臺大國際學院
International College
National Taiwan University

THE 16TH INTERNATIONAL WORKSHOP ON NONDESTRUCTIVE QUALITY EVALUATION OF AGRICULTURAL, LIVESTOCK AND FISHERY PRODUCTS

ORGANIZERS:

- Department of Biomechatronics Engineering, National Taiwan University
- Taiwan Agricultural Mechanization Research & Development Center

CO-ORGANIZERS:

- Chinese Institute of Agricultural Machinery, Taiwan
- Taiwan Institute of Biological Mechatronics
- Center for Intelligent Agriculture Education and Research, National Taiwan University
- Bioenergy Research Center, National Taiwan University

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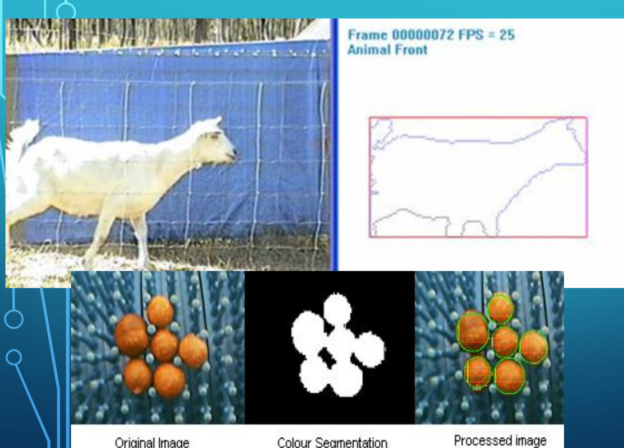
USING NON-INTRUSIVE SENSOR TECHNOLOGIES IN AGRICULTURE PRODUCTION



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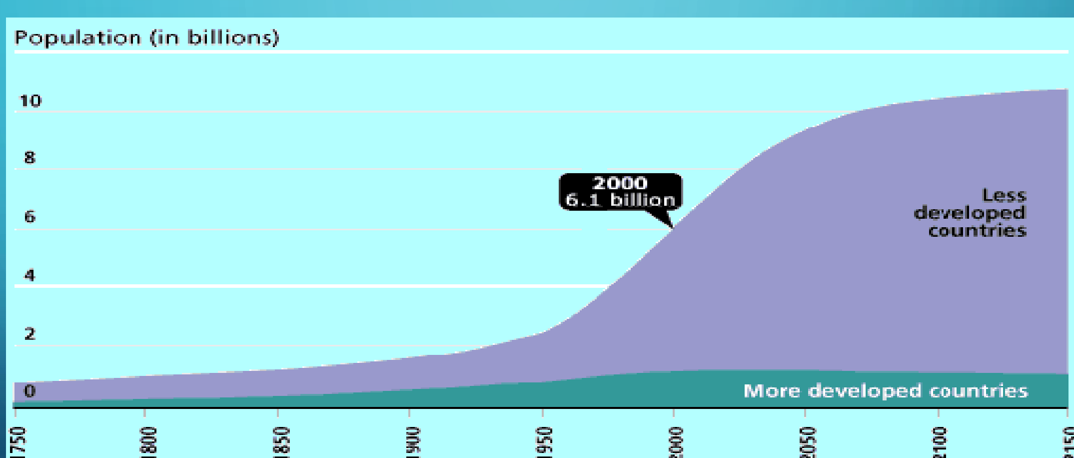
- Dr Mark Dunn, (CSIRO, Australia)
- Prof. Irenilza de Nääs (University of Campinas, Brazil),
- Studies were funded by various organisations, including the EU commission, Australian Pork Limited, RIRDC, Pork CRC, University of Adelaide, AusIndustry and private companies

When not otherwise stated, photos were taken by the author

NEED FOR CONTINUED AGRICULTURAL PRODUCTION

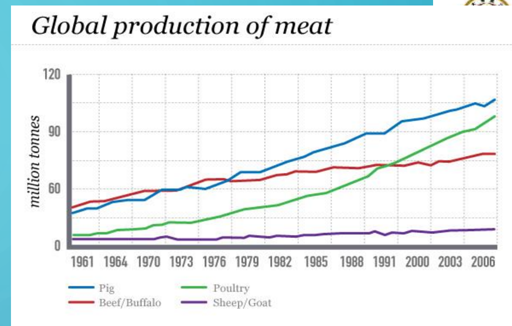
- World population, exponential trend, 10 billion in 2050



Source: Population Bureau (2005). Human Population: Fundamentals of Growth. http://www.prb.org/Content/NavigationMenu/PRB/Educators/Human_Population/Population_Growth/Population_Growth.htm

CHALLENGES

- Increasing human population and therefore, demands for food



- Drivers of efficiency:
  - Economic issues – the long term declines in terms of trade for agricultural products
  - Resource depletion, scarcity and adverse changes in the environment
  - Welfare, social licence for agricultural production

Tokyo Drifts from Seafood to Meat Eating - Our World (unu.edu)

GENERAL ANALYTICAL (DATA SCIENCE) PROCESS

1. Identify problem / question
2. Identify & capture the available data
3. Prepare data: clean & transform
4. Analyze data: Statistics, AI, Modelling
5. Create report/feedback with results, visualization, insights

GENERAL ANALYTICAL (DATA SCIENCE) PROCESS

6. Embed results into business / decision making

- Directly adjust your operation depending on the result – farms are process driven, not designed for fast responses. Furthermore, there are problems with perceived reliability of data.
- Use results for decision making (at various levels of the organization) – farm workers are not necessarily empowered to make decisions. They usually follow SOP.

There are also serious issues with:

- data security, privacy, safety
- data ownership

BASIC CONCEPT

- PLF is aimed at enhancing farm
  - profitability/efficiency,
  - social acceptance and
  - sustainability
- by improving on-farm:
  - acquisition,
  - management and
  - utilisation of INFORMATION
- that can be used for improved
  - health,
  - welfare and
  - production management of various livestock species

TARGETED DATA COLLECTION

- Identify the measurements which are needed to facilitate the MOST important decision making processes on farms – remember the previously mentioned data science steps!
- Health, welfare and productivity indicators (direct & indirect)

AUTOMATED DATA INTERPRETATION

- Identify appropriate data analysis and interpretation systems that allow decisions to be made from the collected data (AI or statistics or Nutritional/biological models, AUSPIG)
- Appropriate interpretation of data for health, welfare assessment

https://www.pig333.com/articles/pig-production-in%E2%80%A6-france-third-largest-pig-producer-in-europe_14568/ https://www.rotecna.com/en/blog/growth-and-opportunities-for-south-african-pigs/

AUTOMATED OR NON-AUTOMATED INTERVENTION

- Identify appropriate electronic or other control systems that enable implementation of control actions based on the analysis of the recorded data (automated climate and feed control systems)
- Automating health, production & welfare interventions?

https://www.alltech.com/blog/us-pork-industry-committed-sustainable-pig-farming https://www.pig-world.co.uk/features/pig-production-in-a-zinc-oxide-free-and-low-medication-world-the-danish-perspective.html

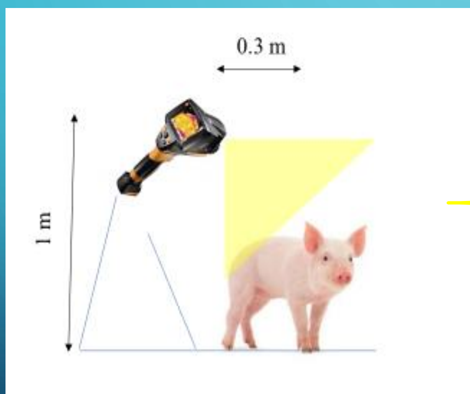
Work undertaken in Brazil (Prof. Naas & team):

With a robust dataset it is possible to develop an AI model that can predict specific stress conditions in pigs such as:

- Surface temperature, and
- Vocalization

The implementation of the models increases over time since the model might be able to continue learning when being used.

PROCESS AUTOMATION
STRESS IN PIGS USING DATA FROM SURFACE TEMPERATURE

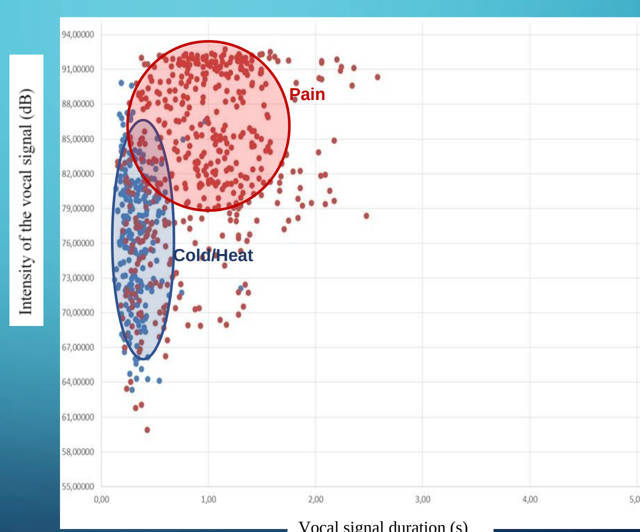


Hunger
Thirst
Fear
Pain
Normal
Cold
Heat

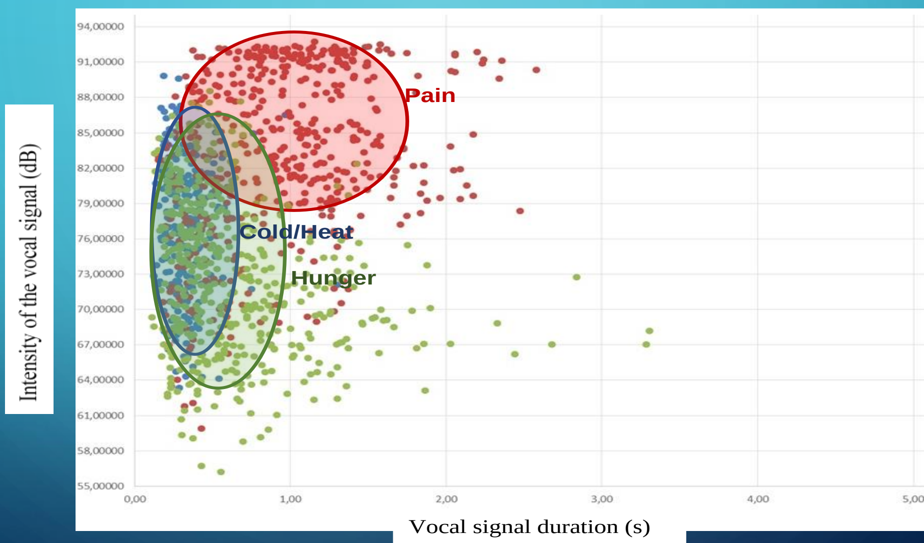
Algorithm developed using data mining and paraconsistent logic

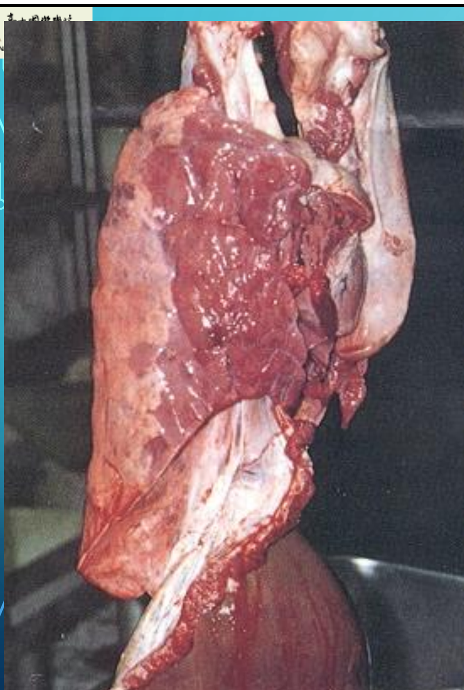
PREDICTING STRESS IN PIGS USING VOCALIZATION

- Vocalizations were recorded during
- cold,
- hunger,
- normal,
- heat,
- fear



SIGNAL ANALYSIS IN DB

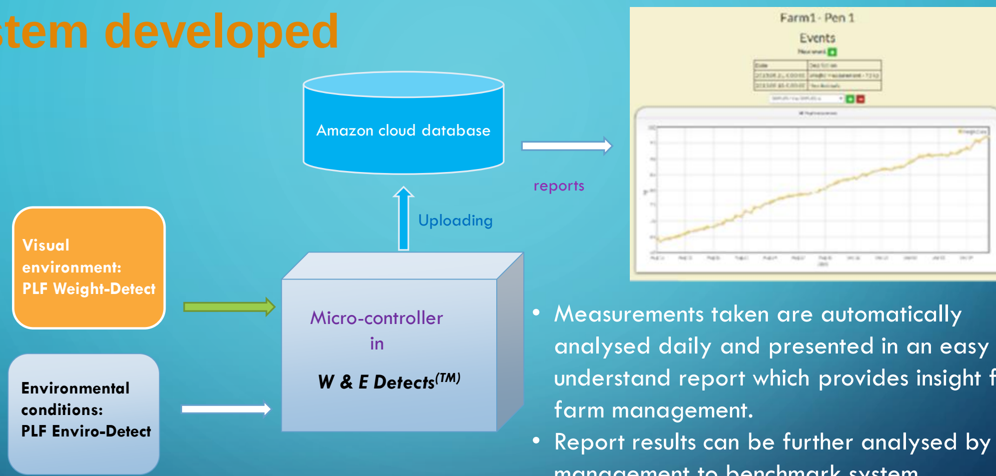




BACKGROUND 2

- high concentration of ammonia (NH_3) and dust (PM 2.5 & 10) are the main concerns
  - Health risks for livestock and farm workers
  - Production loss and compromised health/welfare
- Combined effect of NH_3 and dust can seriously damage respiratory tract of animals and humans (Donham et al., 1977; Banhazi 2018).

System developed

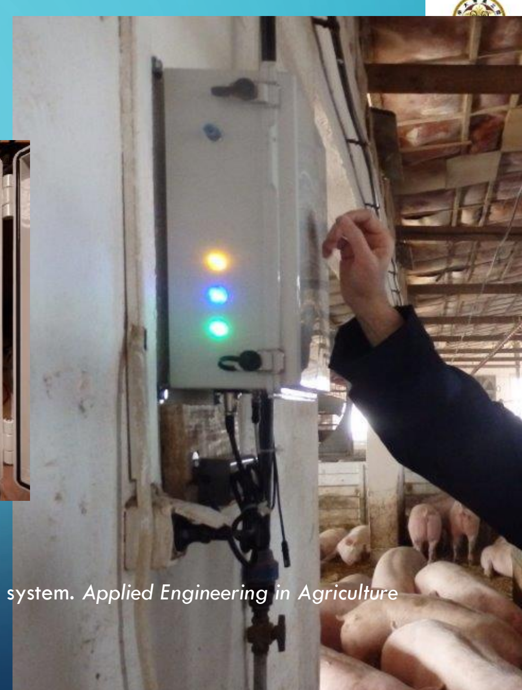


Parameter	Resolution	Range	Accuracy
CO2(ppm)	1	0-10000	±1%
NH3(ppm)	0.5	0-100	±1%
Dust (ug m-3)	10	0-1000	±1%
Temp (oC)	0.1	-40 to 125	±0.5%
RH (%)	0.7	0 to 100	±3%

- Measurements taken are automatically analysed daily and presented in an easy to understand report which provides insight for farm management.
- Report results can be further analysed by management to benchmark system performance.
- **System *enables management to optimize the livestock production process, improve productivity, animal welfare and environmental sustainability***

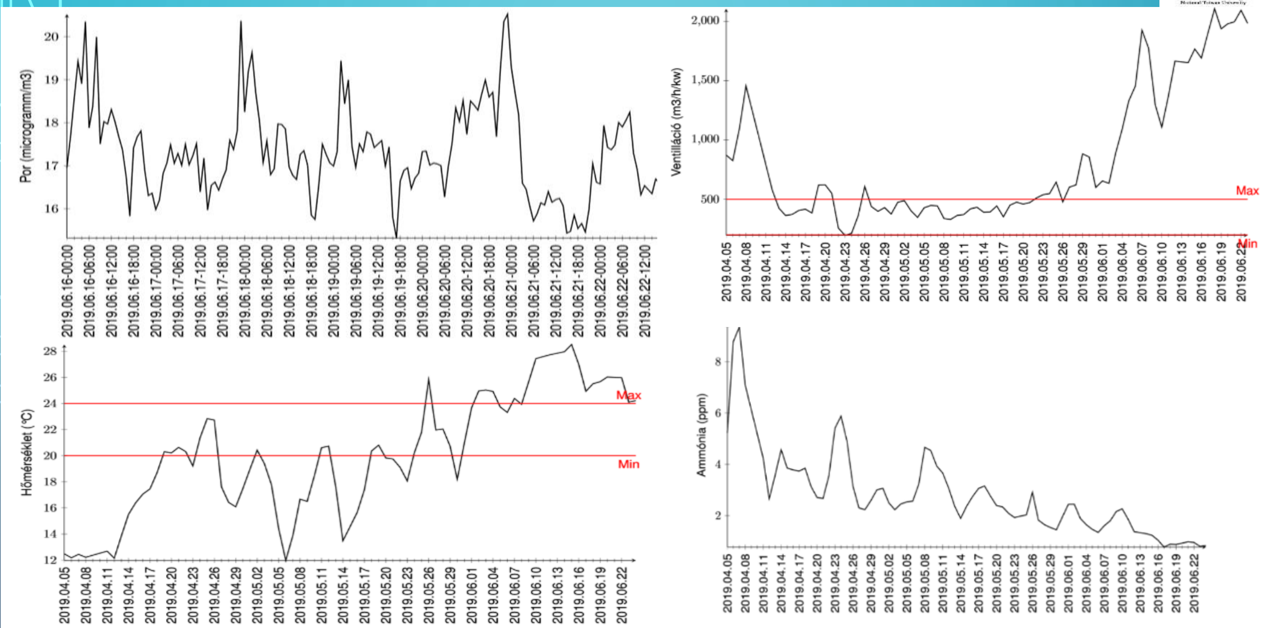
ENVIRO-DETECT™

- **Enviro-Detect™ was created to facilitate routine assessment of environmental conditions on commercial farms**
- **The unit contains cost-effective components for measuring ventilation rates, air temperature, relative humidity, the concentrations (EMISSIONS) of carbon dioxide, ammonia and dust (methane & airspeed)**



Banhazi T.M. (2009) Development of a mobile air quality monitoring system. *Applied Engineering in Agriculture* **25(2) 281-290**

EXAMPLES OF THE AUTOMATED REPORT



WEIGHT-DETECT™

- Designed to determine the average group weight of a pen of pigs
- Sample weights of the pigs within the pen are recorded non-invasively
- Several dimensional measurements are acquired from images to reliably predict live weight
- Weight-Detect™ will provide a performance record of animals on a daily basis

Banhazi T.M., M. Tscharke, W. M. Ferdous, C. Saunders and S-H. Lee (2011) Improved image analysis based system to reliably predict the live weight of pigs on farm: Preliminary results *Australian Journal of Multi-disciplinary Engineering* **8 (2) 107-119**

EXAMPLES OF THE AUTOMATED REPORT

3 PEN 8

1.2.1 Actual status

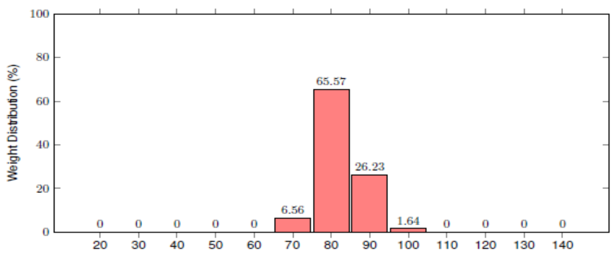


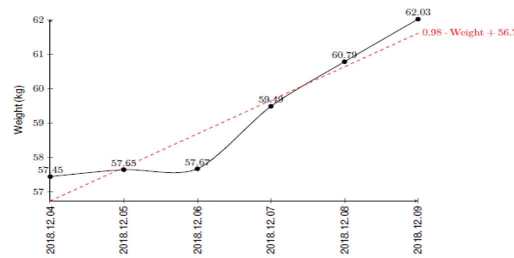
Table 1: Summary (last week)

Days	Starting weight	Finishing weight	Weight gain	Growth rate
7	84.7 kg	88.5 kg	3.7 kg	618.3 g

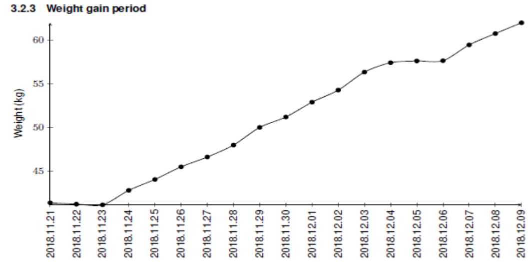
Table 2: Summary (weight gain period)

Days	Starting weight	Finishing weight	Weight gain	Growth rate
58	39.8 kg	88.6 kg	48.8 kg	855.8 g

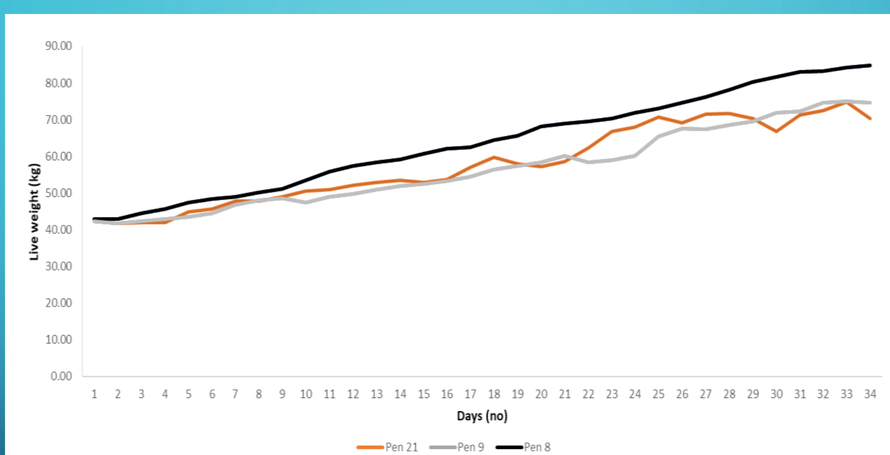
3.2.2 Last week



3.2.3 Weight gain period

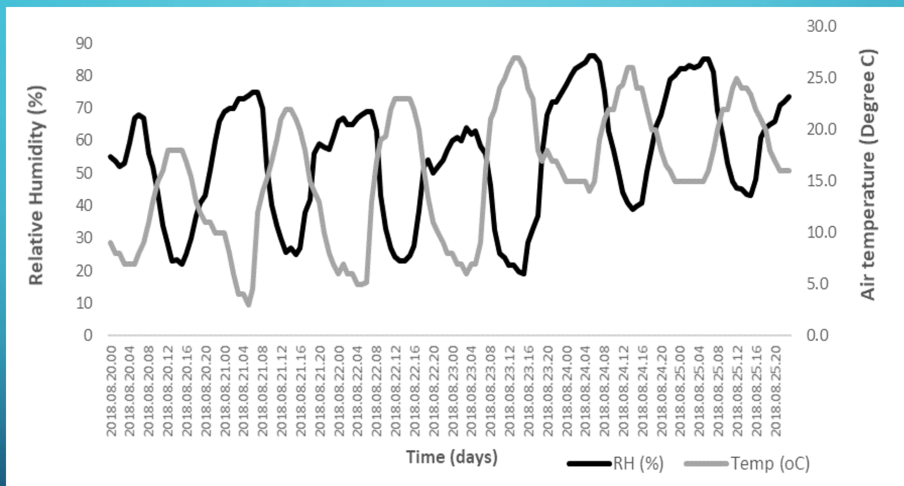


DIFFERENCE IN ADG



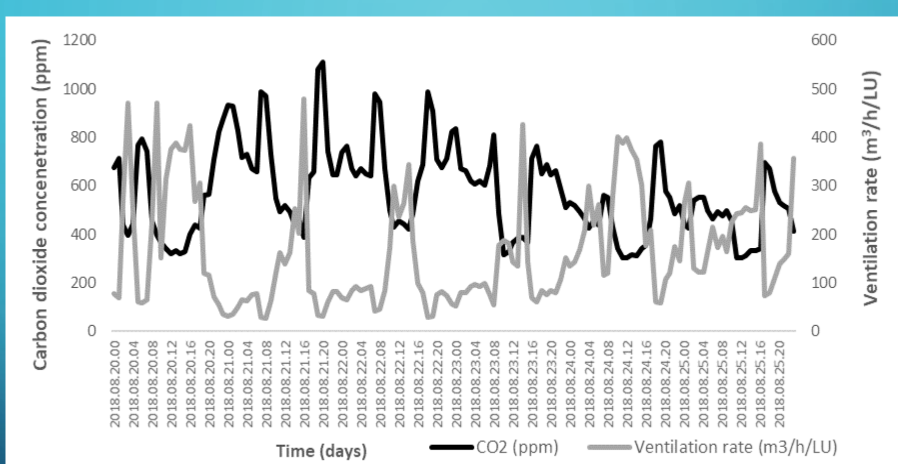
Live weights (kg) recorded on farm 'X' in different pens and different buildings during similar time period. Pigs started from identical starting weight. Pigs in pen 8 achieved an ADG of 1.20 kg over 34 days, while in pen 21 animals grew at a much lower rate achieving an ADG of 0.82 kg over the same 34-day period. Pigs in pen 9 grew at the rate of 0.95 kg (ADG) over 34 days.

AIR TEMPERATURE & RELATIVE HUMIDITY



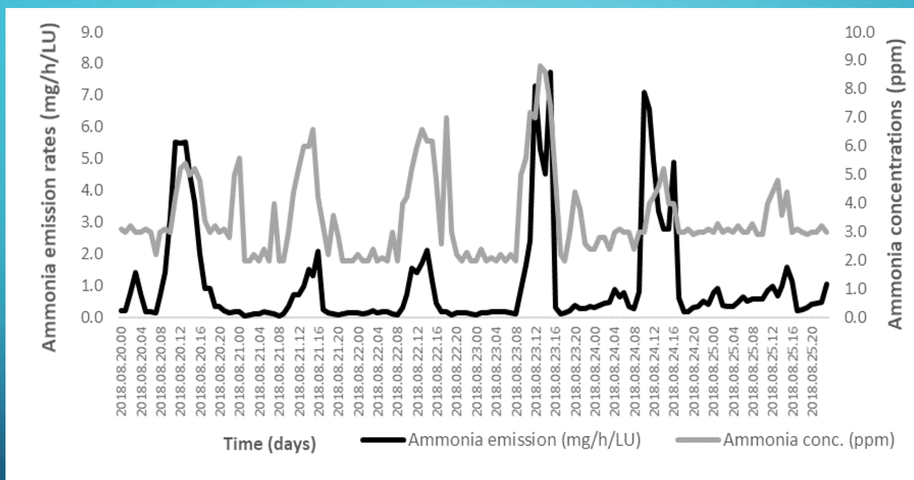
Air temperature (°C) and relative humidity (%) values measured continuously in one of the study buildings on farm 'X' over a 6-day period.

VENTILATION RATE & CO_2 CONCENTRATIONS



Ventilation rate (m^2/h/LU or Livestock Unit) and carbon dioxide concentrations (ppm) values measured continuously in one of the study buildings on farm 'X' over a 6-day period.

AMMONIA CONCENTRATIONS & EMISSIONS



Ammonia concentrations (ppm) and ammonia emission rates (mg/h/LU or Livestock Unit) measured continuously in one of the study buildings on farm 'X' over a 6-day period.

DIFFERENCES IN BUILDING ENVIRONMENTS

Parameters	Building A: pen 8 & 9	Building B: pen 21	P
Temperature (°C)	19.8	17.4	<0.05
Humidity (%)	63	57	<0.05
Carbon dioxide concentration (ppm)	748	477	<0.05
Ventilation rates (m^2/h/LU)	108	198	<0.05
Ammonia concentration (ppm)	1.1	2.9	<0.05
Dust concentrations (mg/m^3)	0.098	0.192	<0.05

Environmental parameters in the different pens/buildings averaged over 34 days

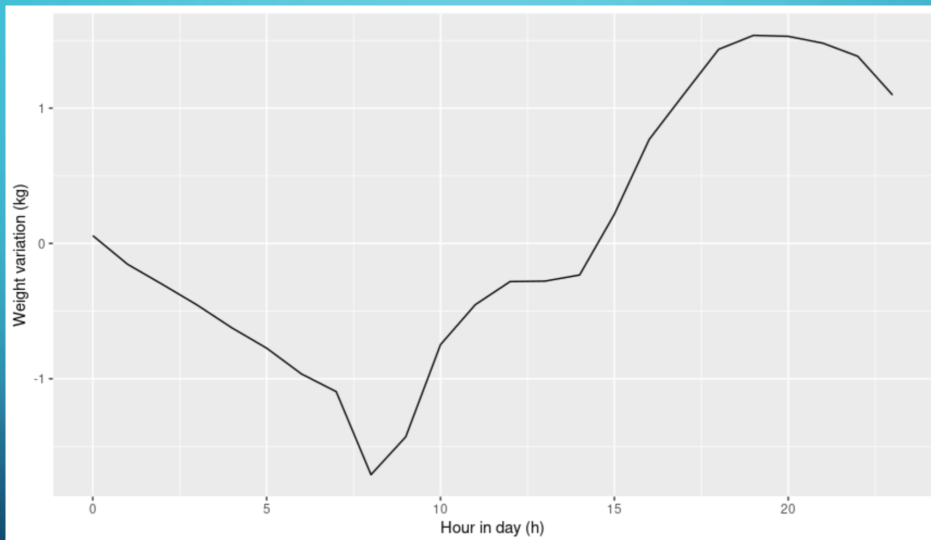
RESULTS

- Significant differences ($p<0.05$) were detected in all environmental parameters recorded in the two livestock buildings
- There was an association between environmental parameters and the performance of pigs in the particular building.
- Other parameters such as health status, medication/vaccination, stocking density etc. could also impact on the performance of animals, BUT the likely influence of the prevailing conditions in the study buildings was obvious.

PIG WEIGHING AND FEEDINGS SYSTEMS

Osborne FIRE Pig Performance Testing System - YouTube

DIURNAL VARIATION OF BODY WEIGHT FOR W2F PIGS



Z. Liua, X. Zhang, B. Ji, T. Banhazi, C. Lia, S. Zhaoa (2023) Analysis of diurnal variations in body weight of wean-to-finish pigs *Biosystems Engineering* 228(2):80-87 https://doi.org/10.1016/j.biosystemseng.2023.02.010

WALK-THROUGH SCALES

https://www.youtube.com/watch?v=_-9MWLXoReA

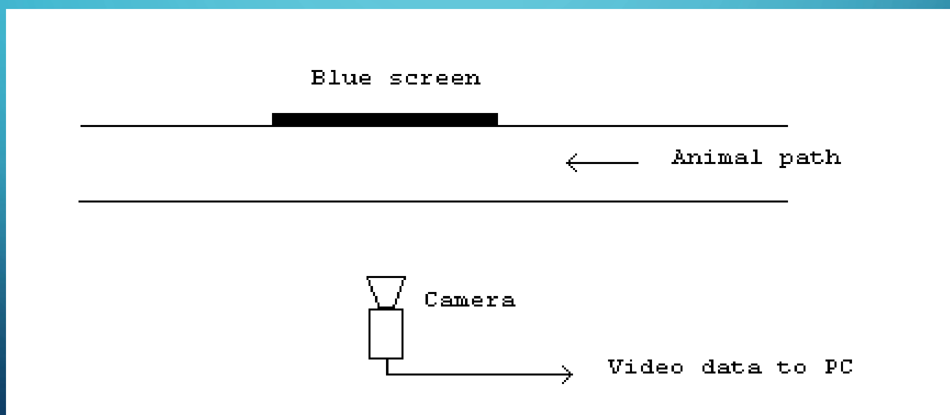
ROBOTIC MILKING: DAILY BODYWEIGHT, FEED INTAKE, PRODUCTION DATA, MILK COMPOSITION, ELECTRICAL CONDUCTIVITY, MILK TEMPERATURE, COLOUR, MILKING ORDER, ETC.

LIVESTOCK CLASSIFICATION AIMS

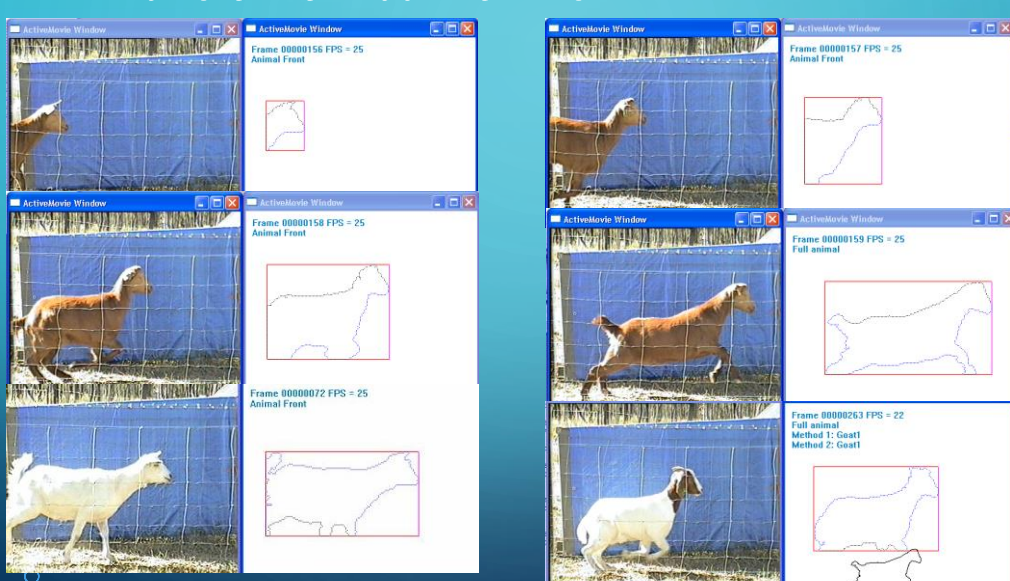
- **Key issue - Resource management**
- **Species identification – wild goat vs. sheep**
- **Action based on species**
  - Detect - Process – Identify – Action
  - Lock out non-agricultural species from watering points to discourage their presence in agricultural areas

LIVESTOCK CLASSIFICATION SETUP

Blue screen technology to ensure uniform background and facilitate easy segmentation

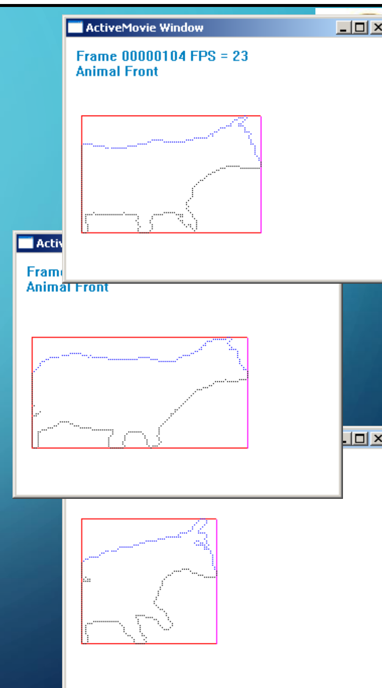


LIVESTOCK CLASSIFICATION

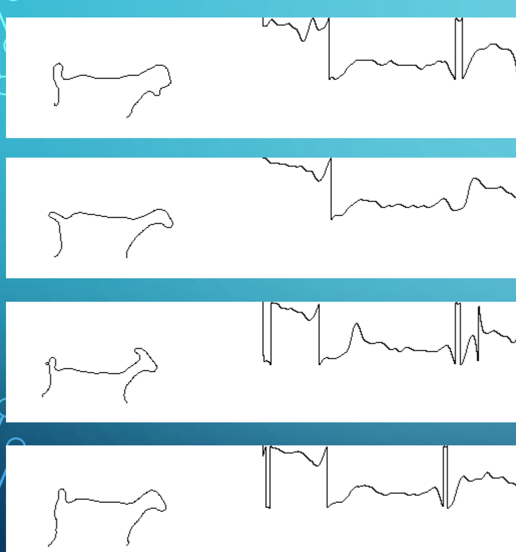


IDENTIFICATION

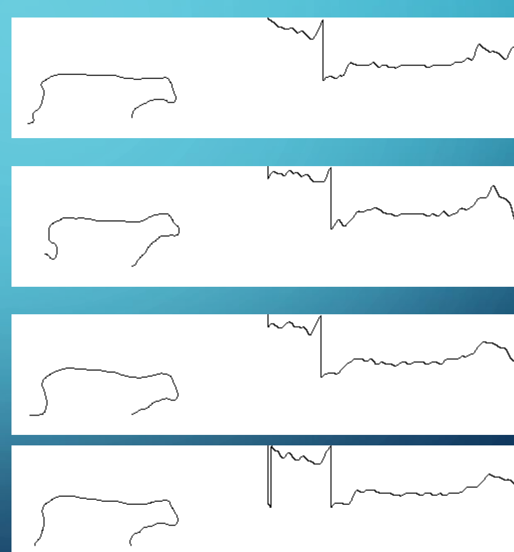
- Outline acquired from silhouette
- Edge detection and tracking
- Shape recognition technique (S-PSI)
- Template/pattern matching –fast technique based on representative samples
- Feature identification:
  - General Shape - height/length
  - Speed & posture
  - Specific Features - nose, head, legs, horns, tails etc.
- Action
  - Gate Open or Close via wireless Data transfer



GOAT TEMPLATES



SHEEP TEMPLATES



MACADAMIA NUTS YIELD MONITORING (USQ, QLD)

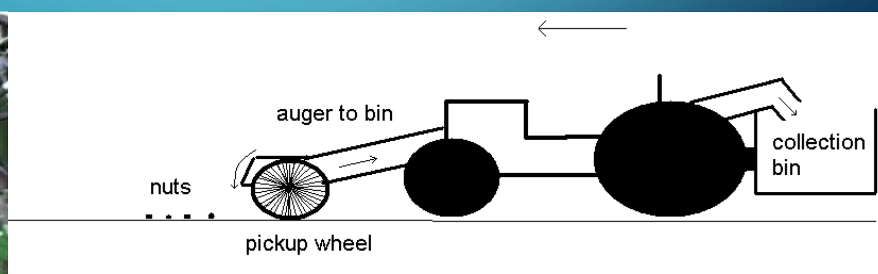
- Accurate results required for variety testing and tree evaluation
- Manual system is very labour intensive = Costly
- Large areas/ volumes to count with different:
  - Colour, size, stage of ripeness
  - Trash problem: husks, twigs, leaves, rocks, etc.






MACADAMIA HARVESTER

- Idea: mount cameras on harvester to real-time count nuts and not trash (husks, rocks, leaves etc.)
- Must be able to process > 9 fps and withstand harsh conditions



HARVESTING VIDEO

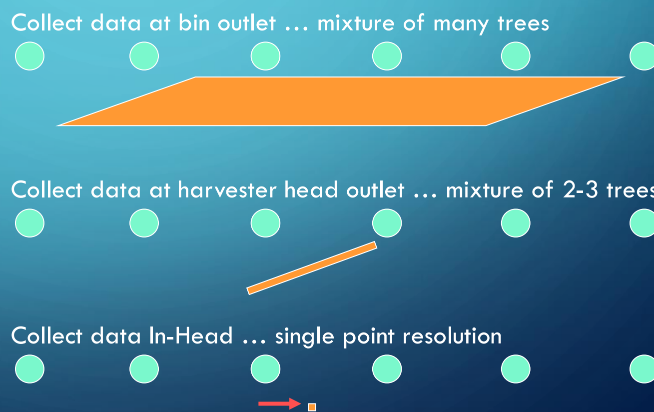
Weblink: Macadamia nut harvester X16 AMB Rousset - YouTube

NUTCAM project objectives

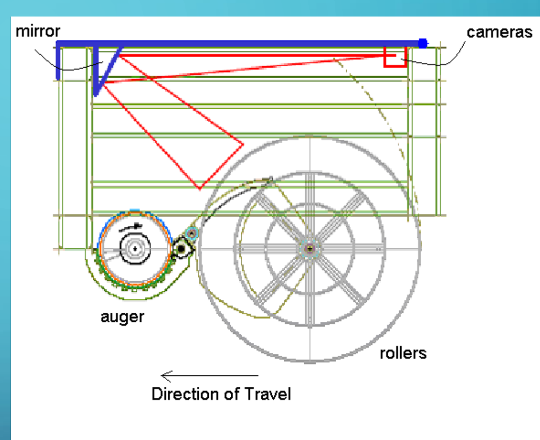
To design and develop an automated method for measuring the yield from individual trees in an orchard.

Data collated to ensure that there are no double-counts and no false data from trash etc.

Data merged with the Location data to create a Nut Count per tree.

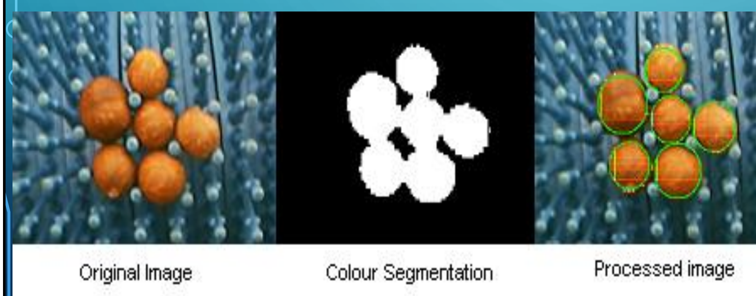


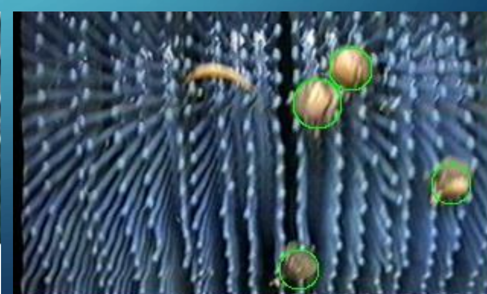
REASON FOR MEASUREMENT LOCATION SELECTED



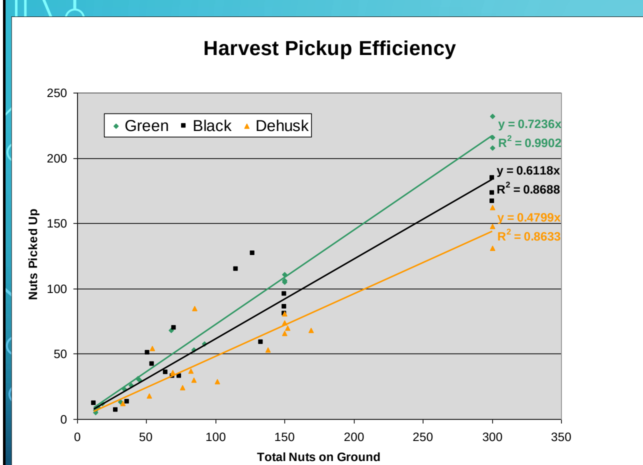
GPS+ Odometer +Treecam = sub cm positioning of data collection

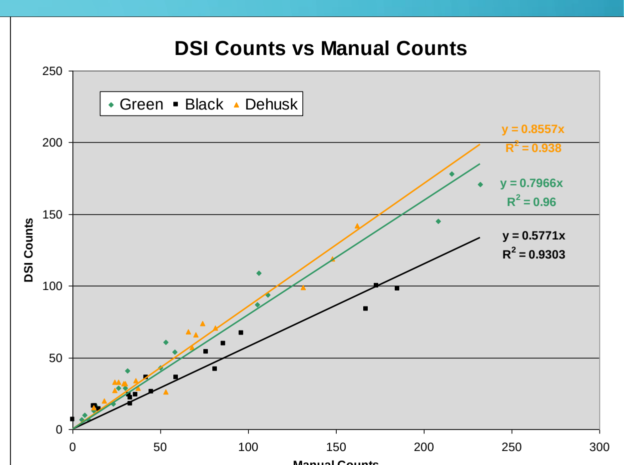
Nutcam



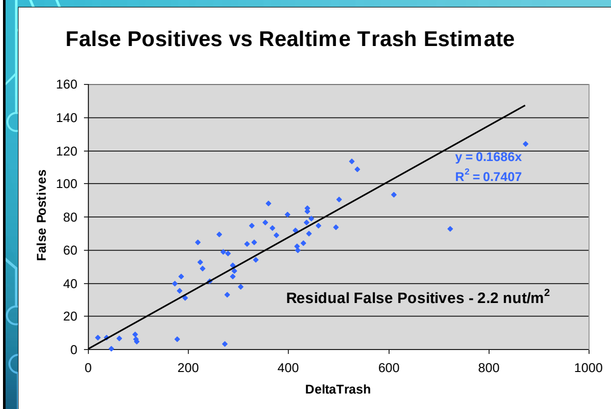


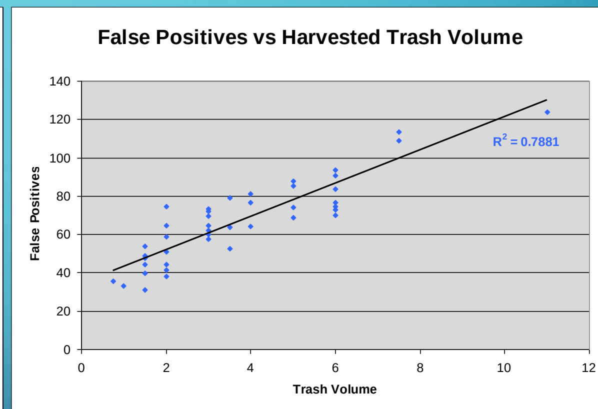
Nut Counts





Trash Estimator





COMMERCIALISATION ISSUES

- How to commercialise research outcomes at universities
- Unfortunately, commercialisation activities are often discouraged due to rigid regulations
- Large % of commercialisation efforts of universities are unsuccessful
- Not surprisingly, given the nature of commercialisation and efforts needed
- How to facilitate commercial involvements – in US & (EU) commercial involvement of uni staff are actively encouraged

SUMMARY AND CONCLUSIONS

The importance of agriculture and limited options to increase agricultural productivity

A better use of SMART agricultural systems is needed

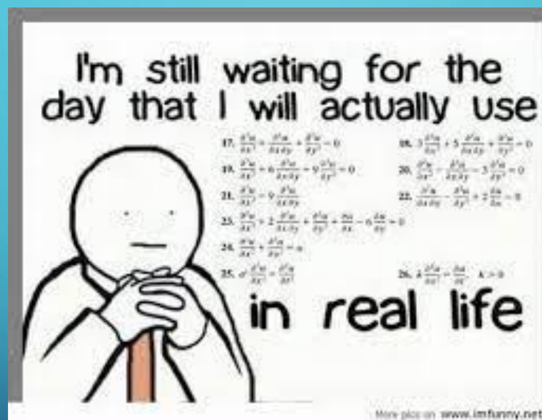
WAP PUBLICATION

Practical Precision Livestock Farming book
'Hands-on experiences with PLF technologies in commercial and R&D settings'
T. Banhazi, V. Halas and F. Maroto-Molina

published by Wageningen Academic Publishers in September, 2022

- Precision livestock farming (PLF) technologies have been heavily promoted in the past, but the **implementation of these technologies is not easy**.
- Numerous technical challenges need to be solved before PLF technologies will supply the desired information in a reliable and consistent manner. Farm **implementations regularly encounter difficulties**. The practical experience associated with these technologies do not always match their theoretical potential.
- 90+ authors from 16 countries were asked to report on the actual practical experiences technology developers and users had under farm conditions to try and understand this difference between practice and theory. This book aims to **eliminate the 'mystery' behind the 'Smart' PLF tools**, and presents the hard facts reported by individuals that have practical experience using these technologies.
- The book also explores various aspects of PLF, including the
  - **challenges associated with developing and using various technologies**,
  - (2) the importance of **training and ethical aspects** of PLF tools,
  - (3) the difficulties related to **commercialisation of PLF systems**.
- We hope that the **honest presentation of the pros and cons** of PLF management tools **will help the supporters of precision farming concepts to better use and interact with these modern technologies.**

THANK YOU VERY MUCH FOR YOUR ATTENTION



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