持拍姿態智慧檢測系統

Smart Gesture Sensing System for Racket Sports

Y. J. Zheng[1], W. C. Wang[1], Y. Y. Chen[2], H. H. Liu[2], R. Chen[1], and C. Y. Lo[2, 3*]

[1]Department of Power Mechanical Engineering
[2]Department of Kinesiology
[2]Institute of NanoEngineering and Microsystems
E-mail: chengyao@mx.nthu.edu.tw

Two capacitive sensing units were designed, fabricated, and embedded into two corresponding fingerstalls through microelectronic and additive manufacturing with flexible materials and ergonomic considerations in this study. The sensing units were routed to an adaptor, which in turn was routed to a transmission port (comprising a signal converter and a Bluetooth module), realizing a wearable and wireless force sensing system. Practical application examinations with badminton actions (forehand cross-net shots) were conducted by players in a standard court to show the effectiveness of the proposed system as proofs-of-concept. Statistical and quantified results reflected the visual observations on valid shots (67% and 39% for the professional and amateur players, respectively) and well-controlled racket-holding attitude (19.69% and 35.31% force application difference between the first two segments of the index finger of the professional and amateur player, respectively). These proved that the proposed system outperforms existing similar systems in the market and is able to not only classify players with different skill levels but also distinguish attitude stability and controllability, showing scientific evidence in sports science for the first time.

References

[1] L. Shu, T. Hua, Y. Wang, Q. Li, D. D. Feng,and X. Tao, "In-Shoe Plantar Pressure Measurement and Analysis System Based on Fabric Pressure Sensing Array", *IEEE Transactions on Information Technology in Biomedicine*, Vol. 14, 767-775 (2010).

[2] A. Chortos, J. Liu, and Z. Bao, "Pursuing prosthetic electronic skin", *Nature Materials*, Vol. 15, 937–950 (2016).

The developed system supports multi-channel force sensing in wearable modules for sports science (Figure 1). Modules detect forces applied to fingers and signals were wired from sensors to the transmitter, which further delivers signals to the remote computer by blue tooth. Besides hardwares, customized graphical user interface was prepared as a software module, which shows upgradable database as a novel business model. In addition to the demonstrative sports science, this system can also be applied to other applications such as health care [1-2].

The system outperforms the existing ones in ergonomic viewpoints and business model. The sensor, transmitter, and software module are designed consumable, long-lasting, and upgradable, respectively; showing continuous business to the developer and various solutions to the user. It also can support operations through mobile devices and APPs for virtual coaching with collected big data and established artificial intelligence via machine learning.

This system contributes on expansion of the dynamic window and miniaturization of the modules. The detection range is up to 30 N, and the sensing unit has a thickness of merely 270 micron, which can be arranged on a 3D-printed ring structure worn on a fingertip of a player. In addition, this work also implements an all-in-one evaluation system with an Arduino toolkit and a Bluetooth module (Figure 2). Through this system, the force sensing results can be transmitted to a data server via wireless signals and be displayed in real time on the graphical user interface of a remote control console (Figure 3).

Results indicated that not only the skill levels can be distinguished (Figure 4 and 5) but also force distributions can be quantified and qualified.

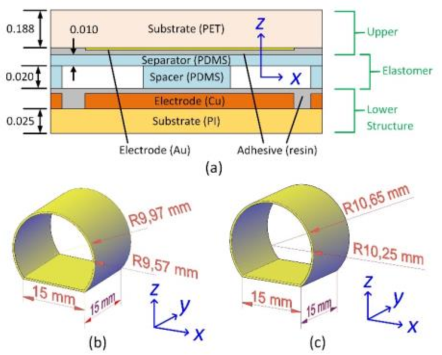

Figure 1. The structure for(a) sensor and fignerstall in the (b) first and (c) second section of index finger.

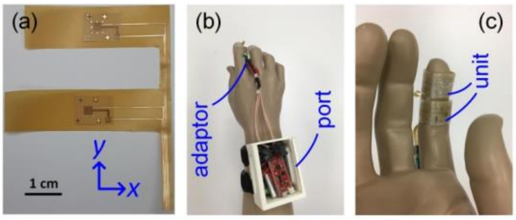

Figure 2. The (a) fabricated sensor with (b) adaptor and transmission port (c) demonstrated on a model.

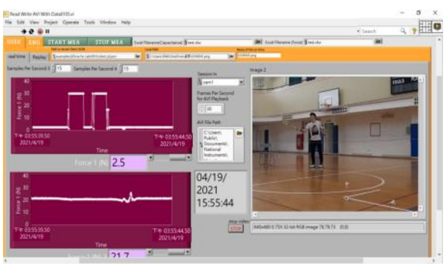

Figure 3. The graphical user interface.

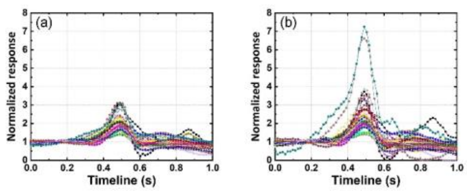

Figure 4. The quantified (a) first and (b) second finger section force for a professional.

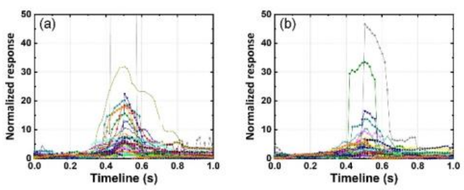

Figure 5. The quantified (a) first and (b) second finger section force for an amateur.