IC3D 2013

Assessment of plant leaf area measurement by using stereo-vision

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Problem :

Reference method :

Measurements were made on 8 plots dedicated to N application assessment in order to have different LAI references
- 2 N applications (0, 180 kg/ha)
- 4 plot repetitions
- 3 dates (8thApril, 6th May, 4th June)
- 5 stereo image couples per plots
- 1 destructive reference measures on 50 cm for each plot

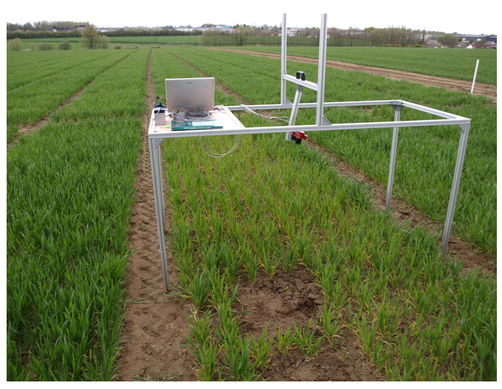
Leaf Area Index : the total one-sided area of the leaves per unit ground surface area
Average Leaf Angle : average angle between leaves and horizontal plane

The plants are harvested manually,the leaves are stripped and stuck on paper sheet, digitalized and the area are computed.

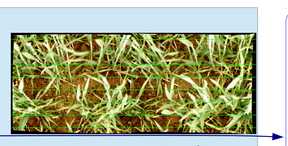
Several persons
Several days

Solution :

The proposed method :



Algorithm



- Histogram equalisation *
- Image rectification *
- Measurement of the disparities in pixels *
  - "modified H. Hirschmuller algorithm"
  - For each pixel of the left image, research in the right image the best match of a block centred on the pixel
  - Block size, MinDisparity, DisparityRange are parameters to be given to the software
- Post treatments *
  - Eliminate doubtful data and hidden pixels
  - Compute xyz in "human" coordinates *
    xyd [pixels] → xyz [m]
- Image segmentation (Leaves/Soil)
  - Linear discriminant analysis * on RGB
- Computation of the areas
  - Leaves
  - Total : based on the mean leave z plane
  - LAI = Leave Area / Total Area
  - ALA : mean of α

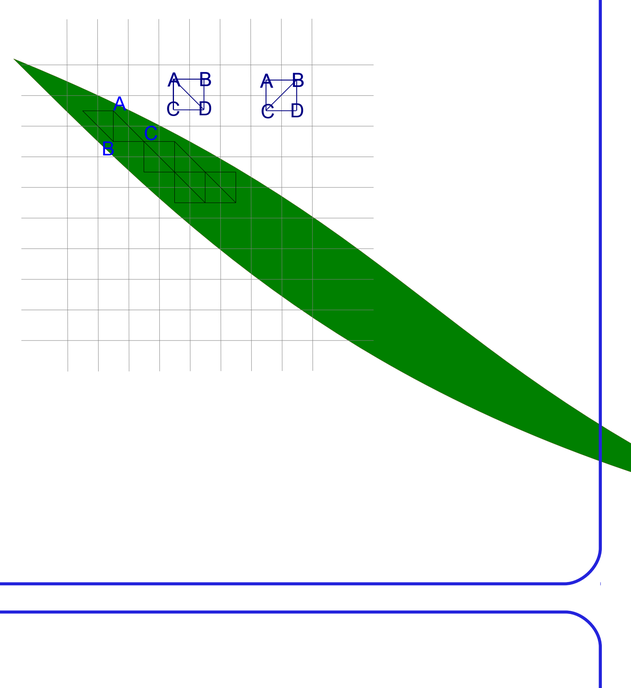
$$\sum_{triangles} |\overrightarrow{AB} \times \overrightarrow{AC}|/2$$

$$CP = \overrightarrow{AB} \times \overrightarrow{AC}$$

$$\alpha = acos\left(\frac{CP_z}{|CP|}\right)$$

Calibration * (indoor, check-board)

* : OpenCV Libraries



Results :

Quantification of the accuracy and the precision by using patterns in laboratory
- 5 patterns
- 5 distances
- 3 orientations

Correlation between estimated and true distance : r = 0.9997, slope= 1.0003

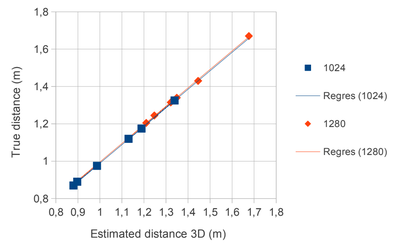
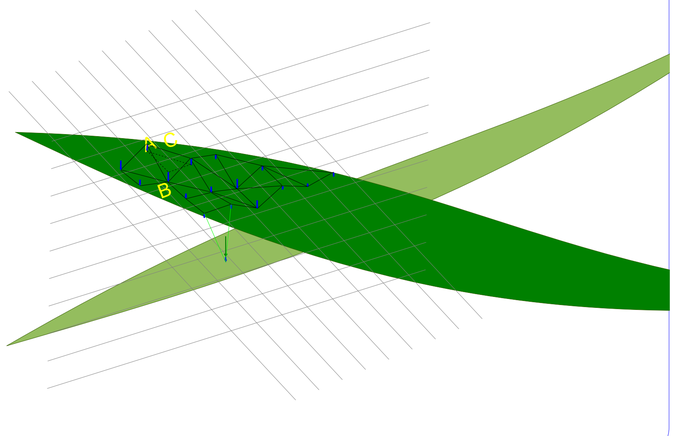


Image sizes	1024*768		1280*960	
	relative (%)	m²	relative (%)	m²
Accuracy	34	0.0053	49	0.0075
Precision	10.9	0.0017	15.8	0.0024

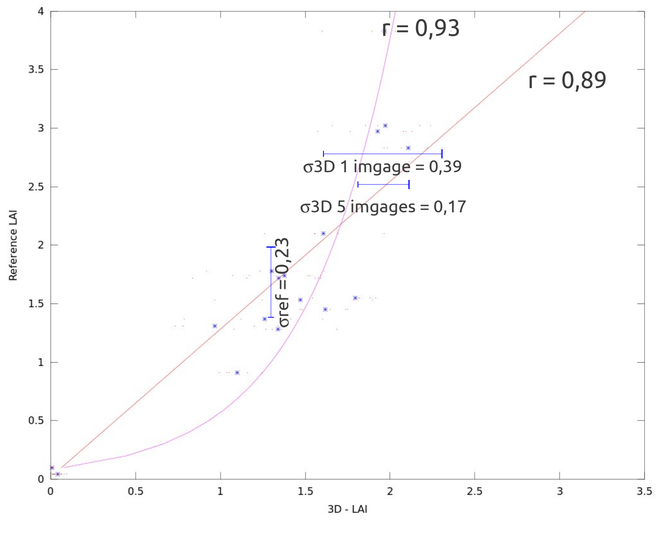
Repetitions on the same spot
- 5 repetitions
- standard deviation on LAI = 0.09 ($m_{LAI} \approx 1$)
- standard deviation on ALA = 0.02 rad ($m_{ALA} \approx 1.3$)

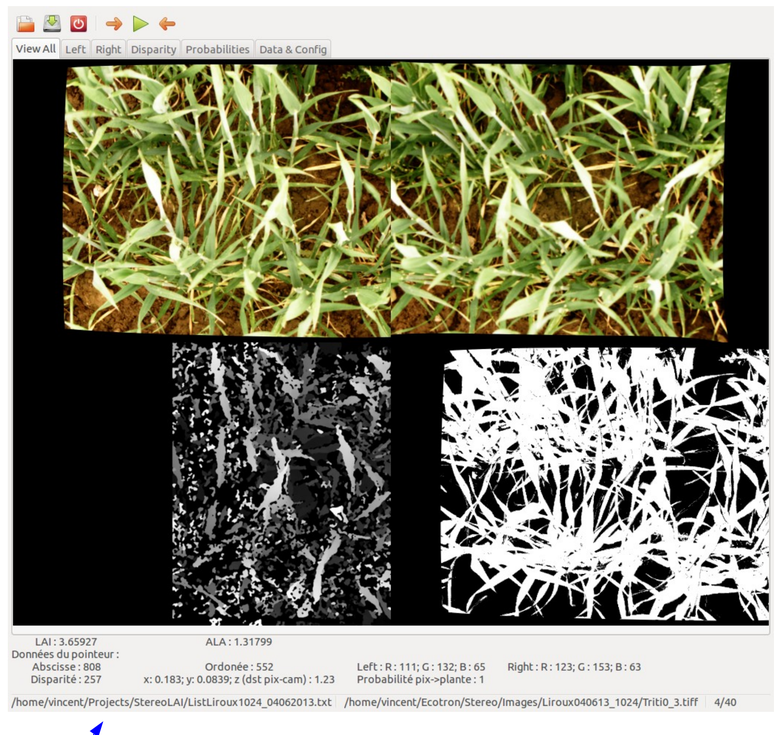
Possible sources of error
- Measurement noise in z
- Leaves criss-crossing
  Angle between normal to the leaf and optical axis has been limited : cos(α) >0.2

Error analysis
Standard deviation on z should be around
$3\ 10^{-4}$ m and $5\ 10^{-4}$ m
Necessity of a regression to estimate Ref LAI



Estimation of the reference LAI by stereo measurments





Two persons
A few hours