National Congress on Theoretical and Applied Mechanics - 2006

Agricultural tools guidance assistance by using machine vision

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Why to assist agricultural tools guidance?

- The classical method for sugarbeet and chicory :

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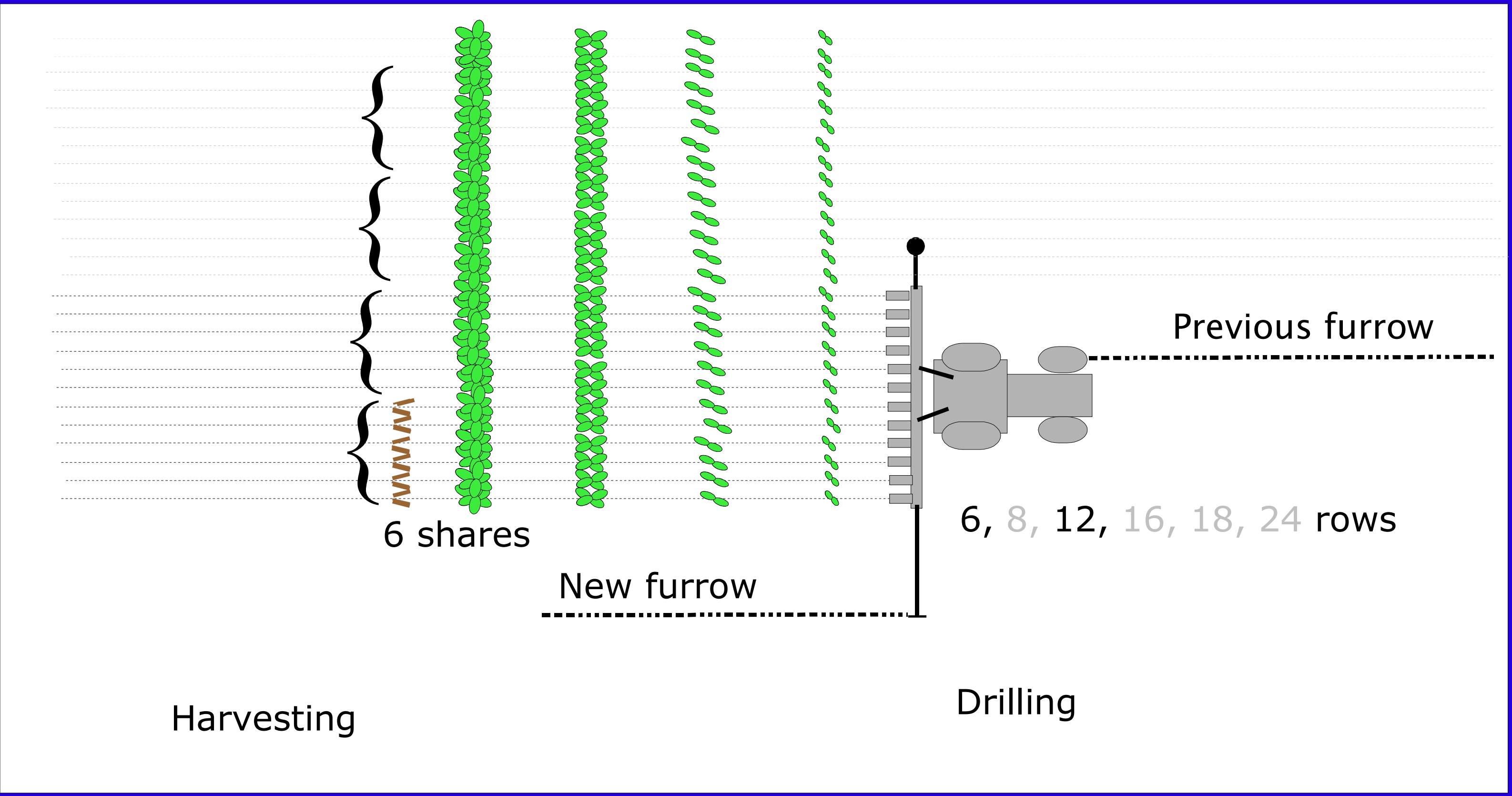

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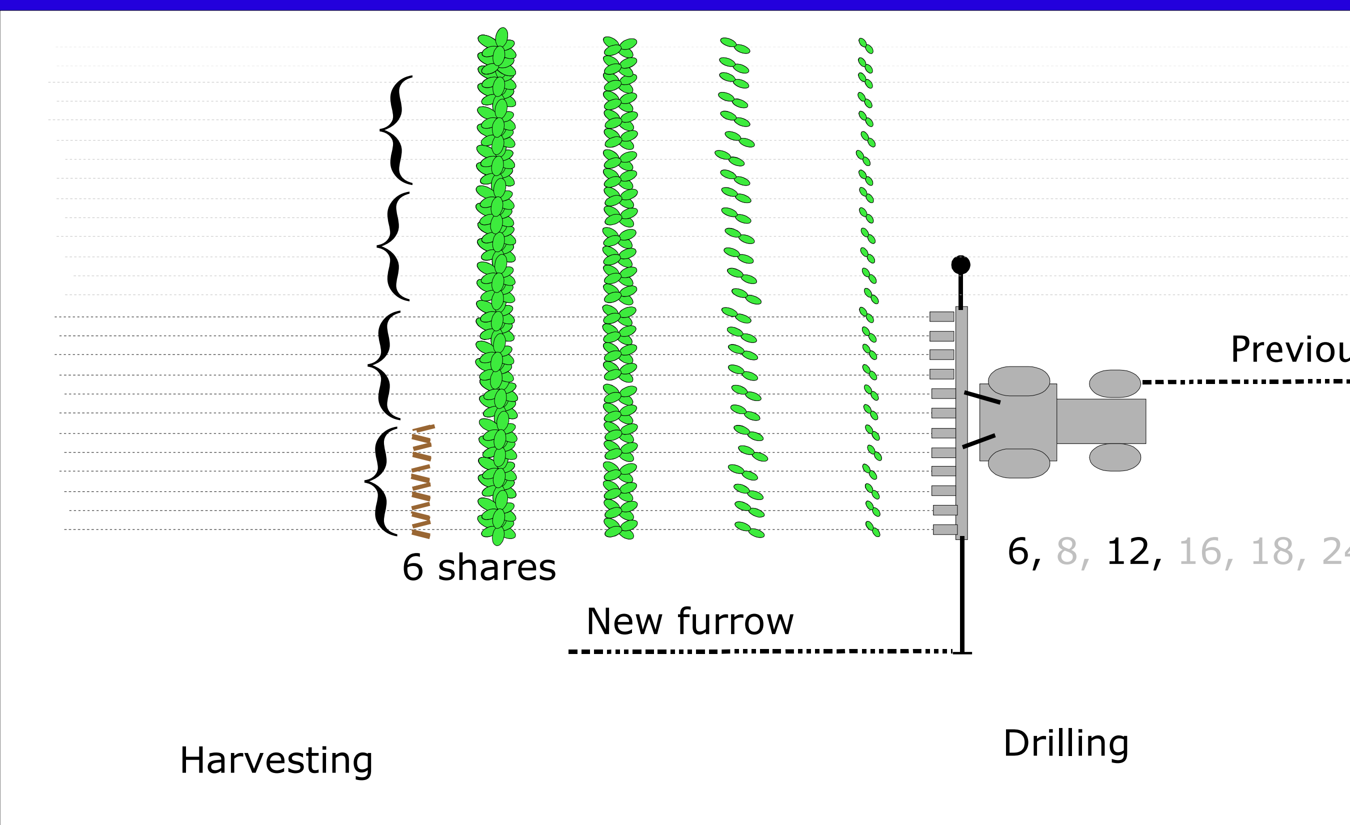
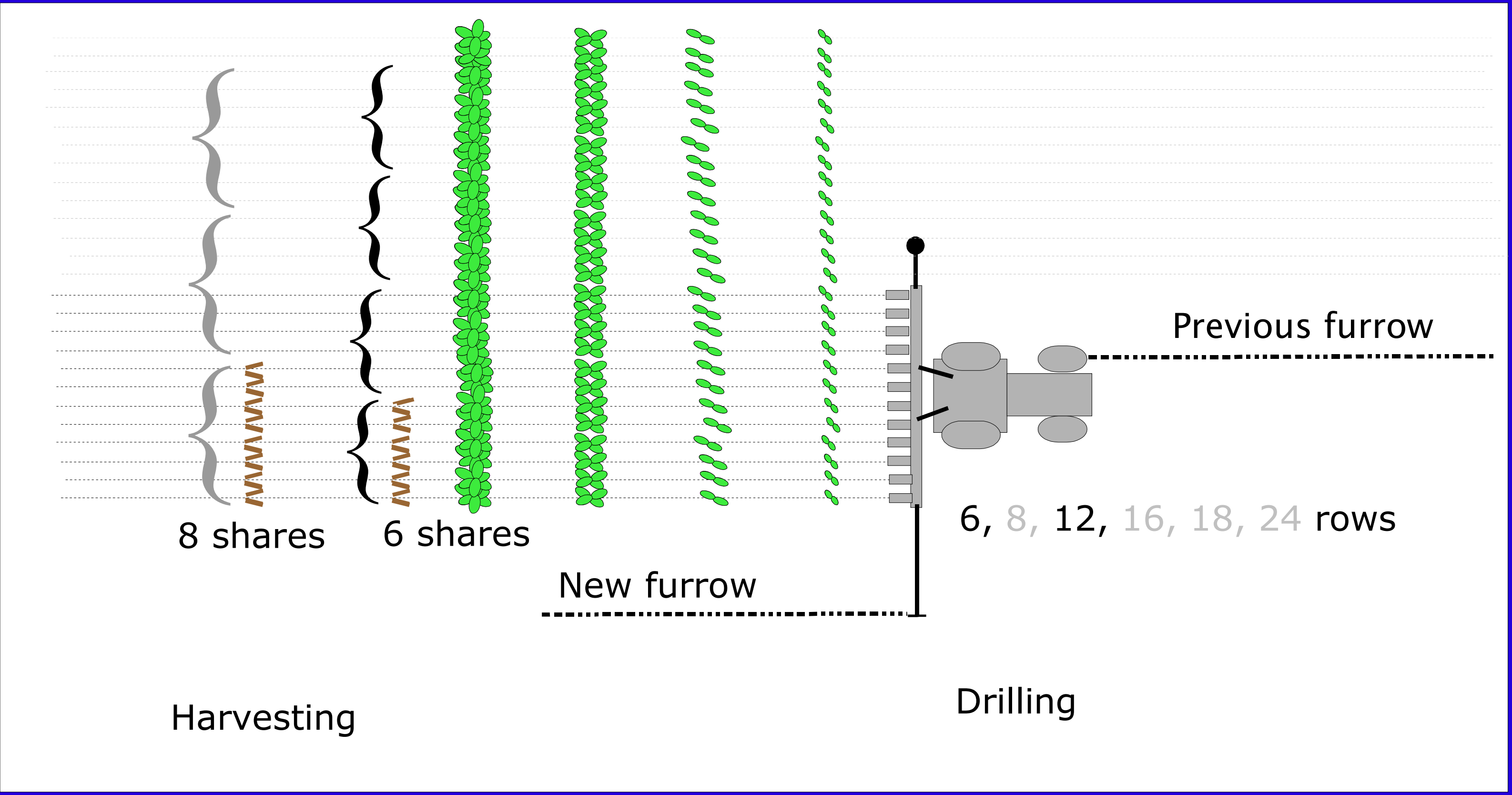
Why to assist agricultural tools guidance?

- The classical method for sugarbeet and chicory :



Why to assist agricultural tools guidance?

- A recent methods for sugarbeet and chicory :



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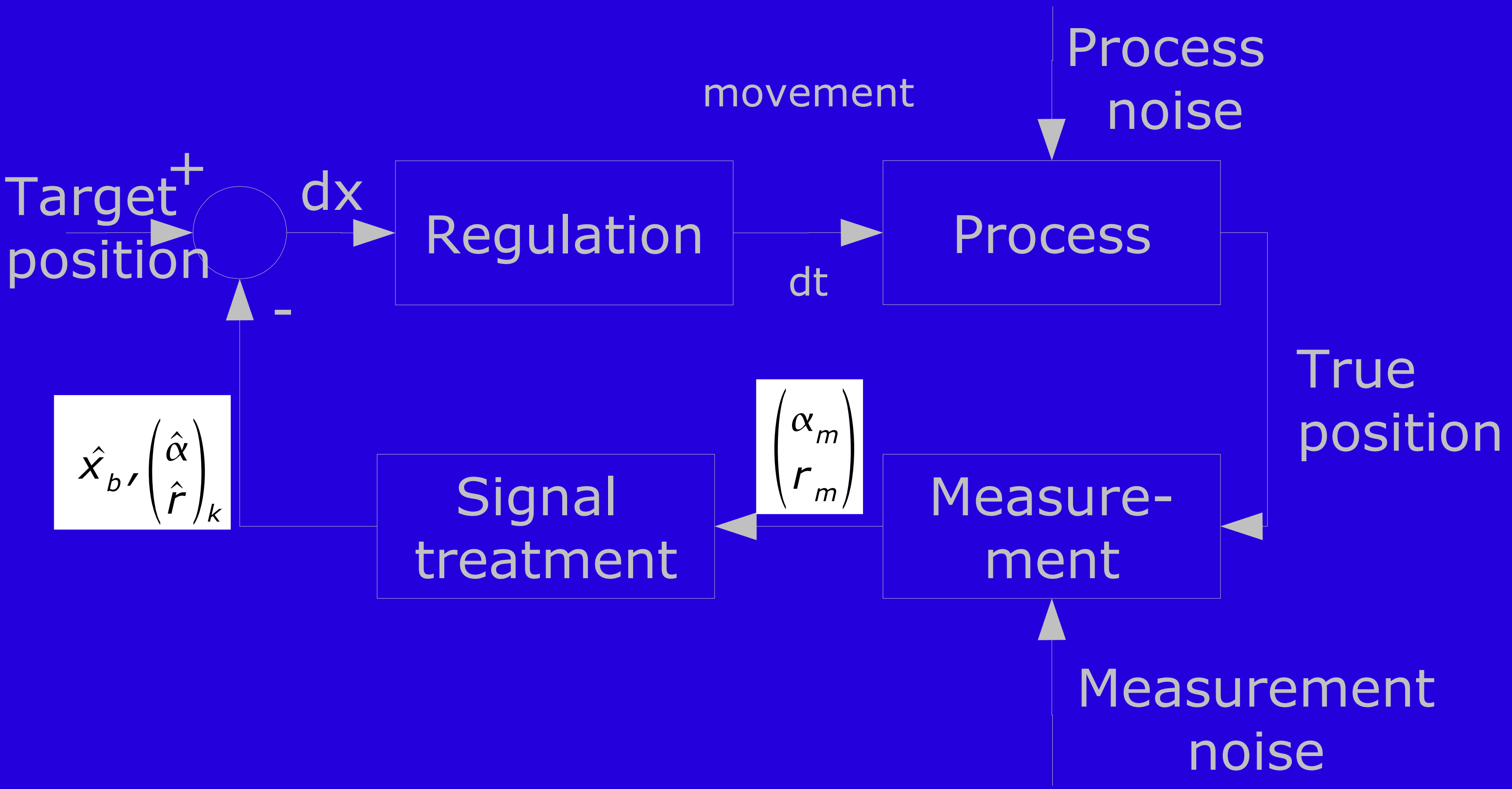
Why to assist agricultural tools guidance?

- New methods for sugarbeet and chicory :
  - 8 row width instead of 6
- Requirements :
  - Precision during drilling
  - Guidance of the harvesting shares

The general regulation



The devices

- The seed drill

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The devices

- The harvesting shares

The measurement

- Image acquisition and treatment
  - Sowing :
    - straight lines
      ⇢Hough transform
    - important noise
    - shadows
    - lures
      ⇢adapted image treatment
      ⇢adapted Hough transform

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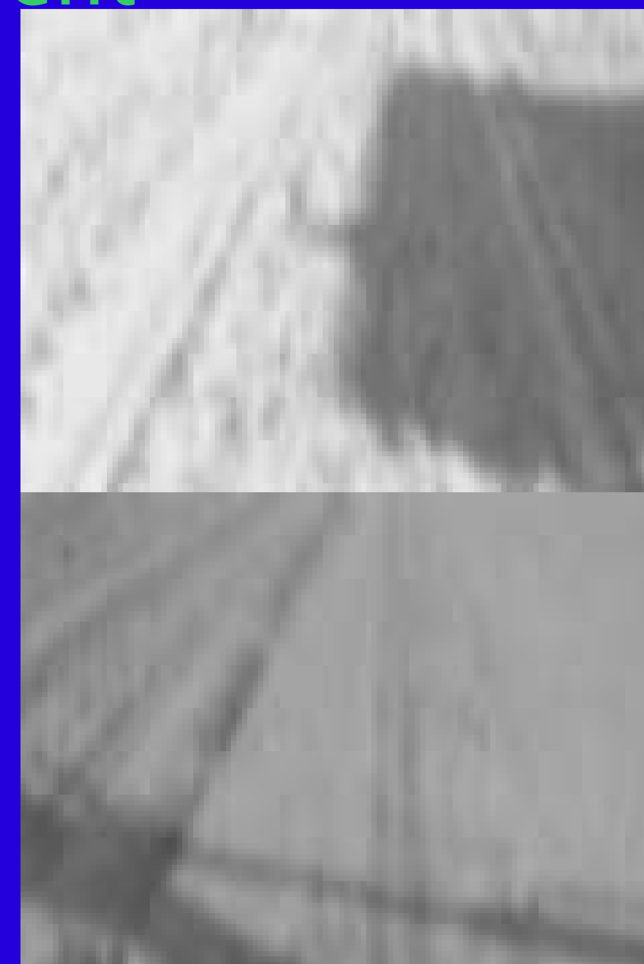
The measurement

- Image acquisition and treatment
  - Extraction of the green channel
  - resizing
  - Gaussian filtering

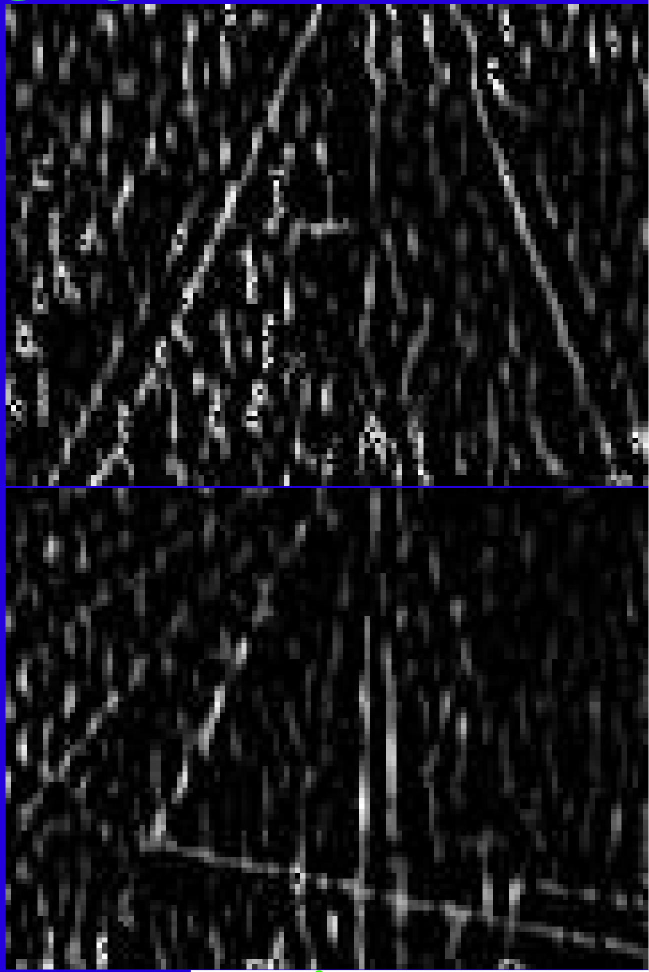


The measurement

- Image acquisition and treatment
  - resizing
    ⇢ background

The measurement

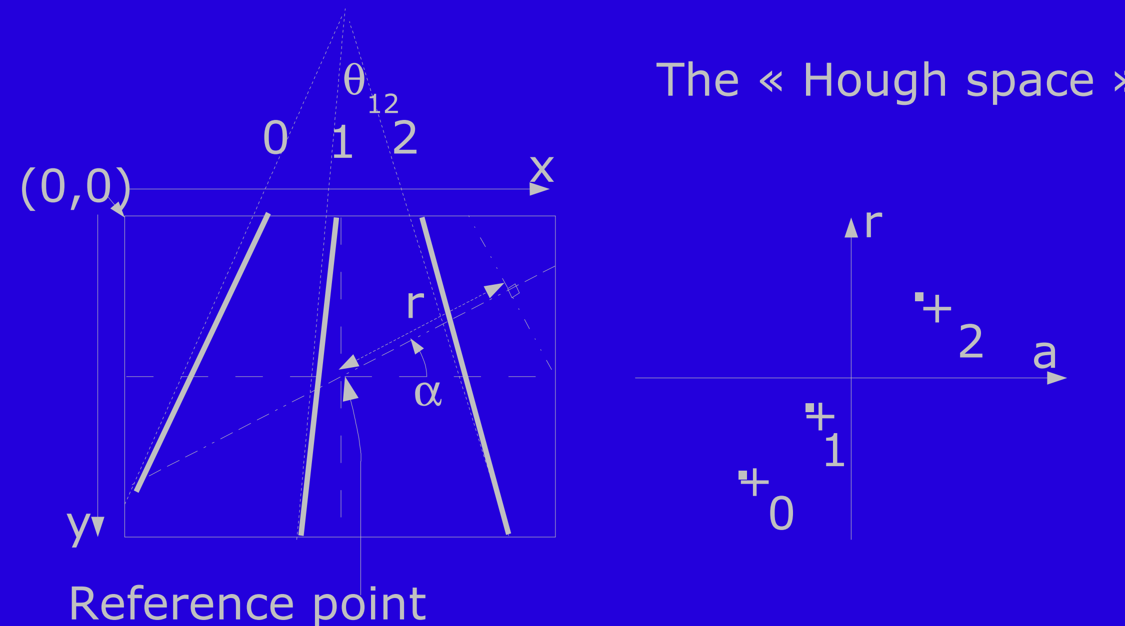
- Image acquisition and treatment
  - background subtraction
    - noise ±
    - shadows √
    - lures x



The measurement

- Image analysis

Classical Hough transform

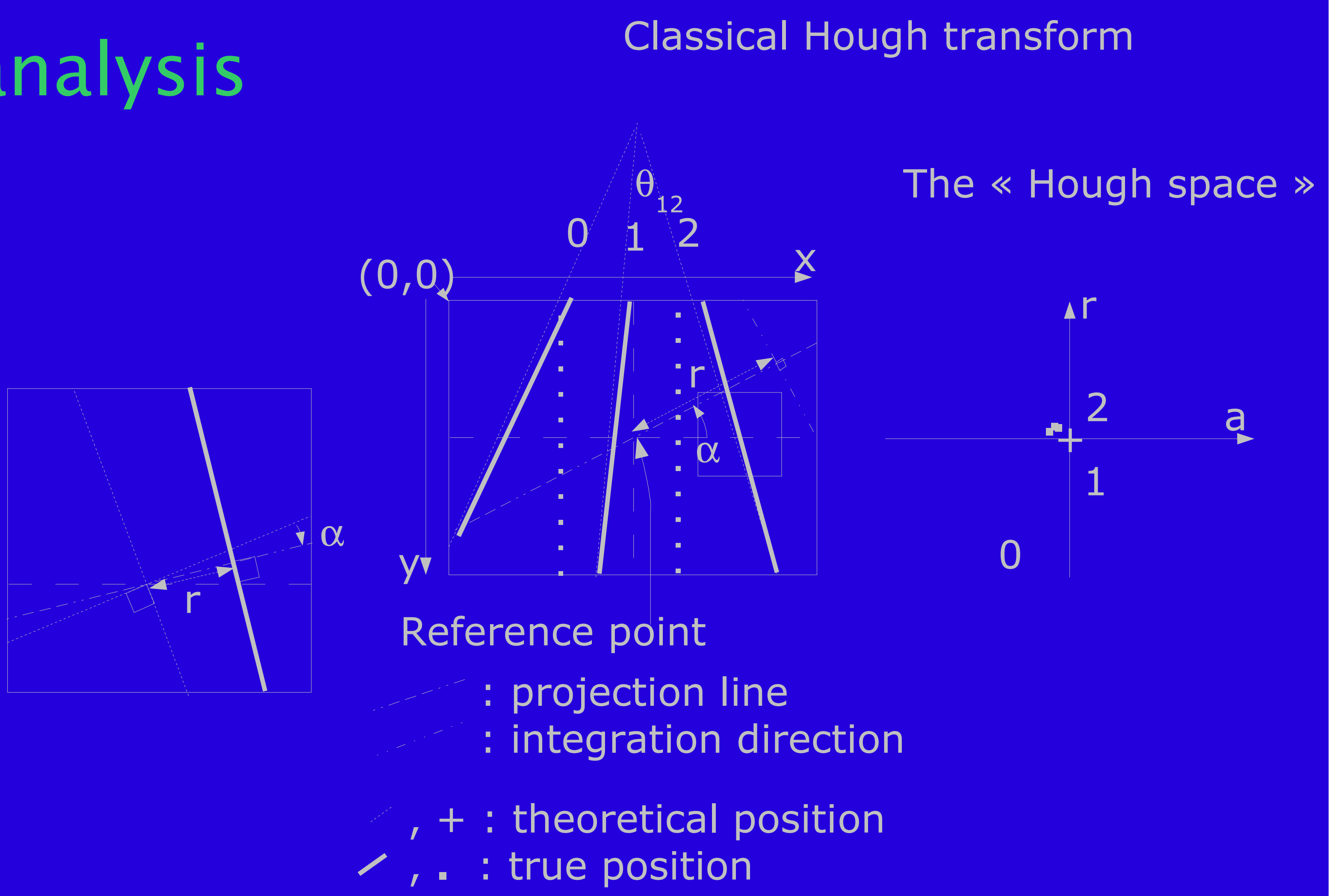


: projection line
: integration direction

, + : theoretical position
, . : true position

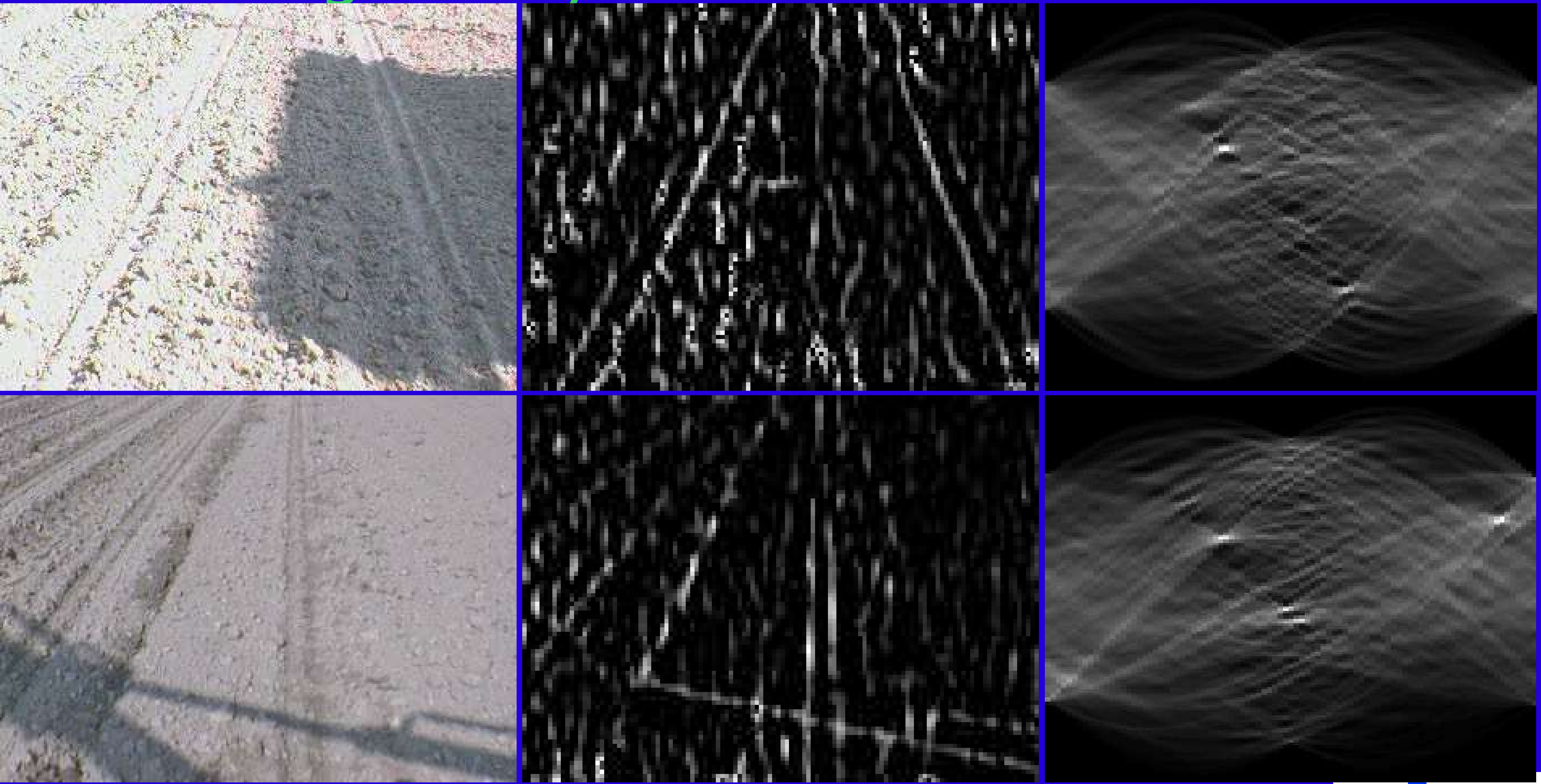
The measurement

- Image analysis



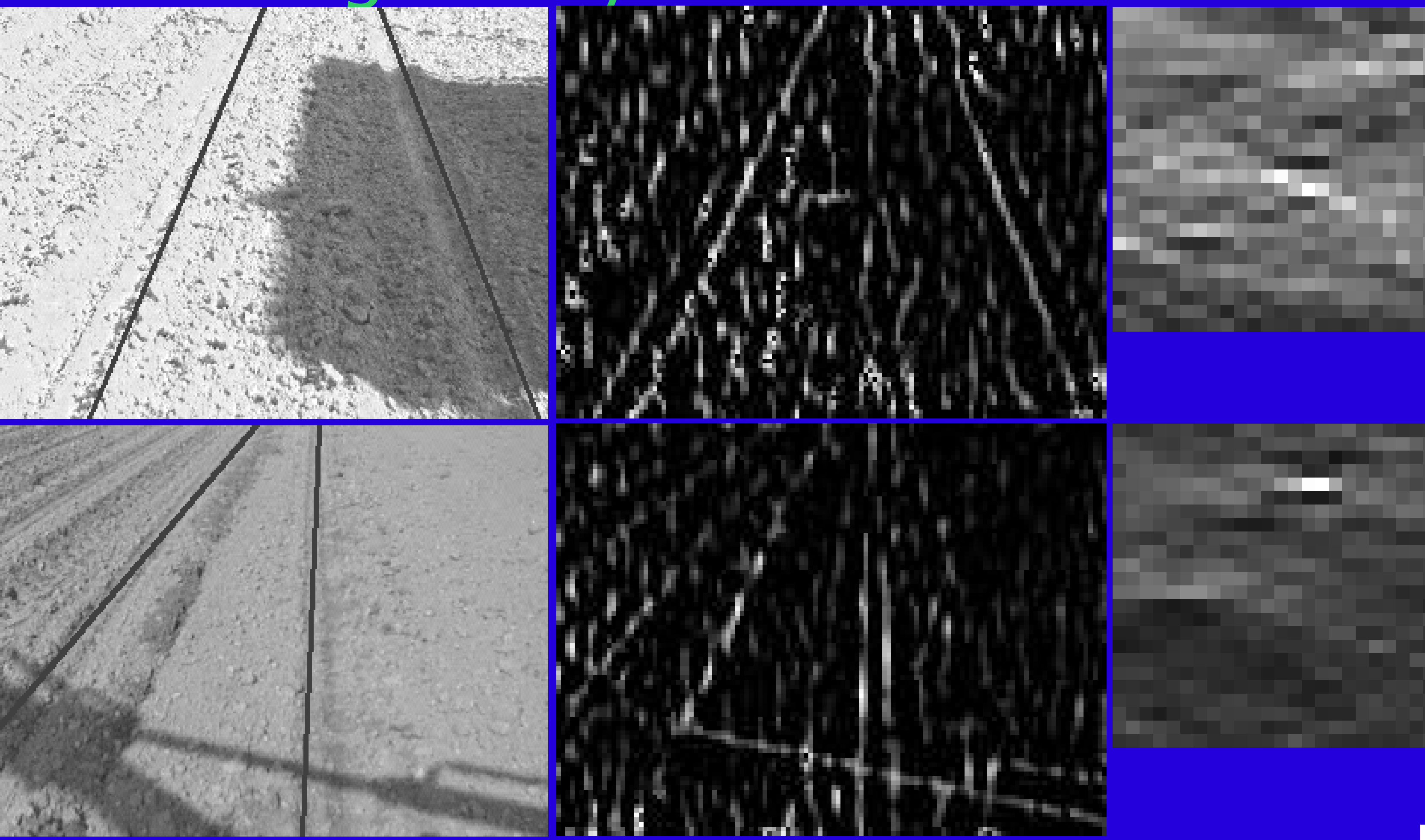
The measurement

- Image analysis



The measurement

- Image analysis



$\rightarrow \alpha, r$

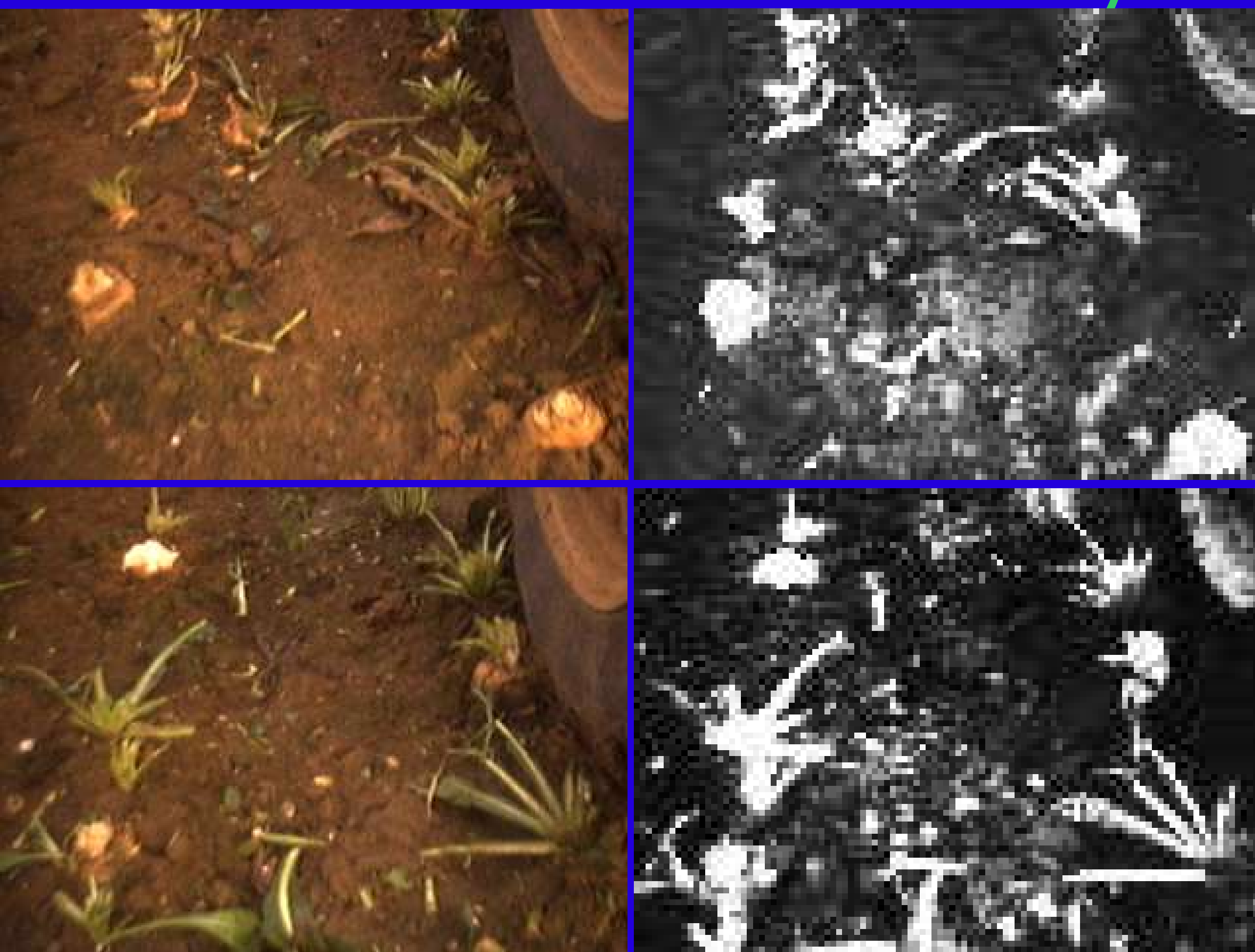
The measurement

- The harvest of chicory

  - wide variety of colours in the “objects” (roots, petioles, flesh) and in the background (soil of different humidity, tire, wheel, rests of leaves, weeds, ...) → classification of the pixels using a neural network
  - use of the adapted Hough transform

The measurement

- The harvest of chicory



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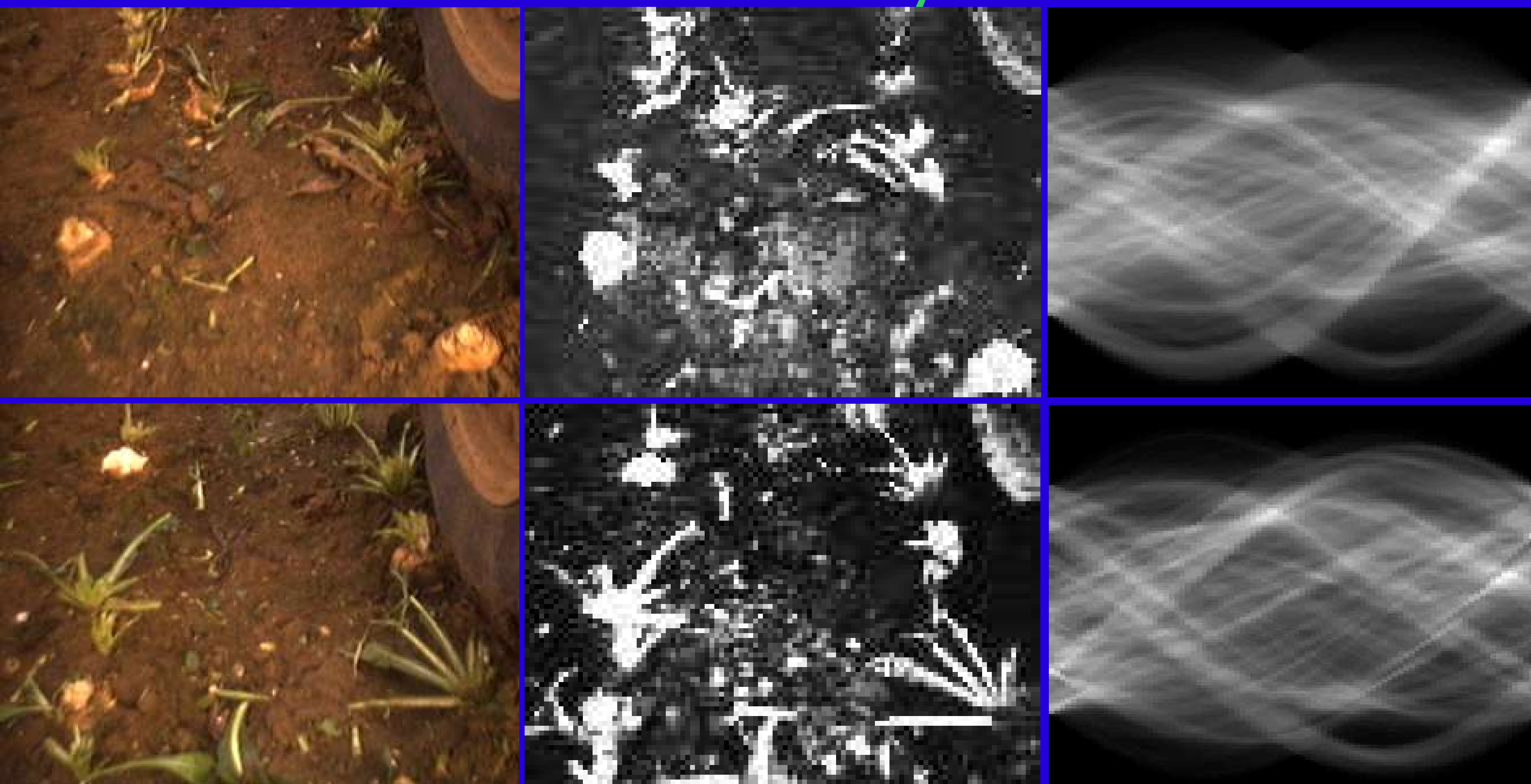
The measurement

- The harvest of chicory



The measurement

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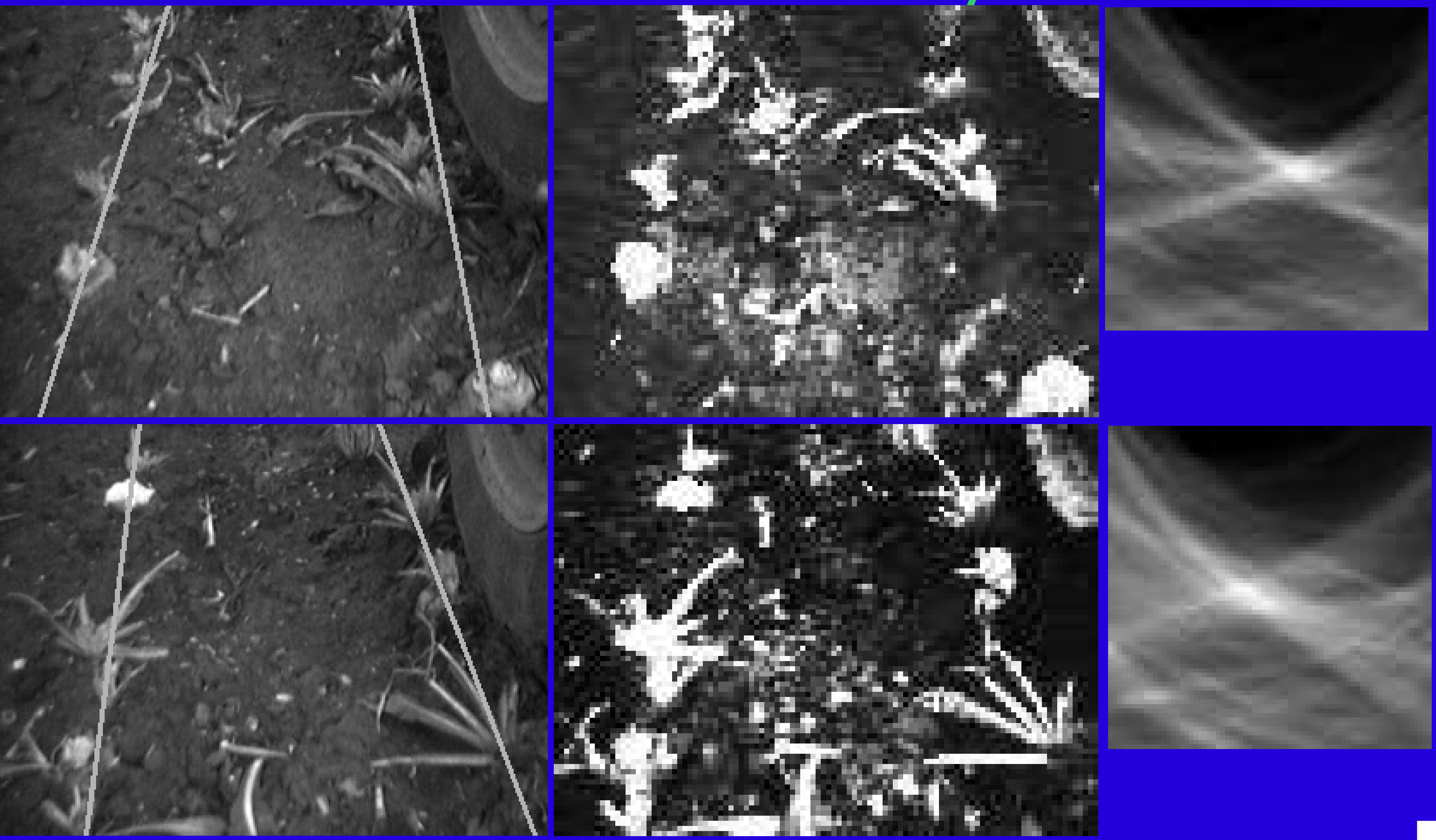
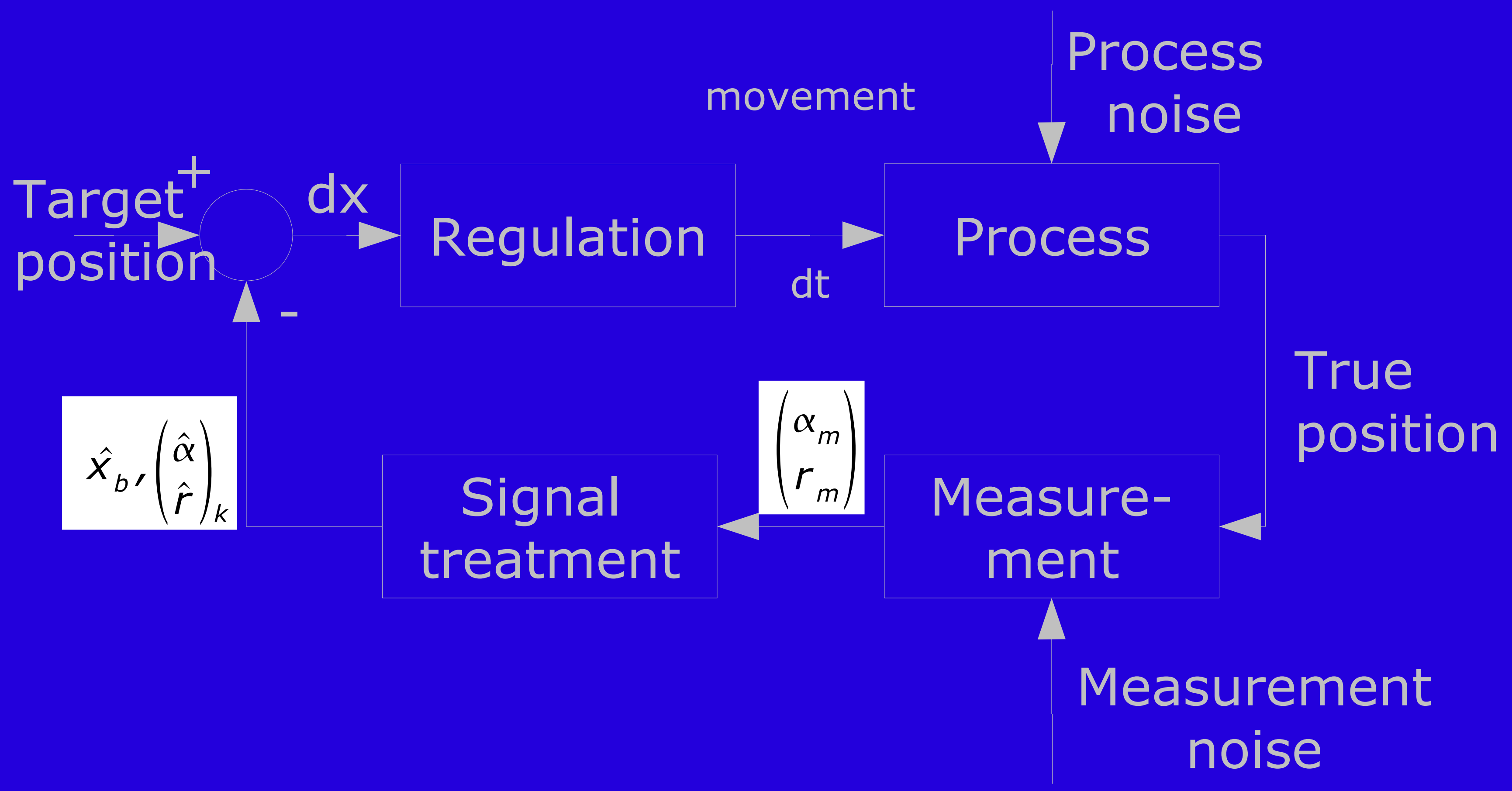


The signal treatment



The signal treatment

- a and r were used as independent state variables :

$$\begin{pmatrix}\alpha_e \\ r_e\end{pmatrix}_k = \begin{pmatrix}a_\alpha & 0 \\ 0 & a_r\end{pmatrix}\begin{pmatrix}\alpha_m \\ r_m\end{pmatrix}_k + \begin{pmatrix}1-a_\alpha & 0 \\ 0 & 1-a_r\end{pmatrix}\begin{pmatrix}\alpha_e \\ r_e\end{pmatrix}_{k-1} + \begin{pmatrix}0 \\ dr_r\end{pmatrix}_{k-1}$$

The noise was not white nor Gaussian

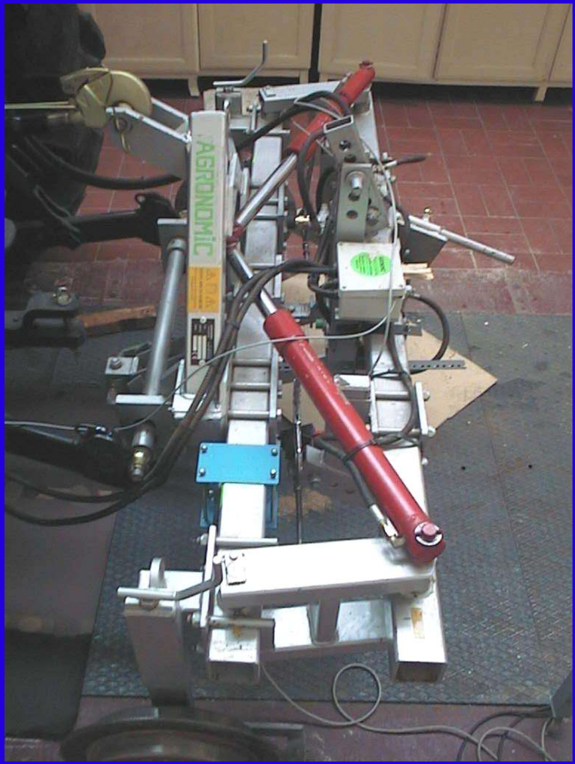
$$a_\alpha = c_\alpha \exp\left(\frac{-[(\alpha_e)_{k-1} - \alpha_m]^2}{s_\alpha{}^2}\right)$$

$$a_r = c_r \exp\left(\frac{-[(r_e + dr_r)_{k-1} - r_m]^2}{s_r{}^2}\right)$$

The regulation and the process

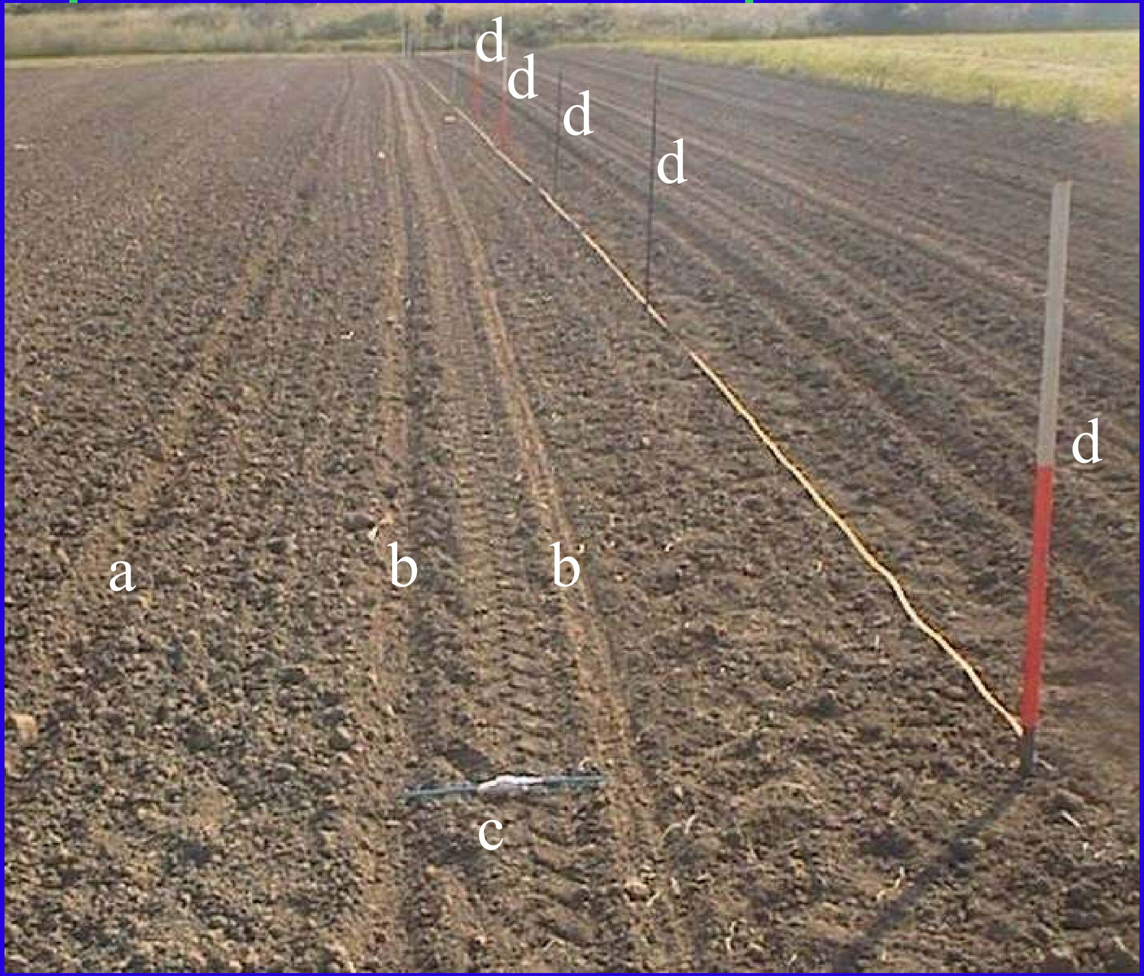
- v=p t +q ⇒ $\begin{matrix} dt_r' \\ dt_r'' \end{matrix} = \dfrac{-q \pm \sqrt{(q^2 + 4\ p\,dx)}}{2\ p}$

- The electro-hydraulic mechanism transform dt into dx



The field tests

- The experimental set up :



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The field tests

- Seed drill guidance :
  - 3 tests with “straight driving style”
    - 2 with sunny conditions
    - 1 with cloudy conditions
  - 2 tests with “sinusoidal driving style”
    - both with sunny conditions
- During harvest :
  - 1 “straight” test, 1 sinusoidal test, both in cloudy conditions

Results

- Sowing

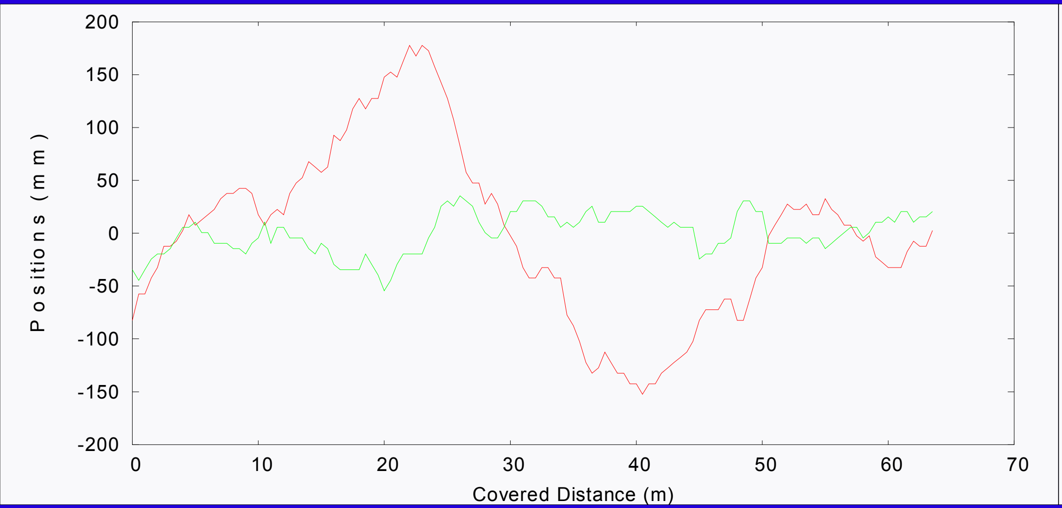
test	s_T	A_T	m_D	s_D	A_D
1, straight, sunny	75,1	295	459	19,4	91
2, sinusoidal, sunny	102	340	448	29	115
3, straight, sunny	81	245	523	13	60
4, sinusoidal, sunny	55	301	516	35	140
5, straight, cloudy	54	180	390	17	95

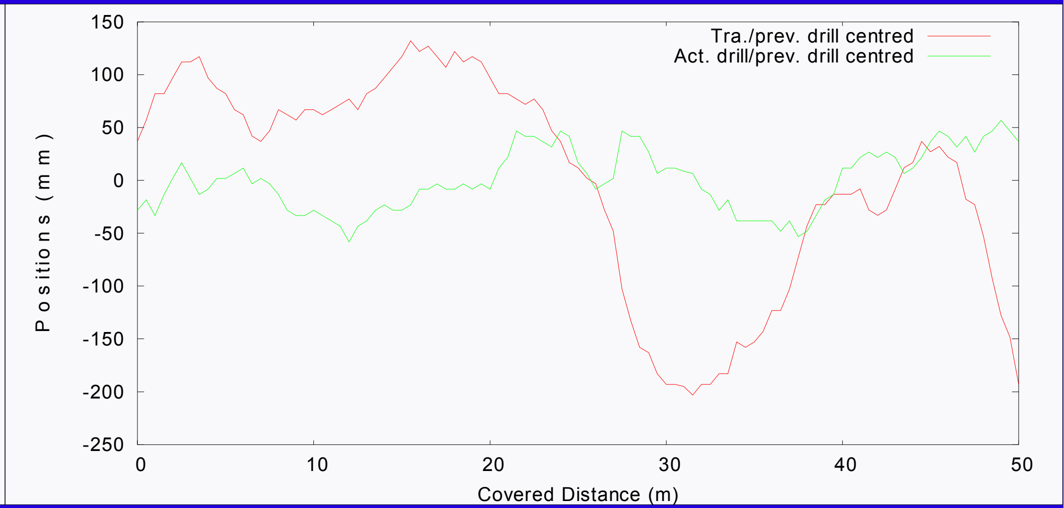
- Harvesting

test	s_T	A_T	s_D	A_D
1, straight, cloudy	19	65	17	55
2, sinusoidal, cloudy	67	260	44	175

Results

- Field measurements





Straight

$s_T = 75, A_T = 295$

$s_D = 19, A_D = 91$

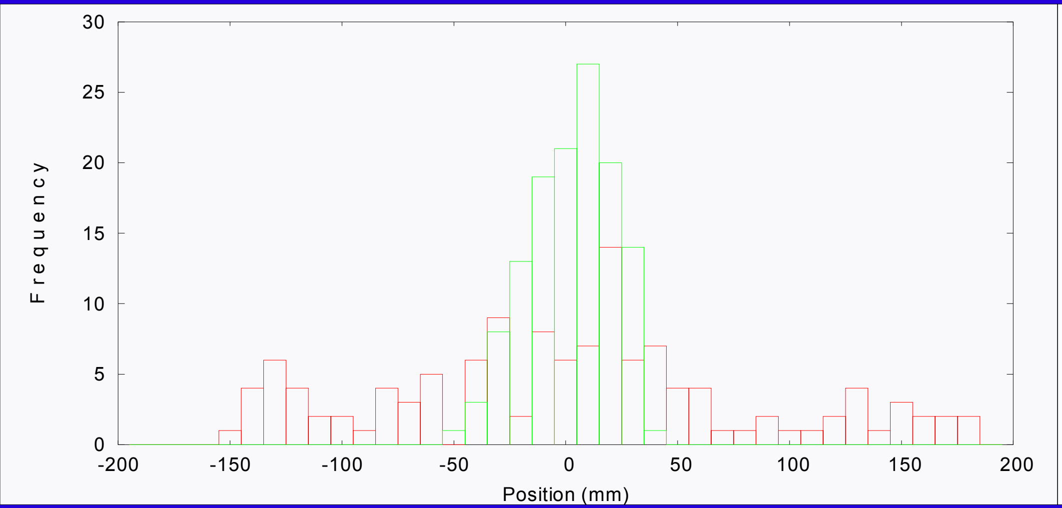
Sinusoidal

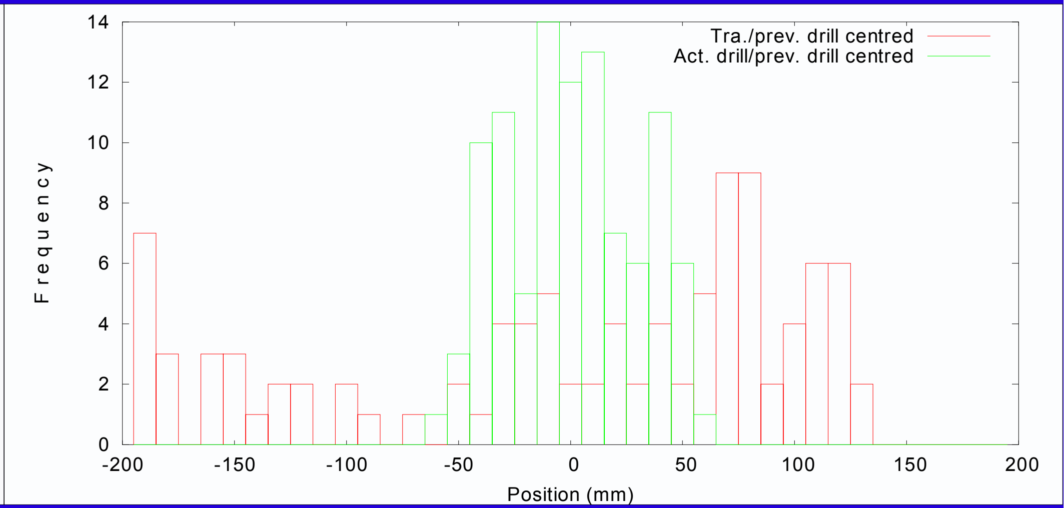
$s_T = 102, A_T = 340$

$s_D = 29, A_D = 115$

Results

- Histograms





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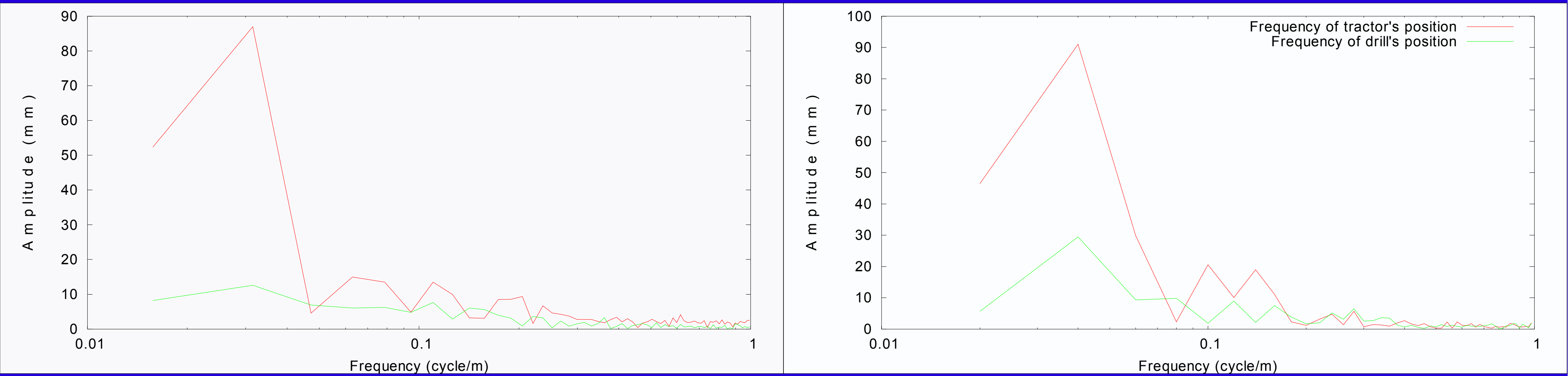
Results

- Frequencies



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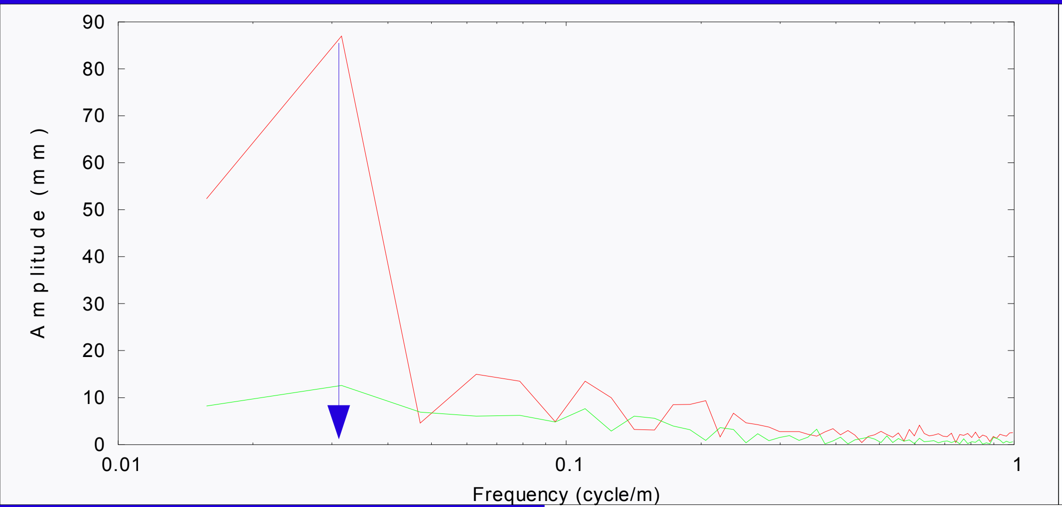
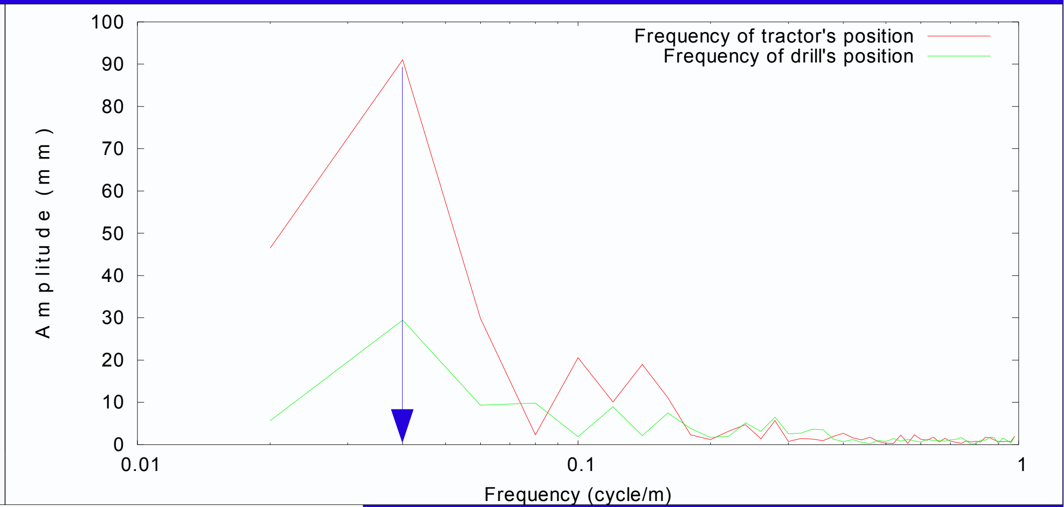
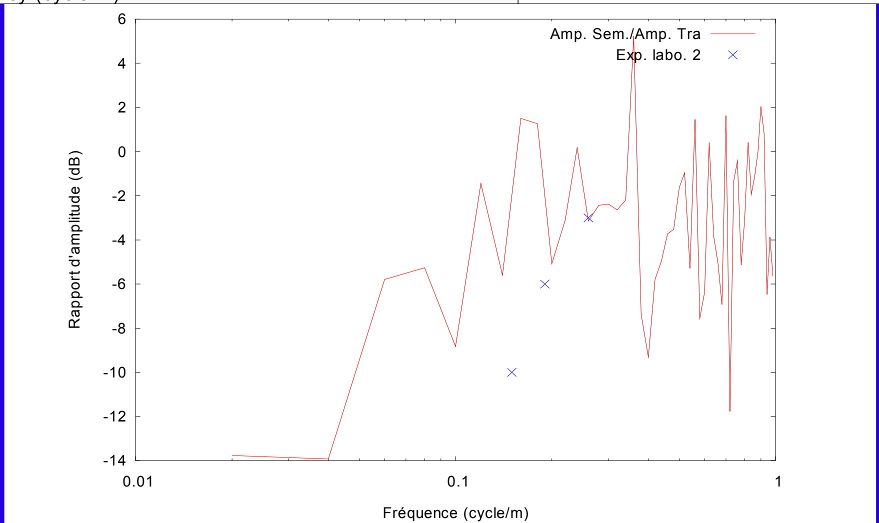
Results

- Frequencies







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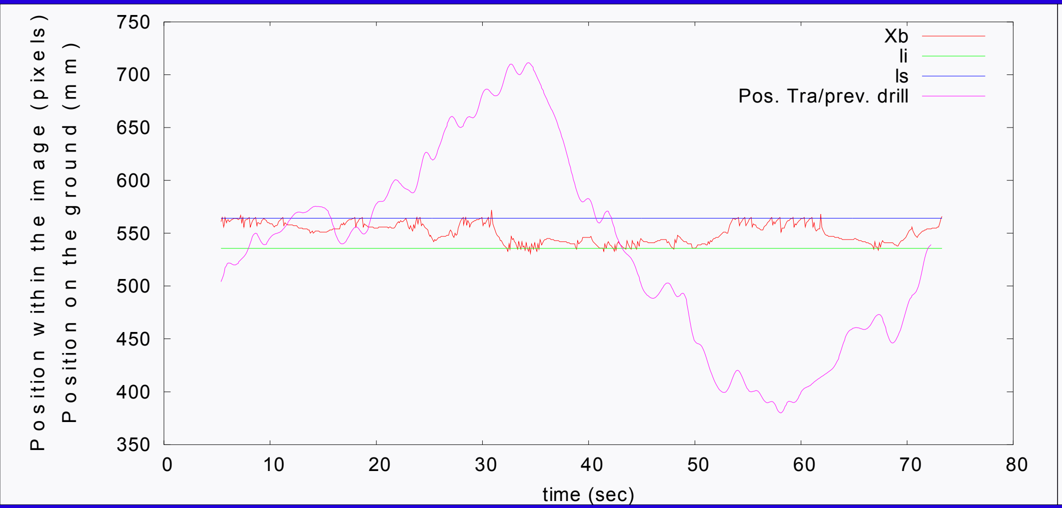
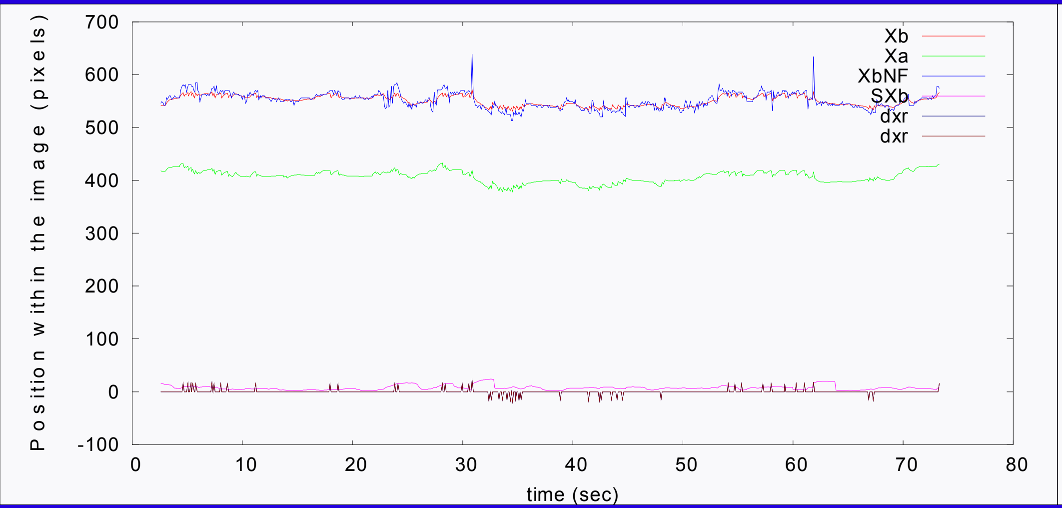
Results

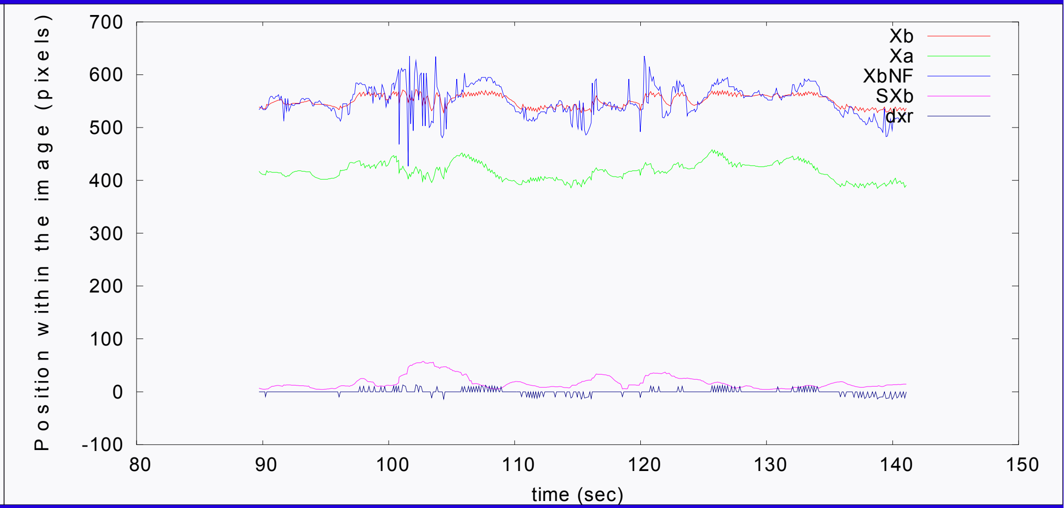
- Computer data & field measures



Results

- Computer data : filtered vs non filtered data





Conclusion

- Trueness (< 30 mm) depends on
  - the mounting of the camera
  - trace aspect
- Precision
  - 23 mm for seed-drill
  - 31 mm for harvesting
- Spatial cutting frequency : 0.14 m^{-1}

Conclusion

- Accurate mounting of the camera is require for