Shi *et al. Chin. J. Mech. Eng. (2021) 34:16*
https://doi.org/10.1186/s10033-021-00542-x

Chinese Journal of Mechanical Engineering

EDITORIAL

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Special Issue on Healthcare Mechatronics

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Healthcare mechatronics is a typical multidisciplinary field involving machinery, medicine, computer, and automation, which has been widely applied in respiratory therapy, urology robot, rehabilitation exoskeleton, artificial heart, etc. Existing progresses has some defects in modeling, design and implementation of healthcare mechatronics. Therefore, exploring new design theories, key technologies and typical applications is an effective to promote the rapid development of this field.

We received 9 papers in this special issue and there are 4 papers selected for publication, covering several aspects such as blood cooling system, serial urology manipulator, lower limb exoskeleton driven by hydraulic and motor actuators.

Firstly, a locally mixed sub-low temperature device proposed by Wang et al. is used to simulate the human blood transfer process via the cold and hot water mixing experiment. Then the static characteristics of the heat transfer system are described by the mathematic model construction and the experimental station verification. By using the parametric regulation, the results of simulation experiments show that 14.52 °C refrigeration can reduce the original temperature of 33.42 °C to 32.02 °C, and the temperature of refrigerated blood rises to 18.64 °C, and the average error is about 0.3 °C. Meanwhile, the efficiency of the heat exchange system also increases significantly, as the thermal conductivity of the vascular sheath increases. Furthermore, the mass increases and the temperature of the mixed blood temperature decreases, as the input cold blood flow rate increases. This work develops subsequent research on local fixed-point sub-low temperature control technology.

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Secondly, a urology robot is used in the minimally invasive surgery of prostatic hyperplasia and tumor. The distribution error of the fixed point is presented by Shi et al. Meanwhile, the tracking accuracy of manipulator end effector on the cone bottom surface of the workspace is guaranteed by the designed control algorithm of the manipulator. By using the digital twin technique, the trajectory mapping and synchronization control are realized between virtual model and the actual manipulator. The experimental results show that compared with PD feedback control, the feed-forward controller can achieve a reduction of 30.0% in the average error of the fixed point of the manipulator and a reduction of 33.3% in the maximum error.

Then a novel hydraulic actuating system (HAS) based on electric-hydrostatic actuator is proposed by Sun et al. which is applied to hip and knee joints to improve the robot's overloading performance. Each HAS includes an electric servo motor, a high-speed micro pump, a specific tank, and other components into a module. Based on the human motion data and load requirements, the dynamic models of the HAS are constructed to validate the system identification. The trajectory tracking and human-exoskeleton interaction experiments have verified the satisfactory compensation effect of external load. Compared with the previous prototype, the total weight of the HAS is reduced by about 40%, and the power density is increased by 1.6 times.

Finally, a humanoid prototype of 2-DOF lower limb exoskeleton is developed by Chen et al. to evaluate the wearable comfortable effect between person and exoskeleton. To improve the measurement accuracy of the human-robot interaction torque, the BPNN is adopted to estimate the interaction force and to compensate for the measurement error of the 3D-force/torque sensor. Meanwhile, the backstepping controller is designed to realize the exoskeleton's passive position control, which means that the person passively adapts to the exoskeleton. On

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the other hand, a variable admittance controller is used to implement the exoskeleton's active follow-up control, which means that the person's motion is motivated by his/her intention and the exoskeleton control tries best to improve the human-robot wearable comfortable performance. To improve the wearable comfortable effect, serval regular gait tasks with different admittance parameters and step frequencies are statistically performed to obtain the optimal admittance control parameters. The BPNN compensation algorithm and two controllers are verified by the experimental exoskeleton prototype with human-robot cooperative motion.

We are fully aware of the on-going research and development efforts on healthcare mechatronics academic field and industry. It is hoped that the selected papers of the special issue can provide some foresight for future research and development, and a good reference for industry practices. Furthermore, we also hope that these work can drive more and more research results about healthcare mechatronics by medical-industrial field intersection and integration in depth. In the future, enough academic research and production applications in healthcare mechatronics will promote the development of our country's intelligent medical device field.

Acknowledgements
Not applicable.

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Funding
Not applicable.

Competing Interests
The authors declare no competing financial interests.

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Received: 9 January 2021 Accepted: 19 January 2021
Published online: 01 February 2021

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