Trends in Plant Science

LiDAR: a new player in analyzing plant phenotypes

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May 8, 2024

Dear Editor:

I would like to submit our manuscript entitled "**LiDAR: a new player in analyzing plant phenotypes**" that we would like considered for publication in the Technology of the Month of *Trends in Plant Science.*

Our group has studied plant phenomics for more than 8 years. Recently, LiDAR has become a powerful tool to study plant phenomics. In this work, we went through the LiDAR working pipeline and application cases in the filed of plant phenomics.

A publication in *Trends in Plant Science* can encourage plant biologists to follow up this "cheat sheet" and unravel its function in studying plant phenomics. As interest increases in this field, and the cost of LiDAR comes down and becomes a routine experimental protocol, we will gain a much deeper understanding of this important yet poorly understood tool.

Thank you for your consideration of our work and I look forward to hearing from you soon.

Sincerely,

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Response to the comments by the reviewers for the article,

LiDAR: a new player in analyzing plant phenotypes

Zhongzhen Tang [1,†], Tianyou Jiang[1,†], Yongzhen Wang [1], Xiaoyong Sun[1,*]

Dear Editor:

We would like to thank the reviewers for their insightful review of our article. Thanks to their precious comments and suggestions, we have been able to make a substantial improvement on the article.

We have changed the three old references to the most recent references from 2024. Reference 7 (2015) and 8 (2021) were suggested by the second reviewers because of the strong relationship with this manuscript, so we decide to keep these two references.

Also, Dr.Fu, Daolin, one of the authors, decided to remove his name from the author list because of personal issue. Thus we removed his name as he requested. The authors should be as follows:

Zhongzhen Tang, Tianyou Jiang, Yongzhen Wang, Xiaoyong Sun.

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Trends in Plant Science | Technology of the Month

LiDAR: a new player in analyzing plant phenotypes

Zhongzhen Tang[1,†], Tianyou Jiang[1,†], Yongzhen Wang[1], Xiaoyong Sun[1,*]

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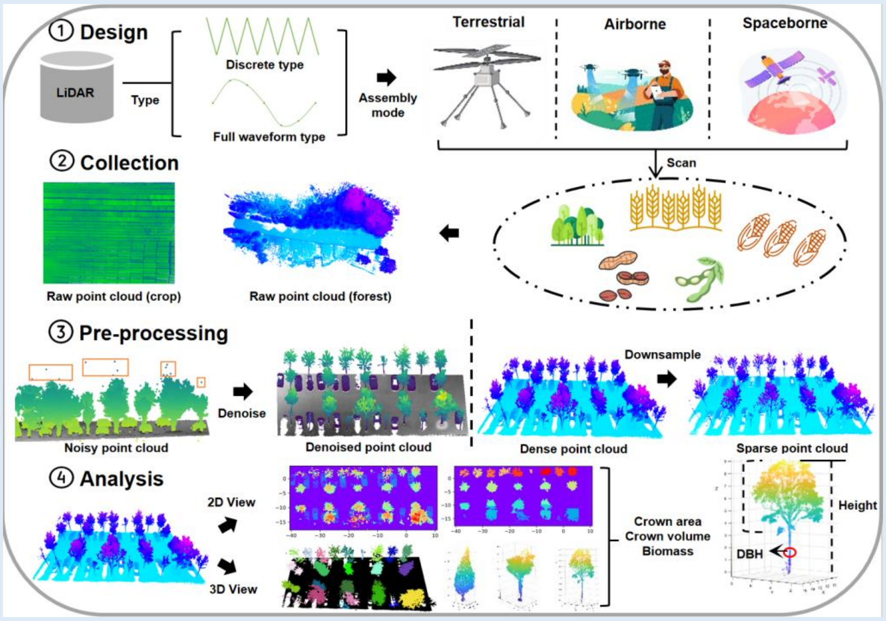
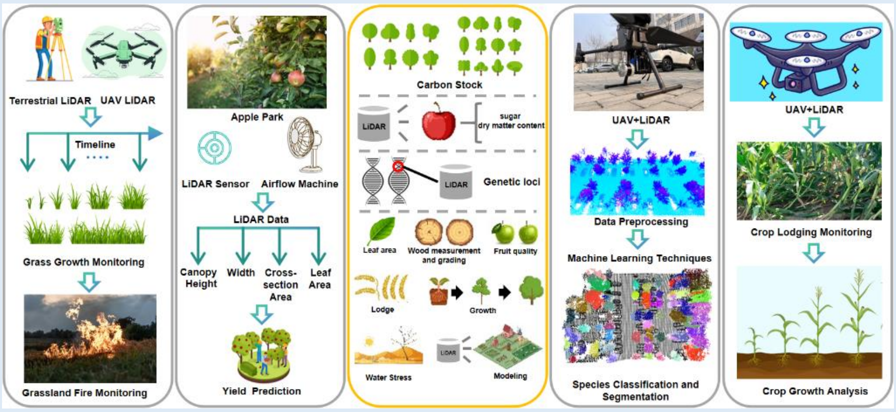


Light detection and ranging (LiDAR) technology employs laser beams to measure the distance and generate contour for a target surface. Various LiDAR types, including discrete and full waveform, collect point cloud data using different assembly modes. Terrestrial LiDAR is utilized for quantifying plant canopy structure, airborne LiDAR is applied to measure biomass, and spaceborne LiDAR is the best choice to monitor plant diversity. Once the collected point cloud undergoes thorough pre-processing, it becomes amenable to analysis, enabling the extraction of plant phenotypes through a series of algorithms. To date, an array of plant phenotypes, encompassing height, structure, vegetation density, and coverage, can be accurately quantified using this data. Furthermore, the assessment of plant biomass is achievable through detailed measurements of plant volume and structure.



LiDAR technology has made notable strides in agriculture, offering a multitude of applications. Its versatile usage spans from precision farming and crop monitoring to autonomous driving, topographic mapping, and empowering farmers with accurate data for informed decision-making. Through the utilization of hyperspectral LiDAR, people can make well-informed decisions regarding not only plant morphology, but also physiological traits, such as fruit quality, sugar content and water stress nowadays.

ADVANTAGES:

LiDAR technology excels in providing highly accurate and precise measurements of plant features such as height, structure, and volume. This precision of distance to various objects is crucial for gathering detailed and reliable data for plant phenotyping.

The production of detailed 3D point cloud data by LiDAR provides a comprehensive view of plants' spatial structure. This 3D information enhances our understanding of plants' physical layout.

LiDAR has the ability to discern subtle changes in plant structure, offering a distinct advantage in continuous monitoring across various growth stages. This capability extends to the early detection of potential stress, or nutrient deficiencies, allowing for timely interventions. Such proactive approach empowers farmers to address issues before they can significantly impact crop yield.

LiDAR technology is effective in large-scale agricultural areas. It can efficiently cover extensive fields, providing a holistic view of the entire crop, which is especially beneficial for commercial farming operations.

CHALLENGES:

LiDAR generates large volumes of point cloud data, leading to complexities in data processing and analysis. More efficient algorithms and computational resources are required to handle and extract meaningful information from these extensive datasets.

LiDAR equipment, especially high-quality sensors and devices capable of capturing detailed plant phenotypes, can be expensive. The initial investment cost might pose a challenge for smaller-scale farmers or agricultural operations with limited budgets.

In areas with dense vegetation or complex canopies, LiDAR may face challenges in penetrating through layers of leaves and branches. This limitation can affect the accuracy of measurements and hinder the assessment of plant structures in such environments.

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Acknowledgments

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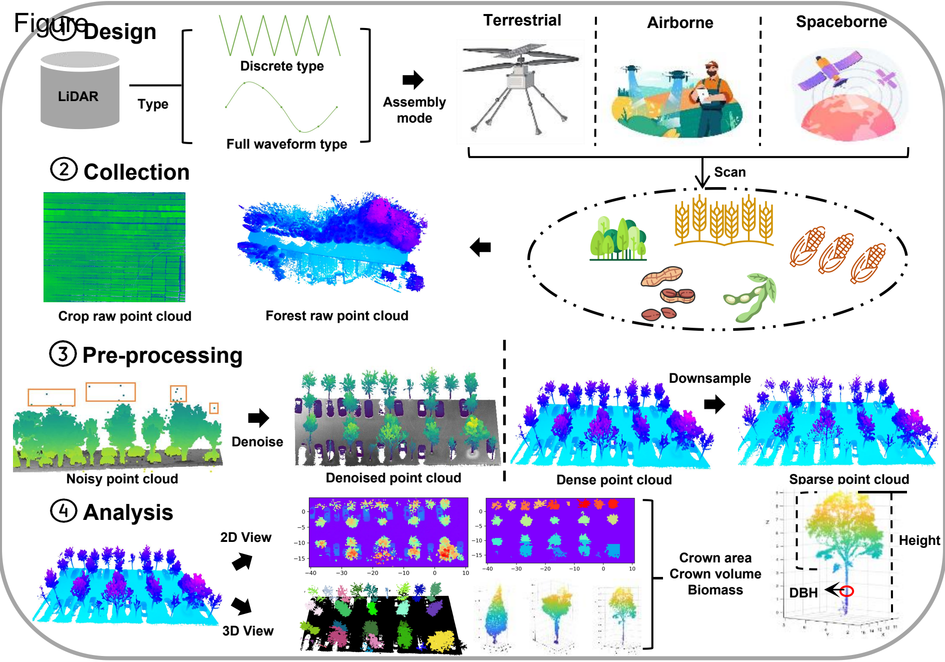
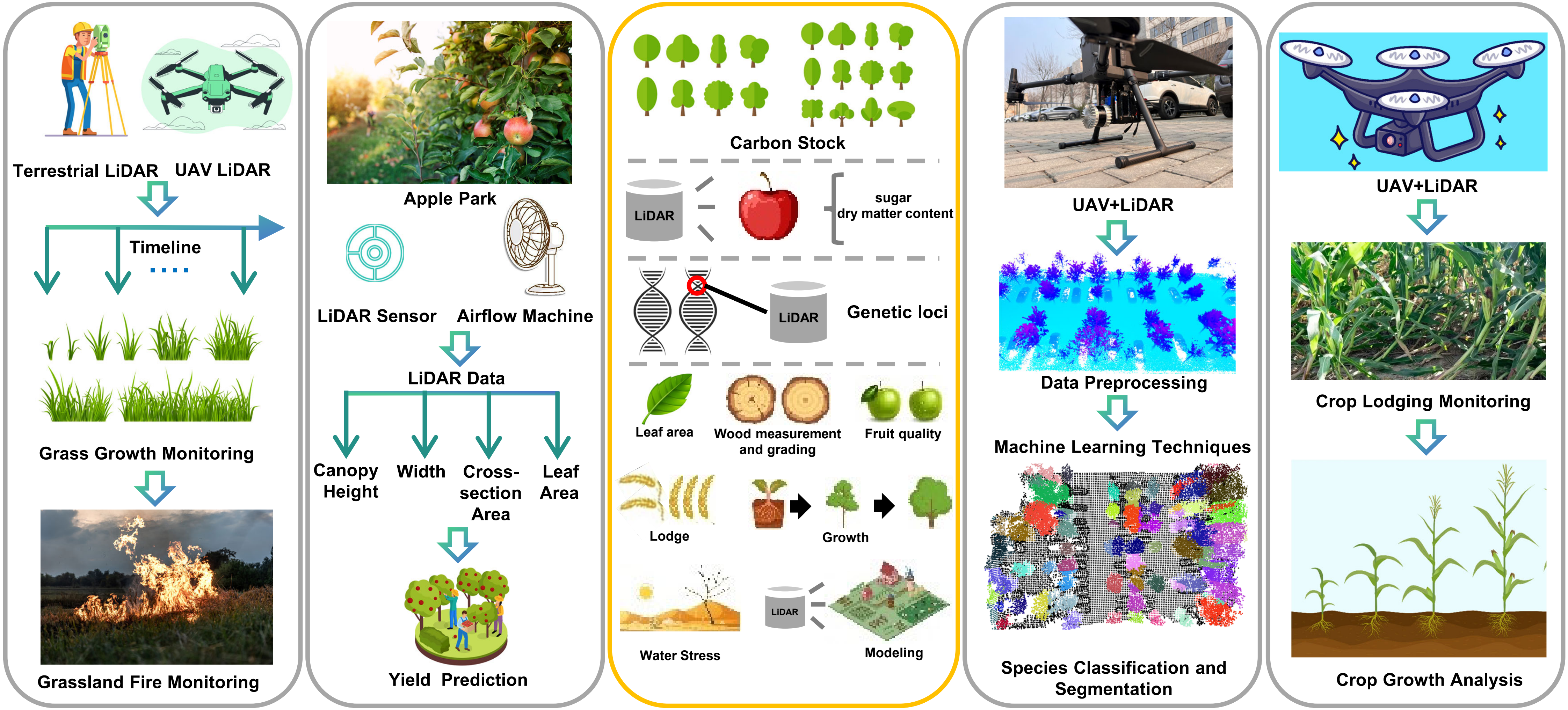


Figure
① Design
LiDAR
Type
Discrete type
Full waveform type
Assembly mode
Terrestrial
Airborne
Spaceborne
Scan
② Collection
Crop raw point cloud
Forest raw point cloud
③ Pre-processing
Noisy point cloud
Denoise
Denoised point cloud
Downsample
Dense point cloud
Sparse point cloud
④ Analysis
2D View
3D View
Crown area
Crown volume
Biomass
Height
DBH

Figure



Terrestrial LiDAR
UAV LiDAR
Timeline
Grass Growth Monitoring
Grassland Fire Monitoring
Apple Park
LiDAR Sensor
Airflow Machine
LiDAR Data
Canopy Height
Width
Cross-section Area
Leaf Area
Yield Prediction
Carbon Stock
LiDAR
sugar
dry matter content
LiDAR
Genetic loci
Leaf area
Wood measurement and grading
Fruit quality
Lodge
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Water Stress
LiDAR
Modeling
UAV+LiDAR
Data Preprocessing
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UAV+LiDAR
Crop Lodging Monitoring
Crop Growth Analysis

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