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Review

1.Deep learning approaches for object recognition in plant diseases: a review

Authors: Zimo Zhou, Yue Zhang, Zhaohui Gu, Simon X. Yang

How to cite: Zhou Z, Zhang Y, Gu Z, Yang SX. Deep learning approaches for object recognition in plant diseases: a review. *Intell Robot* 2023;3(4):514-37. http://dx.doi.org/10.20517/ir.2023.29

Abstract: Plant diseases pose a significant threat to the economic viability of agriculture and the normal functioning of trees in forests. Accurate detection and identification of plant diseases are crucial for smart agricultural and forestry management. Artificial intelligence has been successfully applied to agriculture in recent years. Many intelligent object recognition algorithms, specifically deep learning approaches, have been proposed to identify diseases in plant images. The goal is to reduce labor and improve detection efficiency. This article reviews the application of object detection methods for detecting common plant diseases, such as tomato, citrus, maize, and pine trees. It introduces various object detection models, ranging from basic to modern and sophisticated networks, and compares the innovative aspects and drawbacks of commonly used neural network models. Furthermore, the article discusses current challenges in plant disease detection and object detection methods and suggests promising directions for future work in learning-based plant disease detection systems.

Keywords: Plant disease detection, deep learning, object detection, plant disease management

2.Examining application-specific resiliency implementations in UAV swarm scenarios

Authors: Abhishek Phadke, F. Antonio Medrano

How to cite: Phadke A, Medrano FA. Examining application-specific resiliency implementations in UAV swarm scenarios. *Intell Robot* 2023;3(3):453-78. http://dx.doi.org/10.20517/ir.2023.27

Abstract: The number of real-world scenarios where the use of an unmanned aerial vehicle (UAV) swarm is beneficial has greatly increased in recent years. From precision agriculture to forest fire monitoring, post-disaster search and rescue applications, to military use, the applications are widespread. While it is a perceived requirement that all UAV swarms be inherently resilient, in reality, it is often not so. The incorporation of resilient mechanisms depends on an application usage scenario. This study examines a comprehensive range of application scenarios for UAV swarms to bring forward the

multitude of components that work together to provide a measure of resilience to the overall swarm. A three-category scheme is used to classify swarm applications. While systemic resilience is an interconnected concept, most real-world applications of UAV swarm research focus on making certain components resilient to disturbances. A broad categorization of UAV swarm applications, categorized by recognized components and modules, is presented, and prevalent approaches for novel resilience mechanisms in each category are discussed.

Keywords: UAV, UAS, drone, resilience, disruptions

3.Deep learning-based scene understanding for autonomous robots: a survey

Authors: Jianjun Ni, Yan Chen, Guangyi Tang, Jiamei Shi, Weidong Cao, Pengfei Shi

How to cite: Ni J, Chen Y, Tang G, Shi J, Cao W, Shi P. Deep learning-based scene understanding for autonomous robots: a survey. *Intell Robot* 2023;3(3):374-401. http://dx.doi.org/10.20517/ir.2023.22

Abstract: Autonomous robots are a hot research subject within the fields of science and technology, which has a big impact on social-economic development. The ability of the autonomous robot to perceive and understand its working environment is the basis for solving more complicated issues. In recent years, an increasing number of artificial intelligence-based methods have been proposed in the field of scene understanding for autonomous robots, and deep learning is one of the current key areas in this field. Outstanding gains have been attained in the field of scene understanding for autonomous robots based on deep learning. Thus, this paper presents a review of recent research on the deep learning-based scene understanding for autonomous robots. This survey provides a detailed overview of the evolution of robotic scene understanding and summarizes the applications of deep learning methods in scene understanding for autonomous robots. In addition, the key issues in autonomous robot scene understanding are analyzed, such as pose estimation, saliency prediction, semantic segmentation, and object detection. Then, some representative deep learning-based solutions for these issues are summarized. Finally, future challenges in the field of the scene understanding for autonomous robots are discussed.

Keywords: Autonomous robots, scene understanding, deep learning, object detection, pose estimation

4.A Review of Intelligent Methods of Health Assessment Technology

Authors: Diyi Liu, Linyuan Peng, Zhiyao Zhao

How to cite: Liu D, Peng L, Zhao Z. A review of intelligent methods of health assessment technology. *Intell Robot* 2023;3(3):355-73. http://dx.doi.org/10.20517/ir.2023.16

Abstract: The core technology of prognostics and health management, a key technology that detects system anomalies, is health assessment, which analyzes and diagnoses the current system working status and quantitatively assesses the health of the system. This paper reviews the development of health assessment technology in recent years from three aspects: health definition, health assessment indicators, and health assessment approaches. In terms of health definition, this paper summarizes three common definition methods. Health assessment indicators are reviewed from four levels: process variables, data features, residuals, and fusion indicators. Finally, health assessment approaches are divided into model-based, data-driven, and fusion approaches. Concerning the data-driven approach, rapidly developing health assessment research based on an intelligent approach is discussed. The paper also compares various approaches and identifies the current challenges and development prospects of this technology.

Keywords: Prognostics and health management, health assessment, intelligent methods, industrial systems

5.Intelligent Flood Forecasting and Warning: A Survey

Authors: Yue Zhang, Daiwei Pan, Jesse Van Griensven, Simon X. Yang, Bahram Gharabaghi

How to Cite: Zhang Y, Pan D, Van Griensven J, Yang SX, Gharabaghi B. Intelligent flood forecasting and warning: a survey. *Intell Robot* 2023;3(2):190-212. http://dx.doi.org/10.20517/ir.2023.12

Abstract: Accurately predicting the magnitude and timing of floods is an extremely challenging problem for watershed management, as it aims to provide early warning and save lives. Artificial intelligence for forecasting has become an emerging research field over the past two decades, as computer technology and related areas have been developed in depth. In this paper, three typical machine learning algorithms for flood forecasting are reviewed: supervised learning, unsupervised learning, and semi-supervised learning. Special attention is given to deep learning approaches due to their better performance in various prediction tasks. Deep learning networks can represent flood behavior as powerful and beneficial tools. In addition, a detailed comparison and analysis of the multidimensional performance of different prediction models for flood prediction are presented. Deep learning has extensively promoted the development of real-time accurate flood forecasting techniques for early warning systems. Furthermore, the paper discusses the current challenges and future prospects for intelligent flood forecasting.

Keywords: Flood forecasting, intelligent prediction, supervised learning, unsupervised learning, semi-supervised learning, deep learning

6.An Overview of Intelligent Image Segmentation Using Active Contour Models

Authors: Yiyang Chen, Pengqiang Ge, Guina Wang, Guirong Weng, Hongtian Chen

How to cite: Chen Y, Ge P, Wang G, Weng G, Chen H. An overview of intelligent image segmentation using active contour models. *Intell Robot* 2023;3(1):23-55. http://dx.doi.org/10.20517/ir.2023.02

Abstract: The active contour model (ACM) approach in image segmentation is regarded as a research hotspot in the area of computer vision, which is widely applied in different kinds of applications in practice, such as medical image processing. The essence of ACM is to make use ofuse an enclosed and smooth curve to signify the target boundary, which is usually accomplished by minimizing the associated energy function by means ofthrough the standard descent method. This paper presents an overview of ACMs for handling image segmentation problems in various fields. It begins with an introduction briefly reviewing different ACMs with their pros and cons. Then, some basic knowledge in of the theory of ACMs is explained, and several popular ACMs in terms of three categories, including region-based ACMs, edge-based ACMs, and hybrid ACMs, are detailedly reviewed with their advantages and disadvantages. After that, twelve ACMs are chosen from the literature to conduct three sets of segmentation experiments to segment different kinds of images, and compare the segmentation efficiency and accuracy with different methods. Next, two deep learning-based algorithms are implemented to segment different types of images to compare segmentation results with several ACMs. Experimental results confirm some useful conclusions about their sharing strengths and weaknesses. Lastly, this paper points out some promising research directions that need to be further studied in the future.

Keywords: Active contour model, level set, energy function, intensity inhomogeneity, deep learning

7.Formation Control of Multiple Autonomous Underwater Vehicles: A Review

Authors: Tao Yan, Zhe Xu, Simon X. Yang, S. Andrew Gadsden

How to cite: Yan T, Xu Z, Yang SX, Gadsden SA. Formation control of multiple autonomous underwater vehicles: a review. *Intell Robot* 2023;3(1):1-22. http://dx.doi.org/10.20517/ir.2023.01

Abstract: This paper presents a comprehensive overview of recent developments in formation control of multiple autonomous underwater vehicles (AUVs). Several commonly used structures and approaches for formation coordination are listed, and the advantages and deficiencies of each method are discussed. The difficulties confronted in synthesis of a practical AUVs formation system are clarified and analyzed in terms of the characteristic of AUVs, adverse underwater environments, and communication constraints. The state-of-the-art solutions available for addressing these challenges are reviewed

comprehensively. Based on that, a brief discussion is made, and a list of promising future work is pointed out, which aims to be helpful for the further promotion of AUVs formation applications.

Keywords: Autonomous underwater vehicles (AUVs), formation control, challenges and difficulties, state-of-the-art solutions

Research Article

1.Multi-robot cooperative search for radioactive sources based on particle swarm optimization particle filter

Authors: Minghua Luo, Jianwen Huo, Manlu Liu, Zhongbing Zhou

How to Cite: Luo M, Huo J, Liu M, Zhou Z. Multi-robot cooperative search for radioactive sources based on particle swarm optimization particle filter. *Intell Robot* 2023;3(4):685-97. http://dx.doi.org/10.20517/ir.2023.38

Abstract: Effective management and monitoring of radioactive sources are crucial to ensuring nuclear safety, human health, and the ecological environment. A multi-robot collaborative radioactive source search algorithm based on particle swarm optimization particle filters is proposed. In this algorithm, each robot operates as a mobile observation platform using the latest observations to fuse into particle sampling. At the same time, the particle swarm optimization algorithm moves the particle set to a high-likelihood area to overcome particle degradation. In addition, each particle can learn from the search history of other particles to speed up the convergence of the algorithm. Lastly, the Dynamic Window Approach (DWA) for dynamic window obstacle avoidance is used to avoid obstacles in complex mountainous terrains to achieve efficient source search. Experimental results show that the search success rate of the proposed algorithm is as high as 95%, and its average search time is only 3.43 s.

Keywords: Particle swarm optimization, particle filter, multi-robot, radioactive source search, DWA

2.UAV path planning based on a dual-strategy ant colony optimization algorithm

Authors: Xiaoming Mai, Na Dong, Shuai Liu, Hao Chen

How to Cite: Mai X, Dong N, Liu S, Chen H. UAV path planning based on a dual-strategy ant colony optimization algorithm. *Intell Robot* 2023;3(4):666-84.http://dx.doi.org/10.20517/ir.2023.37

Abstract: With the rapid development of modern communication and automatic control technologies, unmanned aerial vehicles (UAVs) have increasingly gained importance in both military and civilian domains. Path planning, a critical aspect for achieving autonomous aerial navigation, has consistently been a focal point in UAV research. However, traditional ant colony algorithms need to be improved for the drawbacks of susceptibility to local optima and weak convergence capabilities. Consequently, a novel path planning methodology is proposed based on a dual-strategy ant colony algorithm. In detail, an improved state transition probability rule is introduced, redefining ant movement rules by integrating the state transition strategy of deterministic selection during the iterative process. Additionally, heuristic information on adjacent node distance and mountain height is added to further improve the search efficiency of the algorithm. Then, a new dynamically adjusted pheromone update strategy is proposed. The update strategy is continuously adjusted during the iteration process, which is beneficial to the algorithm's global search in the early stage and accelerated convergence in the later stage, preventing the algorithm from falling into local optimality and improving its convergence. Based on the above improvements, a new variation of ant colony optimization (ACO) called dual-strategy ACO algorithm is formed. Experimental results prove that dual-strategy ACO has superior global search capabilities and convergence characteristics from four key aspects: path length, fitness values, iteration number, and running time.

Keywords: Path planning, ant colony optimization algorithm, heuristic information, dynamic adjustment of pheromones

3.Degradation trend prediction of rail stripping for heavy haul railway based on multi-strategy hybrid improved pelican algorithm

Authors: Changfan Zhang, Chang Jiang, Jianhua Liu, Weifeng Yang, Jia He

How to Cite: Zhang C, Jiang C, Liu J, Yang W, He J. Degradation trend prediction of rail stripping for heavy haul railway based on multi-strategy hybrid improved pelican algorithm. *Intell Robot* 2023;3(4):647-65. http://dx.doi.org/10.20517/ir.2023.36

Abstract: As a key component of the heavy-haul railway system, the rail is prone to damages caused by harsh operating conditions. To secure a safe operation, it is of great essence to detect the damage status of the rail. However, current damage detection methods are mainly manual, so problems such as strong subjectivity, lag in providing results, and difficulty in quantifying the degree of damage are easily generated. Therefore, a new prediction method based on the improved pelican algorithm and channel attention mechanism is proposed to evaluate the stripping of heavy-haul railway rails. By processing the rail vibration acceleration, it predicts the stripping damage degree. Specifically, a comprehensive health index measuring the degree of rail stripping is first established by principal component analysis and correlation analysis to avoid the one-sidedness of a single evaluation index. Then, the convolutional bidirectional gated recursive network is trained and generalized, and the pelican algorithm, improved by multiple hybrid strategies, is used to optimize the hyperparameters in the network so as to find the optimal solution

by constantly adjusting the search strategy. The squeeze-excitation channel attention module is then incorporated to re-calibrate the weights of valid features and to improve the accuracy of the model. Finally, the proposed method is tested on a specific rail stripping dataset and a public dataset of PHM2012 bearings, and the generalization and effectiveness performance of the proposed method is proved.

Keywords: Evolution trend of rail stripping, heavy-haul railways, improved pelican algorithm, squeeze-excitation channel attention

4.Rotating 3D laser mapping system for multi-rotor drones

Authors: Meiqi Fu, Hua Zhang, Shuang Wang, Yuhang Shui

How to Cite: Fu M, Zhang H, Wang S, Shui Y. Rotating 3D laser mapping system for multi-rotor drones. *Intell Robot* 2023;3(4):632-46. http://dx.doi.org/10.20517/ir.2023.35

Abstract: Accurate positional estimation is an essential prerequisite for the regular operation of an autonomous rotary-wing Unmanned Aerial Vehicles (UAV). However, the field of view (FOV) limitation problem of lidar makes it more challenging to locate the rotary-wing UAV in an unknown environment. To address rotor drones with an insufficient FOV and the observation blindness of lidar in complex environments, this paper designs a rotorcraft UAV system based on rotating 3D lidar and proposes a simultaneous localization and mapping algorithm for rotating 3D lidar. The algorithm distinguishes between planar and edge features based on the curvature value of the point cloud first. Then, to reduce the impact caused by the UAV motion and lidar rotation, messages about the Inertial Measurement Unit (IMU) and real-time rotation angles are used to compensate for these motions twice, while the IMU measurements are used for state prediction, and the error-sate iterative extended Kalman filter is used to update the residuals after matching line and surface features with sub-map. Finally, Smoother high-rate odometer data was obtained through IMU pre-integration and a first-order low-pass filter. The experimental results show that the proposed rotating lidar unit in indoor and outdoor conditions makes the rotorcraft UAV have a larger FOV, which not only improves the environmental perception capability and positional estimation accuracy of the rotorcraft but enhances the positioning reliability and flight stability of the rotorcraft UAV in complex environments.

Keywords: Unmanned aerial vehicle, rotating 3D lidar, position estimation, environment perception

5.Integrate memory mechanism in multi-granularity deep framework for driver drowsiness detection

Authors: Handan Zhang, Tie Liu, Jie Lyu, Dapeng Chen, Zejian Yuan

How to Cite: Zhang H, Liu T, Lyu J, Chen D, Yuan Z. Integrate memory mechanism in

multi-granularity deep framework for driver drowsiness detection. *Intell Robot* 2023;3(4):614-31. http://dx.doi.org/10.20517/ir.2023.34

Abstract: Driver drowsiness detection is a critical task for early warning of safe driving, while existing spatial feature-based methods face the challenges of large variations of head pose. This paper proposes a novel approach to integrate the memory mechanism in a multi-granularity deep framework to detect driver drowsiness, and the temporal dependencies over sequential frames are well integrated with the spatial deep learning framework on the frontal faces. The proposed approach includes two steps. First, the spatial Multi-granularity Convolutional Neural Network is designed to utilize a group of parallel Convolutional Neural Network extractors on well-aligned facial patches of different granularities and extract facial representations effectively for large variations of head pose. Furthermore, it can flexibly fuse detailed appearance clues of the main parts and local-to-global spatial constraints. Second, the memory mechanism is set up using a deep long short-term memory network of facial representations to explore long-term relationships with variable length over sequential frames, which is capable of distinguishing the states with temporal dependencies, such as blinking and closing eyes. The proposed approach achieves 90.05% accuracy and about 37 frames per second (FPS) speed on the evaluation set of the National Tsing Hua University Driver Drowsiness Detection dataset, which is applied to the intelligent vehicle for driver drowsiness detection. A dataset named Forward Instant Driver Drowsiness Detection is also built and will be publicly accessible to speed up the study of driver drowsiness detection.

Keywords: Driver drowsiness detection, multi-granularity convolutional neural network, visual attention

6.Event-triggered consensus control method with communication faults for multi-UAV

Authors: Zilong Guo, Chen Wei, Yankai Shen, Wanmai Yuan

How to Cite: Guo Z, Wei C, Shen Y, Yuan W. Event-triggered consensus control method with communication faults for multi-UAV. *Intell Robot* 2023;3(4):596-613. http://dx.doi.org/10.20517/ir.2023.32

Abstract: This paper investigates the event-triggered consensus for a group of unmanned aerial vehicles (UAVs) with communication faults under the assumption that the position sensors of some individuals are damaged. The objective is to make the UAV group reach consensus in urgent tasks such as obstacle avoidance or evasion. Using the Lyapunov stability theory, sufficient conditions to achieve system consensus are given based on different velocity and position interaction topologies. Considering the limited capabilities of sensors and processors, an event-triggered consensus protocol is adopted to reduce the sampling frequency. Finally, simulation results illustrate the effectiveness of our approach.

Keywords: Unmanned aerial vehicle, communication faults, consensus, event-triggered control, interaction topology

7.Heterogeneous multi-agent task allocation based on graph neural network ant colony optimization algorithms

Authors: Ziyuan Ma, Huajun Gong

How to Cite: Ma Z, Gong H. Heterogeneous multi-agent task allocation based on graph neural network ant colony optimization algorithms. *Intell Robot* 2023;3(4):581-95. http://dx.doi.org/10.20517/ir.2023.33

Abstract: Heterogeneous multi-agent task allocation is a key optimization problem widely used in fields such as drone swarms and multi-robot coordination. This paper proposes a new paradigm that innovatively combines graph neural networks and ant colony optimization algorithms to solve the assignment problem of heterogeneous multi-agents. The paper introduces an innovative Graph-based Heterogeneous Neural Network Ant Colony Optimization (GHNN-ACO) algorithm for heterogeneous multi-agent scenarios. The multi-agent system is composed of unmanned aerial vehicles, unmanned ships, and unmanned vehicles that work together to effectively respond to emergencies. This method uses graph neural networks to learn the relationship between tasks and agents, forming a graph representation, which is then integrated into ant colony optimization algorithms to guide the search process of ants. Firstly, the algorithm in this paper constructs heterogeneous graph data containing different types of agents and their relationships and uses the algorithm to classify and predict linkages for agent nodes. Secondly, the GHNN-ACO algorithm performs effectively in heterogeneous multi-agent scenarios, providing an effective solution for node classification and link prediction tasks in intelligent agent systems. Thirdly, the algorithm achieves an accuracy rate of 95.31% in assigning multiple tasks to multiple agents. It holds potential application prospects in emergency response and provides a new idea for multi-agent system cooperation.

Keywords: Graph isomerism, neural network, enhanced ant colony optimization algorithms, heterogeneous multi-agent, task allocation

8.Path planning with obstacle avoidance for soft robots based on improved particle swarm optimization algorithm

Authors: Hongwei Liu, Yang Jiang, Manlu Liu, Xinbin Zhang, Jianwen Huo, Haoxiang Su

How to Cite: Liu H, Jiang Y, Liu M, Zhang X, Huo J, Su H. Path planning with obstacle avoidance for soft robots based on improved particle swarm optimization algorithm. *Intell Robot* 2023;3(4):565-80. http://dx.doi.org/10.20517/ir.2023.31

Abstract: Soft-bodied robots have the advantages of high flexibility and multiple degrees

of freedom and have promising applications in exploring complex unstructured environments. Kinematic coupling exists for the soft robot in a problematic space environment for motion planning between the soft robot arm segments. In solving the soft robot inverse kinematics, there are only solutions or even no solutions, and soft robot obstacle avoidance control is tough to exist, as other problems. In this paper, we use the segmental constant curvature assumption to derive the positive and negative kinematic relationships and design the tip self-growth algorithm to reduce the difficulty of solving the parameters in the inverse kinematics of the soft robot to avoid kinematic coupling. Finally, by combining the improved particle swarm algorithm to optimize the paths, the convergence speed and reconciliation accuracy of the algorithm are further accelerated. The simulation results prove that the method can successfully move the soft robot in complex space with high computational efficiency and high accuracy, which verifies the effectiveness of the research.

Keywords: Soft manipulator, particle swarm optimization, path tracking, tip growth type

9.Cooperative search for moving targets with the ability to perceive and evade using multiple UAVs

Authors: Ziyi Wang, Wencheng Zou, Sheng Li

How to Cite: Wang Z, Zou W, Li S. Cooperative search for moving targets with the ability to perceive and evade using multiple UAVs. *Intell Robot* 2023;3(4):538-64. http://dx.doi.org/10.20517/ir.2023.30

Abstract: This paper focuses on the problem of regional cooperative search using multiple unmanned aerial vehicles (UAVs) for targets that have the ability to perceive and evade. When UAVs search for moving targets in a mission area, the targets can perceive the positions and flight direction of UAVs within certain limits and take corresponding evasive actions, which makes the search more challenging than traditional search problems. To address this problem, we first define a detailed motion model for such targets and design various search information maps and their update methods to describe the environmental information based on the prediction of moving targets and the search results of UAVs. We then establish a multi-UAV search path planning optimization model based on the model predictive control, which includes various newly designed objective functions of search benefits and costs. We propose a priority-encoded improved genetic algorithm with a fine-adjustment mechanism to solve this model. The simulation results show that the proposed method can effectively improve the cooperative search efficiency, and more targets can be found at a much faster rate compared to traditional search methods.

Keywords: Unmanned aerial vehicle (UAV), moving target search, path planning, fine-adjustment mechanism

10.Muscle synergy analysis for gesture recognition based on sEMG

images and Shapley value

Authors: Xiaohu Ao, Feng Wang, Rennong Wang, Jinhua She

How to Cite: Ao X, Wang F, Wang R, She J. Muscle synergy analysis for gesture recognition based on sEMG images and Shapley value. *Intell Robot* 2023;3(4):495-513. http://dx.doi.org/10.20517/ir.2023.28

Abstract: Muscle synergy analysis for gesture recognition is a fundamental research area in human-machine interaction, particularly in fields such as rehabilitation. However, previous methods for analyzing muscle synergy are typically not end-to-end and lack interpretability. Specifically, these methods involve extracting specific features for gesture recognition from surface electromyography (sEMG) signals and then conducting muscle synergy analysis based on those features. Addressing these limitations, we devised an end-to-end framework, namely Shapley-value-based muscle synergy (SVMS), for muscle synergy analysis. Our approach involves converting sEMG signals into grayscale sEMG images using a sliding window. Subsequently, we convert adjacent grayscale images into color images for gesture recognition. We then use the gradient-weighted class activation mapping (Grad-CAM) method to identify significant feature areas for sEMG images during gesture recognition. Grad-CAM generates a heatmap representation of the images, highlighting the regions that the model uses to make its prediction. Finally, we conduct a quantitative analysis of muscle synergy in the specific area obtained by Grad-CAM based on the Shapley value. The experimental results demonstrate the effectiveness of our SVMS method for muscle synergy analysis. Moreover, we are able to achieve a recognition accuracy of 94.26% for twelve gestures while reducing the required electrode channel information from ten to six dimensions and the analysis rounds from about 1000 to nine.

Keywords: Shapley-value-based muscle synergy analysis (SVMS), surface electromyography (sEMG) image, gesture recognition, Grad-CAM

11.Adaptive robust control for biped walking under uncertain external forces

Authors: Helin Wang, Qijun Chen

How to Cite: Wang H, Chen Q. Adaptive robust control for biped walking under uncertain external forces. *Intell Robot* 2023;3(3):479-94.http://dx.doi.org/10.20517/ir.2023.26

Abstract: Adaptability and robustness are important expressions of the intelligent walking ability of biped robots. This paper is concerned with the problem of dynamical biped walking and robust control of biped robots under external forces. Due to the characteristics of strong coupling and hybrid, the robotic system is modeled as a rigid kinematic chain with Lagrange equations. A novel adaptive feedback controller is proposed based on sliding mode control (SMC) and hybrid zero dynamics. The novelty of the proposed work lies in taking the uncertainty of upper-bound error into consideration. The hybrid robust control is

mentioned to approximate unknown dynamic functions with the adaptive weight. The restricted Poincare return map is utilized to analyze the stability of a nonlinear impulsive system. It ensures that the flow of the continuous subsystem can pass through the impact cross section. Finally, the simulation results illustrate that the proposed adaptive SMC control system can favorably track the reference trajectories, even when a fault occurs, which verifies the effectiveness of the proposed method.

Keywords: Biped walking, impulse hybrid system, adaptive sliding mode control, stability analysis

12.A wearable assistive system for the visually impaired using object detection, distance measurement and tactile presentation

Authors: Yiwen Chen, Junjie Shen, Hideyuki Sawada

How to Cite: Chen Y, Shen J, Sawada H. A wearable assistive system for the visually impaired using object detection, distance measurement and tactile presentation. *Intell Robot* 2023;3(3):420-35. http://dx.doi.org/10.20517/ir.2023.24

Abstract: With the current development of society, ensuring traffic and walking safety for the visually impaired is becoming increasingly important. We propose a wearable system based on a system previously developed by us that uses object recognition, a distance measurement function, and the corresponding vibration pattern presentation to support the mobility of the visually impaired. The system recognizes obstacles in front of a user in real time, measures their distances, processes the information, and then presents safety actions through vibration patterns from a tactile glove woven with shape memory alloy (SMA) actuators. The deep learning model is compressed to achieve real-time recognition using a microcomputer while maintaining recognition accuracy. Measurements of the distances to multiple objects are realized using a stereo camera, and vibration patterns are presented through a tactile glove in response to these distances. Experiments are conducted to verify the system performance to provide safe navigation depending on the positions and the distances of multiple obstacles in front of the user.

Keywords: SMA, tactile display, wearable device, visually impaired, object detection, distance measurement, deep learning, model compression

13.A distributed multi-vehicle pursuit scheme: generative multi-adversarial reinforcement learning

Authors: Xinhang Li, Yiying Yang, Qinwen Wang, Zheng Yuan, Chen Xu, Lei Li, Lin Zhang

How to Cite: Li X, Yang Y, Wang Q, Yuan Z, Xu C, Li L, Zhang L. A distributed multi-vehicle pursuit scheme: generative multi-adversarial reinforcement learning. *Intell Robot* 2023;3(3):436-52. http://dx.doi.org/10.20517/ir.2023.25

Abstract: Multi-vehicle pursuit (MVP) is one of the most challenging problems for intelligent traffic management systems due to multi-source heterogeneous data and its mission nature. While many reinforcement learning (RL) algorithms have shown promising abilities for MVP in structured grid-pattern roads, their lack of dynamic and effective traffic awareness limits pursuing efficiency. The sparse reward of pursuing tasks still hinders the optimization of these RL algorithms. Therefore, this paper proposes a distributed generative multi-adversarial RL for MVP (DGMARL-MVP) in urban traffic scenes. In DGMARL-MVP, a generative multi-adversarial network is designed to improve the Bellman equation by generating the potential dense reward, thereby properly guiding strategy optimization of distributed multi-agent RL. Moreover, a graph neural network-based intersecting cognition is proposed to extract integrated features of traffic situations and relationships among agents from multi-source heterogeneous data. These integrated and comprehensive traffic features are used to assist RL decision-making and improve pursuing efficiency. Extensive experimental results show that the DGMARL-MVP can reduce the pursuit time by 5.47% compared with proximal policy optimization and improve the pursuing average success rate up to 85.67%. Codes are open-sourced in Github.

Keywords: Generative multi-adversarial reinforcement learning, graph neural network, intersecting cognition, multivehicle pursuit

14.Reinforcement learning methods for network-based transfer parameter selection

Authors: Yue Guo, Yu Wang, I-Hsuan Yang, Katia Sycara

How to Cite: Guo Y, Wang Y, Yang IH, Sycara K. Reinforcement learning methods for network-based transfer parameter selection. *Intell Robot* 2023;3(3):402-19. http://dx.doi.org/10.20517/ir.2023.23

Abstract: A significant challenge in self-driving technology involves the domain-specific training of prediction models on intentions of other surrounding vehicles. Separately processing domain-specific models requires substantial human resources, time, and equipment for data collection and training. For instance, substantial difficulties arise when directly applying a prediction model developed with data from China to the United States market due to complex factors such as differing driving behaviors and traffic rules. The emergence of transfer learning seems to offer solutions, enabling the reuse of models and data to enhance prediction efficiency across international markets. However, many transfer learning methods require a comparison between source and target data domains to determine what can be transferred, a process that can often be legally restricted. A specialized area of transfer learning, known as network-based transfer, could potentially provide a solution. This approach involves pre-training and fine-tuning "student" models using selected parameters from a "teacher" model. However, as networks typically have a large number of parameters, it raises questions about the most efficient methods for parameter selection to optimize transfer learning. An automatic parameter selector through

reinforcement learning has been developed in this paper, named "Automatic Transfer Selector via Reinforcement Learning". This technique enhances the efficiency of parameter selection for transfer prediction between international self-driving markets, in contrast to manual methods. With this innovative approach, technicians are relieved from the labor-intensive task of testing each parameter combination, or enduring lengthy training periods to evaluate the impact of prediction transfer. Experiments have been conducted using a temporal convolutional neural network fully trained with the data from the Chinese market and one month's US data, focusing on improving the training efficiency of specific driving scenarios in the US. Results show that the proposed approach significantly improves the prediction transfer process.

Keywords: Reinforcement learning, transfer learning, deep learning, self-driving, network-based transfer

15.Discrete Sequence Rearrangement based Self-Supervised Chinese Named Entity Recognition for Robot Instruction Parsing

Authors: Cong Jiang, Qingyang Xu, Yong Song, Xianfeng Yuan, Bao Pang, Yibin Li

How to Cite: Jiang C, Xu Q, Song Y, Yuan X, Pang B, Li Y. Discrete sequence rearrangement based self-supervised chinese named entity recognition for robotinstruction parsing. *Intell Robot* 2023;3(3):337-54. http://dx.doi.org/10.20517/ir.2023.21

Abstract: Named entity recognition (NER) plays an important role in information extraction tasks, but most models rely on large-scale labeled data. Getting the model to move away from large-scale labeled datasets is challenging. In this paper, a SCNER (Self-Supervised NER) model is proposed. The BiLSTM (Bidirectional LSTM) is adopted as the named entity extractor, and an Instruction Generation Subsystem (IGS) is proposed to generate "Retelling Instructions", which analyzes the similarities between the input instructions and "Retelling Instructions" as the losses for model training. A series of rules based on traditional learning rules have been proposed for discrete forward computation and error backpropagation. It mimics language learning in human infants and constructs a SCNER model. This model is used for robot instruction understanding and can be trained on unlabeled datasets to extract named entities from instructions. Experimental results show that the proposed model is competitive with the supervised BiLSTM-CRF and BERT-NER models. In addition, the model is applied to a real robot, which verifies the practicality of SCNER.

Keywords: Chinese named entity recognition, self-supervised, robotics, discrete sequence rearrangement

16.Stability Compensation of An Admittance-controlled Cartesian Robot Considering Physical Interaction with A Human Operator

Authors: Narawich Songthumjitti, Takeshi Inaba

How to Cite: Songthumjitti N, Inaba T. Stability compensation of an admittance-controlled cartesian robot considering physical interaction with a human operator. *Intell Robot* 2023;3(3):306-36. http://dx.doi.org/10.20517/ir.2023.20

Abstract: In human-machine systems, admittance control is widely used for controlling robots. However, the problem with this method is that the stability can be impacted by the stiffness of the machine and the human operator. In order to minimize the oscillation issue that is caused by insufficient structure stiffness, this study used compensation methods, specifically feed-forward and acceleration feedback. Simulation results show that both compensation methods can expand the stability region of the system. Nevertheless, feedback compensation is more appropriate than feed-forward when taking into account uncertainties in the structure parameters of the system. Even when the system is not perfectly implemented, feedback compensation can keep the system stable, whereas feed-forward compensation causes a significantly reduced stability region. From the experiment, it is also confirmed that the feedback system has an advantage over the feed-forward system, and this simple feedback using an accelerometer can compensate for the insufficient stiffness of the robot structure and greatly enhance the stability of the human-machine system.

Keywords: Human-machine system, admittance model, system stability, compensator, feed-forward, feedback

17. Robust Distributed Model Predictive Control of Connected Vehicle Platoon against DoS Attacks

Authors: Hao Zeng, Zehua Ye, Dan Zhang, Qun Lu

How to Cite: Zeng H, Ye Z, Zhang D, Lu Q. Robust distributed model predictive control of connected vehicle platoon against DoS attacks. *Intell Robot* 2023;3(3):288-305. http://dx.doi.org/10.20517/ir.2023.19

Abstract: This paper investigates the robust distributed model predictive control (DMPC) of connected vehicle platoon (CVP) systems subject to denial-of-service (DoS) attacks. The main objective is to design a DMPC algorithm that enables the CVP system to achieve exponential tracking performance. First, a switched system model is proposed for the networked CVP system in the presence of DoS attacks. Then the sufficient conditions for the exponential stability of tracking the performance of the CVP control system under DoS attacks are obtained by constructing a specific Lyapunov function and using the topological matrix decoupling technique. In our paper, the DoS attack phenomenon is handled by introducing the frequency and duration parameters, and a quantitative relationship between the exponential decay rate of the CVP system and the DoS attacks parameters is established based on the conditions proposed in the system design, and the critical value of the DoS attack duration ratio is also derived. Finally, the effectiveness of the proposed

algorithm is verified through a simulation of a CVP system consisting of one leading vehicle and three following vehicles.

Keywords: Distributed model predictive control (DMPC), connected vehicle platoon (CVP), denial-of-service (DoS) attacks, switched system, linear matrix inequalities (LMIs)

18.GPI Observer-based Active Disturbance Rejection Control for A Morphing Quadrotor

Authors: Chunhui He, Haosheng Sun, Qingxiang Wu, Yuanhao Su, Ning Sun

How to Cite: He C, Sun H, Wu Q, Su Y, Sun N. GPI observer-based active disturbance rejection control for a morphing quadrotor. *Intell Robot* 2023;3(3):274-87. http://dx.doi.org/10.20517/ir.2023.18

Abstract: Quadrotors are widely used in transportation, aerial photography, agricultural protection, and other important fields. Nevertheless, quadrotors with a fixed structure will face great challenges when crossing through or entering narrow spaces for operations. To improve quadrotor crossing ability in different environments, a morphing quadrotor is designed in this paper, and four servo motors are added to independently change four arm rotation angles. Meanwhile, the dynamic model and dynamic control allocation matrix are established. In addition, considering that the internal dynamic variation caused by morphologic changes and external disturbances may compromise system stability, a control method based on the generalized proportional integral (GPI) observer is proposed to increase the system robustness, and the corresponding stability analysis is provided. Finally, simulation results demonstrate the effectiveness of the proposed GPI observer-based active disturbance rejection control method.

Keywords: Morphing quadrotor, dynamic control allocation, generalized proportional integral observer, active disturbance rejection control

19.State-Sensitive Event-triggered Path Following Control of Autonomous Ground Vehicles

Authors: Hong-Tao Sun, Jinming Huang, Zhi Chen, Zhiwen Wang

How to Cite: Sun HT, Huang J, Chen Z, Wang Z. State-sensitive event-triggered path following control of autonomous ground vehicles. *Intell Robot* 2023;3(3):257-73. http://dx.doi.org/10.20517/ir.2023.17

Abstract: This paper investigates an improved event-triggered control based on the perception of state measurement for path following control of autonomous ground vehicles. Firstly, in order to regulate the event-triggered thresholds dynamically, a barrier-like function is first used to develop such a novel state-sensitive event-triggered communication

(SS-ETC) scheme. Different from the existing variable-threshold ETC schemes, the proposed SS-ETC incorporates the state measurements directly in the event threshold adjustment, eliminating the need for additional terms or dynamics introduced in previous works. Secondly, the networked path following control modeling issues, which include both physical dynamics and the SS-ETC scheme, are characterized by the input delay approach. The controller design method is well derived, ensuring the preservation of input-to-state stability of the path following control system. The main advantage of this paper lies in the proposed SS-ETC, which shows a better trade-off between control and communication. Finally, several simulation experiments are conducted to verify the effectiveness of the proposed event-triggered control scheme.

Keywords: Networked control systems, event-triggered scheme, autonomous ground vehicles, path following control

20.Robust Coverage Control of Multiple USVs with Time-Varying Disturbances

Authors: Qihai Sun, Zhi-Wei Liu, Ming Chi, Ming-Feng Ge, Dingxin He

How to Cite: Sun Q, Liu ZW, Chi M, Ge MF, He D. Robust coverage control of multiple USVs with time-varying disturbances. *Intell Robot* 2023;3(3):242-56. http://dx.doi.org/10.20517/ir.2023.15

Abstract: This paper investigates the problem of optimal coverage control for multiple unmanned surface vehicles (USVs) in the presence of time-varying disturbances. To solve this problem, the disturbance vector observer is designed to approximate the unknown time-varying disturbances. It is demonstrated that the estimated disturbance vector converges to the actual disturbance vector within a finite time. To achieve the optimal coverage effect of the task region, the control idea of layer-by-layer design is borrowed, and the desired velocities of the USV are designed. By following the desired velocities, the USV network can achieve the optimal coverage effect of the task region. Based on the estimated disturbances, a robust coverage controller is designed to achieve the tracking of desired velocities by the USV within a finite time, ultimately achieving optimal coverage effect of the task region by the USV network. Finally, corresponding simulation results are provided to validate the effectiveness of the proposed approach.

Keywords: Coverage control, disturbance observation, multiple unmanned surface vehicles, finite time control

21.A Bio-Inspired Algorithm in Image-Based Path Planning and Localization Using Visual Features and Maps

Authors: Daniel Short, Tingjun Lei, Chaomin Luo, Daniel W. Carruth, Zhuming Bi

How to Cite: Short D, Lei T, Luo C, Carruth DW, Bi Z. A bio-inspired algorithm in image-based path planning and localization using visual features and maps. *Intell Robot* 2023;3(2):222-41. http://dx.doi.org/10.20517/ir.2023.14

Abstract: With the growing applications of autonomous robots and vehicles in unknown environments, studies on image-based localization and navigation have attracted a great deal of attention. This study is significantly motivated by the observation that relatively little research has been published on the integration of cutting-edge path planning algorithms for robust, reliable, and effective image-based navigation. To address this gap, a biologically inspired Bat Algorithm (BA) is introduced and adopted for image-based path planning in this paper. The proposed algorithm utilizes visual features as the reference in generating a path for an autonomous vehicle, and these features are extracted from the obtained images by convolutional neural networks (CNNs). The paper proceeds as follows: first, the requirements for image-based localization and navigation are described. Second, the principles of the BA are explained in order to expound on the justifications for its successful incorporation in image-based navigation. Third, in the proposed image-based navigation system, the BA is developed and implemented as a path planning tool for global path planning. Finally, the performance of the BA is analyzed and verified through simulation and comparison studies to demonstrate its effectiveness.

Keywords: Image-based navigation, Bat Algorithm, path planning, localization, autonomous vehicles, Mapping

22. The Cooperatability of the First-Order Multi-Agent Systems Consisting of a Leader and a Follower with Multiplicative Noises under Markov Switching Topologies

Authors: Dianqiang Li, Tao Li

How to Cite: Li D, Li T. The cooperatability of the first-order multi-agent systems consisting of a leader and a follower with multiplicative noises under Markov switching topologies. *Intell Robot* 2023;3(2):213-21. http://dx.doi.org/10.20517/ir.2023.13

Abstract: We investigate the cooperatability of the first-order leader-following multi-agent systems consisting of a leader and a follower with multiplicative noises under Markov switching topologies. Each agent exhibits first-order linear dynamics, and there are multiplicative noises along with information exchange among the agents. What is more, the communication topologies are Markov switching topologies. By utilizing the stability theory of the stochastic differential equations with Markovian switching and the Markov chain theory, we establish the necessary and sufficient conditions for the cooperatability of the leader-following multi-agent systems. The conditions are outlined below: (i) The product of the system parameter and the square of multiplicative noise intensities should be less than 1/2; (ii) The transition rate from the unconnected graph to the connected graph should be twice the system parameter; (iii) The transition rate from the connected graph to the unconnected graph should be less than a constant that is related to the system

parameter, the intensities of multiplicative noises, and the transition rate from the unconnected graph to the connected graph. Finally, the effectiveness of our control strategy is demonstrated by the population growth systems.

Keywords: Leader-following, Markov switching topologies, multiplicative noises, cooperatability

23. Adaptive Backstepping Control of High-Order Fully Actuated Nonlinear Systems with Event-Triggered Strategy

Authors: Chengyuan Yan, Jianwei Xia, Xinru Liu, Huarong Yue, Chong Li

How to Cite: Yan C, Xia J, Liu X, Yue H, Li C. Adaptive backstepping control of high-order fully actuated nonlinear systems with event-triggered strategy. *Intell Robot* 2023;3(2):176-89. http://dx.doi.org/10.20517/ir.2023.11

Abstract: This paper investigates the problem of adaptive event-triggered fuzzy control for nonlinear high-order fully actuated systems. In this paper, a completely unknown nonlinear function is considered, and its prior knowledge is unknown. To solve this problem, the fuzzy logic system technology is applied to approximate the unknown nonlinear function. In order to save communication resources, a novel high-order event-triggered controller is proposed under backstepping control. With the help of Lyapunov stability theory, it is proved that all signals of the closed-loop system are bounded. Finally, the theoretical results are applied to the robot system to verify their validity.

Keywords: Fuzzy logic system, event-triggered strategy, high-order fully actuated nonlinear systems, adaptive control

24. Reinforcement Learning with Parameterized Action Space and Sparse Reward for UAV Navigation

Authors: Shiying Feng, Xiaofeng Li, Lu Ren, Shuiqing Xu

How to Cite: Feng S, Li X, Ren L, Xu S. Reinforcement learning with parameterized action space and sparse reward for UAV navigation. *Intell Robot* 2023;3(2):161-75. http://dx.doi.org/10.20517/ir.2023.10

Abstract: Autonomous navigation of unmanned aerial vehicles (UAVs) is widely used in building rescue systems. As the complexity of the task increases, traditional methods based on environment models are hard to apply. In this paper, a reinforcement learning (RL) algorithm is proposed to solve the UAV navigation problem. The UAV navigation task is modeled as a Markov Decision Process (MDP) with parameterized actions. In addition, the sparse reward problem is also taken into account. To address these issues, we develop the HER-MPDQN by combining Multi-Pass Deep Q-Network (MP-DQN) and Hindsight

Experience Replay (HER). Two UAV navigation simulation environments with progressive difficulty are constructed to evaluate our method. The results show that HER-MPDQN outperforms other baselines in relatively simple tasks. Especially for complex tasks involving relay operations, only our method can achieve satisfactory performance.

Keywords: Deep reinforcement learning, parameterized action space, sparse reward

25. Application of Distributed and Decentralized Technologies in the Management of Intelligent Transport Systems

Authors: Luba Eremina, Anton Mamoiko, Guo Aohua

How to Cite: Eremina L, Mamoiko A, Aohua G. Application of distributed and decentralized technologies in the management of intelligent transport systems. *Intell Robot* 2023;3(2):148-60. http://dx.doi.org/10.20517/ir.2023.09

Abstract: Shifting focus from the field of distributed and decentralized technologies in the management of intelligent transportation systems (ITS), we now delve into the specific application of blockchain in transportation management. Blockchain is a fundamental component of distributed and decentralized technologies. The research paper discusses the utilization of blockchain technology in managing transportation systems through multi-agent systems. Specifically, the use of blockchain technology is examined in the context of the quick road system (QRS) in ITS to provide a service for obtaining a special fare status. This service aims to establish a decentralized network that facilitates real-time road lane sharing. The study indicates that depending on traffic situations, drivers can share their lane space with other vehicles traveling on the same route by exchanging incentives via blockchain with other private car owners, thereby allowing for faster travel for individuals in a hurry or those requiring priority access to fast lanes. The paper also addresses the increasing number of connected devices in ITS due to the development of the internet of things (IoT) technology. It highlights the importance of efficiently utilizing large datasets and identifies the internet of vehicles (IoV) as a crucial area of integration for existing IoT technologies to address smart traffic within multi-agent systems.

Keywords: Traffic, blockchain, intelligent transport systems, Internet of Things, smart contracting, end-to-end technologies, digitalization

26. Semi-Supervised Joint Adaptation Transfer Network with Conditional Adversarial Learning for Rotary Machine Fault Diagnosis

Authors: Chun Liu, Shaojie Li, Hongtian Chen, Xianchao Xiu, Chen Peng

How to Cite: Liu C, Li S, Chen H, Xiu X, Peng C. Semi-supervised joint adaptation transfer network with conditional adversarial learning for rotary machine fault diagnosis. *Intell Robot* 2023;3(2):131-43. http://dx.doi.org/10.20517/ir.2023.07

Abstract: At present, artificial intelligence is booming and has made major breakthroughs in fault diagnosis scenarios. However, the high diagnostic accuracy of most mainstream fault diagnosis methods must rely on sufficient data to train the diagnostic models. In addition, there is another assumption that needs to be satisfied: the consistency of training and test data distribution. When theseprerequisites are not available, the effectiveness of the diagnosis model declines dramatically. To address this problem, we propose a semi-supervised joint adaptation transfer network with conditional adversarial learning for rotary machine fault diagnosis. To fully utilize the fault features implied in unlabeled data, pseudo-labels are generated through threshold filtering to obtain an initial pre-trained model. Then, a joint domain adaptation transfer network module based on conditional adversarial learning and distance metric is introduced to ensure the consistency of the distribution in two different domains. Lastly, in three groups of experiments with different settings: a single fault with variable load, a single fault with variable speed, and a mixed fault with variable speed and load, it was confirmed that our method can obtain competitive diagnostic performance.

Keywords: Fault diagnosis, joint adaptation transfer network, conditional adversarial learning, rotary machine

27.Operational Control with Set-Points Tuning - Application to Mobile Robots

Authors: Xiaomo Yan, Hong Wang

How to Cite: Yan X, Wang H. Operational control with set-points tuning - application to mobile robots. *Intell Robot* 2023;3(2):113-30. http://dx.doi.org/10.20517/ir.2023.06

Abstract: This paper proposes a novel method for the optimal tuning of set points for multiple-layered control system structure widely seen in robotics and other complex industrial processes composed of a number of subsystems. The terminal sliding mode control (SMC) is used as the low-level control strategy to ensure the stability of subsystems. When uncertainties exist, it can be shown that the deteriorated system performance will be improved by the outer loop with set points tuning. For this purpose, the learning of the new set point is designed to compensate for the effects caused by uncertainties during the system operation. At the same time, the system is proven to stay with the original set point when the compensation is introduced. A practical application to a holonomic mobile robot system is given to illustrate the presented method. Desired results have been obtained

Keywords: Set point reselection, mobile robot, terminal sliding mode control, hamilton–jacobi–bellman(HJB) equation

28.Human Gait Tracking for Rehabilitation Exoskeleton: Adaptive

Fractional Order Sliding Mode Control Approach

Authors: Yuan Zhou, Zhe Sun, Bo Chen, Guangpu Huang, Xiang Wu, Tian Wang

How to cite: Zhou Y, Sun Z, Chen B, Huang G, Wu X, Wang T. Human gait tracking for rehabilitation exoskeleton: adaptive fractional order sliding mode control approach. *Intell Robot* 2023;3(1):95-112. http://dx.doi.org/10.20517/ir.2023.05

Abstract: To improve the rehabilitation training effect of hemiplegic patients, in this paper, a discrete adaptive fractional order fast terminal sliding mode control approach is proposed for the lower limb exoskeleton system to implement high-precision human gait tracking tasks. Firstly, a discrete dynamic model is established based on the Lagrange system discretization criterion for the lower limb exoskeleton robot. Then, in order to design a discrete adaptive fractional order fast terminal sliding mode controller, the Grünwald–Letnikov fractional order operator is introduced to combine with fast terminal attractor to construct a fractional order fast terminal sliding surface. An adaptive parameter adjustment strategy is proposed for the reaching law of sliding mode control, which drives the sliding mode to the stable region dynamically. Moreover, the stability of the control system is proved in the sense of Lyapunov, and the guidelines for selecting the control parameters are given. Finally, the simulations are tested on the MATLAB-Opensim co-simulation platform. Compared with the conventional discrete sliding mode control and discrete fast terminal sliding mode control, the results verify the superiority of the proposed method in improving lower limb rehabilitation training.

Keywords: Lower-limb exoskeleton, adaptive discrete-time sliding mode, fractional order control, finite-time convergence

29.UAV Maneuver Decision-making via Deep Reinforcement Learning for Short-range Air Combat

Authors: Zhiqiang Zheng, Haibin Duan

How to cite: Zheng Z, Duan H. UAV maneuver decision-making via deep reinforcement learning for short-range air combat. *Intell Robot* 2023;3(1):76-94. http://dx.doi.org/10.20517/ir.2023.04

Abstract: The unmanned aerial vehicle (UAV) has been applied in unmanned air combat because of its flexibility and practicality. The short-range air combat situation is rapidly changing, and the UAV has to make the autonomous maneuver decision as quickly as possible. In this paper, a type of short-range air combat maneuver decision method based on deep reinforcement learning is proposed. Firstly, the combat environment, including UAV motion model and the position and velocity relationships, is described. On this basic, the combat process is established. Secondly, some improved points based on proximal policy optimization (PPO) are proposed to enhance the maneuver decision-making ability. The gate recurrent unit (GRU) can help PPO make decisions with continuous timestep

data. The actor network's input is the observation of UAV, however, the input of the critic network, named state, includes the blood values which cannot be observed directly. In addition, the action space with 15 basic actions and well-designed reward function are proposed to combine the air combat environment and PPO. In particular, the reward function is divided into dense reward, event reward and end-game reward to ensure the training feasibility. The training process is composed of three phases to shorten the training time. Finally, the designed maneuver decision method is verified through the ablation study and confrontment tests. The results show that the UAV with the proposed maneuver decision method can obtain an effective action policy to make a more flexible decision in air combat.

Keywords: Short-range air combat, unmanned aerial vehicle, deep reinforcement learning, maneuver decision, proximal policy optimization, flight simulation

30.GMAW Welding Procedure Expert System Based on Machine Learning

Authors: Xuewu Wang, Qian Chen, Hao Sun, Xiuwei Wang, Huaicheng Yan

How to cite: Wang X, Chen Q, Sun H, Wang X, Yan H. GMAW welding procedure expert system based on machine learning. *Intell Robot* 2023;3(1):56-75. http://dx.doi.org/10.20517/ir.2023.03

Abstract: In order to simplify the robot preparation before welding and improve the automation of the whole welding process, an intelligent expert system for Gas Metal Arc Welding is designed in this paper. In the system, the user inputs the initial welding information and the output interface displays suitable welding procedure parameter schemes. The user can choose the schemes according to the actual requirements or directly generate the welding procedure specification required by the enterprise format for direct use. In addition, the system also combines the database technology and XGBoost algorithm in the field of machine learning, migrates the model trained on the data set to predict the welding raw data, accumulates more data for daily use to optimize the model, which makes the whole system more systematic and intelligent, and achieves the goal of more accurate use.

Keywords: Welding, expert system, machine learning, database

Editorial

1.ChatGPT in Connected and Autonomous Vehicles: Benefits and Challenges

Authors: Lei Lei, Hao Zhang, Simon X. Yang

How to cite: Lei L, Zhang H, Yang SX. ChatGPT in connected and autonomous vehicles: benefits and challenges. Intell Robot 2023;3(2):144-7. http://dx.doi.org/10.20517/ir.2023.08

Abstract: The OpenAI chatbot ChatGPT has achieved unprecedented success since its launch in November 2022. The Artificial Intelligence (AI) technologies behind ChatGPT are expected to have far-reaching effects on various technological fields beyond natural language processing. This editorial discusses the potential benefits and challenges that ChatGPT may bring to the connected and autonomous vehicles (CAVs). CAVs have been heavily researched in both the automotive and communications industries in recent years, where the AI technologies have played an indispensable role. Exploring how and to what extent ChatGPT will affect this field is an interesting and timely research topic.

Keywords: ChatGPT, connected and autonomous vehicles