Steering of a seeding process with a multi-sensor system

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FIG WORKING WEEK 2012
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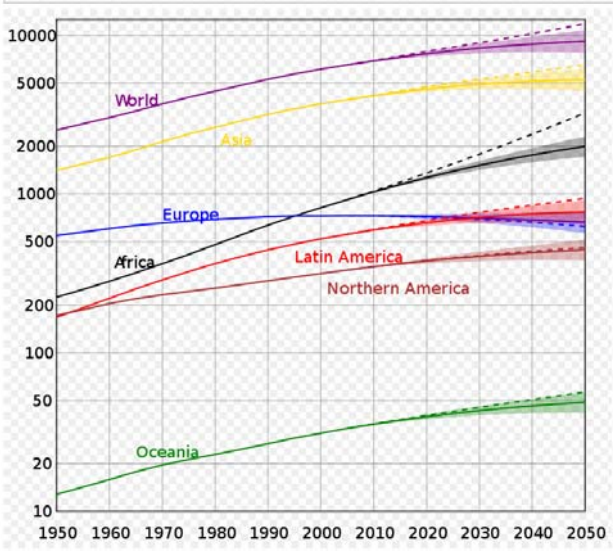
importance of agriculture

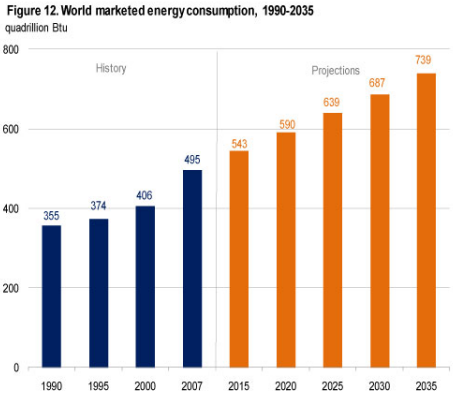
world population

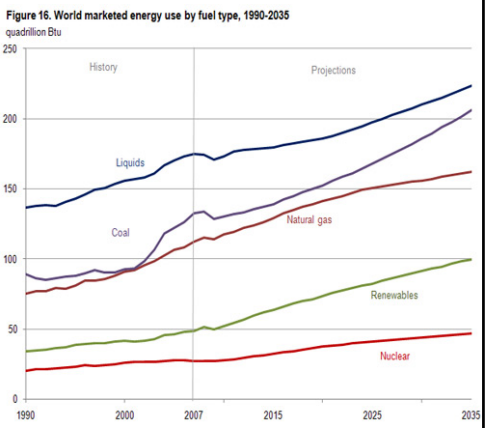


www.wikipedia.org from UNO

importance of agriculture

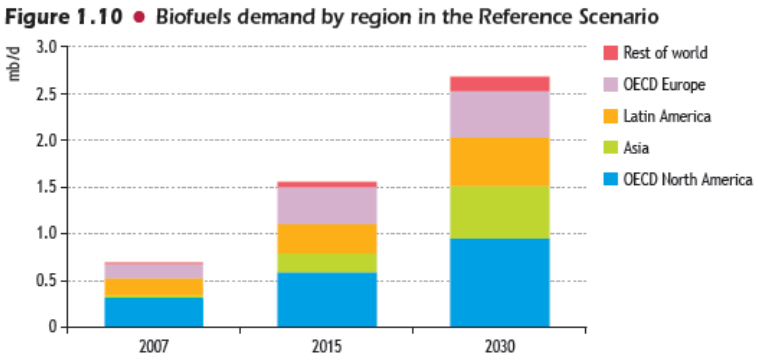
Energy consumption





Source: US energy information administration, july 2010

importance of agriculture



Source: International Energy Agency, 2009

Changed dietary habits

Table 5.2-2
Consumption of meat, milk and milk products in various world regions.
[1]Without butter; [2]Mean for the 3-year span
Source: FAO, 2006b

	Meat [kg/person/year]			
	1969/1971[2]	**1999/2001[2]**	**2030**	**2050**
Developing countries	*10.7*	*26.7*	*38*	*44*
Sub-Saharan Africa	10.2	9.5	14	18
North Africa/Middle East	12.6	21.7	35	43
Latin America	33.5	58.5	79	90
South Asia	3.9	5.5	12	18
East & South-East Asia	9.2	39.8	62	73
Transition countries	*49.5*	*44.4*	*59*	*68*
Industrialized countries	*69.7*	*90.2*	*99*	*103*
World	**26.1**	**37.4**	**47**	**52**

+ 30%

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Changed dietary habits

Land requirement

animal/plant 7

Table 5.2-5
Land requirement of foods in relation to the energy content of the consumable product (based on yields in the USA, case study of New York state).
Source: Peters et al., 2007

	Land requirement [m²/1.000 kcal]
Animal-based foods	
Beef	31.2
Poultry	9.0
Pork	7.3
Eggs	6.0
Full-cream milk	5.0
Plant-based foods	
Oil fruits	3.2
Fruit	2.3
Pulses	2.2
Vegetables	1.7
Cereals	1.1

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Food crisis

Change in price June to December 2010

	[%]
Wheat	75
Sorghum	88
Beans	48
Rice	17
maize	73

the world bank, food price watch 2011

	Total population (millions)	Poverty rate change (millions)
Low-income countries	828	9,5
Midle-income countries	4.758	34,1
total	5.586	43,7

Poverty line: 1,25$ per person per day

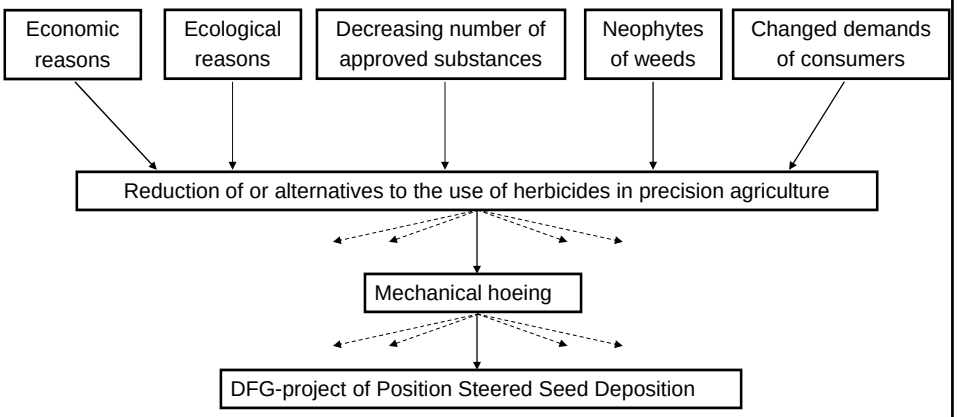
conclusion

- **Increasing world population**
- **Increasing energy consumption**
- **Increasing biofuel**
- **Change in dietary habits**
- **Decreasing arable land (desertification, …)**

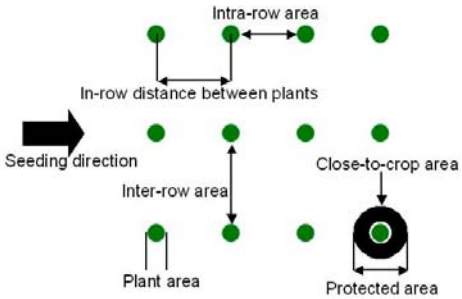
Increase of efficiency necessary

Sugar beet

weed control sugar beet



mechanical hoe



Areas in a row crop field


Conventional hoe [Hatzenbichler]

No problem: Inter-row area (~ 80% of the area)

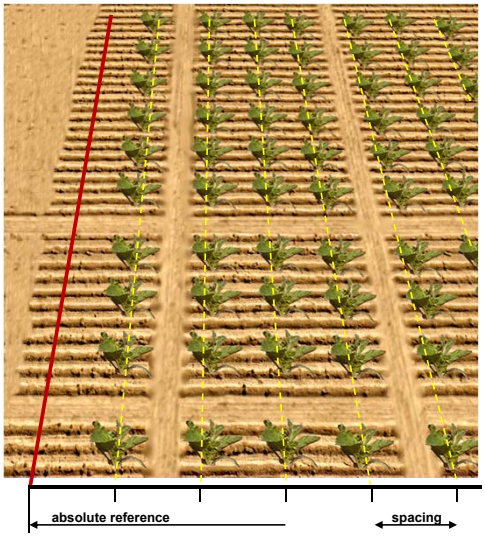
PROBLEM: Intra-row area

objective

controlled seed deposition

- **longitudinal and lateral rows**
- **knowledge of each crop plant position**
- **seed map**

- **automated phenotyping techniques**
- **autonomous robotic weed control**
- **intra-row weeding**

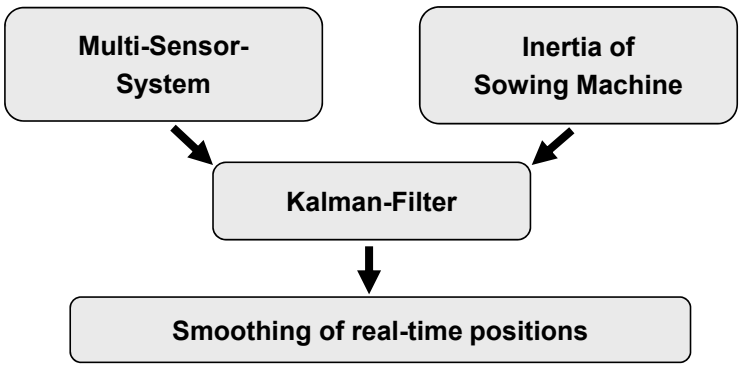


seeding machine

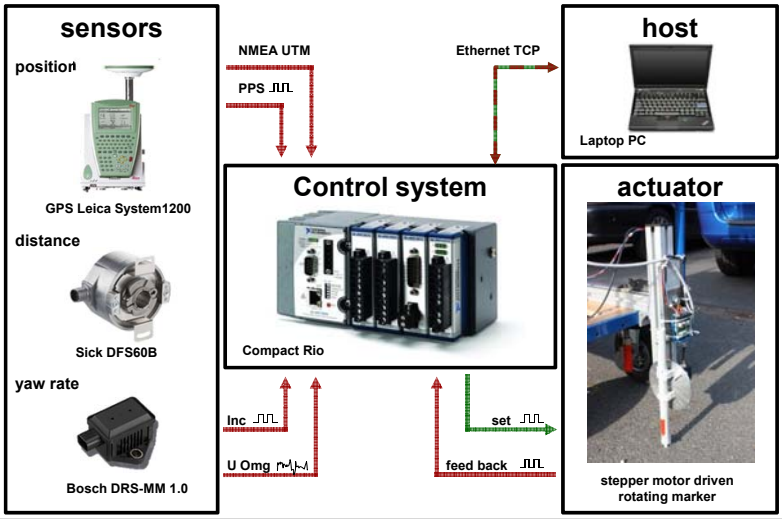
Kverneland Monopill SE (Kverneland)

approach

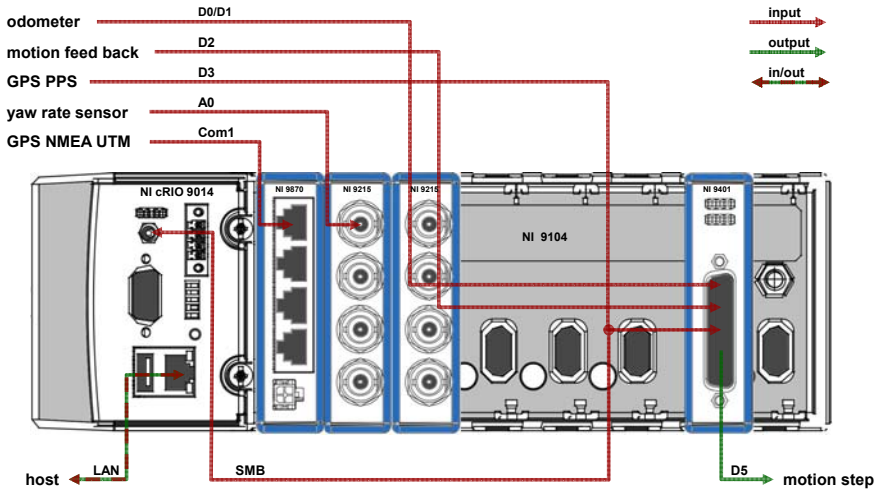
- Implementation in form of a special filter approach and a realisation of measurement acquisition
- Standard deviation with 1 cm at a velocity of 1,5 m/s under field conditions



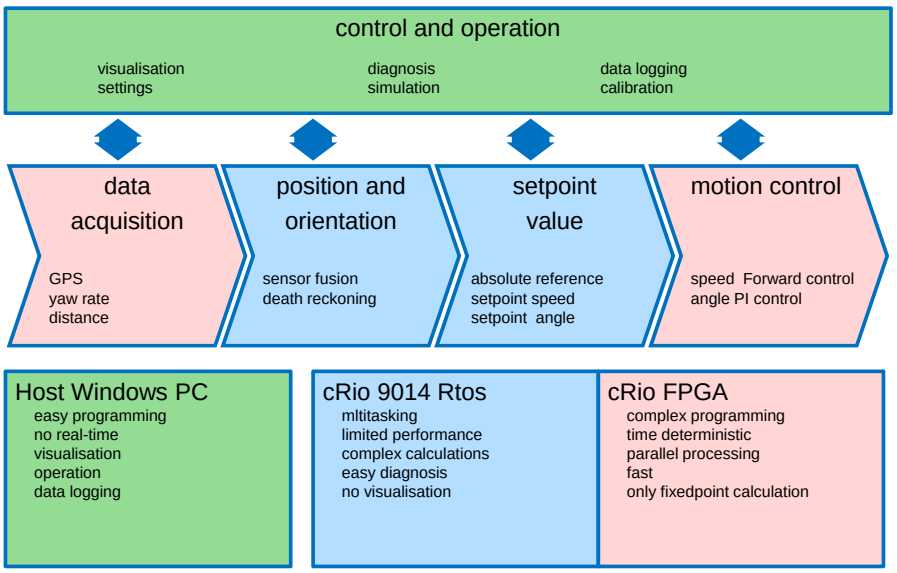
mobile platform



measurement and control hardware

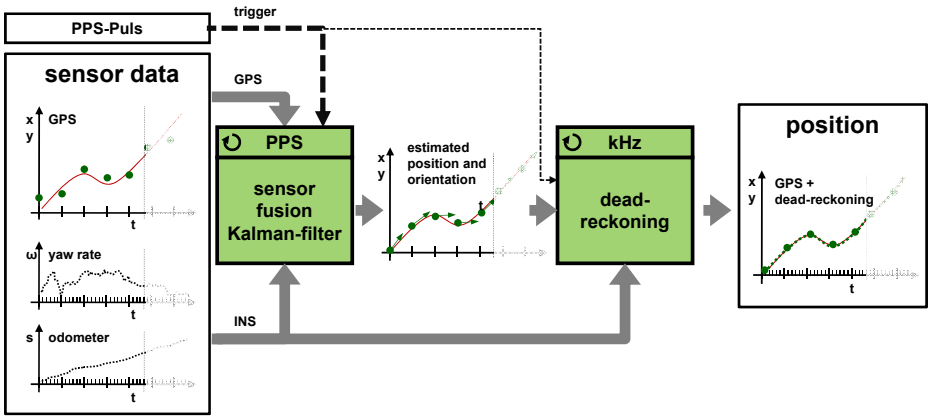


configuration

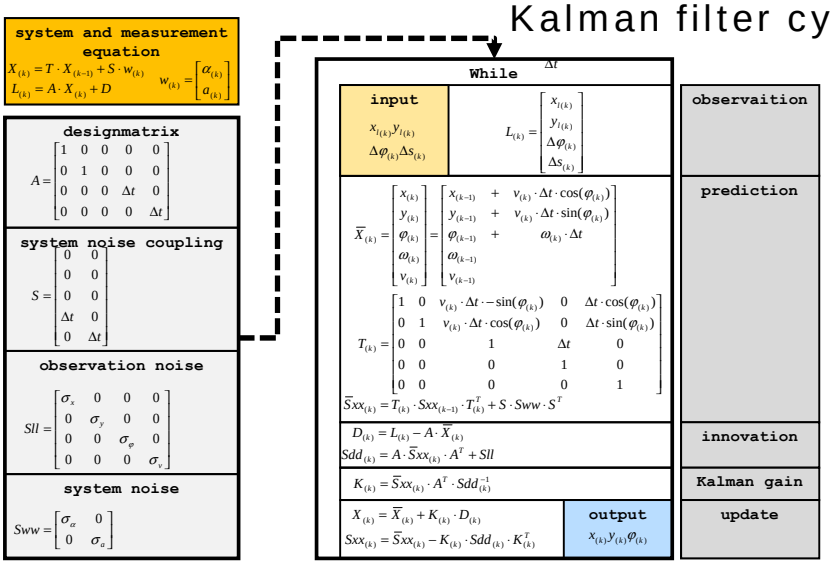


real-time calculation process

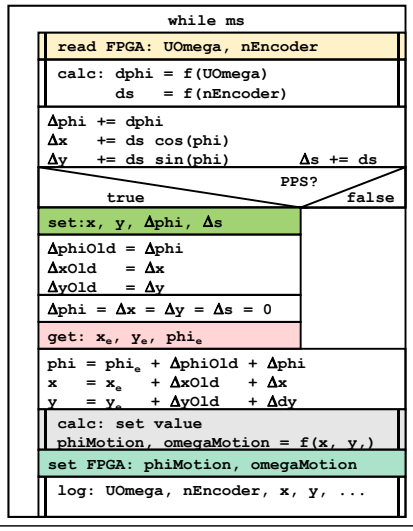
position calculation



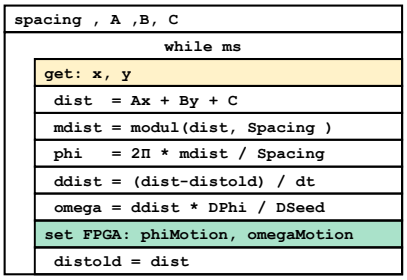
Kalman filter cycle



dead-reckoning



setpoint value



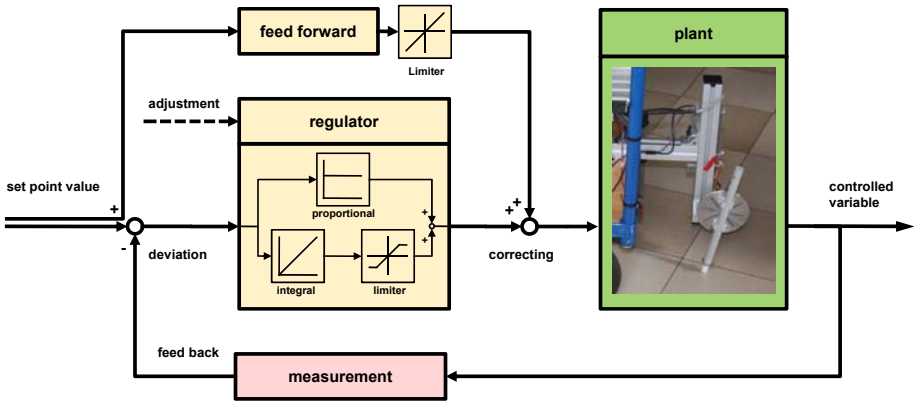
$$P1, P2 = A \cdot x + B \cdot y + C = 0$$

$$dist_{(k)} = A \cdot x_{(k)} + B \cdot y_{(k)} + C$$

real-time calculation process

closed loop control

- **PI-controller with feed forward**
- **motor angle feed back**

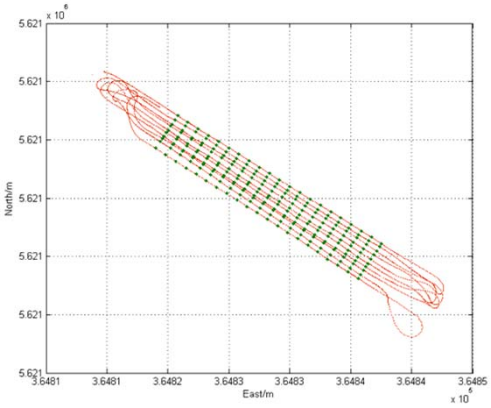


test and results

experiment

- **speed 1m/s**
- **track length 18m**
- **spacing 1m**
- **180 points**
- **diameter 5mm**

host application with actual position, track and seeding positions

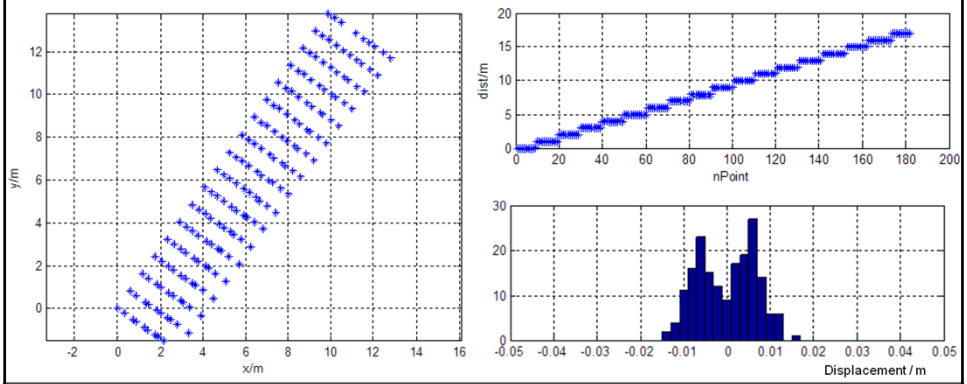


seeding map with motion path in UTM coordinates

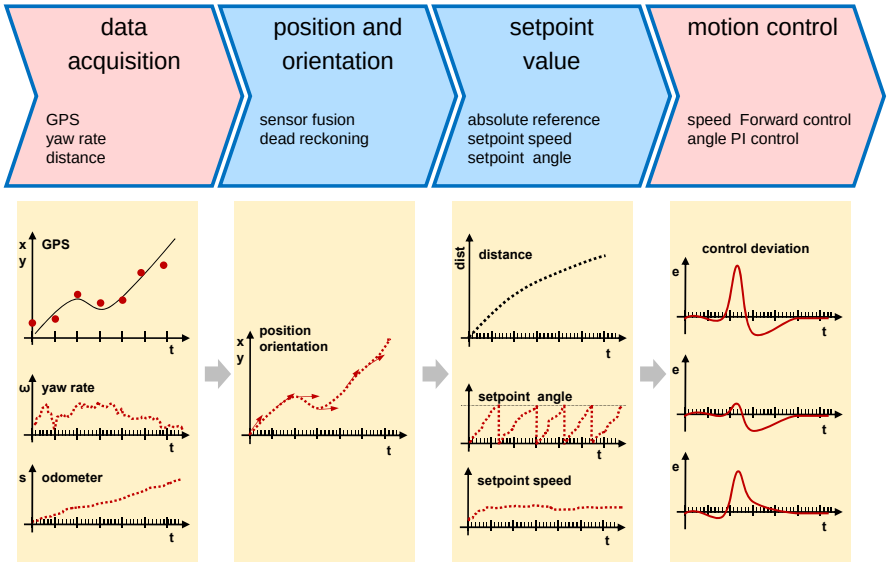
test and results

result

- **surveyed with a Leica total station and prism pole**
- **eccentricity forward and backward track direction**
- **standard deviation less than 1cm was reached**



conclusions and outlook



conclusions and outlook

- **the National Instruments hardware and software concept gives an opportunity to develop complex and fast measurement and control applications**
- **it is possible to process the position with high accuracy just in time with a reliable RTK-GPS position and low cost inertial sensors in a Kalman filter**
- **a standard deviation of less than 1cm was reached so that it is possible to create lateral rows in the field for the weed control like intra-row weeding**
- **development system gives the opportunity to create additional applications like taking precise georeferenced photos of defined objects with orientation**