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基于深度学习和高斯过程回归的玉米冠下视觉导航路径提取方法

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摘要: 面对田间作业过程中大型机器机动性差及复杂场景下导航路径拟合精度差的问题,提出一种基于深度学习和高斯过程回归的玉米冠层下导航路径提取方法。首先,基于四足机器人采集玉米冠下作物行图像,对 Mask R-CNN 实例分割方法进行改进,在特征融合网络引入简化路径增强特征金字塔网络(Simple path aggregation network, Simple-PAN),通过增加自底向上的路径增强模块和特征融合操作模块,提高图像上下文特征的融合能力。其次,以模型识别的冠下作物行目标为基础构建两侧区域分界线,计算可通行区域两侧下垂叶片的分布情况,优化基于加权平均的导航路径算法。对高斯过程回归(Gaussian process regression, GPR)算法进行改进,添加 DotProduct 线性核对曲线拟合进行优化,优化 GPR 方法的直线拟合效果。最后,在验证集上进行导航路径识别,计算不同方法拟合导航路径的平均偏差。试验结果表明,该算法能够适应玉米田中叶片遮挡根茎的情况,优化的 Mask R-CNN 模型具备更高的冠下目标分割精度,基于改进 GPR 算法拟合的导航线平均偏差为 0.7 像素,处理一帧分辨率为 1 280 像素×720 像素的图像平均耗时为 227 ms,该算法能提供在玉米冠层下具备一定避障能力的导航路径,满足导航实时性和准确性的要求。结果可为田间智能农业装备的导航算法研究提供技术与理论支撑。

关键词: 玉米冠下作物行; 深度学习; 视觉导航; 路径识别; 避障; 高斯过程回归

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Deep Learning and Gaussian Process Regression Based Path Extraction for Visual Navigation under Canopy

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Abstract: Facing the problem of difficult maneuvering of large machines during field operations and poor fitting accuracy of navigation paths in complex scenarios, a method of extracting navigation paths under the maize canopy was proposed based on deep learning and Gaussian process regression. Firstly, based on the quadruped robot collecting images of crop rows under the corn canopy, the Mask R-CNN instance segmentation method was improved, and the simple path aggregation network (Simple-PAN) was introduced into the feature fusion network, and the bottom-up path augmentation module and the feature fusion operation module were increased to improve the image context feature extraction module and the fusion capability of image context features. Secondly, the dividing line between the two sides of the area was constructed on the basis of the crop row target under the crown identified by the model, the distribution of the drooping leaves on both sides of the passable area was calculated, and the navigation path algorithm was optimized based on weighted average. The Gaussian process regression (GPR) algorithm was improved, and the DotProduct linear kernel was added to optimize the curve fitting and

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