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Session 14
Integration of PLF and context data to improve decision making

LiDAR technology as a contactless tool for quantitative analysis of body condition score in beef cattle

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Introduction

Digital technologies are changing farm management by providing tools that can greatly enhance productivity, animal welfare, and sustainability

BCS is a crucial aspect of livestock management, serving as a key indicator of animal productivity, health and welfare

The use of contactless methods for assessing BCS offers the dual benefits of reducing stress on animals and minimizing the risk for the operators involved

The use of technologies can make the assessment of the BCS quantitative

Introduction

Computers and Electronics in Agriculture 174 (2020) 105510

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journal homepage: www.elsevier.com/locate/compag

Original papers

Advances in horse morphometric measurements using LiDAR

M. Pérez-Ruiz[a,*], D. Tarrat-Martín[a], M.J. Sánchez-Guerrero[b], M. Valera[b]

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Article

Automated Cow Body Condition Scoring Using Multiple 3D Cameras and Convolutional Neural Networks

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Abstract: Body condition scoring is an objective scoring method used to evaluate the health of a cow by determining the amount of subcutaneous fat in a cow. Automated body condition scoring becoming vital to large commercial dairy farms as it helps farmers score their cows more often ar more consistently compared to manual scoring. A common approach to automated body conditi scoring is to utilise a CNN-based model trained with data from a depth camera. The approach presented in this paper make use of three depth cameras placed at different positions near the rear a cow to train three independent CNNs. Ensemble modelling is used to combine the estimations the three individual CNN models. The paper aims to test the performance impact of using ensemb modelling with the data from three separate depth cameras. The paper also looks at which of the three cameras and combinations thereof provide a good balance between computational cost ar performance. The results of this study show that utilising the data from three depth cameras to tra three separate models merged through ensemble modelling yields significantly improved automat body condition scoring accuracy compared to a single-depth camera and CNN model approa This paper also explored the real-world performance of these models on embedded platforms comparing the computational cost to the performance of the various models.

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Article

Validation of an Automated Body Condition Scoring System Using 3D Imaging

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Automatic method for quantitatively analyzing the body condition of livestock from 3D shape

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ARTICLE INFO

Keywords:
Body Condition Score
3D shape analysis
Precision livestock farming
Deep learning

ABSTRACT

Body condition has always been an important indicator reflecting the health status of livestock, and new automated and contactless methods for assessing it have also been continuously proposed. In recent years, with the continuous expansion of research on quantitative analysis of three-dimensional shapes in the field of agriculture, amount of studies has shown that quantitative analysis of shapes can promote the development of smart agriculture. This article proposed a method for quantitatively analyzing the local three-dimensional shape of livestock to evaluate their body conditions. This is a universal method that can be applied to various species. It uses the method of point-to-point correspondence in the three-dimensional shape to finely calculate the difference between shapes, and then maps the difference value to the range of the body condition score. The article analyzed the shape of 198 dairy cows, 100 beef cattle, and 201 pigs using body condition scores as test parameters. The accuracy of body condition evaluation within the range of error of 0.5 for dairy cows, 1 for beef cattle, and 0.5 for pigs are 100%, 87.61%, and 92.09%, respectively. Compared to previous methods for assessing body condition, the method proposed in this paper is more accurate and versatile. The dataset used in this study, along with the code implementation have been made publicly available in https://gitee.com/kznd/lshape-analyser/tree/master/MATLAB.

sensors MDPI

Article

Non-Contact Body Measurement for Qinchuan Cattle with LiDAR Sensor

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Estimation of beef cow body condition score: a machine learning approach using three-dimensional image data and a simple approach with heart girth measurements

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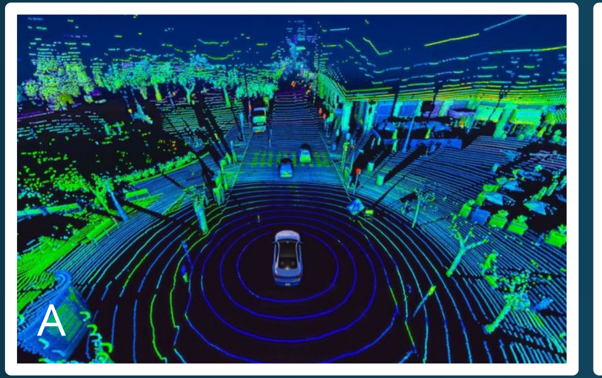
ARTICLE INFO

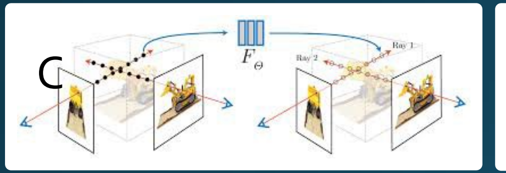
Keywords:
Body condition score
Heart girth
Japanese Black cows
Machine learning
Three-dimensional camera

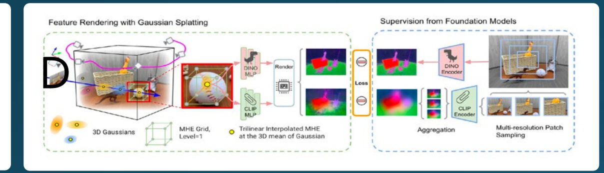
ABSTRACT

Body condition score (BCS) is a proxy for evaluating body fat reserves. However, monitoring BCS is a time-consuming and subjective task. Thus, we aimed to develop a method for estimating the BCS of beef cows using three-dimensional (3D) body features of cows' rump area derived from 3D camera data. Three-dimensional surface data of the rump area from 39 multiparous cows were obtained using a 3D camera, and four 3D body features were extracted. The BCSs of the cows were scored by experts, and models for predicting BCS by 3D features were developed using machine learning algorithms. The derived model yielded an overall accuracy, precision, sensitivity, and F-measure of 90%, 88%, 90%, and 88%, respectively. Additionally, we evaluated a simple practical method to estimate BCS using the difference between heart girth (HG) and tightened heart girth (THG) for 118 multiparous cows. A cumulative logistic regression model for estimating BCS by the difference was developed, and the derived generalized coefficient of determination was 0.81. These results suggest that 3D images are useful for estimating the BCS of beef cows and that the difference between HG and THG can be used to estimate BCS as a simple practical method.

Introduction







A. Light Detection and Ranging (LiDAR)
B. Photogrammetry
C. Neural Radiance Field (NERF)
D. 3D Gaussian Splatting (GAUSS)

Are tools able to accurately reconstruct 3D objects shapes

These tools are available for smartphones, representing an opportunity for a cost-effective and accurate shape computation

LiDAR technology as a contactless tool for quantitative analysis of body condition score in beef cattle

To assess the reliability of 3D shapes obtained from smartphone applications, including the LIDAR tool, to assess the animal Body Condition Score of beef cattle

Specific objectives
of this preliminary study were:

1. Use various smartphone applications to reconstruct 3D shapes of cattle using point cloud analysis
2. Compare the accuracy between the digital and conventional manual measurements
3. Evaluate the results and applicability of proposed procedure to estimate body condition score

Materials & Methods

1) Identification of animals

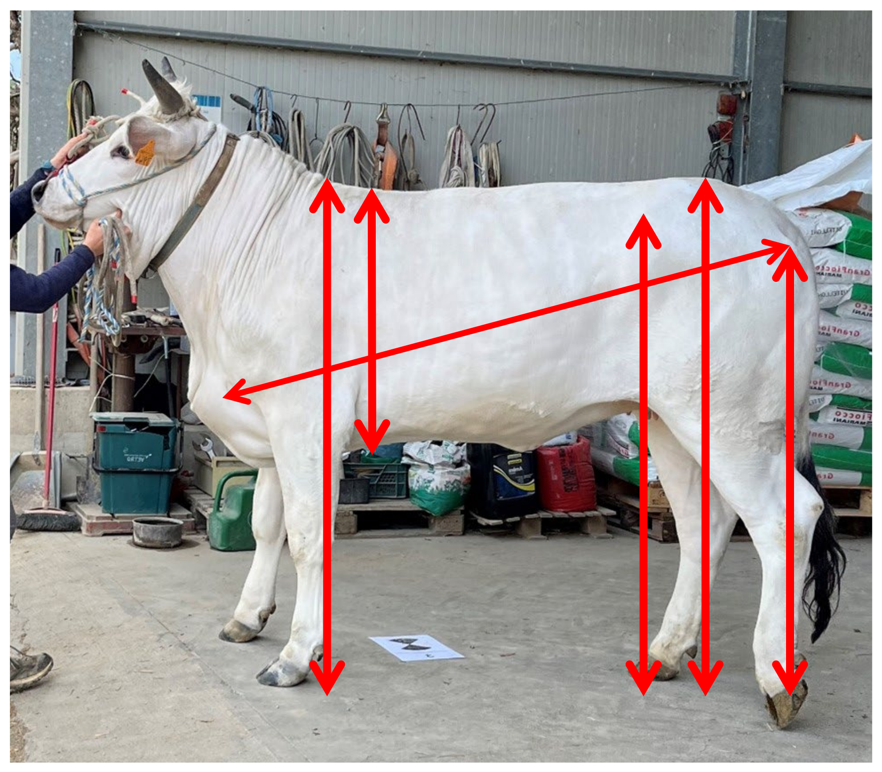
Marche region, Ancona
Marchigiana cattle, cow-calf system

Three Marchigiana cows registered in the National Herd Book of National Association of Italian Beef-Cattle Breeders (ANABIC)

All cows were in the same physiological status (first trimester of pregnancy)

Materials & Methods

2) Identification of zoometric measurements to compare the accuracy of 3D reconstructions



10 linear zoometric measurements resulted detectable from 3D animals' reconstructions:
Wither Height (WH), Chest Height (CH), Shoulder Width (SW), Chest Width (CW), Body Length (BL), Pin Height (PH), Rood Height (RH), Pin Width (PW), Trochanter Width (TW), and Rump Length (RL)

They were also measured on the animals' 3D shapes

Materials & Methods

3) Setting up of technologies

A smartphone	3 Applications	4 Tools
	Recon-3D	• LIDAR • PHOTOGRAMMETRY
	KIRI Engine	• GAUSSIAN • NERF
	LUMA AI	• NERF

Materials & Methods

3) Setting up of technologies

Installation and processing of target points by using Terrestrial Laser Scanning (TLS) toll

Target points were necessary for data processing, scaling the resulted images from applications with the surrounding environment in which the animals were during the scanning

Materials & Methods

4) Acquisition and processing of cattle data – 3D animals' measurements

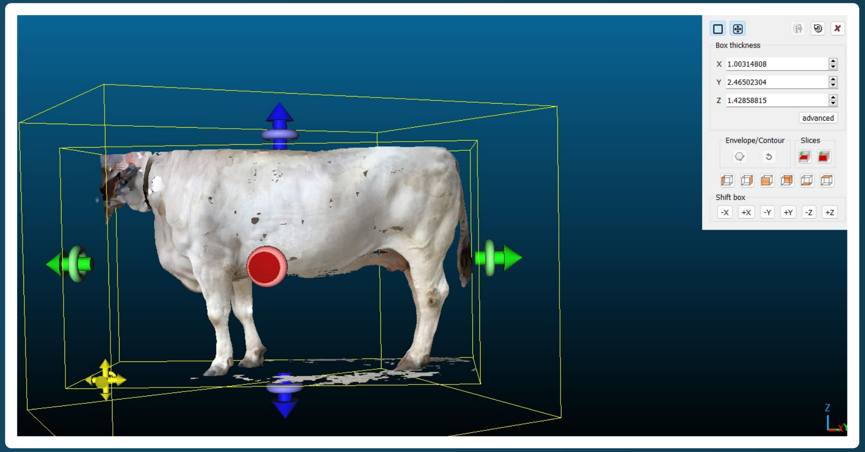
The animals were placed at the center of the four target points, ensuring they are always visible in the 3D model

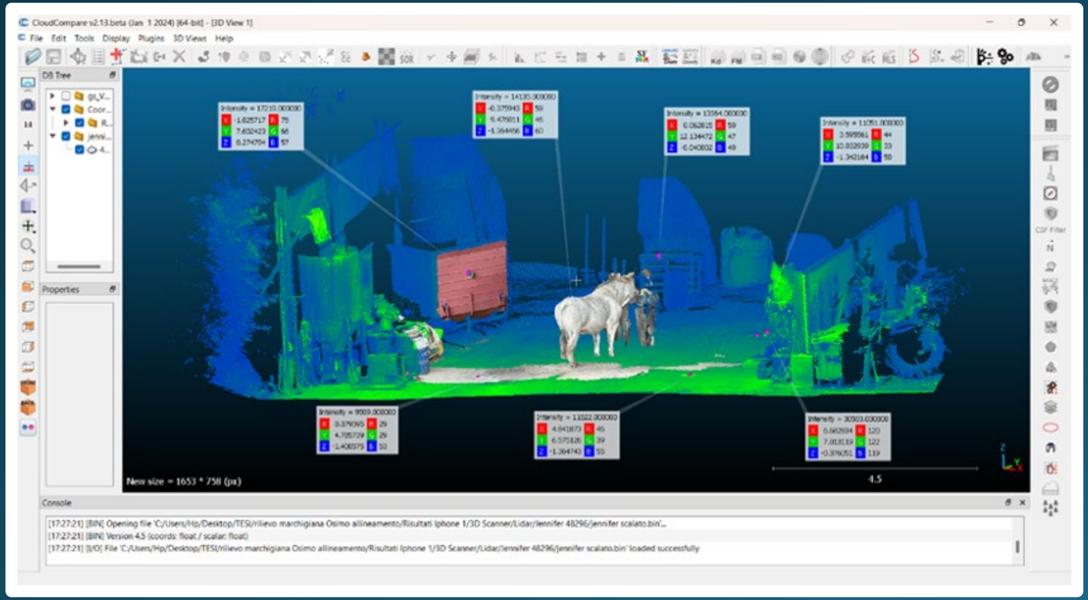
Each application was performed according to its specific instructions making three scans at different heights for each cow

The point clouds (3D image) of each cow were generated and saved in the smartphone's memory, and then processed using the CloudCompare software

Materials & Methods

4) Acquisition and processing of cattle data – 3D animals' measurements





The 3D models obtained from the smartphone apps were scaled by identifying at least 3 target points

Point cloud manual filtering to facilitate the extraction of the measurements of zoometric variables, filtered from noise points and objects in the workspace

From the point cloud generated and filtered through the CloudCompare software, the same measurements of zoometric variables taken on real animals were detected manually

Materials & Methods

5) Evaluation of accuracy of cattle's measurements

To compare the accuracy between digital and manual measurements, statistical analysis carried out have including:

- Mean
- Relative Error (r.e.)
- Pearson correlation coefficient (r)
- Determination coefficient (R^2)
- Root Mean Square Error (RMSE)
- BIAS
- Regression analysis

The differences between measurements from LiDAR reconstructions and those obtained from other tools were also investigated

Results & Discussion

Recon 3D - LiDAR *vs* Manual Measurement											
Measures		WH cm	CH cm	SW cm	CW cm	BL cm	PH cm	RH cm	PW cm	TW cm	RL cm
COW 1	Man	149,33	76,67	57,33	57,33	175,00	136,00	149,00	22,50	55,00	56,67
	3D	142,44	78,26	56,54	53,34	170,51	137,94	147,37	34,44	55,09	52,45
	r.e. %	**4,62**	**-2,08**	**1,39**	**6,96**	**2,57**	**-1,42**	**1,10**	**-53,09**	**-0,17**	**7,44**
COW 2	Man	149,67	75,00	62,67	56,67	172,50	140,00	152,67	24,75	58,00	56,00
	3D	146,85	74,92	65,13	60,31	181,15	133,96	148,80	36,76	62,73	59,49
	r.e. %	**1,88**	**0,11**	**-3,93**	**-6,43**	**-5,01**	**4,31**	**2,53**	**-48,53**	**-8,15**	**-6,23**
COW 3	Man	148,67	75,00	53,00	50,50	164,00	144,50	156,67	21,50	54,33	49,67
	3D	143,98	75,86	55,54	48,60	165,69	135,03	152,01	24,89	58,76	50,32
	r.e. %	**3,15**	**-1,14**	**-4,80**	**3,77**	**-1,03**	**6,55**	**2,97**	**-15,77**	**-8,14**	**-1,32**
r		**0,48**	**0,96**	**0,93**	**0,75**	**0,58**	**-0,68**	**0,98**	**0,85**	**0,78**	**0,61**
RMSE		**5,08**	**1,05**	**2,09**	**3,31**	**5,71**	**6,58**	**3,62**	**9,97**	**3,74**	**3,18**
BIAS		**-4,80**	**0,79**	**1,40**	**-0,75**	**1,95**	**-4,52**	**-3,38**	**9,12**	**3,08**	**-0,02**

The 3D measurements with the combination Recon 3D-LIDAR here reported show a good match with manual ones, confirmed by low r.e. values (-53.09 is the higest one)

Results & Discussion

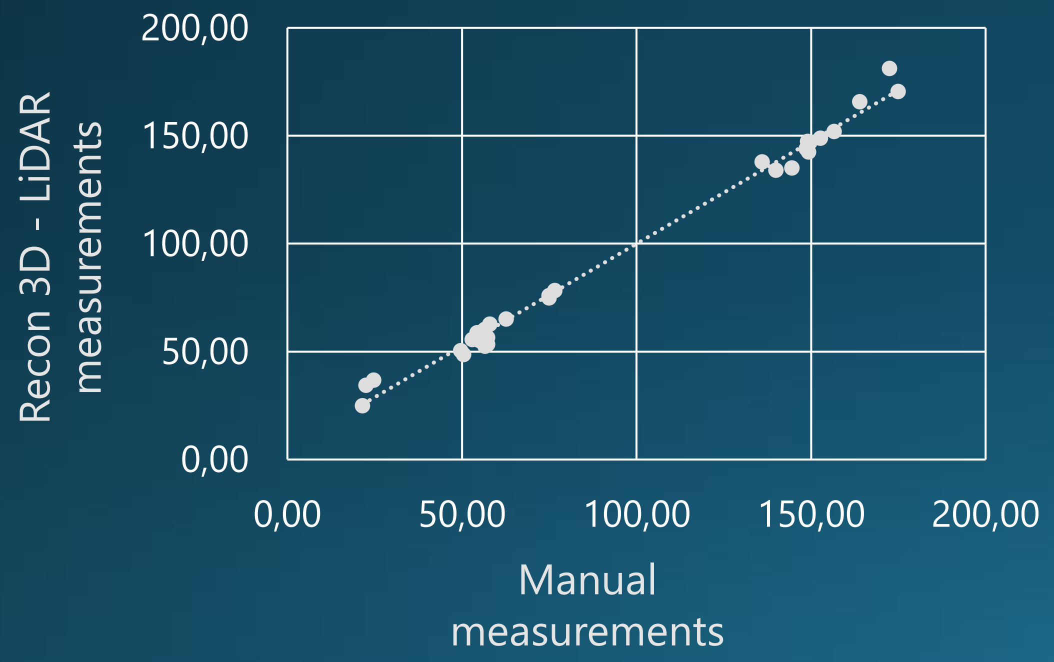
3D measurements for PIN WIDTH are clearly always overestimated highlighting critical issues for this measurement that must be considered and resolved

Measures	WH	CH	SW	CW	BL	PH	RH	PW	TW	RL
r	0,48	0,96	0,93	0,75	0,58	-0,68	0,98	0,85	0,78	0,61
RMSE	5,08	1,05	2,09	3,31	5,71	6,58	3,62	9,97	3,74	3,18
BIAS	-4,80	0,79	1,40	-0,75	1,95	-4,52	-3,38	9,12	3,08	-0,02

Results & Discussion

Recon 3D - LiDAR
vs Manual Measurement

$R^2 = 0{,}9921$



Results & Discussion

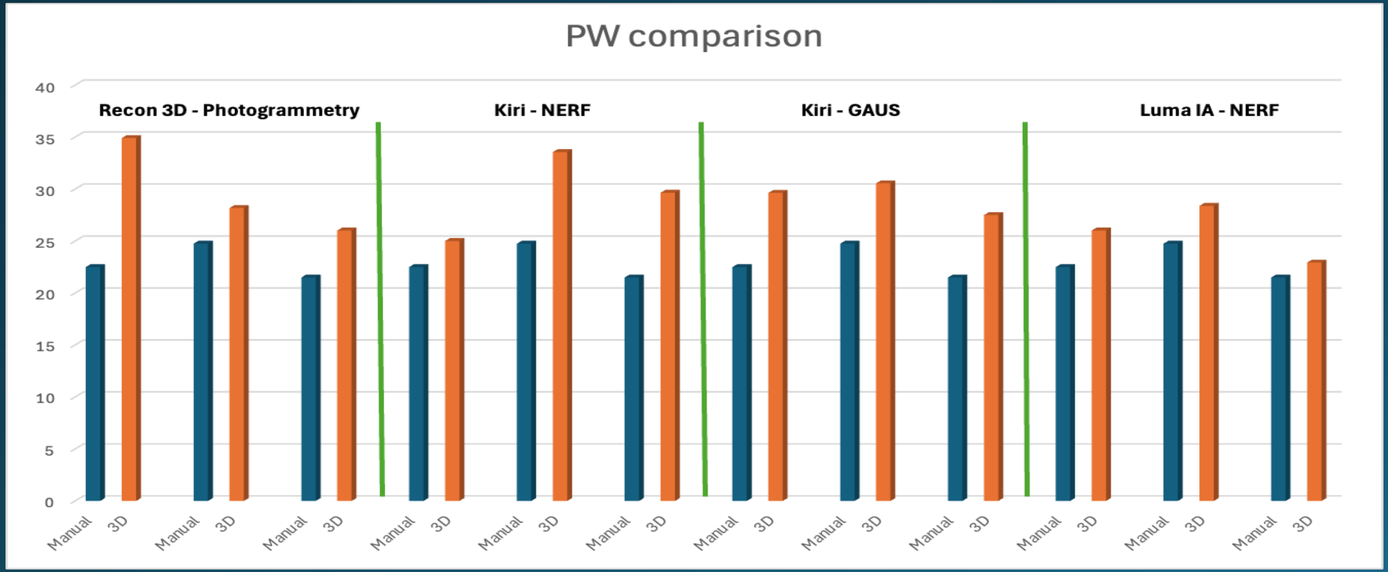
All measurements have also been performed with the other applications (Recon3D, Kiri, Luma IA) and tools showing several higher r.e. values than the ones resulting from the combination Recon 3D-LIDAR

Kiri - NERF *vs* Manual Measurement

Measures		WH cm	CH cm	SW cm	CW cm	BL cm	PH cm	RH cm	PW cm	TW cm	RL cm
COW 1	Man	149,33	76,67	57,33	57,33	175,00	136,00	149,00	22,50	55,00	56,67
	3D	151,27	82,56	59,05	55,03	166,65	139,34	149,69	25,01	58,94	54,95
	r.e.%	**-1,30**	**-7,69**	**-2,99**	**4,02**	**4,77**	**-2,46**	**-0,47**	**-11,15**	**-7,17**	**3,03**
COW 2	Man	149,67	75,00	62,67	56,67	172,50	140,00	152,67	24,75	58,00	56,00
	3D	160,03	96,27	78,37	69,57	209,17	159,53	176,85	33,56	64,44	66,71
	r.e.%	**-6,93**	**-28,35**	**-25,06**	**-22,77**	**-21,26**	**-13,95**	**-15,84**	**-35,59**	**-11,10**	**-19,12**
COW 3	Man	148,67	75,00	53,00	50,50	164,00	144,50	156,67	21,50	54,33	49,67
	3D	151,70	71,97	59,76	45,39	170,44	133,89	154,17	29,65	58,02	51,12
	r.e.%	**-2,04**	**4,04**	**-12,75**	**10,11**	**-3,93**	**7,34**	**1,59**	**-37,90**	**-6,79**	**-2,93**
r		**0,73**	**-0,07**	**0,88**	**0,75**	**0,22**	**-0,24**	**0,13**	**0,64**	**1,00**	**0,62**
RMSE		**6,33**	**12,86**	**9,92**	**8,12**	**22,03**	**12,98**	**14,04**	**7,08**	**4,85**	**6,32**
BIAS		**5,11**	**8,04**	**8,06**	**1,83**	**11,59**	**4,09**	**7,46**	**6,49**	**4,69**	**3,48**

Results & Discussion

Again, interesting is the PW measurement that is always overestimated with the other 3 applications and 4 tools with respect to the manual ones



Recon 3D - Photogrammetry *vs* Manual Measurement										
Meas.	WH	CH	SW	CW	BL	PH	RH	PW	TW	RL
r	**0,34**	**0,88**	**0,87**	**0,71**	**-0,81**	**0,43**	**0,96**	**0,02**	**0,89**	**0,86**
RMSE	**2,58**	**4,64**	**12,22**	**15,19**	**8,15**	**3,28**	**1,15**	**7,88**	**3,74**	**4,23**
BIAS	**-0,40**	**4,54**	**9,69**	**9,66**	**2,17**	**0,88**	**-0,65**	**6,79**	**0,52**	**3,12**

Kiri - NERF *vs* Manual Measurement										
Meas.	WH	CH	SW	CW	BL	PH	RH	PW	TW	RL
R	**0,73**	**-0,07**	**0,88**	**0,75**	**0,22**	**-0,24**	**0,13**	**0,64**	**1,00**	**0,62**
RMSE	**6,33**	**12,86**	**9,92**	**8,12**	**22,03**	**12,98**	**14,04**	**7,08**	**4,85**	**6,32**
BIAS	**5,11**	**8,04**	**8,06**	**1,83**	**11,59**	**4,09**	**7,46**	**6,49**	**4,69**	**3,48**

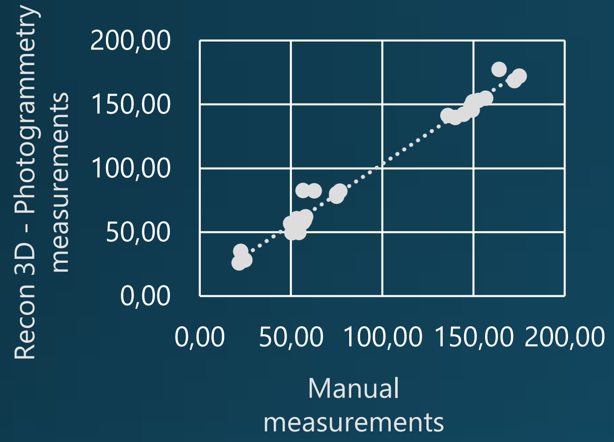
Kiri - GAUSS *vs* Manual Measurement										
Meas.	WH	CH	SW	CW	BL	PH	RH	PW	TW	RL
r	**-0,20**	**1,00**	**0,95**	**-0,16**	**0,26**	**0,73**	**1,00**	**0,90**	**0,95**	**-0,81**
RMSE	**2,61**	**5,36**	**9,53**	**8,12**	**8,66**	**3,16**	**1,41**	**6,34**	**4,65**	**7,36**
BIAS	**2,02**	**5,32**	**6,68**	**5,75**	**7,36**	**0,98**	**1,30**	**6,32**	**4,00**	**-2,32**

LUMA - NERF *vs* Manual Measurement										
Meas.	WH	CH	SW	CW	BL	PH	RH	PW	TW	RL
r	**1,00**	**-0,30**	**0,79**	**0,40**	**0,99**	**-0,31**	**-0,25**	**0,96**	**0,88**	**0,99**
RMSE	**10,31**	**7,40**	**5,52**	**3,45**	**6,16**	**12,23**	**9,76**	**3,04**	**3,91**	**8,82**
BIAS	**8,94**	**7,17**	**3,69**	**-1,21**	**5,50**	**5,23**	**6,01**	**2,87**	**2,68**	**8,28**

Results & Discussion

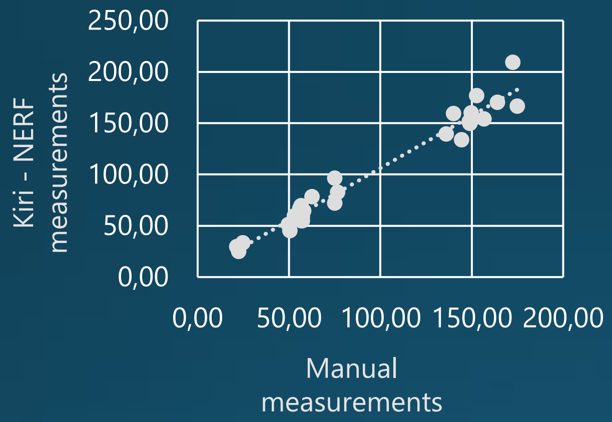
Recon 3D - Photogrammetry
vs Manual Measurement

R^2 = 0,9838



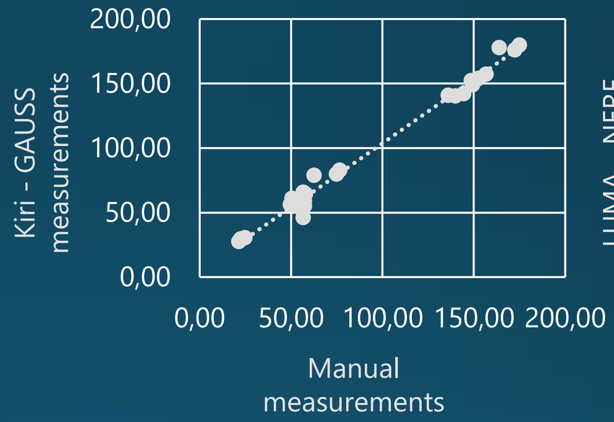
Kiri - NERF
vs Manual Measurement

R^2 = 0,9659



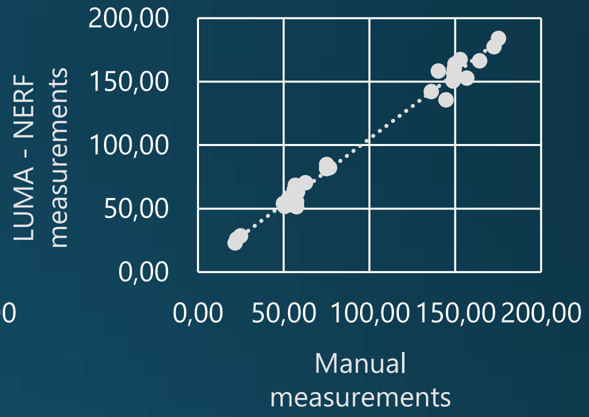
Kiri - GAUSS
vs Manual Measurement

R^2 = 0,9901



LUMA - NERF
vs Manual Measurement

R^2 = 0,9880



Conclusions, Future prospectives & Limitations

3 applications and 4 tools for smartphone allowed the reconstruction of 3D animals' shapes

Due to high level of details, **best results** were obtained through **Recon 3D LIDAR** tool

Results are strongly dependent by animal's position and behavior during the scanning process

This preliminary study offers a new perspectives for assessing animal's morphology and BCS evaluation using a cost-effective and contactless tool

3D animals' data processing will be improved, and specific algorithms are being developed to allow the automatic discrimination between the BCS classes and to directly estimate animals' weight

Limitations:

- smartphone applications used don't allow user to set different processing parameters
- need to modulate the approach according to the complexity of the shape and the measurement that need to be detected
- scan approach is not easy with unfriendly animals

Thanks for your attention!

Contact

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Finanziato dall'Unione europea NextGenerationEU

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