Agricultural Research Organization
(ARO) Israel

Improving cow welfare: Sensor based detection of lameness

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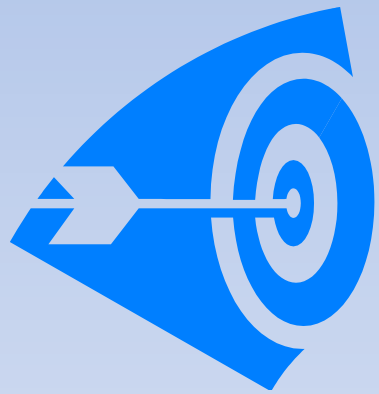
Outline

- BioBusiness project
- Problem posing
- Behaviour sensing approach
  - Sensors
  - Database building
  - Model development
  - Validation results
  - Conclusion
- Computer vision approach
  - Preliminary results



EU-project BioBusiness

- Biology + Technology
- **Consortium:**

5 Academia

KATHOLIEKE UNIVERSITEIT LEUVEN

RVC Royal Veterinary College University of London

TIERÄRZTLICHE HOCHSCHULE HANNOVER STIFTUNG 17 78

ANIMAL SCIENCES GROUP WAGENINGEN UR

UNIVERSITÀ DEGLI STUDI DI MILANO

2 Research

Agricultural Research Organisation (ARO)

anses

3 Industry

Fancom

PETERSIME

DeLaval

- **Concept:**

6 PhD's

Animal Sc.

Biology

Veterinary Sc.

2 PhD's

Engineering

ICT

Technology

3 Researchers

Product Dev.

Marketing

11 fellows

Training

Product Oriented Research

Precision Livestock Farming (PLF)

Problem: lameness

- Underestimated problem
- Pain → welfare
- Economic: €60/cow/year (Bruijnis et al., 2010)

- Visual identification by locomotion scoring
  - Subjective
  - Time consuming

- Automated and objective methods!
  - Monitor lameness prevalence farm

Hypothesis

- Lameness = change in daily routine
  → behaviour sensing
- Lameness = change in gait
  → computer vision

Sensors

- HR-Tag™ (SCR Engineers Ltd., Netanya, Israel)
  - Cow identification
  - Ruminating time [min/2h]
  - Activity [activity index/2h]

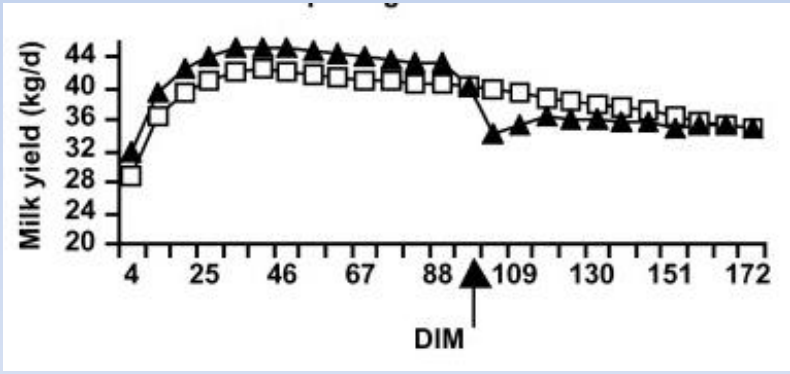
  →heat detection

- Free Flow™ (SCR Engineers Ltd., Netanya, Israel)
  - Milk yield

Database

- Sep 2011 – May 2012 → 8 months
- Days In Milk > 40 → avoid post-calving diseases

- Lame cows (n=44)
  - Diagnosed and treated for hoof and leg problem
  - No other severe disease (mastitis, digestive problem,…)

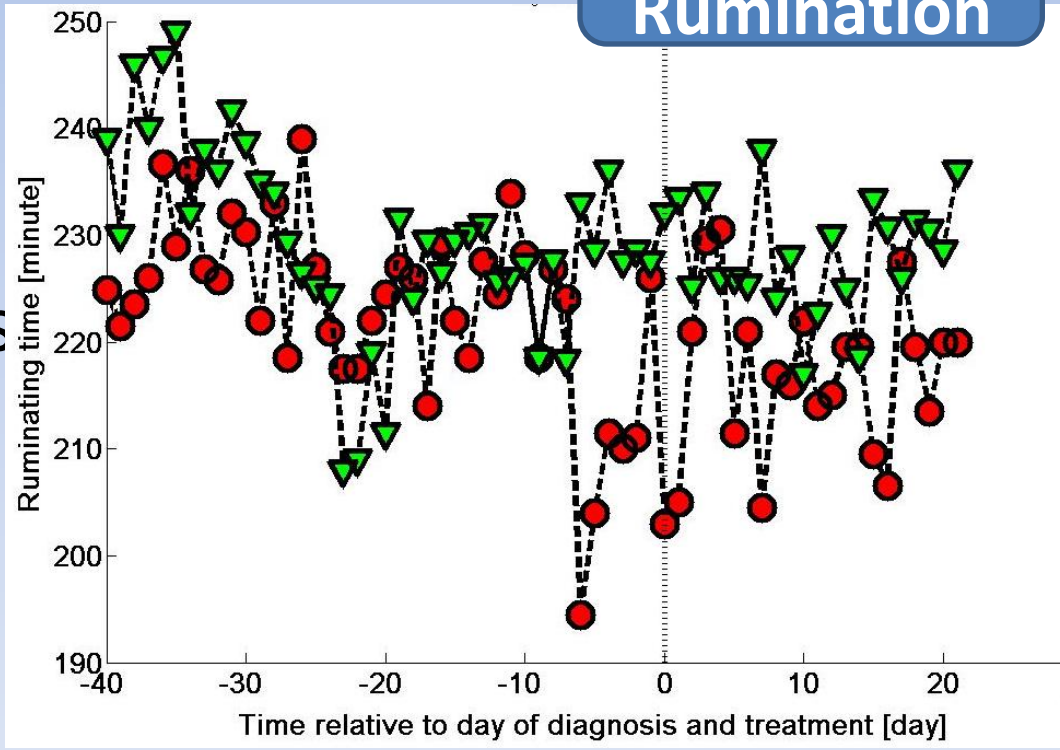


- Not-Lame cows (n=74)
  - No diagnosis for any disease
  - Issues with reproduction are allowed
  - Smooth lactation curve

State variable selection

39 variables created:

- Night vs day analysis
- Milking time
- Slope
- Absolute values
- Standard deviations
- Relative values
  - 1 week difference
  - 1 day difference



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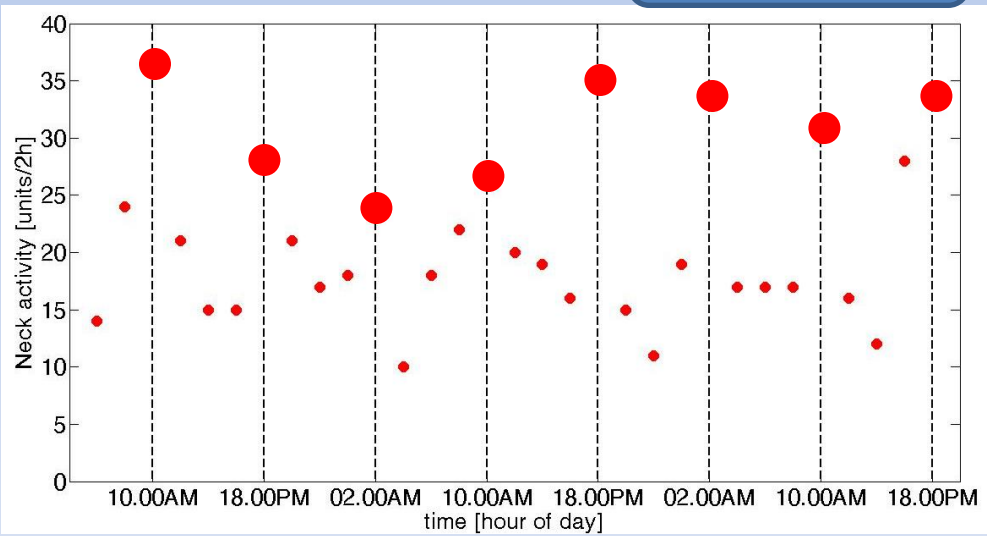
Activity



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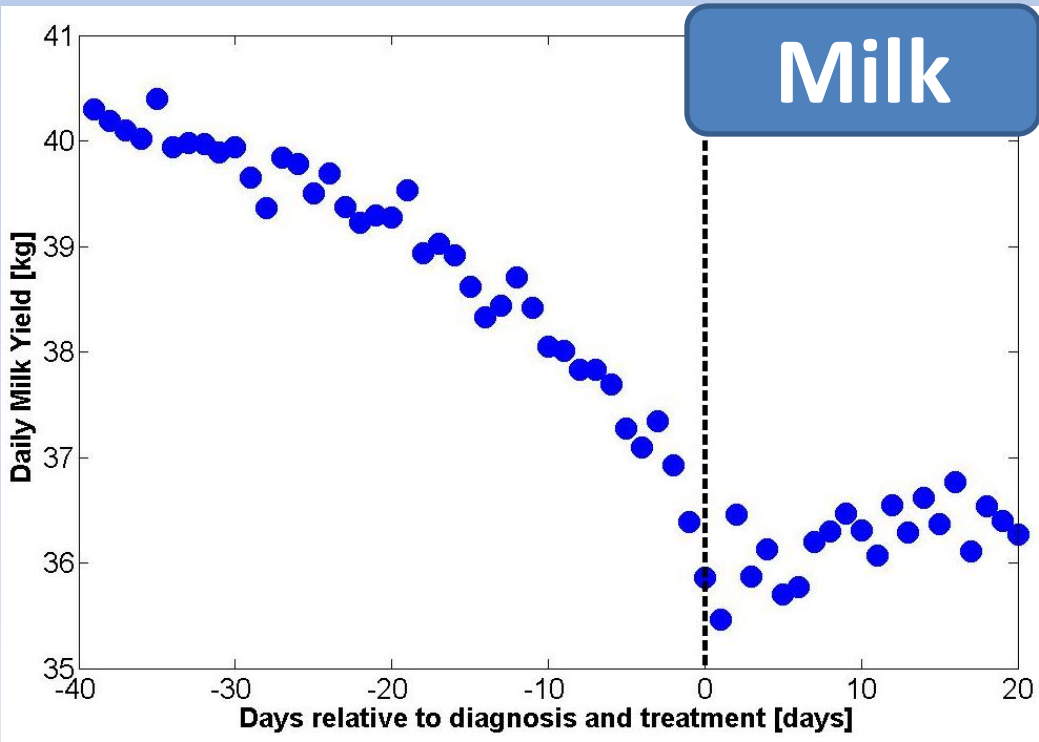


Model Development

- Output (Lame/NotLame)
- Day ~ [-7:-1]

Milk			Neck Activity			Ruminating Time		
var	Day	corr	var	Day	corr	var	Day	corr
Yield	-4	**-0.45**	Night/day ratio	-6	**0.38**	Night period	-6	**-0.30**
Slope	-4	-0.43	Daily sum	-7	-0.29	Daily diff.	-6	-0.29
Week ratio	-4	-0.35	3p max.	-7	-0.25	3p min.	-3	-0.27

→ Milk > neck activity > rumination

→ Not 1 significant parameter

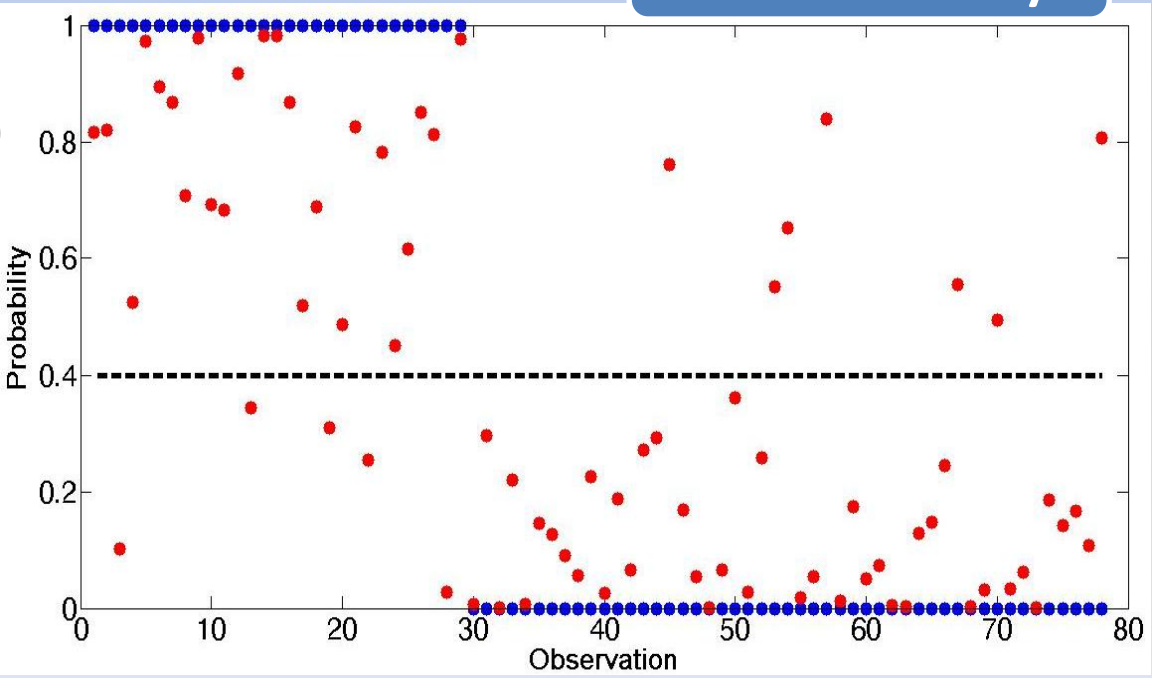
→ Combination of Milk, Rumination and Activity

Model Development

- Logistic regression
  - 2 model outputs: lame / not-lame
  - Combination of input variables
  - $z = \beta_0 + \beta_1 * x_1 + \beta_2 * x_2 + \ldots + \beta_n * x_n$
  - Probability =

    $\exp(z) / 1+\exp(z)$

Probability



Model Validation

- 7 input variables:
  - Milk: Daily yield, week slope, week ratio and difference
  - Neck activity: day period sum, day/night ratio
  - Rumination: night period ruminating time

	Calibration			Validation			
	Golden Standard		0.83		Golden Standard		0.90
Model	Lame	Not-lame		Model	Lame	Not-Lame	
Lame	20	4	0.83	Lame	14	3	0.82
Not-lame	9	45	0.83	Not-Lame	1	22	0.96
	0.69	0.92	78		0.93	0.88	40

Discussion

- Database
  - Existing farm data
  - Golden standard: herd health reports vs locomotion scoring
  - Database with extremes (lame vs. not-lame)
- Other types of models and improvements
  - Classification tree model → accuracy = 0.73
- Time tolerance of lameness detection
- Early detection vs. showing pain

Conclusion

- Correlation:

  milk > neck activity > rumination

- Day- and night period data also important
- Logistic regression model best fit
  - Accuracy = 0.90
- Room for improvement

Hypothesis

- Lameness = change in daily routine

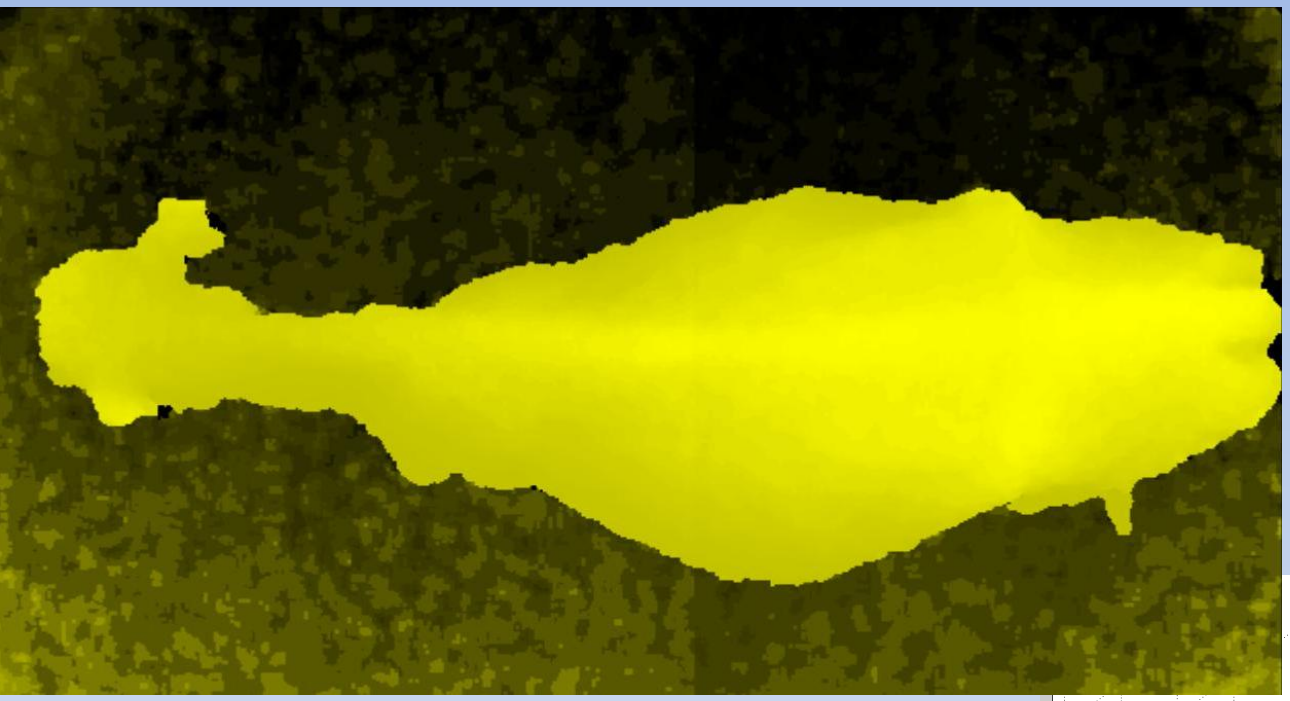
  →behaviour sensing

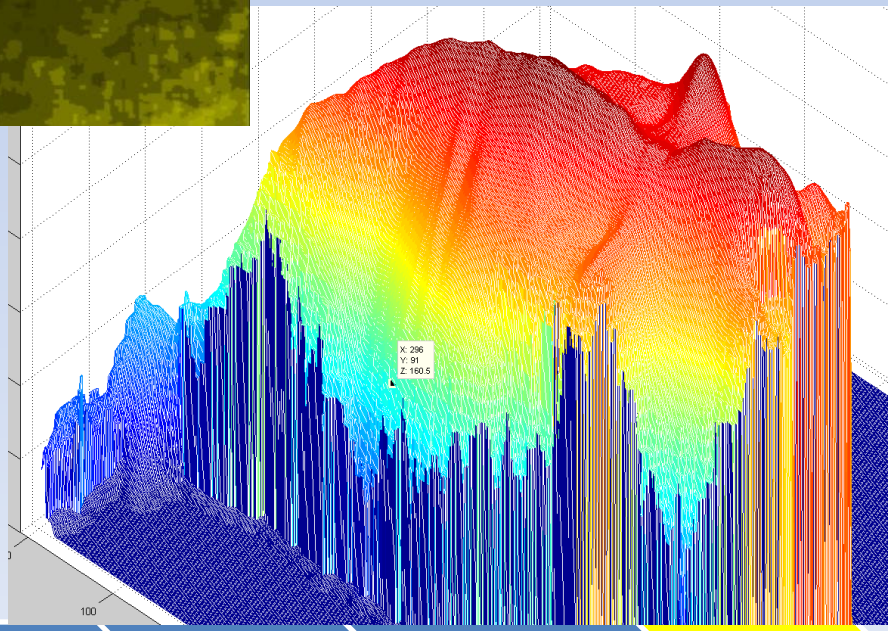
- Lameness = change in gait
  - Arched back
  - Gait asymmetry
  - Head bob

  → Computer vision

Setup

First Results: depth image

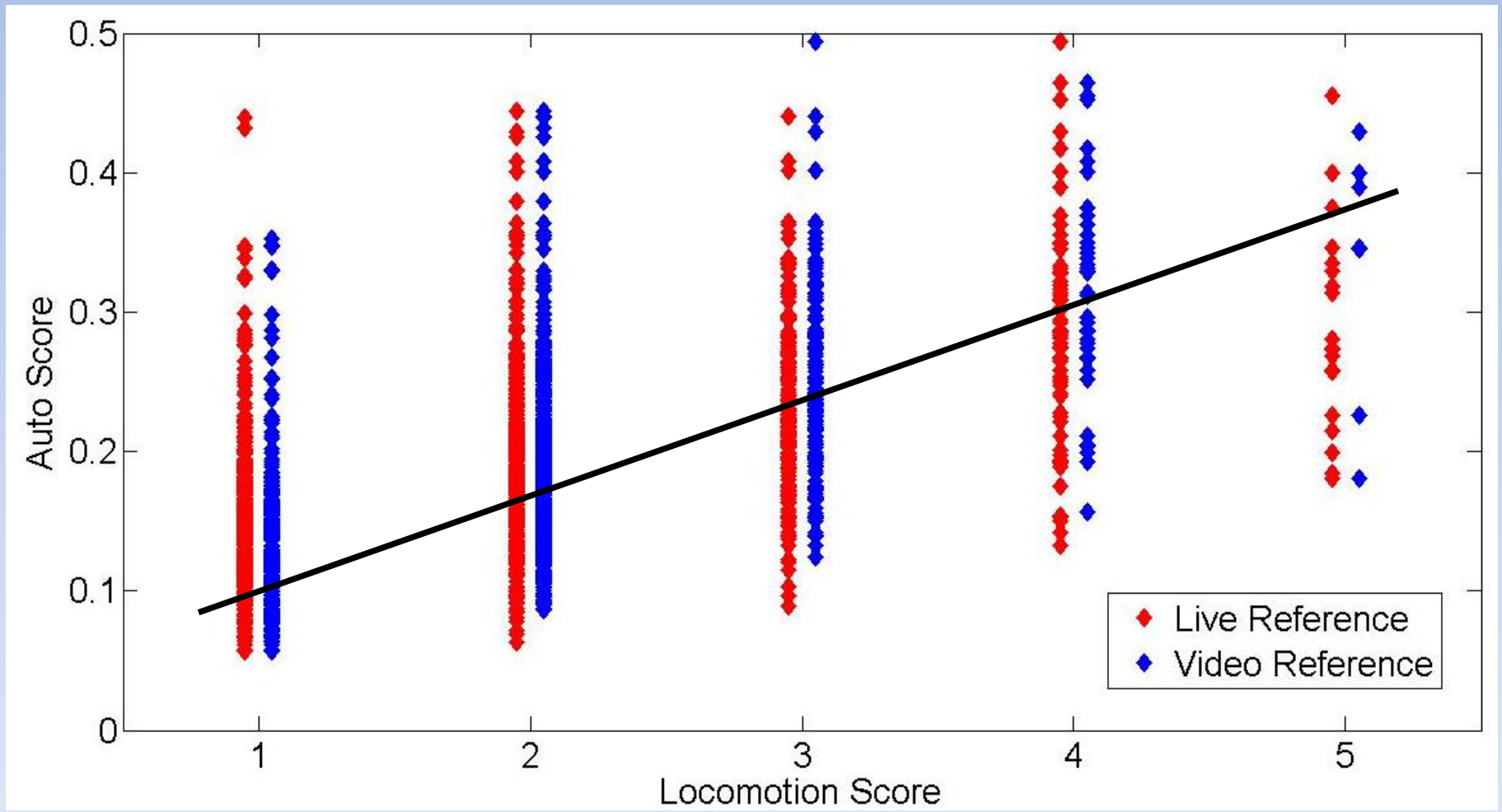




Extraction of arched back

First Results: mathematical model

AS = 0.0564*LS + 0.0731
R^2=0.3539



Future work

- Integrated system:
  - Behaviour sensing
  - Machine vision
- Incorporated in herd management software:

  → list of lame cows

Agricultural Research Organization

Israel

Thank you!

More Questions?

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