

Computer vision system for heifer height and weight estimation

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Extension Service
Ministry of Agriculture



Institute of
Agricultural
Engineering



Precision Livestock
Farming (PLF) Lab



Ben-Gurion University Faculty
of Engineering Sciences
model development



ISRAEL

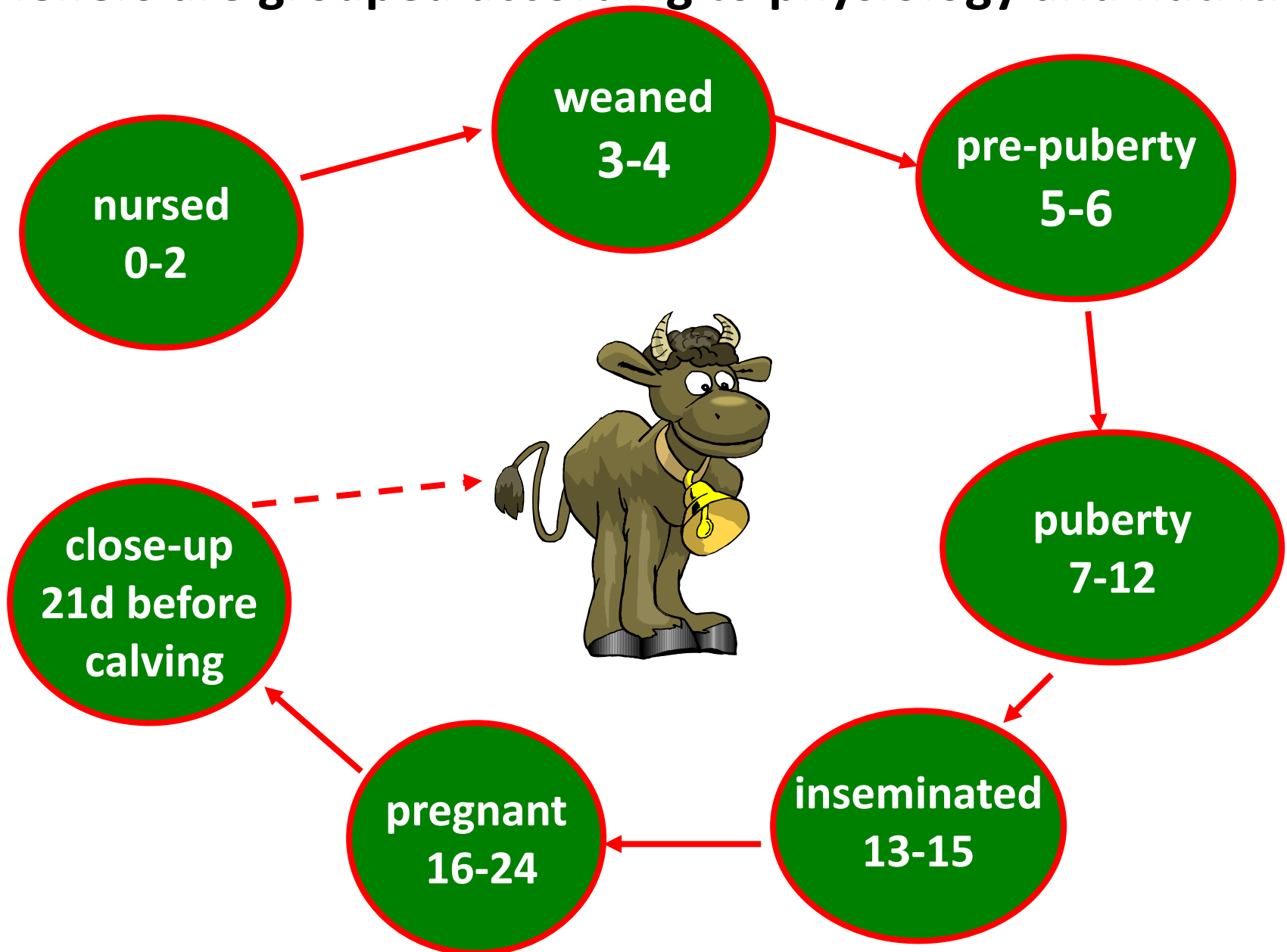
Importance of heifer management

- 135,000 Israeli Holstein cows, **120,000 heifers**
- 776 dairy farms (95-465 cows/farm). 100% A.I.
- Zero Grazing
- National Herd Book - 85% of the cows
- Well-adapted to the local environment
- Average Yield 11,970 Kg per cow per year (3.75% Fat 3.45% Protein)
- **33% of the herd 1st lactation yielding 10,850 Kg**
- Intensive dairy cattle production

Importance of heifer management

- ✓ Heifers play an important role in the future success of all dairy farms
- ✓ Excellent management help to achieve the main objectives on heifers raising until first calving :
 - Reducing mortality and morbidity
 - Normal and healthy growth
 - First insemination at the desired time
 - Normal calving and proper BCS at 23-24 months
 - Low extent of metabolic events after calving

Heifers are grouped according to physiology and nutrition



Homogeneous groups: development, animal health, animal behaviour



Dairy heifers are a large expense (feed, buildings, and labor) yet they return no money to the farm until they calve.

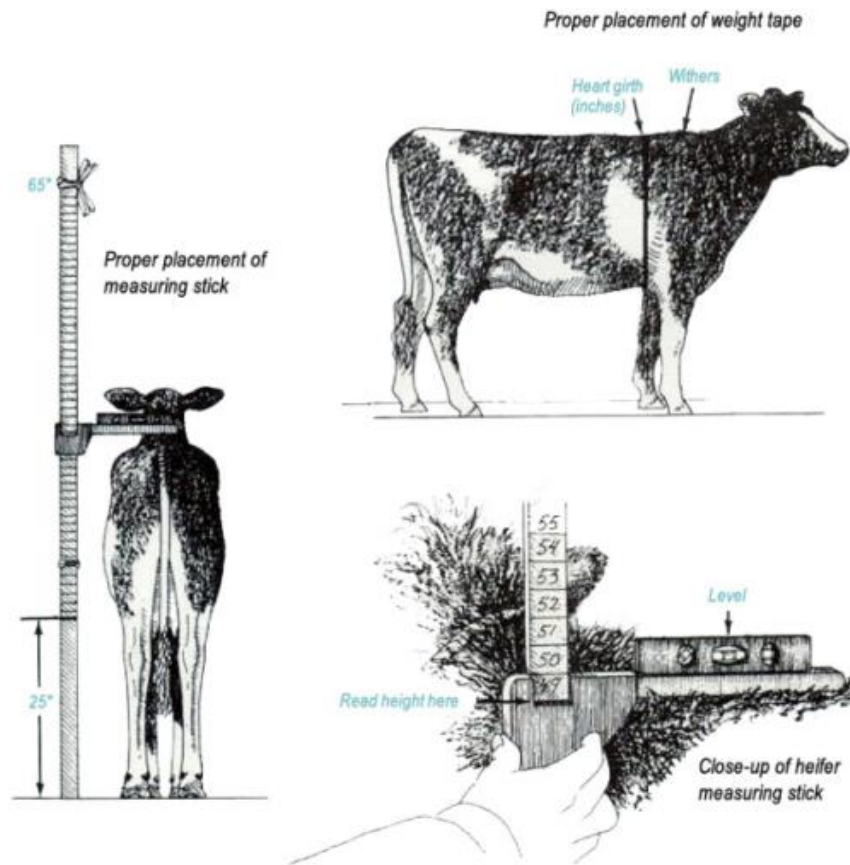
Good heifer management may yield the best quality heifer, with high production, at minimal cost.

**The cost of an heifer until first calving (in Israel) is about 2,780 euro, 17% of cow's total expenses.
(40% more than in USA, 45% more than in England)**

- Animal dimensions play a vital role in supporting management decisions regarding a farm's livestock
- There is high correlation between rate of growth: weight and height (skeletal development) of the heifer with calving difficulties and performance during first lactation
- It is advisable to take the maximum measures to bring them to calving at optimal weight and height



Monitoring Growth:

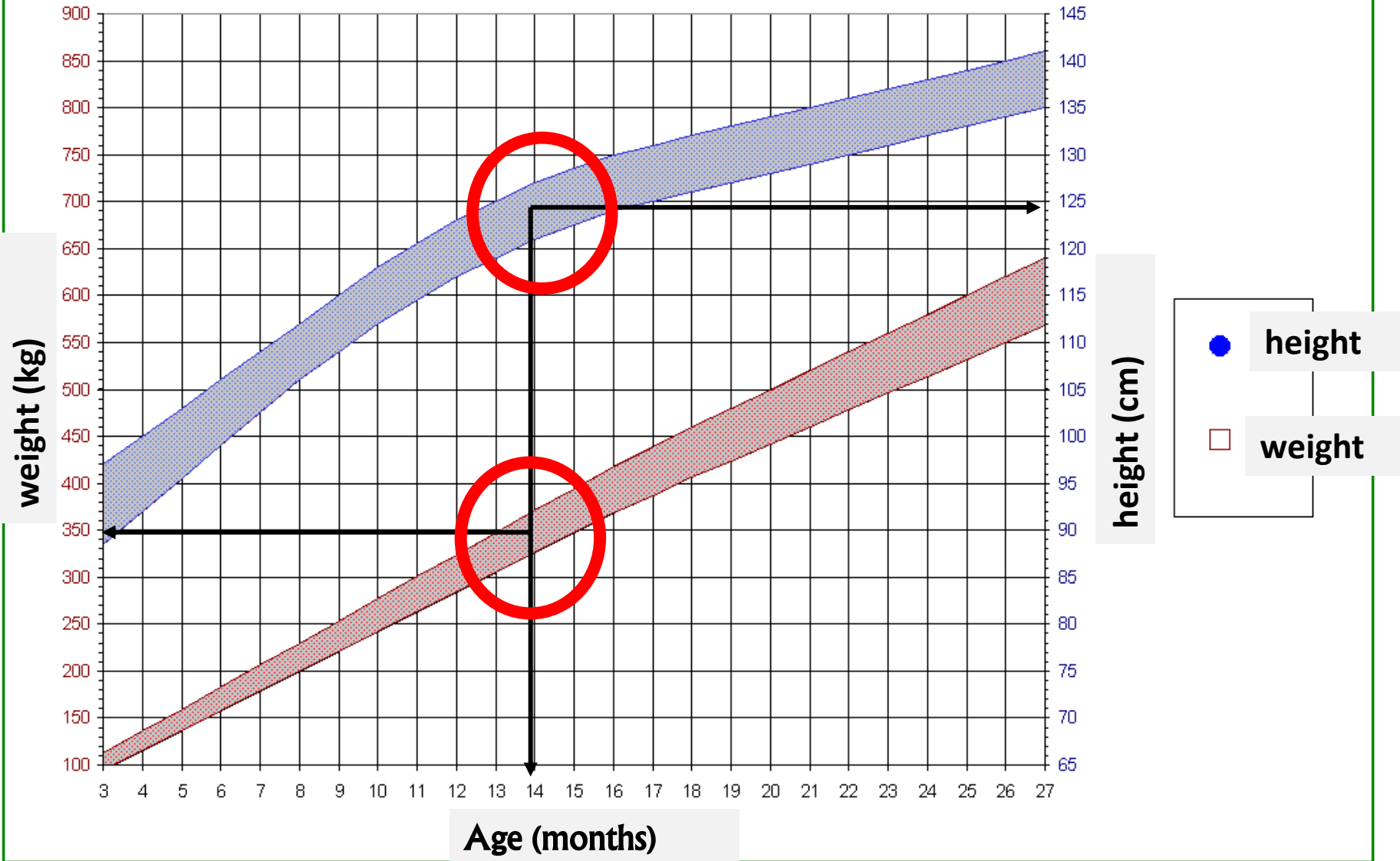


Dairy heifers' are still measured manually:
heifers must stand on concrete floor on the standing lane, tided up on the headlock barrier, holding the head upright –
body weight can be estimated using a weight tape, and height at the withers can be measured with measuring stick
body weight can be also measured using a scale

Customized Dairy Heifer Growth Chart



PennState Extension



Compares heifer performance to growth requirements

Manual measurement difficulties :

1. An expensive time consuming and stressful task for both the farmer and the animal (inaccuracy, beats and kicks, animal welfare)
2. The common heifer growth protocol is adjusted to groups according to age, so:

The nutritional requirements of an individual heifer within an age group, derived from the assessment of physiological requirements rather than measurement.

The accepted recommendations in Israel are based on a group average sample.

Despite the great importance of heifers

Only few dairy farmers apply this protocol



The absence of a reliable, objective, automated individual measurement system hinders effective management.

This research suggests an approach that utilizes a fully automated system and continuous monitoring to measure heifers body with a single low-cost 3D sensor camera –

An innovative device

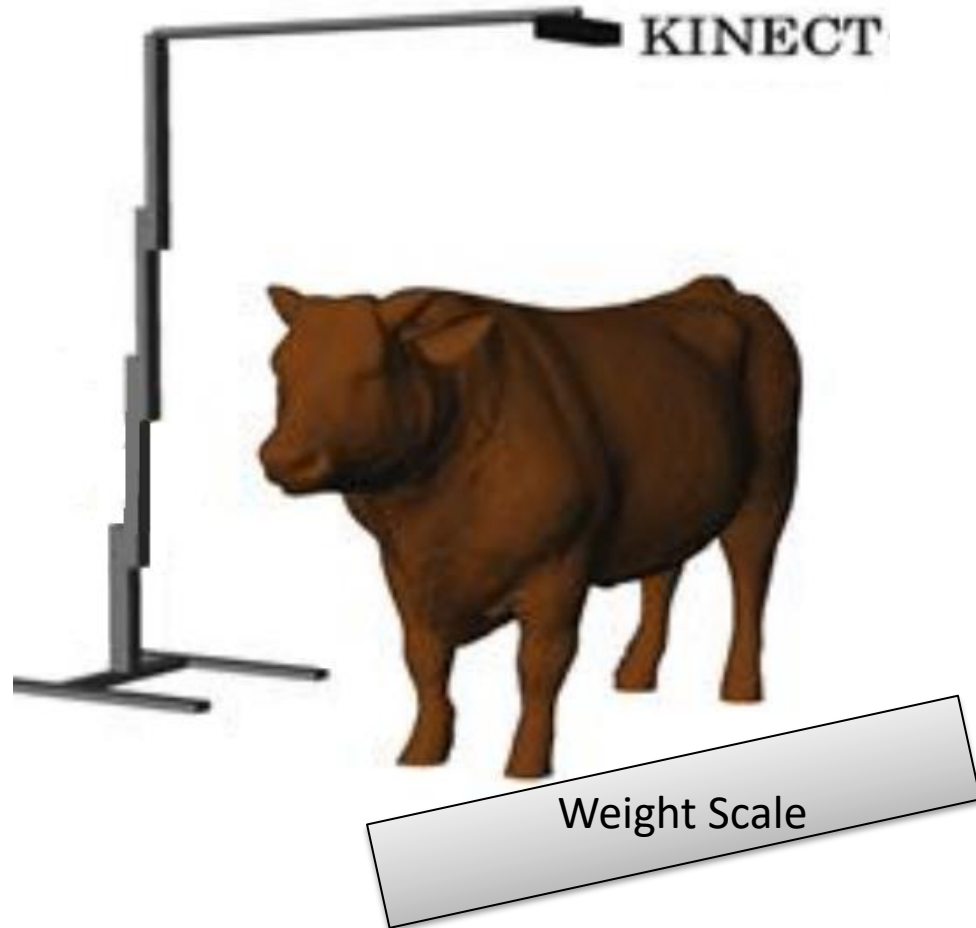
The objective is

- To develop automatic monitoring system of heifer height and weight.
- Aiming feed adjustment and earlier detection of growth disorders

Experimental methodologies :

1. Electro-optical engineering - a model based on image processing and 3D camera.
2. Mechanical design of a prototype
3. Development. A trail in the Volcani Center's Dairy Farm
4. Validation trail in a commercial farm

Materials and Methods: 3D Kinect camera installed on the ceiling above a BW scale, including identification system (reader, antenna, proximity sensor) of each heifer that comes under the camera

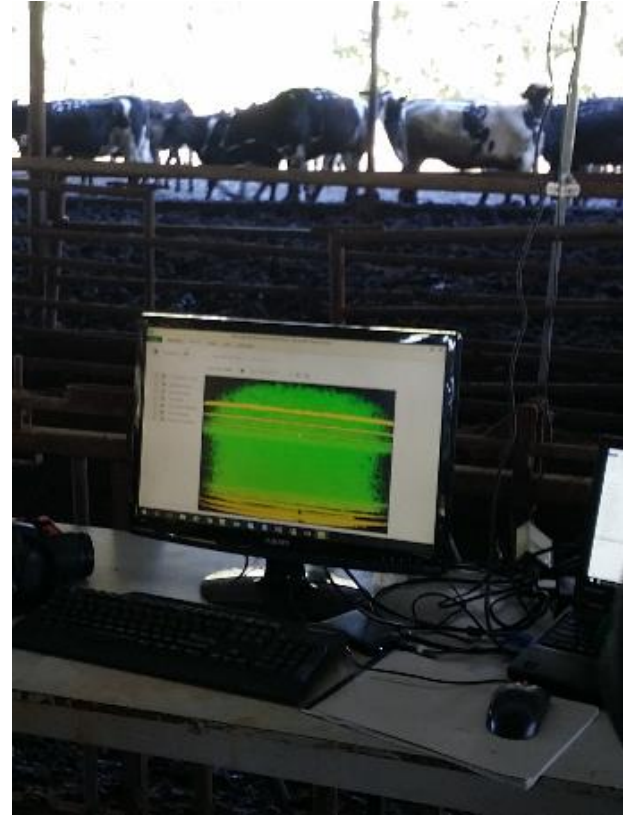
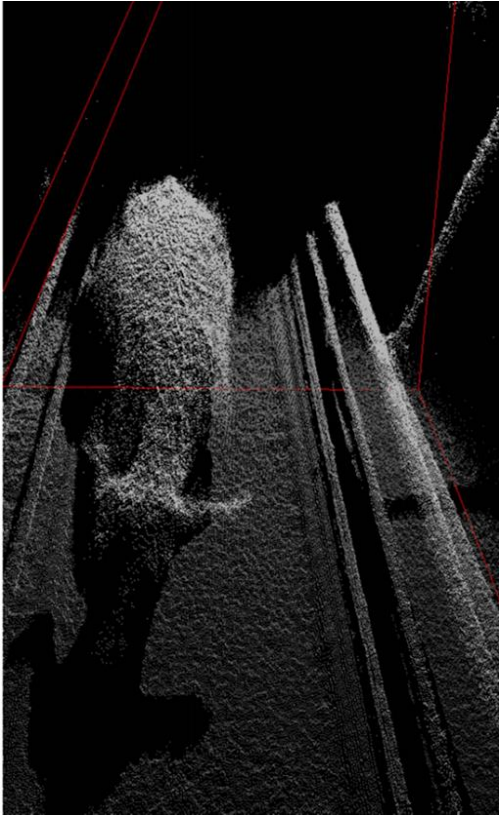




Processes to test the camera and the model

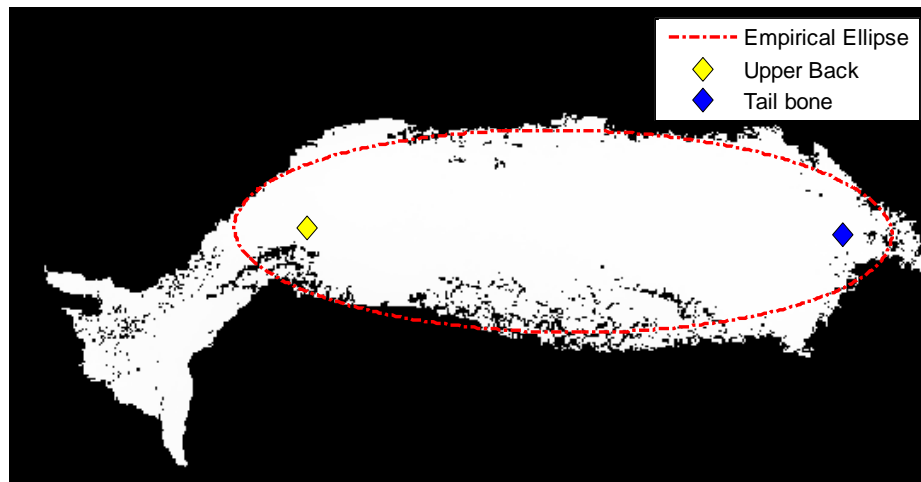


Stage 1 of development - raw image



The software produces a three-dimensional image: raw image before processing

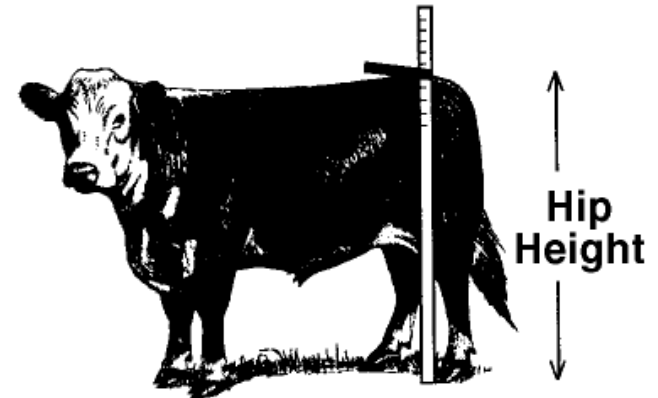
Stage 2 in development: noise filtering...



In the right, the raw image, and in left, after filtering the noises and reaching the ellipse

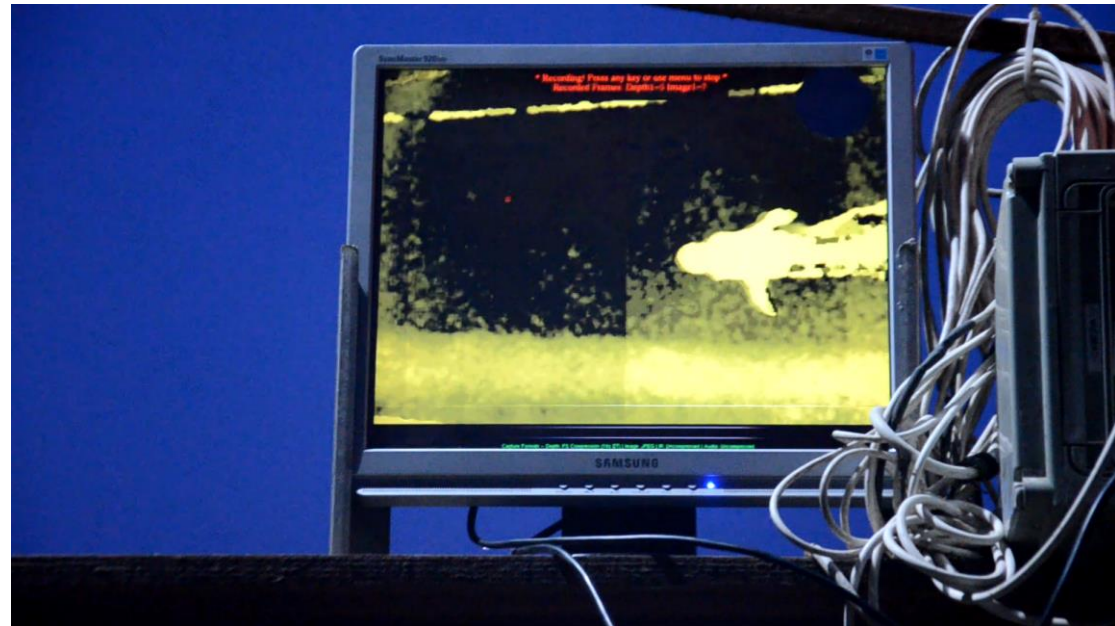
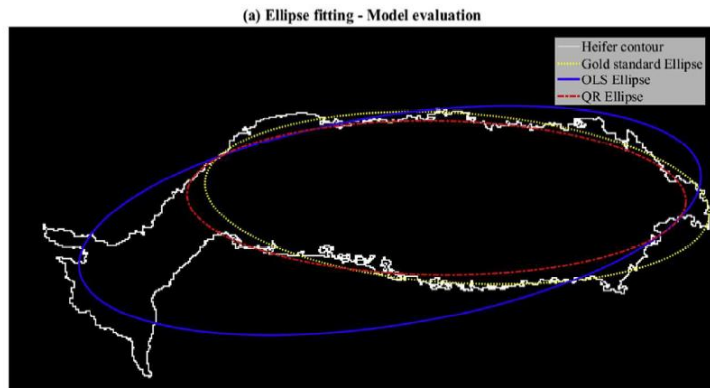
In the image processing process, the following parameters were selected:

- **Withers height**
- **Body weight**
- **In order to strengthen the reliability of the method, we also measured the hip height of the tail root.**
- **During the lecture we will not relate to these findings**

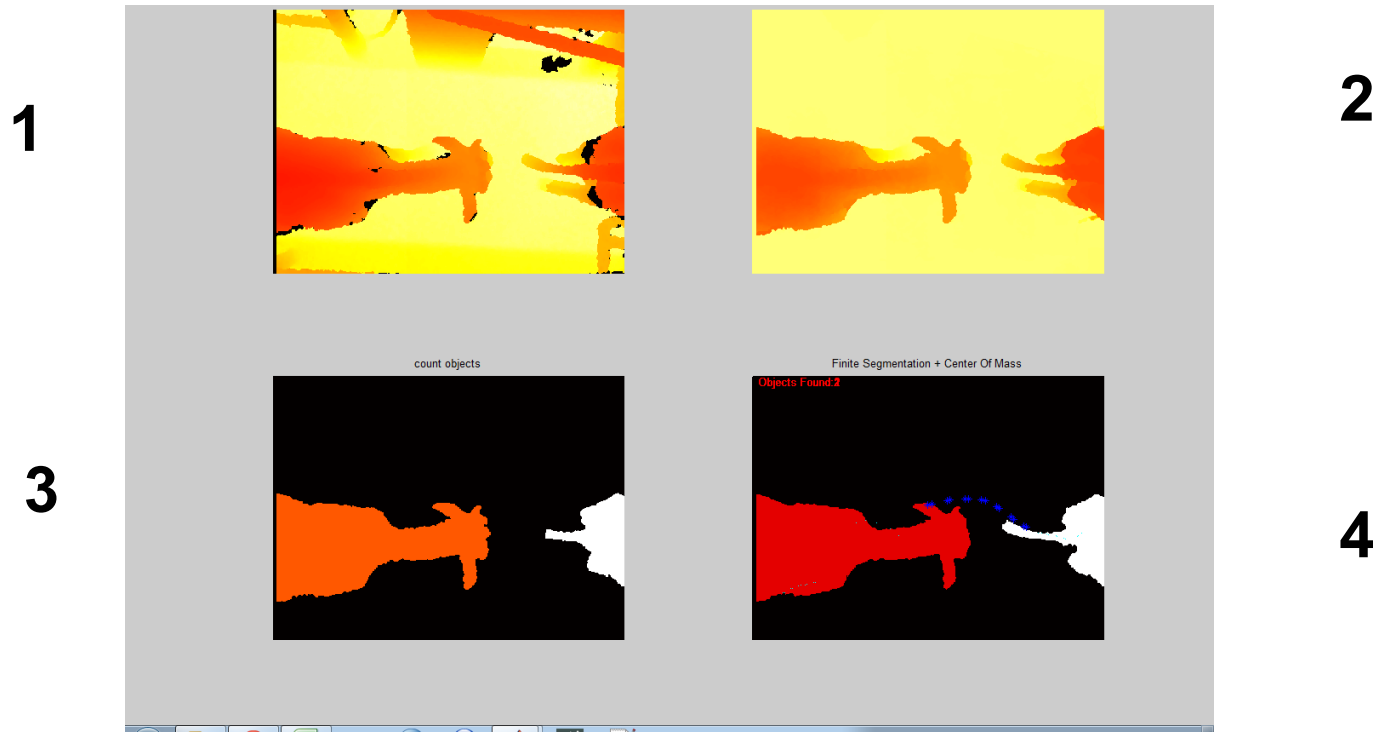


For processing the main parameters, we examined:

- An estimated volume of the heifer based on a **double integral** from the distance data within the ellipse
- Cross-sectional area of the heifer (ellipse)
- Withers height of the heifer, hip height of the tail root
- Radiuses of the estimated ellipse
- The area of the ellipse
- Age of the heifer



Steps to image processing:



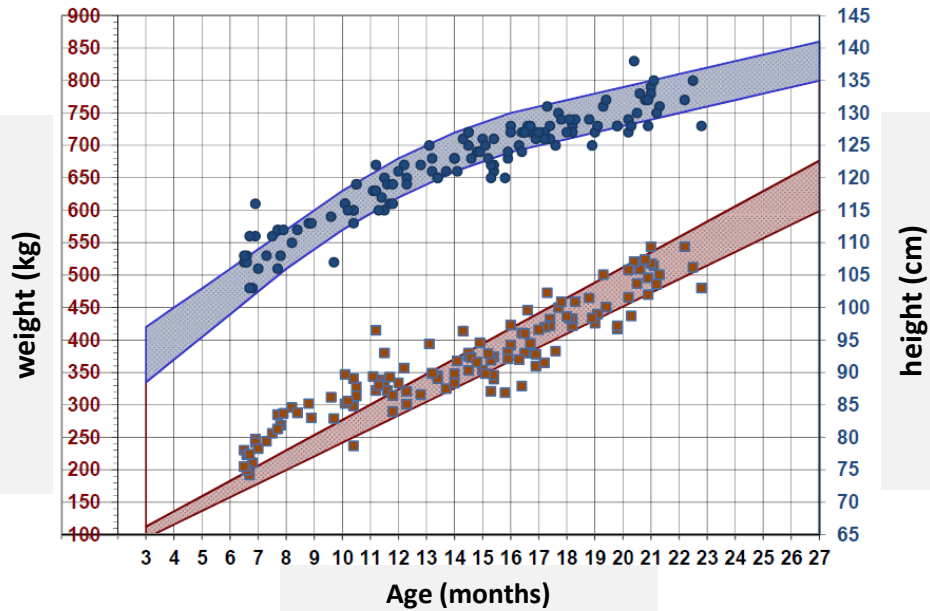
1. Picture, which includes details that are not interesting in the picture (fences, other heifers...) for the extraction of the relevant parameters
2. A clean picture of black holes and interesting elements
3. Differentiation between adjacent heifers (in the same picture) - "Segmentation"
4. Picture that counts objects and follows their center of mass movement.

Experiment at the Volcani Institute

n=117	avg	max	min	SD
age (months)	13.0	21.7	4.0	4.565
withers height (cm)	120.3	138.0	98.0	9.904
BW (kg)	355.2	572.0	160.0	99.598



Validation experiment at the Ein Hahoreshe dairy farm



Heifer measurement



n=124

avg

max

min

SD

age (months)

14.4

22.7

6.9

4.465

withers height (cm)

121.9

137.5

106.0

7.689

BW (kg)

369.9

544.0

233.0

82.504

Validation experiment conducted at the Ein Hahoresh dairy farm



Results

In the model conducted in the dairy barn at the Volcani Institute.

n=117	R ²	RMSE*	MRAE**
wither height (cm)	98.5%	1.2	0.8%
body weight (kg)	94.6%	22.6	5.6%

*Root Mean squared error

**Mean relative absolute error

To sum up this preliminary experiment, it is possible to say that the proposed innovation in the identification of the heifers body using the model, enables precise estimation of the heifers body from the Kinect image.

Results

In the validation experiment conducted at the Ein Hahoresh dairy farm:

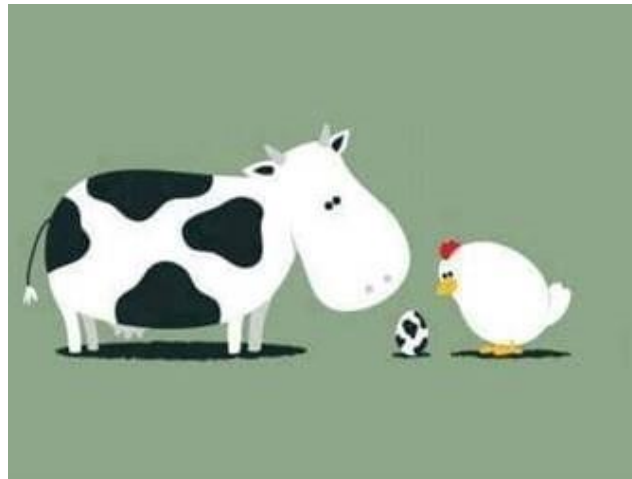
n=124	R ²	RMSE*	MRAE**
wither height (cm)	92.2%	2.9	1.9%
body weight (kg)	97.0%	20.4	4.9%

*Root Mean squared error

**Mean relative absolute error

In conclusion:

- A system was developed to measure stable and reliable over time, of the dimensions of the body of dairy heifers
- High level of accuracy was developed
- In future research, these principles could be applied to other farm animals such as cattle, pigs, horses, etc.



In conclusion...

- The possibility of placing and installing the system above water troughs, transit passages, or along the feeders, will be examined in order to enable full automation and accessibility of the product to each dairy farm
- If the new system will be common in a large number of farms, it will be possible to calculate the curve of development of the best Israeli cart in terms of height and weight or even individual curves adapted to each farm.

Engineering details and mathematical models: you are invited to read the article in Biosystems ENGINEERING

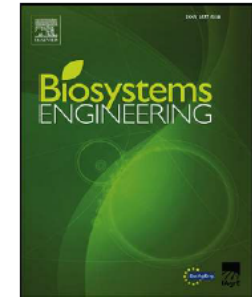


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Research Paper

3D Computer-vision system for automatically estimating heifer height and body mass

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Lesson learned

Applying 3D kinect camera: pros and cons factors:

- **Camera location – needed space in the farm, noisy background, sunlight,**
 - **Existing RFID (Radio Frequency Identification) vs. biometric ID**
 - **Pre-processing, filtering the noises, segmentation**
 - **Applying ellipse shape for cow object recognition**
 - **Quantile regression & Feature extraction,**
 - **Three objective functions (height 1, height 2, body weight)**
- Validation in the farms**

Thanks

To the dairy team at the Volcani Institute and the Ein Hahoresh dairy farm

To the audience for your attention



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