Proceedings of First International ICSC Symposium on ENGINEERING OF INTELLIGENT SYSTEMS (EIS 2004) :
February 29 – March 2, 2004. University of Madeira

Reference ID

A NEW APPROACH IN THE CONTROL PROBLEM OF A BINOCULAR HEAD SYSTEM

G. N. Marichal/ Department of Applied Physics, University of La Laguna La Laguna 38271. Tenerife. Spain
Tel:+34 922 318329/Fax: +34 922 318288 /Email: nico@cyc.ull.es

J. Toledo/ Department of Applied Physics, University of La Laguna La Laguna 38271. Tenerife. Spain
Tel:+34 922 318287/Fax: +34 922 318288 /Email: jonay@cyc.ull.es

L. Acosta/ Department of Applied Physics, University of La Laguna La Laguna 38271. Tenerife. Spain
Tel:+34 922 318287/Fax: +34 922 318288 /Email: leo@cyc.ull.es

J. N. Rodríguez/ Department of Applied Physics, University of La Laguna La Laguna 38271. Tenerife. Spain
Tel:+34 922 318329/Fax: +34 922 318288 /Email: jonathan@cyc.ull.es

E. J. González / Department of Applied Physics, University of La Laguna La Laguna 38271. Tenerife. Spain
Tel:+34 922 318287/Fax: +34 922 318288 /Email: evelio@cyc.ull.es

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. The presented technique uses a Neuro-Fuzzy system along with a classical control strategy, and as a result a new behaviour more similar to a human one is achieved.

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 with is important within the time frame of its relevance, while simultaneously disregarding background irrelevancies. The sensory system must there be capable of shifting focus to the locations of something interesting and tracking it if is moving. Active vision systems play an important role in order to achieve this objective. Tracking of people and events is an application of active vision systems. In these applications, often attention must be focused in one or more targets [1]. In addition, much of human social behaviour is influenced by directional, foveated nature of our visual perception [2]. This 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 and many other fields [3][4]. An important aspect in the construction of an active vision system is the drive system [5] . 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 servo motors. 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. ROBOTIC SYSTEM.

A Neuro-Fuzzy system has been applied to improve the behaviour of a binocular head. This binocular head is shown in Figure 1. It consists of two cameras with four degrees of freedom. Four servo motors of continuous current are used to move the cameras in order to track any target. In Figure 2 a sketch of the system is shown, where the different degrees of freedom are pointed out. The speed of the motors depends on the kind of target to follow. Because of that, it is convenient the servo motors arrive at their desired angles, as fast as possible. In the following, the desired angles to reach are considered as setpoints. In this work, Futaba S3003 servomotors have been used. Each servomotor costs about 15 $. These servo motors have as inputs the setpoints, expressed by a PWM (Pulse Width Modulation) signal. Inside the servo motor a kind of proportional control strategy is implemented.

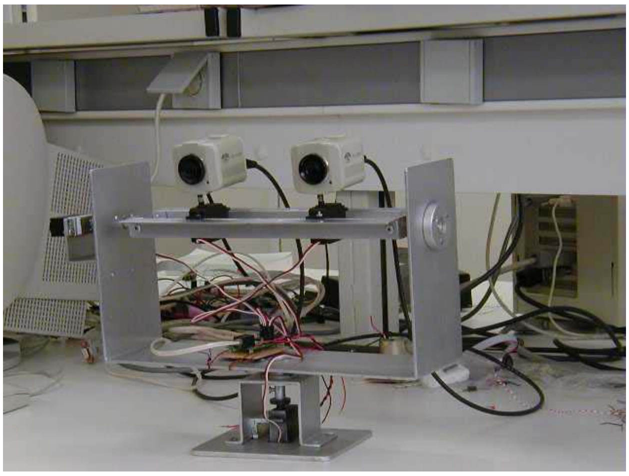

Figure 1. - Photograph of the binocular head.

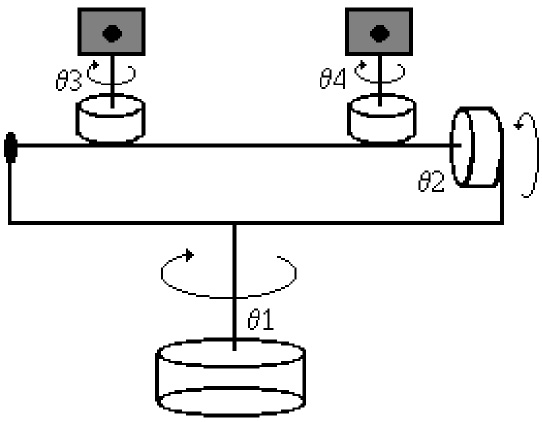

Figure. 2 - sketch of the binocular head

This strategy is very simple. Consequently, its cost is lower than other more sophisticated control strategies. However, this algorithm presents a suboptimal behavior in some cases. Overall, because the proportional constant is fixed for all operating conditions. Furthermore, each servomotor is working in different charge conditions.

In the case presented in this paper, a Neuro-Fuzzy strategy has been applied to overcome the proportional controller problems. In this approach, the Futaba S3003 servo motors are used in combination with Neuro-Fuzzy Systems. The Neuro- Fuzzy systems are applied to generate the setpoints supported to the servo motors. In this way, a considerable improvement of these low price servo motors is got, increasing their life times. In this approach one Neuro-Fuzzy system is used for each degree of freedom. Because of that, the servomotors for each link could have different technical characteristics without supposing any limitation in the application of the Neuro-Fuzzy strategy. Each Neuro-Fuzzy System has two inputs and two outputs.

The inputs are the current positions of the different links of the Binocular head and the desired positions for each of them. The outputs are related with the timing for providing new setpoints between the initial position and the final position for a movement. A way of getting better movements is to divide the movement into different parts, where each part corresponds to the path to reach a setpoint. Furthermore, the setpoints are the inputs of the servo motors, pointing out the desired angles to reach. It is necessary a high accuracy control time to send the right inputs in the right time periods. The Neuro-Fuzzy systems have been programmed in a computer. The computer is in charge of sending the new setpoints to the different links. 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 servo motors and the computer serial port. Its price is about 44 $. The Serial Servocontroller is an

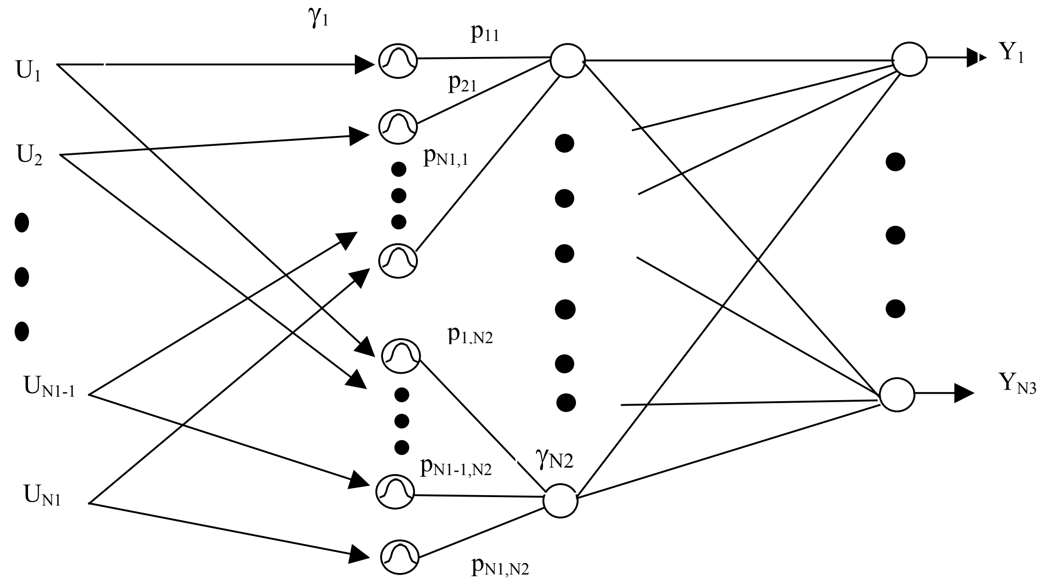

Figure 3- Diagram of the Neuro-Fuzzy System

electronic module that controls up to eight pulse-proportional hobby servo motors according to instructions received serially at 9600 baud. The Serial Servocontroller sends the servo's positions packed in a byte, that is, servo's position are expressed in units from 0 to 255. It is important to remark that this hardware or a similar one is necessary in order the binocular head to perform its task.

Taking into account this procedure, the first output of the Neuro-Fuzzy system gives the temporal period, where, first setpoint is applied. On the contrary, second output sets an incremental temporal period for the other setpoints up to the final setpoint. Note as the final setpoint corresponds to the desired position for that desired movement of the binocular head.

In the approach presented in this paper, the Neuro-Fuzzy systems provide as setpoints as the difference between the initial position and the final position allows for a movement. Obviously, the number of possible setpoints is linked directly to the electronics of the Serial Servocontroller. In this case, only 256 different configurations are possibles, that is, Serial Servocontroller controls servos as much as 180º, with each unit corresponding to a 0.70º change in shaft position.

3. NEURO-FUZZY SYSTEM.

Several intelligent strategies have been applied to solve a wide range of problems. The fuzzy logic is one of these intelligent strategies [6] [7]. It has been applied in a wide range of technical applications. A fundamental point in order to get a satisfactory result is to define an adequate set of fuzzy rules and memberships. One of the difficulties to apply the Fuzzy Logic approach is to obtain the fuzzy rules, and the membership functions. A Neuro-Fuzzy approach has been used in this case. The purpose has been to extract automatically the Fuzzy rules and the membership functions. In the case treated in this work, the Fuzzy rules are extracted by the parameters provided by a human. These parameters are related with the better way of moving a particular binocular head in order to get its target. The operator would provide some of these sets of parameters, which avoid a undesirable behaviour and the Neuro-Fuzzy System, should be able to extract the corresponding Fuzzy rules and membership functions. In Figure 3, a whole sketch of the Neuro-Fuzzy system is shown. A Learning algorithm [8] has been used in order to adjust the parameters shown in Figure 3.

4. IMPLEMENTATION.

Such as it was shown in the previous section, a training process is necessary to choose conveniently the Neuro-Fuzzy system parameters. This process is carried out in an off-line mode and it is based on the experience of an expert.

The expert has to provide the right timing for the different movements. These data are provided in a direct way, that is, a software application guides him in the whole process. Because of that, it is not necessary any previous knowledge about the applied strategies. This makes easier the definition of the most adequate fuzzy rules. It is important to remark that this approach allows the movement to be more human, along with getting softer movements.

In order to apply a Neuro-Fuzzy strategy a Neuro-Fuzzy system as the one presented in section 3 has been chosen. The Neuro-Fuzzy system is built up of two inputs and two outputs. The inputs are the current angular position and the desired angular position, respectively. The first output refers to the initial period of time while the first setpoint is being applied. On the contrary, the second output refers to the time frame each of the other setpoints up to the final setpoint are applied. Note as, the period of time while first setpoint is being applied has been considered different than the other setpoints. It has considered in this way because it is necessary to apply the setpoint in a greater frame time in the initialization of the movement. In this way the servomotor is able to acquire an adequate speed, overall taking into account that most of the times the servomotors start from the rest. In order to apply the Neuro-Fuzzy strategy it is necessary to generate a set of inputs and desired outputs for a particular binocular head.. Each training pattern consists of four values. First one is the current angular position expressed by degree units, however, the second one refers to the desired final angular position for that movement. Third value refers to the initial period while first setpoint is being applied. At last, fourth value refers to the period of time the other setpoints are applied up to the desired final setpoint. These parameters are provided by the expert. Because of that, a simple software has been developed in order the expert to see the effects produced by a particular choice of the parameters.

In summary, different movements are provided to the subsequent training process. In this way, the resultant Neuro-Fuzzy system will be able to show a similar behaviour to an expert would like.

Several trials have been carried out. The difference between the typical proportional action, and the Neuro-Fuzzy actions corresponding to one of the trials is shown in Figure 4. In this case, the training process has been started with 160 fuzzy rules. The Neuro-Fuzzy strategy (solid line) produces a better movement than the proportional action (dash line), arriving at the final position at the same time. In the case presented, a squared root error of 2.1051E-4 is obtained for the first output of the Neuro-Fuzzy system after 30000 epoques. In a similar way, a square root error of 0.0010 is obtained for the second output. At the end of the training process the number of fuzzy rules have been reduced to 33. It is important to remark that the results shown in Fig [4] correspond to the Neuro-Fuzzy system after the training process has concluded. In Figure 4 only the results corresponding to one degree of freedom have been shown, a similar process have been followed for the other degrees of freedom.

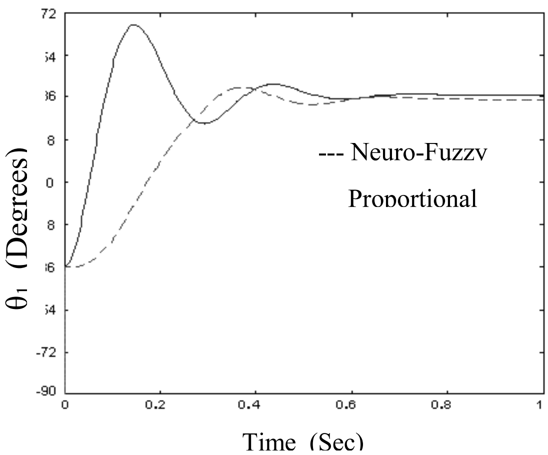

Figure 4 – Classical strategy versus Neuro-Fuzzy approach

Similar trials have been carried out with other degrees of freedom. Taking into account the obtained results it could be said that the best performance of the Neuro-Fuzzy Strategy will be associated with links, where inertial effects are considerable. However, in the cases where great inertial effects are not present, the Neuro-Fuzzy strategy still keeps a good performance.

5. CONCLUSIONS.

In this paper, a new approach to steer low price servo motors of a robotic system has been shown. It is not necessary to append new elements to the system in order to apply this strategy. This fact allows keeping a low price for the whole system. The algorithms have been tested and they have shown satisfactory results. Furthermore, the binocular head mimics the human behaviour, making it more convenient in interaction human-machine applications.

ACKNOWLEDGMENTS

This research has been supported by the Spanish Government under the Project DPI2001-3681.

REFERENCES

[1] Eklundh, J. O., K. Pahlavan and T. Uhlin. The kth head-eye system. In : Vision as a Process. Chap. 15, pp. 237-259. 1995.

[2] C. Breazeal and B. Scassellati. A Context-dependent attention system for a social robot. Proccedings of IJCAI-99, pp. 1146-1151, 1999.

[3] Michael Swain and Markus A. Stricker (eds): Promising Directions in Active Vision. International Journal of Computer Vision, Special Issue on Active Vision I, Vol. 11, 2:109-126, 1993.

[4] D. H. Ballard. Animate Vision. Artificial Intelligence 48:57-86, 1991.

[5] C. Gosselin, E. St-Pierre, and M. Gagne. On the development of the agile eye. In IEEE Robotics and Automation Magazine. pp. 29-37, December 1996.

[6] C.H. Chen, “Fuzzy Logic and Neural Networks Handbook”, Mc. Graw-Hill. 1996.

[7] Kosko B. “Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence”. Prentice-Hall.1992.

[8] Marichal G. N., Acosta L., Moreno L., Méndez J.A., Rodrigo J.J., Sigue M.. (2001) “Obstacle avoidance for a mobile robot: A neuro-fuzzy approach”. Fuzzy Set and Systems. Vol. 124, Nº 2, pp. 171-179.

[9] Miller W., III, R. Sutton and P. Werbos, eds. (1990). Neural Networks for Control. The Mit Press, Cambridge..