International Journal of Swarm Intelligence and Evolutionary Computation

Fang et al., Int J Swarm Intel Evol Comput 2015, 4:1
DOI: 10.4172/2090-4908.1000e108

Editorial Open Access

A Novel Data Glove Design Based on Inertial and Magnetic Sensors

Bin Fang[1], **Fuchun Sun**[2], **Huaping Liu**[3*]

[1]*Tsinghua National Laboratory for Information Science and Technology, Tsinghua University, Beijing, China*
[2]*State Key Laboratory of Intelligent Technology and Systems, Tsinghua University, Beijing, China*
[3]*Department of Computer Science and Technology, Tsinghua University, Beijing, China*

Introduction

Human hands are interacting with and manipulating the environment in a huge number of tasks in our everyday life. It is then not surprising that a considerable amount of research efforts has been devoted to developing technologies for measuring and characterize the human hand mechanics, which are critical to many active areas of academic research and commercial product development. The development of the most popular devices for hand movement acquisition, glove-based systems, started about 30 years ago and continues to engage a growing number of researchers.

Early devices such as Sayre Glove, MIT-LED glove, and the Digital Entry Data Glove were equipped with a limited number of sensors, were hard wired, and cumbersome. They were developed to serve very specific applications, were used briefly and were never commercialized. More recently device such as Cyber-Glove [1] [Figure 1a], 5DT data Glove [2] [Figure 1b] Human glove [3] [Figure 1c] are becoming commercially available. Cyber-Glove is equipped with 18 or 22 piezo-resistive sensors and it is considered one of the most accurate glove systems currently available. The 5DT data glove uses proprietary optical-fiber flexor sensors and the Human glove uses 20 Hall Effect sensors. These devices vary widely in core sensing technologies, device complexity, data richness (resolution, bandwidth), and mechanical robustness. Commercial motion data gloves usually use expensive motion-sensing fibers and motion analyzers, and are consequently too costly for the consumer market. Hence, some research aim is to lower the cost of such equipment [4] designed the low-cost data glove that used single-channel video instead of expensive motion-sensing fibers or multi-channel video and the visual motion data glove is composed of an inexpensive consumer glove with attached thin-bar-type optical indicators (Figure 2).

In this editorial, we proposed the novel design of data glove based on inertial and magnetic sensors. The inertial and magnetic sensors, which can provide 3D orientations, are composed of tri-axial gyros, tri-axial accelerometers and tri-axial magnetometers. It is lightweight, low-cost, portable and low on energy usage. Nowadays it has been widely used in various domains, including the unmanned aerial vehicle, underwater robot and mobile robots [5-6]. Especially, the small wearable inertial/magnetic sensors are becoming increasingly popular for assessment of three-dimensional (3D) measurement of human motion in and outside the laboratory setting [7-8]. They provide advantages over typical laboratory-based optoelectronic systems, suffering neither from measurement volume limitations (field of view of cameras) nor marker occlusion. It also provides higher accuracy for linear acceleration and angular velocity measurements, as these vectors are measured directly rather than inferred via differentiation.

(a) (b) (c)

Figure 1: Commercial glove

The proposed data glove is using the inertial and magnetic sensors to estimate the orientations of fingers to determine the pose of the hand, hence the size of the sensors must be considered to ensure that they are enough small to be equipped on the knuckles. With advances in MEMS technology, the sensors are becoming smaller and integrated, so that they are suitable for measuring the hand pose. The nine-axis MEMS sensor named MPU-9250 is adopted in the paper. It is a 9-axis Motion-Tracking device that combines a 3-axis gyroscope, a 3-axis accelerometer, and 3-axis magnetometer in a small3 × 3 × 1 mm package. We use this sensor to make the sensor board; the size is 10 × 15 × 2.6 mm (Figure 3a). Hence the sensor boards are deployed on the each section of the hand. In our design, the ARM is used to calculating the measurements of the sensors and the size of the processing boardis 30 × 40 × 3 mm (Figure 3b).

The data glove is composed of 15 sensors boards, and each finger is deployed three sensor boards. The sensor boards are using I2C bus communication to connect to the processing board, which processes the raw data and estimate the orientations of the hand. Then the processing board encapsulates the computed results into a packet, and sends the packet to the PC through a Bluetooth interface. The baud rate for transmitting data via the Bluetooth is 115200 bps. By using this design, the hand motion of conducting the tasks for rehabilitation can be tracked and transmitted to the program running on the PC immediately. The system overall is shown in (Figure 4).

In our design, the measurements of the inertial and magnetic sensors are used to determine the pose of the hand, and the estimated algorithm is the key technology. According to the three kinds of sensors, there are two independent ways to determine the attitude and heading. One is obtained from open-loop gyros. It has high dynamic characteristic, however, the gyro errors would create wandering attitude angles and the gradual instability of the integration drifting. The other way is determined from open-loop accelerometers and magnetometers. The orientations can be correctly obtained from accelerometers and

***Corresponding author:** Huaping Liu, Department of Computer Science and Technology, Tsinghua University, Beijing, China, Tel: 86-10-62797371; E-mail: hpliu@tsinghua.edu.cn

Received January 30, 2015; **Accepted** February 08, 2015; **Published** February 14, 2015

Citation: Fang B, Sun F, Liu H (2015) A Novel Data Glove Design Based on Inertial and Magnetic Sensors. Int J Swarm Intel Evol Comput 4: e108. doi: 10.4172/2090-4908.1000e108

Figure 2: Low-cost visual motion data glove

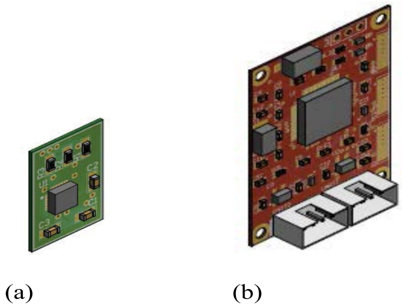

Figure 3: The main circuit boards of the data glove

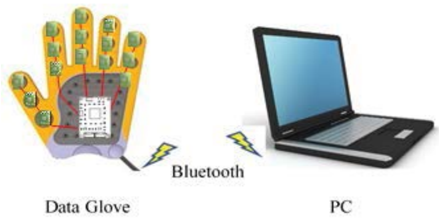

Figure 4: System architecture

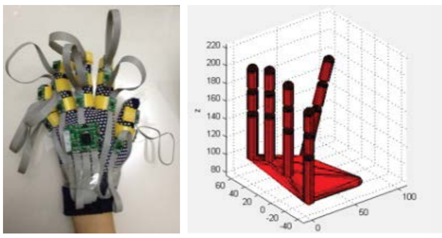

Figure 5: The data glove

magnetometers in the ideal environment. The independent ways are both quite difficult to achieve acceptable performance. Sensor fusion is the great choice to attain the stable and accurate orientations. Generally, the multisensory fusion algorithm first determines the sensor's change in 3D orientation over time by continuously integrating the angular velocity vector measured by the gyroscopes. The algorithm then employs the 3D accelerometer measurements to prevent integration drift with respect to Earth's gravity vector (attitude or inclination) and the 3D magnetometer measurements to prevent integration drift with respect to magnetic north (heading). In this process, the Kalman filter is a useful tool for combining the measured data. The Extended Kalman filter [9] is a general method for determining orientation and has been applied in the products of AHRS [10]. However, the EKF suffers from the drawback: it is not easy to choose the numerous parameters and computation. And the complementary filter is proposed [11]. Complementary filters have been widely used to combine two independent noisy measurements of the same signal, where each measurement is corrupted by different types of spectral noise. The filter provides an estimate of the true signal by fusing high-pass signals that provided by gyroscopes and the data from low-pass accelerometers and magnetometers which provide a relatively accurate measurement at low frequencies. Recently, Martin and Salaun [12] proposed a new nonlinear observer-invariant observer which respects the symmetries of the system equations. In addition, deterministic algorithm, which uses a minimal set of data, is another class for estimating three-axis attitude. The proposed data glove used the fifteen sensor boards used, which means 3×45 measurements can be attained and so much information is processed by only one processor, therefore, a fast and effective estimation method should be proposed to determine the pose of the hand. We use the linear kalman filter to estimate the each orientation of the sensor boards. Then results are sent to the PC and the virtual hand is shown the state of the human hand (Figure 5).

The proposed data glove is designed by the inertial and magnetic sensors, which provide the detailed kinematic information of the hand. It can be the input device for the control of robots or the diagnostic medical devices like wearable hand rehabilitation system.

References

1. http://www.cyberglovesystems.com/
2. http://www.5dt.com/?page_id=115
3. http://www.hmw.it
4. Han Y M (2010) "A low-cost visual motion data glove as an input device to interpret human hand gestures". *IEEE Trans. Consumer Electronics* 56: 501-509
5. Najib M, Jean-Michel P, Tarek H (2006) Attitude and gyro bias estimation for a VTOL UAV. Control Eng Practice 14: 1511-1520.
6. Chou W, Fang B, Ding L (2013) Two-step optimal filter Design for the low-cost attitude and heading reference systems. IET Science, Measurement & Technology 7: 240-248.
7. Yun X, Bachmann ER (2006) Design, implementation, and experimental results of a quaternion-based kalman filter for human body motion tracking. IEEE transaction on robotics 22: 1216-1227
8. Sabatini AM (2011) Estimating three-dimensional orientation of human body parts by inertial/magnetic sensing, Sensors 11: 1489-1525.
9. Angelo MS (2006) Quaternion-based extended Kalman filter for determining orientation by inertial and magnetic sensing. IEEE Trans Biomed Eng 53: 1346-1356
10. https://www.xsens.com/
11. Robert M, Tarek H, Pflimlin JM (2008) Nonlinear Complementary Filters on the Special Orthogonal Group. IEEE T AUTOMAT CONTR 53: 1203-1218.
12. Martin P, Salaun E (2010) Design and implementation of a low-cost observer-based attitude and heading reference system. Control Engineering Practice 18: 712-722

Citation: Fang B, Sun F, Liu H (2015) A Novel Data Glove Design Based on Inertial and Magnetic Sensors. Int J Swarm Intel Evol Comput 4: e108. doi: 10.4172/2090-4908.1000e108