Towards Automated Spectroscopy: Leveraging a Robotic Arm for Enhanced Spectroscopic Measurements

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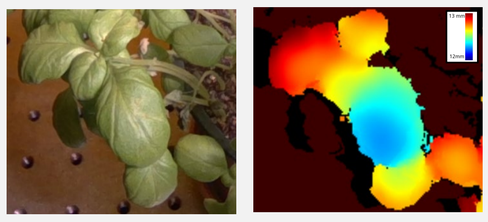
Dynamic and scene aware spectroscopic measurements

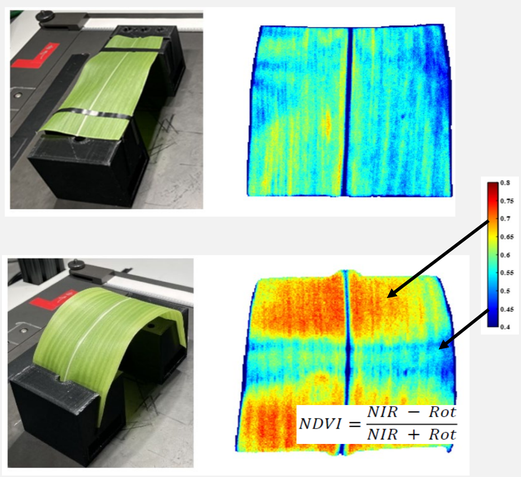
- The robot mounted spectroscopic system can take reflection measurements from a distance
- Depending on the object to be measured the same spot spectrum can be measured from different angles
- The angle of the measurement is known



Context: Shortcomings of hyperspectral imaging

- Hyperspectral cameras typically have a tradeoff between spatial and spectral resolution
- Most information is not necessary for decision but generates huge data volumes
- The individual pixel are measured at an unknown angle
- The spectrum of plant leaves is angle depended [3]
- Not every spot can be used for a measurement

NDVI Heatmap



[1]

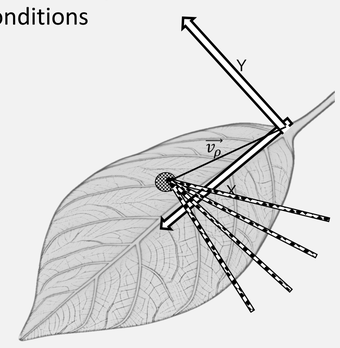
no leaf

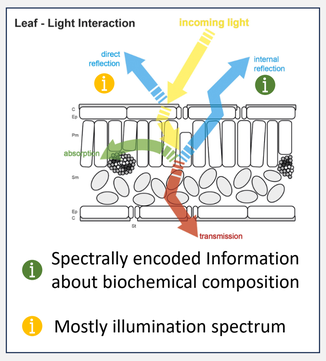
specular reflection

shadow

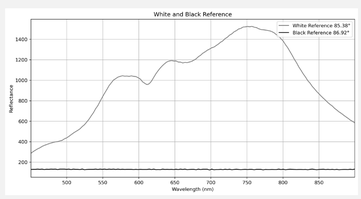
Possible application and first measurements

- Measure the same spot on a leaf from different angles
- Outlook: Study of angular reflectance of different plants under different conditions

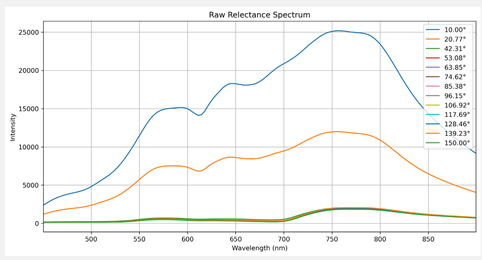


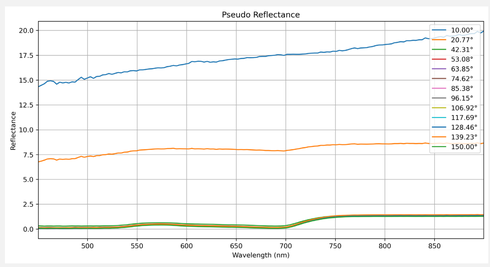


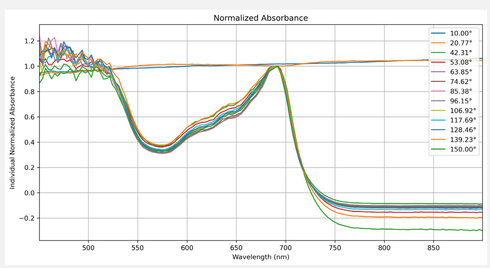
[2]



Illumination at 35° polar angle

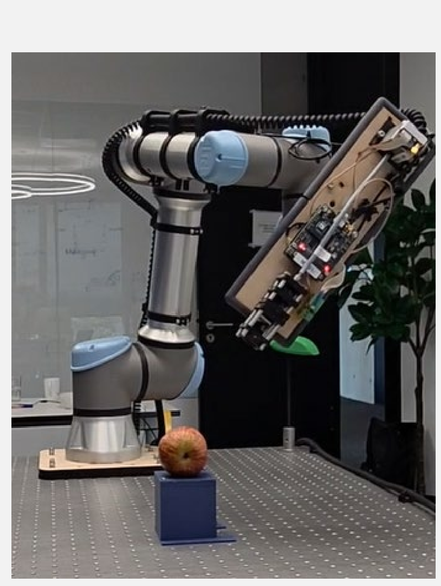


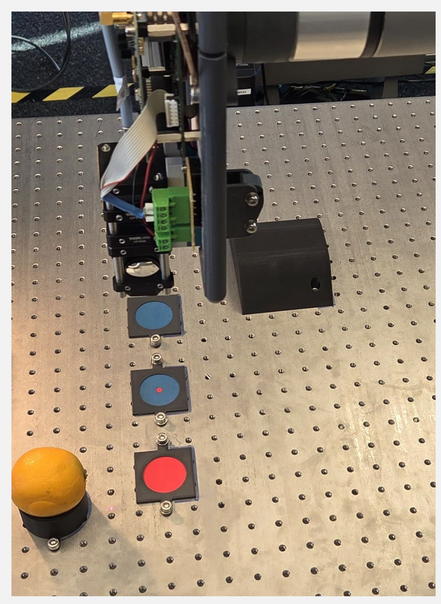


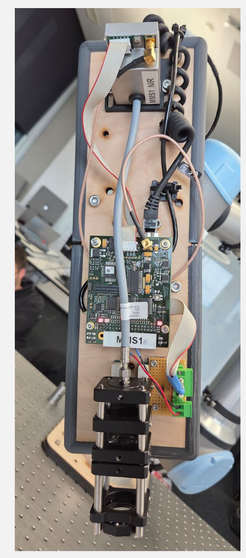


Hardware

- Robot
  - UR5e 6 dof collaborative robot arm
    - Repeatability (ISO 9283): ± 0,03 mm
    - Max tcp speed: 4 m/s
- Spectrometer
  - Zeiss UV-NIR MMS
  - Outlook: Zeiss NIR PGS







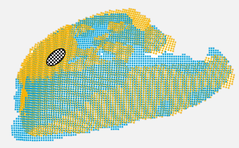
Software

- Full ros2 stack
  - Angular measurements are implemented as an action
- Custom ros2 wrapper for tec5 ethernet spectroscopy interface board
- Currently running on wsl2

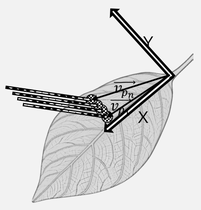
ROS 2

Outlook

Point cloud integration



Trajectory scans



References

[1] Image modified. Original source taken from: Zhang, Libo / Jin, Jian / Wang, Liangju / Rehman, Tanzeel U. / Gee, Mark T. Elimination of Leaf Angle Impacts on Plant Reflectance Spectra Using Fusion of Hyperspectral Images and 3D Point Clouds
[2] Image modified. Original source taken from: Mahlein, A.-K. (2016). Plant Disease Detection by Imaging Sensors – Parallels and Specific Demands for Precision Agriculture and Plant Phenotyping. Plant Disease, 100(2), 241–251
[3] Balasus, Jens / Hegemann, Tim / Khanh, Tran Quoc Optische Blatteigenschaften zur Verwendung in virtuellen Pflanzenmodellen 2021

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