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Review Article

Review of Active Disturbance Rejection Control-based Exoskeleton System

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Abstract

Stroke is a primary contributor to decreased ability to carry out activities of daily living. Understanding and refining rehabilitation therapies to target cortical neuron plasticity to enhance recovery of upper or lower limb function has been a major emphasis. To provide regulated and assisted mobility of the paretic limb, therapists have coupled traditional therapy with the use of mechanical and robotic equipment (Exoskeleton). The capacity to deliver higher degrees of intensity and repeatable repetitive task practice through the use of intervention devices is one of the most important mechanisms for improving rehabilitation efficacy. Active disturbance rejection control (ADRC) and it is an innovative design method. In the absence of suitable models and in the presence of model uncertainty, it has been recognized as an effective control method. In this short review, the speaking specially about ADRC as new trend for Exoskeleton control system.

Keywords: Robotic Exoskeleton; Rehabilitation; ADRC; Healthcare; Control Methods

Introduction

ADRC is a well-developed research and application field in the design of automatic control systems for a range of dynamically controlled systems. Its origins can be traced back to the nineteenth century [1-3]. The Some fundamentally important themes were already being taught to modern ADRC. During the final half of the twentieth century, it was very popular in the Soviet Union. Its maturation as a useful and novel controller design tool has begun. Since the 1980s and throughout the twenty-first century one of the Over the years, the primary difficulties and concerns related with ADRC have been the absence of a broadly accepted mathematical foundation for theoretical the subject's foundations [4,5]. The straightforward characteristics, which allow for direct applications and implementations, have reached a remarkable state of development. Slowly, but steadily, the necessary rigorous foundation has begun to emerge in recent publications, putting the entire framework into a wider acceptability and expanding the possibilities for practical advancements in academic laboratories and industrial settings all over the world.

In a wide range of scenarios, the strategy is straightforward, elegant, and effective. The disturbance is unstructured in general, i.e., it may be caused by unknown or neglected internal system variables, or it may be caused by external phenomena affecting the system. Disturbances are supposed to be unpredictable, unknown, and unmolded in any scenario. As previously stated, we divide the nature of the disturbances into two categories: endogenous disturbances, which are dependent on internal variables such as states, outputs, and even control inputs, unmolded parasitic, and nonlinearities; and exogenous disturbances, which are dependent on external variables such as states, outputs, and even control inputs.

ADRC is a newly created control approach that aims to close the gap between theory and practice in control [6]. It has the same ease of use as a standard PID control, but with more advanced capabilities like smoothing setpoint jumps via a transient profile generator and nonlinear feedback combination. All unknowns in the regulated process, such as unknown process model and disturbances, are treated as “generalized disturbances” by ADRC, and the controller is designed to reject them. ADRC, like PID control, does not necessitate a model of the controlled process and so has a wide range of applications [7]. It has been demonstrated that ADRC provides superior control.

Exoskeleton system modelling

Exoskeletons and other helpful robotics could be essential in treating locomotion concerns. A customer robotic system employed to restore or enhance limb function is termed as an exoskeleton [8]. Lower leg exoskeletons are now the most popular applications in rehabilitation and improving quality of life, yet exoskeletons are employed in a variety of fields including industrial, army, and healthcare. Figure 1 depicts a schematic representation of a Exoskeleton device [9-11].

Figure 1: Exoskeleton device.

ADRC in exoskeleton device

Wearable robotic exoskeletons are mechanical structures with joints and connections that are compatible with human limbs [12]. Many robotic lower-limb exoskeletons, such as BLEEX [13], AUTONOMYO [14], and others, have been used to help the lower extremities. The rehabilitation programs PH-EXOS [15], and HAL [16] have been developed. Or to increase one’s power. Hip–knee–ankle exoskeletons are the most common type of robotic exoskeleton. Based on the varied help, hip–knee motion, hip motion, or knee motion Functions [17]. In control technologies for robotic hip exoskeletons, different approaches to the generation of assistive torque or rehabilitation trajectories were proposed. The availability of all state variables is required for the construction of a state feedback controller, however this condition is not always met; in certain circumstances, due to defective sensors, some states are unavailable or immeasurable [18]. Hence, observer based technique is utilized to reconstruct such state variables or using in general ADRC technique. There are many problems for using classical control methods for Exoskeleton system to overcome such control difficulties, the (ADRC) method is proposed.

The rapid adoption of ADRC in industry over the last three decades demonstrates its widespread use in motion control, flight control, and process control applications, as well as in a variety of other domains. The architecture of ADRC is built to produce the best results by actively reducing internal and external uncertainty as a whole [19]. Lower Exoskeleton rehabilitation is a subset of lower limb rehabilitation. Robotic devices, orthotics, exoskeletons, and prostheses are being developed to help users with gait rehabilitation and other exercises such as sitting, standing, and so on. The functions of orthoses and exoskeletons are similar [20]. ADRC has been employed for numerous robotic rehabilitation devices for tracking applications in recent years because to its popularity and efficacy. ADRC has been employed for numerous robotic rehabilitation devices for tracking applications in recent years because to its popularity and efficacy. Based on a linear extended state observer (LESO), in [21], ADRC applied to the lower limb exoskeleton for the hip and knee joints, where clinical gait was studied. As a reference, data is used. The findings for PID and ADRC are compared, and the results demonstrate that ADRC outperforms PID for hip and knee trajectories based on error comparison. A framework similar to [21] is used to maintain track of active ankle-foot orthosis (AAFO) [23], in which the authors updated the ADRC by include the Control Lyapunov Function (CLF) instead of the PD controller, using Sontag’s formula. The input to state (ISS) structure is used to ensure stability, and modifications and tests are used to demonstrate ARDC’s usefulness. Another paper [24] deals with nonlinearities such as pressure fluctuation and friction during exoskeleton control and introduces a novel function to avoid shaking during inflation.

Position monitoring, force and impedance control, bio signals-based control, and adaptive control are some of the control systems used in rehabilitation. One of them is position tracking. Repeatability and position control are two main control techniques for robotic rehabilitation systems. For the patient's recovery, the controller helps to increase motion precision [25-27].

Conclusion

The development of robotic and mechanical devices (Exoskeleton) to increase upper or lower-limb function following stroke is a burgeoning subject, according to this survey of rehabilitation equipment. This is especially true as the understanding and nature of targeting brain targets grows. Many diverse means of delivering rehabilitative therapies can be seen in the spectrum of devices suggested (in trial or prototype stages) or commercially available. There are several training factors that can be changed within these devices to target recovery of function of the paretic upper limb, ranging from simple single DOF mechanical to very complicated multi-DOF exoskeleton robotic devices. Furthermore, the study demonstrates that robotic devices do not provide an effective platform for better understanding and improving brain adaption processes, or for providing outpatient therapy at home. Instead, a push for low-cost, simple, and effective mechanical devices that combine variables that promote positive brain plasticity could give various benefits. Still there are less research for ADRC in Exoskeleton system.

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