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Brief paper

A neuro-fuzzy method applied to the motors of a stereovision system

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Abstract

In this paper, a new approach for steering a binocular head is presented. This approach is based on extracting the expert's knowledge in order to improve the behaviour of the classical control strategies. This is carried out without inserting new elements in the system. Neuro-fuzzy techniques have been chosen in order to reach this target. As a result, a more friendly robotic system is achieved.

Keywords: Neural networks; Control; Fuzzy logic; Robotics; Neuro-fuzzy systems

1. Introduction

The real world itself is an unstructured, dynamic environment. A robot operating in the real world should be equipped with mechanisms to fixate its attention on that which is important within the time frame of its relevance. At the same time, these mechanisms should allow disregarding background irrelevancies. The sensory system must therefore be capable of shifting focus to the locations of interest. Moreover, it could be able to track these targets, while it is moving. Active vision systems play an important role in order to achieve this objective. Tracking of people and events is a usual application of active vision systems. In these applications, often attention must be focused on one or more targets (Pahlavan and Eklundh, 1993; Murray et al., 1993). In addition, much of human social behaviour is influenced by directional, foveated nature of our visual perception. This fact introduces an extra dimension to the control problem. Several active vision-systems have been developed for many applications as in the areas of service robots, quality management, aids for handicapped people and many other fields (Swain and Stricker, 1993; Ballard, 1991). An important aspect in the construction of an active vision system is the drive system (Gosselin et al., 1996). In this paper, a novel idea is presented in order to improve the system drive of a binocular camera platform, keeping a low price for the whole system. This binocular camera head is based on actuating the joints by low-cost hobby servomotors. Section 2 describes in detail the whole robotic system, considering the head along with its control architecture. Section 3 is focused on explaining the algorithms to be used, while Section 4 is dedicated to explain the implementation phase and the obtained results.

2. Application

A neuro-fuzzy system has been applied to improve the behaviour of a binocular head. This binocular head is shown in Fig. 1. It consists of two cameras with four degrees of freedom. Four servomotors of direct current are used to move the cameras in order to track any target. In Fig. 2, a sketch of the system is shown, where the different degrees of freedom are pointed out. Each servomotor is associated with each degree of freedom. In this work, Futaba S3003 servomotors have been used. Each servomotor costs about 15 $. These servomotors have as inputs the desired angles to reach, expressed as a pulse width modulation (PWM) signal. That is, a pulse of 1.25 ms width correspond to a desired angle of 0° and a pulse of 1.75 ms corresponds to a desired angle of 180°. Hence, the desired angles among 0° and 180° are between 1.25 and 1.75 ms. These desired angles will be named as setpoints in the following. Inside the servomotor, a kind of proportional control strategy is implemented.

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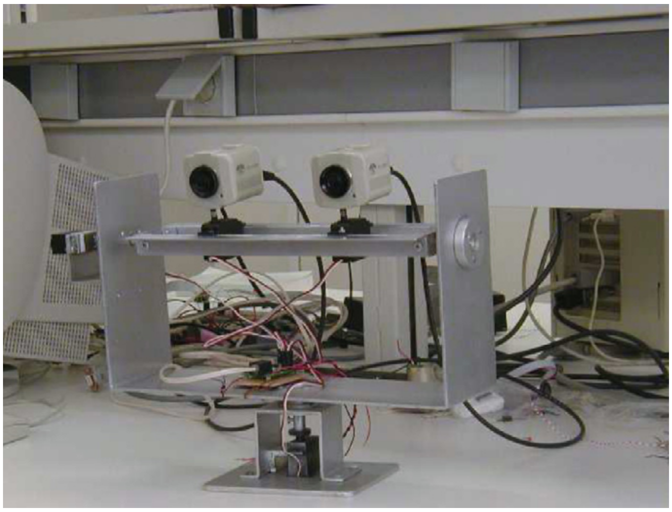

Fig. 1. Photograph of the binocular head.

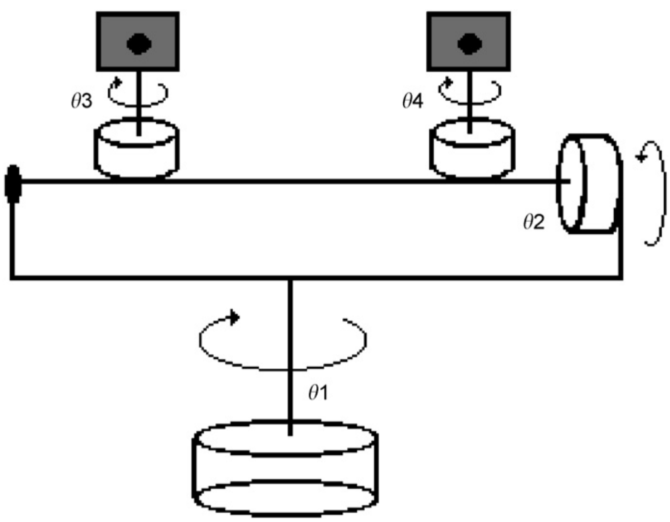

Fig. 2. Sketch of the binocular head.

This strategy is very simple. Consequently, its cost is lower than other more sophisticated control strategies. However, this algorithm presents a suboptimal behaviour in some cases. Overall, because of proportional constant is fixed for all operating conditions. Furthermore, each servomotor is working in different charge conditions; given each degree of freedom has different dynamical features in the general case.

In the case presented in this paper, a neuro-fuzzy strategy has been applied in order to overcome the proportional controller problems. The Futaba S3003 servomotors are used in combination with neuro-fuzzy systems. The neuro-fuzzy systems are used to generate the setpoints, sent to the servomotors. In this way, a considerable improvement of these low-price servomotors is achieved, in terms of efficiency and lifetime. In this approach, one neuro-fuzzy system is used for each degree of freedom. Because of that, the servomotors could have different technical characteristics, given each neuro-fuzzy system could be adapted to each particular servomotor.

In Fig. 3, a sketch of the whole system is presented. The neuro-fuzzy systems have been programmed in a computer, as it is shown in this figure. The computer sends the setpoints to the different servomotors by a serial port. In this work, a serial port using the standard RS232 Protocol has been used. In addition, a Serial Servocontroller has been used for connecting the servomotors and the computer serial port. Its price is about 44 \$. The Serial Servocontroller is an electronic module that controls up to eight pulse-proportional hobby servomotors according to instructions received serially at 9600 baud. The Serial Servocontroller, shown in Fig. 3, sends the setpoints packed in a byte. Hence, these setpoints are expressed in units from 0 to 255. Note that these setpoints are the desired angles, sent to the servomotors. A simple block diagram of these servomotors can be seen in Fig. 3, where, similar servomotors have been considered for all joints. The servomotors could be different among them, without any limitation in the application of the proposed methods. It is also important to remark that this hardware or a similar one is necessary in order the binocular head to perform its task. That is, if other classical strategy were used inside the servomotors, this hardware or a similar one must be used.

Each neuro-fuzzy system has two inputs and two outputs. The inputs are the current position of the particular joint of the binocular head and its desired position. While, the outputs are related to the timing for providing setpoints between the current position of the particular joint and the desired position to reach for that joint. That is, the proposed method is based on dividing the desired trajectory between the current joint angle and the final desired joint angle into different pieces. The extreme points of these pieces are the possible setpoints between the current joint angle and the final desired joint angle. Taking into account this procedure, the first output of the neuro-fuzzy system gives the period, where, first setpoint is applied. On the contrary, second output sets an incremental period for the other setpoints up to the final setpoint. Note that the final setpoint is equal to the desired final joint angle or the nearest value. These setpoints are between the current joint angle and the final desired angle. It is important to remark that the number of these setpoints is linked directly to the electronics of the Serial Servocontroller. In this case, only 256 different configurations are possible, that is, the Serial Servocontroller controls the servomotors as much as 180°, with each unit corresponding to a 0.70° of change in shaft position. Therefore, these setpoints are the angles between the current joint angle and the desired final joint angle in increments of 0.7°.

3. Neuro-fuzzy approach

Several intelligent strategies have been applied to solve a wide range of problems. In the presented case, a neuro-fuzzy strategy has been applied, although at the beginning of the work other intelligent strategies were considered.