Analyzing Head and Eye Movement System with CORBA

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Abstract

In order to study the vestibular system in different organs of movement as well as their collaboration between working mechanism, this paper designs a model of the common object request broker architecture (CORBA) for the head and eye movement system based on the vestibular function. By analyzing physiological characteristics of the head and eye movement model, and further introducing the structure features of CORBA. It focuses on the component composition and the model design of CORBA components library. According to the physiology work model of head and eye movement, the CORBA model of head and eye movement is established. As well as the structure of the model is designed in real application of head and eye movement measurement system.This paper provides a new way to research the head and eye movement system through using mathematical modeling and application structure which is based on vestibular function.

Keywords: software architecture, vestibular function, CORBA, head and eye movement

1. Introduction

Currently, the main methods of researching the vestibular system are divided into two directions. The first direction is using biological methods [1, 2]. Biological method mainly by changing the different stimulation factors to organisms vestibular system, observe the different phenomena with the comparison group and then obtain the biological characteristics of the vestibular system. For example, use electrophysiology, biochemistry and molecular neurobiology and other specific biological methods to stimulate the vestibular system of organism, observe the different responses of organisms in the different stimulus conditions, or the vestibular system receiving the experimental organism slice experiments. Ultimately come to the biological characteristics of the vestibular system. The second direction is to establish the physical model [3]. Firstly, use the methods of mathematical modeling to establish mathematical model for the vestibular system of the organism, then make experimental analysis for the ideal model created and derived control equation of the mathematical model. By changing the input parameter values of the equations to improve the established model or create a new model to simulate and search the vestibular system of organism.

2. Physiological Analysis of Head and Eye Movement System

In physiology, the main function of the vestibular system can be described as follows: When the human body doing linear variable motion to any angle in the horizontal direction Otolith, under the inertia effect, will pull the utricle cilia of hair cells to stimulate the hair cells. Then the hair cell generates nerve impulse which will be sent to nerve center of the vestibular system, resulting in variable speed feel and linear variable-speed reflection in this direction. When head position changes in space, it will cause changes in the relative position of the otolith and hair cells in the space and the corresponding cells will produce nerve impulse in the role of pulling. Finally the nerve center analyzes the nerve impulse and provides the data of the head positions change.
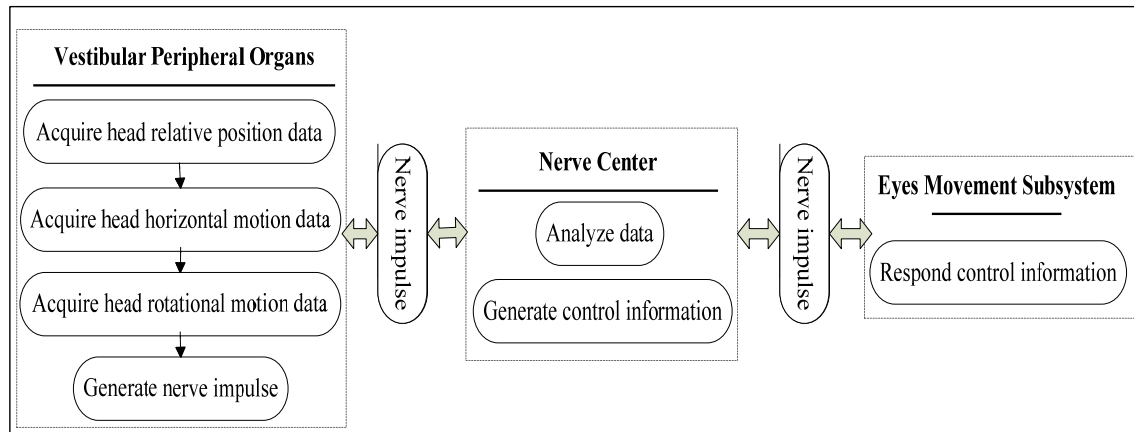
Figure 1. Physiological Structure of Head and Eye Movement System

When the body doing the rotation variable motion around a vertical axis, lymph within the lateral semicircular canal flows under pressure lashing the crista to make the cupula to one side. The internal cilia are bend by the tilt of crista to make the hair cells produce nerve impulses. The nerve impulse generated by hair cells, passing through the vestibular system to nerve center, generates rotation feeling around the vertical axis and rotary variable-speed reflection. Similar to the lateral semicircular canal, the other two pairs of semicircular canals can accept the rotation variable motion stimulus in the same plane. Finally, the nerve impulse generated by the vestibular nerve center dominates the eye movement subsystem.

According to the description of the vestibular system in physiology above, we can design a model to show the function of various organs in the vestibular system, as well as the interactions between them. The physical view of the vestibular system is shown in Figure 1. Figure 1 shows the vestibular system consists of six main functional modules, respectively is: the head relative motion module, head horizontal movement module, rotational movement of the head module, vestibular nerve, eye movement system and nerve impulse. Every module completes the physiology of the corresponding function described above.

3. Description of the CORBA Architecture

CORBA is a solution proposed by the object management group (OMG) to solve the interconnection of hardware and software systems in the distributed processing environment (DPE). The reference model [4-6] of object management architecture (OMA) describes the concept of infrastructure followed by the OMG standards. OMA is composed by the following five components: object request broker (ORB), object service, public facility, domain interface, and application object. Its core is ORB. Object service is a basic set of services which is provided for the use and implementation of an object. Public facility is a set of sharing services which is provided to the end-user application interface. Domain interface is the component for the service of the application areas. Application interface is provided by the developer for their interfaces, and does not belong to the OMG standards. The ORB provides a mechanism, through which the object can be transparent to the requesting and receiving the response. The distributed interoperable object can use the ORB to construct interoperable applications. The OMA Model is shown in Figure 2.

CORBA absorbs lots of technologies, which include software object-oriented technology, distributed computing technology, multi-layer architecture, interface technology and so on. Overall, the main features of the CORBA specification [7, 8] are as follows: (1) Distributed computing: the features of distributed computing model are described as the distributivity, parallelity, transparency, sharing. (2) The multi-layer architecture: CORBA itself is the middle ware in the middle layer, the middle layer in CORBA is more concerned about the object interoperability, product compatibility, versatility. And the system rules can be met through the effective integration of various resources that can be from any companies around the world. (3) Interface technology: interface technology is mainly from the software integration

point of view to consider the issue, and used to solve two problems: one is that how to provide a clear design standards, making the software can be maintain their independence and consistency in the overall design, detailed design, the specific coding phase and maintenance phase, the other is how to provide a packaging, enabling software development can be implemented in different languages.
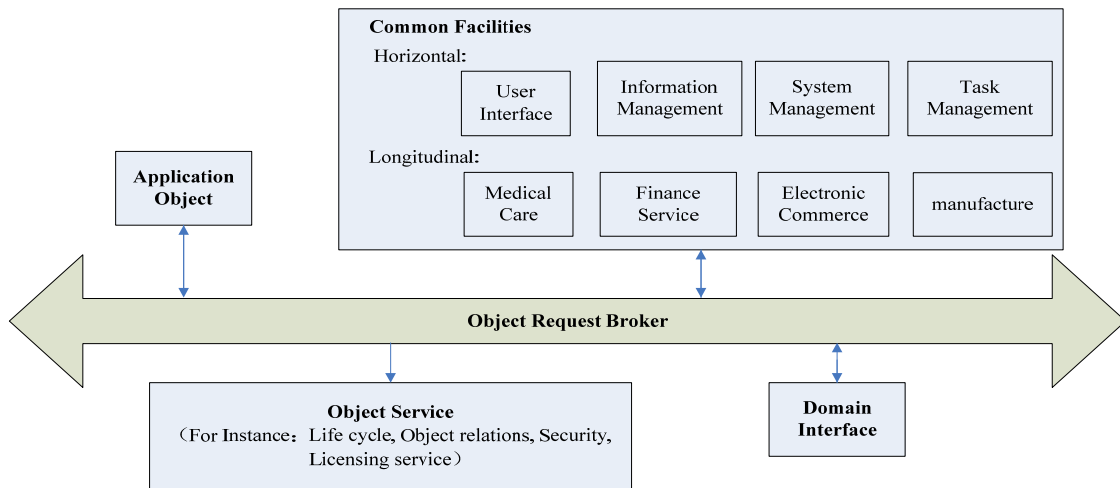
Figure 2. OMA Model

4.   Design Model of Head and Eye Movement System

On the basis of the analysis as previously, according to the design methods and principles in literature [9-12], a CORBA model of the head and eye movement system based on vestibular function can be designed. The goal of designing this model is to integrate the system's distributed architecture and reuse the components, in order to facilitate system maintenance and upgrade. The head and eye movement system designed in accordance with the architecture model is shown in Figure 3.
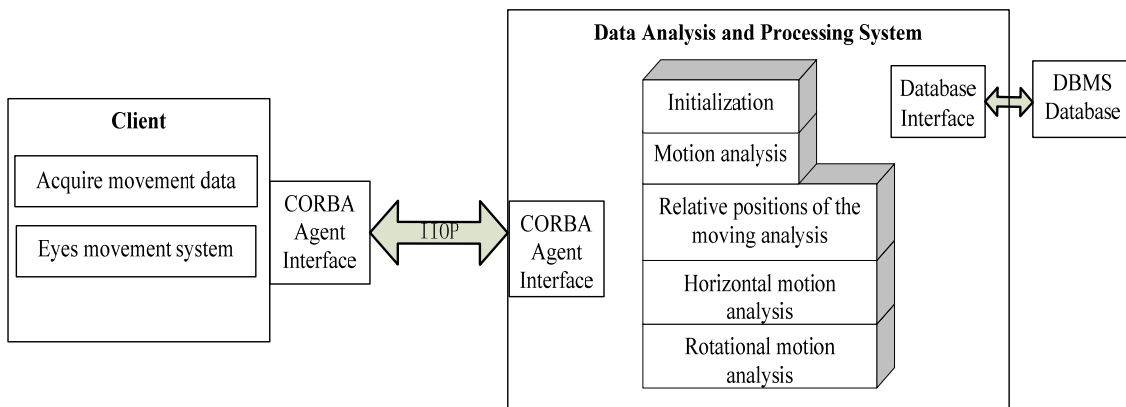
Figure 3. Model of Head and Eye Movement System

4.1. Data Processing and Control System

This subsystem is responsible for dealing with head movement information collected by the client and sending domination information to the client [13, 14].

This subsystem includes the following modules: (1) Initialization component: initializing the system including the system startup function initialization, for example, initialing attitude

sensors. (2) Analysis component: by analyzing the form data of movement, giving the form of the head movement, for example, the horizontal movement and rotational movement. (3) Relative motion analysis component: giving the data of position change provided by the head at current position relative to the the previous time. (4) Horizontal movement analysis component: analyzing the head horizontal movement's velocity, acceleration, and other physical quantities, providing the domination information for the client. (5) Rotary motion analysis component: analyzing the head rotary movement physical quantities such as angular velocity, angular acceleration, and providing the domination information for the client.

4.2. Client

Client has two main functions: collecting movement data and responding the instruction provided by the data processing and control system. (1) Movement data collection: this component is responsible for the collection of the physical data of the client's movement, and sending the data to the data processing and control system through Internet Inter-ORB Protocol (IIOP). (2) Eye movement system: it is a controlled subsystem which responds the instruction sent by the data processing and control system such as changing the eye' freeze-frame time.

4.3. CORBA Interface and Database

CORBA interface: connecting different modules and different structural systems by providing a uniform CORBA interface in which the protocol used is Internet Internal Object Request Broker Protocol (Internet Inter-ORB Protocol). The main advantages of this design pattern are as follows: (1) Introduction of middle ware: distributed centralized platform, as transaction processing, processes the business requests from client to the service object. (2) The client and the object are completely separated, the client does not need to understand the service object and its specific location. (3) Bus mechanisms: It can be integrated in the distributed system in any environment, using any language as long as the software is developed in line with the definition of interface specification.

The back-end database records the head and eye movement data and the results of analysis.

5. Head and Eye Movement Measurement System

The head and eye movement measurement system is an implementation of the above model of architecture.

The structure of the head and eye movement measurement system is mainly composed of three parts, which are helmet, host computer and control computer. There are an inertial measurement unit and two-way high-speed cameras in the helmet to collect the data of movement posture and eye balls' movement image. The control computer packages the date collected, and sends the data packages to host computer through wireless transmission. Host computer completes the function of data analysis and processing. The CORBA chart of head and eye movement measurement system is shown in Figure 4.
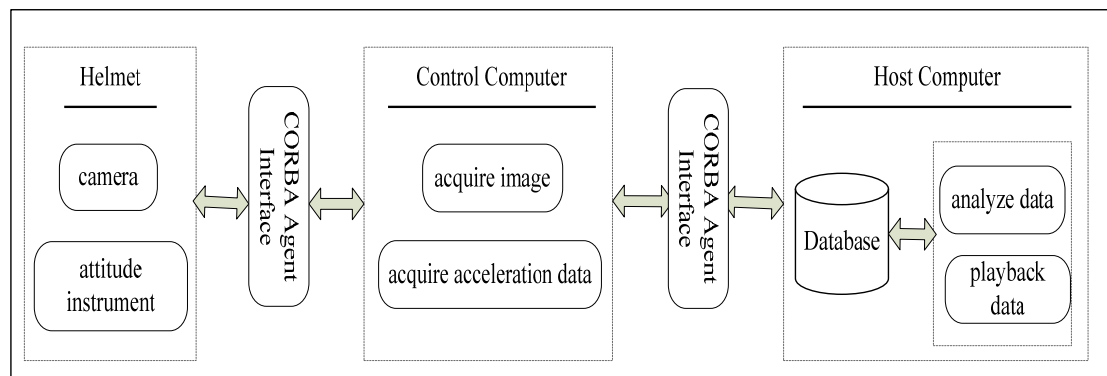

Figure 4. Structure Designed of Head and Eye Measure System

5.1. Helmet

This part completes the function of acquiring the original data of client's movement in the CORBA chart of the head and eye movement system. Mainly, this module is composed of the left and right two-way cameras and attitude instrument, completing the acquisition of the original data of the head movement including the data acquisition of the left and right cameras and the attitude instrument. Camera: video acquisition part, the control system can get the camera's connection direction from the configuration file which can be set in camera's serial number. When the camera is in the normal state it will acquire the eye balls' movement data of testers. Attitude instrument: providing three-axis acceleration and three-way rotation angle of the head movement data of esters.

5.2. Control Computer

This part completes the function of processing the original data of client's motion in the the CORBA chart of the head and eye movement system. Mainly, this module processes the the original data of head movement, including acquiring and processing video data, acceleration data, quaternion, then packaging the data and sending them to the host computer. Through this unified connection method, host computer can connect control computer and access the data coming from the control computer. In addition, this module is also responsible for testing the system state, including the working status of the two cameras, the state of attitude instrument, the network connectivity status, and battery state detection.

5.3. Host Computer

This subsystem completes the functions of the data processing and control system in the head and eye movement system in CORBA chart above. This subsystem receives the data of head and eye movement, then analyzes the data and draws the curve in real time. And the subsystem has four modules, which are self-test module, data receiving module, data analysis and processing module and data store module. (1) Self-test module: checking each module working status of the host computer. (2) Data receiving module: receiving data from the control computer via wireless transmission. (3) Data analysis and process module: according to the data received, real-time analysis of the data of head and eye' movement, calculating the relevant parameters. (4) Data store module: storing the original data of head and eye' movement, playback, freezing, printing and so on.

6.   Conclusion

The structure designed above has been applied to the head and eye movement measurement apparatus. The head and eye measurement way based on the structure above is a new research method in the field of measuring head and eye movement.

This head and eye movement measurement apparatus has abandoned the manacle of the traditional motion simulation platform, using a new method of head and eye real-time measurement to solve the problem of the test data acquisition about vestibular function, that is analysis of the motion stimulus by human body and respond the relationship between head and eye movement. The apparatus has the communication way of diversity, testing equipment high sampling rate and regulating equipment of multi-degree of freedom, in order to improve the detection accuracy, and reduces the stimulation device requirements, makes suitable exercise environment platform range more wider, and can be expanded to meet other need. In the eye movement data measurement, it is mainly the two-dimensional eye-movement measurement at home, but the overseas research progress has been to the three-dimensional measurement, and this eye movement measurement apparatus can complete the three-dimensional eye movement measurement.In this field, further improves the eye movement speed, accuracy of three-dimensional determination, that also shows the system structure designed based on vestibular function is reasonable.

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