing and moving on the tatami, learning how to position on the mat thanks to the system's recommendations and anticipation work.
- Managing physical effort, so physiological parameters allow to determine when the learner is overexerting and recommend to reduce effort or vice versa.
- Managing emotions, keeping concentration and avoiding nervousness, thanks to physiological monitoring and combat performance.

REFERENCES

- [1] O. C. Santos, "Training the Body: The Potential of AIED to Support Personalized Motor Skills Learning," Int. J. Artif. Intell. Educ., vol. 26, no. 2, pp. 730–755, Jun. 2016, doi: 10.1007/s40593-016-0103-2.
- [2] O. C. Santos, "Artificial Intelligence in Psychomotor Learning: Modeling Human Motion from Inertial Sensor Data," Int. J. Artif. Intell. Tools, vol. 28, no. 4, Jun. 2019, doi: 10.1142/S0218213019400062.
- [3] L. M. Neagu, E. Rigaud, S. Travadel, M. Dascalu, and R. V. Rughinis, "Intelligent tutoring systems for psychomotor training – a systematic literature review," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Jun. 2020, vol. 12149 LNCS, pp. 335–341, doi: 10.1007/978-3-030-49663-0_40.
- [4] J. Echeverria and O. C. Santos, "KUMITRON: Artificial Intelligence System to Monitor Karate Fights that Synchronize Aerial Images with Physiological and Inertial Signals," in *IUI*, 2021, pp. 37–39, Accessed: Mar. 25, 2021. [Online]. Available: https://camps.aptaracorp.com/ACM_PMS/PMS/ACM/IUI21COMPANION/29/c84fc8c9-6e17-11eb-8d84-166a08e17233/OUT/iui21companion-29.html.
- [5] V. Camomilla, E. Bergamini, S. Fantozzi, and G. Vannozzi, "Trends Supporting the In-Field Use of Wearable Inertial Sensors for Sport Performance Evaluation: A Systematic Review," *Sensors*, vol. 18, no. 3, p. 873, Mar. 2018, doi: 10.3390/s18030873.
- [6] T. Hachaj, M. R. Ogiela, and M. Piekarczyk, "The open online repository of karate motion capture data: A tool for scientists and sport educators," in 2017 IEEE Symposium Series on Computational Intelligence, SSCI 2017 - Proceedings, Feb. 2018, vol. 2018-Janua, pp. 1–5, doi: 10.1109/SSCI.2017.8285270.
- [7] T. M. Takala, Y. Hirao, H. Morikawa, and T. Kawai, "Martial Arts Training in Virtual Reality with Full-body Tracking and Physically Simulated Opponents," in 2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), May 2020, pp. 858–858, doi: 10.1109/vrw50115.2020.00282.
- [8] J. Tholander and C. Johansson, "Design qualities for whole body interaction Learning from golf, skateboarding and bodybugging," Nord. 2010 Extending Boundaries - Proc. 6th Nord. Conf. Human-Computer Interact., pp. 493–502, 2010, doi: 10.1145/1868914.1868970.
- M. P. Wozniak et al., "Subtletee: Augmenting Posture Awareness for Beginner Golfers," Proc. ACM Human-Computer Interact., vol. 4, no. ISS, pp. 1–24, Nov. 2020, doi: 10.1145/3427332.
- [10] P. H. Han, Y. S. Chen, Y. Zhong, H. L. Wang, and Y. P. Hung, "My Tai-Chi coaches: An augmented-learning tool for practicing Tai-Chi Chuan," in ACM International Conference Proceeding Series, Mar. 2017, pp. 1–4, doi: 10.1145/3041164.3041194.
- [11] J. La Delfa, M. A. Baytas, R. Patibanda, H. Ngari, R. A. Khot, and F. "Floyd" Mueller, "Drone Chi: Somaesthetic Human-Drone Interaction," in *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, Apr. 2020, pp. 1– 13, doi: 10.1145/3313831.3376786.
- [12] X. Zhou, S. Liu, G. Pavlakos, V. Kumar, and K. Daniilidis, "Human Motion Capture Using a Drone," Proc. IEEE Int. Conf. Robot. Autom., pp. 2027–2033, Apr. 2018, Accessed: Jan. 16, 2021. [Online]. Available: http://arxiv.org/abs/1804.06112.
- [13] C. Malleson, J. Collomosse, and A. Hilton, "Real-Time Multi-person Motion Capture from Multi-view Video and IMUs," Int. J. Comput. Vis., vol. 128, no. 6, pp. 1594–1611, Jun. 2020, doi: 10.1007/s11263-019-01270-5.
- [14] N. Haralabidis, D. J. Saxby, C. Pizzolato, L. Needham, D. Cazzola, and C. Minahan, "Fusing Accelerometry with Videography to Monitor the Effect of Fatigue on Punching Performance in Elite Boxers," *Sensors*, vol. 20, no. 20, p. 5749, Oct. 2020, doi: 10.3390/s20205749.
- [15] CE, "I (Legislative acts) REGULATIONS REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repeali," 2016.
- [16] G. Funakoshi, MY WAY OF LIFE. Kordansha, 1981.
- [17] S. Mor-Stabilini, "The Essence of Karate-do: Sankido Example," in IDO MOVEMENT FOR CULTURE. Journal of Martial Arts Anthropology, 2013, vol. 13, no. 4, pp. 45–48.
- [18] Y.-C. Chang, T.-M. Yeh, F.-Y. Pai, and T.-P. Huang, "Sport Activity for Health!! The Effects of Karate Participants' Involvement, Perceived Value, and Leisure Benefits on Recommendation Intention," *Int. J. Environ. Res. Public Health*, vol. 15, no. 5, p. 953, May 2018, doi: 10.3390/ijerph15050953.
- [19] J. Echeverria and O. C. Santos, "Punch Anticipation in a Karate Combat with Computer Vision (accepted)," in *UMAP*, 2021.