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# REMOTE MONITORING OF URBAN VEGETATION BASED ON IMAGE ANALYSIS

**Master's Degree Thesis**

Specialty 7-06-0532-03 Land Management, Cadasters, Geodesy and Geomatics

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# GENERAL CHARACTERISTICS OF THE WORK

**Keywords:** UAV REMOTE SENSING, VEGETATION INDICES, URBAN CARBON SINK, MULTISPECTRAL IMAGERY, CANOPY HEIGHT MODEL, EREBAI.

**The purpose of the work:** To estimate carbon storage of urban vegetation using UAV multispectral images and a three-dimensional hierarchical modeling approach, including a novel vegetation index (EREBAI) for improved classification accuracy.

**The tasks:** 1) Master multispectral UAV data processing using ENVI, QGIS, and Python; 2) Analyze spectral reflectance characteristics of urban vegetation and non-vegetation surfaces; 3) Construct and compare vegetation indices (including EREBAI, NDVI, NDRE, etc.) to evaluate classification accuracy under urban interference conditions; 4) Stratify urban vegetation into trees, shrubs, and ground cover using CHM derived from DSM data; 5) Quantify vegetation carbon storage using a hierarchical estimation model, incorporating field survey data and IPCC coefficients. 6)Object of the study: Multispectral UAV images collected over Zhejiang Shuren University campus, containing vegetation types (trees, shrubs, grassland), artificial structures (roads, buildings), and water bodies. The images were captured using a MicaSense RedEdge-MX camera mounted on a DJI Matrice 300 RTK UAV.

**The object of the study:** $O_2$ absorption by different urban vegetation strata based on structure-specific carbon sequestration models.

**The subject of the study:** Layer extraction of urban remote sensing images and carbon storage of vegetation

**The results obtained and their novelty：** The EREBAI (Enhanced Red-Edge with Blue Adjustment Index) developed in this study achieved a user accuracy of 98.82% and an overall accuracy of 91.5%, outperforming traditional indices like NDVI (OA = 91.25%, UA = 81.54%). Vegetation reflectance in the Red Edge (717 nm) and NIR (840 nm) bands reached up to 35–40% for healthy shrubs and trees, showing strong spectral separability from artificial surfaces. A Canopy Height Model (CHM) was derived from DSM with vertical accuracy RMSE = 0.15 m, enabling vegetation classification into three strata:

Arbor layer ($H > 3$ m): 74,185.5 m² (65.7%)

Shrub layer ($0.5 \text{ m} \leq H \leq 3$ m): 10,282.42 m² (9.1%)

Ground cover layer ($H < 0.5$ m): 28,474.94 m² (25.2%)

Carbon stock estimation revealed:

Tree layer: 1234.7 t C/year (92.4% of total)

Shrub layer: 78.9 t C/year (5.9%)

Ground cover: 22.4 t C/year (1.7%)

Total: 1336.0 t C/year

**The structure of the thesis：** The thesis is presented in 67 pages, consisting of: An introduction, Three chapters (theoretical background, methods, results & evaluation), A conclusion, And a reference list of 62 cited works. It includes 15 figures and 18 tables summarizing spectral data, vegetation stratification, carbon storage, and index performance.

# 作品的总体特征

**关键词：**无人机遥感、植被指数、城市碳汇、多光谱图像、冠层高度模型、EREBAI。

**工作目的：**使用无人机多光谱图像和三维分层建模方法估算城市植被的碳储量，包括一种新的植被指数（EREBAI），以提高分类准确性。

**任务：** 1）掌握使用 ENVI、QGIS 和 Python 进行多光谱无人机数据处理；2）分析城市植被和非植被表面的光谱反射特征；3）构建和比较植被指数（包括 EREBAI、NDVI、NDRE 等）以评估城市干扰条件下的分类精度；4）使用从 DSM 数据导出的 CHM 将城市植被分层为乔木、灌木和地被植物；5）使用分层估算模型量化植被碳储量，结合实地调查数据和 IPCC 系数。6）研究对象：在浙江树人大学校园上空收集的多光谱无人机图像，包含植被类型（乔木、灌木、草地）、人工结构（道路、建筑物）和水体。使用安装在 DJI Matrice 300 RTK 无人机上的 MicaSense RedEdge -MX 相机捕获图像。

**研究对象：**基于结构特定碳封存模型的城市不同植被层对 $O_2$的吸收。

**研究主题：**城市遥感影像图层提取及植被碳储量

**所得结果及其创新之处：**本研究开发的 EREBAI（增强红边蓝调指数）实现了 98.82% 的用户准确度和 91.5% 的总体准确度，优于 NDVI 等传统指数（OA = 91.25%，UA = 81.54%）。 健康灌木和树木在红边（717 nm）和近红外（840 nm）波段的反射率高达 35%至 40%，与人工地表的光谱分离性强。基于 DSM 模型构建了冠层高度模型（CHM），垂直精度 RMSE = 0.15 m，可将植被分为三层：

乔木层（高 > 3 m）：74,185.5 m²（65.7%）

灌木层（0.5 m ≤ H ≤ 3 m）：10,282.42 m²（9.1%）

地面覆盖层（H < 0.5 m）：28,474.94 m²（25.2%）

碳储量估算显示：

乔木层：1234.7 吨碳/年（占总量的 92.4%）

灌木层：78.9 吨碳/年（5.9%）

地面覆盖：22.4 吨碳/年（1.7%）

总计：1336.0 吨碳/年

**论文结构：**论文共 67 页，包括：引言、三章（理论背景、方法、结果与评估）、结论以及 62 篇参考文献列表。论文包含 15 幅图和 18 个表格，概述了光谱数据、植被分层、碳储量和指标表现。