A Rigid-Elastic Hybrid Finger Exoskeleton Rehabilitation System (FERS) for Stroke Patients With Motor Impairment

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Rehabilitation needs for stroke patients with motor impairment have garnered great attention worldwide. Addressing the limitations observed in existing hand rehabilitation devices, particularly in aspects like Finger Precision, Fine Motor Coordination, and Isolated Finger Movement, as well as mitigating the risk of accidental pain and injury caused by the exoskeleton itself, a novel hybrid finger exoskeleton rehabilitation system supporting the index finger and thumb has been designed and implemented, incorporating the exoskeleton structure and a versatile user interface. Its advantages include precise control of each finger joint, more Degree of Freedom (DOF) and Range of Motion (ROM) movements, pain and injury protection, a user-friendly interface, cheaper, and lighter. Noteworthy features include an optimal Multi-bar Serial Linkage with a compact Z-shape structure and specialized palm components to reduce size, and elastic elements to alleviate excess force. The hybrid materials used offer advantages from both rigid and elastic components. The 3D-printed exoskeleton structure, inclusive of 6 motors, weighs a mere 300g. Versatile user interface methods, such as GUI Phone App, Mechanical Switch, AI Voice Control, and Computer Vision with Machine Learning which enables preliminary autonomous grasping, have been integrated. Experimental results confirm the successful achievement of all design goals, showcasing all 7 DOF movements and precise control on each joint and phalanx during rehabilitation training. Performance in practical tests, demonstrating the ability to grasp, pinch, type, and touch, plus a 100% repeatability rate, proves the rehabilitation system's significance in aiding individuals with finger impairment due to stroke and spinal cord injuries.