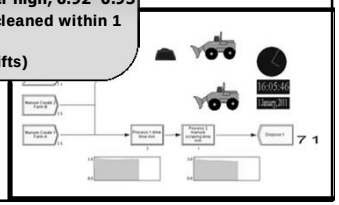
A mega dairy in India - results

Farming area 5. Manure scraping

Model suggests:

- two tractor shovels are sufficient for the entire farm.
- (before the model- four shovels)
- Tractor utilization is rather high, 0.92–0.95
- The 36 cowsheds can be cleaned within 1 shift
- (before the model two shifts)



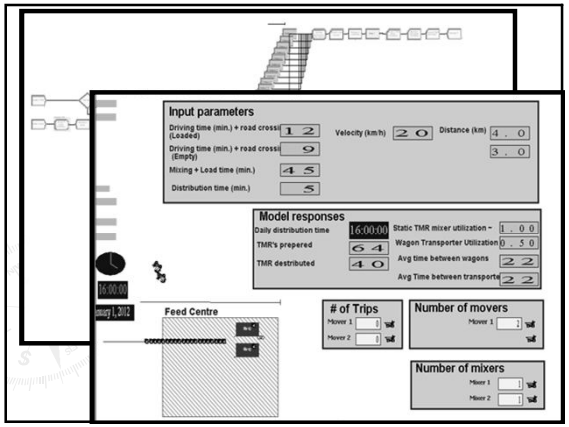
Manure-scraping simulation program objects and user interface

A mega dairy in India - results

Farming area 6. Cow-feed processing and distribution center

Model suggests:

- Two mixers and two wagons are required to finish 42 rounds within 16.25 h per day (two 8-h shifts).
- (before the model – three shifts, four wagon and three mixers)

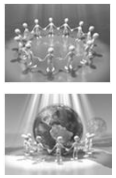


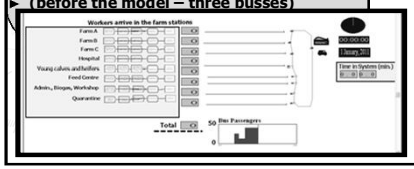
A mega dairy in India - results

Farming area 7. Labor traffic

Model suggests:

- one single bus carrying 50 passengers seems to be sufficient.
- The bus utilization was 0.28.
- Average transfer time for a worker was 0.34 h each way.
- (before the model – three busses)





Labor traffic simulation program objects and user interface: layout view

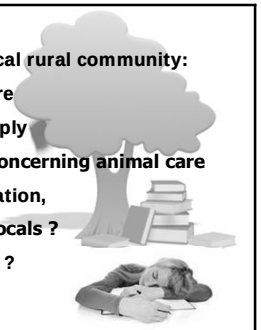
Conclusions (1)

- The current design tools (statistic CAD drawing, Excel, each components separately) **failed** to handle the mutual interaction between the several facilities
- A design concept for a mega dairy was developed.
- The model incorporates:
  - cow traffic,
  - milking parlors,
  - vet treatment,
  - manure handling,
  - cow cooling,
  - feed-center operation,
  - workers' transportation
  - A problematic junction, and their interrelations

Conclusions (2)

- The model found bottle necks
- The model maximized production capacity in terms of cows throughput in the milking parlor
- The simulation suggested "optimal solution".
- The model recommendations were discussed with and were **accepted** by the farm managers and designers.
- In further research other aspects should be incorporate:
  - Local community interaction: social issues, animal care tradition
  - Environment
  - Branding and social networks

Open questions



A mega dairy influences the local rural community:

- **Roads and water infrastructure**
- **Land price, and local feed supply**
- **Local community's tradition concerning animal care**
- **Odour smell, water contamination,**
- **Social – are the workers are locals ?**
- **Branding and social networks ?**
- **How big do you want to go ?**
- **Environment, Sustainability ?**

Further discussion -

אילן הלחמי פלאפון 0506220112, halachmi@volcani.agri.gov.il

From cows to fish - simulating livestock systems

- **Study the animal behaviour**
- **Simulation**
- **Model verification and validation**
- **RSM – Regression - Optimization**
- **Work with the model, meetings, discussions**
- **Conclusions, reporting, documentation**

Quantifying the animal behavior

- **Using sensors to measure**
  - **physiological,**
  - **behavioral, and**
  - **production indicators**
- **Focus on cow level:**
  - **reproductive, health, time budget and performance**

The *precision farming* concept

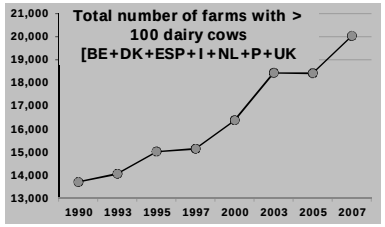
- **Spreading sensors at key locations of the Farm**
- **Process the data, Analysis & reports**

(**'*Management by exception*', 'individual traits' 'abnormal behavior etc.)**

- **Timely Decision making**

Trends in animal husbandry

- A shift from **Small to Large** farms with thousands of animals (From Cow Names to Cow Numbers).
- From Family-run to Organizations & Employees



Smart sensing

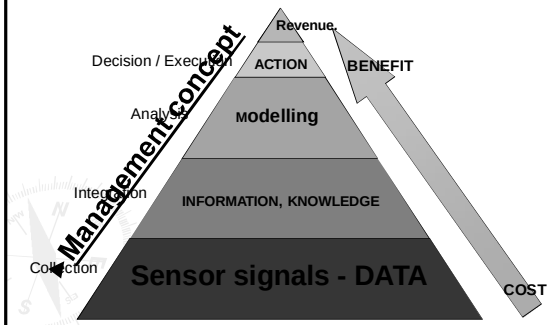
ALLOW caring for the individual animals"

These trends Require

►**sensing techniques, and**

►**A management concept**

From Data to Revenue



Outline - Quantifying animal behavior into a simulation model

► **5 Case study**

- Automatic **body condition scoring**
- Automatic cow **lameness detection**
- **Approaching calving** sensors
- Automatic early detection of **calving diseases**
- Feed efficiency with **robotic milking**

Sensor development

Decision making

►**What can be learned ?**

אוניברסיטת בן-גוריון בנגב
Ben-Gurion University of the Negev

Agricultural Research Organization
ARO
Israel

Amos Bercovich
Y. Edan, V. Alchanatis, E. Maltz, I. Halachmi

Automatic body condition scoring

Automatic Body condition scoring (BCS)

►**Body condition scoring (BCS)** estimates energy reserves (fatness) of cows

► **Important management tool**

- health issues
- Optimal time for 1st insemination
- feed management

Thin ---------- Fat

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The Problem

►**Manual**

- **Hard work**
- **Labor & Time consuming**

►**Subjective**

- **Technician**
- **Previously seen cows**

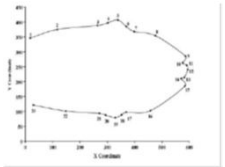
halachmi@volcani.agri.gov.il

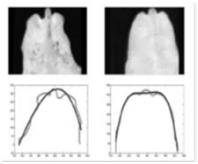
Previous work

Manual labeling of 23 anatomical points
- Bewley et al., JDS 2008
- †Azzaro et al., JDS 2011

•Polynomial fitting to cow contour

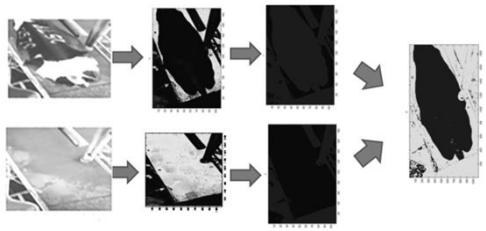
•Thermal camera
- Halachmi, Klopcic et al., JDS 2008





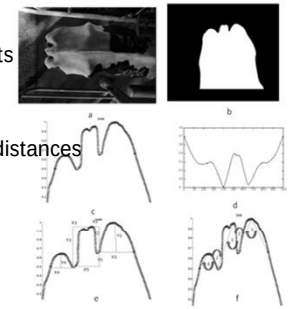
†CoRFiLaC, Consorzio Ricerca Filiera Lattiero Casearia, Regione Siciliana, 97100 Ragusa, Italy

Algorithms-segmentation

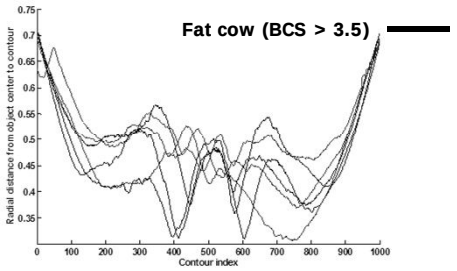


Feature Extraction

Cow contour:
- Interpolation 1000 points
- Scaling to 0-1 range
- 5 anatomical points
- Horizontal and vertical distances
- 5 angles
- 1 dimension curve

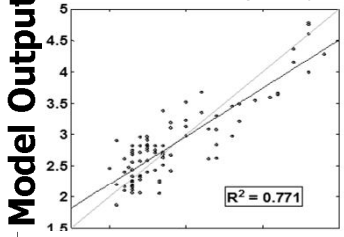


Algorithms *Fast Fourier transform*



Results

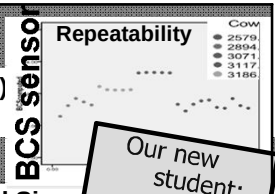
(Training database :87 cows)



Gold Reference - Manual BCS

BCS Sensor

►Regular camera (RGB)



Model

►Image Processing and Signa

Our new student: Fuzzy Logic, Adaptive methods

Applied Results (1-

Range	0-1/4	0-1/2	0-3/4	0-1
Training set	53%	82 %	98%	100%
Testing set	43%	72 %	94%	100%

2013 Accepted by the JDS

Outline

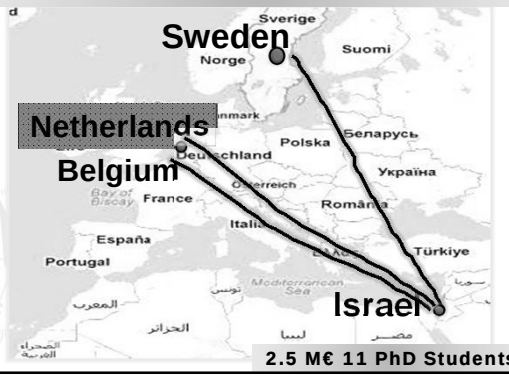
- **Animal Smart Sensing – needs and theory**
- **5 Case study**
  - Automatic **body condition scoring**
  - Automatic cow **lameness detection**
  - **Approaching calving** sensors
  - Automatic early detection of **calving diseases**
  - Real-time **milk analyzer** with **robotic milking**
- **What can be learned ?**

Sensor development

Automatic lameness detection – case study 4

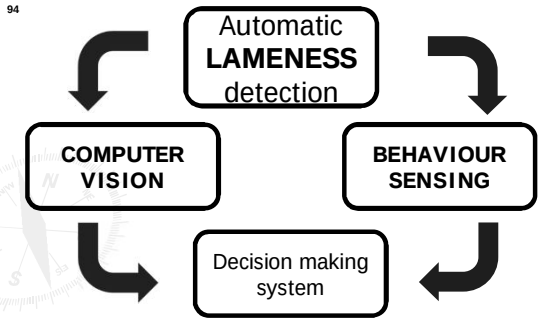
Tom van Hertem 's Ph.D.

Marie Curie EU-FP7 BioBusiness project



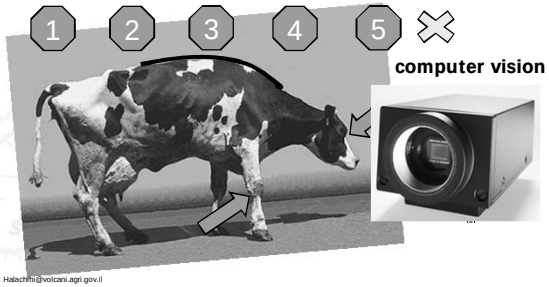
2.5 M€ 11 PhD Students

Two combined ways



Step 1: selecting key indicators

Could use: Lying behavior , Rumination, Neck Activity, Body Weight, Milk components. etc



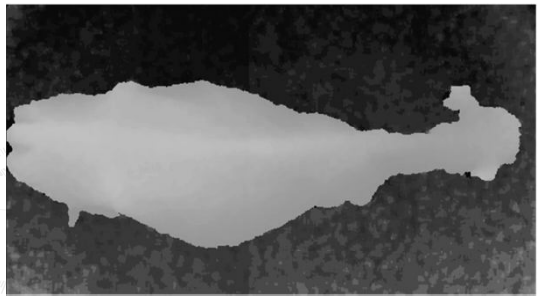
Halachmi@volcani.agri.gov.il

3rd Setup: 3D-camera

Halachmi@volcani.agri.gov.il

ARO, The Volcani Centre - 23 May 2013

3rd Setup: 3D-camera



ARO, Bet Dagan - 23 May 2013

Halachmi@volcani.agri.gov.il

Behavior Sensing

- SCR HR-Tag™
  - **Ruminating time [min/2h]**
  - **Activity [activity index/2h]**
- SCR Milk meter

Halachmi@volcani.agri.gov.il

Model Development

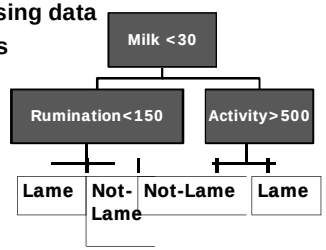
- **Logistic regression:**
- 7 input variables:
  - Milk: Daily yield, week slope, ratio and difference
  - Neck activity: daily sum, day/night ratio
  - Rumination: only night

Validation			
	Reference		**0.86**
Model	Lame	Not-Lame	
Lame	39	11	
Not-Lame	5	63	
	0.89	**0.85**	118

ISAE, Bet Dagan - 23 May 2013

Model Development

- **Classification Tree**
- **Dichotomous question (yes/no) at each node**
  - **Cope with missing data**
  - **Intuitive results**
  - **Camera**



Halachmi@volcani.agri.gov.il

Algorithm Verification

	Sensitivity	Specificity	Accuracy
Calibration	0.76	0.93	0.90
Verification	0.54	0.90	0.83

Sensitivity = ability to detect lame animals
Specificity = ability to detect not-lame animals
Accuracy = ability to detect lame and not-lame animals (correct classification rate)

ISAE, Bet Dagan - 23 May 2013

Algorithm Verification

N=744 cows

Model Score \ Reference Score	1 (90.9 %)	2	3	4	5 (60.8 %)
1	0.25	0.08	0.03	0.01	0
2	0.09	0.27	0.08	0.03	0.01
3	0.01	0.03	0.05	0.02	0.01
4	0	0.01	0.01	0.02	0
5	0	0	0	0	0.02

Tom van Hertem ISAE, Bet Dagan - 23 May 2013

Lameness Sensor

Rumination, Ne… …ity, Milk, 3D-Camera

Next step: BCS & Lameness

The Decision Model

►Logistic Regression and Classification Tree

Applied Results

►TBD at the end of the project. ARO library

Outline

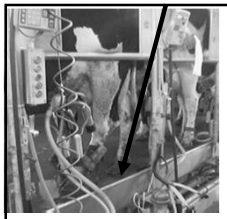
►5 Case study

- ✓Automatic **body condition scoring**
- ✓Automatic cow **lameness detection**
- ▪ **Approaching calving** sensors
- ▪ Automatic early detection of **calving diseases**
- ▪ Real-time **milk analyzer** with **robotic milking**

Sensor development

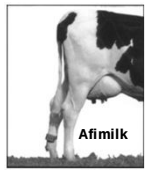
Decision making

►What can be learned ?



Lying sensor (Leg angle)

Ephraim Maltz



Sensing approach calving - the Algorithm

1. Lying time – down ↓

2. Number of steps – up ↑

Behavior 1

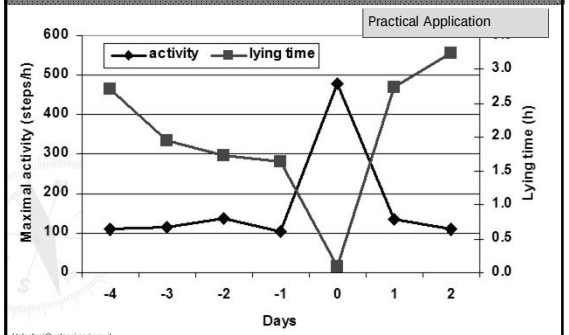
Behavior 2

Direction of the daily change

Halachmi@volcani.agri.gov.il

Sensing an approached calving

Practical Application



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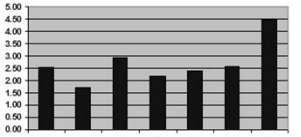
The Ratio: Steps/lying = "restless index"

Behavior 2

Practical Application



Behavior 1

Days before calving

Approached calving - two Sensors

- Steps, Lying sensor (leg angle)

Decision Model

- Multi Variables Regression ~ "restless"

Applied Results

- 76%
- Maltz and Antler. CIGAR2008 Brazil

Outline

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  - Real-time **milk analyzer** with **robotic milking**
- What can be learned ?

Sensor development

Decision making

Automatic early detection of calving diseases

Machteld Steensels 's Ph.D.

Halachmi@volcani.agri.gov.il

Which sensors?

State-of-the-art commercial sensors

Data collection

- 4 farms
  - 1 x 1100 cows/farm
  - 3 x 300 cows/farm

Which model?

- Logistic regression model
  - Probability of being sick
    - $f(z) = (1 + e\text{-}z)\text{-}1$
    - $z = \beta 0 + \beta 1\ x1 + \beta 2\ x2 + \ldots + \beta k\ xk$
- Model outcome: 0 – Healthy : 1 – Ketotic
- Variables: Rumination Time, Activity and Milk Yield

Halachmi@volcani.agri.gov.il

Model Calibration

Coefficients in the validation phase:

- **On 1 farm → to others**

Or

- **On a % of farm data (within a farm)**
  - **2/3; "Leave one out", etc**
  - **equal number of healthy and sick cows**

Halachmi@volcani.agri.gov.il

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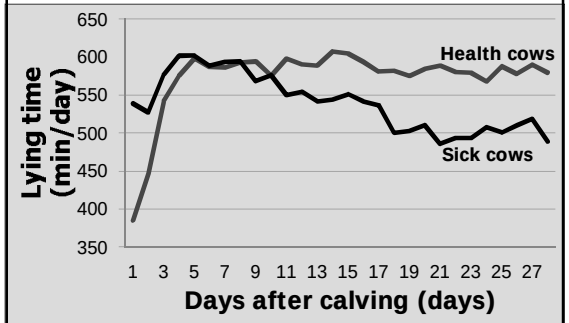
Lying time

Lying is an important issue to animal welfare

What about health ?

Dr. Ilan Halachmi halachmi@volcani.agri.gov.il

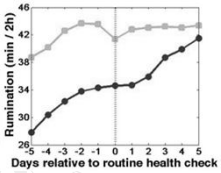
Preliminary results: Lying behavior



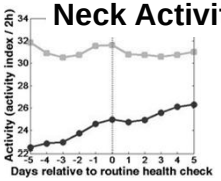
143 sick cows – 140 healthy cows, Summer

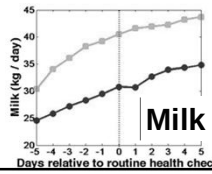
Healthy vs. ketotic cows

Runimation



Neck Activity





Milk

18

Rumination (minutes/day)

Relative to claving day

	Day 2	Day 3	Day 4	Day 5	Day 6
Healthy	348±4.4	393±4.5	430±4.7	451±4.9	461±4.8
Light	308±7.8	355±7.5	383±7.4	406±7.0	424±7.5
Moderate & Severe	260±20.4	302±18.9	341±20.6	371±19.5	359±22.4

Mean ± SE

Machteld Steensels ISAE, Bet Dagan - 23 May 2013

Model: Validation

Farm	Correct
1	83 %
2	70 %
3	91 %
4	67 %
5	77 %

Model accuracy

				CALIBRATION			
				Farm 1	Farm 2	Farm 3	Farm 4
	Farm		N_{tot}	Acc.	Acc.	Acc.	Acc.
VALIDATION	Farm 1	Ket	121	**0.74**	0.62		
		Heal	309				
	Farm 2	Ket	29	0.64	**0.77**	0.70	0.66
		Hea	46				
	Farm 3	Ket	33	0.69	0.56	**0.79**	0.53
		Hea	61				
	Farm 4	Ket	20	0.72	0.70	0.66	**0.75**
		Hea	87				

per farm calibration ?

1

Ketosis: Many Sensors

Lying behavior , Rumination, Neck Activity, BW, Milk components

Decision Model

- **Logistic Regression**

Applied Results

- **Ref: Machteld's PhD, in the ARO library**

Precision feeding

- **A New EU-Project. 2013-2017 (6.5 M€)**

Outline

- **Animal Smart Sensing – needs and theory**
- **5 Case study**
  - ~~Automatic **body condition scoring**~~
  - ~~Automatic cow **lameness detection**~~
  - ~~**Approaching calving** sensors~~
  - ~~Automatic early detection of **calving diseases**~~
  - ~~Feed eficency with **robotic milking**~~
- **What can be learned ?**

Sensor development

Decision making

Take Home message

- **The right key indicators**
- **Automatic data collection**
- **Cow individual data**
- **Data processing & machine learning**
- ***Modelling and Management* Concept**

Meeting outline

- ~~**RSM simulation optimization**~~
- ~~**Case study**~~
  - ~~**Aquaculture**~~
  - ~~**Milking robots, Mega-**~~
  - ~~**Automatic**~~
  - ~~**Automatic early d** **calving diseases**~~
  - ~~**automati** **meness detection**~~
  - ~~**approaching calving sensors**~~

OR Mod

Thank you for your attentio

Looking forward to cooperation

halachmi@volcani.agri.gov.il

Animal behaviour