GRASPING SIMULATION AND VIRTUAL TESTING FOR AN ANTHROPOMORPHIC HAND

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ABSTRACT. Virtual reality and robotics are two terms which nowadays are highly connected. This work deals with a hardware structure capable of real-time processing which uses a neural network for controlling the movement of articulated joints, resulting a great decrease in hand operation rates. The hardware structure assumed in this work is based on the AER (Address-Event-Representation) communication protocol, and the neural network will be modeled by the Neural Networks Toolbox of Matlab. The anthropomorphic hand is comprised by two fingers and an opposite thumb, and the hand fingers has tactile and position measuring sensors. From the results obtained in this work, simulation and modeling of anthropomorphic hand will be made in virtual reality, and the real-time control capabilities of the gripper will be analyzed and also for helping in the grasping tasks.

Keywords: Anthropomorphic hand, real-time control, virtual reality, neurobiological neural networks

REZUMAT. În prezent realitatea virtuală și robotica sunt doi termeni afași în strânsă legatură. Această lucrare tratează câteva aspecte de comandă a unui prehensor antropomorf capabil de procesare în timp real. Pentru analiza informaţiilor primate de la senzori și pentru a transmite comenzile prelucrate la motoare, se folosește o rețea neuronală modatată în Matlab cu ajutorul modului Neural Network Toolbox. Privind aspectul constructiv, prehensorul are ca bază de comunicare protocolul AER și este
1. INTRODUCTION

Real-time control is a complex problem in haptic devices such as anthropomorphic hands, and neuro-inspired approaches can be a good solution to achieve a reduced response delay in control algorithms. In this paper it is presented a hardware structure capable to achieve real-time processing, based on the AER (Address-Event-Representation). For processing the incoming information from the sensors and to send the proper commands to the control motors it was implemented a neural network capable to solve this problem. In order to be able to make complex operations like grasping, a virtual approach is needed for calculating the hand kinematics and the best grasping position. Right now there is only one specialized software for accomplishing this tasks and it is called Grasp IT! In this paper it is also presented another approach which is under development. It uses a Cyber Glove in a virtual environment and it is more detailed in the following sections.

2. UPCT ANTHROPOMORPHIC HAND

The UPCT anthropomorphic robot design hand is based on the biomechanics modelling the human hand (Fig. 1), as well as on designs by manufacturers of robot hands. The hand has two fingers and an opposing thumb, and four degrees of freedom for each finger. The fingers are mounted on a rigid palm. Each joint of the finger is actuated through 2 polystyrene tendons, routed through pulleys and driven by DC motors. The joints are moved by an agonist-antagonist opponent system. In order to measure joint position, velocity, and direction of rotation, hall-effect position sensors were integrated at each joint of the fingers. Tactile sensors based on FSR (Force Resistive Sensing) technology are mounted on all the joints and on the palm emulating artificial tactile surfaces [1]. The flexibility of these sensors is very suitable for the implementation on the curved surface of the fingertips for precision grasping and manipulations tasks. Each one of the fingers that conforms the biomechanical hand is driven by a mechanism constituted by an assembly of pulleys that control the movements of the different phalanges. Each finger is comprised of three articulations with possibility of turn and an additional articulation that permits to reproduce the movement of abduction, besides serving of element of union of the digit with the palm.

The anthropomorphic gripper.

3. AER HAND INTERFACE

To manage properly the anthropomorphic hand, the AER interface has to control 12 up/down dc motors that have two channel encoders (Fig. 2). The set of sensors available in the hand are:

-  9 potentiometers for the finger articulations;
-  12 contact resistors for the fingertip and the palm;
-  12 tension sensor for the tendons of the fingers;
-  12 current sensors for the power consumption of the motors of the hand.

The sensor information is fundamental for allowing debuging control algorithms in the hand platform. The AER-Hand interface has been developed to communi-
cate AER systems with an anthropomorphic robotic hand using two AER buses: one for incoming commands and another for outgoing information of the motors and the sensors. It is based around a Spartan 3 400 FPGA that allows an easier debugging, a future expansion, a hardware based control and co-processing.

The information received from the sensors is sent using the sending-bus to the PCI AER board which is connected to the PCI slot of the computer. The communication is enhanced using the AER protocol for high-speed communication (Fig. 3). Then the received data is interpreted by the software which will be basically a software modelled neural network. The received information from the sensors will be the input data and the output data will be a specific command to the motors. This answer will then go the opposite way, following the same path backwards, only that the hand interface will receive the command on the second bus, the receiving-bus.

Address-Event-Representation (AER) is a communication protocol for transferring asynchronous events between VLSI chips (Fig. 5), originally developed for bio-inspired processing systems (for example, image processing). Such systems may consist of a complicated hierarchical structure with many chips that transmit data among them in real time, while performing some processing (for example, convolutions). The information transmitted is a sequence of spikes coded using high speed digital buses. These multi-layer and multi-chip AER systems perform actually not only image processing, but also audio processing, filtering, learning, locomotion, etc.

**4. AER PROTOCOL AND THE PCI AER CAVIAR BOARD**

The purpose of the PCI-AER board (Fig. 4) is to transfer data to and from the board. The theoretical maximum PCI32/33 bandwidth is around 133 Mbytes/s. This would allow for approximately 33 Mevents/s considering 2 bytes per address and two bytes for timing information. Realistic figures in practice are closer to 15 Mevents/s [2]. This is the amount of data that can be processed by the board.

**5. VIRTUAL GRASPING AND SIMULATION FOR THE ANTHROPOMORPHIC HAND**

For this aspect there are two approaches. First one involves using Grasp IT. This software was developed by Andrew Miller and it’s a grasping simulator that can aid both robotic hand designers and for grasping planning tasks. It provides an interactive environment where the user can manipulate the degrees of freedom of any given hand model to form grasps (Figure 6). As contact between the links of the hand and an object occur, the simulator analyzes the new grasp on the y and provides...
the user with instant feedback concerning the quality of the grasp [4]. This information includes not only numerical quality measures, but also an indication of the grasp's weak point as well as projections of the 6-dimensional space of forces and torques that can be applied by the grasp. This approach can help analyzing the best grasp and sending kinematics data to the command and control software for the anthropomorphic hand.

A grasp strategy consists of a preshape and a set of digit trajectories, from which a grasp can be formed without movement of the robot wrist. The preshape is a prescribed hand configuration and the digit trajectories are the motions of the tips of each digit after the preshaped formed and the wrist position has been fixed.

Grasp strategies constrain the range of possible digit movements whilst still allowing a sufficient number of degrees of freedom to be able to cope with a wide range of objects. Finally the grasp stability depends very much on the object geometry. Our approach can generate several grasping strategies for the same object because there are numerous ways of grasping an object and still maintaining the stability.

6. CONCLUSIONS

The AER based systems can achieve real-time processing because of the high speed communication of this protocol and the use of a neural network for processing the received informations and for sending the proper commands to the motors. In order to make complex operations like grasping it is needed a virtual simulation and testing for sending the kinematics of the anthropomorphic hand and to help in the grasping process by choosing the best grasping position of the fingers.

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