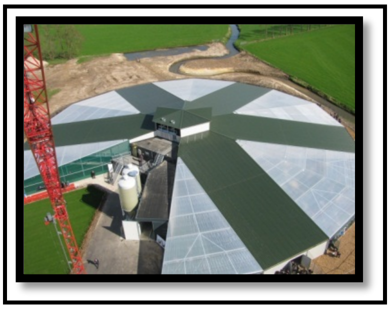
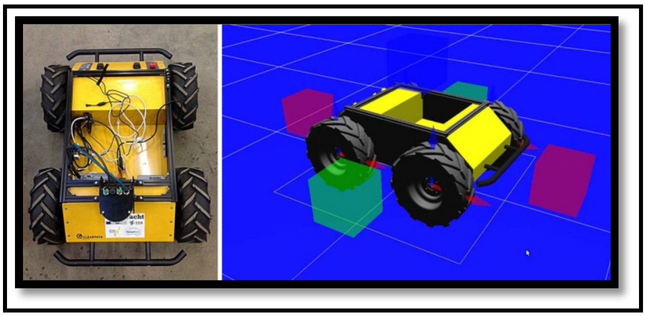
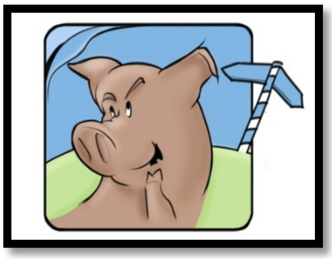
FARM TECHNOLOGY GROUP

ANNUAL REPORT 2012






WAGENINGEN UNIVERSITY
WAGENINGEN UR

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Farm Technology Group
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Preface

Dear reader,

We are pleased and proud to present the annual report of the Farm Technology Group of 2012. The report contains contact information, mission and vision of the group, cv-'s of the staff, a short description of on-going PhD projects, finished MSc projects, a list of publications as well as a list of courses we teach in the BSc and MSc programmes Biosystems Engineering.

In short, our work focusses on the following three societal issues:

- limited availability and quality of labour in agricultural production systems,
- the health of men, plant and animals in production systems, and
- integral sustainability of production systems and chains.

We address these issues using the following four scientific focus fields:

- knowledge and technology of sensing, and methods for data processing and interpretation,
- modelling of biosystems,
- technology & control systems for automation and robotics,
- development of design methodology for complex socio-technical biosystems.

The Farm Technology Group focusses on two main research areas, being:

1 Sensing, data processing and interpretation, followed by intelligent operations (e.g. process management, manipulation, robotics – precision agriculture)

2 Design of sustainable systems and technology, and development of improved methods

The Farm Technology Group is a lively and growing group. With a growing number of PhD students we address the above topics yielding a growing number of scientific publications in peer reviewed journals and knowledge and experience that can be applied in agricultural practice. .

Also, the Farm Technology group is one of the main suppliers of the BSc and MSc programmes Biosystems Engineering at Wageningen University, the only higher education study on engineering and technology for agriculture and biosystems in the Netherlands. The BSc programme Biosystems Engineering is still in the top 3 of best evaluated academic BSc programmes in the Netherlands, after having been number one for several years!

We hope you will enjoy reading this annual report. Feel free to contact us for more information on research and education or check our website: www.wageningenur.nl/fte.

Yours faithfully,

Prof. Eldert van Henten

Prof. Peter Groot Koerkamp

General information

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Mission of the Farm Technology Group

Our mission

The members of the Farm Technology Group see it as their mission "To enhance, exploit and disseminate the potential of technology in primary agricultural production processes to fulfill the needs of mankind and nature in a sustainable way".

Our vision of agricultural production

When it comes to needs of mankind and nature, the perspective has rapidly changed during the past decades. With a growing global population, the demand for food is increasing continuously and food production is and will be the key issue of agricultural production. However, the past decades have also shown a gradual diversification of the product portfolio in Western Europe. Feed, fuel and fibres are gaining importance besides food and flowers and productions of functional foods, pharmaceuticals, renewable resources from plants etc. will appear on the agenda. Also the character of farm enterprises is changing. Besides being a part of a worldwide production chain, nowadays farms in the Netherlands no longer only contribute to agricultural production but, as part of the society and the environment they operate in, contribute to recreation, nature conservation and health care. Meeting the growing and diverse demands of the global society puts strong pressure on nature with its limited available resources.

In the coming years key issues in this field will be: 1) efficient use of natural resources like energy, water, and chemicals, 2) welfare of animals and health of animals, plants and human beings (food safety), 3) reduction of the environmental impact of agricultural production, and 4) supporting, alleviating or replacing human labor. Enhancing and exploiting the potential of technology is the way to meet this complex and challenging set of objectives. We refer to our work as Biosystems Engineering.

Our core business: Biosystems Engineering

We define 'Biosystems Engineering' as a scientific approach that combines methods and tools from technical sciences with biological, environmental, agricultural and social sciences in order to study, understand, manage and design biosystems that encompass technical components and biological organisms (plants, animals) as well as human interactions with both these groups of entities.

The main scientific challenges in Biosystems Engineering are the complexity of production systems including many and usually non-linear interactions between the various entities. Additionally, variability of nature apparent through variation in position, size, shape and colour of objects as well as variability in the response of processes in time together with uncertainty in for instance the weather, pose considerable research challenges. Focus is not only on studying and understanding these complex systems, but typicall for engineering, also on management, control and (re) design of such systems, with a special focus on the technology.

Our research instruments and expertise cover fields like sensor technology, data analysis, systems analysis, continuous time and discrete time modelling, systems engineering, integral systems design, systems optimization and management and control of production processes, mechatronics and precision agriculture techniques.

Being an intermediate between plant sciences, animal sciences, environmental sciences and sometimes social sciences on one hand and technology on the other hand, the group holds a unique position both within Wageningen UR and nationally. Many scientific challenges arise on the edge between nature and technology. It is the ambition of the Farm Technology Group to play a leading role in this scientific field, nationally and globally. We expect to achieve this through targeted networking and collaboration with research groups in related non-technological and technological fields to develop new scientific knowledge in support of the challenging field of Biosystems Engineering.

Exploiting the potential of technology, some examples

Systems engineering and systems optimization. Through networking with stakeholders, group members identify needs of mankind and nature as well as the pertaining sustainability issues and translate these in innovative system designs. Instead of focusing on single disciplinary solutions but using the paradigm of systems engineering and the development of new methods, the group is able to produce new farm system concepts based on a multidisciplinary approach. Examples of projects include the design of protected cultivation systems with for instance low inputs of fossil energy when focusing on the Netherlands. Another project, with a more global view, deals with the design of protected cultivation systems that are adapted to local climate and economic conditions. In a parallel project especially the ecological sustainability of organic laying hen systems is analyzed and redesign of such systems is pursued. In past years a new system for laying hen production was developed, the so called Roundel. A pilot of that system is currently being built and under investigation.

Welfare of animals and health of animals, plants and humans. Assuring health of animals, plants and humans in agricultural production is of growing concern in the Netherlands and considerable costs are associated to maintain required health levels not to mention the input and potential emission and transfer to the food chain of chemicals to cure occurring diseases. One way our group tackles this issue is to design so called robust livestock systems in which implicit robustness of the system with animals reduces health problems. The group is involved in projects on the design of husbandry systems where welfare, health and environment are substantially improved. An alternative approach we take is to detect health issues for instance in plants as early as possible, so that timely and plant specific treatment is possible. Stress detection based on the emission of volatile organic compounds by the stressed plants is used as a cue in this line of research. This approach will be extended to livestock farming as well.

High-tech automation and robotics. To maintain a healthy and productive crop, satisfy food safety concerns, reduce the use of chemicals and improve the efficiency of production, all within the limitations of the availability and cost of labor, requires automation and precision technology. A system has been developed for plant specific removal of volunteer potatoes in sugar beet fields to prevent spreading of *Phytophthora infestans*. It includes vision, perception and precision spraying. Such fundamental technical components are also used in other farm automation projects. The group developed a small robot WURking to be used for crop scouting in arable farming as well as a large autonomous robot called the Intelligent Autonomous Weeder (IAW). Complexity and variability of the biological working environment are challenging issues.

The research network of the Farm Technology Group

Embedding in graduate schools

Research of the Farm Technology Group is embedded in the following graduate schools:

1. De Wit Graduate School of Production Ecology and Resource Conservation (PE&RC),
2. Wageningen Institute of Agricultural Science (WIAS),
3. The Netherlands Graduate School of Science, Technology and Modern Culture (WTMC).

Cooperation within Wageningen UR

The two current chair leaders also hold a part time position at DLO institutes within the Plant Sciences Group (van Henten) and the Animal Sciences Group (Groot Koerkamp). The past three years, this has resulted in many new, funded, collaborative research initiatives. There is a strong mutual interest to extend this collaboration. The DLO institutes show a strong interest in PhD projects to work on themes of long-term strategic interest. On the other hand, through the link with these institutes, the chair group is able to more proactively respond to and anticipate developments in primary production and society and to obtain research funds more easily. But there is also a strong collaboration with various research groups within Wageningen University. Currently, more than 50% of the current (PhD-) projects are based on collaboration with groups within WUR. These groups are mainly located in the Plant Sciences Group and the Animal Sciences Group, to a lesser extent in the Environmental Sciences Group and occasionally in the Social Sciences Group and the Agrotechnology and Food Sciences Group.

Cooperation with universities and research institutes outside WUR

A growing number of projects is carried out in collaboration with groups outside WUR. In various modalities the members of the Farm Technology Group collaborate with the following universities and research institutes world-wide:

1. EU FutureFarm (University of Almeria, Spain; Helsinki University of technology, Finland; Aarhus University, Denmark; University of Copenhagen, Denmark; Aristotle University of Technology, Greece; Centre for Research and Technology, Greece)
2. EU CROPS (University of Leuven, Belgium; Ben-Gurion University of the Negev, Israel; University of Ljubljana, Slovenia; Umeå University, Sweden; Università degli Studi di Milano, Italy; Instituto de Automatica Industrial, Spain; Technical University Munich, Germany; Swedish University of Agricultural Sciences, Sweden)
3. RoboNed (TU Twente, TU Delft, TU Eindhoven)
4. EU Bio-Business (University of Leuven, Belgium)
5. Ehime University, Japan

6. IAM-BRAIN, Japan
7. Forschungzentrum Jülich, Germany
8. Public University of Navarra, Pamplona, Spain
9. China Agricultural University, China
10. Chinese Academy of Agricultural Sciences, Beijing, China
11. MIT, Boston, USA
12. Field Robot Event, University of Hohenheim, Germany and University of Applied Sciences, Osnabrück, Germany
13. University of Illinois, Urbana-Champaign, USA
14. CRA, Agricultural Research Council, Italy
15. University of Milan, Italy
16. Cranfield University, UK

Cooperation with industry

Science yields impact when results of research are really implemented and used in agricultural practice. Therefore the Farm Technology Group seeks support and collaboration with commercial companies in its research projects. The group collaborates with:

1. Agritechnics, Doetinchem, The Netherlands
2. Claas, Harsewinkel, Germany
3. Kverneland Mechatronics, Nieuw Vennep, The Netherlands
4. Rijk Zwaan, Fijnaart, The Netherlands
5. Tyker Technology, Wageningen, The Netherlands
6. Vencomatic bv. & Rondeel bv, Eersel, The Netherlands
7. GD, Deventer, The Netherlands
8. Commercial Farms
9. Monteny Milieu Advies, Renkum, The Netherlands
10. Swaans beton, Heeze, The Netherlands

Prof.dr.ir. Peter Groot Koerkamp

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Prof.dr.ir. P.W.G. Groot Koerkamp
Email: peter.grootkoerkamp@wur.nl

Affiliations:

Professor of Biosystems Engineering

Senior scientist at Wageningen UR Livestock Research.

Education

1998 PhD, Wageningen University, Wageningen, The Netherlands

1990 MSc, Wageningen University, Wageningen, The Netherlands (with honours)

Expertise

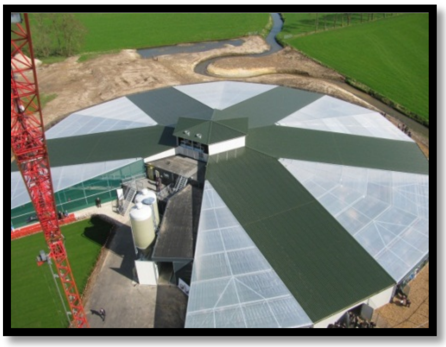
System thinking, production technology for animal production systems, innovation processes, sustainability of animal production systems, technology development, specialization in measurement of environmental aspects of animal production systems (gaseous emissions, dust, losses, energy), specialization in poultry and dairy production, statistical techniques for precision livestock farming. Special interest in animal health and welfare and design methodology for sustainable production.

Current activities

Management of Farm Technology Group, teaching, supervision of PhD, MSc and BSc students. Membership of editorial board of IJABE (China), Journal of the Science of Food and Agriculture, and member of several international professional organizations (NVTL, EurAgEng, ASABE, WPSA, ISAH).

Contribution to courses

FTE11306, FTE30306, FTE80812, FTE80436



Opening of the first Roundel house for laying hens on April 9, 2010 in Barneveld
Left: top view with 5 sections, right laying hens foraging in the day light area

Prof.dr.ir. Eldert van Henten

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Prof.dr.ir. E.J. van Henten
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Affiliations

Professor of Biosystems Engineering

Head of Farm Technology Group

Senior scientist at Wageningen UR Greenhouse Horticulture

Education

1994 PhD, Agricultural and Environmental Sciences, Wageningen University, Wageningen, The Netherlands

1987 MSc, Agricultural Sciences, Wageningen University, Wageningen, The Netherlands (with honours)

Expertise

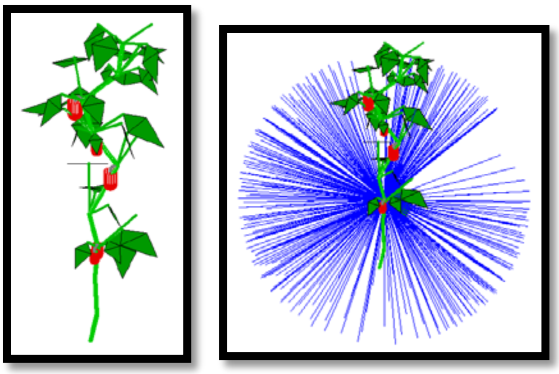
Protected cultivation, arable farming, sensing, modelling, design and (optimal) control of bio-systems, bio-robotics, high-tech automation, company logistics.

Current activities

Management of Farm Technology Group, project acquisition, teaching, supervision of PhD, MSc and BSc students. Member of editorial boards of Biosystems Engineering, Computers and Electronics in Agriculture and International Journal of Agricultural and Biological Engineering. Member of (inter)national professional organizations: EurAgEng, ASABE, ISHS (chair of working group on sensors, vision and robotics), BSHS, IFAC, IEEE Robotics and Automation Society (co-chair of the special interest group on agricultural robotics and automation), RoboNed (chair of the special interest group on agricultural robotics), NVTL.

Contribution to courses

FTE12303, FTE12803, FTE31306, SCO22306, FTE32806, FTE33306, YEI80812, FTE80436



Robotic harvesting of sweet pepper; model calculation of the visibility of a fruit in a sweet pepper plant (De Swart, 2012)

Ing. Sam Blaauw

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Ing. S.K. Blaauw
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Affiliations:

Teaching assistant Farm Technology Group

IT support officer at WUR Facilities and Services

Education:

1989 Bachelor Dutch Agriculture (Specializations: agricultural engineering, IT) Prof. H.C. van Hall institute for higher agricultural education, Groningen (The Netherlands)

Expertise:

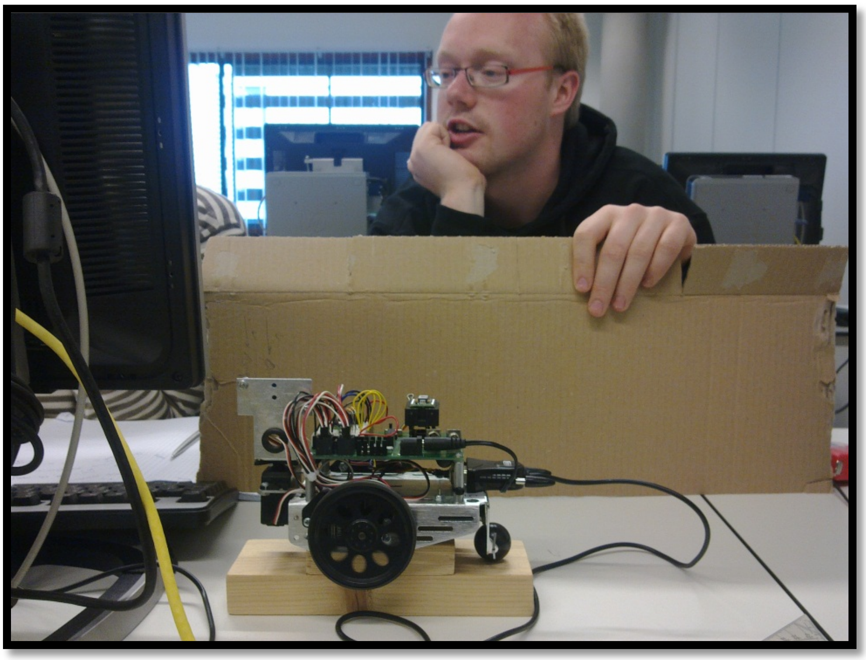
Agricultural Engineering, Computers and Internet, CAD, Teaching

Current activities:

Teaching various practical trainings, technical support of research projects of PhD and MSc students, IT support chair group, webmaster www.fieldrobot.nl, member WURking field robot team

Contribution to courses:

FTE32806, FTE24806, FTE13807, FTE34306



Practical of the course Automation for Bioproduction

Dr.ir. Jan Willem Hofstee

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Affiliations:

Assistant professor at Farm Technology Group

Programme director BSc Biosystems Engineering (BAT) and MSc Agricultural and Bioresource Engineering (MAB)

Education

1993 PhD Agricultural and Environmental Sciences, Wageningen Agricultural University

1986 MSc Agricultural Engineering (with honours), Wageningen University, Wageningen, The Netherlands

Expertise

Machine vision, automation, precision farming

Physical properties of fertilizers, spreading fertilizers

Computer Integrated Agriculture

Precision detection and control of weeds

Yield mapping of potatoes with machine vision

Member of NVTL, EurAgEng, ASABE

Member of committee for assessment of technology for environmental issues (water quality)

Member editorial board Computers and Electronics in Agriculture

Current activities

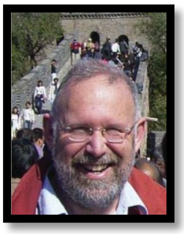
Teaching courses, supervision of BSc, MSc and PhD students, research on precision farming, automation and machine vision.

Contribution to courses

BRD22306, FTE12303, FTE12803, FTE13303, FTE13807, FTE25806, YEI80324, FTE804nn, YMC60809

Automated detection and control of volunteer potato plants

Dr.ir. Willem Hoogmoed



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Affiliations:

Assistant professor Farm Technology Group

Expertise:

Agricultural engineering with focus on soil tillage / soil technology; conservation tillage; soil structure; farm mechanization, including animal traction; soil sensors; soil physics

Research:

Technology aspects of mulch based cropping systems (in the framework of a EU-funded FP7 project "OSCAR")

Application of proximal (on-the-go) soil sensors for precision farming (PhD project)

Interaction between animal manure processing and tillage systems (PhD project)

Teaching:

Teaching and supervising thesis work of MSc students on various aspects of tillage and technology: sensors, precision farming, conservation tillage systems.

Setting up MSc programme in Sustainable Agriculture at Stellenbosch University, South Africa (NUFFIC project)

Lecturing and coordinating courses (BSc and MSc level):

FTE24306, FTE32306, FTE33306, FTE50806

Controlled traffic in Dutch organic farming

Conservation agriculture in Africa

Ir. Bert van ’t Ooster

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Affiliations:

Assistant professor at Farm Technology Group

PhD student stationed at Wageningen UR Greenhouse Horticulture

Education:

1984 – MSc Agricultural Engineering, Wageningen University (with honours).

Expertise:

Agricultural engineering, biosystems design, horticultural production systems, animal production systems, indoor climate in agricultural production facilities (greenhouses, animal houses, and product storages mainly potato and root crops), physics, psychrometrics, climate equipment, solar energy, (natural) ventilation.

Simulation of crop handling processes in horticultural production systems.

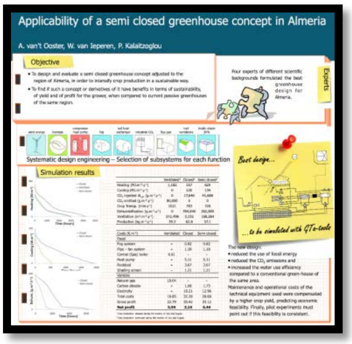
Model development on continuous and discrete processes in matlab, simulink, simevents, visual basic, visual fortran and c.

Current activities:

Teaching of several courses, supervision of BSc and MSc students, PhD research on Systematic design of automated sustainable horticultural production systems

Contribution to courses:

FTE33806, FTE31306, FTE25303



Simulation of semi-closed greenhouse concepts for the Mediterranean region

Hanneke Pompe, MPS

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Affiliations:
Lecturer, internship coordinator.

Education:

1983, MPS (Master of Professional Studies) Agricultural Engineering, Cornell University, Ithaca, New York, USA

1973, BSc Horticulture, Higher Horticultural College, Utrecht, The Netherlands.

Expertise:

Relations between cow behavior, labor requirement, technology and facility lay-out

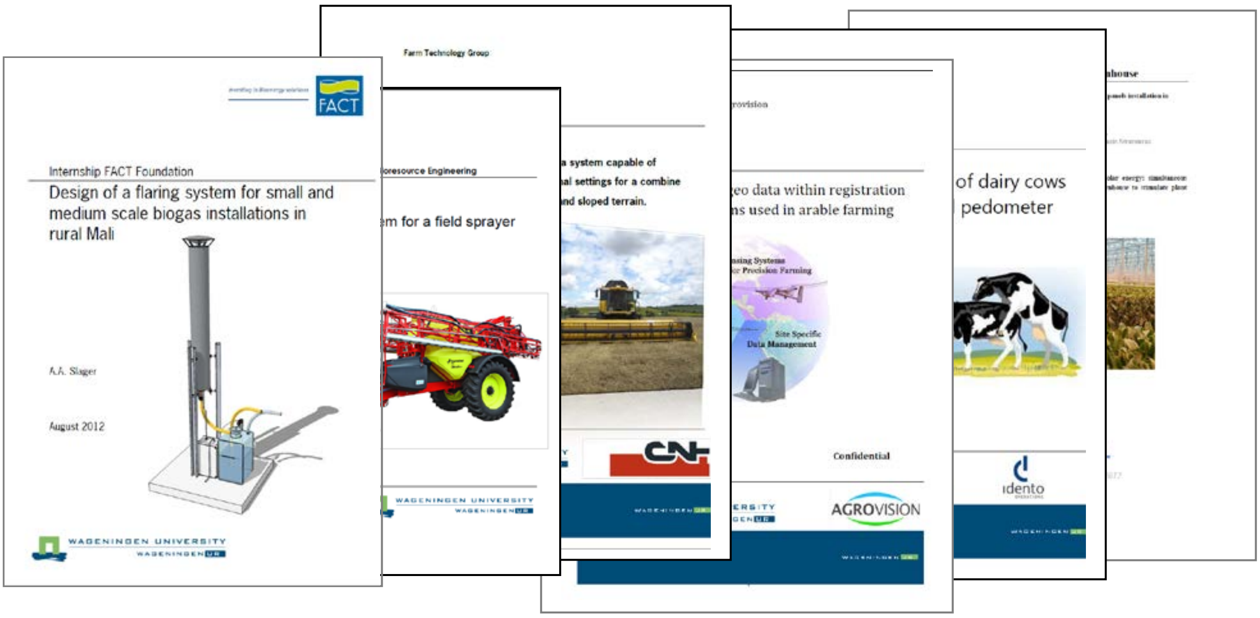
Discrete-event simulation and logistics.

Current activities:

Coordinating internships, process coaching, teaching

Contribution to courses:

FTE-25806, FTE-30306, FTE-70400, YAM-60312



Research projects

- Development of a sweet-pepper harvesting robot
- Optimal management of energy resources in greenhouse production system
- Resilience in farm animals
- Sensor data fusion for assessing soil properties
- Design methods for sustainable production systems
- Development of an automated poultry red mite monitoring system
- Development of an assessment strategy to determine the ammonia emission from dairy cow houses
- Mobile-based autonomous system for real time detection and removal of volunteer potato plants in sugar beet field
- Moving beyond manure/Integrated manure management to improve the environmental performance in the chain from animal to crop
- Automation for poultry production
- Development of new anaerobic digestion methods to optimize energy yield and P recovery from animal waste
- Development and application of a novel design method to unify heterogeneous, and apparent contradictory, needs in animal production systems
- Assessment of the methane emission of individual dairy cows at farm house level – design, test and validation of a measurement method
- HUBRINA – Human-robot co-working in master-slave systems in agriculture

Ir. Wouter (C.W.) Bac

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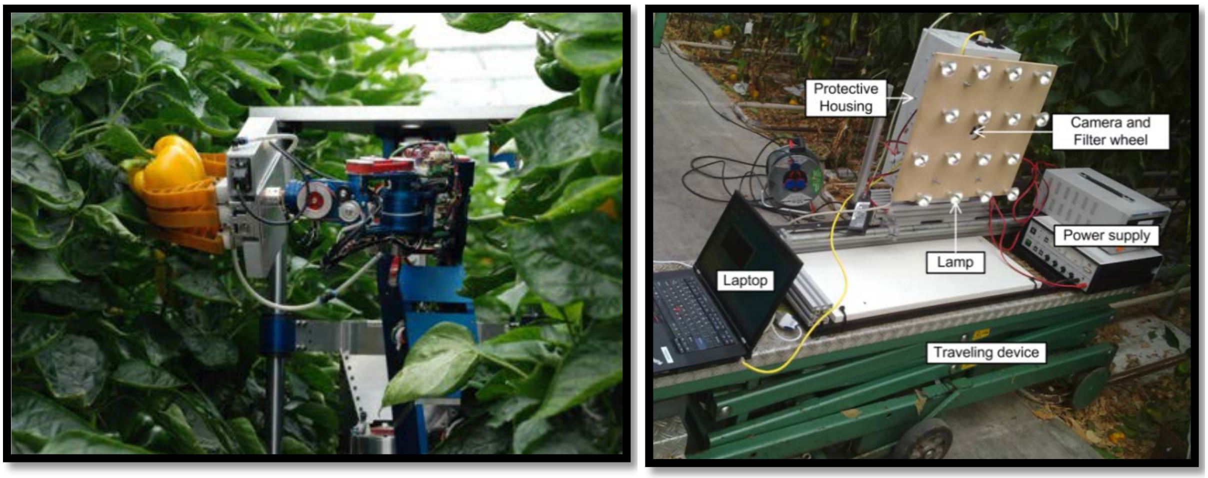
Supervisors: Prof.dr.ir. E.J. van Henten en Dr. J. Hemming
In collaboration with: Wageningen UR Greenhouse Horticulture

Development of a sweet-pepper harvesting robot

This PhD research is part of the EU funded CROPS project in which robotic systems are under development for apple harvesting, grape harvesting, sweet-pepper harvesting, spraying and navigation in forestry. Wageningen UR Greenhouse horticulture leads the development of a sweet-pepper harvesting robot and this PhD project is embedded in this development. The PhD project comprises four objectives. First objective is to review state-of-the-art literature regarding robotic systems for high-value crops. Robots are reviewed in terms of performance, design choices and algorithms used. Based on this data, bottlenecks and challenges are defined as a first step toward commercialization of robotic systems for plant maintenance operations in high-value crops. Secondly, an objective is to distinguish plant parts of a sweet-pepper plant by means of multi-spectral imaging and image processing algorithms. Plant parts such as stems and fruits are hard obstacles, which should be avoided by the robot arm and gripper. Leaves are soft obstacles that can be touched and pushed aside if required. The third objective is to develop a motion-planning algorithm that is able to avoid hard obstacles and can guide the arm toward ripe fruits. Finally, all hardware- and software components will be combined to perform a field test and to determine robot performance in terms of harvest success, damage rate and cycle time.



A sweet-pepper harvesting robot

Peter (P.J.M.) van Beveren, MSc

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Supervisors: Prof.dr.ir. E.J. van Henten
Dr. J. Bontsema, Prof.dr.ir. G.van Straten
In collaboration with: Wageningen UR Greenhouse Horticulture, Hortimax B.V., Lek Habo Groep B.V., Boonekamp Roses B.V.

Optimal management of energy resources in greenhouse production systems[1]

In the interest of reducing energy consumption and CO_2 emission while maintaining productivity, greenhouse growers have installed a wide range of auxiliary equipment, such as assimilate lighting, heat exchangers, short and long-term heat buffers, co-generation units and heat pumps. The task of the grower to manage his equipment in the most economical way has become very complicated, not only because of the complex physics of the greenhouse dynamics, but also because of the uncertainty in the weather, and, in addition, the strongly fluctuating market prices of energy. The main challenge of this project is to formulate and solve this optimization problem and to develop optimal scheduling or management procedures.

[1] This research is supported by the Dutch Technology Foundation STW, which is part of the Netherlands Organisation for Scientific Research (NWO), and which is partly funded by the Ministry of Economic Affairs.

Drs. Ingrid (I.D.E.) van Dixhoorn

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Resilience in Farm animals

The main objective of this research is to identify and quantify generic measures that indicate the capability of individual animals (at a particular moment) to cope with (infectious) disruptions. This is referred to as the resilience, or more precisely *the precariousness*, of individual farm animals and it will be quantified by describing the dynamics of one or more physiological variables (referred to as biomarkers) which can be measured easily and repeatedly in growing piglets.

The hypotheses that will be tested in this research are:

1. There are biological variables within the complex system of an animal that can be used as indicators for the resilience concept of precariousness and can be measured continuously during (long) periods of the life time of an animal
2. The continuous dynamic signal of this indicator can be analysed and modelled so that the characteristics of the biomarker can be assessed.
3. The biomarker varies in time and between animals, and has a predictive value with respect to the ability of the animal to respond to infectious disturbances and other perturbations.
4. The theory of critical slowing down as assessed by Scheffer *et al.*, (2009) on population dynamics can be applied to individual animals. Precariousness is reduced whenever critical slowing down is approaching, meaning that it is more difficult for these animals to adapt after only small perturbations.

Sultan (H.S.) Mahmood, MSc

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Supervisors: Prof.dr.ir. E.J. van Henten, Dr.ir. W.B. Hoogmoed

Sensor data fusion for assessing soil properties

Precision agriculture is an emerging high-technology agricultural management system whose fundamental aim is to increase the profitability of crops, to optimize the use of agricultural inputs and to reduce potentially negative environmental impacts by localized management based on the quantification of in-field spatial and temporal variability. The development of various types of soil sensors is expected to increase the effectiveness of soil characterization in precision agriculture. There are different satellite-based, airborne and ground-based soil sensors used to characterize important soil properties. Satellite or aerial remote sensing suffer from inadequate spatial and temporal resolution, while the proximal remote sensing methods may give fine-scale information on soil properties of interest. Therefore, the conventional laboratory methods are being replaced or complemented with proximal or ground-based soil sensors as analytical soil sensing techniques. Keeping in view the above facts and issues, it was hypothesized that:

1. The fusion of multiple soil sensors (combining the outputs of different sensors) will improve the accuracy of predictions of various soil properties and permit their application over a greater range of soil physical and chemical properties.
2. Sensor data fusion system for sensing soil properties can form an integral component of technology in precision agriculture.

The overall objective of this PhD study was to use a multiple soil sensors data fusion technique for modeling important soil properties and to assess and evaluate its significance and scope in precision agriculture. In this study three different types of soil sensors with different measuring principles have been used. They include an EM38 (an electromagnetic induction sensor), a visible-near infrared spectrometer and a gamma radiometer. Field experiments were in Lelystad, within the BASIS' project using a controlled traffic farming system. Two types of crop management systems, conventional and organic are under three different types of tillage practices e.g., ploughing, minimal tillage and in-between ploughing and minimal tillage. Near Wageningen measurements were done on a heavy clay soil. Data handling and analysis was done by applying different multivariate statistical techniques. Defense of the thesis will be mid-2013.

Use of EM38 in the field

Use of VNIR (visible-infrared) sensor in the laboratory

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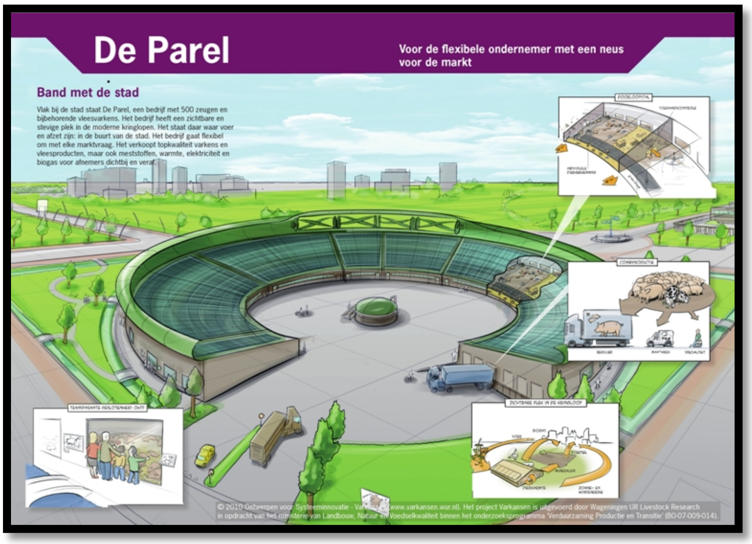
Dr. A.P. Bos, Dr. S.F. Spoelstra

Design methods for sustainable production systems

Hanneke's research is about the design of sustainable animal husbandry systems. Wageningen UR Livestock Research Institute developed a design approach in which several scientific disciplines are brought together to design sustainable animal husbandry systems, the so-called RIO approach. RIO – a Dutch acronym for Reflexive Interactive Design – aims at system innovation in animal husbandry by following an interactive approach with multiple stakeholders. It forms a platform where a practical realisation of reflexive modernization as a social phenomenon is carried out, and where reflective learning processes of individual participants may take place.

During a particular RIO project, called Varkansen, data are gathered to understand the relationship between reflexive modernization as a social phenomenon and the individual learning process. Furthermore an analytical tool is developed to analyse those data and scrutinize the theoretical and practical connexion between reflexive modernization and reflective learning in a project setting. Based on those insights recommendations can be made for the outline of future projects aiming at system innovation.



A result of the interdisciplinary design project Varkansen

Ir. Monique (M.F.) Mul

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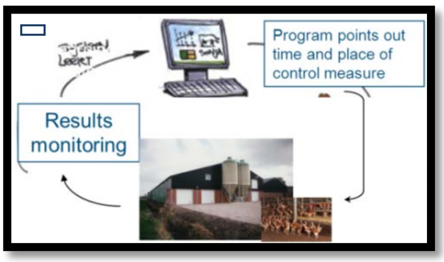
Development of an automated Poultry Red Mite monitoring system

The Poultry Red Mite (Dermanyssus gallinae) is the most common ectoparasite in poultry farms worldwide and can be a true pest as a Poultry Red Mites (PRM) infestation may result in high economic losses, veterinary risks and allergic reactions among farm workers. PRM feed on blood of poultry and sometimes humans in order to develop to the adult stage and reproduce. In Europe, there is a large number of outbreaks due to increasing resistance of PRM to some acaricides and a ban on other chemical pesticides. Therefore, recent research has been focused on more sustainable control methods such as the use of natural enemies, attract and kill methods using fungi and development of a vaccine. Application of these methods is most effective when applied in poultry houses with relative low numbers of PRM. For an effective, timely and place specific application of most control methods, monitoring of the size, place and the development of the PRM population is necessary. Currently, existing monitoring methods for poultry red mite are labor intensive, mostly applicable to one poultry housing system and fit for research purposes only. Thus, we aim to develop an automated monitoring device for poultry red mite in layer farms which is composed of an automated counter of PRM and a dynamic adaptive model. This monitoring device assesses the PRM population in 1) the actual situation, 2) after a treatment (effect) and 3) in future situations (necessary to indicate timely future treatment).

The idea and the development of the automated mite monitor is unique due to the cooperation of researchers working in very many different fields; Animal Husbandry, Entomology, Technology and Statistics. The best ideas of all fields come together in this research and therefore real new products can be developed.

The objective of research in 2012 was to develop a reliable and economical automated mite counter wherein PRM will walk into, will not clutch, mites can be collected and which is robust enough to place in a poultry facility. So-called cafeteria-tests and test with mites in petri dishes and in a poultry facility were carried out to develop the first prototype of a reliable counting device for PRM.

Present labour intensive way of mite monitoring



Future mite monitoring

Dennis (J.W.) Snoek MSc

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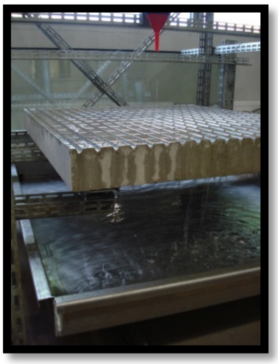
In collaboration with: ASG – Wageningen UR Livestock Research

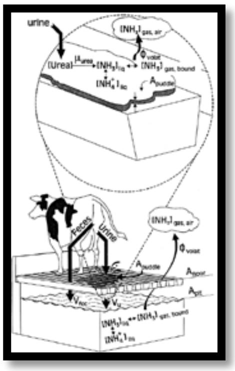
Development of an assessment strategy to determine the ammonia emission from dairy cow houses

National (Netherlands) and international policy aim to decrease the ammonia emission from dairy production. Measures to reduce emissions are under development, e.g. feeding strategies, covering of slurry pits, and new designs of floors for walking alleys in dairy cow houses. For various reasons good assessment of the emission reduction, and by that the effectiveness of a measure, is difficult and costly. In addition, the emission from traditional, apparently the same, cubicle houses varies strongly. In the ideal situation the ammonia emission from an arbitrary cubicle dairy cow house can be assessed with sufficient accuracy and with limited time and costs. The house is either traditional or with reduction measures. Moreover, the assessed emission level can be corrected for 1) standardized outdoor climate conditions and 2) effects of specific circumstances, in order to 3) distinguish the effect of specific reduction measures from other effects and sources of variation. This PhD is a first step towards this final goal.

Focus of this PhD, and the main objective, is to develop an ‘ammonia assessment strategy’. This strategy is an emission model in combination with measurements of key variables of the ammonia emission processes under practical circumstances. The goal of this strategy is to determine the ammonia emission in a precise and cost effective way in a dairy cow house. The strategy should apply for any dairy cow house with a specific design, at a specific location, with specific climate conditions.

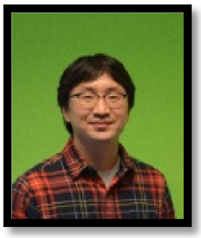


Transportation of water by a floor element;



Dairy cow urinating at a slatted floor, cow urination simulation (Snoek, 2009). and the related parameters and processes (Monteny et al., 1998).

Hyun (H.K.) Suh, MSc



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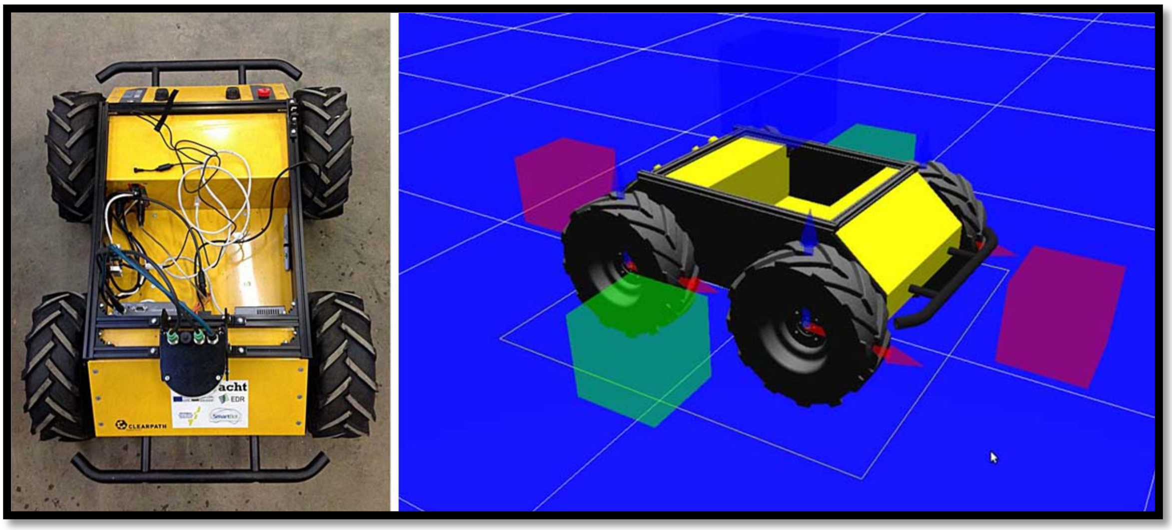
In collaboration with: EU SmartBot

Mobile-based autonomous system for real time detection and removal of volunteer potato plants in sugar beet field

This research basically succeeds the work previously done by Ard Nieuwenhuizen (Nieuwenhuizen, 2009), and continues to develop an automated system based on mobile platform for fast and effective control of volunteer potato plants in sugar beet field. A major need for an automated weed control system together with consideration of environmental issues and concerns leads to develop small and lightweight, but self-guided and fully autonomous, mobile based system for effective control of volunteer potatoes in sugar beet field. The development work for this system mainly consists of three procedures such as detection unit development, weed removal unit development, and integration into mobile platform with Robot Operating System (ROS).

I have joined this project on September 2012, and have been working since to address practical challenges as well as feasible solutions. Three major challenges are identified such as variation of outdoor illumination, occlusion of plant canopies, and precise timing/positioning of chemical droplet. For this PhD project, thorough investigation will be made not only to overcome the challenges faced, but also to obtain reliable and practical level of autonomous weed control system for real time operation. The HDR stereo colour vision and micro-sprayer will be integrated into the Clearpath Husky A200, which is now ROS-enabled mobile platform.



Clearpath Husky A200 – Mobile platform(left), Husky in 3D simulation environment

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In collaboration with: Animal Production Systems

Moving beyond manure/Integrated manure management to improve the environmental performance in the chain from animal to crop

Intensification of animal and crop production systems in the past 50 years has led to disintegrated farming systems resulting in displacement of crop and livestock farming and higher environmental impact. Manure and fertilizer management are key areas in the related environmental impact of modern farming systems. Innovations in crop and animal production systems, such as anaerobic digestion of manure for energy production and processing of manure into liquid fertilizer, have emerged, which can partly counter negative environmental side effects. However, little research has been done on the integration of measures addressing more managerial aspects and including multiple environmental effects in the chain from animal to crop. This research aims at improving the environmental performance through reductions of nitrogen, phosphorus and carbon emissions, in the chain from animal to crop by: tailoring manure products and management, and soil management to crop production needs (Figure 1). Managerial aspects included in the study are: manure product and quality, application amount, timing, placement and application technology in addition with soil tillage. By setting environmental goals and by using a methodical approach to engineering design, new chains from animal to crop and management approaches are designed aiming at low environmental impact. Life Cycle Assessment (LCA) is applied as a methodology to quantify the environmental consequences of these designed chains. Environmental indicators included in the assessment are greenhouse gas emissions, acidification potential, eutrophication potential, fossil fuel depletion and particulate matter formation. Final results of the research give fundamental insight in the environmental consequences of applying several combinations of manure and soil management techniques in the chain from animal to crop.

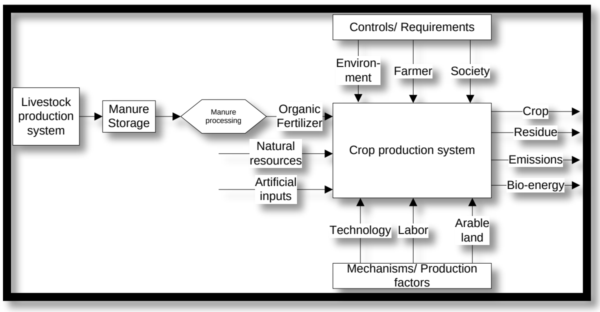

Figure 1: Schematic overview of the manure management and crop production system (IDEF0)

Ir. Bastiaan (B.A.)Vroegindeweij

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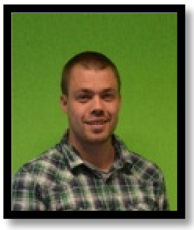
Supervisors: Prof.dr.ir. P.W.G. Groot Koerkamp, Prof.dr.ir. E.J. van Henten



Automation for Poultry Production

As a result of the current change to loose-housing systems with more freedom for the animals, also working methods and management strategies are changing. In modern poultry housings for example, farmer have to manage a flock instead of a housing as with the traditional cages.

Next, also some old problems reoccur, like the presence of misplaced eggs, caused by hens placing their eggs outside the laying nests. These eggs create an extra workload for the farmers and reduce their profits. A lot of research has been done to decrease the number of floor eggs, but a solution to overcome this problem was not yet found.

Current measures to deal with these issues all rely on manual labour and control. For example, the (preventive) collection of these floor eggs is currently done by the farmer by hand. It is a physically and time demanding job, so that there is a need to ease and improve this collection. During the Field Robot Event of 2007, the idea of collecting floor eggs (outer-nest eggs on the litter) with help of a robot emerged.

In my research, I'm working on the evaluation of current & new technology for use in automation on their potentials when dealing with such problems. Target of this research is to come up with new solutions for further automation of poultry production, and more specifically for a vehicle that collects floor eggs autonomously and with special attention for the characteristics of this problem.

Specific examples are the testing of localization methods on their accuracy inside modern aviary housings and modeling floor laying behavior and using this to perform path-planning for the collection of floor eggs. The latter one is designed specific for the complex task of gathering floor eggs, but can also be used for other purposes like cleaning areas or searching for objects. Another important issue is object recognition, which can be used for performing desired tasks as well as ensuring operational safety of the vehicle. Finally, also the financial aspects and the machine-animal interactions are taken into account.

The first trials with a robot inside a commercial poultry house, to assess the localisation systems and the reaction of the animals

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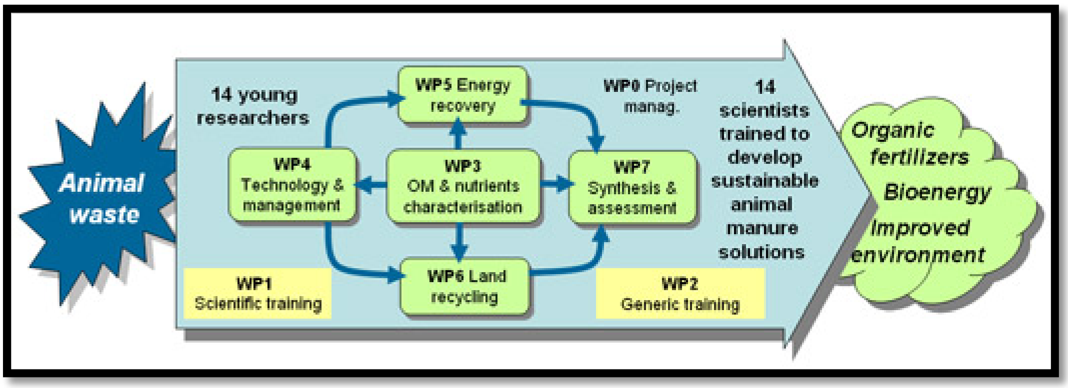
In collaboration with: Wageningen UR Livestock research

Development of new anaerobic digestion methods to optimize energy yield and P recovery from animal waste

The project "*Development of anaerobic digestion methods for optimal energy yield and P recovery from animal manure production*" is one of 12 PhD projects of the Marie Curie training network named Reuse waste started in January 2012. The project gathers 8 EU research groups of leading universities, research institutes, companies from the regions with the most intensive livestock production in Europe that focuses on manure management systems. The figure below describes research activities of the network in which my PhD project stands for work package *WP5 Energy recovery*. The aim of this work package is to develop new technologies for bioenergy and nutrient recovery from manure organic matter. The main objective of this PhD project (which is named 5.1within the Reuse waste network) is to develop new technologies for characterization, treatment, recovery and utilization of energy and nutrients in manure and to integrate the new developed knowledge into manure management system. Specific objectives including the a) development and assessment of new technologies for bioenergy production from manure; b) improve and test technologies for P recovery from manures; c) develop new methods for combining methane production and P recovery.



Scheme of research activities of the Reusewaste network *(Source: Reusewaste.eu)*

Left, the CAD model of the sweet pepper. Middle, two half ring encircling the sweet pepper. Right, the final prototype to be tested in the field.

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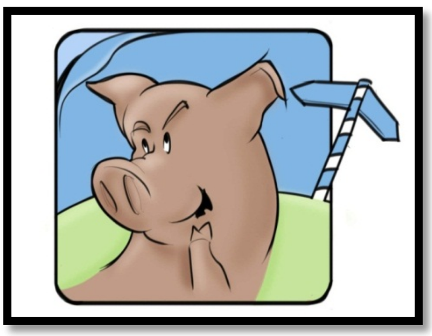
Development and application of a novel design method to unify heterogeneous, and apparent contradictory, needs in animal production systems

Is it possible to achieve an in all aspects sustainable animal-based food production? Which means that all the different requirements and needs of all the different sustainability aspects, people, animal and environment are unified. An ambition that can only be achieved when you acknowledge the different needs during the design process of new and alternative systems. It appears that the animal plays a central and crucial role. Not only is the animal a product, user, stakeholder, but a possible contributor to system goals and functions as well. By letting the animals do what they are inclined, naturally motived to do, you can profit from that on other sustainability goals. How we can make this work in a structured design methodology is one of the challenges of this research.
In this project research is done on the often perceived contradictions between animal welfare and the environment. Especially in our current production systems with the current chosen solutions contradictions between these two sustainability aspects, animal welfare and environment, is an issue. To be able to circumvent these contradictions in the design of future alternative systems, a new design methodology is set-up. A design methodology that acknowledges all the different stakeholders and is able to unify the complexity of needs in new integrated solutions. A leading principle is to deploy the animal better, so we all can benefit from what comes naturally for the animals, in terms of the welfare of the animal itself as well as human welfare, environment and profit. Taking this principle as guidance we propose that this is an opportunity to overcome some significant contradictions current animal-based food production experiences.



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Assessment of the methane emission of individual dairy cows at farm house level

Methane emission from dairy cattle accounts for a significant portion of the global CH_4 budget which is a substantial contributor to the Global Greenhouse effect. Also as a by-product of microbial fermentation process, methane generation results in about 6-10% loss of the gross energy intake (GEI). In this project we shall design, test and validate an assessment method to determine the methane emission of individual dairy cattle at farm house level. With such a measurement system the variation of the methane emission between a large number of cows can be determined in practice. Through understanding and evaluating methane emission from individual dairy cattle in large numbers, the methane conversion expressed as the methane emission per unit of milk production can be assessed within the dairy cattle. This information can be used for breeding dairy cattle with low methane conversion which contributes to reducing the environmental impact of dairy farms and increasing the productivity. Besides breeding, also the effect of other mitigation measures can be assessed at animal level, like feeding measures. This project includes following studies: 1) Design and construct the measurement equipment & set-up for methane emission from individual dairy cattle and test under experimental small-scale condition; 2) Evaluate and validate different set-up measurement methods under practical conditions by measurements with real cows; 3) Carry out a proof of principle under practical conditions (up to 50 cows) where methane emission and conversion will be measured during a long period. Strengths and weaknesses of each method were evaluated what further research should be undertaken to improve the methodology according to measurement requirements at farm level.

In order to explore the level and dynamics in time and space of CH_4 and CO_2 concentrations at different positions in non-occupied and occupied cubicles, and also analysis the influence from cows, two explorative experiments were done during summer and winter period this year. 9 sampling tubes were installed around the cubicles which CH_4 and CO_2 concentration can be monitored continuously, and also the behaviour of cows in the cubicles were recorded at the same time. The results of summer experiments were already submitted to the conference of GGAA 2013. In 2013, we will design and test the cubicle measurement method by considering the influence factors from these experiments.

Summer and winter experiments: Sampling positions around the cubicles (left) and measurement system (right)

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In collaboration with: Tyker Technology, Wageningen UR Greenhouse horticulture

HUBRINA - Human-robot co-working in master-slave systems in agriculture

Despite all research effort, fully autonomous robots are not used in farming today. The main problem is the safety and robustness of fully autonomous systems. Human supervision is a way to bridge this gap. To benefit from robot technology in practice on a shorter term, there is a need for agricultural robots cooperating with humans in master-slave systems. In this project a master-slave robot control for agricultural operations in agriculture was developed and its feasibility was demonstrated. In a master-slave system, one tractor, the master, is steered by the farmer while the second tractor, the slave, automatically follows the master at a safe distance. This allows the farmer to guarantee machine safety and to supervise the work done by both machines. To realize master-slave operation the following modules were developed. A path generation module produced paths for both master and slave tractors covering the whole field. GPS based path tracking was implemented on both master and slave. A distance control algorithm on the slave maintained a proper and safe distance between master and slave. As exchange of status data is crucial for safe operation, communication between master and slave was implemented including suitable safety measures. Control systems were developed and implemented in software. Prior to testing on the field, control systems were tested on the tractor hardware platform using a simulation in the loop approach. Having passed all tests, in 2012, the master-slave concept was successfully demonstrated on the field with two Claas Xerion tractors.

Master-slave operation of two Claas Xerion tractors

BSc projects completed in 2012

Schipper, R (2012, March 20)
Ontwerp van zeewieroogstmachine voor SBIR teeltsystemen

Pauw, W (2012, March 26)
De zoektocht naar hoe documentaire kan bijdragen aan het maatschappelijk debat over voedselproductie

Bouwman, SA (2012, May 24)
Het verdampingsproces van water uit een plas

Kool, F (2012, August 20)
Het effect van het urineergedrag van melkkoeien op de ammoniakemissie van melkveestallen

Hoveling, J (2012, August 30)
Body condition score met behulp van een 3D camera

Ormel, RS (2012, August 30)
Sensors and safety systems

Simons, FN (2012, August 30)
Het effect van verschillende opfokbehandelingen op robuustheid en kostenfuncties voor gewichtsvariatie bij leghennen

Schetters, KWG (2012, August 30)
De verdeelnauwkeurigheid van zelfrijdende bemesters

Crommert, JW van de (2012, August 30)
Understanding the silagen process

Swart, TGP de (2012, October 9)
Bereikbaarheidsanalyse van paprika's aan een virtuele plant

Verhoijsen, W. (2012, December 17)
Probleemanalyse vleeskuikensector en bepaling van herkenningstechnieken voor dode kuikens

MSc projects completed in 2012

Meer, JB van der (2012, February 2)
Improvement of the adaptive model for dynamic feeding of dairy cows

Zerom, HH (2012, February 8)
Estimation of mesh size and starch content of potato by machine vision application

Jong, R. de (2012, May 25)
Design of a sensor for poultry red mite in laying hen houses

Verhoijsen, R (2012, May 25)
Development of air quality improving systems in growing-finishing pig production

Wennekers, M (2012, May 25)
Effects of a heater on indoor climate and animal performance in laying hen houses

Boogaard,FP (2012, June 25)
Comparison of two fundamentally different approaches to manipulator motion planning

Lopez, AL (2012, June 25)
LCA Algae and rapeseed

Sijbrandij, FD (2012, August 23)
Decision algorithms for an automatic orchard sprayer

Kleymenov, S. (2012, September 20)
Indoor localization for an autonomous vehicle inside a poultry housing

Burgos, R.L (2012, September 14)
Effect of light illumination and wavelength light range on fattening pigs excretory behaviour along the time

Kroes, K (2012, October 16)
Design and evaluation of a Black Soldier Fly (Hermetia illucens) rearing system

Jongmans, D. (2012, October 25)
Design of a prototype planter for simultaneous cover and main crop sowing in conservation agriculture

Vossebeld, HF (2012, November 29)
Assessment of three 3D sensors for localisation of sweet-pepper plant parts

Winden, RJP van (2012, December 11)
Economic feasibility of an innovative dairy farming system and redesign of a manure segregating system

Garcia Garmendia, A (2012, December 17)
Application of critical control point theory in precision agriculture

Zundert, T van (2012, December 20)
LCA of the Dutch greenhouse tomato production system

Education

The Farm Technology Group is one of the main suppliers of courses for the Bachelor Biosytems Engineering (BAT) and the MSc Agricultural and Bioresource Engineering (MAB). For that program, the chairgroup offers or contributes considerably to the following courses:

FTE-12303 Introduction Biosystems Engineering part 1 (Dutch)
FTE-12803 Introduction Biosystems Engineering part 2 (Dutch)
FTE-13303 Introduction to Engineering 1 (Dutch)
FTE-13807 Engineering 2 (Dutch)
FTE-24306 Research Methods Biosystems Engineering 1 (Dutch)
FTE-24806 Engineering Design (Dutch)
FTE-25303 Building Physics and Climate Engineering (English)
FTE-25806 Research Methods Biosystems Engineering 2 (Dutch)
FTE-30306 Livestock Technology (English)
FTE-31306 Greenhouse Technology (English)
FTE-32306 Advanced Soil Technology (English)
FTE-32806 Automation for Bio-production (English)
FTE-33306 Advanced Biosystems Engineering (English)
FTE-33806 Biosystems Design (English)
FTE-34306 Evaluation and Redesign of Biosystems (English)
FTE-50806 Conservation Agriculture (English)
FTE-704nn MSc Internship Farm Technology (24, 27, 30, 33, 36, 39 credits)
FTE-80812 Bachelor completion Agrotechnology
FTE-804nn MSc Thesis Farm Technology (24, 27, 30, 33, 36, 39 credits)
SCO-22306 Sensor Technology
YEI-80324 Bachelor thesis Biosystems Engineering

FTE-12303 Introduction Biosystems Engineering part 1 (Dutch)

This course is the introduction course to the domain biosystems engineering. Students get an overview of the technology used in different biosystems for the production of food and non-food and they will get a good insight into the role of the different courses in the study programme.

Systems approach is the connecting thread in the course and the course will start therefore with an introduction to systems theory and analysis. The course then continues with lectures, tutorials, and practicals on topics relevant in nowadays biosystems engineering: automation, energy, environment and welfare, climate control, and (agro)production chains and logistics. Special attention is given to the importance of the (agro)production chain for technology in biosystems. Students work in small groups on calculations and computer simulations related to real problems in the area of biosystems engineering. Excursions are organized to make the technology visible to the students on different levels in the production chain (farm, processing industry, wholesaler) visible.

The course also incorporates some skills modules. The module CCI makes the students acquainted with the more advanced functions of office applications (Word, PowerPoint and especially Excel). The module Information literacy makes the students acquainted with retrieval of information from different sources. Students have to prepare a report on relevant technology in the framework of biosystems engineering. An introduction to oral presenting is also part of the course and at the end of the course the students have to give a brief presentation on the report they prepared.

In the first part are the introduction to systems theory and analysis, two of the five relevant topics, the module CCI and the introduction of the module information literacy.

FTE-12803 Introduction Biosystems Engineering part 2 (Dutch)

This course is the continuation of FTE-12303 Introduction Agrotechnology part 1. See the description of that course. This second part covers the remaining three relevant topics, the module oral presenting and the preparation of the report.

FTE-13303 Introduction to Engineering 1

In this course the students are introduced to selected engineering topics that demonstrate how engineers approach problem solving and arrive at correct solutions. These subject areas are common to most engineering disciplines that require the application of fundamental engineering concepts. Subjects in the course are engineering solutions, presentation of technical information, engineering measurements and estimation, dimensions and units, mechanics, material balance, energy, and electrical theory. Students will also follow some practicals at ptc+ in Ede. Attention is also paid to the engineering profession. This course includes some excursions to relevant companies. The students also have to prepare a brief internship to be spent (in the next period) at a relevant company or organization in the field of biosystems engineering.

FTE-13807 Engineering 2 (Dutch)

This course is the second part of introduction to engineering. In this part there is a module on CAD (Computer Aided Design), electronics, and lectures and tutorials on mechanics. There are also some excursions to relevant industries or organizations and students have to fulfil a brief internship. At the end they have to prepare and present a poster on their experience and inform the other students on their experience.

In the CAD module the students learn the basic principles of CAD. It starts with making hand sketches of simple technical objects and continues with the learning of a 3D modelling programme (AutoCAD Inventor). In this programme parts of technical systems are modelled and technical drawings documented. Finally, calculations on mechanical stress will be done.

The module electronics gives an introduction to the basics of modern electronics. From the basic elements (resistors, capacitors and coils) circuits will be built and analyzed with a focus on the frequency response. The theory of diodes and transistors will be explained and tested in practice. All this being the start of more advanced elements like the operational amplifier in both feedback and non-feedback applications. Furthermore the production process (steps and techniques) of integrated circuits (chips) will be presented. In the course students will also learn about basic digital circuits (gates, flip-flops) forming the fundamental base of modern digital computers.

FTE-24306 Research Methods Biosystems Engineering 1 (Dutch)

In this course the students learn the different steps of doing research: problem analysis - problem definition - objective of the research - research questions - project proposal - execution of the research - presentation of results - discussion - conclusion. The students will exercise these different steps by a number of related assignments.

Included in the course are practical exercises where the students are faced with biological and natural variability and where they are instructed how to approach this phenomenon present in most biosystems.

In this course the students prepare (in groups) their own research project (selecting topic, making project proposal, search for information) which is to be executed in the course Research methods biosystems engineering 2.

FTE-24806 Engineering Design

In this course the students will learn the consecutive steps of the structured design methodology according to Van den Kroonenberg and exercise the related tools. Main content parts of the course are making an inventory of the needs, defining the design problem, perform a novelty and state-of-the-art research (patent search), learn and apply intuitive and discursive methods, setting up a brief of requirements, assessment of the main function, function analysis (IDEF0), developing a morphological chart, evaluation of alternatives, and systematic choosing of solutions.

In groups students will design a technical device in CAD. They have to create the different parts, assemblies and documentations of the device. As a result 3D model of the device is generated with engineering drawings that allow prototyping of the (best) concept. The student will exercise methods and use design supporting software in the case study. An excursion will be made to manufacturing industry to show the students the practice of engineering design and manufacturing in industry.

FTE-25303 Building Physics and Climate Engineering (English)

This course is the continuation of Physical Transport Phenomena and has the objective to introduce you to the climate engineering items relevant for biosystems engineering. The following subjects are part of the course:

- building physics - thermal insulation of constructions and thermal stability of constructions and room systems;
- psychrometrics - Physical properties of humid air and air conditioning processes;
- comfort areas for indoor climate;
- ventilation requirement calculation;
- design and evaluation of air distribution systems;
- energy demand for agroproduction in buildings;
- solar energy - passive and active for solar energy collection and use;
- (data processing in Excel).

FTE-25806 Research Methods Biosystems Engineering 2 (Dutch)

In this course the students have to execute in groups their own small research project. The students have to prepare a report on their project and present the results orally.
Explicit attention in this course will be given to the different aspects of group work (team activities, organizational, social).

FTE-30306 Livestock Technology (English)

Developments in livestock production systems are driven by (internal) farm and sector opportunities, market & consumer demands, national and international legislation and societal issues, as covered by the sustainability concept People, Planet & Profit. This course focuses on technological aspects and processes in livestock production systems and on development and application of new technology to support realization of sustainable animal production systems. In this course these systems are mainly delimited to on farm production and directly related links in the food chain. The interactions and relations between the biological entities (at animal level), technological artifacts and human management play a central role. The course deals with technological aspects of five sustainability themes and with three
engineering themes. The five sustainability themes are animal welfare (animal needs & surroundings), animal health, and environment (gaseous emissions and animal waste handling), food safety, and food quality. The three engineering themes are 1) building physics and indoor climate 2) mechanics of building constructions (statics) and 3) farm management and logistics. For each theme current systems and technology are described, in depth knowledge on the technology is presented, management and control of related problems are dealt with as well as the latest innovations in each area. Typical examples of subjects are 1) constraints for the design of sustainable systems including societal demands, 2) sensors and information technology for quality monitoring, product processing, milking and feeding systems, 3) the concept of precision livestock farming, 4) management of the aerial environment of animals, 5) minimization of emission hazardous gases, and waste processing.

FTE-31306 Greenhouse Technology (English)

The content of the course focuses on engineering aspects of greenhouse horticulture systems in relation to crop growth and development. The course aims to prepare for a major on Greenhouse Engineering and puts emphasis on calculation and analysis. In depth topics of the course are crop response and growth factors, physics of the greenhouse climate, cultivation systems, greenhouse construction, aerial environment, root environment, greenhouse climate and equipment for climate control, new and smart technology.
As a student you will be confronted with theoretical backgrounds and with methods that are generally used in protected cultivation. You will use this knowledge in exercises (both manual

and model based) and in analysis of an integrated system. Focus is both on the Dutch and on the international protected cultivation.

FTE-32306 Advanced Soil Technology (English)

This course offers a common part with an in-depth treatment of various aspects of soil technology and tillage, such as: (a) methodologies and techniques for measuring soil physical, mechanical and dynamical parameters, both in the field and in the laboratory; (b) approaches for research in tillage and soil mechanics, modeling the effects of tillage on soil structure and related parameters (water, gas, strength, erosion), including prediction methods. In this part, each student studies a scientific paper and reports approach, methodology and findings to fellow students, followed by discussion.
In addition to this common part, the student chooses to study in detail a case, leading either to a specialization in 'agro technology' (labor, machinery, agronomy) or to an emphasis on tropical subjects (tillage systems for various climatic regions, irrigated farming and conservation tillage systems).

FTE-32806 Automation for Bio-production (English)

Agriculture is challenged to overcome increasing labor costs, decreasing availability of labor and increasing demands concerning precision, product quality and reduction of environmental and animal load. As can be seen in Western Europe an important solution is to replace human labor by automation in areas such as arable farming, livestock farming, and horticulture. Examples of automation are milking robots, GPS steering of tractors, autonomous vehicles and automated harvesting in greenhouse production. The design and implementation of such automated systems is expected to be at the heart of agricultural innovation the next decades.
The guideline for this course is taken from the robotics domain and is stated as: 'Robotics is the intelligent transformation of perception into mechanical action'. To realize these transformations sensors, actuators, manipulators, vehicles, computers and decision systems, are important components. These components and how they may be applied to design automated agricultural systems constitute the contents of this course.
The theoretical part of this course will be presented during lectures. Practical assignments concern the design, programming and control of robot manipulators and autonomous vehicles.

FTE-33306 Advanced Biosystems Engineering (English)

This course is the introductory course for the MSc Biosystems engineering. The central theme for the course is how society is going to be prepared in the post-fossil fuel area for the production of food, fuel, and biomaterials. The main objective is to introduce a systematic approach to technology development and engineering of systems for a biobased society. The starting point is the technology for sustainable (future) production of biomass for food or non-food. An important connecting thread throughout the course is the development of alternative systems for the production of biomass where system boundaries may move. Today's production of biomass is organized on-farm and the processing is off-farm but this may be challenged in the future to reach a more optimal and sustainable system. Chains and cyclic processes are important since solutions are expected to arrive from approaches beyond farm level.

The course also gives an overview of the different techniques available for a biosystems engineer and provides a link to different other courses in the programme.

FTE-33806 Biosystems Design (English)

In the course the students apply a structural engineering design method to a typical biosystems engineering related design problem with a focus on system innovation. Sustainability aspects of ecological, economical and social order play an important role in the course. The problems / cases in this course are more complex and on a higher systems level than in the course Engineering Design (FTE-24806). It includes an extensive state-of-the-art analysis (semantic search, patent and knowledge research, market exploration and innovation trend analysis). Important aspects of the course are also the organizational aspects of the design project, e.g. the role of stakeholders and the design contract. The design methods taught in FTE-24806 are starting point and extended with methods like technology landscaping, theory of inventive problem solving and predictive failure analysis. Some typical case studies of technological innovations in biosystems have to be studied and will be presented and discussed. Students have to apply the theory and the ideas behind it to their own design case.

Part of the course is a multiple day excursion in which relevant organisations, universities, and industries in the Netherlands and surrounding countries are visited. The students have to write a report of this excursion. This multiple day excursion is organised together with the excursion in the course FTE-34306 Evaluation and Redesign of Biosystems.

FTE-34306 Evaluation and Redesign of Biosystems (English)

This course focuses mainly on the evaluation of design concepts based on innovative ideas and technology for new biosystems. These biosystems have to be evaluated on different aspects to determine whether the ideas are realistic or not (the critical success factors). A preliminary design will be evaluated on different aspects to determine whether the idea will be feasible or not and determine the critical success factors. The students will learn and apply different types of evaluation (economical costs and benefits, various environmental impacts, physical layout and impact, timeliness, work methods and labor requirement,.....) Important aspect is that for a full assessment on all aspects the evaluation of the design concepts has to be performed under limiting availability and uncertainty of information. Students have to address experts and various information sources to make best educated assumptions, and analyze the importance of the different factors by a sensitivity analysis of the different success factors for the unknown parameters. They have to reflect on the chosen assumptions and calculation methods and indicate which of them are limiting.

The course comprises a multiple day excursion with visits to relevant organizations, universities, and industries in the Netherlands and surrounding countries. The students have to write a report of this excursion. This multiple day excursion is a joint activity with the excursion in the course FTE-33806 Biosystems design.

FTE-50806 Conservation Agriculture (English)

This course examines the concept of Conservation Agriculture (CA) and its effects on ecosystem services. CA is a system based on integrated management of available soil, water and biological resources, combined with as little external inputs as feasible. CA relies on three principles, which must be considered together for appropriate understanding, design and application:

- a (semi-)permanent organic soil cover in order to protect the soil physically from sun, rain and wind and to feed the soil biota;
- minimal disturbance to the soil through no or reduced tillage, and;

- crop rotations to optimize the use efficiency of natural and external resources. CA is spreading rapidly in Europe and abroad as a potentially powerful basket of technologies, applicable in a wide range of environments to achieve sustained production, reduce environmental and economic risks and protect land and water resources. However, its effect on soil ecosystem services generally receives little attention.

Course components:

  - replacement of mechanical by biological tillage (soil micro-organisms, roots and soil fauna taking over the tillage function)
  - biological soil fertility management and water balancing through soil cover and crop rotation management
  - trade-offs between various uses of crop residues;
  - the choice and management of (cover) crops and crop rotations are meant to ensure sufficient biomass production of food and other crops, livestock feed and residue cover for the soil.

Crop residue management is meant to stimulate soil structure formation by the soil biota, improve soil fertility and soil water management and help to control diseases, pests and weeds with less dependence on pesticides. Novel technologies and equipment for field operations CA implies the design and use of modern precision agriculture technologies such as the use of RTK/GPS and adapted equipment to cultivate the land without trafficking;

Management and management options at farm level;

CA demands a different, unconventional way of making choices on crops and crop rotations, and needs to consider alternative and additional factors for taking decisions on how to manage the farm Soil ecosystem services

CA claims to be beneficial in terms of reduction of soil erosion and water run-off and the sustained provision of ecosystem services, such as water storage and supply under conditions of water surpluses and shortages, respectively; the retention of nutrients; the reduction of soil-borne pests and diseases; and the sequestration of carbon.

The course critically addresses the above issues by discussing and studying the various components of CA, with special emphasis on management and soil. It will analyze the bottlenecks in application of CA in order to find an explanation of the successes as well as the failures..

SCO-22306 Sensor Technology

Sensing is an important part of automation in agriculture and the Farm Technology Group provides major contributions to this course. The focus of the course is on a proper usage of sensors. Therefore this course presents briefly a number of different sensors to measure pressure, temperature, pH, velocity, acceleration, position, distance and angles etc. This course teaches you how to obtain information concerning accuracy and disturbances from datasheets and other documentation that comes with any sensor. Different types of sensor errors and ways to suppress them can be distinguished and are addressed in this course. This course also teaches different measurement principles such as compensation and Wheatstone bridges. These principles guide the engineer when designing a measurement set-up. The accuracy of sensors can often be improved by calibration that is also considered in this course. Signal conditioning, analog to digital (A/D) conversion and sampling (frequency spectrum, Shannon' s theorem, spectral analysis of signals) are important issues treated in this course as well as related phenomena as aliasing and filtering.

Considerable attention will be given to imaging sensors. Imaging sensors are a very special, sophisticated type of sensors that are being used to obtain 2 or 3 dimensional information of a system. These sensors become increasingly important in agricultural automation. The processing of the resulting images using computer vision techniques constitutes an important part of this course.

YEI-80324 Bachelor thesis Biosystems Engineering

The student works individually under supervision of a staff member on a thesis subject relevant for the domain of the study programme. The student has to analyse the problem, prepare a project plan, execute the project plan, do experiments if necessary, write a thesis report and present the work in an oral presentation. The essence of the course is that the student proofs that she/he master the competences related to the BSc Biosystems Engineering.

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In: XXVIII International Horticultural Congress on Science and Horticulture, Lisbon, Portugal, August 22-27, 2010. - Acta Horticulturae 927 (2012). - ISSN 0567-7572Lisabon Portugal : ISHS, 2012 - ISBN 9789066057241 - p. 51 - 58.
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Real-Time Detection and Control of Weeds: Present and Future
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