2024年第01期总428期

农牧业信息化专题

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会议论文

1．基于无地图激光雷达的葡萄园自主导航系统

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2024年1月1日

学术文献

1．Computing paradigms for smart farming in the era of drones: a systematic review（无人机时代智能农业的计算范式：系统回顾）

简介：In the current era of agricultural robotization, it is necessary to use a suitable automated data collection system for constant plant, animal, and machine monitoring. In this context, cloud computing (CC) is a well-established paradigm for building service-centric farming applications. However, the huge amount of data has put an important burden on data centers and network bandwidth and pointed out issues that cloud-based applications face such as large latency, bottlenecks because of central processing, compromised security, and lack of offline processing. Fog computing (FC), edge computing (EC), and mobile edge computing (MEC) (or flying edge computing FEC) are gaining exponential attention and becoming attractive solutions to bring CC processes within reach of users and address computation-intensive offloading and latency issues. These paradigms from cloud to mobile edge computing are already forming a unique ecosystem with different architectures, storage, and processing capabilities. The heterogeneity of this ecosystem comes with certain limitations and challenges. This paper carries out a systematic review of the latest high-quality literature and aims to identify similarities, differences, and the main use cases in the mentioned computing paradigms, particularly when using drones. Our expectation from this work is to become a good reference for researchers and help them address hot topics and challenging issues related to this scope.

来源：ANNALS OF TELECOMMUNICATIONS；

发布日期:2023-11-18

全文链接:

http://agri.nais.net.cn/file1/M00/03/63/CsgkOWWOZ3CAFVwwABNCxMWJ4go891.pdf

2．Visual Navigation and Obstacle Avoidance Control for Agricultural Robots via LiDAR and Camera（基于激光雷达和相机的农业机器人视觉导航与避障控制）

简介：非结构化农业环境中的避障控制和导航是自主机器人安全运行的关键，尤其是对于农业机械，应考虑成本和稳定性。本文设计了一种基于激光雷达和视觉摄像机的农业机器人导航避障系统。采用改进的聚类算法对激光雷达实时采集的障碍物信息进行快速、准确的分析。同时，将凸包算法与旋转卡尺算法相结合，获得聚类数据的凸多边形的最大直径。基于障碍物的危险区域，开发了避障路径和航向控制方法。此外，通过对复杂果园环境图像进行色彩空间分析和特征分析，选择HSV色彩空间的最优H分量，得到基于均值滤波和腐蚀处理的理想视觉引导轨迹图像。最后，将所提出的算法集成到三轮移动差动机器人（TWMDR）平台上进行避障实验，结果表明了所提出算法的有效性和鲁棒性。研究结论在农业机器人的精确避障和智能导航控制方面取得了满意的效果。

来源：REMOTE SENSING；

发布日期:2023-11-17

全文链接:

http://agri.nais.net.cn/file1/M00/10/35/CsgkOGWOZuKAAOiRAafAlRaEI84775.pdf

3．An automated apple harvesting robot-From system design to field evaluation（一种自动苹果收获机器人——从系统设计到田间评估）

简介：Decreased availability and rising cost in labor poses a serious threat to the long-term profitability and sustainability of the apple industry in the United States and many other countries. Harvest automation is thus urgently needed. In this paper, we present the unified system design and field evaluation of a new apple harvesting robot. The robot is mainly composed of a specially designed perception component, a four-degree-of-freedom manipulator, an improved vacuum-based soft end-effector, and a dropping/catching component to receive and transport picked fruits. Software algorithms are developed to enable synergistic coordination of the hardware components for efficient, automated harvesting of apples in challenging orchard environments. Specifically, by integrating modified triangulation and image processing and analysis algorithms, a novel perception strategy is developed to achieve robust apple detection and precise localization. Improved planning and control algorithms are developed to guide the robot to the target positions. The performance of the robotic system was evaluated through field tests in two apple orchards with different tree architectures and foliage conditions. In the orchard where trees were young and well-pruned, the robot achieved 82.4% successful harvesting rate. In a second, older orchard with dense, clustered branches and foliage, the robot had 65.2% successful rate. The average cycle time to harvest a fruit was approximately 6 s, which included software algorithm processing and hardware execution. Moreover, through an in-depth analysis of the obtained results, limitations and planned future works are discussed.

来源：JOURNAL OF FIELD ROBOTICS

发布日期:2023-11-14

全文链接:

http://agri.nais.net.cn/file1/M00/03/63/CsgkOWWOaaWAbKqbADJGp6U7pU8161.pdf

4 .Motion-Control Strategy for a Heavy-Duty Transport Hexapod Robot on Rugged Agricultural Terrains（农业崎岖地形重型运输六足机器人运动控制策略）

简介：Legged agricultural transportation robots are efficient tools that can autonomously transport goods over agricultural terrain, and their introduction helps to improve the efficiency and quality of agricultural production. Their effectiveness depends on their adaptability to different environmental conditions, which is especially true for heavy-duty robots that exert ground forces. Therefore, this study proposes a motion-control strategy for a heavy-duty transport hexapod robot. Two critical tasks were accomplished in this paper: (1) estimating the support surface angle based on the robot's foot position and body posture, and accordingly determining the motion constraint conditions on this support surface and the body posture based on energy optimization; (2) proposing an adaptive fuzzy impedance algorithm for real-time force-position composite control for adjusting foot position, in order to reduce the steady-state force tracking error caused by terrain stiffness, thus ensuring body stability through tracking of variable foot-end forces. An element of

hardware in the loop control platform for a 3.55-ton device was designed and compared with the current popular force-control methods under different external contact terrains. The results show that the proposed control method can effectively reduce force errors, establish support forces faster on less-stiff environments, and reduce the torso tilt during phase switching.

来源：AGRICULTURE-BASEL

发布日期:2023-11-11

全文链接:

http://agri.nais.net.cn/file1/M00/10/35/CsgkOGWOaSCAHKveAGzseQMcL_A527.pdf

5．Design and experiment of an integrated navigation system for a paddy field scouting robot(水田侦察机器人综合导航系统的设计与试验)

简介：The navigation system is a crucial part of a paddy field scouting robot, which directly affects the working performance of the robot. The navigation error of the robot was enlarged by the inclination of the robot, which was caused by the uneven surface of the paddy fields. In this study, a map-based navigation system was proposed. The robot navigation map was derived from the planting map of a transplanter. An IMU was integrated with the GNSS to correct the navigation error using the inclination data of the robot through the Kalman filtering technique. A series of simulations and tests were performed to evaluate the performance of the integrated navigation system, including a line following test, a rough road simulation and test, and a row tracking test, as well as a field validation test. The lateral position offset and bearing angle deviation were measured and analyzed to assess the performance. The test results showed that the integrated navigation system significantly reduced the lateral position offset and bearing angle variation by 38.3 % and 26.7 % respectively as compared to the control group without the IMU correction. In the field validation test, the average lateral position offset was 5.93 cm, which was deemed acceptable for paddy field scouting operation in terms of navigation accuracy. In conclusion, the proposed integrated navigation system could be readily applied to the paddy field scouting robot to minimize navigation errors due to uneven ground and random inclination.

来源：COMPUTERS AND ELECTRONICS IN AGRICULTURE

发布日期:2023-10-23

全文链接:

http://agri.nais.net.cn/file1/M00/10/35/CsgkOGWOalGAQ4DDAISLX420PnY748.pdf

会议论文

1．A Map-Free LiDAR-Based System for Autonomous Navigation in Vineyards(基于无地图激光雷达的葡萄园自主导航系统)

简介：Agricultural robots have the potential to increase production yields and reduce costs by performing repetitive and time-consuming tasks. However, for robots to be effective,

they must be able to navigate autonomously in fields or orchards without human intervention. In this paper, we introduce a navigation system that utilizes LiDAR and wheel encoder sensors for in-row, turn, and end-row navigation in row structured agricultural environments, such as vineyards. Our approach exploits the simple and precise geometrical structure of plants organized in parallel rows. We tested our system in both simulated and real environments, and the results demonstrate the effectiveness of our approach in achieving accurate and robust navigation. Our navigation system achieves mean displacement errors from the center line of 0.049m and 0.372m for in-row navigation in the simulated and real environments, respectively. In addition, we developed an end-row points detection that allows end-row navigation in vineyards, a task often ignored by most works.
来源： 2023 European Conference on Mobile Robots (ECMR)；
发布日期:2023-09-27
全文链接:
http://agri.nais.net.cn/file1/M00/03/63/CsgkOWWOaxeAWH6dABvJTO8Tr_I518.pdf