MICROCONTROLLER NEURAL NETWORK SOLUTION

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Abstract: The paper describes a solution for the neural network implement with microcontroller. One of the difficulties of the microcontroller neural network realization is the parameter acquiring and transmission. The neural network inputs consist in analog signals from the process. A solution for input signals conversion and transmission to microcontroller is presented. This method allows the remote connection of the converted numeric signals and an economic solution for neural network implement. The experimental results are presented and discussed.

Keywords: neural network, microcontroller, infrared remote transmission, modulation, analog to digital conversion

1. INTRODUCTION

The appearance of digital computers and the development of modern theories of learning and neural processing both occurred at about the same time, during the late 1940's. Since that time, the digital computer has been used as a tool to model individual neurons as well as clusters of neurons, which are called neural networks. A large body of neurophysiologic research has accumulated since then.

A microcontroller (also MCU or µC) is a functional computer system-on-a-chip. It contains a processor core, memory, and programmable input/output peripherals. This structure can be used for neuro-fuzzy implement.

Microchip technology, a leading provider of microcontroller and analog semiconductors, offers complete embedded control solutions that combine time-to-market advantages with high performance and increased functionality. Microchip's board family of 8-bit microcontrollers features a proprietary RISC-based architecture and is marketed under PIC microcontroller brand name.

The paper describes a PIC microcontroller solution for neuro-fuzzy implementation of climatic system. The presented solution foresees wireless transmission of measured parameters using locally analog to digital converters and infrared transmitters. First, the climatic control neural network structure is presented then the hardware implement is illustrated.

The neural network represents a simplt example. This is a neural network technology implemented with PIC microcontroller demonstration example. It is a simple neuron with tree inputs and two outputs. The neural network inputs receive, by wireless connection, the numeric values of the analog signals: temperature, humidity and the desired comfort.

In our example the neural network output is compared to multiple values, with the output going to the best fit. Instead of thinking of the output numeric values, think of numeric range as a shape instead; a circle, square and triangle will suffice. In our case, each output neuron relates to a particular behavior of the climatic system and transmits the commands to the execution elements.

Finally in the paper the experimental results are presented and discussed. The realized application demonstrates then efficiency of microcontroller utilization in the artificial intelligence domain.

2. THE NEURAL NETWORK

The neural network has three inputs and two-output single neuron showed in the figure 1. The inputs receive signals of the temperature, humidity and desired comfort trough the infrared transceiver. The neural network outputs command the heat system and the ventilation of the climatic equipment.

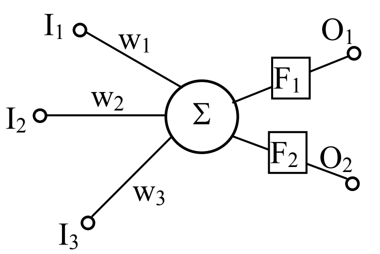

Figure 1. The Neural Network.

Typically in neural networks, individual neurons have a singular threshold (positive or negative) that, once exceeded, activates the output of neuron. In our example, the output is compared to multiple values, with the output going to the best fit. In our case, each output neuron relates to a particular behavior: heating coldness, drying or humidification.

In figure 1 the w_n take the inputs weight that is obtained in the learning process and the F_n represents the linear transfer functions (linear filters). The equation of neural network is the following:

$$O_n = F_n\left(\sum_{i=1}^{3} w_i I_i\right) \tag{1}$$

The linear transfer function allows a continuous variation of the neural network outputs that permit the specific execution elements command.

2.1. Wireless parameters transmission

The neural network inputs receive the numeric signals by infrared connection. With that end view an infrared transmitter and an infrared receiver for common remote control are used. Also, it is necessary to use an analog to digital converter for the analog signals. The principle block scheme of the input data wireless system is showed in figure 2.

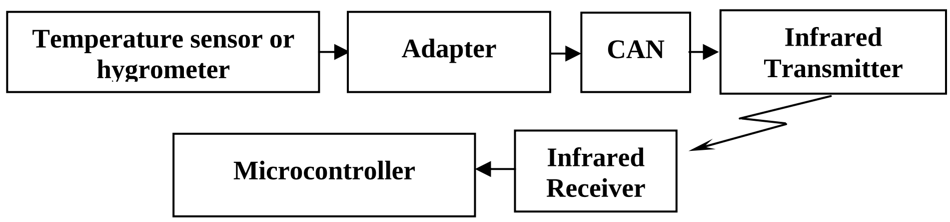

Figure 2. Wireless system scheme block.

For the infrared receiver the TSOP48 integrated circuit is used. The TSOP48 series are miniaturized receivers for infrared remote control systems. PIN diode and preamplifier are assembled on lead frame, the epoxy package is designed as IR filter. The demodulated output signal can directly be decoded by a microprocessor. TSOP48 is the standard IR remote control receiver series, supporting all major transmission codes. We can make use of only one receiver for all tree inputs because each signals sensor groups is address identified.

The circuit of the TSOP48 is designed in that way that unexpected output pulses due to noise or disturbance signals are avoided. A bandpass filter, an integrator stage and an automatic gain control are used to suppress such disturbances. The distinguishing mark between data signal and disturbance signal are carrier frequency, burst length and duty cycle. The data signal should fulfill the following condition:

- Carrier frequency should be close to center frequency of the bandpass (38kHz).
- Burst length should be 10 cycles/burst or longer.
- After each burst, which is between 10 cycles and 70 cycles a gap, time of at least 14 cycles is necessary.
- For each burst, which is longer than 1.8ms, a corresponding gap time is necessary at some time in the data stream. This gap time should be at least 4 times longer than the burst.
- Up to 800 short bursts per second can be received continuously.

The block diagram of the infrared receiver is presented in figure 3.

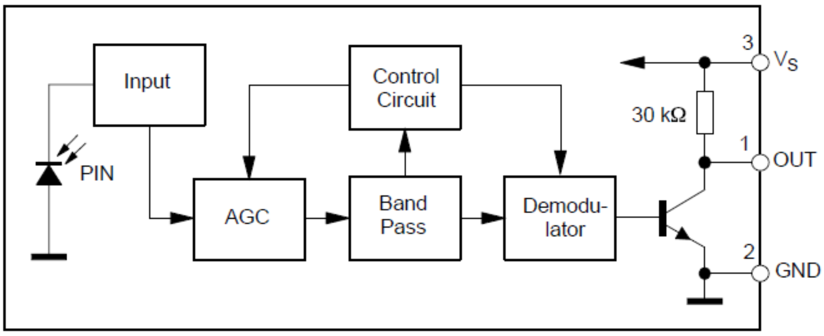

Figure 3. Infrared receiver block diagram.

The main component of the transmitter is the analog to digital converter. For our application the MCP3201 Microchip integrated circuit is used.

The MCP3201 are 12-bit successive approximation register (SAR ADCs) that offer standby currents of less than 1 µA, and active currents of 300 µA at 100 ksps. The device offer on-board sample and hold circuitry and has one pseudo-differential input with exceptional linearity specifications of ±1 LSB DNL and ±1 LSB INL over temperature. Communication with the device is accomplished by using a simple serial interface compatible with the serial peripheral interface (SPI) protocol. Both devices operate over a broad voltage range of 2.7V to 5.5V.

The serial output of analog to digital converter is coupled with the identification bits and forms the inputs words for neural network. Every sensor has it own ADC and identifications bits. In this mode a single infrared receiver can be used. The microcontroller must separate the signal inputs based on the identification bits.

2.2. The structure of experimental installation

To demonstrate the efficiency of the climatic neural system a distributed structure was chosen. We use two-temperature sensor a hygrometer and a prescription element. The schematic diagram is presented in figure 4.

The sensors for temperature and humidity, convert the continuous measured values and broadcasting the digital signal. The positions of the sensor are random in the climatic space. This thing allows the optimization of the control and the obtained results.

The central command system includes the infrared receiver MCP3201, the microcontroller and the interface for execution elements. The infrared receiver is connected to the B port of the microcontroller for the interrupt on change facilities utilization. When a transition is encountered at the microcontroller B port pin an interrupt is generated. The interrupt subroutine receives the two bytes of the sensor-transmitted word.

The neural network microcontroller algorithm supplies the command signals to the interface for the heating and the ventilation system.

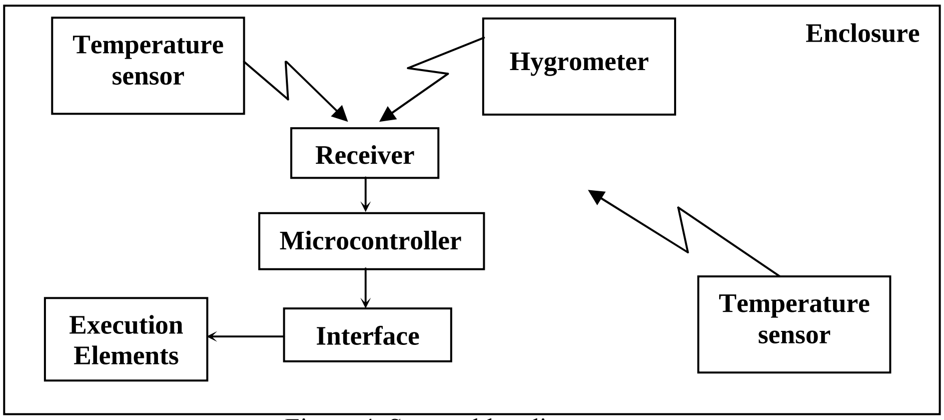

Figure 4. System bloc diagram.

The mobility of sensors represents the main advantage of the presented solution. At the same time the flexibility of the used sensor number allow the adaptation of the complexity of the system structure depending on the particular conditions.

3. CONCLUSIONS

The results show that the air-conditioning system can be achieved by the microcontrollers that have minimal resources such as 16F627 microcontroller.

Using wireless sensors enable their location anywhere in air-conditioning space that allows the optimization of process.

Implementation of neural network using multiplexing signals via an infrared receiver enables the neural networks to achieve any entries and only give the limitations of resources to available microcontroller. In this case the only condition that is necessary is that the issue to be received in direct vision. Also it is not necessary that the microcontroller to have a digital interface, analog conversion is done due the sensor.

Experiments have shown that the system correspond to the proposed solution and proves to be an appropriate solution for such applications.

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