

MICRODRIVE AND TELEMETRY SYSTEM FOR MULTI-UNIT EXTRACELLULAR STUDIES

A. Caballero-Ruiz¹, L. Ruiz-Huerta¹, E. Kussul¹, F. Heredia²

¹ Centro de Ciencias Aplicadas y Desarrollo Tecnológico, Universidad Nacional Autónoma de México
Mexico City, Mexico

² Centro de Investigación Regional "Dr. Hideyo Noguchi", Universidad Autónoma de Yucatán
Merida, Yucatan, Mexico

INTRODUCTION

In the biomedical field, the measurement of the electrical neural activity in animals enables researchers to establish valuable models of human pathologies [1] and to determine the effect of new drugs in the treatment of them [2]. In order to investigate the electrical neural activity in small animals like birds or rats by means of microelectrodes, these need to be introduced into the multiple layers of the animal's neural zone (neocortex) to register multiple neurons without disturbing its behavior [3,4].

The most common trouble being observed in this kind of measurement is the vibrations produced by the natural movement of the animal which affects the experiments. As a result of these vibrations, changes in the original position of the microelectrodes or neural damage occur and, therefore, the loss of the microelectrodes' neural signal takes place. For this reason, some researchers have proposed special systems based on devices that allow the microelectrodes to be displaced in order to record other neurons when the problem mentioned above arises.

Nowadays, manual screw-based systems are the most common mechanisms used to carry out this kind of microelectrodes displacement. However, such systems have a drawback: to rotate manually the mini lead screw that will make the microelectrodes move to a new position of study, the animal has to be immobilized (to do so, the application of anesthesia is sometimes required), which alters the results of the experiment by modifying the animal's spontaneous behavior. In the study of the neural response, it is necessary to cover some design demands to obtain reliable results, being the principal of those the study of the animal in free behavior [4-8].

In this paper, the design of an automated microdrive and a telemetry system for multi-unit extra cellular studies in rats based on a low-cost stepping micromotor is presented.

MICRODRIVES FOR EXTRACELLULAR STUDIES IN ANIMALS

Some works have reported systems for recording the electrical extracellular activity in animals using implanted microelectrodes in the animal craniums, which are placed by manual positioning devices. These works highlight the necessity of sensing some neurons simultaneously and relocating manually the microelectrodes array when the signal is lost. Nevertheless, all the information is transmitted via cables, which affect the animal's spontaneous behavior.

In this kind of studies, the process starts by setting the microelectrodes array in a fixed position into the animal's neocortex, the technique to recording the neural activity is via cables, and the positioning system is manual. Such methodologies give good results in studies in which the experimentation time is short. An experiment could go on from some minutes to some hours, but some studies require long time of experimentation to demonstrate its reliability. Therefore, in order to increase the reliability of the neural studies in animals, some research groups proposed wireless systems for recording and transmitting electrical signals, but the positioning systems are still manual [10,11]. Other authors emphasize the influence of anesthesia in the animal's neural activity [12, 13].

Another example of a system intended to increase the reliability of neural studies was presented in 2001 [14] in which a miniature

motorized microdrive was reported. In this work, an automated microdrive by means of a commercial DC micromotor was proposed. The whole system consisted of three microelectrodes moving independently. Although this system represents a good alternative to automate a microdrive, the way to record the neural activity is made by a wire system.

MICRODRIVE AND TELEMETRY SYSTEM DESIGN

Combining a wireless system for the recording of neural activity with an automated microdrive system, which is moved along the different target places of the animal's neocortex, is advantageous. In order to accomplish these tasks, the development of an automated electromechanical device (microdrive) for moving the microelectrodes and the development of a telemetry-telecommand system for recording the neural activity and for controlling the microdrive is proposed. The microdrive will be placed as implant on the rat's head, which contains an array of four microelectrodes. The microdrive and the microelectrodes will be connected to the telemetry-telecommand system that will be placed on the rat's back. Such a telemetry-telecommand system is based on a transceiver, which will perform two tasks: one of them will be to amplify the neural signals from the array to be transmitted in a wireless way to an external PC; the other will be to receive the control signals coming from the PC to relocate the microelectrodes when the signal is lost. Figure 1 shows the proposed system.

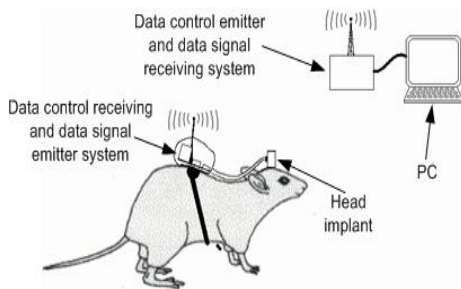


FIGURE 1. Automated microdrive and a telemetry system for multi-unit extra cellular studies in rats.

Automated microdrive

There are some considerations to take into account in the microdrive design: First, its maximum weight should be 25 g so that the rat can carry it on its head. Second, its size must be

smaller than 15x15x15 mm, which will allow the animal to behave freely [14]. Third, the system resolution must be between 10 to 20 μm in order to allow the researcher to find new neural zones as the multiple electrodes array is relocated. Fourth, the movement range of the system must be 10 mm. Finally, the proposal has to represent a low-cost alternative.

Taking into account the experience of the researchers of the Laboratory of Micromechanics and Mechatronics in the development of micromechanical systems, and particularly in the development of micromechanical systems, as well as in the development of actuators for the automation of micromachines tools [9]; we propose an automated microdrive based on a microstepping motor, which reduces the total cost of the microdrive.

Figure 2 shows the proposed design. Basically, the microdrive is composed by a stepping micromotor (a), which is coupled to a leadscrew (b), by means of a three-gears drive (c). The leadscrew is placed between two bearings (d). A nut (g) moving along the leadscrew allows the multiple microelectrode array (i) to be displaced. The nut will be guided (h) in order to avoid free spinning. The multiple microelectrodes array is epoxy glued to the nut. The microdrive is supported by means of the principal (e) and the secondary plates (f). The microelectrodes will be guided and supported by a syringe cannula (j). The microdrive will be screwed to the rat's head.

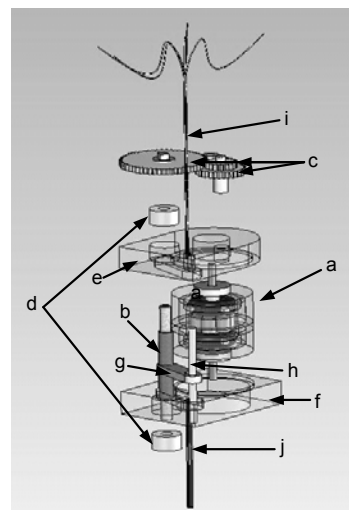


FIGURE 2. Proposed design.

Figure 3 shows how the microdrive is placed on the rat's cranium.

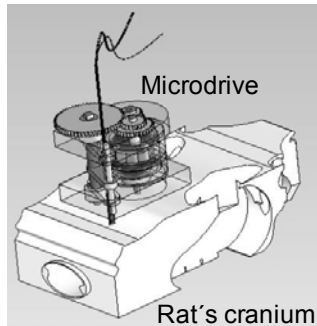


FIGURE 3. Scheme of the microdrive placed on the rat's cranium.

Telemetry-telecommand system

This system is divided into two transceiver modules (Figure 4). One of them placed on the back rat. The second one is connected to the parallel port of a PC.

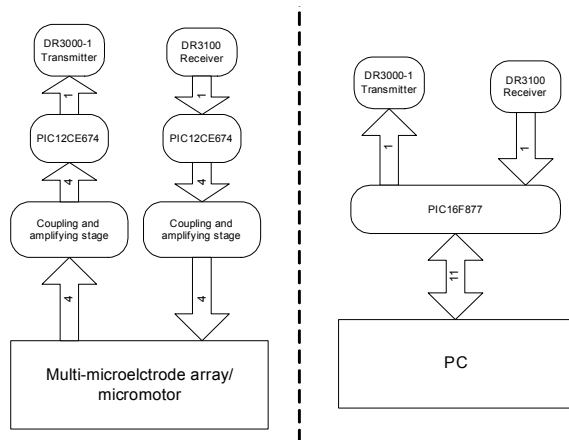


FIGURE 4. Block diagram of the rat module and the PC module.

The rat module is used to receive, via the DR3100 transceiver, the control data from the PC in order to control the microdrive. The control data is used by the PIC12CE674 microcontroller to generate the pulse sequence for controlling the position of the multiple microelectrodes array and a current amplifying stage is placed between the micromotor and the microcontroller.

In the same module, the DR3000-1 transceiver is used to transmit the neural data signals. Those signals coming from neurons are coupled by a J-FET voltage follower and amplified using a Darlington transistor. An offset voltage is

added to the signals before being sent to a RISC PIC12CE674 microcontroller with 4 channels having a 8-bit A/D converter each one. Finally, the digitalized signals are sent to the DR3000-1 transceiver.

The second module employs a PIC16F877 microcontroller to receive, via the DR3000-1 transceiver, the neural data and delivers this information, via parallel port in Enhanced Parallel Port mode to a near PC. The user selects in the PC the number of steps that the motor has to execute; this information is received via the parallel port by the PIC16F877 microcontroller, which in turn transmits the data by means of its serial port to the DR3100 transceiver configured as a transmitter.

PRELIMINARY RESULTS

Figure 5 shows the first prototype of the microdrive. The employed Lorentz-Force stepping micromotor is composed by two stators to increase the torque and the rotor made by a phenolic disk which has six inserts of permanent magnet to obtain 12 steps per revolution. The current consumption of this motor is 600 mA providing a torque of about 250 μ Nm. This micromotor weights approximately 1 g. The micromotor is coupled to a three-gear drive with a 4.31:1 relation and a leadscrew having a pitch of 0.4 mm. The microdrive has the following characteristics:

General dimensions	13x14.5x16.6 mm
Total weight	\approx 5 g
Range of displacement	1.2 mm
Resolution	\approx 7.5 μ m/step



FIGURE 5. Microdrive prototype.

A prototype of an electronic circuit was developed to test the capabilities of the RF transceiver system. The system was tested using a signal generator and the results are shown in figure 6. The sample rate for this experiment was 10.5 ksamples/sec. The current

consumption of the electronic system placed on the rat's back is approximately 30 mA.

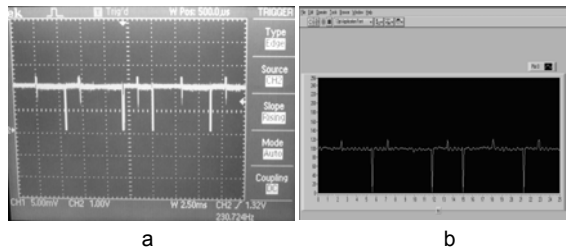


FIGURE 6. A. Signal to test the telemetry data acquiring system; B. Recorded signal using the telemetry data acquiring system.

CONCLUSIONS

Automated microdrives for extracellular studies of neural response in rats represent a good application in the micromechanical field. The telemetry-telecommand system and the microdrive fulfill the requirements and will allow to develop reliable studies of neural response in animals. It is necessary to improve the micromotor design in order to decrease the current consumption. The design described in this work can include other motors in order to move each electrode independently, using a shifting system. In the near future we will present the results of the microdrive characterization.

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