Journal of Quality Measurement and Analysis
Jurnal Pengukuran Kualiti dan Analisis

JQMA 8(2) 2012, 77-87

PELICINAN ANALISIS DATA FUNGSIAN TERHADAP DATA BIOMEKANIK KETEPATAN TEMBAKAN

(Functional Data Analysis Smoothing on Biomechanics Shooting Accuracy Data)

WAN ROZITA WAN DIN, AZMIN SHAM RAMBELY & ABDUL AZIZ JEMAIN

ABSTRAK

Proses pelicinan adalah mandatori terhadap data yang dijana menggunakan peralatan mekanikal bagi membuang hingar. Kajian ini membentangkan ujian pelicinan ke atas data biomekanikal dengan menggunakan analisis data fungsian (ADF) yang merupakan suatu kaedah baharu dalam bidang statistik yang menganalisis data dalam bentuk fungsian. ADF juga memberi beberapa pembaharuan tambahan dari segi pelicinan data, pelarasan lengkung dan teknik analisis terbitan di samping kaedah analisis berstatistik biasa. Data ketepatan tembakan menggunakan rifel M16 diperoleh daripada sepuluh subjek tentera berumur 31 ± 6.2 tahun dengan berat badan 71.6 ± 10.4 kg dan ketinggian 166.3 ± 5.9 cm melalui peralatan analisis gerakan Vicon yang terdiri daripada tujuh kamera dan 39 penanda inframerah yang dilekatkan pada sendi utama badan. Beberapa ujian pelicinan melalui kaedah ADF dibentangkan bagi menetapkan parameter terbaik yang seterusnya dipilih terhadap data biomekanik ketepatan tembakan. Parameter terbaik bagi data biomekanik ketepatan menembak adalah dengan menggunakan modul pelicinan kembangan splin-B kuintik dengan menetapkan penalti kekasaran pada terbitan keempat dan jumlah pelicinan bersamaan dengan 1e-12. ADF terbukti sebagai satu daripada kaedah yang dapat melicinkan data biomekanik dengan sangat baik dan membolehkan data digunakan untuk analisis seterusnya.

Kata kunci: pelicinan; hingar; analisis data fungsian; rifel; biomekanik ketepatan tembakan

ABSTRACT

Smoothing process is mandatory for data generated through mechanical equipments in order to remove noise. This paper presents the smoothing tests done towards biomechanical data through functional data analysis (FDA) method. FDA is a new branch of statistics which analyses data in the forms of functions and also provides special features like smoothing, aligning curves and derivatives analysis techniques together with normal statistical analysis methods. Shooting accuracy data using rifle M16 were collected from ten military subjects, age 31 ± 6.2 years, weigh 71.6 ± 10.4 kg and with height 166.3 ± 5.9 cm, using the Vicon motion analysis system and 39 infrared body markers attached to body joints. Smoothing tests are presented to choose the most suitable smoothing parameters for biomechanics shooting accuracy data. Smoothing by using B-spline quintic basis and directly specified roughness penalty by penalising fourth derivatives together with smoothing amount λ of 1e-12 are the best parameters selected. FDA proved to be one of the best methods in smoothing biomechanical data which enables data for further analysis processing.

Keywords: smoothing; noise; functional data analysis; rifle; biomechanical shooting accuracy

Rujukan

Allard P., Stokes I. A. & Blanchi J. P. 1995. *Three Dimensional Analysis of Human Movement.* Champaign, IL: Human Kinetics.

Anderssen R.S. & Bloomfield P. 1974. Numerical differentiation procedures for non-exact data. *Numerische Mathematik* **22**: 157-182.

Cullum J. 1971. Numerical differentiation and regularisation. *SIAM Journal on Numerical Analysis* **8**: 254-265.
D'Amico M & Ferrigno G. 1990. Technique for the evaluation of derivatives from noisy biomechanical displacement data using a model-based-bandwidth-selection procedure. *Medical Biology and Engineering Computing* **30**: 851-855.
Din W. R. W., Rambely A. S. & Jemain A. A. 2011. Load carriage analysis for Malaysian military using functional data analysis technique. Proceedings of 4th International Conference on Modelling, Simulation & Applied Optimization (ICMSAO), IEEE Xplore, pp. 1-8, Kuala Lumpur.
Dohrmann C., Busby H. & Trujillo D. 1988. Smoothing noisy data using dynamic programming and generalised cross validation. *Journal of Biomechanical Engineering* **110**: 37-41.
Elmer S. J. & Martin J. C. 2009. Fourier Series Approximations and Low pass filtering : Facilitating learning of digital signal processing for biomechanics students. *Sportscience* **13**: 1-8.
Erer K. S. 2007. Adaptive usage of the Butterworth digital filter. *Journal of Biomechanics* **40** (2007): 2934-2943.
Giakas G. & Baltzopolous V. 1997. A comparison of automatic filtering techniques applied to biomechanical walking data. *Jounal of Biomechanics* **30**(8): 847-850
Manal K. & Rose W. 2007. A general solution for the time delay introduced by a low-pass Butterworth digital filter: An application to musculoskeletal modeling. *Journal of Biomechanics* **40**: 678-681.
Nagano A. 2003. Optimal digital filter cutoff frequency of jumping kinematics. *Journal of Sport and Health Science* **1**(2):196-201.
Ramsay J. O., Hooker G. & Graves S. 2009. *Functional data analysis with R and MATLAB*, New York: Springer.
Ramsay J. O. & Silverman B. W. 2005. *Functional data analysis.* Ed. Ke-2. New York: Springer.
Robertson D. G. E. & Dowling J. J. 2003. Design and responses of Butterworth and critically damped digital filters. *Journal of Electromyography and Kinesiology* **13**: 569-573.
Sabatini A. M. 2003. Real-time Kalman filter applied to biomechanical data for state estimation and numerical differentiation. *Med. Biol. Eng. Computing* **41**: 2-10.
Simons W. & Yang K. 1991. Differentiation of human motion data using combined spline and least squares concepts. *Journal of Biomechanical Engineering* **113:** 348-351.
Wan Din W. R. & Rambely A. S. 2011. Biomechanics of a rifle-firing model: Effects of rifle dynamics on target accuracy. *International Journal of Applied Mathematics & Statistics* **23:** Number D11.
Winter D. A. 1990. *Biomechanics and motor control of human movement.* Ed. Ke-2. Toronto, Ontario: Wiley-Interscience.
Winter D. A. 2005. *Biomechanics and motor control of human movement.* Ed. Ke-3. Toronto, Ontario: Wiley-Interscience.
Wood G. A. 1982. Data smoothing and differentiating procedures in biomechanics. *Exercise and sport science Reviews* **10**: 308-62.
Yu B. 1989. Determination of the optimum cutoff frequency in the digital filter data smoothing procedure. *Proceeding of the 12th International Congress of Biomechanics*, University of California, Los Angeles.

[1]Pusat Asasi Pertahanan dan Sains Gunaan
Universiti Pertahanan Nasional Malaysia
57000 Kem Sg Besi
Kuala Lumpur
MALAYSIA
*Mel-e: wwanrozita@yahoo.com**

[2] Pusat Pengajian Sains Matematik
Fakulti Sains dan Teknologi
Universiti Kebangsaan Malaysia
43600 UKM Bangi
Selangor DE, Malaysia
Mel-e: asr@ukm.my, azizj@ukm.my

* *Corresponding author*