

基于激光 达和 分影像的 叶混交林树种识别

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摘要:【目的】比较不同模型之间树种识别性能,确定最优深度学习模型,根据不同时期的识别精度确定最适宜树种识别的具体时期。【方法】以安徽省六安市金寨县天马自然保护区内三大优势树种,茅栗(*Castanea seguinii*)、短柄枹桐(*Quercus glandulifera*)、化香(*Platycarya strobilacea*)为研究对象,利用 LiDAR360 软件中集成的相对最小路径算法对落叶期点云数据(2022 年 3 月)进行分割,利用 Open3D 中凸包算法确定单木点云边界,并投影在 2D 平面上,得到单木边界矢量图。利用单木边界确定高分影像的单木冠层范围,并结合人工判读对一些边界进行局部修改得到高分影像的单木冠层边界,最后通过 Arc py 工具包对冠层进行提取,得到树木不同时期(2022 年 4 月、2022 年 7 月、2022 年 9 月)各个单木的冠层图像数据,同时,将不同时期的影像进行混合得到全时期数据。将归一化后的样本数据按照 6: 2: 2 随机划分训练集、测试集和验证集,在 PyTorch 框架下构建 AlexNet、AlexNet-SE、ResNet-50 三种深度学习模型,其中训练集和测试集进行模型训练,通过比较损失值和准确率来选择最优模型进行保存,使用验证集进行模型泛化能力验证,通过计算训练后的混淆矩阵得到总体精度(Overall Accuracy, OA)、生产者精度(Producer's Accuracy, PA)、用户精度(User's Accuracy, UA)和 Kappa 系数,比较不同时期分类结果,确定最佳树种识别时期。【结果】不同深度学习对研究区内优势树种识别,其中 4 月份的影像数据中, AlexNet 总体精度为 96.80%, Kappa 系数 0.9518; AlexNet-SE 总体精度为 97.92%, Kappa 系数 0.9687; ResNet-50 总体精度为 98.87%, Kappa 系数 0.9830。7 月份的影像数据中, AlexNet 总体精度为 96.73%, Kappa 系数 0.9508; AlexNet-SE 总体精度为 97.22%, Kappa 系数 0.9581; ResNet-50 总体精度为 98.59%, Kappa 系数 0.9788。9 月份的影像数据中, AlexNet 总体精度为 96.37%, Kappa 系数 0.9453; AlexNet-SE 总体精度为 97.15%, Kappa 系数 0.9571; ResNet-50 总体精度为 98.17%, Kappa 系数 0.9725。在全时期的数据集中, AlexNet 总体精度为 95.22%, Kappa 系数 0.9279; AlexNet-SE 总体精度为 96.30%, Kappa 系数 0.9444; ResNet-50 总体精度为 97.82%, Kappa 系数 0.9671。【结论】在不同时期的数据集中, ResNet-50 使用残差块加深了网络学习的深度, ResNet-50 精度优于 AlexNet-SE、Alex-Net 模型, AlexNet-SE 在 AlexNet 的基础上添加了注意力机制, AlexNet-SE 模型的验证集精度一直优于 AlexNet 模型。根据树种识别的精度可以确定, 4 月份时本研究区内树种识别的最佳时期, 7 月份识别效果稍差, 而 9 月份识别效果最差。并且在进行全时期数据集训练时, 虽然模型波动性不大, 但是使树种识别精度降低。

关键词: 激光雷达; 高分影像; 树种识别; 阔叶混交林

Tree Species Identification of Broadleaf Mixed Forest Based on Lidar Data and High-resolution Images

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Abstract: 【Objective】 By comparing the tree species recognition performance between different models, the optimal deep learning model is determined. And the specific period of the most suitable tree species recognition is determined according to the recognition accuracy of different periods. 【Method】 In this paper, three dominant tree species, *Castanea seguinii*, *Quercus glandulifera* and *Platycarya strobilacea*, in Tianma National Nature Reserve, Jinzhai County, Lu'an City, Anhui Province, were taken as the research objects. The comparative shortest-path algorithm integrated in LiDAR360 software was used to segment the point cloud data of deciduous period (March

2022). The convex hull algorithm in Openi3D was used to determine the boundary of single tree point cloud, which was projected on the 2D plane to obtain single tree boundary. The individual tree boundary is used to determine the individual tree canopy range of the high-resolution image. Combining with the manual interpretation, the individual tree canopy boundary is obtained by local modification of some boundaries. Finally, the canopy image data of each individual tree in different periods (April 2022, July 2022, September 2022) is obtain by the Arcpy toolkit. The normalized sample data were randomly divided into training set, test set and verification set according to 6 : 2 : 2. Three deep learning models of AlexNet, AlexNet-SE and ResNet-50 were constructed under the PyTorch framework. The training set and test set were used for model training. The optimal model was selected by comparing the loss value and accuracy. The verification set was used to verify the generalization ability of the model. The overall accuracy, producer's accuracy, user's accuracy and Kappa coefficient were obtained by calculating the confusion matrix after training. The results of different periods were compared to determine the best tree species identification period. **【Result】** In terms of tree species identification accuracy at different times, in April image data, the overall accuracy of AlexNet was 96.80%, with a Kappa coefficient 0.9518. The overall accuracy of AlexNet-SE was 97.92%, with a Kappa coefficient 0.9687. The overall accuracy of ResNet-50 was 98.87%, with a Kappa coefficient 0.9830. In July image data, the overall accuracy of AlexNet was 96.73%, with a Kappa coefficient 0.9508. The overall accuracy of AlexNet-SE was 97.22%, with a Kappa coefficient 0.9581. The overall accuracy of ResNet-50 was 98.59%, with a Kappa coefficient 0.9788. In September image data, the overall accuracy of AlexNet was 96.37%, with a Kappa coefficient 0.9453. The overall accuracy of AlexNet-SE was 97.15%, with a Kappa coefficient 0.9571. In the data of the whole period, the overall accuracy of AlexNet was 95.22%,with a Kappa coefficient 0.9279. The overall accuracy of AlexNet-SE was 96.30%, with a Kappa coefficient 0.9444. The overall accuracy of ResNet-50 was 97.82%, with a Kappa coefficient 0.9671. **【Conclusion】** In different periods, ResNet-50 uses residual blocks to deepen the depth of network learning. The accuracy of ResNet-50 is better than AlexNet-SE and Alex-Net models. AlexNet-SE adds an attention mechanism on the basis of AlexNet. The accuracy of the verification set of the AlexNet-SE model has always been better than the AlexNet model. According to the accuracy of tree species identification, it can be determined that the best time for tree species identification in this study area is in April, the recognition performance in July is slightly worse, and the September is the worst. The model volatility is not large for entire period data, but the tree species recognition accuracy is reduced.

Key words: lidar; high-resolution images; tree species identification; broadleaf mixed forest.