applied sciences

Editorial

Special Feature on Advanced Mobile Robotics

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Received: 29 October 2019; Accepted: 31 October 2019; Published: 4 November 2019

1. Introduction

Mobile robots and their applications are involved with many research fields including electrical engineering, mechanical engineering, computer science, artificial intelligence and cognitive science. Mobile robots are widely used for transportation, surveillance, inspection, interaction with human, medical system and entertainment. This Special Issue handles recent development of mobile robots and their research, and it will help find or enhance the principle of robotics and practical applications in real world.

The Special Issue is intended to be a collection of multidisciplinary work in the field of mobile robotics. Various approaches and integrative contributions are introduced through this Special Issue. Motion control of mobile robots, aerial robots/vehicles, robot navigation, localization and mapping, robot vision and 3D sensing, networked robots, swarm robotics, biologically-inspired robotics, learning and adaptation in robotics, human-robot interaction and control systems for industrial robots are covered.

2. Advanced Mobile Robotics

This Special Issue includes a variety of research fields related to mobile robotics. Initially, multi-agent robots or multi-robots are introduced. It covers cooperation of multi-agent robots or formation control. Trajectory planning methods and applications are listed. Robot navigations have been studied as classical robot application. Autonomous navigation examples are demonstrated. Then services robots are introduced as human-robot interaction. Furthermore, unmanned aerial vehicles (UAVs) or autonomous underwater vehicles (AUVs) are shown for autonomous navigation or map building. Path planning problem has been a well-established field but new intelligent approaches are introduced. Quadruped robots and biped robots are presented. Also, robot manipulators are handled with their accuracy control. Control methods with snake robots or exoskeleton are shown. Further, various experiments and tests of wheeled robots are demonstrated. Learning and adaptation is a key issue in robotics. Many researchers have developed new algorithms or applications based on learning and adaptation. Finally, a variety of applications with a new style of actuators are introduced.

A transportation problem with multi-robots is a demanding work, where a team of robots is supposed to collect a set of samples scattered in an environment and transport them to a storage facility. Burlacu at al. [1] showed that the task can be transformed to an optimal assignment problem with mathematical modeling and suboptimal relaxations are available for the solution. Multiple mobile robots often experience path planning problems and a real-time navigation algorithm with obstacle avoidance has been suggested by Huang et al. [2] based on a fish swarm algorithm to guide two phases of global and local path planning. In some environments, multiple mobile robots together manipulate an object in a cooperative way. Fan et al. [3] considered possible modes and mode transitions for cooperative planning. Mobile robots also handle autonomous transportation of pallets in smart factory logistics. Li et al. [4] used an intelligent mobile robot platform consisting of master–slave parallel robots.

Multi-agent robots have been applied to formation control by Kowalczyk [5] and its control is integrated with distributed goal assignment. Biologically-inspired learning and adaptation can even be applied to control of networked mobile robots. Self-evolving formation control with mobile robots was demonstrated by Xu et al. [6]. Cooperation among multi-agent robots is needed in search and rescue tasks. The navigation of the robot swarm and the consensus of the robots have been tested for a victim detection task by Cardona and Calderon [7]. Another application of multi-robot systems can be found in the welding process. Trajectory planning for the position/force cooperative control in the multi-robot manipulators has been addressed by Gan et al. [8].

Trajectory planning has been a challenging issue in industrial robots. Robotic operations in logistics are involved with pick and place operations of a manipulator. Planning a trajectory has been handled with deep reinforcement learning by Iriondo et al. [9]. Chen and Li [10] suggested geodesic trajectory planning with constraints on the end-effector and joint which is involved with the trajectory properties of the end-effector. Optical polishing also needs trajectory planning, and the accuracy of trajectory and runtime of trajectory can influence the polishing quality. Thus, Zhao and Guo [11] proposed that applying a B-spline curve method improves the performance.

In robot navigation, loop closure detection is important to reduce the cumulative errors of pose estimation for a mobile robot. A new loop closure detection algorithm with multi-scale deep feature fusion, that is, CNN (convolutional neural network) has been introduced by Chen at al. [12]. In low-texture environments, data association and closed-loop detection are challenging problems in the SLAM (simultaneous localization and mapping) method. Wang et al. [13] showed that the data association process and the back-end optimization stage with sensors, the IMU (Inertial Measurement Unit) sensor and a 2D LiDAR (Light Detection and Ranging), can be improved to enhance navigation performance. The SLAM algorithm is applied to a non-flat road with a 3D LiDAR sensor by Wang et al. [14]. The data association problem for map consistency is solved with iterative matching algorithm, reducing the computation cost. Alonso-Ramirez et al. [15] showed that mobile robots can detect and recognize household furniture, using the analysis and integration of geometric features over 3D points with a color-depth camera. A spatial model of the environment is demanding work for the navigation map. Villaseñor et al. [16] introduced a new object-mapping algorithm, approximating point clouds with multiple ellipsoids.

Mobile service robot needs to handle the human–machine interactive scene, and Wang et al. [17] proposed a topological map construction pipeline with regional dynamic growth algorithm; the map has a representation of topological information as well as occupied information. Autonomous service robots in an indoor complex environment need to find paths with obstacles and also interact with patients. Chien et al. [18] showed an adaptive neuro-fuzzy system with 3D depth camera, infrared sensors and sonar sensors for path planning of a service robot.The service robot also used facial features for personal recognition.

Recently, control of UAVs (unmanned aerial vehicles) has been a challenging problem and an example of a task is that a robot needs to avoid collision with an enemy UAV in its flying path to the goal. Cheng et al. [19] formulated this as a Markov decision process and applied temporal-difference reinforcement learning to the robot control. The learned policy can achieve a good performance to reach the goal without colliding with the enemy. For a UAV controller, fast and iterative real-time auto-tuning of parameters has been tested for altitude control by Giernacki [20]. It considered environmental disturbances as well as change of environmental conditions. UAV (Unmanned Aerial Vehicle) application can be available for wheat crops. Wang et al. [21] investigated the working efficiency of a UAV with sprayers in the field. Spraying technology using UAVs (Unmanned Aerial Vehicles) can be applied to agricultural production for protecting plants against pesticides. Wen et al. [22] showed a PWM (Pulse Width Modulation) spray system with UAVs, based on the plant diseases and insect pests map in the target area. It also considers actual droplet deposition and deposition density in the operation unit, using PID (Proportional Integrative Derivative) control. Nguyen et al. [23] proposed a robust fault diagnosis method for quadcopter UAVs (Unmanned Aerial Vehicles). It uses a sliding mode observer to estimate the fault magnitude and location. Inspired by the flight mechanism of the insect dragonfly, a wing root control mechanism was introduced to the MAV (micro air vehicle) stabilizing hovering, by Jang and Yang [24]. It was shown that the mechanism can control the flight mode easily.

A nonlinear robust adaptive control scheme was proposed by Fan et al. [25] to handle the path following control problem, for example, steering a USV (unmanned surface vessel) to follow the desired path with disturbances. They used radial basis function neural networks for the controller. An attitude-tracking control was applied to an AUV (autonomous underwater vehicle) by Wang et al. [26]. It was involved with a disturbance-rejection control for hover and transition mode of the vehicle. AUVs (autonomous underwater vehicles) need spot hover and high-speed capabilities to explore an ocean. For this application, Wang et al. [27] presented an adaptive nonlinear control to an AUV with tri-tiltrotor. Li et al. [28] investigated a particular model of remotely operated vehicles (ROVs) as autonomous underwater vehicles (AUVs), involved with an ocean current model and a cable disturbing force.

Many robotic tasks are involved with pathplanning. Path planning is a challenging issue in robotic tasks. Jung et al. [29] proposed a new path planning method to handle curvilinear obstacles. Zeng et al. [30] presented reinforcement learning with subgoal graphs, leading to near-optimal subgoal sequences as motion-planning policies. A Tetris-inspired reconfigurable cleaning robot was demonstrated with efficient tiling path planning by Kouzehgar et al. [31]. Multi-criteria decision making wasused to handle two objectives, energy and area coverage. An interesting problem of mobile robots is path planning to a specific target position in a cluttered environment. Xue [32] presented a multi-objective evolutionary algorithm for the path planning problem. Another approach, authored by Gawron and Michałek [33], is available for the path planning problem of mobile robots. They showed that their path planning, which is collision-free, satisfies curvature constraints, and preserves continuity of the curvature arc-length derivative.

The structure design and recovery for a damaged quadruped robot has been tackled by Chattunyakit et al. [34]. They showed a caterpillar-inspired quadruped robot whichimitatesthe prolegs of caterpillars, and a mudskipper-inspired crawling algorithm based on reinforcement learning, which improves the adaptation of locomotion. Hayat et al. [35] designed a quadruped wheeled robot and showed its kinematic formulation. Jia et al. [36] tackled the motion stability of quadruped robots with dynamic gait. A dynamic stability criterion and measurement is proposed in the approach.

There have also been many studies with biped robots. Reinforcement learning can be applied to efficient gait control of a biped robot. Gil et al. [37] showed a reinforcement learning mechanism to handle stability and efficiency of movement, thus improving speed and precision of the trajectory. Yang et al. [38] showed an interesting work to transform the complex motion of robot turning into a simple translational motion. The inertial forces can be analyzed for the turning walk of humanoid robots. Bai et al. [39] showed a miniaturized continuous hopping robot consisting of a servo motor and the clockwork spring so that it has a good energy storage speed. Biped climbing robots need to move in a complex truss environment. Gu et al. [40] proposed a grip planning method for biped robots to produce optimal collision-free grip sequences under kinematic constraints. Glass façade is a challenging problem, since frames between glass panels become barriers for a cleaning robot, degrading the performance of area coverage. Nansai et al. [41] presented a new style of façade cleaning robot with a biped mechanism with active suction system.

Handling robot manipulators is one of non-trivial problems. Kinematics and their system model are important factors to solve the problem. Vo et al. [42] proposed an adaptive sliding-model control to industrial robotic manipulators. It uses a system model with radial-basis function neural network. The control system provides high tracking accuracy as well as fast response time. Kelemen et al. [43] introduced a new approach for the inverse kinematics solution of a redundant manipulator. The method considers weight matrices to prioritize tasks, thus controlling the robot behavior efficiently. A quasi-analytic inverse kinematics approach has been suggested for an active slave manipulator in the surgical robot by Bai et al. [44]. The approach can meet the real-time and high-accuracy requirements of control for the robot.

Sanfilippo et al. [45] demonstrated snake robot locomotion in a cluttered environment. The system uses a perception-driven locomotion and handles compliant motion and fine torque control for elastic joints. A snake robot needs to raise its head to obtain visual space, for example, to track a flying object. Zhang et al. [46] analyzed head-raising motion of the snake robot, which is related to the angle sequences of roll, pitch and yaw. Another snake-like robot and its analysis was presented by Nansai et al. [47]. Singular configuration analysis was provided in the work.

Recently, exoskeletons draw much attention from researchers. Nomura et al. [48] suggested a novel power assist control for a powered exoskeleton. They used motion sensors on the wearer's body to detect the walking motion quickly, where electromyography is not required. Li et al. [49] showed that an augmentation exoskeleton can be developed for load carriage. The mean activities of muscle increase significantly with exoskeleton assistance.

Wheeled robots still have interesting issues in mobile robotics. To support autonomous vehicle driving on the road, a method to imitate the lane-changing operation of excellent drivers was introduced by Geng et al. [50]. As a result, the ride comfort of the vehicle was improved. Four-wheel steering and four-wheel drive (4WS4WD) vehicles include redundant manipulations in mobile robots. Tan et al. [51] used model predictive control and particle swarm optimization as an optimization process for steering angles and wheel forces. A new application of robot control can be found in the work of climbing robots. Xu et al. [52] presented a model of a three-wheel-drive climbing robot with high-altitude safety recovery mechanism, engaged in automatic inspection of bridge cables. Ikeda et al. [53] proposed step-climbing tactics, such that a mobile robot with manipulators can help a heavy hand cart climb a step. The wheeled robot holds or pushes a hand cart by imitating human motion.

Learning and adaptation are important key issues in robotics. An adaptive system based on reservoir computing and recurrent neural networks has been applied to couple control signals and robotic behaviors by Melidis and Marocco [54]. Yamauchi and Suzuki [55] focused on designing a base action set for a complex task with a wheel robot, and developed an algorithm to search for the base action to change the environment. Kim [56] showed an agent model to chase a high-speed evader. It controls the relative speed of the pursuer with respect to the evader, depending on the distance between them. Kuo et al. [57] showed an obstacle avoidance approach based on velocity potential function. They focused on curvature constraints for a mobile robot.

New actuators have been developed and tested for a variety of applications by researchers. A passive ski robot without an actuator was developed by Saga et al. [58] to understand the turn mechanism, ski deflection and skier posture mechanics during sliding. It can reveal the factors affecting ski turns, for example, the center of gravity (COG) and the ski shape. New applications of mobile robots are available in an underground coal mine for explosion safety. Novák et al. [59] investigated the safety regulations and practice solutions with tele-operated mobile robots. Zhang et al. [60] argued that a robotic drilling task can be handled with a sliding mode control. Controlling the drilling end-effector achieves dynamic stabilization and tracking accuracy. Sun et al. [61] designed a novel robot to assist human astronauts in a space station, and demonstrated its walking, rolling and sliding motion. For pneumatic positioning and force-control systems, Kanno et al. [62] proposed a three-port poppet-type servo valve to reduce air leakage of the spool-type servo valves. It is effective even in experiments with pressure and position control. A new class of actuator was studied especially in micro-robots. Chen et al. [63] proposed a high step-up ratio flyback converter for a piezoelectric bimorph actuator in micro mobile robot. Medical devices and rehabilitation mechanisms are often involved with smart materials such as electro-rheological fluids, magneto-rheological fluids and shape memory alloys. Sohn et al. [64] introduced various systems for those robots and medical devices, depending on design configuration or operating principles.

Acknowledgments: We would like to thank all the authors and reviewers who contributed to this Special Issue. There have been many ceaseless efforts from the authors, and the reviewers' feedback and comments greatly helped the authors to improve the papers. Also, we would like to express our special thanks to the editorial team and Daria Shi, the managing editor of Applied Sciences.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Burlacu, A.; Kloetzer, M.; Mahulea, C. Numerical Evaluation of Sample Gathering Solutions for Mobile Robots. *Appl. Sci.* **2019**, *9*, 791. [CrossRef]
2. Huang, Y.; Li, Z.; Jiang, Y.; Cheng, L. Cooperative Path Planning for Multiple Mobile Robots Via HAFSA and an Expansion Logic Strategy. *Appl. Sci.* **2019**, *9*, 672. [CrossRef]
3. Fan, C.; Shirafuji, S.; Ota, J. Modal Planning for Cooperative Non-Prehensile Manipulation by Mobile Robots. *Appl. Sci.* **2019**, *9*, 462. [CrossRef]
4. Li, G.; Lin, R.; Li, M.; Sun, R.; Piao, S. A Master-Slave Separate Parallel Intelligent Mobile Robot Used for Autonomous Pallet Transportation. *Appl. Sci.* **2019**, *9*, 368. [CrossRef]
5. Kowalczyk, W. Formation Control and Distributed Goal Assignment for Multi-Agent Non-Holonomic Systems. *Appl. Sci.* **2019**, *9*, 1311. [CrossRef]
6. Xu, S.S.D.; Huang, H.C.; Chiu, T.C.; Lin, S.K. Biologically-Inspired Learning and Adaptation of Self-Evolving Control for Networked Mobile Robots. *Appl. Sci.* **2019**, *9*, 1034.
7. Cardona, G.A.; Calderon, J.M. Robot Swarm Navigation and Victim Detection Using Rendezvous Consensus in Search and Rescue Operations. *Appl. Sci.* **2019**, *9*, 1702. [CrossRef]
8. Gan, Y.; Duan, J.; Chen, M.; Dai, X. Multi-Robot Trajectory Planning and Position/Force Coordination Control in Complex Welding Tasks. *Appl. Sci.* **2019**, *9*, 924. [CrossRef]
9. Iriondo, A.; Lazkano, E.; Susperregi, L.; Urain, J.; Fernandez, A.; Molina, J. Pick and Place Operations in Logistics Using a Mobile Manipulator Controlled with Deep Reinforcement Learning. *Appl. Sci.* **2019**, *9*, 348. [CrossRef]
10. Chen, Y.; Li, L. Predictable Trajectory Planning of Industrial Robots with Constraints. *Appl. Sci.* **2018**, *8*, 2648. [CrossRef]
11. Zhao, D.; Guo, H. A Trajectory Planning Method for Polishing Optical Elements Based on a Non-Uniform Rational B-Spline Curve. *Appl. Sci.* **2018**, *8*, 1355. [CrossRef]
12. Chen, B.; Yuan, D.; Liu, C.; Wu, Q. Loop Closure Detection Based on Multi-Scale Deep Feature Fusion. *Appl. Sci.* **2019**, *9*, 1120. [CrossRef]
13. Wang, Z.; Chen, Y.; Mei, Y.; Yang, K.; Cai, B. IMU-Assisted 2D SLAM Method for Low-Texture and Dynamic Environments. *Appl. Sci.* **2018**, *8*, 2534. [CrossRef]
14. Wang, J.; Zhao, M.; Chen, W. MIM–SLAM: A Multi-Level ICP Matching Method for Mobile Robot in Large-Scale and Sparse Scenes. *Appl. Sci.* **2018**, *8*, 2432. [CrossRef]
15. Alonso Ramirez, O.; Marin Hernandez, A.; Rios Figueroa, H.V.; Devy, M.; Pomares Hernandez, S.E.; Rechy Ramirez, E.J. A Graph Representation Composed of Geometrical Components for Household Furniture Detection by Autonomous Mobile Robots. *Appl. Sci.* **2018**, *8*, 2234. [CrossRef]
16. Villasenor, C.; Arana Daniel, N.; Alanis, A.Y.; Lopez Franco, C.; Gomez Avila, J. Multiellipsoidal Mapping Algorithm. *Appl. Sci.* **2018**, *8*, 1239. [CrossRef]
17. Wang, F.; Liu, Y.; Xiao, L.; Wu, C.; Chu, H. Topological Map Construction Based on Region Dynamic Growing and Map Representation Method. *Appl. Sci.* **2019**, *9*, 816. [CrossRef]
18. Chien, J.C.; Dang, Z.Y.; Lee, J.D. Navigating a Service Robot for Indoor Complex Environments. *Appl. Sci.* **2019**, *9*, 491. [CrossRef]
19. Cheng, Q.; Wang, X.; Yang, J.; Shen, L. Automated Enemy Avoidance of Unmanned Aerial Vehicles Based on Reinforcement Learning. *Appl. Sci.* **2019**, *9*, 669. [CrossRef]
20. Giernacki, W. Iterative Learning Method for In-Flight Auto-Tuning of UAV Controllers Based on Basic Sensory Information. *Appl. Sci.* **2019**, *9*, 648. [CrossRef]
21. Wang, G.; Lan, Y.; Yuan, H.; Qi, H.; Chen, P.; Ouyang, F.; Han, Y. Comparison of Spray Deposition, Control Efficacy on Wheat Aphids and Working Efficiency in the Wheat Field of the Unmanned Aerial Vehicle with Boom Sprayer and Two Conventional Knapsack Sprayers. *Appl. Sci.* **2019**, *9*, 218. [CrossRef]
22. Wen, S.; Zhang, Q.; Deng, J.; Lan, Y.; Yin, X.; Shan, J. Design and Experiment of a Variable Spray System for Unmanned Aerial Vehicles Based on PID and PWM Control. *Appl. Sci.* **2018**, *8*, 2482. [CrossRef]

23. Nguyen, N.P.; Hong, S.K. Sliding Mode Thau Observer for Actuator Fault Diagnosis of Quadcopter UAVs. *Appl. Sci.* **2018**, *8*, 1893. [CrossRef]
24. Jang, J.H.; Yang, G.H. Design of Wing Root Rotation Mechanism for Dragonfly-Inspired Micro Air Vehicle. *Appl. Sci.* **2018**, *8*, 1868. [CrossRef]
25. Fan, Y.; Huang, H.; Tan, Y. Robust Adaptive Path Following Control of an Unmanned Surface Vessel Subject to Input Saturation and Uncertainties. *Appl. Sci.* **2019**, *9*, 1815. [CrossRef]
26. Wang, T.; Wang, J.; Wu, C.; Zhao, M.; Ge, T. Disturbance-Rejection Control for the Hover and Transition Modes of a Negative-Buoyancy Quad Tilt-Rotor Autonomous Underwater Vehicle. *Appl. Sci.* **2018**, *8*, 2459. [CrossRef]
27. Wang, T.; Wu, C.; Wang, J.; Ge, T. Modeling and Control of Negative-Buoyancy Tri-Tilt-Rotor Autonomous Underwater Vehicles Based on Immersion and Invariance Methodology. *Appl. Sci.* **2018**, *8*, 1150. [CrossRef]
28. Li, X.; Zhao, M.; Ge, T. A Nonlinear Observer for Remotely Operated Vehicles with Cable Effect in Ocean Currents. *Appl. Sci.* **2018**, *8*, 867. [CrossRef]
29. Jung, J.W.; So, B.C.; Kang, J.G.; Lim, D.W.; Son, Y. Expanded Douglas–Peucker Polygonal Approximation and Opposite Angle-Based Exact Cell Decomposition for Path Planning with Curvilinear Obstacles. *Appl. Sci.* **2019**, *9*, 638. [CrossRef]
30. Zeng, J.; Qin, L.; Hu, Y.; Hu, C.; Yin, Q. Combining Subgoal Graphs with Reinforcement Learning to Build a Rational Pathfinder. *Appl. Sci.* **2019**, *9*, 323. [CrossRef]
31. Kouzehgar, M.; Elara, M.R.; Philip, M.A.; Arunmozhi, M.; Prabakaran, V. Multi-Criteria Decision Making for Efficient Tiling Path Planning in a Tetris-Inspired Self-Reconfigurable Cleaning Robot. *Appl. Sci.* **2019**, *9*, 63. [CrossRef]
32. Xue, Y. Mobile Robot Path Planning with a Non-Dominated Sorting Genetic Algorithm. *Appl. Sci.* **2018**, *8*, 2253. [CrossRef]
33. Gawron, T.; Michalek, M.M. A G3-Continuous Extend Procedure for Path Planning of Mobile Robots with Limited Motion Curvature and State Constraints. *Appl. Sci.* **2018**, *8*, 2127. [CrossRef]
34. Chattunyakit, S.; Kobayashi, Y.; Emaru, T.; Ravankar, A.A. Bio-Inspired Structure and Behavior of Self-Recovery Quadruped Robot with a Limited Number of Functional Legs. *Appl. Sci.* **2019**, *9*, 799. [CrossRef]
35. Hayat, A.A.; Elangovan, K.; Elara, M.R.; Teja, M.S. Tarantula: Design, Modeling, and Kinematic Identification of a Quadruped Wheeled Robot. *Appl. Sci.* **2019**, *9*, 94. [CrossRef]
36. Jia, Y.; Luo, X.; Han, B.; Liang, G.; Zhao, J.; Zhao, Y. Stability Criterion for Dynamic Gaits of Quadruped Robot. *Appl. Sci.* **2018**, *8*, 2381. [CrossRef]
37. Gil, C.R.; Calvo, H.; Sossa, H. Learning an Efficient Gait Cycle of a Biped Robot Based on Reinforcement Learning and Artificial Neural Networks. *Appl. Sci.* **2019**, *9*, 502. [CrossRef]
38. Yang, T.; Zhang, W.; Chen, X.; Yu, Z.; Meng, L.; Huang, Q. Turning Gait Planning Method for Humanoid Robots. *Appl. Sci.* **2018**, *8*, 1257. [CrossRef]
39. Bai, L.; Zheng, F.; Chen, X.; Sun, Y.; Hou, J. Design and Experimental Evaluation of a Single-Actuator Continuous Hopping Robot Using the Geared Symmetric Multi-Bar Mechanism. *Appl. Sci.* **2019**, *9*, 13. [CrossRef]
40. Gu, S.; Zhu, H.; Li, H.; Guan, Y.; Zhang, H. Optimal Collision-Free Grip Planning for Biped Climbing Robots in Complex Truss Environment. *Appl. Sci.* **2018**, *8*, 2533. [CrossRef]
41. Nansai, S.; Onodera, K.; Veerajagadheswar, P.; Elara, M.R.; Iwase, M. Design and Experiment of a Novel Façade Cleaning Robot with a Biped Mechanism. *Appl. Sci.* **2018**, *8*, 2398. [CrossRef]
42. Vo, A.T.; Kang, H.J. An Adaptive Neural Non-Singular Fast-Terminal Sliding-Mode Control for Industrial Robotic Manipulators. *Appl. Sci.* **2018**, *8*, 2562. [CrossRef]
43. Kelemen, M.; Virgala, I.; Liptak, T.; Mikova, L.; Filakovsky, F.; Bulej, V. A Novel Approach for a Inverse Kinematics Solution of a Redundant Manipulator. *Appl. Sci.* **2018**, *8*, 2229. [CrossRef]
44. Bai, L.; Yang, J.; Chen, X.; Jiang, P.; Liu, F.; Zheng, F.; Sun, Y. Solving the Time-Varying Inverse Kinematics Problem for the Da Vinci Surgical Robot. *Appl. Sci.* **2019**, *9*, 546. [CrossRef]
45. Sanfilippo, F.; Helgerud, E.; Stadheim, P.A.; Aronsen, S.L. Serpens: A Highly Compliant Low-Cost ROS-Based Snake Robot with Series Elastic Actuators, Stereoscopic Vision and a Screw-Less Assembly Mechanism. *Appl. Sci.* **2019**, *9*, 396. [CrossRef]

46. Zhang, X.; Liu, J.; Ju, Z.; Yang, C. Head-Raising of Snake Robots Based on a Predefined Spiral Curve Method. *Appl. Sci.* **2018**, *8*, 2011. [CrossRef]
47. Nansai, S.; Iwase, M.; Itoh, H. Generalized Singularity Analysis of Snake-Like Robot. *Appl. Sci.* **2018**, *8*, 1873. [CrossRef]
48. Nomura, S.; Takahashi, Y.; Sahashi, K.; Murai, S.; Kawai, M.; Taniai, Y.; Naniwa, T. Power Assist Control Based on Human Motion Estimation Using Motion Sensors for Powered Exoskeleton without Binding Legs. *Appl. Sci.* **2019**, *9*, 164. [CrossRef]
49. Li, H.; Cheng, W.; Liu, F.; Zhang, M.; Wang, K. The Effects on Muscle Activity and Discomfort of Varying Load Carriage With and Without an Augmentation Exoskeleton. *Appl. Sci.* **2018**, *8*, 2638. [CrossRef]
50. Geng, G.; Wu, Z.; Jiang, H.; Sun, L.; Duan, C. Study on Path Planning Method for Imitating the Lane-Changing Operation of Excellent Drivers. *Appl. Sci.* **2018**, *8*, 814. [CrossRef]
51. Tan, Q.; Dai, P.; Zhang, Z.; Katupitiya, J. MPC and PSO Based Control Methodology for Path Tracking of 4WS4WD Vehicles. *Appl. Sci.* **2018**, *8*, 1000. [CrossRef]
52. Xu, F.; Jiang, Q.; Lv, F.; Wu, M.; Zhang, L. The Dynamic Coupling Analysis for All-Wheel-Drive Climbing Robot Based on Safety Recovery Mechanism Model. *Appl. Sci.* **2018**, *8*, 2123. [CrossRef]
53. Ikeda, H.; Kawabe, T.; Wada, R.; Sato, K. Step-Climbing Tactics Using a Mobile Robot Pushing a Hand Cart. *Appl. Sci.* **2018**, *8*, 2114. [CrossRef]
54. Melidis, C.; Marocco, D. Effective Behavioural Dynamic Coupling Through Echo State Networks. *Appl. Sci.* **2019**, *9*, 1300. [CrossRef]
55. Yamauchi, S.; Suzuki, K. Algorithm for Base Action Set Generation Focusing on Undiscovered Sensor Values. *Appl. Sci.* **2019**, *9*, 161. [CrossRef]
56. Kim, J. Controllers to Chase a High-Speed Evader Using a Pursuer with Variable Speed. *Appl. Sci.* **2018**, *8*, 1976. [CrossRef]
57. Kuo, P.L.; Wang, C.H.; Chou, H.J.; Liu, J.S. A Real-Time Hydrodynamic-Based Obstacle Avoidance System for Non-Holonomic Mobile Robots with Curvature Constraints. *Appl. Sci.* **2018**, *8*, 2144. [CrossRef]
58. Saga, T.; Saga, N. Alpine Skiing Robot Using a Passive Turn with Variable Mechanism. *Appl. Sci.* **2018**, *8*, 2643. [CrossRef]
59. Novak, P.; Kot, T.; Babjak, J.; Konecny, Z.; Moczulski, W.; Lopez, A.R. Implementation of Explosion Safety Regulations in Design of a Mobile Robot for Coal Mines. *Appl. Sci.* **2018**, *8*, 2300. [CrossRef]
60. Zhang, L.; Dhupia, J.S.; Wu, M.; Huang, H. A Robotic Drilling End-Effector and Its Sliding Mode Control for the Normal Adjustment. *Appl. Sci.* **2018**, *8*, 1892. [CrossRef]
61. Sun, Z.; Li, H.; Jiang, Z.; Song, Z.; Mo, Y.; Ceccarelli, M. Prototype Design and Performance Tests of Beijing's Astronaut Robot. *Appl. Sci.* **2018**, *8*, 1342. [CrossRef]
62. Kanno, T.; Hasegawa, T.; Miyazaki, T.; Yamamoto, N.; Haraguchi, D.; Kawashima, K. Development of a Poppet-Type Pneumatic Servo Valve. *Appl. Sci.* **2018**, *8*, 2094. [CrossRef]
63. Chen, C.; Liu, M.; Wang, Y. A Dual Stage Low Power Converter Driving for Piezoelectric Actuator Applied in Micro Mobile Robot. *Appl. Sci.* **2018**, *8*, 1666. [CrossRef]
64. Sohn, J.W.; Kim, G.W.; Choi, S.B. A State-Of-The-Art Review on Robots and Medical Devices Using Smart Fluids and Shape Memory Alloys. *Appl. Sci.* **2018**, *8*, 1928. [CrossRef]

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