Penerbit Akademia Baru

Journal of Advanced Research in Engineering Knowledge

Journal homepage: www.akademiabaru.com/arek.html
ISSN: 2600-8440

Ontology-based Modelling of Human Arm Movements for the Representation of Gestural Information

Open Access

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ARTICLE INFO

Article history:
Received 29 February 2019
Received in revised form 12 April 2019
Accepted 19 April 2019
Available online 21 April 2019

ABSTRACT

In the research of the human motion analysis, the characteristic movements of the human upper body are intensively investigated to be employed to many applications such as sign language recognition, robot control and gait analysis for rehabilitation. The human upper body consists of many body parts such as both arms including fingers, facials and head movements. Previously, many researches proposed the use of various sensors to record arm movements and the acquired data are used to train the computer to understand the behavioural motion of arms movements by using various algorithmic approaches. However, the current challenge is to increase the knowledge level of the computational systems to recognize gestural information containing in arm movements. The objectives of this research are to construct, derive and analyse the arm movement's model based on the concept of ontology. The gestural information is investigated from characteristic features of arm movements. The knowledge of the computational systems about gestural information is developed by describing the characteristic features of arm movements in the form of the hierarchical network model. The hierarchical network is defined as a structure containing characteristic features placed in mathematical orders and have the relations among them. On the other hand, the concept of ontology is proposed to model the characteristic features network of arm movements. The scenario is called Knowledge-Based-Approach (KBA) where relations among characteristic features are described. The high-speed motion capture system is proposed to collect arm movements data in the experiments. The successful of the proposed methodologies to model the arm movement could help improve the accuracy of the intelligence systems to recognize gestural information containing in arm movements for various digital applications in the future.

Keywords:
Dynamic arm movement, modelling, Ontology

1. Introduction

Previously, several approaches to recognize arm motions were proposed for the implementation in the various digital applications [1-6]. Arm movements contain many physical quantities, and modelling algorithms are required to form mathematical quantities from the available physical data [7,8]. Furthermore, movements data obtained through the tracking devices are low level information and it needs to be combined to produce high level semantic features information which can be used to investigate various motion features [6]. Once arm movements data have been collected through tracking devices, it needs to be analyzed for the systems to understand the behavior of the

characteristic arm features through various computational approaches. The conventional approach to model arm movements is by using deterministic approach which is based on artificial intelligence methods [9-12]. However, the performance of the proposed arm movement's model could be improved by using knowledge-based approaches.

The outline of this research paper is as follows. Section 1 describes the introduction of the research. Section 2 discusses the proposed methodologies of the research works. Section 3 discusses the expected contribution of the research and conclusions of this research is discussed in Section 4.

2. Methodology

The flow diagram of the proposed research methodologies is shown in Fig. 1. The research activity is divided to a (a) Data Collection, (b) Extracting the characteristic features of arm movement, (c) Similarity measure among the characteristic features, (d) Design a part-of-Relation based on the similarity value and (e) Design the hierarchical structure model of the characteristic features and the evaluation performance of the proposed methods through the recognition approach [13-15].

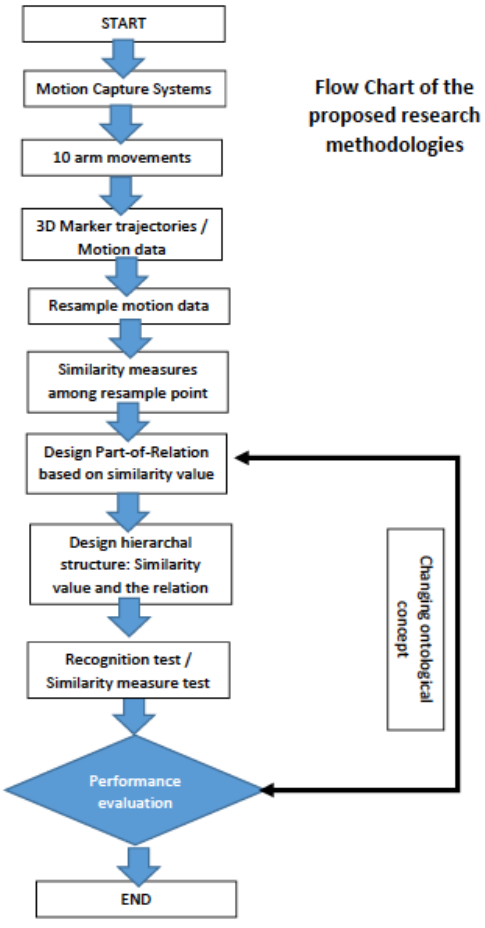

Fig. 1. The flow diagram of the proposed research

In data collection activities, an Optical motion capture systems (MOCAP) which was available in the Bio-mechanics Laboratory, UniMAP was used to acquire motion data of the arm. Three optical markers were placed at the position of the wrist, elbow and shoulder. Twenty subjects were selected to perform 5 gestural movements (5 geometrical gestures). Each subject performs each geometrical

gesture for 20 times. The collected data were used to model the ontological structure of arm movements.

In extracting the characteristic features of arm movement activities, a signal processing approach was used to extract features from the trajectories of the arm movements. A resampling algorithm technique was employed, and the resampling points obtained were stored as the characteristic features of the arm. The resampled points were used to model arm movements, which were based on the ontological approach. A Lab View System Design Software is used to do the analysis.

To measure the similarity among the characteristic features (resampled points), a similarity measure technique was to investigate the similarity value among the resampled points. The best performance of the similarity measure method was selected in order to be employed in this research. The part-of-relation among the resampled points is investigated based on the measured similarity value. A set theory approach will be used to define the relation based on the measured similarity value.

To design the hierarchical structure of the characteristic features, the similarity values and its relations were represented in the structure of hierarchy. This structure is defined as the model of arm movements. The evaluation performance was conducted for the purpose of testing the accuracy of the proposed arm movement's model. The evaluation technique proposed is through the recognition of the unknown gestural motion as input to the model.

3. Results

3.1 Experimental Environment Setup- Acquisition of Geometrical Gesture

Qualisys motion capture (MOCAP) was used to capture the movement of the subject's right arm while performing arm gesture. The original raw gestural data from motion capture consist of three axis coordinates which were *x*-, *y*- and *z*- axes. These values represent the trajectories the of arm movements. For the purpose of modelling ontological framework, 20 subjects were involved in the experiments. In the preliminary experiments, a reflected marker was attached to the subject's right hand and the subjects were instructed to perform 5 geometrical gestures. **Fig. 2** shows the environment of the experiment and **Fig. 3** shows a set of geometrical gestures used in the experiments **G** = {Round, Square, Diamond, Triangle, Eight}.

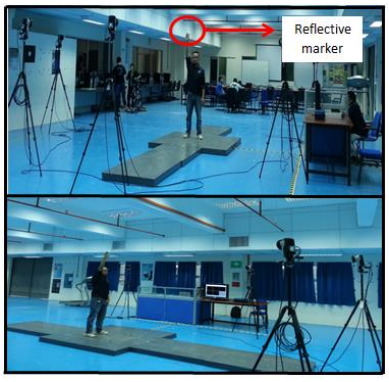

Fig. 2. The environment of the data collection experiment

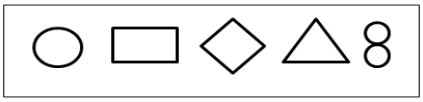

Fig. 3. Five geometrical gestures used in the experiments

3.2 Pattern of Arm Movement Data

Fig. 4, 5 and 6 show the arm trajectories while performing the gesture "#Eight" by the subjects #1, #2 and #3. The blue, green and magenta lines show the position of *x*-, *y*- and *z*- axes, respectively. The position of *x*- and *z*- axes change significantly in the movements, while the y-axis changes with the smaller amount of movement. Additionally, y-axis represent the depth movement of the trajectories. Due to nature of the selected gestures used in the experiments, which employ the 2-dimensional space *x*- and *z*-axes, the y-axis is neglected in the further experiments.

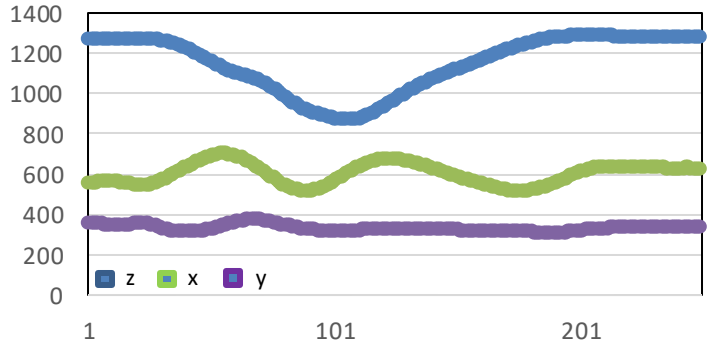

Fig. 4. Right arm movement data of *x, y* and *z*-axes when performing gesture "#Eight" by subject #1

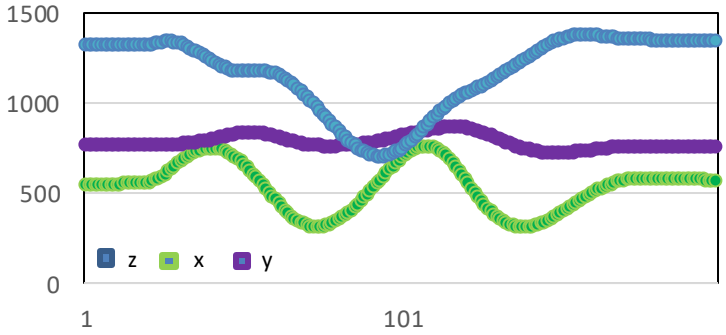

Fig. 5. Right arm movement data of *x, y* and *z*-axes when performing gesture "#Eight" by subject #2

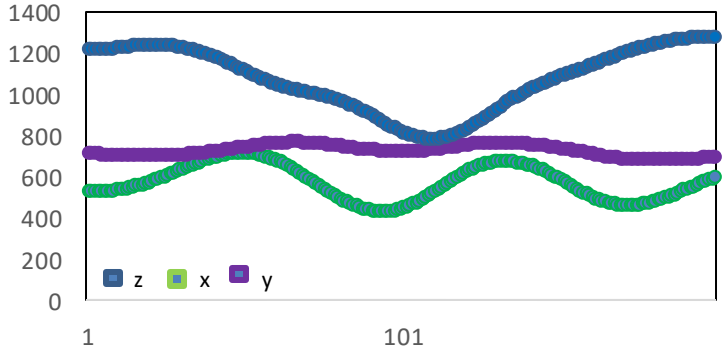

Fig. 6. Right arm movement data of *x, y* and *z*-axes when performing gesture "#Eight" by subject #3

3.3 Similarities Among Repetition of Gestures

Fig. 7 shows the arm trajectories while performing the gesture "#Eight" by the subjects #1. The trajectories show the position of *z*-axis. The trajectories produced has a similar pattern though it is performed by the same subject with several repetitions. Due to the reason of reducing individuality factors as shown from the Fig.7, a pattern recognition approach needs to be employed, thus could possibly be increased the arm gesture recognition accuracy.

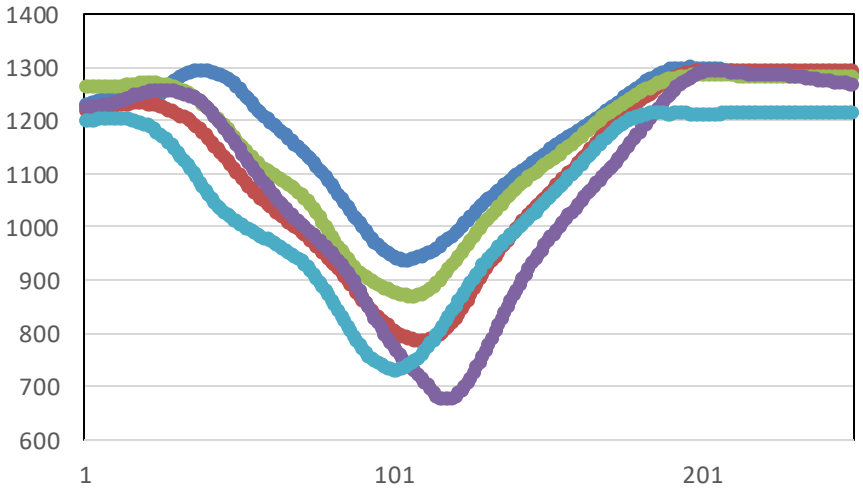

Fig. 7. Right arm movement data of *z*-axis when performing gesture "#Eight" by 5 times repetition

4. Conclusions

The research paper proposes the development of ontology based modelling of human arm movement for the recognition of arm gestures. In the methodologies, several stages are proposed started from the designing of experimental setup until the performance measurement of the systems through the recognition of the gestures. In the preliminary studies, the experimental environments are designed by using an optical motion capture systems. The acquired arm movement data showed that the depth movements could be neglected due to the nature of the selected gestures. Moreover, a pattern recognition approach or a pattern extraction technique is required to reduce the individuality factor of the subject.

Acknowledgement

This research was funded by a grant from Ministry of Higher Education of Malaysia (FRGS Grant 9003-00634).

References

[1] Hienz, Hermann, Kirsti Grobel, and Georg Offner. "Real-time hand-arm motion analysis using a single video camera." In *Proceedings of the Second International Conference on Automatic Face and Gesture Recognition*, pp. 323-327. IEEE, 1996.

[2] Bernmark, Eva, and Christina Wiktorin. "A triaxial accelerometer for measuring arm movements." *Applied ergonomics* 33, no. 6 (2002): 541-547.

[3] Lementec, J-C., and Peter Bajcsy. "Recognition of arm gestures using multiple orientation sensors: gesture classification." In *Proceedings. The 7th International IEEE Conference on Intelligent Transportation Systems (IEEE Cat. No. 04TH8749)*, pp. 965-970. IEEE, 2004.

[4] Liu, Jianwei, Dingguo Zhang, Xinjun Sheng, and Xiangyang Zhu. "Quantification and solutions of arm movements effect on sEMG pattern recognition." *Biomedical Signal Processing and Control* 13 (2014): 189-197.

[5] Garbarini, Francesca, Marco Rabuffetti, Alessandro Piedimonte, Gianluca Solito, and Anna Berti. "Bimanual coupling effects during arm immobilization and passive movements." *Human movement science* 41 (2015): 114-126.

[6] Dahlqvist, Camilla, Gert-Åke Hansson, and Mikael Forsman. "Validity of a small low-cost triaxial accelerometer with integrated logger for uncomplicated measurements of postures and movements of head, upper back and upper arms." *Applied ergonomics* 55 (2016): 108-116.

[7] Hachaj, Tomasz, and Marek R. Ogiela. "Full body movements recognition–unsupervised learning approach with heuristic R-GDL method." *Digital Signal Processing* 46 (2015): 239-252.

[8] Samadani, Ali-Akbar, Ali Ghodsi, and Dana Kulić. "Discriminative functional analysis of human movements." *Pattern Recognition Letters* 34, no. 15 (2013): 1829-1839.

[9] D. Rubine (1991): "Specifing Gestures by Example," In the Proceedings of SIGGRAPH' 91, ACM Press, pp. 329-337.

[10] S. Nagaya, S. Seki and R. Oka (1995): "A Proposal of Pattern Space Trajectory for Gesture Spotting Recognition," In the Proceeding of MIRU, pp. 157-162.

[11] Arroyave-Tobón, Santiago, Gilberto Osorio-Gómez, and Juan F. Cardona-McCormick. "Air-modelling: a tool for gesture-based solid modelling in context during early design stages in AR environments." *Computers in Industry* 66 (2015): 73-81.

[12] Ramani, Karthik. "A gesture-free geometric approach for mid-air expression of design intent in 3D virtual pottery." *Computer-Aided Design* 69 (2015): 11-24.

[13] Ikram, K., Wan Khairunizam, Azri A. Aziz, I. Zunaidi, S. A. Bakar, Z. M. Razlan, Rudzuan Mohd Nor, and W. A. Mustafa. "Ontological Approach on Designing Knowledge Domain Presentation of MOCAP based on Arm Movement." In *2018 International Conference on Intelligent Informatics and Biomedical Sciences (ICIIBMS)*, vol. 3, pp. 268-272. IEEE, 2018.

[14] Ikram, Khairul, I. Zunaidi, Rudzuan Mohd Nor, Wan Khairunizam, S. A. Bakar, W. A. Mustafa, Azri Aziz, and Z. M. Razlan. "Building Attribute Domain of Arm Motions for the Representation of Gestural Information." In *2018 International Conference on Computational Approach in Smart Systems Design and Applications (ICASSDA)*, pp. 1-4. IEEE, 2018.

[15] Ikram, K., Wan Khairunizam, Azri A. Aziz, S. A. Bakar, Z. M. Razlan, I. Zunaidi, and H. Desa. "Adaptive gesture recognition based on human physical characteristic." In *2018 IEEE 14th International Colloquium on Signal Processing & Its Applications (CSPA)*, pp. 129-134. IEEE, 2018.