Design of Hardware Accelerator for Fuzzy Automaton using Dynamic Reconfiguration

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Introduction

Nowadays, computational intelligence has been applied to transform human behavior and experience into mathematical representations that can be interpreted by computer programs. The development of intelligent control systems and intelligent decision support systems (IDSS) (Fig. 1) are part of this trend. Moreover, Partial reconfiguration allows some regions of the FPGA to be dynamically reconfigured while other tasks are still running in the remainder of the device. A hardware accelerator was developed for a fuzzy automaton-based decision support system in the context of testing eye-hand coordination skills for handicapped children. A Zynq-7000 FPGA platform (Fig. 3) was used for this project. MatLab simulations and a test bench environment were designed to verify the results of the hardware simulations and implementation.

Research and Discussion

Fig. 1 shows the Intelligent decision support system (IDSS). Two parameters were measured: the time the subject needed to move the stylus along the full length of the labyrinth and the accuracy of the stylus movement in terms of the number of occasions the stylus crossed the walls of the labyrinth. The result of this research is to develop a hardware accelerator for the implementation of a flexible decision support system.

Moreover, the hardware and software block diagram of system. The time and accuracy fuzzified inputs are generated by host computer. The objective of the this research is to develop a hardware accelerator for a flexible version of the IDSS that can dynamically switch from one fuzzy automaton to the other in a very short time by checking the status of an added input signal.

This capability is not crucial for a system like testing the eye-hand coordination skill levels but it is in the case of controlling autonomous robots operating in an uncertain, real-time environment. One of strong point of this research is that the system can reconfiguration and reprogrammable the hardware when the system is still working. The Fig. 4 & 5 display the software and hardware interfaces between users and the system. The users can select what hardware functions will be downloaded to the system. In the future this option will be decided by system itself by basing on the current operating conditions.

Results

This research was run successfully on FPGA and MatLab. By using Partial Reconfigurable function on the Zedboard, this design can apply reconfigurable states transition (12-states and 15-states) in the eye-hand coordination dynamically (Fig. 6). Moreover, this design is controlled by embedded software programmed on the ARM-Core. Therefore, it is very flexible for users to develop more functions in future by improving and integrating more capabilities of software.

Fig. 7 & 8 indicates the ISIM simulation and Chipscope real-time results. Moreover, this design is rechecked by Matlab simulation (Fig. 9 & 10).

Conclusions

The results of the hardware implementation of the key component of a flexible decision support system were presented. Reconfiguration was applied and it was demonstrated that real-time reconfiguration of a fuzzy automation is feasible. The embedded software running on the ARM-core to control the hardware reconfiguration is one of advantage property of this research.

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