EMBEDDED DESIGN METHODOLOGY FOR INDUSTRIAL ROBOT ARCHITECTURE USING FPGA

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Abstract:

This paper presents an embedded architecture for industrial robot control applied to visual serving system. FPGA design is used for drive the motor control of embedded processors. It is independent type of robot. The motors are well equipped with incremental position encoders and driven by pulse width modulated signals. The main advantage of this paper is utilization of minimum power; expenditure is low, high stability, flexibility and expandability. Component based design model is used to develop the IP cores and embedded architecture, which interprets a mechatronic system by computation, communication, configuration and coordination components, together with composition of these components and black boxes.

Keywords: hardware and software architecture, industrial robot control, component-based design model, Field Programmable Gate Array.

1. INTRODUCTION

Industrial robot control system have evolved from open-loop, position controlled to closed-loop, adaptive controlled systems in recent decades (Prats et al., 2008; Carozzi et al., 1995; Gu and De Silva, 2004). The needs of addressing swift real-time response, coping with unpredictable human interaction and hazard safety issues requires the next generation of robot controllers to be fast, robust and sophisticated. In medication robotics, small scale haptic devices and rehabilitation system are being developed (Song et al., 2011), the mobility of the devices requires the controller to be compact while retaining a sufficient performance; robotic catheter operating systems for surgery (Guo et al., 2012) involving sensor fusion requires high precision control, measurement and calibration.

Currently, closed-loop hardware systems are mainly dominated by microprocessors and digital ICs such as DSPs and RISC, delivering high-speed performance combined with the required flexibility inherent to all programmable solutions (Le-Huy, 1994). Subsequent advantages of DSP-based robot control systems are denoted by five main features (Chang et al., 2006): rapid development cycle, high bandwidth to cost ratio, compact design, modular and upward compatibility, plus open architecture using ANSI C. However, lack of standardisation remains a major disadvantage of DSPs or ICs. In terms of hardware, there are significant variations in bus compatibility, chip and board design, as well as final system integration. In terms of software development and system migration, recent technological progress in the field of very large-scale integration (VLSI) technology and electronic design automation (EDA) techniques has created opportunities for development of more complex high-performance hardware platforms in industrial control.

Flexible hardware such as field programmable gate array (FPGA) is currently considered an appropriate solution to increase control performance (Monmasson and Cirstea, 2007). Due to its reprogrammability, FPGA technology combines low cost development with a rising integration density (Berkeley Design Technology Inc., 2006) making it well highly suitable for embedded systems.In machine control applications domain (Liu et al.,2007; Chang et al., 2006), a growing demand in data throughput arises. FPGA technology is successfully implemented in many electric applications such as pulse width modulation (PWM) invertors, induction machine drives, motion controls (Dubey et al., 2007), neural networks control, as well as velocity measurements (Galvan et al., 1996; Hebert et al., 1993). The success is a natural consequence of cost reduction, low power consumption, reliability, real-time characteristic and significant control performance improvement by dedicated parallel computations.Current commercial industrial robot controllers (ABB,2011; KUKA, 2007) are based on modular hardware architectures, consisting of a central processor behaving as a coordinator and various additional co-processors performing low level motor control. These industrial architectures are designed to ensure robot reliability and maintainability. The commercial industrial software is usually integrated in the hardware platform and focuses on position-based motion control applications; in addition, lack of extendibility with alternative sensors or axis makes it difficult, or even impossible to extend the functionality of the robot. To address the require of complicated motion control, as well as implementing control algorithm, open source robot control software alternatives (Bruyninckx, 2001; Gu and De Silva, 2004; Gerkey et al., 2001) are being developed, maintained and widely used. However, open hardware configuration is still in an initial stage.