

Application of Data Science, Digital Tools, and Precision Farming in Changing-World's Animal Production

Ilan Halachmi

EAAP Krakow, Poland
9-11 April 2025

The PLF Lab.



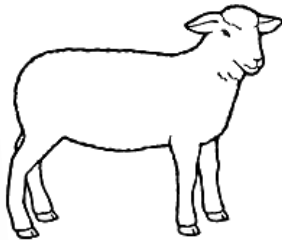
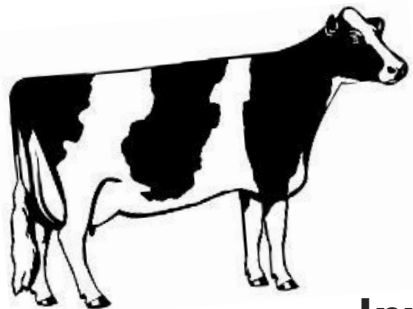
Agricultural Research
Organization (ARO),
Volcani Inst., Israel



Institute of
Agricultural
Engineering



Precision Livestock
Farming (PLF) Lab



BSF Israel
True Circular Economy



Sm@RT
Small Ruminant Technologies

101000471

TECH
CARE

GA862050



Innovative academic research to the field; teamwork; business guidance

Lecture objective and structure (30 min.):

3 ways AI is helping the EU agriculture

1. Measuring, predicting and optimizing complex systems
2. Accelerating development of sustainability solutions – farm operation, **phenotyping**
3. Empowering a sustainability staff and students

Our six AI milestones (case studies) currently running in my lab, to be presented today:

1. Sheep & Goats animal welfare + Biometric ID
2. Individual animal Feed efficiency
3. Mitigation heat stress (broilers)
4. Lameness detection

Lately Starting projects

5. Virtual fence
6. Black soldier Fly (BSF)

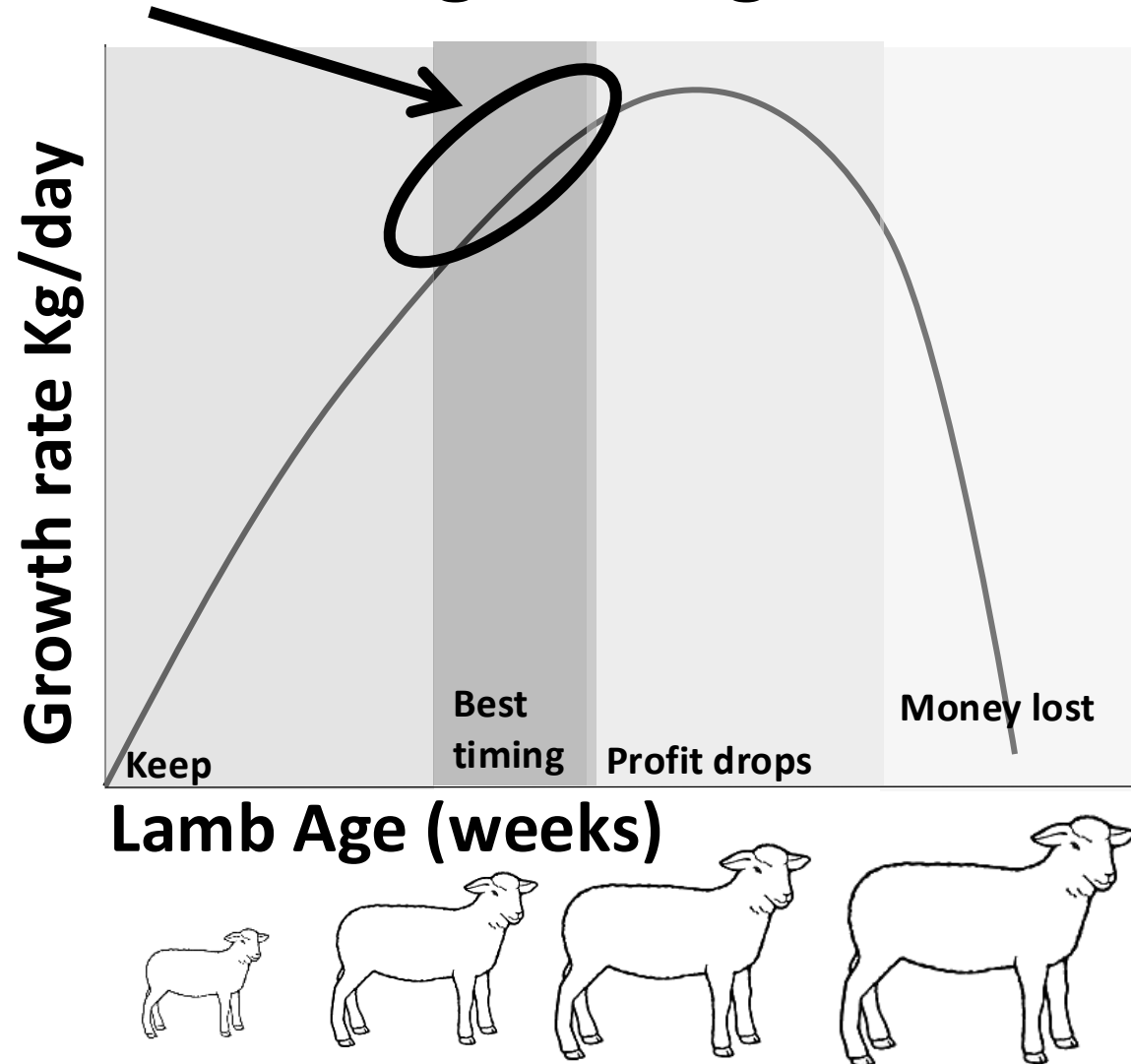
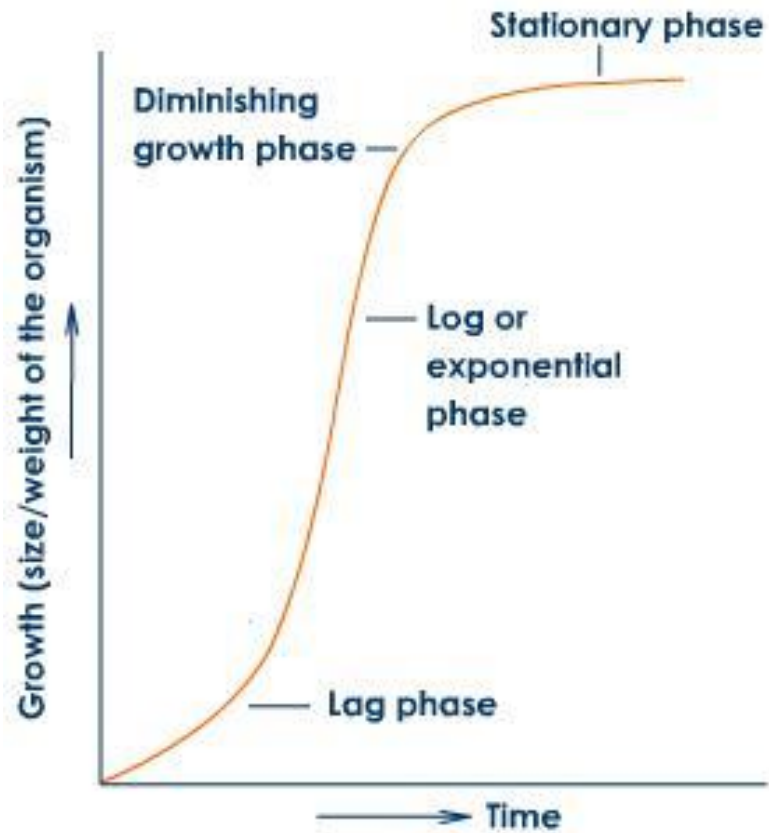
Encouraging discussion and future cooperation

The applied AI tools will be presented at each case study.

Small ruminants

Research & practical problem (Cont.)

Optimal marketing timing



Timeline prototype milestones

Holistic One Health: Full Nutrient Recycling

2017

Begin R&D on weight/health correlation

Can we identify weight changes in the relevant resolution

Kendel



2018

Begin work on the hardware device



2019

Introduce professional 4 legged device to the field
Seasonal issues

2020

Begin work on 2-legged weighing device

TechCare



Mar 2021

The year of SW, AI, DL and Plastic

Sm@rt



2022

From POC to product



PLF technologies in SR

2017

2018

2020

2021

Hardware development

Improving Animal Welfare management: Caring for the individual animal



Comp., sensing & communications systems:

› Real-Time Data Processing, **AI Based Insights**

(We monitor drinking behaviour and body weight)

Two paints marking system: (1) Easy Sorting

(2) Automated Animal Marking

Individual identification

Pre-existing water trough:

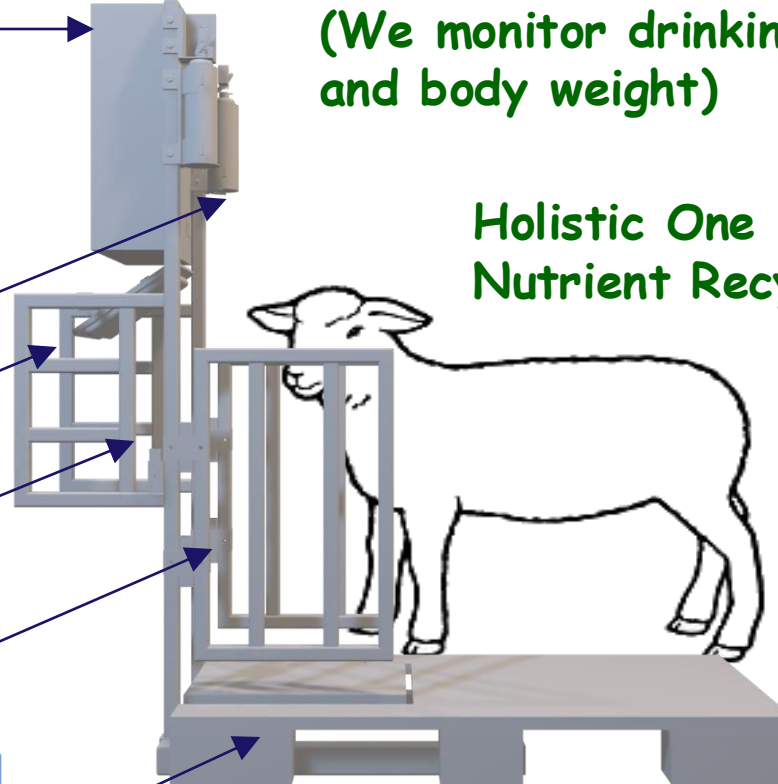
- › Simple Integration
- › Modular To Fit In Every Farm

Monitor water flow, quantity, and attendance

Optic sensor: Intake Validation; Livestock Management

Body weight Scales: Efficiency Automated Weight Data Collection

Holistic One Health: Full Nutrient Recycling



Our “precious” invention

Monitoring Animal Welfare

Solution adaptability and practicality:

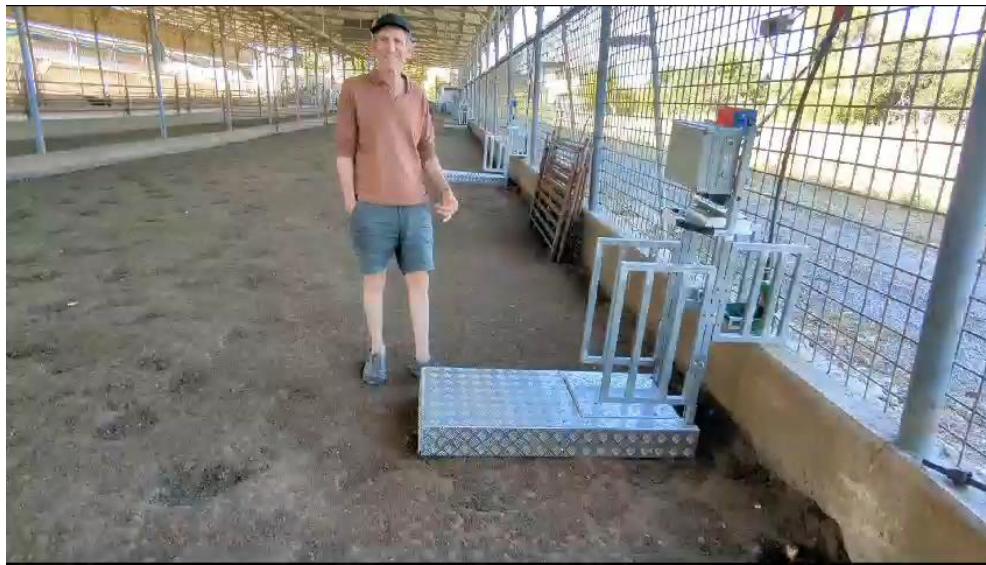


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Sm@RT Ruminant Technologies

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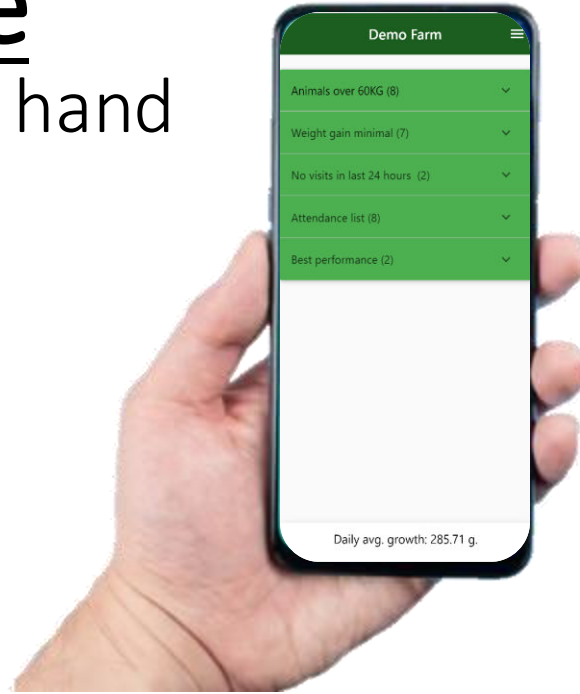


Water is provided only in the trough. AI



The Farmer side

PLF technologies at hand



Objective Phenotyping

'Fast growers'

Market Expansion: TechCare developed technologies could open new market opportunities for products derived from healthier and more productive livestock,



The impact of a “smart water trough” on a sheep and goats smallholder farm. A Bar-Shamai,, Halachmi et al... 11th European Conference on Precision Livestock Farming, 1208-1215



Adoption and Dissemination of Technologies:

From academic research to on-farm application

Voluntarily Milking order

Study aim was to automat SCC/bacterial detection

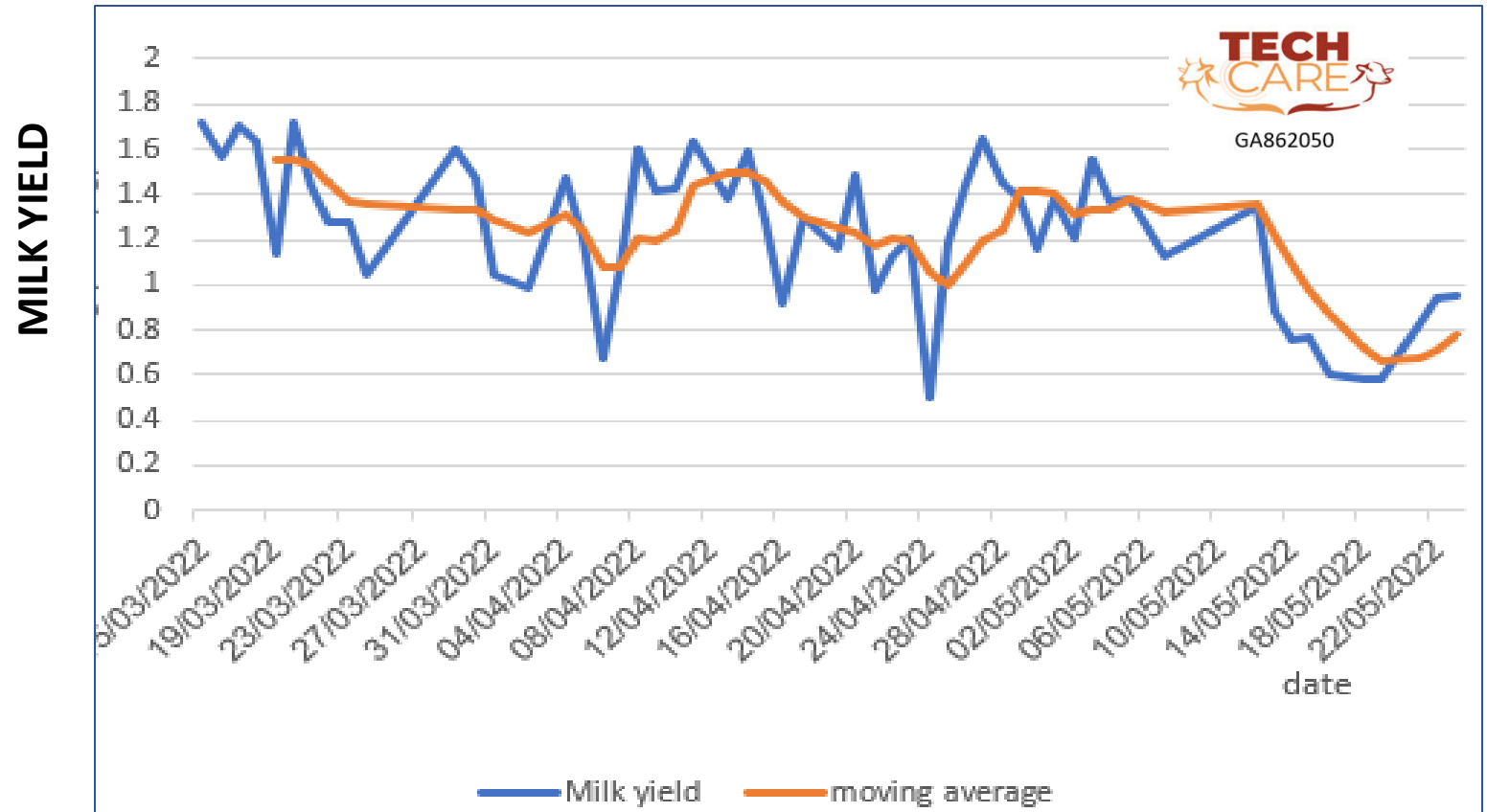


Our PLF lab is happy to cooperate

Before AI Smoothing algorithms

Among the others,
5 days “moving average” of milk
yield,

to "smooth" day-to-day variability.



Research AI Models & Results

Trained 3 algorithms

- Logistics Regression, Decision Tree, **Random Forest**

Most important parameters:

```
importance(BstModelRF,type=2)

##              MeanDecreaseGini
## milkingord      9.011295
## milkyield      8.239076
## fat           8.718753
## protein       5.018438
## lactose        20.102152
## age          1.017924
## weight         2.840350
```

Accuracy 92%



Biometric ID

Biometric identification of dairy cows via real-time facial recognition. N Bergman, Y Yitzhaky, I Halachmi. Animal 18 (3), 101079

Machine vision-based automatic lamb identification and drinking activity in a commercial farm . A Alon, I Shimshoni, Halachmi et al. Animal 17 (9), 100923

Biometric identification of sheep via a machine-vision system. A Hitelman, Y Edan, A Godo, R Berenstein, J Lepar, I Halachmi. Computers and Electronics in Agriculture 194, 106713

Materials

Individual Lamb Monitoring System

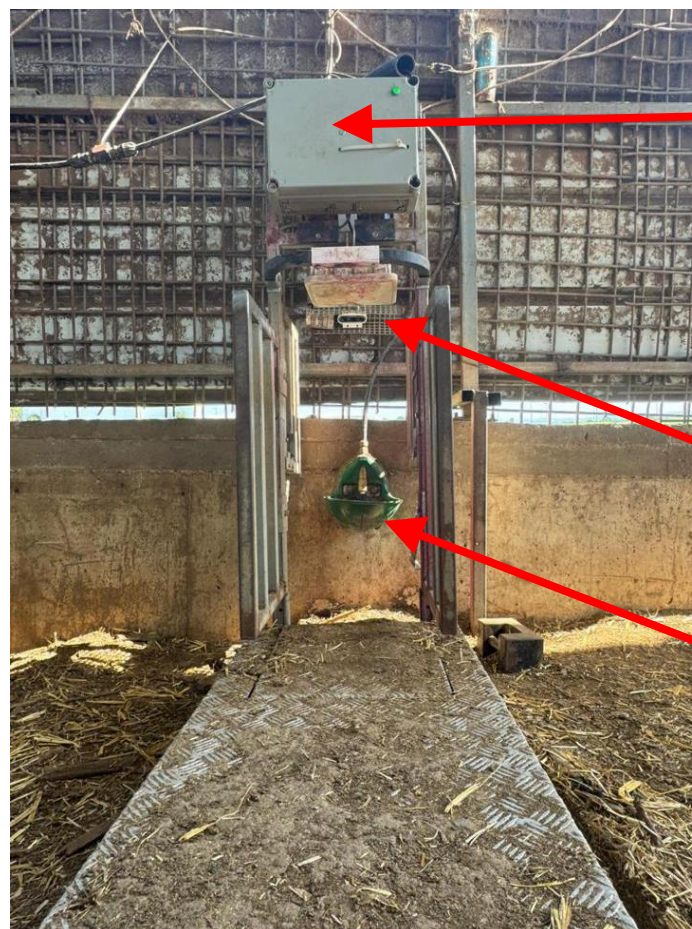
NVIDIA® Jetson AGX



Intel RealSense
Depth Camera D435



Existing water trough



Innovative academic research to the field; teamwork; business guidance

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Materials

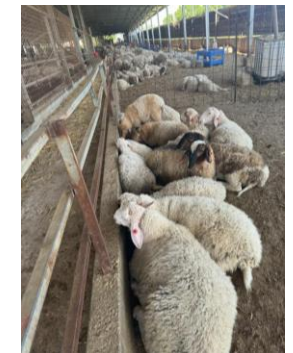
Individual Lamb Monitoring System



Images of the device in the farm

A total of 215 visits were collected from 38 lambs per experiment .

The experiments were conducted at the Ivri Farm, Azarya, Israel.



Research AI Models & Results

Table 3: Impact of the plastic Ear Tag Recognition on Model Performance

Model	Body Part Combination	Accuracy	Precision	Recall	F1_Score
CLIP	face+back+leg +ear tag recognition	0.88	0.89	0.88	0.88
ResNet18	face+back+leg +ear tag recognition	0.9	0.91	0.89	0.9
ResNet50	face+back+leg +ear tag recognition	0.92	0.93	0.91	0.92
ResNet50	face+back+leg	0.83	0.86	0.83	0.83



- Adding ear tag recognition boosts performance for all models.
- ResNet50 achieves the best overall performance: accuracy (0.92), precision (0.93), recall (0.91), F1-score (0.92).
- CLIP and ResNet18 also improve with ear tag recognition.

Individual animal Feed efficiency

Chris Knight (yesterday): “Produce more feed from fewer animals”, “edible from inedible “



A machine vision system to predict individual cow feed intake of different feeds in a cowshed. M Saar, Y Edan, A Godo, J Lepar, Y Parmet, I Halachmi. Animal 16 (1), 100432

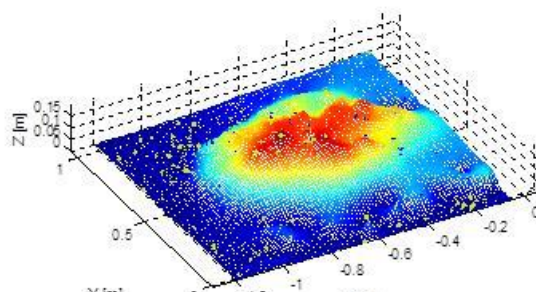
Design a system for measuring individual cow feed intake in commercial dairies. V Bloch, H Levit, I Halachmi. Animal 15 (7), 100277

Method and apparatus for monitoring a dairy cow feed efficiency

Victor Bloch; Harel Levit; Beni Katz, Ilan Halachmi

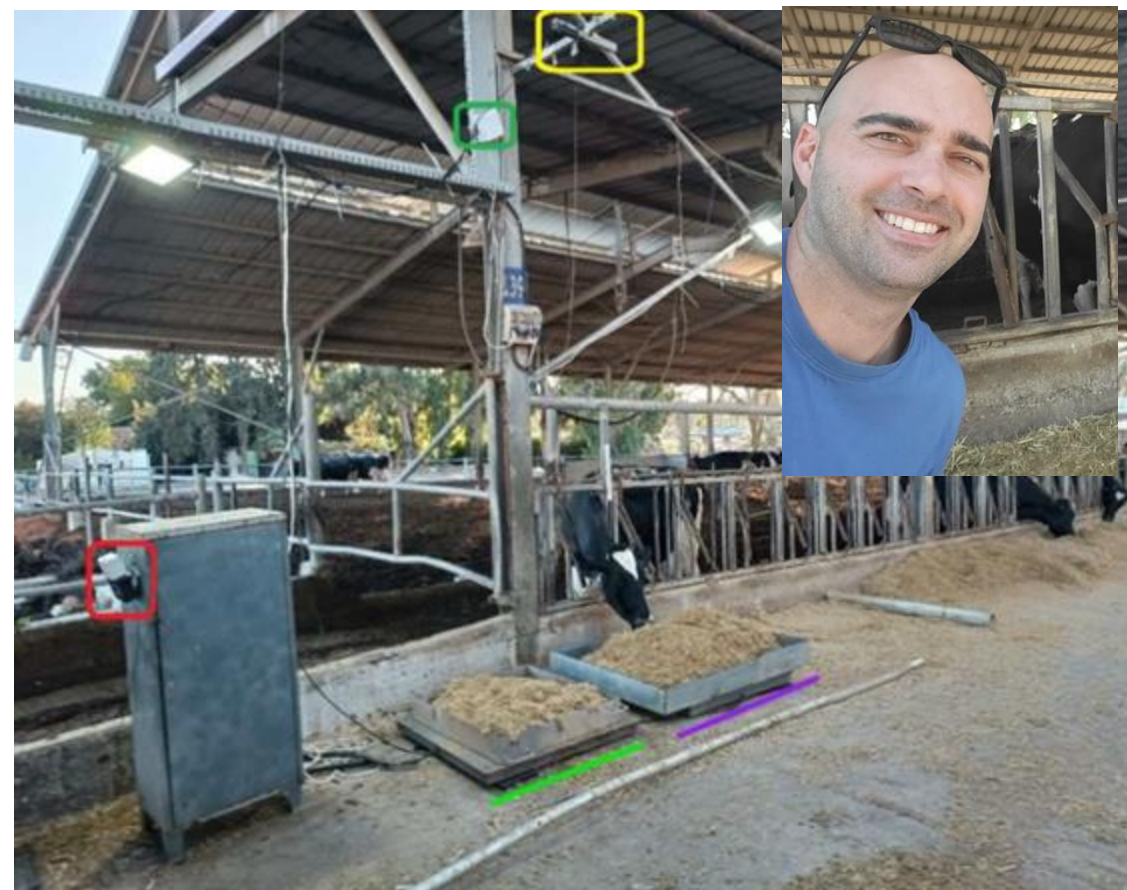


Photogrammetry



Weight Scales (ref); 3-D Camera – Yellow;

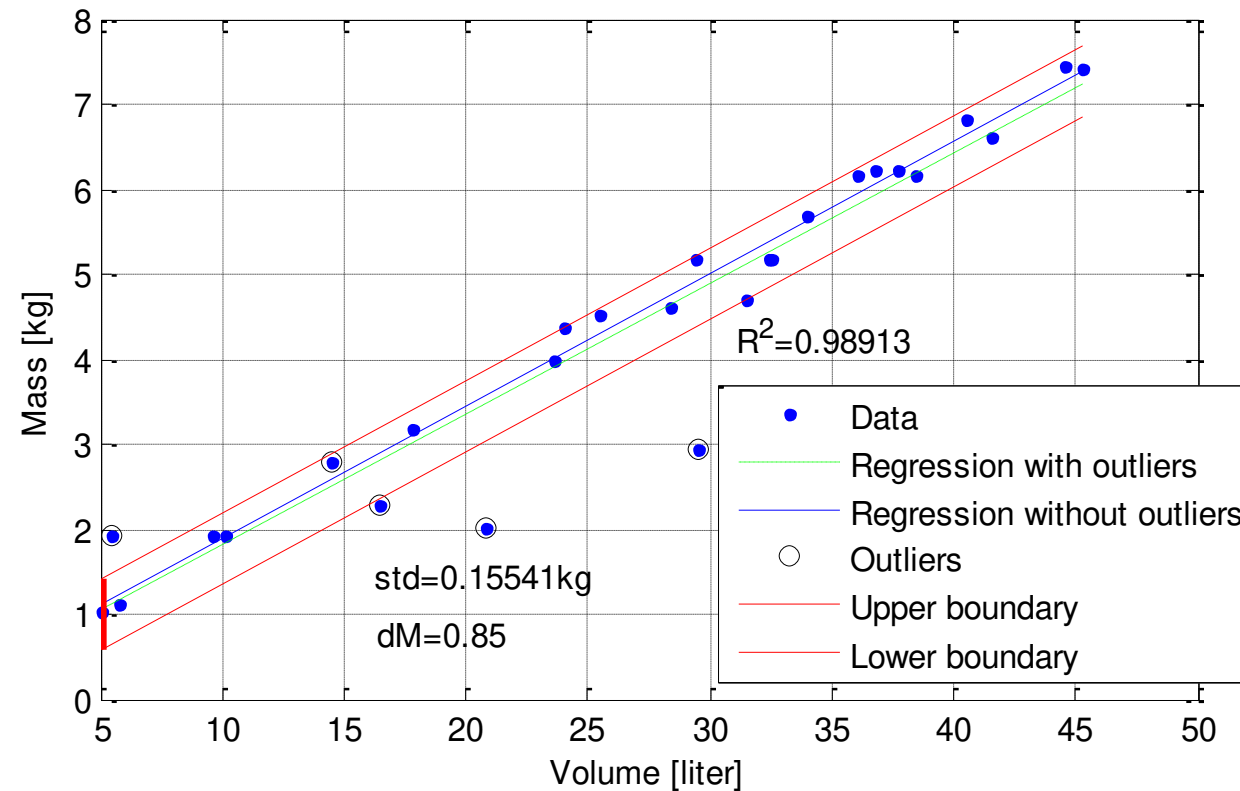
Weather Station - Red



Innovative academic research to the field

Method and apparatus for monitoring a dairy cow feed efficiency

Victor Bloch; Harel Levit; Ilan Halachmi



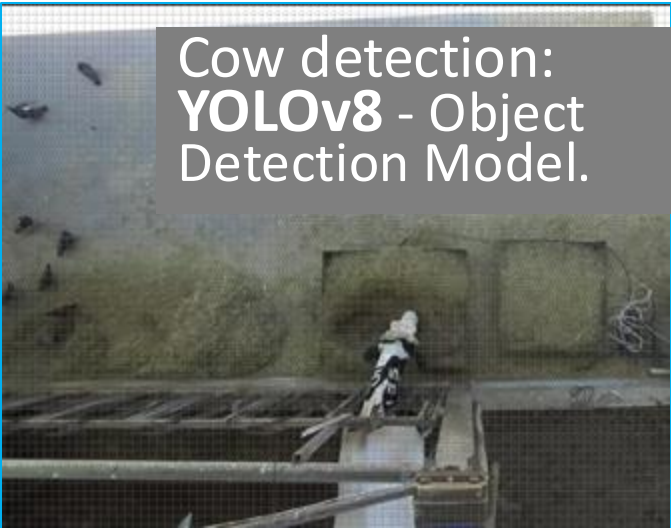
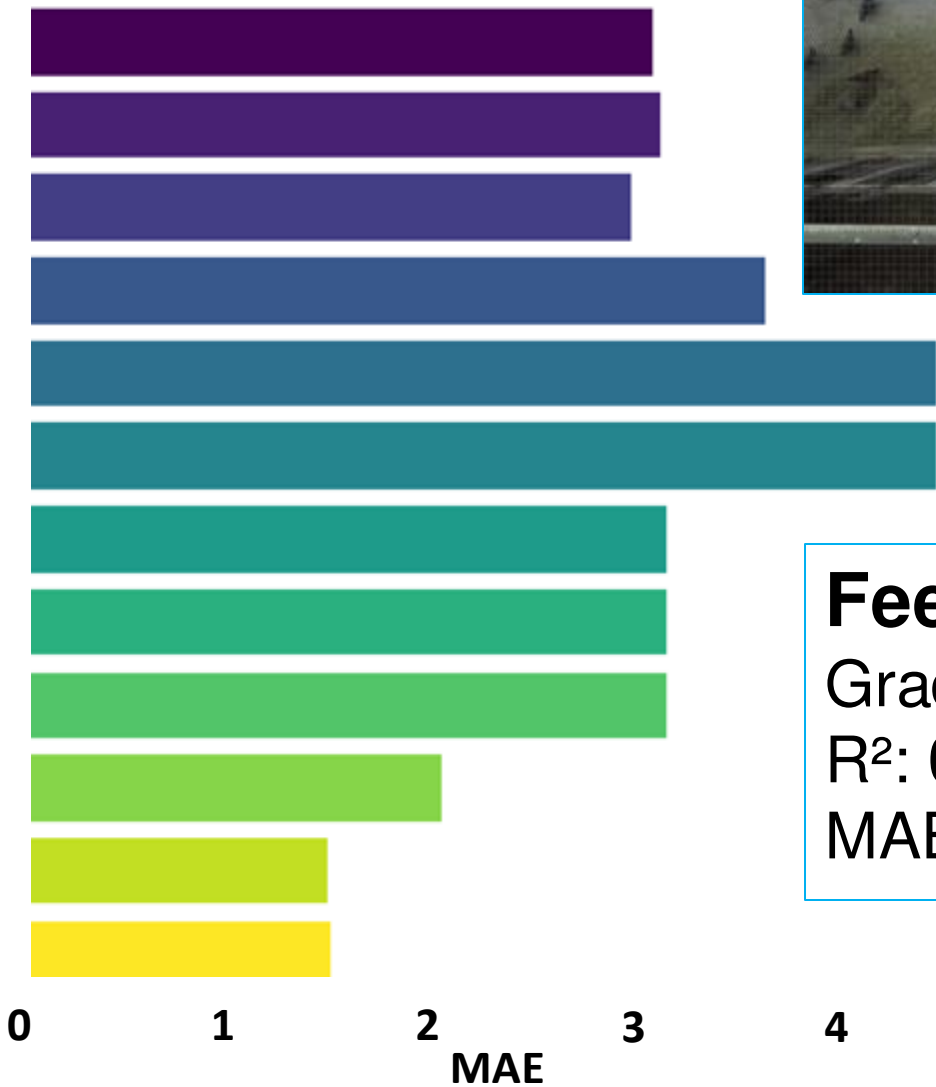
Digital Tools

- Linear Regression
- Linear Regression (Forward Selection)
- Linear Regression (Backward Selection)
- PCA Regression
- PCA Regression (Forward Selection)
- PCA Regression (Backward Selection)
- Ridge
- Lasso
- Elastic-Net
- Decision Tree
- Random Forest
- Gradient Boost



Results

MAE = Mean Absolute Error

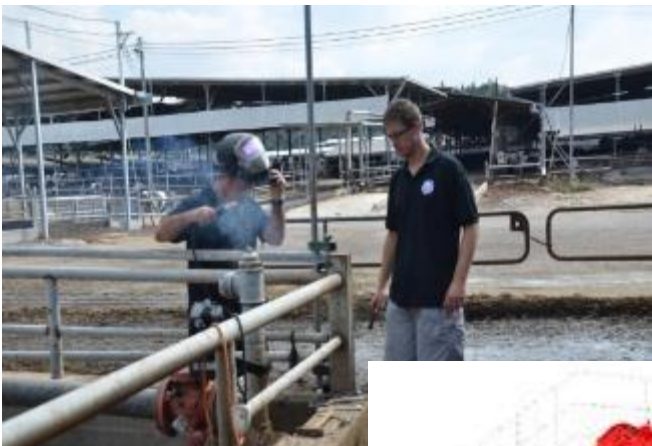


Cow detection:
YOLOv8 - Object
Detection Model.

Feed best model:
Gradient Boosting
 R^2 : 0.8
MAE: 1.5 KG

Automatic lameness detection

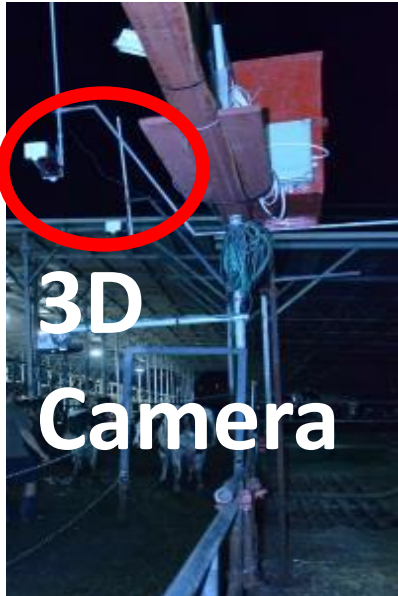
Technology



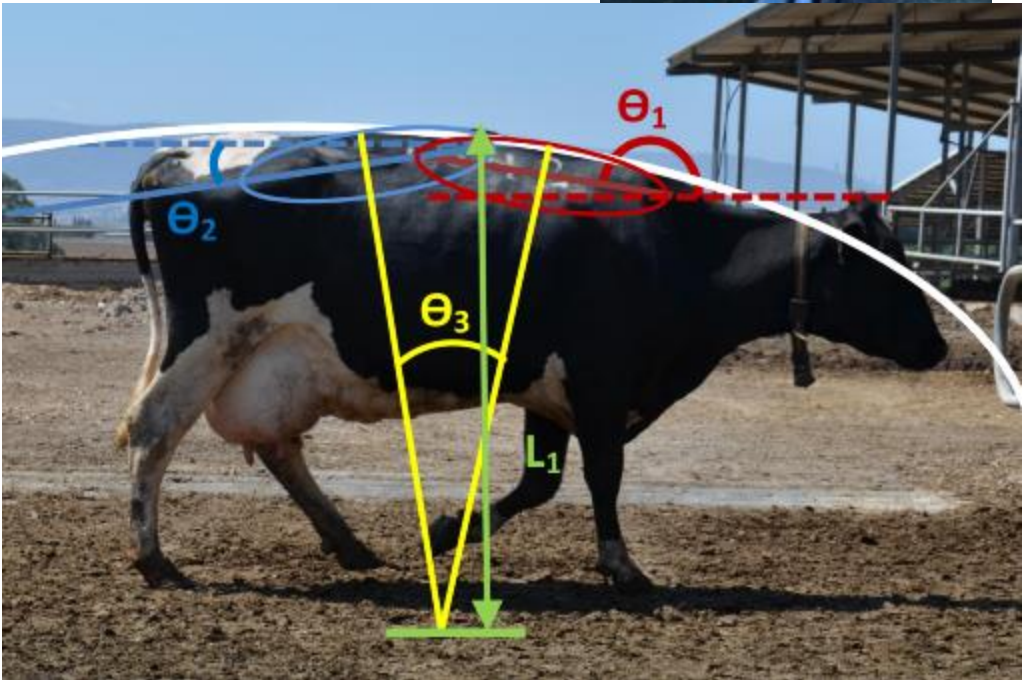
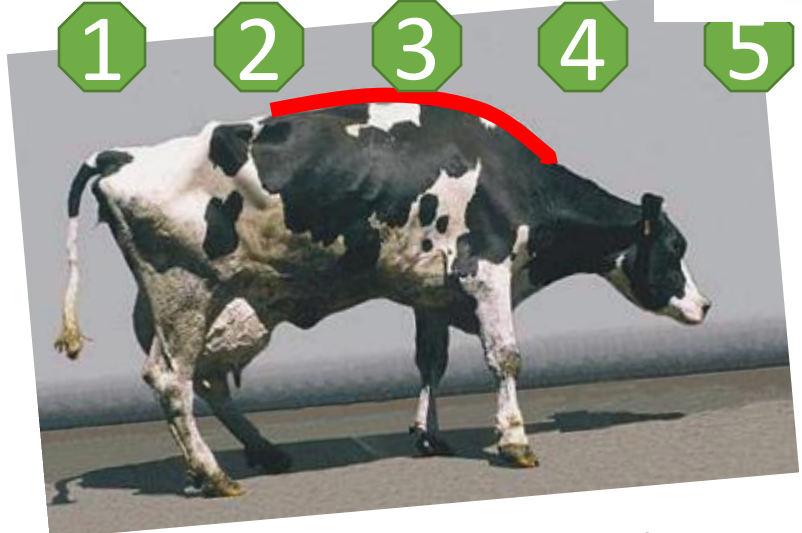
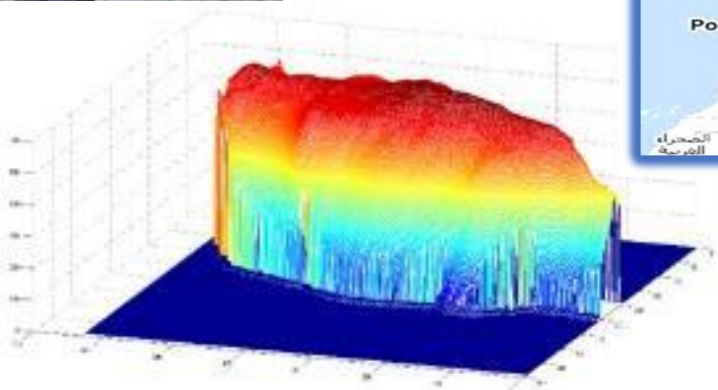
Machteld Steensels Ph.D. student
Tom van Hertem Ph.D. student
EU-FP7 BioBusiness project
2.5 M€ 11 PhD Students



Our PLF lab is happy to cooperate

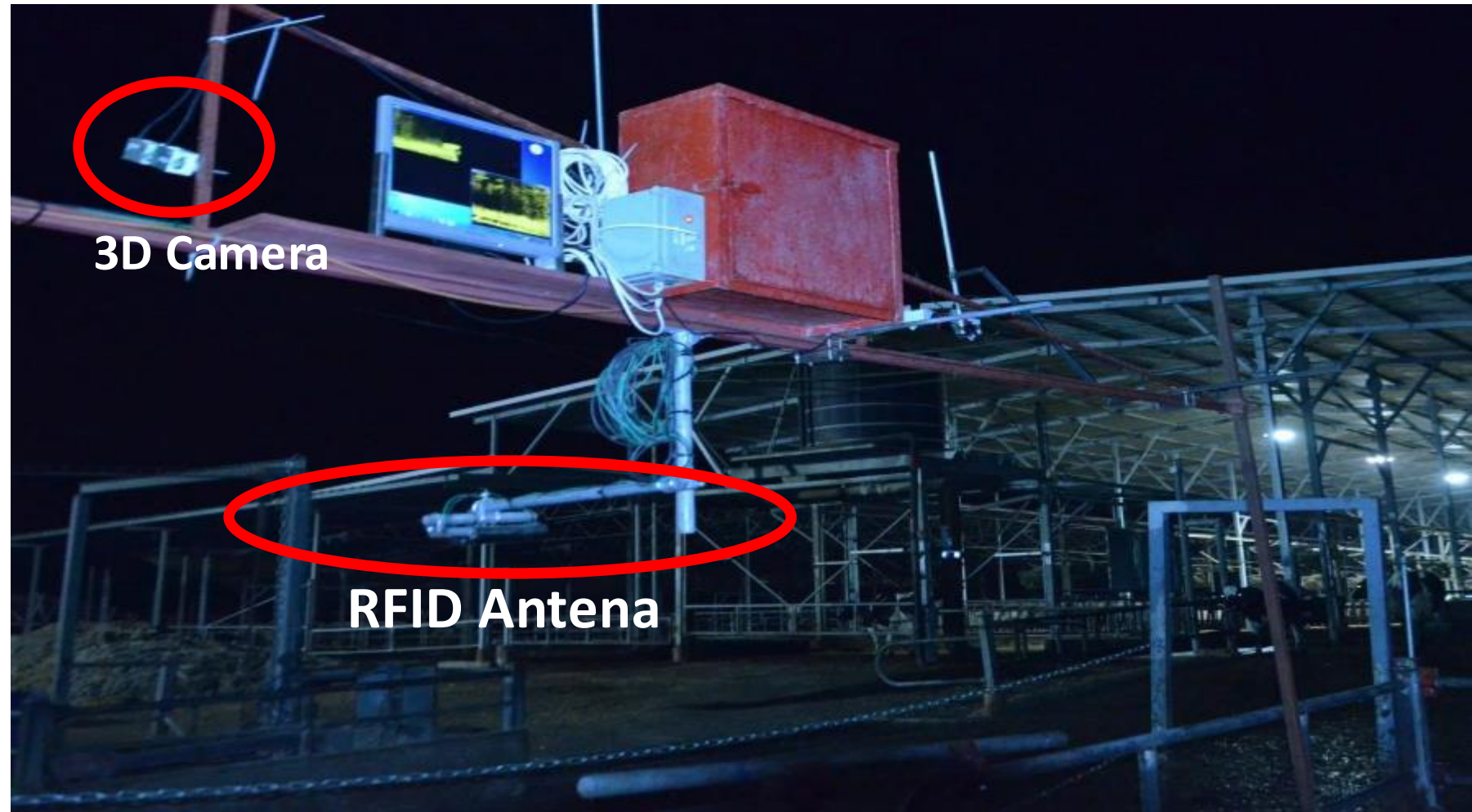
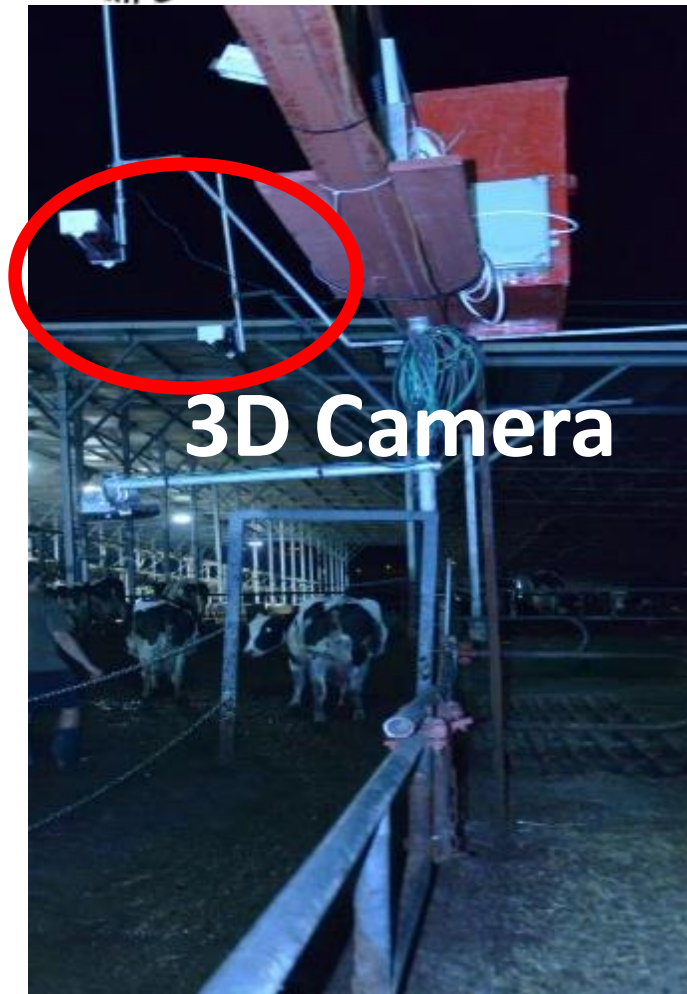


3D
Camera

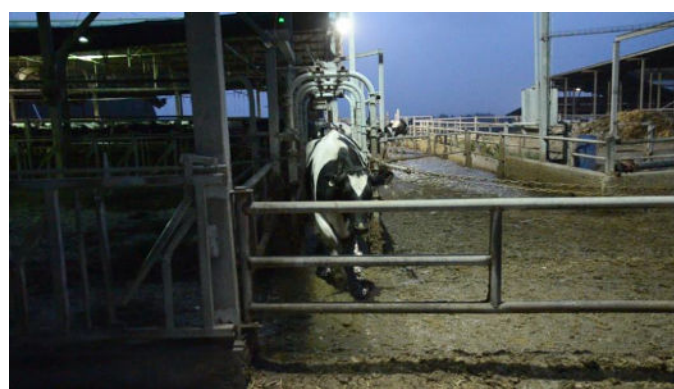
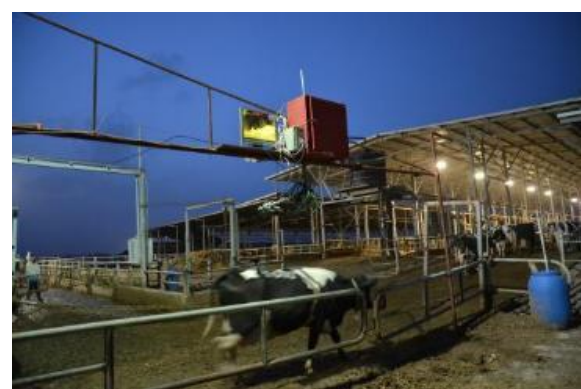
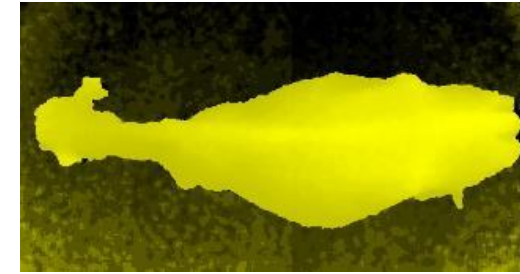
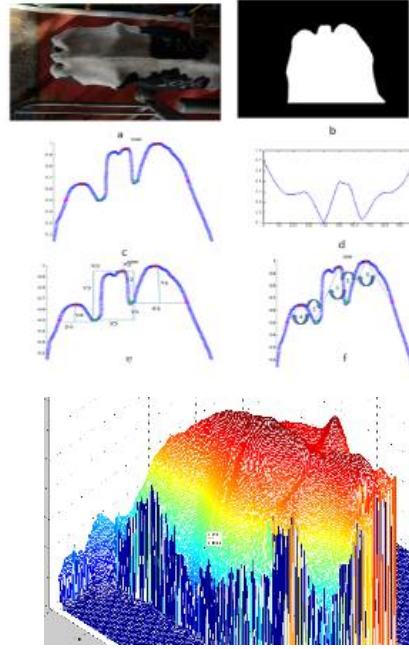


From Innovative academic research to the field

3rd Setup: 3D-camera - 1200 cows in Kibbutz Yefat



PLF: precision livestock farming



From innovative academic research to the field – Kibutz Yefat 1200 cows in milking

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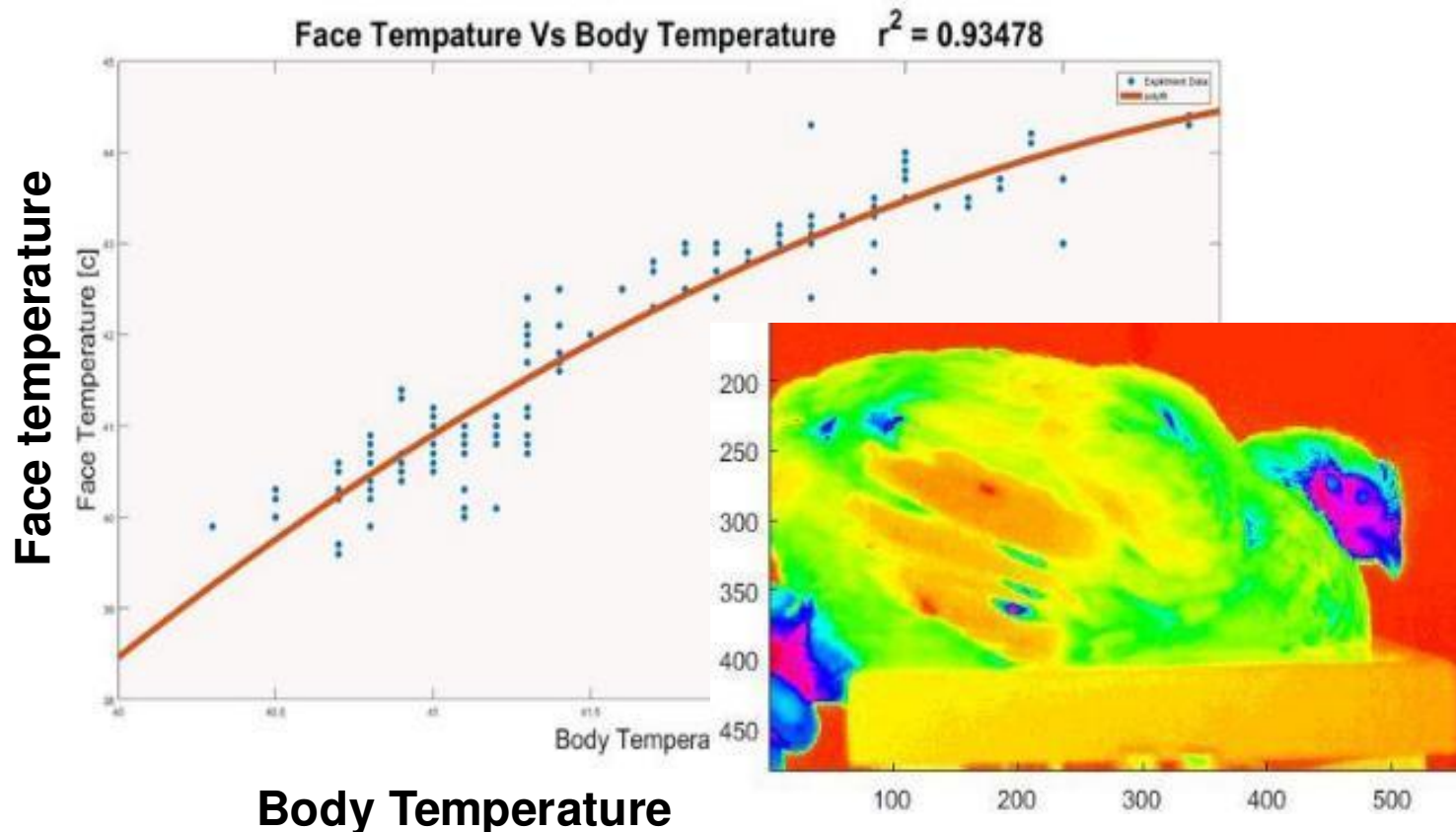
Precision Livestock Farming (PLF) Lab
חקלאות מדייקת של חיות משק



Agricultural Research Organization
(ARO),
The Volcani Centre, Israel



Mitigation heat stress in Broilers. Thermal imaging



Nathan Barchilon,

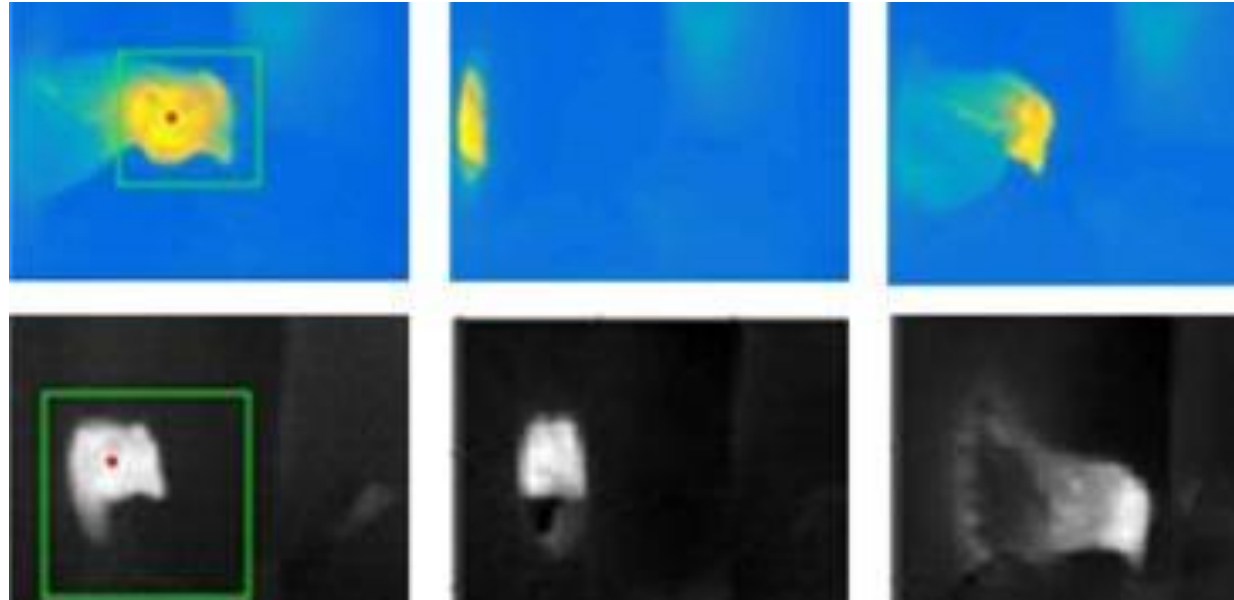
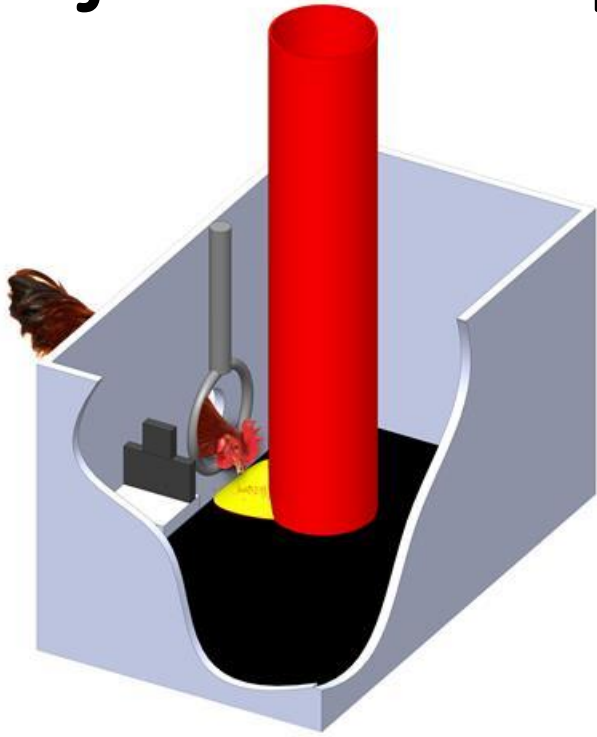
'Shelly Druyan'

Ilan Halachmi

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Innovative academic research to the field – commercialized

Project development

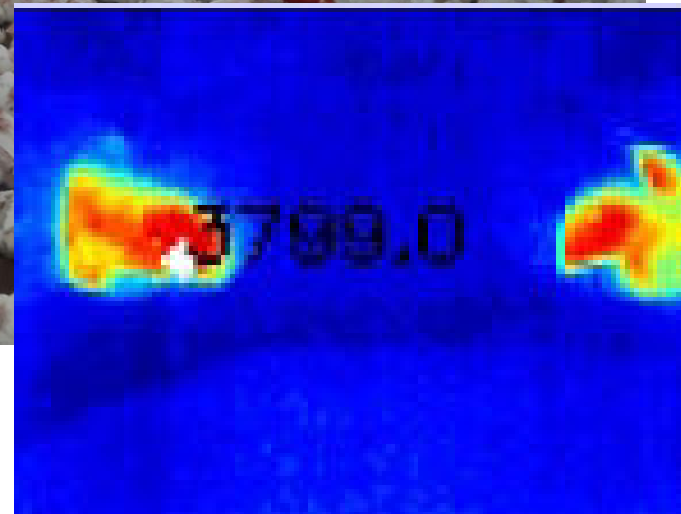
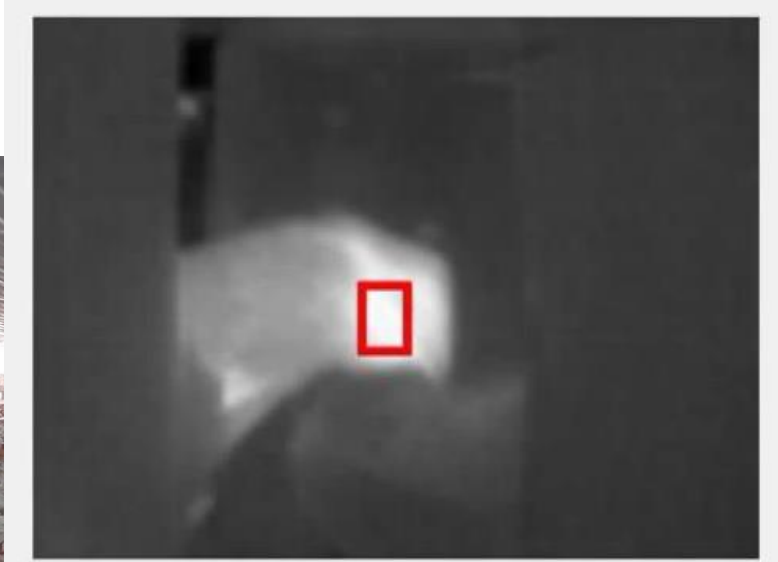


Innovative academic research to the field – commercialized

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Mitigation heat stress in Broilers.

Thermal imaging

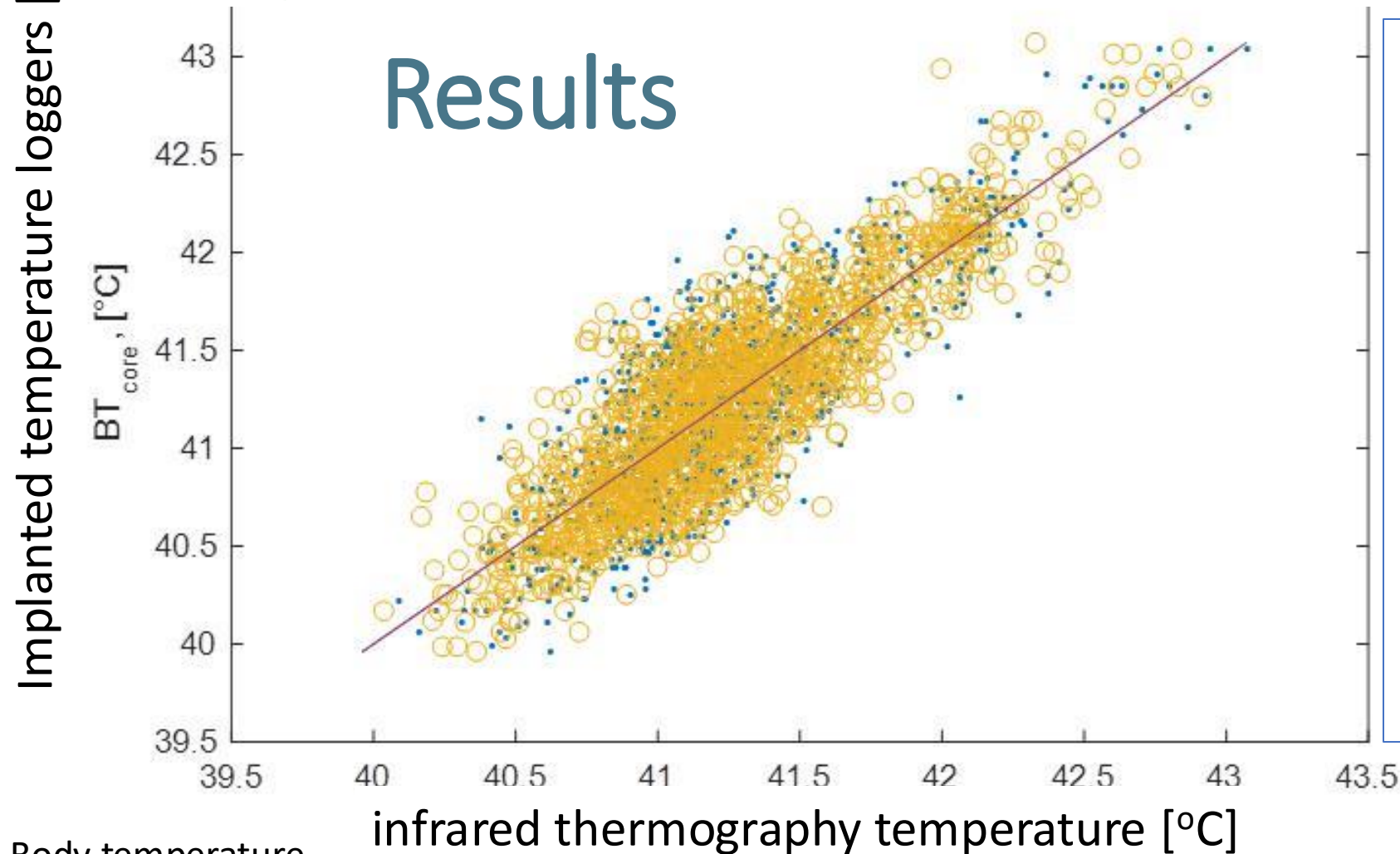


Innovative academic research to the field

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Mitigation heat stress in Broilers. Thermal imaging

Results



Classifying vocal responses of broilers to environmental stressors via artificial neural network, T Lev-Ron, Halachmi et al., Animal 19 (1), 101378

A machine vision system to detect and count laying hens in battery cages. O Geffen, Halachmi et al. Animal 14 (12), 2628-2634

Dynamic cooling strategy based on individual animal response mitigated heat stress in dairy cows. H Levit, S Halachmi et al. Animal 15 (2), 100093

Body temperature

- Implanted temperature loggers in the broiler abdominal cavity (BT_{core}) is compared with
- infrared thermography temperature (BT_{IR}) monitored by FlirOne (dots) and Lepton (circles) cameras.

Innovative academic research to the field

Black soldier Fly (BSF)

BSF – black soldier fly (“a new farm animal”) ?



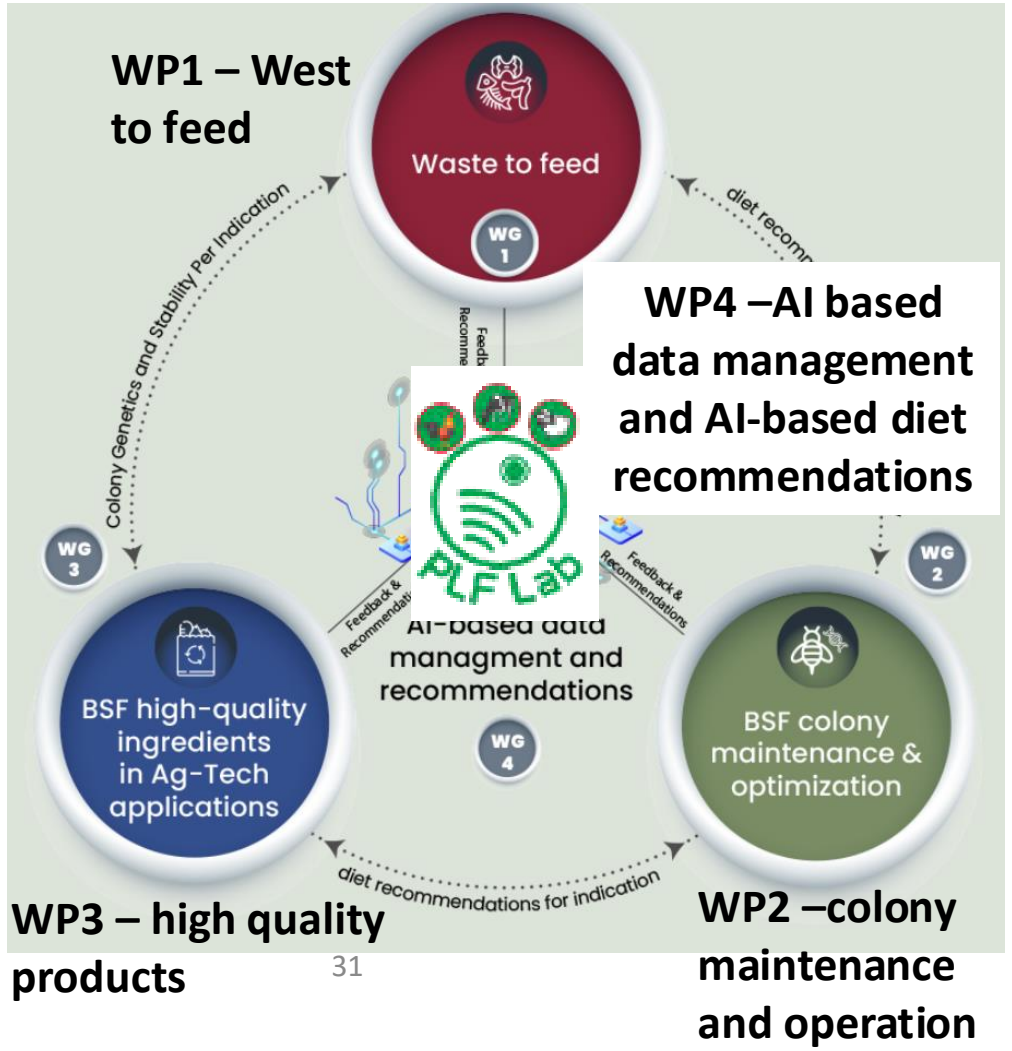
Creativity: From Innovative research to the field

Designing Optimal Diets for the Black Soldier Fly (BSF)

Asaf Fux, Supervisors: Prof. Ilan Shimshoni, Prof. Ilan Halachmi

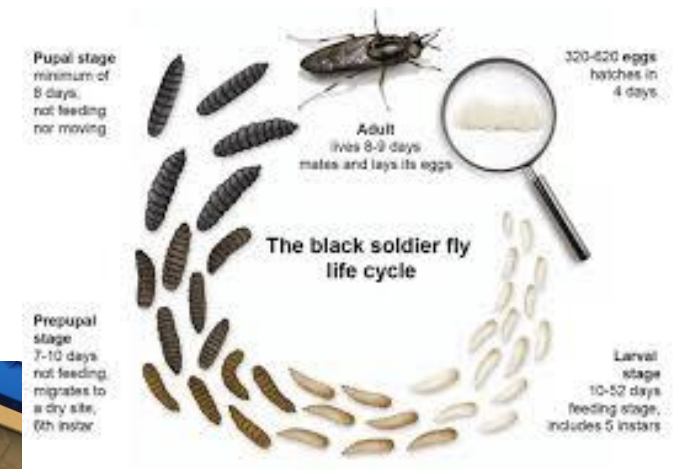


BSF Israel website: <https://bsf-israel.com/>
Linkedin: <https://www.linkedin.com/company/bsf-israel/?viewAsMember=true>



Research Hypothesis & Objectives

- Develop DSS to optimize BSF diet
- Validated optimal diet composition

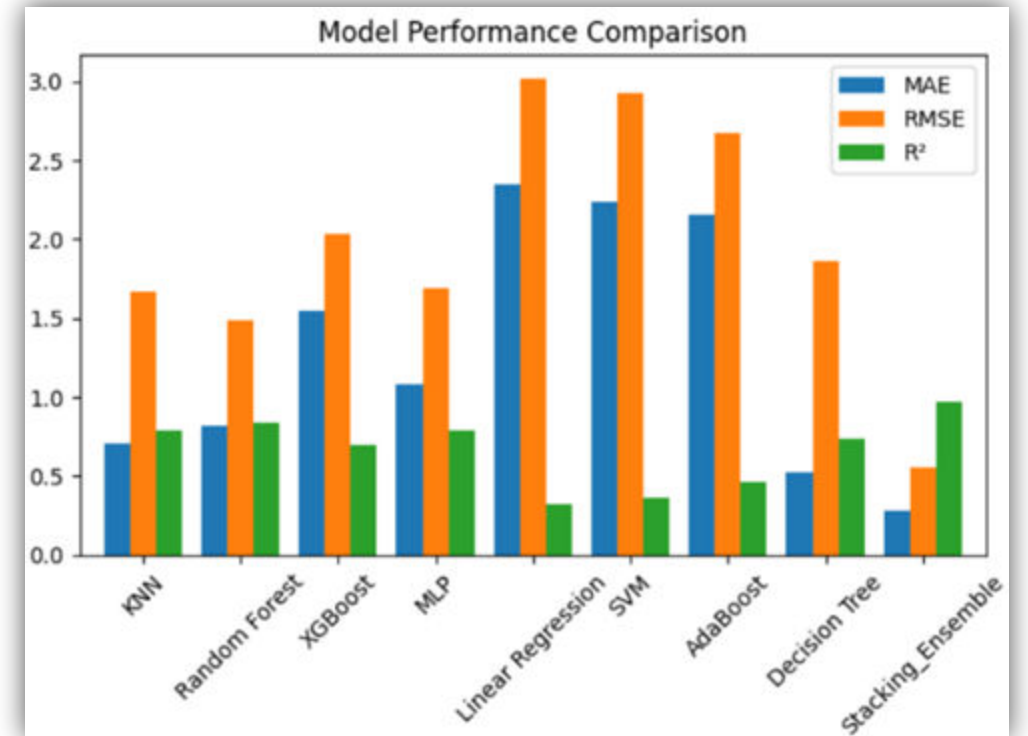
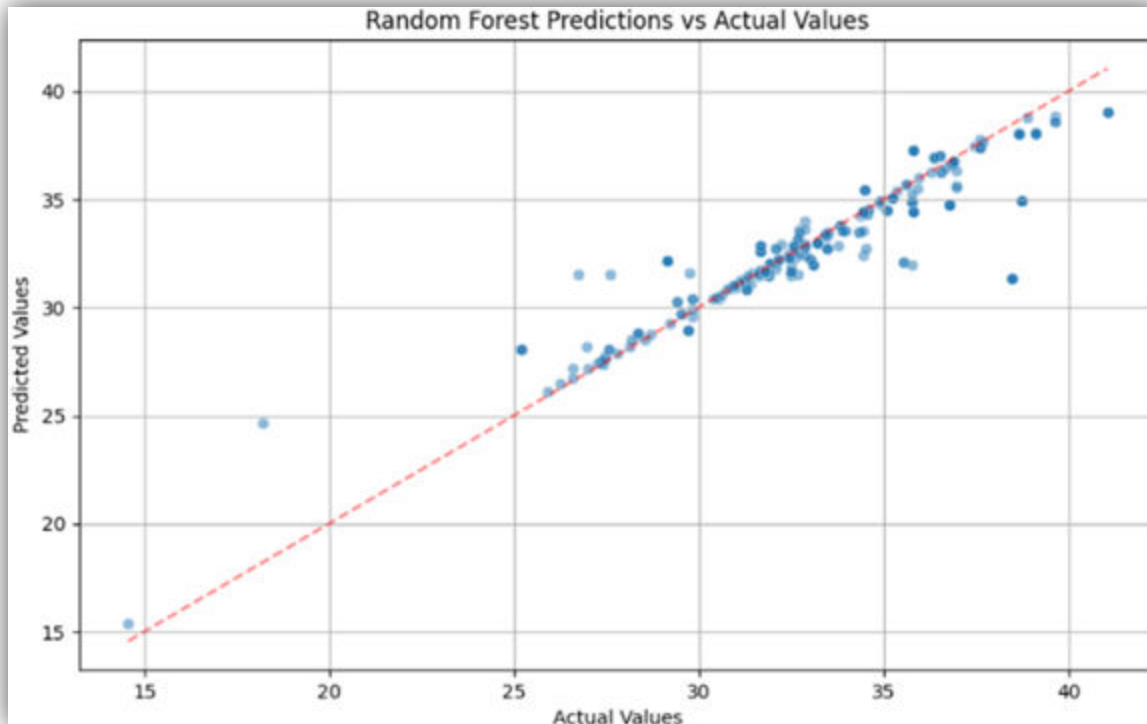


Best Business For Unemployed Youth
Black Soldier Fly Farming



Model Performance & Results

- Improve models (higher R^2 and lower RMSE)
- Improved protein, fat, and total larval biomass prediction



Research AI Models

- Over 3000 experiments , five farm sites
- Trained 8 algorithms
 - MLP, SVM, KNN, XGBoost, AdaBoost, Decision Tree, Random Forest, Linear Regression
- **ensemble** Consisted of: Random Forest, KNN, XGBoost



Target Variable	RMSE (Bogina et al., n.d.)	RMSE (Current Study)	Difference in RMSE
Protein, %	2.00	0.55	1.45
Fat, %	3.61	2.47	1.14
Total Larval Biomass, gr'	296.1	160.7	135.4

Comparative Analysis with Previous Study

Virtual fence

Designing, installation, and field testing of a 'virtual fence'



Our PLF lab is happy to cooperate

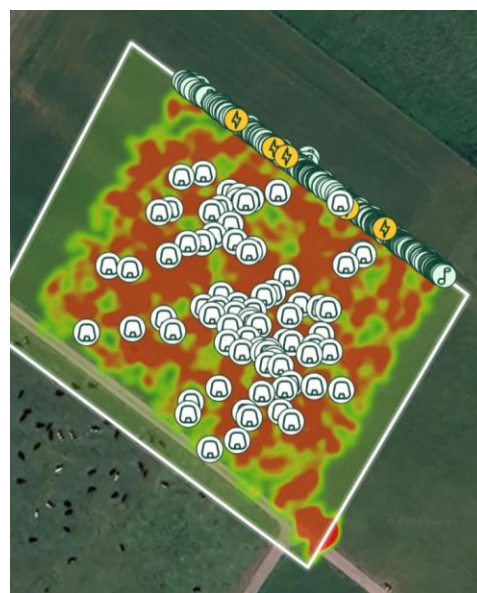


A sabbatical year in Ireland ✓



What is a virtual fence (VF) ?

- Virtual fence (VF) allows for altering grazing spaces without additional labour.
 - - expand livestock into marginal environment
- The cows learn fast
- Provide video pictures and data - grazing return time, sound-electrical shock, milk yield



Video 1 electrical signal



Video 2 – only sound signal

What is a virtual fence ?

Replacing physical fence (stone, iron, wood, wire etc

Replacing shepherd dogs

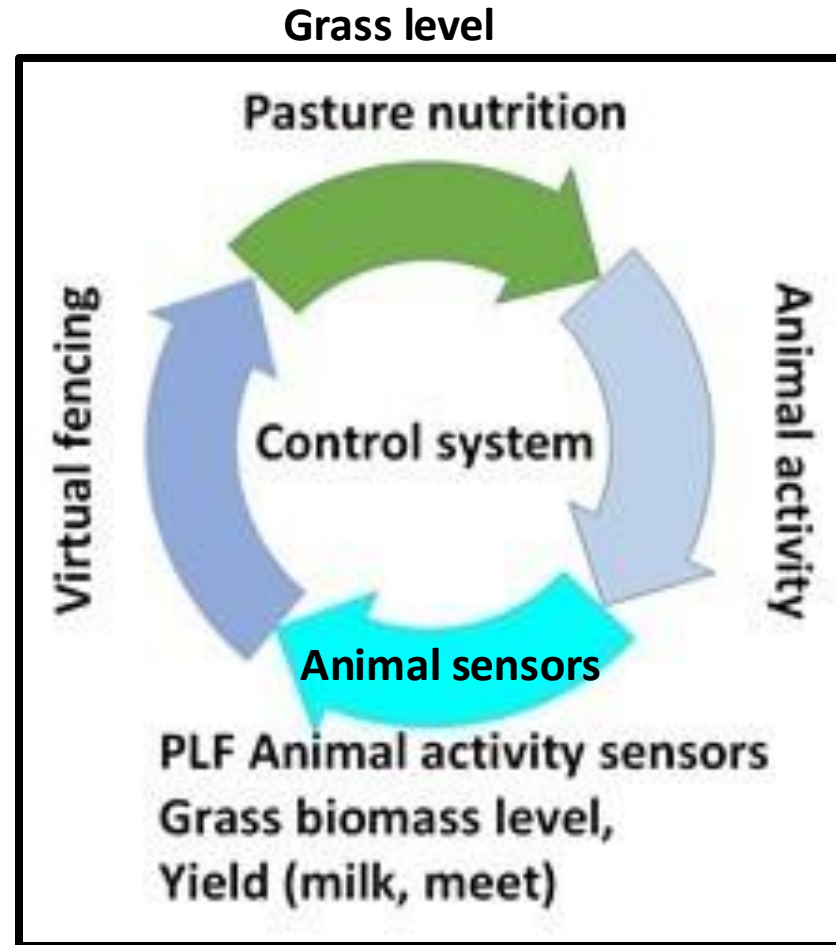
Dynamic free-range grazing space with no labor needed



A Control system

Close the loop – grazing – animal – farmer – one welfare

Cascade loop control



The Sci. concept

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Lecture objective and structure (30 min.):

3 ways AI is helping the EU agriculture

1. Measuring, predicting and optimizing complex systems
2. Accelerating development of sustainability solutions
3. Empowering a sustainability staff and students



(TBD ? – AI disadvantages, there are !)

Phenotyping

Our six AI milestones (case studies) running in my lab, presented today:

1. Sheep & Goats animal welfare + Biometric ID



2. Individual animal Feed efficiency



3. Mitigation heat stress (broilers)



4. Lameness detection



5. Virtual fence



6. Black soldier Fly (BSF)



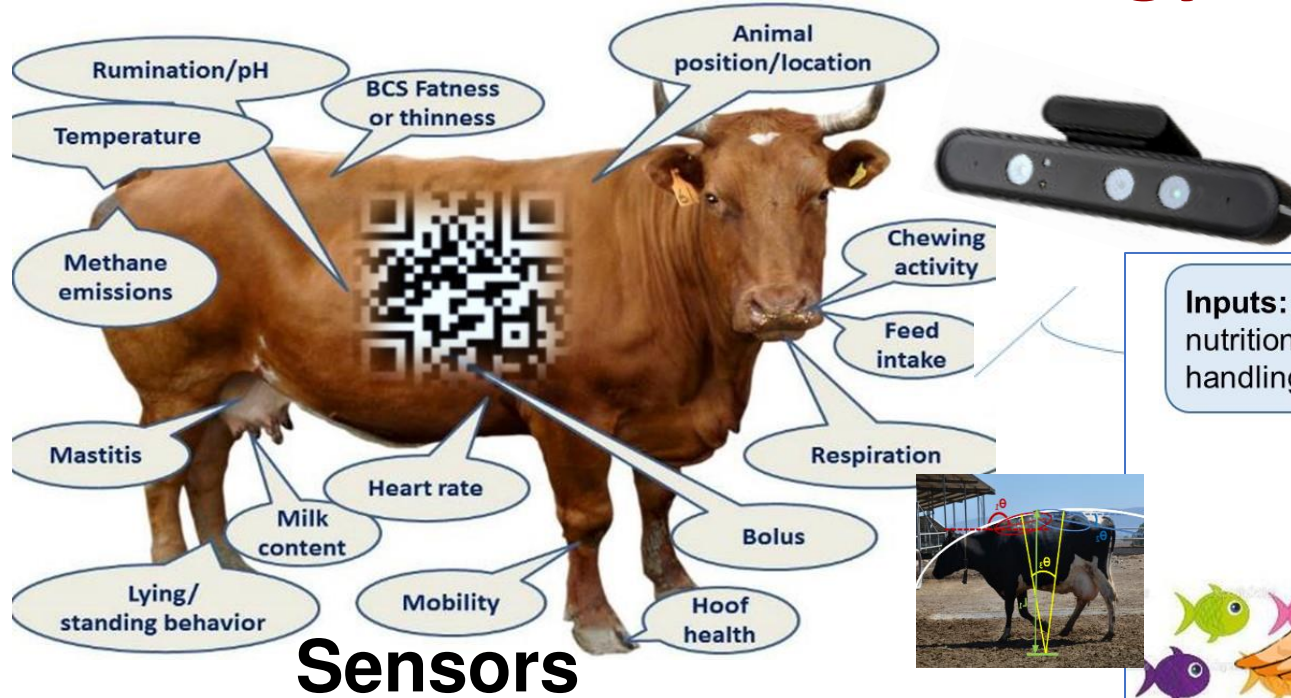
The applied AI tools were presented at each case study

Encouraging discussion and future cooperation

What is PLF ? Technology

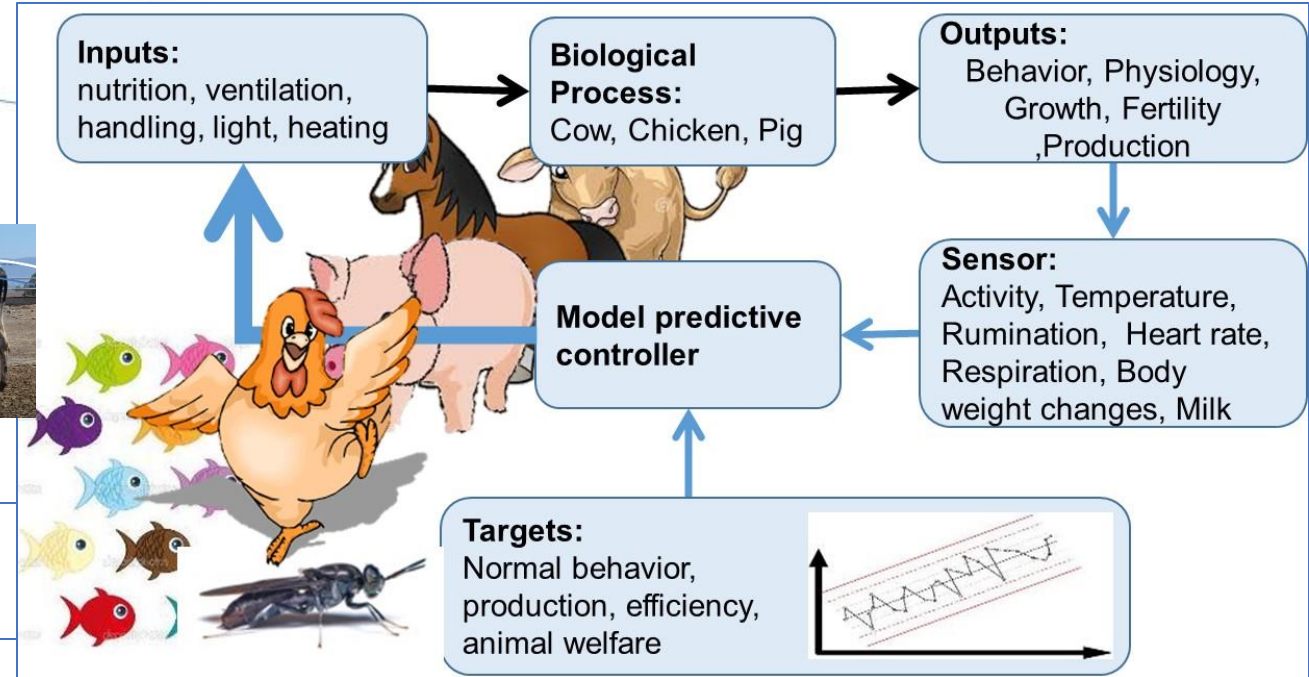


Our expertise



In reality – we are drowning in data but starved for actionable list

Holistic One Health: Full Nutrient Recycling



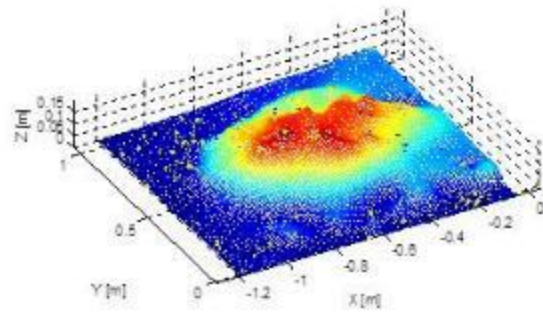
Digital Tech., AI Models

Our PLF lab is happy to cooperate

PLF from research to on-farm impact



Automatic lameness detection (3D camera)



Monitoring cow individual feed efficiency

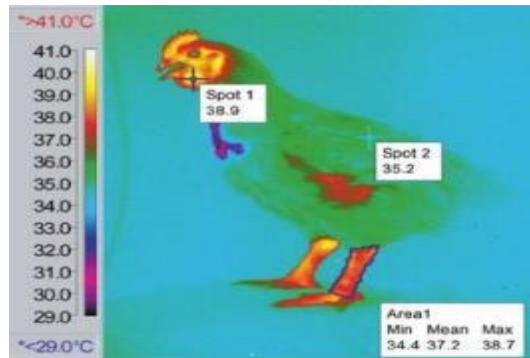
Technology

- Thermal imaging
- 3D camera
- Vary sensors
- Real-time analysis
- AI Machine learning and Big data



Small ruminants

Automatic BCS, Heifer height, Attenuating heat stress



Climate control based on animal response, thermal imaging



The Israeli PLF Lab.

Lab business development: Eitan Metuki <eitan@spark.co.il>

Prof. Ilan Halachmi :
halachmi@volcani.agri.gov.il

Review paper: *halachmi et al., Annual review of animal bioscience. 2019 (7):403–425*

Our PLF lab is happy to cooperate

An interesting observer and find the presented information:

PLF Conferences:

www.plf-lab.com



ECPLF conference



Research papers

Halachmi, Ilan, Marcella Guarino, Jeffrey Bewley, and Matti Pastell. "Smart Animal Agriculture: Application of Real-Time Sensors to Improve Animal Well-Being and Production"

Annual review of animal biosciences 2019.(7):403–425



A PLF section
(Editor)

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Book: PLF Applications
(editor, Wagennigen Press)

EU Projects sites:



FP6 OPTISCORE: electronic sensors to create animal condition scoring protocols



FreeWalk

DairyCare

COST 2006 SMART, 2016 DairyCare, and few more

The six case-study presented today are in these papers (Only last 5 years)

[Biometric identification of dairy cows via real-time facial recognition.](#) N Bergman, Y Yitzhaky, I Halachmi. animal 18 (3), 101079

[Classifying vocal responses of broilers to environmental stressors via artificial neural network,](#) T Lev-Ron, Y Yitzhaky, I Halachmi, S Druyan. animal 19 (1), 101378

[The impact of a “smart water trough” on a sheep and goats smallholder farm.](#) A Bar-Shamai,, Halachmi et al... 11th European Conference on Precision Livestock Farming, 1208-1215

[Machine vision-based automatic lamb identification and drinking activity in a commercial farm .](#) A Alon, I Shimshoni, A Godo, R Berenstein, J Lepar, N Bergman, ... animal 17 (9), 100923

[Biometric identification of sheep via a machine-vision system.](#) A Hitelman, Y Edan, A Godo, R Berenstein, J Lepar, I Halachmi. Computers and Electronics in Agriculture 194, 106713

[A machine vision system to predict individual cow feed intake of different feeds in a cowshed.](#) M Saar, Y Edan, A Godo, J Lepar, Y Parmet, I Halachmi. Animal 16 (1), 100432

[Design a system for measuring individual cow feed intake in commercial dairies.](#) V Bloch, H Levit, I Halachmi. Animal 15 (7), 100277

[Advancements in sensor technology and decision support intelligent tools to assist smart livestock farming.](#) LO Tedeschi, PL Greenwood, I Halachmi. Journal of Animal Science 99 (2), skab038

[Dynamic cooling strategy based on individual animal response mitigated heat stress in dairy cows.](#) H Levit, S Pinto, T Amon, E Gershon, A Kleinjan-Elazary, V Bloch, ...Animal 15 (2), 100093

[A machine vision system to detect and count laying hens in battery cages.](#) O Geffen, Y Yitzhaky, N Barchilon, S Druyan, I Halachmi. Animal 14 (12), 2628-2634

[Smart animal agriculture: application of real-time sensors to improve animal well-being and production.](#) I Halachmi, M Guarino, J Bewley, M Pastell. Annual review of animal biosciences 7 (1), 403-425

Thank you all

**Comments ?,
Cooperation Ideas ?,
Questions?**



Further details and cooperation:

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Mobile (WhatsApp): +972-506220112



יצירתיות במחקר ומעבר מאקדמיה לשטח – חיזוק תחושת הצוות