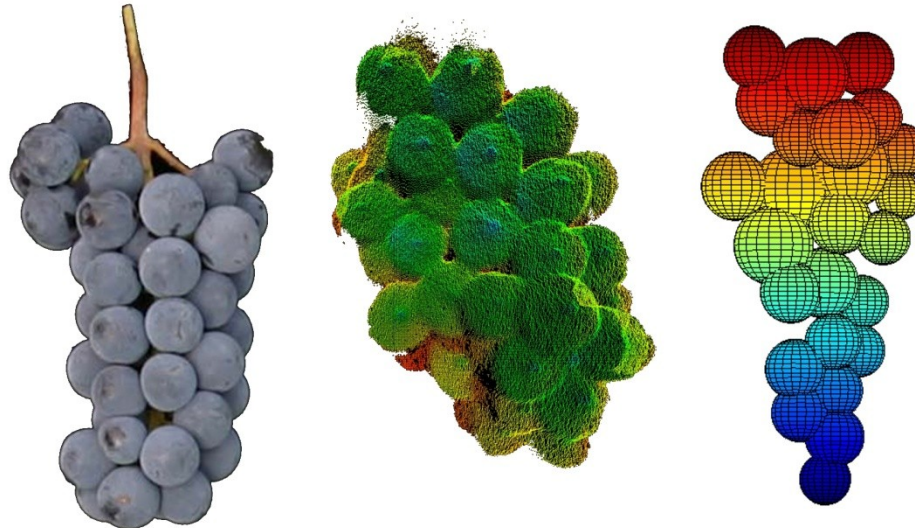


# ***The benefit of plant models for laser generated data***

***- advantages of a symbiosis -***

**Dipl. Inf. Stefan Paulus  
Institute of Geodesy und Geoinformation  
Professorship of Geodesy  
University of Bonn**

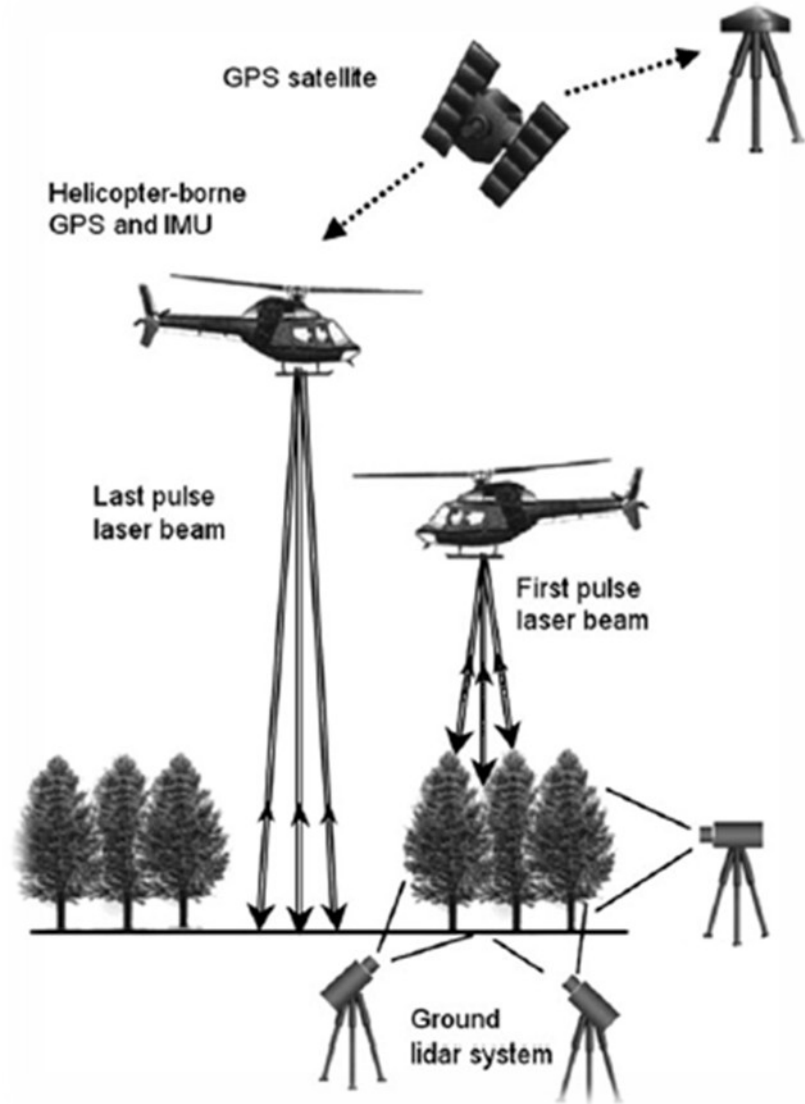


- **state of the art**
- **motivation**
- **problems and difficulties**
- **benefit of models**
- **perspective**



## Laserscanning of plants

- with **airborne** laserscanners
  - inertial system + GPS
- with **ground** based laserscanner
  - time of flight
  - phase shift
- in the **laboratory**
  - triangulation
  - structured light
  - with different geometric approaches



Omasa 2007

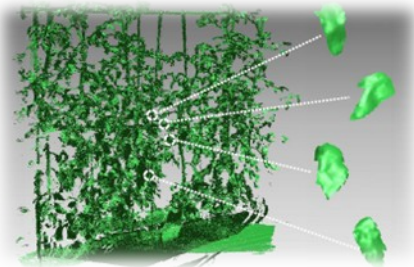
## Extraction of various parameters:

- canopy height / mean tree height
- distribution of leaf area in space
- gap propability

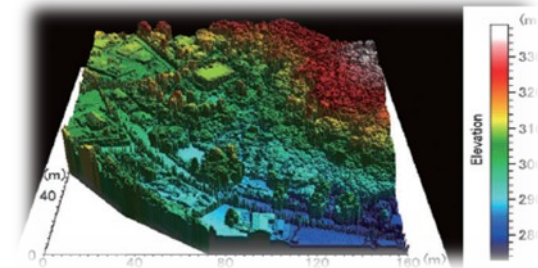
Omasa 2007

- breast hight, diameter
- carbon stocks from biomass estimation
- shape analysis

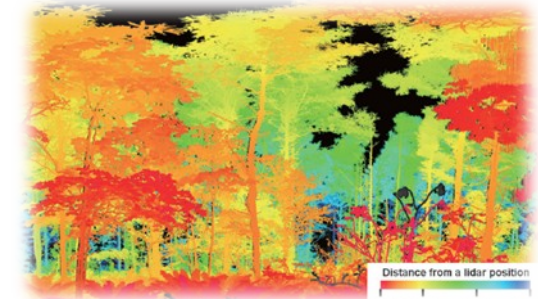
Omasa 2007



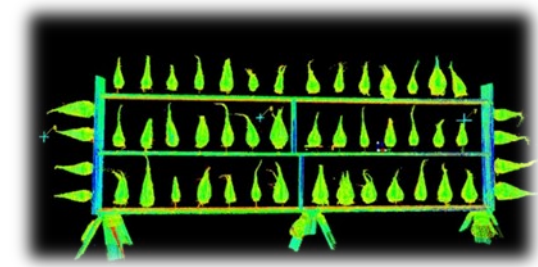
Hosoi 2011



Omasa 2007



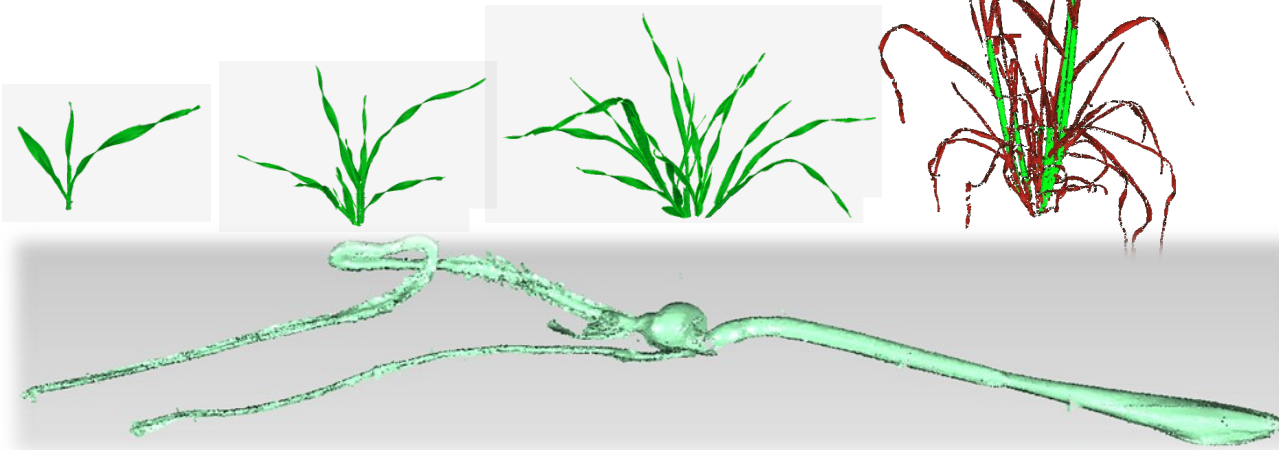
Omasa 2007



## High resolution laser scanning of plants



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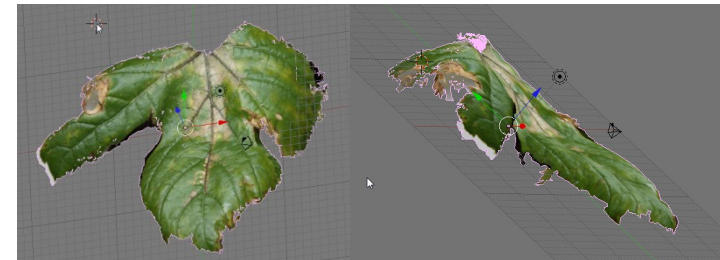
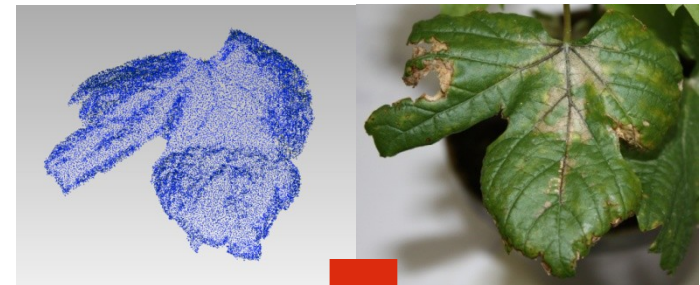
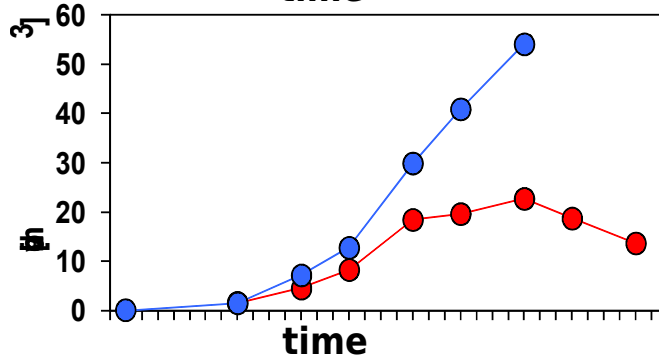
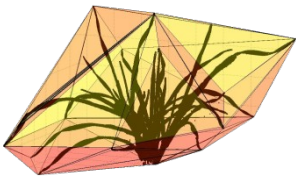
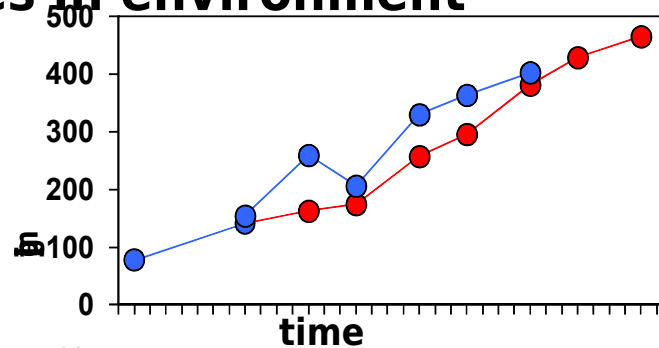
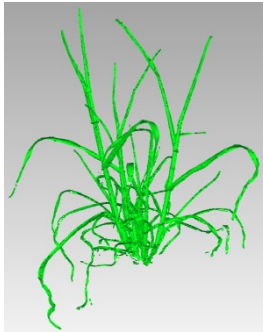


Perceptron 2008

## today:

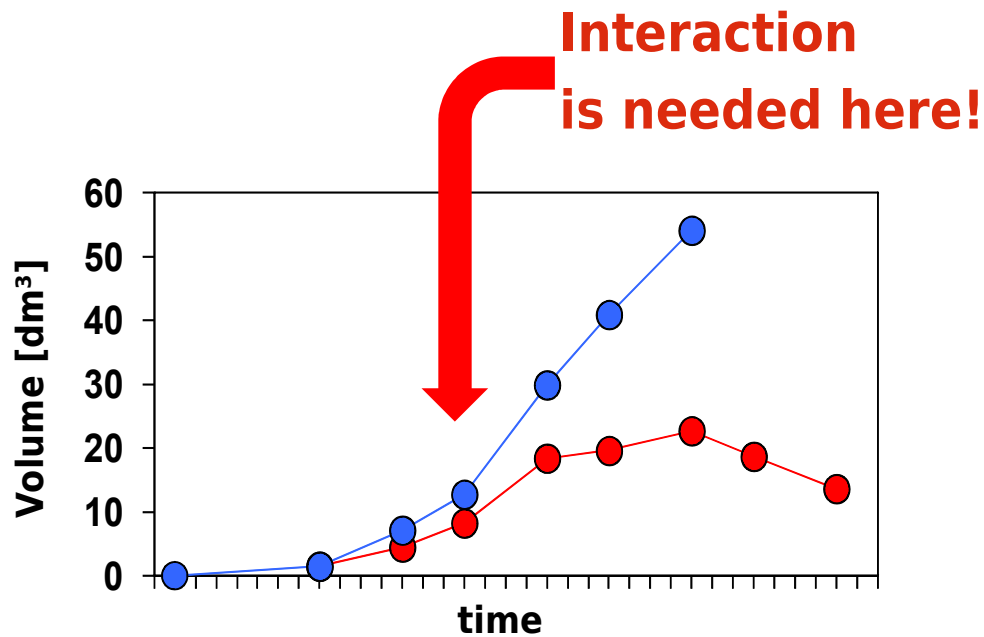
- Derivation of morphological characteristics
- Sensor fusion with RGB/IR/hyperspectral camera data
- Reference system for calibration of other sensors
- Observation of smallest changes to quantify plant response

## to changes in environment



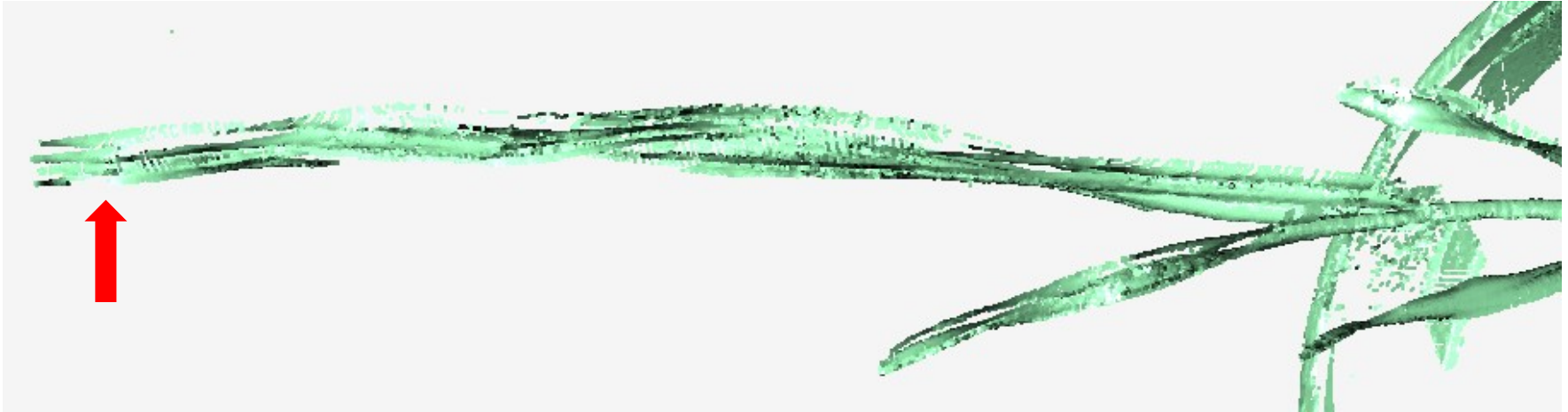
## In future:

- usage directly in the field
- target-actual comparison
- prediction of parameters due to environment
- adjustment of application and geometry

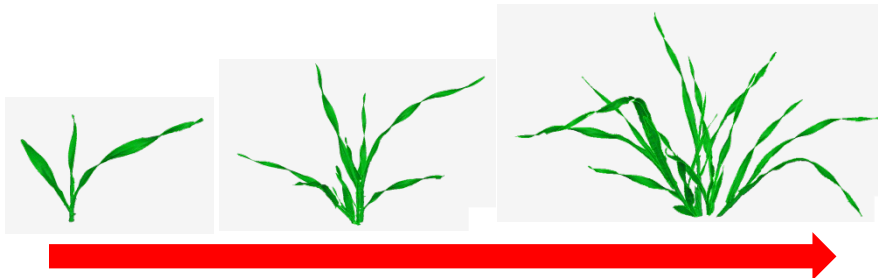


Llorens 2011

## 1. Plant motion due to growth and vibrations

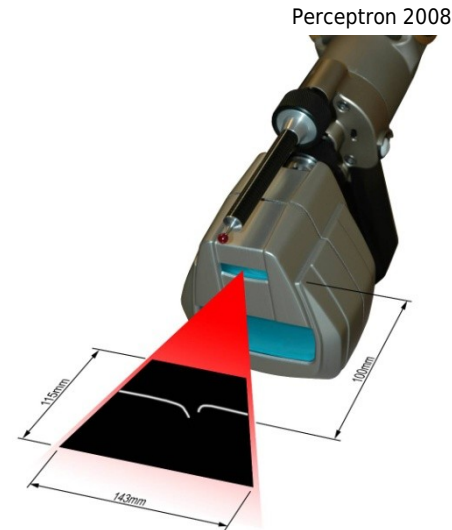
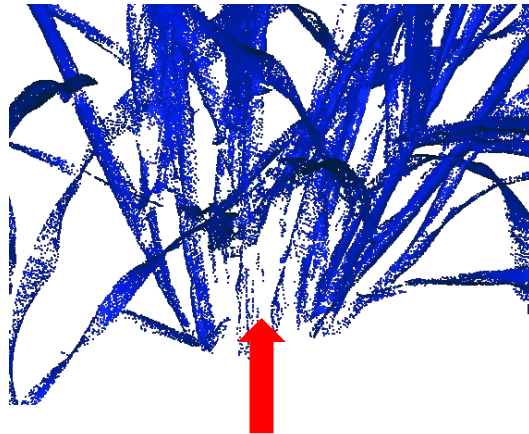


## 2. Change of plant structure und arrangement

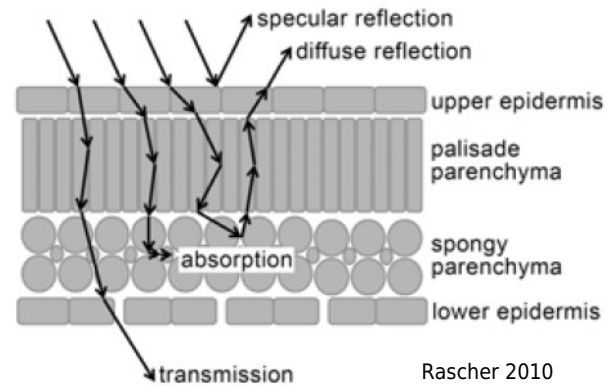




## 3. Occlusion due to sensor range and structure



## 4. Penetration of the laser beam and the plant surface



## In short:

- penetration → improve the technique
- occlusion → ???
- change in structure → ???
- plant motion → ???

## Benefit of physical (or FSPM) models

- coordinate system for the plant
- knowledge of structure
- independant from sensor
- connection between parts is known, this enables tracking

 phyto-reference-system



**laserscan**

**s**

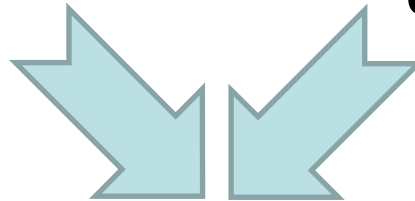


**mode**

**i**

- resolution
- accuracy
- geometry deformation
- geometry parameters

- prediction
- structure & connection
- interaction
- growth & development



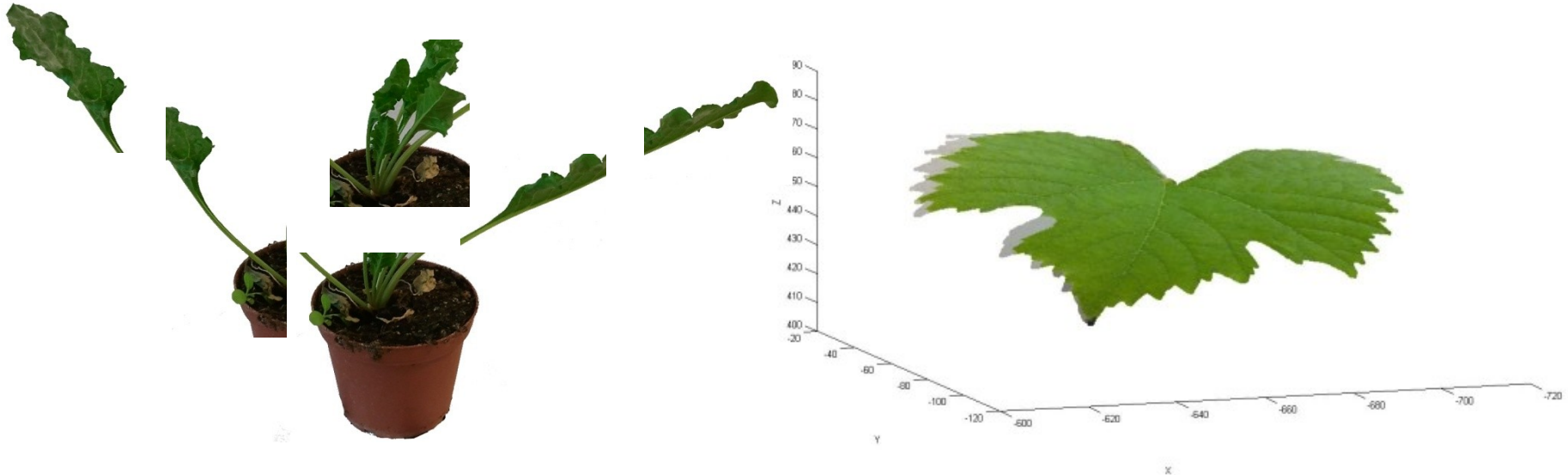
laserscan  
s

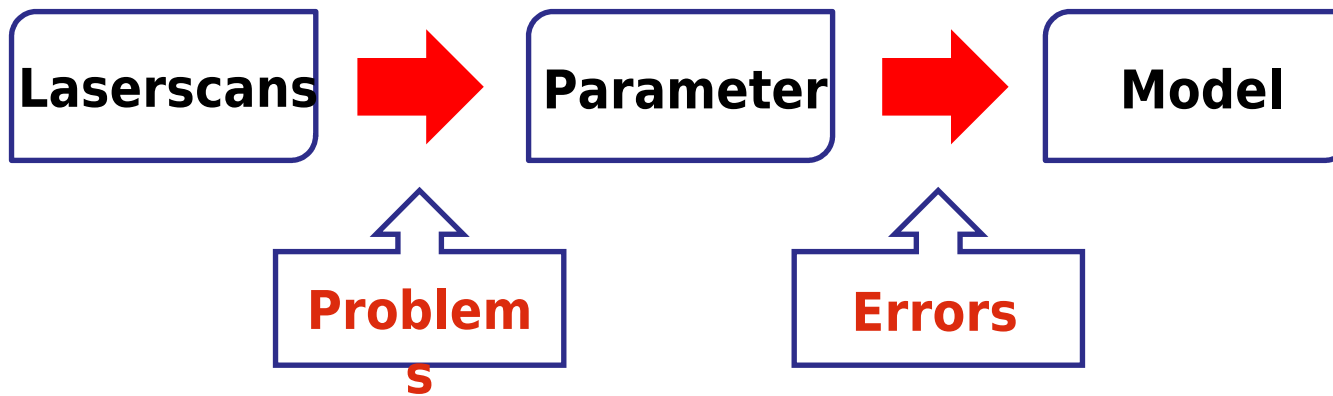
mode  
l

high resolution plant puzzle aligned by underlying grammar system

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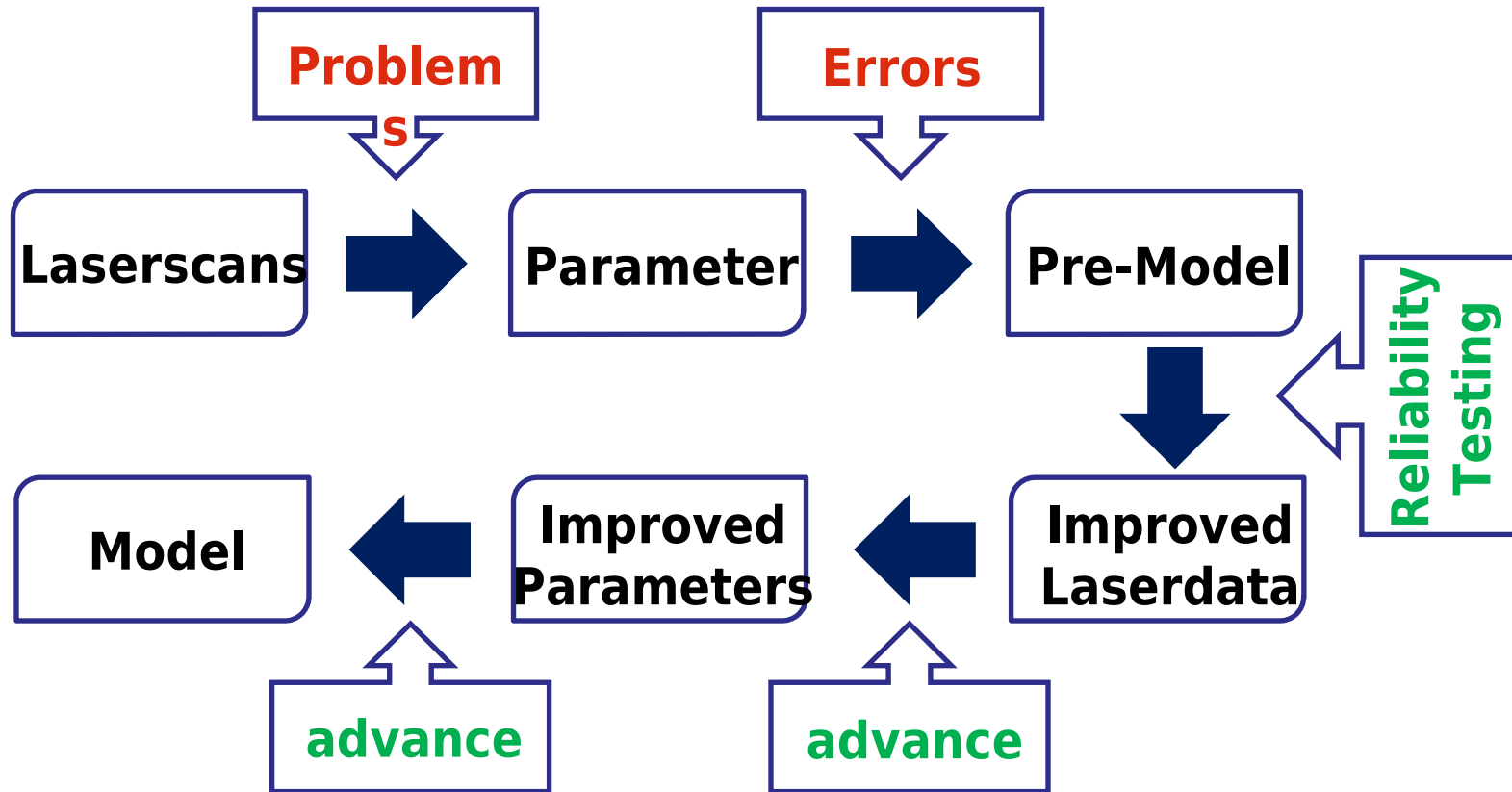
- local data can be aligned to the whole structure
- by this, motion can be eliminated resp. is less disturbing
- different sensors like RGB or hyperspectral camera can be fused in a more accurate way





- **Laser penetration**
- **Occlusions**
- **Accuracy**
- **Resolution**

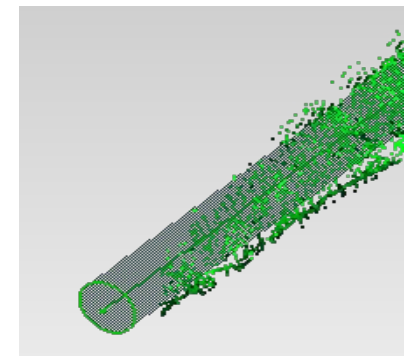
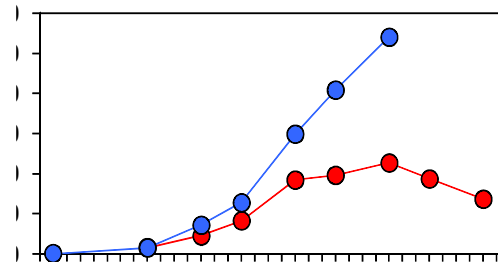
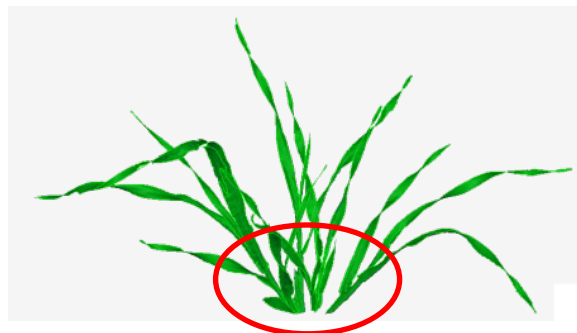
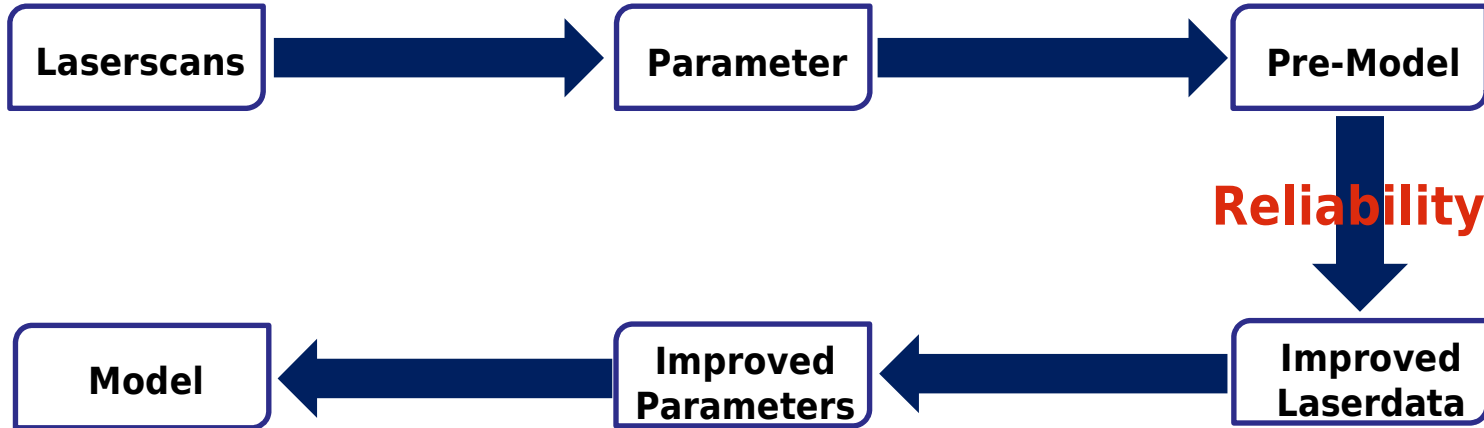
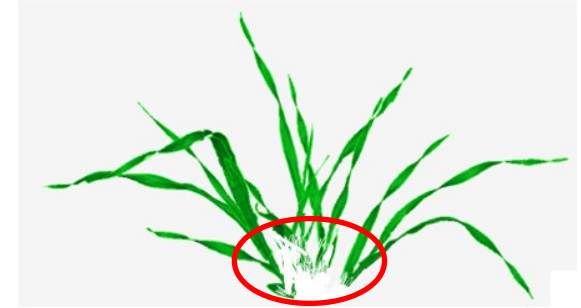
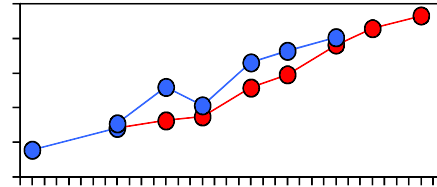
- **Errors**
- **Uncertainty**
- **no data**



- prediction
- sensor crossing
- less errors

- plant coordinate system
- less occlusion
- better data connection





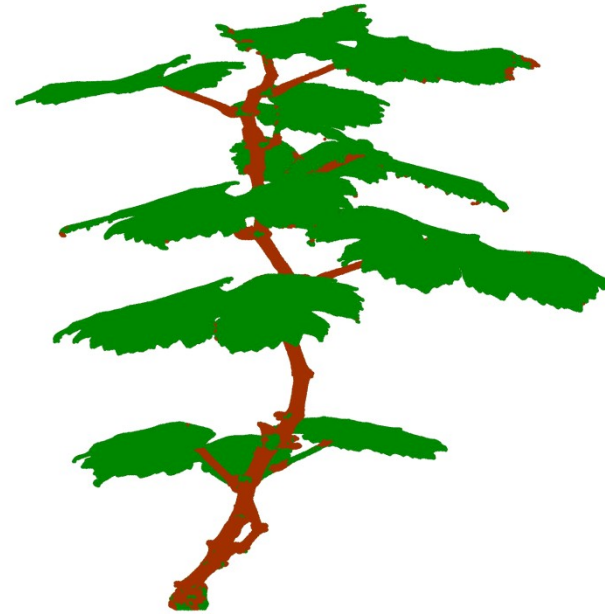
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- **better results for known techniques**
- **laserscanning under difficult circumstances**
- **parameter extraction under bad point cloud conditions**



- **better classification results for automated classification**



**leaf / stem classification by using SVM**



**Thanks for your attention.  
Feel free to ask!**



**Laserscanning im Pflanzenbereich bietet höchste Auflösungen bei gleichzeitiger nicht invasiver Messung. Aus den resultierenden Punktwolken lassen sich Parameter ableiten, aus denen der Zustand der Pflanze bzgl. bspw. Trockenstress hervorgeht. Probleme ergeben sich aus der Eigenbewegung der Pflanze, der Dimension der Deformation (Wachstum und äußere Einflüsse), sowie einer unzureichenden 3D Zuordnung, die Fusion verschiedener Sensoren und Teilscans sowie Vergleich zu unterschiedlichen Zeitpunkten erschweren. Pflanzenmodelle bieten hier Lösungen durch Pflanzen-bezogene Koordinatensysteme, die zeitlich und räumliche Zuordnungen ermöglichen.**

**Laserscanning of plants provides highly accurate spatial resolution information together with non-invasive measurements. The resulting point cloud can be used to extract parameters describing plant state changes in response to i.e. drought stress. Problems resulting from plant motion, dimension of deformation caused by growth and outer influences as well as from insufficient 3D correspondence of scan parts among each other, complicates fusion of different sensors and scan parts and also the comparison of data of different dates. Plant models are solutions to these problems by providing plant-applied coordinate systems that enable spatio-temporal registration.**