Assistive Robotics as Alternative Treatment for Tremor

E. Rocon¹, J.A. Gallego¹, J.M. Belda-Lois², and J.L. Pons¹

¹ Bioengineering Group, CAR-CSIC, Madrid, Spain
e.rocon@csic.es
http://www.car.upm-csic.es/bioingenieria/
² Instituto de Biomecánica de Valencia, Valencia, Spain

Abstract. Tremor is the most common movement disorder and strongly increases in incidence and prevalence with ageing. Although not life threatening, upper limb tremors hamper independent life of 65% of those suffering from them, greatly impacting on their quality of life. Current treatments of tremor include drugs and surgery. However, tremor is not effectively managed in 25% of patients. Therefore, further research and new therapeutic options are required for an effective management of pathological tremor. This paper introduces some rehabilitation robots developed for tremor suppression based on biomechanical loading, their evaluation and the identification of their limitations. At the end, authors aim to provide a view of the potential of this novel approach for tremor management and the plans for commercialization.

Keywords: tremor, assistive robotics, biomechanical loading.

1 Introduction

Tremor is defined as a rhythmical, involuntary oscillatory movement of a body part.⁰ Under certain circumstances, like the performance of precise tasks, or prolonged maintenance of a posture, we all exhibit a certain degree of tremor. This is called physiological tremor.¹ When tremor arises from a neurological condition, becoming cause of disability, it is referred to as pathological tremor.² Pathological tremor is the most prevalent movement disorder,³ and projection studies foresee that prevalence will double by 2050.⁴ Importantly, pathological tremor, referred to as tremor in the remainder in the document, does not constitute a monolithic entity, and appears caused by ten different so-called syndromes. Among them, Parkinson’s disease (PD), and essential tremor (ET) are the most relevant in terms of prevalence.⁵ Tremors are currently managed through pharmacotherapy or surgery, consisting either in stereotactic thalamotomy, or more commonly nowadays, in Deep Brain Stimulation (DBS). Unfortunately, both alternatives have significant drawbacks associated: drugs often induce side effects, and show decreased effectiveness over years of use, while DBS is related to increased risk of intracranial haemorrhage (4% of patients), and psychiatric manifestations, and the percentage of...
eligible patients is extremely low; for instance, only 1.6 to 4.5 % of those with Parkinsons Disease, [2]. As for the tremors themselves, the mechanisms accounting for the alleviation of their symptoms by drugs, thalamotomy or DBS are unknown, hampering the refinement of the existing treatment forms, and the development of novel ones. As a result, tremor is not effectively managed in a significant proportion of patients, up to 25 % according to some estimates [1], and is a major cause of dependance and loss in quality of life. In addition, tremor carries important social and psychological burden associated, which further affects both patients’ and relatives’ lives. This motivates that the development of novel therapies for tremor is matter of paramount importance.

It has been established in the literature that most of the different types of tremor respond to biomechanical loading. In particular, it has been clinically tested that the shunt increase of damping and/or inertia in the upper limb leads to a reduction of the tremorous motion, i.e. the change in impedance characteristics of the upper limb has a direct effect on the tremor characteristics, [7].

This paper describes two research projects in which two different wearable robots based on force loading were developed and validated for tremor management. The first consisted of a robotic exoskeleton that applied forces to different joints of the upper limb and consistently attenuated moderate and severe tremors. The second approach takes the form of a neuroprosthesis based on transcutaneous neurostimulation. This system is based on the same approach of biomechanical loading but using human muscles as actuators. It was evaluated with patients and successfully alleviated mild tremors, although to a lesser extent than moderate or severe ones, but it moves toward the implementation of a textile-based device that better fulfills patient expectations. This paper is organized as follows. The robotic exoskeleton is briefly described in the next section, which is followed by a description of the development and validation of the neuroprosthesis. Section 4 discuss the major findings of both approaches. The paper concludes by outlining current and future research in the field of biomechanical loading.

2 Wearable Orthosis for Tremor Suppression

The active orthosis (exoskeleton) WOTAS was developed under the framework of the European project DRIFTS [8]. The concept of WOTAS is to develop an active upper limb exoskeleton based on robotics technologies capable of applying forces to cancel tremor and retrieve kinematic information from the tremorous upper limb. The overall aim of this project was to develop a powered orthosis to provide means of testing non-grounded tremor reduction strategies in three joints of the upper limb. This robotic orthosis platform is able to monitor, diagnose and control tremor in subjects. This robotic exoskeleton is equipped with kinematics (angular position, velocity and acceleration) and kinetic (interaction force between limb and orthosis) sensors. Moreover, it could also apply dynamic force to the articulations of the upper limb by means of a set of flat DC motors + pancake gears [8]. Innovations of the WOTAS exoskeleton are its portability, it