OPINION

Performance of Artificial Leg Bionics Design

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ABSTRACT

Some performance test trials are necessary in the study and development of intelligent prostheses. A heterogeneous biped walking robot model is offered as an excellent experimental platform for the performance testing of intelligent prosthesis. The major role of an artificial leg in a heterogeneous biped walking robot is to imitate a healthy normal stride for the disabled, allowing intelligent bionic legs to follow the goal trajectory. The pneumatic artificial muscles (PAM) are well-suited for use in prosthetic legs. The bionic design of an artificial limb primarily consist consists of the construction of the hip, knee, and ankle joints, with the four-bar mechanism serving as the mechanical structure of the knee joint and PAM serving as the knee joint's driving source. Second, the PAM performance test platform is constructed in order to establish the link between output force, shrinkage rate, and input pressure under observed isobaric circumstances, as well as the mathematical model of PAM. Finally, a collaborative simulation platform is built using virtual prototype technology, with the PID control algorithm employed for verification simulation. The results reveal that the mechanical limb is capable of following the desired path.

INTRODUCTION

The reproduction of biological processes by mechanical and electrical devices is known as bionics. Bionics was created by p-physician and researcher Jack Steele in 1958 to define the study of biological entities to address technical challenges. Personal electronics improvements have sparked discoveries in bionics in recent years. Sensors in the fingers of artificial hands are now being used to detect and modify the strength of the grasp. IBM developers presented a brain-machine interface in 2018 that used deep-learning algorithms and commercial off-the-shelf (COTS) system components to teach a robotic arm to function by thought. While bionics is concerned with developing new concepts for mechanical and electrical systems, cybernetics is concerned with understanding how biological organisms behave. Intelligent prosthetics are used to replace impaired limbs in the field of biological rehabilitation to give ease for lower limb amputees, and the development and study of intelligent prosthetics necessitate excellent artificial legs. The majority of two-legged robots are driven by direct-current (DC) servo motors, however, some also employ pneumatic and hydraulic systems. Although hydraulic device driving position precision can be ensured, its stiffness is high, and leakage and pollution are possible. Pneumatic device drive is mostly utilised for joint position control, and sealing cylinder requirements are high. PAM offers the benefits of simple construction, high flexibility, great output force, lightweight, and mechanical qualities akin to human muscle as a novel form of pneumatic component. As a result, a pneumatic artificial muscle is used as the knee joint's driving device, integrating humanoid robot and intelligent prosthesis research to explore the artificial leg in the walking robot mode of heterogeneous legs and replicate the stride of healthy impaired people's legs. Chou and Hannaford investigated the PAM in depth from a biological standpoint. The static mathematical model of the pneumatic artificial muscle was inferred and its static features were examined using the principle of energy conservation. To characterise hysteresis in pleated PAM, Van Damme et al. suggested a Preisach-based model. The parameters of the Bouc-Wen model were determined to be optimised by Zhong, and their interactions with pressure applied to PAM were examined. For simple and efficient trajectory tracking control of a bionic joint controlled by a single PAM, Wang et al. suggested a cascade control technique based on robust modelling. Between a modified version of the Hindmarsh–Rose model, La Rosa et al. established a single chain through inhibitive chemical synapse and explored its shift in slow-regular oscillation and chaotic oscillation. The most frequent kind is neural network-based modelling (NN-based modelling). It provides several benefits, including large-scale parallel computing, distributed knowledge storage, and powerful self-learning capabilities. The NN approach is commonly used in industry to estimate process variables in real-time for monitoring and control since it does not require any prior knowledge of a process model. The researcher presented a parallel process for a humanoid lower limb, in which the muscle was unevenly distributed using PAM. Researchers suggested a bionic shoulder joint robot with a spherical hinge and a PAM driving system. In this work, an enhanced artificial limb is constructed to have better flexibility and gait than a human leg. In summary, this study develops an artificial leg's mechanical system, as well as the PAM experimental platform and mathematical modelling.

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Furthermore, virtual prototyping simulation. The four-bar mechanism is employed in the construction of the knee joint, and the artificial leg's structure is synthetically built. It resembles the human lower limb joint and can better match the humanoid needs of a mechanical leg. In terms of driving, pneumatic artificial muscles are employed to drive the knee joint, eliminating the significant stiffness and other concerns that servo motors and hydraulic devices bring. An experimental platform for assessing the performance of the pneumatic artificial muscle is constructed, revealing that the pneumatic artificial muscle's characteristic curve is comparable to that of biological muscle. A more precise mathematical model is developed and tested against experimental data. The results reveal that it is capable of properly representing the static features of the pneumatic artificial muscle, establishing the groundwork for control simulation. The pneumatic artificial muscle driving joint is dynamically analysed, and a mathematical model of the driving joint is created. The virtual prototype of an artificial limb is modelled using a joint simulation platform and the PID control method. The simulation findings reveal the pneumatic artificial muscle-driven prosthetic action.