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System Integration of an Upper Limb Disorder Part-Task Trainer with PC-based Control

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Abstract

The application of a high-fidelity part-task trainer for clinical education on upper limb disorders allows students to carry out recurring practices, gain skills and build up their confidence prior to engaging with real patients. The standardization of the symptoms' assessment assists in the improvement of clinical findings which are not just limited to spasticity, but also leadpipe rigidity and cogwheel rigidity. The deployment of the Beckhoff PC-based control technology enables high precision in simulating spasticity characteristics thus increasing trainee proficiency. With the growing number of medical schools and therapy training centers, it solves the dilemma of patient unavailability and the difficulty of obtaining patient assistance for the preparation of apprenticeship training.

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Keywords: spasticity; part-task trainer; system integration; PC-based control technology

1. Introduction

Part-task training technology is defined as groundwork on some sets of work of the entire task as an introduction to the performance of the whole task. Part-task procedures are intended to develop learning efficiency and to reduce costs. It consists of splitting a task into sub-tasks to be presented to the learner. Part-task education allows the trainee to perform subsets of a task in isolation from the whole. Whole-task training consists of presenting a whole task to learners so that they are able to put into effect the task as a single component. Whole training eradicates the fear of having to reintegrate the sub-tasks which are crucial in part-task training schemes. The work task becomes more complex with the whole task method. Preparing individuals for whole task methods is potentially risky and costly, and part-task training is helpful for the upkeeping of skills that are essential only in irregular instances. Thus, research shifted towards part-task training and research of the best means of segmenting and reintegrating a task as well as the solidity of learning that takes place in these part-training approaches [1]. With relation to clinical education and therapy, the ability to analyze the level of upper limb disorder symptoms is important before the

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prescription of a suitable rehabilitation programme. Differences among therapists lead to different rehabilitation session involvement. Thus, this paper introduces the integration PC-based control into medical training devices.

Upper limb disorder can be divided into musculoskeletel and neurologogical disorders. In this paper, we are focusing on simulating spasticity for preliminary work with the aim of eventually implementing it for other symptoms in future. Spasticity is a heightened, velocity-dependent stretch reflex commonly found in post brain injury such as stroke, traumatic brain injury and cerebral palsy [2]. Spasticity occurs from neurological disorders of the upper limb or lower limb which can be observed among patients experiencing problems in the central nervous system such as stroke patients. Spasticity is a symptom associated with the disability of the human body and joints. Spasticity may cause pain, joint deformity, difficulty in performing activities of daily living, muscle tightness or stiffness, or failure on muscle task. Post stroke rehabilitation consumes a huge amount of health care resources in terms of cost related to hospitalisation and home assistance [3]. It is imperative that clinicians and the multidisciplinary team members are able to recognise spasticity when it does occur so that the correct program and intervention can be applied.

2. Function

These sections describe the specific function of the upper limb disorder part-task trainer with reference to the clinical records of spasticity symptoms from Noor Ayuni Che Zakaria et al. [4]. From the clinical data, a sample of the spasticity symptom profile from the Modified Ashworth Scale 1+ is shown in Fig. 1 to clarify the function of this prototype in detail. A moment around the elbow joint exerted by the patients show the catch phenomenon. Catch is a phenomenon of muscle resistance occurring during impulsive passive movement. Catch is proportional to the angular velocity.

Fig 2 shows the overall function of the system integration. In order to design an upper limb disorder part-task trainer, the main purpose of the system is to be able to imitate the upper limb muscle tone. To achieve the objective, the prototype outer design shall resemble the human upper limb and possess the function to inspect the elbow angle position. Based on previous clinical databases, it will need to be able to associate real-time data with the actual patient data. Furthermore, it is essential to provide feedback according to the tone of the upper limb disorder symptom.

An additional function of the prototype is the fact that it can be used as a teaching and learning method for the trainer. This includes a warning alarm system to inform the trainer if the system detects stretch speed that is out of range. Moreover, it must provide a friendly user interface for training purposes. On the other hand, the system shall be upgradable to more features for future improvements and research such as additional complicated software functions and various types of inputs or outputs and motors at a lower cost of implementation. With some addition on the function, the system shall be expanded to replicate existing and future potential limb disorder symptoms through minor tweaks in the software and hardware.

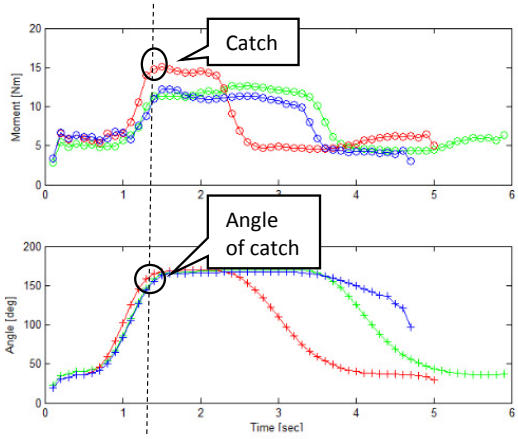

Fig. 1. Upper limb spasticity symptom characteristics for Modified Ashworth Scale 1+