Tremor suppression by Functional Electrical Stimulation

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INTRODUCTION

Pathological tremor is the most common movement disorder. More than 5% of the population over the age of 50 has some form of pathological tremor, and there is no effective treatment for 25% of cases. The most common tremor pathology is essential tremor, characterised in that tremors are the only visible symptom of the pathology. For this reason, in this specific case it would be suitable to provide a system capable of suppressing the pathological tremor.

Although the tremor does not imply any health risks in itself, it is highly disabling, since it can interfere extensively in many everyday activities such as eating, drinking or shaving. For this reason, the suppression of tremors in other pathologies, such as Parkinson’s disease, can also be beneficial, even when the actual pathology is not treated.

Faced with this situation, the European TREMOR project, in which the Institute of Biomechanics of Valencia (IBV) is involved, is exploring the feasibility of using Functional Electrical Stimulation (FES) as a system for suppressing pathological tremor in the upper limbs. Functional Electrical Stimulation is a methodology that enables the activation of muscle groups by applying an electrical field. It is extensively used in rehabilitation and intensive physical fitness programmes, although the most straightforward devices have gained popularity as passive exercise systems.

The TREMOR project, directed by the Bioengineering Group of the CSIC, is broken down into three major phases:

1. Determining the needs of the users and conceptual design of the system.
2. Developing the system components.
3. Validating the system and analysing its feasibility.

Phase 1 of the project is already complete, phase 2 is nearing completion and phase 3 is still in the early stages.

The IBV’s involvement in phase 1 consisted of researching the needs of users and defining the conceptual design. In phase 2 a biomechanical model was developed for controlling movement via FES. In phase 3, the sensitivity to FES of the candidate pathologies was analysed.

At this time, the first tremor suppression tests are under way. The results will be published at a later date, in a subsequent issue of the Biomecánica journal.
Below is a description of the most important results obtained.

**RESULTS OBTAINED**

**Conceptual design of the tremor suppression system**

The purpose of this task is to discover relevant aspects in the design of an FES tremor suppression system that will guarantee that patients who suffer from pathological tremor will find it acceptable.

The conceptual design was based on the needs of potential users. For this purpose, a discussion group was set up among patients with pathological tremor and professionals involved in treating these pathologies. The discussion group produced a map of restrictions with critical design aspects to ensure that a tremor suppression system will be acceptable. Next, a series of sketches were drawn to show possible design solutions that were compatible with the restrictions. The other partners in the project were contacted to obtain information on the technological possibilities of the developments. A group of users was selected to individually rank the designs in accordance with their own preferences (Figure 1) in order to determine the optimum parameters for the conceptual design of the system.

**Analysis of sensitivity to FES among the target group**

Since high electrical field values can cause unpleasant sensations, the purpose of this trial was to determine the tolerance thresholds for various FES parameters and various candidate pathologies.

Experiments were designed for assessing sensitivity to pain. In them, the parameters of the stimulation frequency, the intensity, as well as the side on which the stimulation was applied (flexor or extensor), the pathology of the tremor and the responsiveness to stimulation were all controlled. The last of these aspects was the reason why the patients were asked to take the tests during different sessions. The results (Figure 2) show that the system is not the best option for patients with hereditary cerebellar ataxia, given their increased sensitivity to electrical stimulation. However, the system was considered suitable for patients with essential tremor and tremor caused by Parkinson's disease. Responsiveness to stimulation was not the most important parameter and we can see how the maximum intensity tolerated by the sample group was around 20 mA, which sets a new design restriction for the system.

**Development of a biomechanical model for movement control via FES**

The biomechanical model is necessary in order to activate the muscles to the point of suppressing the tremor while still allowing voluntary movement.

As for the biomechanical modelling tests (Figure 3), a methodology was developed which enables good prediction of the physiological response of the arm to stimulation. The model (Figure 4) was based on earlier physiological models published...
hed in the scientific literature although, unlike the latter, the new system enables identification in blocks, meaning that all the parameters of the system can be obtained by empirical means, from the biomechanical parameters (inertia, viscosity and rigidity), to those that determine the ratio between stimulation variables and the activation of stimulated muscle groups. It is therefore particularly well suited for tremor suppression systems, since the system configuration time can be very short (several seconds), while recently published biomechanical models for FES control require identification procedures that can last longer than thirty minutes.

**CONCLUSIONS**

Functional Electrical Stimulation is a technique with major potential in the field of Rehabilitation and Personal Autonomy. Also, the use of FES for pathological tremor suppression in the upper limbs can expand its scope of application.

In order for a system with these characteristics to cover the needs of patients who suffer from tremors, it must be able to mitigate their effects, not interfere with voluntary movements and not produce pain or discomfort, as well as being accepted by the users.

The TREMOR project is studying the feasibility of using FES not only by analysing the effectiveness of this methodology, but also by studying how it will enhance the quality of life for the people who use it.

Therefore, by means of the TREMOR project, we hope to develop a system that meets all the necessary requirements to improve the quality of life of patients who suffer from certain pathological tremors.

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