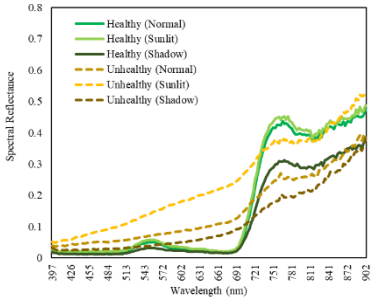
News Article for RISUD Strategic Focus Area (SFA) Scheme

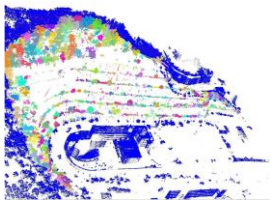
		Name	Department
1.	**Principal Investigator**:	Charles M.S. Wong	LSGI
2.	**Name of SFA:**	Urban Ecology	
3.	**Project Title:**	New Technologies for Smart Management of Urban Trees	

4. **Third Year Progress/Achievement (***in layman's language, no more than 2 pages***)**

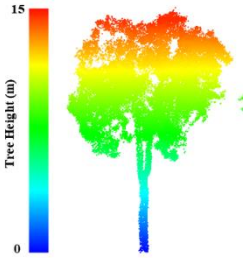
The growth of trees varies with physical, biological, and environmental conditions. This increases the challenge of tree risk assessment through the traditional method. Ground scale data about tree health condition, dimension, location, and species composition are obtained through on-site field sampling method, which is costly, labor-intensive, time-consuming, and difficult to repeat. With the growing compactness of our city, the vulnerability of urban trees surges, especially under unexpected climatic conditions. Therefore, this project has developed and implemented emerging technologies for smart management of urban trees in Hong Kong. A summary of the objectives achieved in this study is given below:

1) Identification of potentially dangerous trees using remote sensing techniques by (i) identifying urban tree species and tree health conditions from hyperspectral and near infra-red imaging, chlorophyll fluorescence and thermal imagery; (ii) retrieving tree attributes using consume grade UAV cameras, augmented reality, and 3D models developed from LiDAR data; (iii) monitoring phenology and its interaction with climate change. Tree parameters of Stonewall trees were extracted, and estimated Leaf Area Index of Old and Valuable Trees was also evaluated. A hyperspectral library of 19 urban tree species was developed to characterize and classify urban tree species in Hong Kong.

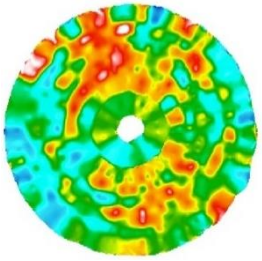




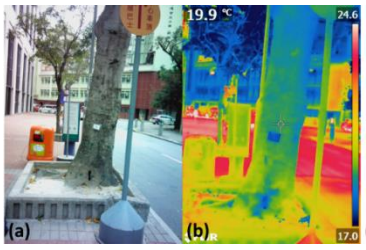
UAV airborne LiDAR scanning and field survey were conducted in four sample plots in the Kowloon Peninsula in late-2018 and early-2019 to acquire airborne LiDAR data. The results were promising when compared with the ground-truth result. The developed methodology could be used on LiDAR point clouds to extract single tree crowns and their associated parameters in consideration of local forest circumstances and data acquisition settings.



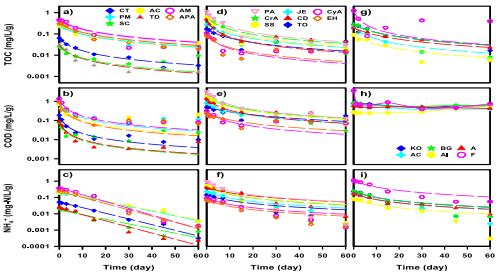
2) Field verifications of the causes of tree risk through non-invasive sensing techniques, including GPR assessment and thermal infrared imaging. The GPR was used to study the tree root distribution at four sites, and results showed that up to about 1.5m depth of the distribution could be mapped. The radargram across a traverse next to the tree trunk indicates a hyperbolic reflection. The identified wet-dry boundary and tree root distribution clearly illustrate that the trees are absorbing water, which indirectly suggests the healthy status of the trees. It is currently the only non-destructive method to study tree root distribution in the near-surface, and thus it is worth to conduct further research for application.



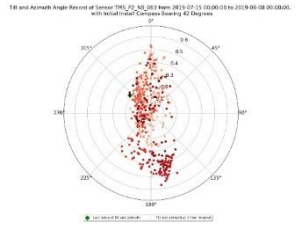
To investigate the relationship between structural defect and surface temperature of trees, fieldwork was conducted to acquire thermal images for over 12 selected trees. The images were used to develop an algorithm for detecting tree defects with known cavity size and area. The shadow cast by overhead tree crown and auxiliary branches will lower the surface temperature of the tree trunk. Air temperature under the tree canopy is much cooler than the air outside the canopy, in which some studies suggested that there could be a difference of more than 7°C resulting from the shading effect.

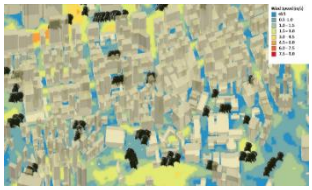


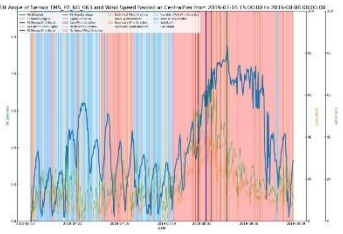
3) Procedural laboratory testing through sampling by expert determines the actual health of trees and tree dangers to the surroundings. The ability of the plants to purify wastewater was demonstrated. It was most difficult to remove COD from stormwater with the mangrove plants. In most cases, the removal rate of ammonia was significantly faster in a continuous flow process than a batch process. Plant species such as *Phragmites australis*, *Crinum asiaticum*, and *Scaevola sericea* can be used for pollutants removal in the synthetic stormwater treatment process. *Commelina diffusa* should not be used in saline environment.



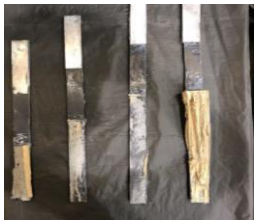
4) Acquisition of Big Data of static tree attributes and dynamic tree movement data through collecting near real-time data from tree sensors. It is crucial to forecast the tilting angle as an indicator to determine stability of a tree which is exposed to wind force. For testing, the sensors have been installed on 8,000 trees in various locations under a variety of environmental conditions, to have a comprehensive analysis for the whole system. Our team has studied the pattern of tree stability in multilateral directions, in a bid to understand the correlation of pattern such as the species with smooth and rough bark, the effect of sunlight intensity and sun orientation, and the moving trajectory of trees, as well as the impact of wind and rainstorms. A Digital Elevation Model (DEM) of 0.5-meter spatial resolution, 3D building models with the height attribute included, and 3D geometry of trees were used to simulate airflow in the study area using Airflow Analyst.

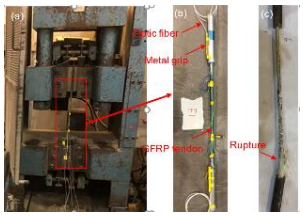


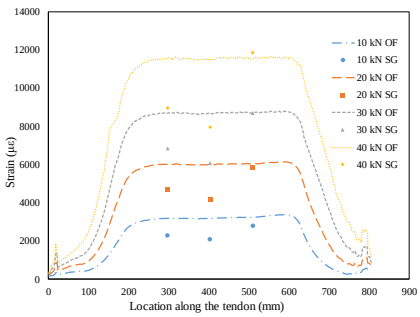




5) Rectification of potentially dangerous trees using a fabricated FRP implant with a customized adjustable testing frame has been designed to fix the specimens. In general, two types of failure modes have been observed. For the first type, failure happens in the wood base. For this failure mode, it was observed that a remaining part of the wood is bonded to the FRP on the pulled out FRP strip. Therefore, the bond in such case is stronger than the wood base, indicating sufficient bond strength. For the second type, failure occurs at the adhesive tape or FRP surface. In this case, the strength of the wood base is larger than the strength of the FRP and the adhesive tape, indicating insufficient bond strength. The fabricated GFRP tendon was tested under tension to evaluate its mechanical properties and the performance of the embedded BOTDA fiber optics. A total of ten tendons were tested under tension until failure on the testing frame. The GFRP tendon was inserted into the metal grips at two ends to facilitate the gripping of the clamps on the testing frame. Monotonic tensile loading was applied to the tendons until the failure of the tendons.







6) Knowledge sharing and technology transfer, policy recommendation, and community engagement through public seminars of the advanced technology have been continuously carried out. The team is recently awarded by the "Dean's Award for Outstanding Achievement in Technology Transfer 2021" by the Faculty of Construction and Environment, The Hong Kong Polytechnic University. The team has been actively engaged in various academic events to promote our project and the geospatial technology adopted since the last reporting period. These events have been undertaken for academic and community sharing to the Government officials, overseas academia, students, as well as the general public to transfer the knowledge of new technologies for tree management.