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DEVELOPMENT OF AN EMBEDDED ARTIFICIAL VISION SYSTEM FOR AN AUTONOMOUS ROBOT

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Abstract. *This paper presents a completely autonomous system which is able to find, detect and recognize objects by different patterns. A low-cost artificial vision system was implemented using only a webcam and a complex image processing algorithm, SIFT. This vision system can be embedded in any autonomous robot, but for experiments and demonstration it was tested on the Khepera III autonomous robot platform and the extension board KoreBotLE with ARM PXA255 XScale 400MHz processor. This paper describes all the steps and details necessary for implementing embedded artificial vision at all levels: hardware, firmware, software and behaviour. There are given solutions for different problems caused by hardware restrictions and then the results and constraints of this low-cost vision system are presented. The software system was developed to overcome hardware limitation, so that the robot could gather visual data simultaneously to the image processing, in real-time. The main contribution of the paper is the development of a method of using a complex and highly efficient image processing algorithm, SIFT, on an embedded system with reduced processing capabilities. A number of experiments were done to prove that this low-cost artificial vision system is feasible and enhances the robot's cognitive skills by processing complex visual data obtained from a simple webcam.*
Keywords: Autonomous robot, Biologically inspired cognitive architecture, Artificial vision system, Embedded computing, Image processing

1. **Introduction.** To most living creatures, vision provides 90% of the information about the environment, and so it contributes very much to the environmental adaptation, orientation, maintaining the balance and the activity of the cortex. Correspondingly, an artificial system equipped with a vision system can reach high performances and can perform very complex tasks.

A cognitive vision system can reach four generic operating levels: detection, localization, recognition and understanding [1]. The system should be modeled using a goal oriented behaviour, being able to adapt to visual changes in the environment and anticipate upcoming events. These abilities can be obtained by semantic "learning" ("understanding" shapes and behaviours), by storing information about the environment, about itself and about the relationship to the environment, and by a detailed analysis over the "seen" objects or scenes.

This paper presents an embedded artificial vision system for an autonomous robot which should be capable of finding objects, identifying them if they are known to the robot or store them in an object library if perceived for the first time. This paper describes all the steps followed in developing a complex cognitive robotics application and also points out restrictions of the embedded system and methods to adapt to hardware limitations. Four