3D NAVIGATION NATURAL INTERACTION WITH MOVEMENT SENSOR TECHNOLOGY

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ABSTRACT

This paper presents our designed three dimensional (3D) natural interaction navigation system using Micro-electro-mechanical systems (MEMS) CHR-6dm with ZigBee wireless technology for broader interactive coverage range usage. Related sensor interface software and sensor data observation are presented. Furthermore, local machine platform realization for Google Earth (GE) 3D navigation using movement of human beings is illustrated. In the end, global heritage navigation effect using this developed 3D gesture navigation system is shown.

1 INTRODUCTION

Currently, intelligent networking and computing platforms, such as PCs, tablets, PDAs, mobile phones, smart objects, etc., play an ever more important role for people and their social life. User interaction technology is a key factor of these machines, as they can better understand and support the expressions of people. Natural interaction is defined based on human senses, like: gestures, expressions, movements, hearing, vision, and so on. Therefore, natural interaction application design could provide more sensing capabilities for new machines to support human spontaneous ways of discovering the real world [1].

In order to capture the human senses, a variety of sensor technologies have been designed and integrated for natural interaction paradigm realization. For instance, Microsoft's Kinect, as a three dimensional (3D) motion sensing video camera with real-time dynamic capture, image recognition, microphone input, audio recognition, social association interaction, has also been used in gesture-based human-computer interaction (HCI) [2]. Another popular game console is Nintendo's Wii Remote Controller – Wiimote which contains accelerometer, Infra-Red (IR) camera, wireless Bluetooth connectivity, speaker and vibration motor. As a natural input device, demonstrator kit with Wiimote applied for e-teaching is developed and evaluated [3].

Considering natural interactive design and application, the sensors which can express natural senses of human beings could better help people to interact with machines using more natural and direct presentation. Both of natural interaction exemplifications and sensor technologies which are typically used as natural interaction facilities are two critical focuses in our research work.

Micro-electro-mechanical systems (MEMS) attitude and heading reference system (AHRS) is chosen as main used sensor system in this research about 3D natural interaction navigation using gesture. Corresponding cognition load carried by communication is reduced as this sensor technology could transmit gesture to computer and this embodied interaction is understood as more natural and direct expressions than traditional interaction ways. The effects of using embodied interactions to improve learning performance have been analyzed by some previous research. Barsalou indicates that embodied states can truly influence cognition and be influenced by cognition as well. This is called Embodied Cognition: when we perceive, act, interact with things and events in the surroundings, our bodies can link minds to the world [4, 5].

We put MEMS AHRS sensor system in natural interaction exemplification for this research project. In that GE technology supplies visible geographical and 3D navigation functions, we connect GE navigation programming and development technology with user sensor data input to realize natural interaction 3D navigation via gesture symbol expression. The better movement analysis and tracking abilities supplied by MEMS sensor induce more flexible and a diversity of gesture interactive design opportunities. Additionally, in order to extend the limited coverage distance of Wiimote and Kinect, we apply ZigBee wireless technology instead of Bluetooth to our research project. The larger wireless coverage range can help to realize more actual virtual world exploration in computer-assisted cinema with virtual reality technology. At the same time, we construct local machine software platform utilized in standalone application.

This paper makes these main contributions. Firstly, the hardware prototype of movement sensor system with ZigBee wireless technology is designed and developed for the purpose of larger coverage range gesture interaction tool realization. Secondly, software construction of natural interaction system implements human being's gesture interaction that control 3D navigation. Thirdly, local machine system development and 3D gesture navigation practise explore the platform construction and application of human computer interaction system.

2 RELATED WORK

L.Y.Zhang et al. [6] describe their paradigm of GE interaction with videos which are geographically and perspectively placed as “viewports” inside the world. They use GPS and compass to collect location and direction information that causes a natural organization of information that is superimposed on maps that can be browsed and queried.

T. Matsumoto et al. [7] present a new mobile HCI design with “Full-Embodied Web” concept that applies natural embodied interactions to a special mobile device for augmenting users’ experiences in real world by acquiring information from social web resources. GPS sensor and camera with 3D accelerometers are exposed through the web service technology to construct embodied interaction for integrated web application.

Kamel Boulos et al. [8] design the usage of depth sensors such as Microsoft Kinect and ASUS Xtion and provide this natural user interface (NUI) to control 3D virtual globes, such as: GE also including its Street View mode, Bing Maps 3D, and NASA World Wind.

Different from these systems, we exploit the advantage of inertial measurement unit (IMU) and MEMS sensor technology in processing movement information and ZigBee-assisted technology to realize broader coverage range and better freedom than camera-supported sensor system and Bluetooth wireless assisted sensor system with the development possibility of more diverse gesture interaction designs. In addition, IMU and MEMS sensors also can support finer movement information measurement than GPS for outside usage.

3 3D MOVEMENT SENSOR SYSTEM

3.1 CHR-6dm AHRS Hardware

Figure 1: *CHR-6dm AHRS hardware.*

Our chosen CHR-6dm board as figure 1 shown above integrates one 3-axis gyroscope, one 3-axis accelerometers, and one 3-axis magnetometers with the Extended Kalman Filter (EKF) embedded on the board. This board is a cost-effective orientation sensor providing real time yaw, pitch, and roll angle outputs at up to 300 Hz [9]. These three angles informations are attitude estimation results calculated by embedded EKF module that needs 3-axis gyroscope, accelerometers and magnetometers all together.

In addition, one Xbee series 2 OEM RF module is connected to this CHR-6dm sensor system because of the broader coverage range, longer battery supporting periods, priority of faster connection to network and lower cost of ZigBee technology [10]. This wireless connection could help gesture communication with much better freedom.

3.2 CHR-6dm AHRS Interface Software

The AHRS interface pc software running on computer connected to CHR-6dm movement interaction sensor system is provided by CH Robotics company and it is realized by C# programming technology with all source code and library resources availability.

To successfully use this CHR-6dm AHRS system for movement tracking, some setup and calibration are needed to accomplish. The procedures details are described and sensor signal observation picture is embedded below,

1. Serial port connection
2. Magnetometer calibration

Normally, Magnetometer measurement is influenced by ambient parameters, like: temperature, magnetic perturbations introduced close to the sensor. Therefore, magnetometer should be calibrated by magnetometer calibration method[1] before correctly and scientifically use this sensor system. Via magnetometer calibration window in this interface software, user need to click “start data collection” firstly. During the process of data collection, user also need to rotate sensor to cover almost all possible angles. After data collection, calcibration computation can output calibration matrix which are needed to write to RAM or FLASH.

3. Yaw, pitch and roll angles calibration

In order to setup navigation coordinate system, yaw, pitch and roll angles are needed to calibrate. In EKF window of this interface software, Mag Ref Vector is to calibrate yaw angle and user should orient sensor to the direction of perpendicularity to the gravity before setting yaw reference according to yaw reference setting[2]. For pitch and roll angles calibration, user should put sensor with x and y axis in the directed moving coordinate system and set accel reference following pitch and roll calibration procedures[3]. These setting result are also required to update to RAM or FLASH as well.

4. Sensor measurement signal observation and analysis

On Figure 2 displayed below, EKF estimated angles about yaw, pitch and roll, measured angular rates of yaw, pitch

[1] http://www.youtube.com/watch?v=PnbZK2mpY04
[2] http://www.youtube.com/watch?v=Y1PbymP0oAU
[3] http://www.youtube.com/watch?v=ZJN3kUOMaMw

and roll, could be observed with real time measurement property. On the graph of estimated angles, yaw, pitch and roll angles characterized by different colour fluctuate in real time following user gesture, and they are utilized to modulate GE view rotation on the screen. Additionally, this AHRS interface software also provides data storage function for off-line data analysis.

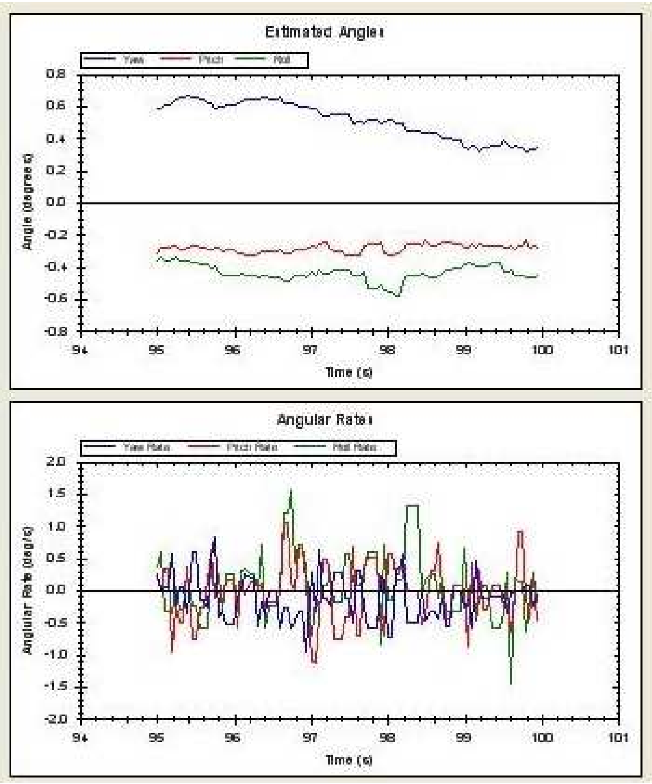

Figure 2: *sensor signal observation by CHR-6dm AHRS interface software.*

4 3D NAVIGATION PLATFORM SYSTEM WITH GESTURE INTERACTION

In order to represent the cubic, direct and natural effects and advantages of gesture interaction, we choose GE navigation technology which may help to explore 3D buildings, imagery, terrain, cities, places and businesses as interaction and navigation platform by virtual journey. For the purpose of prototype realization of 3D navigation platform system using gesture interaction, local machine platform with C# calling GE COM API technology, windows API technology and event-driven method is constructed.

GE provides individual free version, Plus version, and Pro version. GE free version lets you fly anywhere on Earth to view satellite imagery, maps, terrain, 3D buildings, from galaxies in outer space to the canyons of the ocean. For individual development, individual free version is quite enough for platform prototype construction.

After GE is installed successfully, open Visual Studio and create a windows application project, and choose "add reference…" in "Project" menu, then switch to Tab "COM" and choose "Google Earth 1.0 Type Library". Once the reference of EARTHLib is added in this proect, we can call the interface to develop application program.

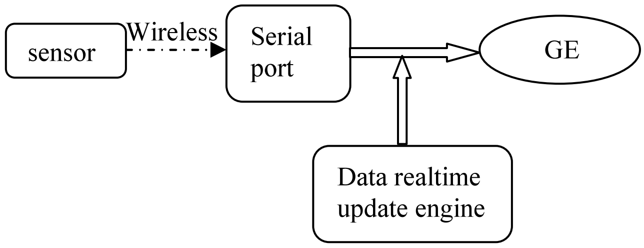

Figure 3: *3D navigation local machine platform architecture.*

This developed 3D navigation local machine platform as the architecture figure 3 with the c# programming mainly covers these components below,

- Serial port data packet receiving on computer with fixed periods
- Serial port data package processing
- GE view showing and resizing
  The view size of GE could be resized by user preference.
- Sensor data real-time update to GE view navigation by data realtime update engine
  Sensor data realtime update engine controlled by timer, can update GE view navigation and rotation according to sensor data that measures user movement.

5 NAVIGATION REAL EFFECT USING 3D GESTURE INTERACTION TOOL

Applying this developed 3D embodied navigation platform both including hardware and software system to real navigation experience and making it more interesting and meaningful, some specific global heritage funds (GHF) points navigation integrating professional world heritage culture knowledge are supported in GE using JavaScript programming technique, such as: Chavin de Huantar, Peru; Lijiang Ancient Town, China; Cyrene, Libya.

When user moves CHR-6dm sensor system following pitch angle, this Earth will rotate with latitude variation. If user moves sensor with yaw angle rotation, this Earth will move following longitude modification. Roll angle rotation will induce zoom in or zoom out. The relationship between the navigation and angles could be understood from Figure 4.

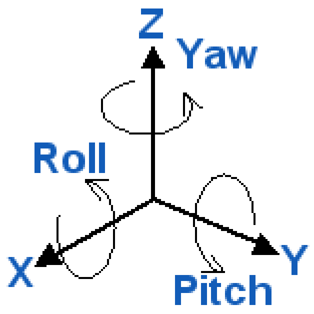

Figure 4: *view navigation and attitude angles.*

Regarding the heritage places interested by user, they can rotate CHR-6dm sensor system to modulate longitude and latitude with zoom in/out to move GE view to arrive at heritage position. Vibration on z axis in Figure 4 could stimulate this heritage knowledge window appearance as Figure 5 for more profound heritage culture knowledge acquirement by user. When user is experiencing virtual world heritage exploration via this tool, they could feel more natural, direct and interesting. The feedback from some users of this virtual world exploration reflects positive usage evaluation.

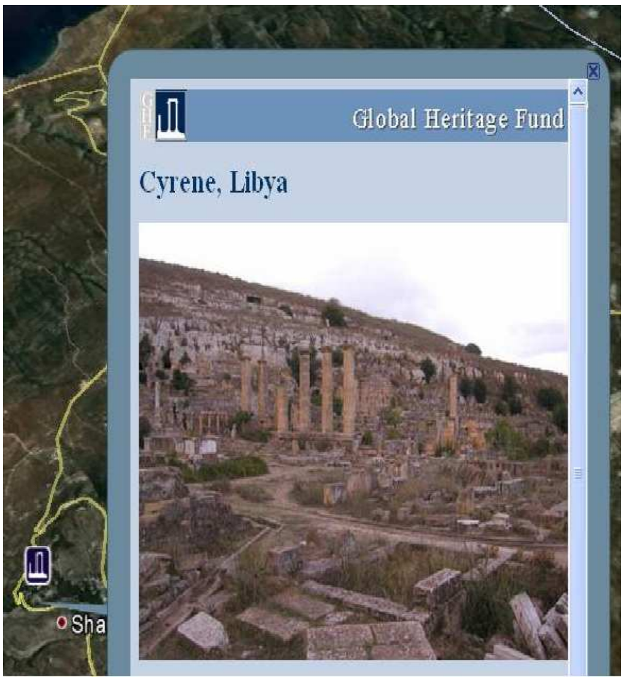

Figure 5: *3D embodied navigation zoom screenshot.*

6 CONCLUSION

For the purpose of realizing natural interaction application taking full use of human natural senses with broader interactive coverage range, we develop one suite of wireless sensor system integrated with CHR-6dm AHRS and ZigBee technology. The software architecture and technological methods are described. The 3D embodied natural interaction navigation effect is provided by the screenshot of navigation result. This research with hardware and constructed software platform proves the feasibility of this designed 3D natural navigation interaction with embodied information.

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