AI-Powered Conformation Analysis: A CNN Approach for Accurate Horse Morphometry

M. Zanchi, **C. Bordin, T. Danese, L. Ozella, E. Valle**

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UNIVERSITÀ DI TORINO

The importance of horse morphometry

Horse structural characteristics

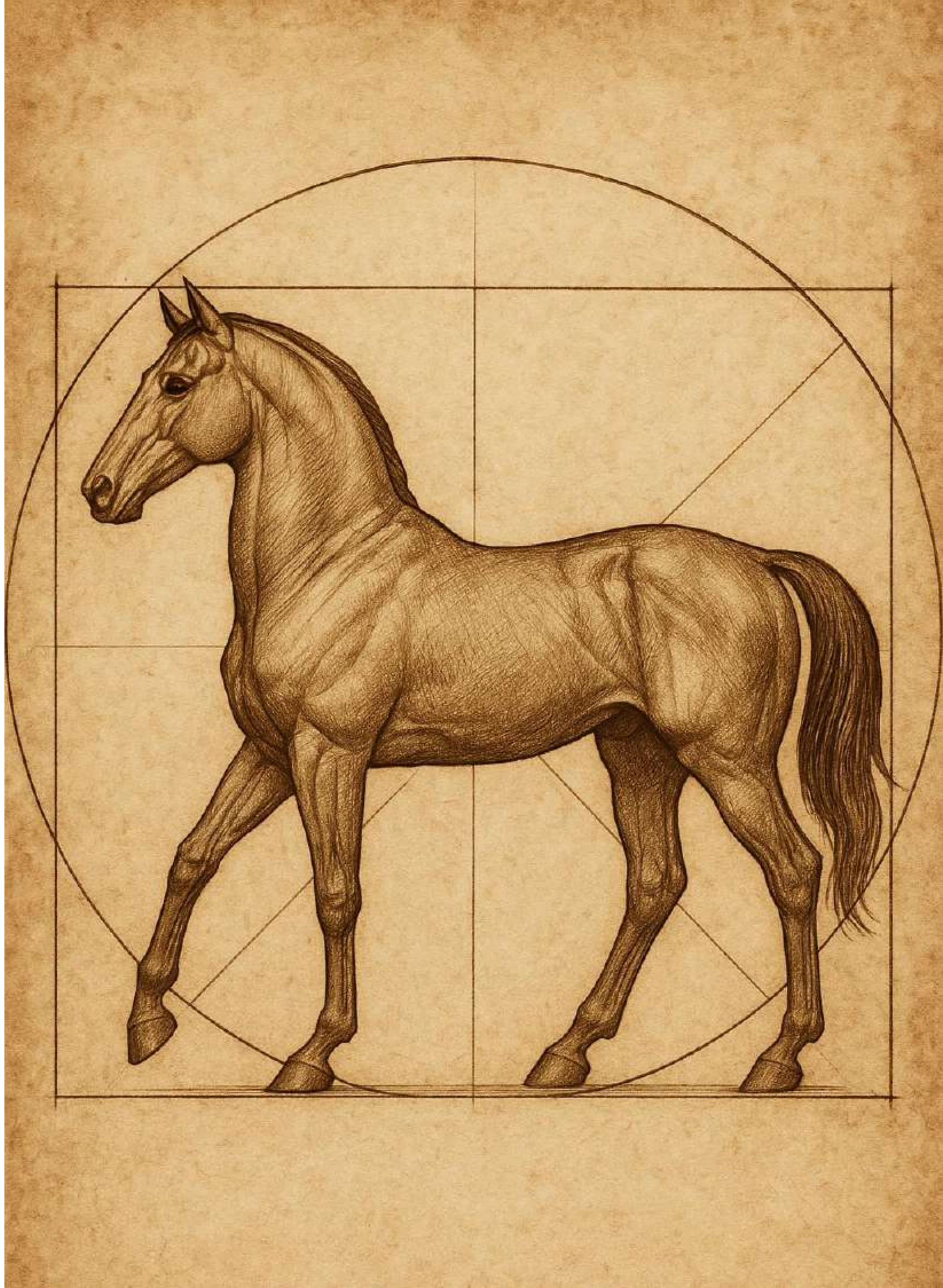
Body proportions and angular measurements directly influence:

- Efficiency of movement
- Athletic performance and capabilities

Role of conformation in equestrian sports

Critical for assessing:

- Performance potential
- Physical aptitude
- Health



Challeges of traditional evaluation

Traditional morphometric evaluation

Experts manually assess the lengths and proportions of a horse body using visual inspection and physical measurements

Challenges

Manual methods are:

- Time-consuming
- Labor-intensive
- Influenced by subjective judgment

A solution: Deep Learning

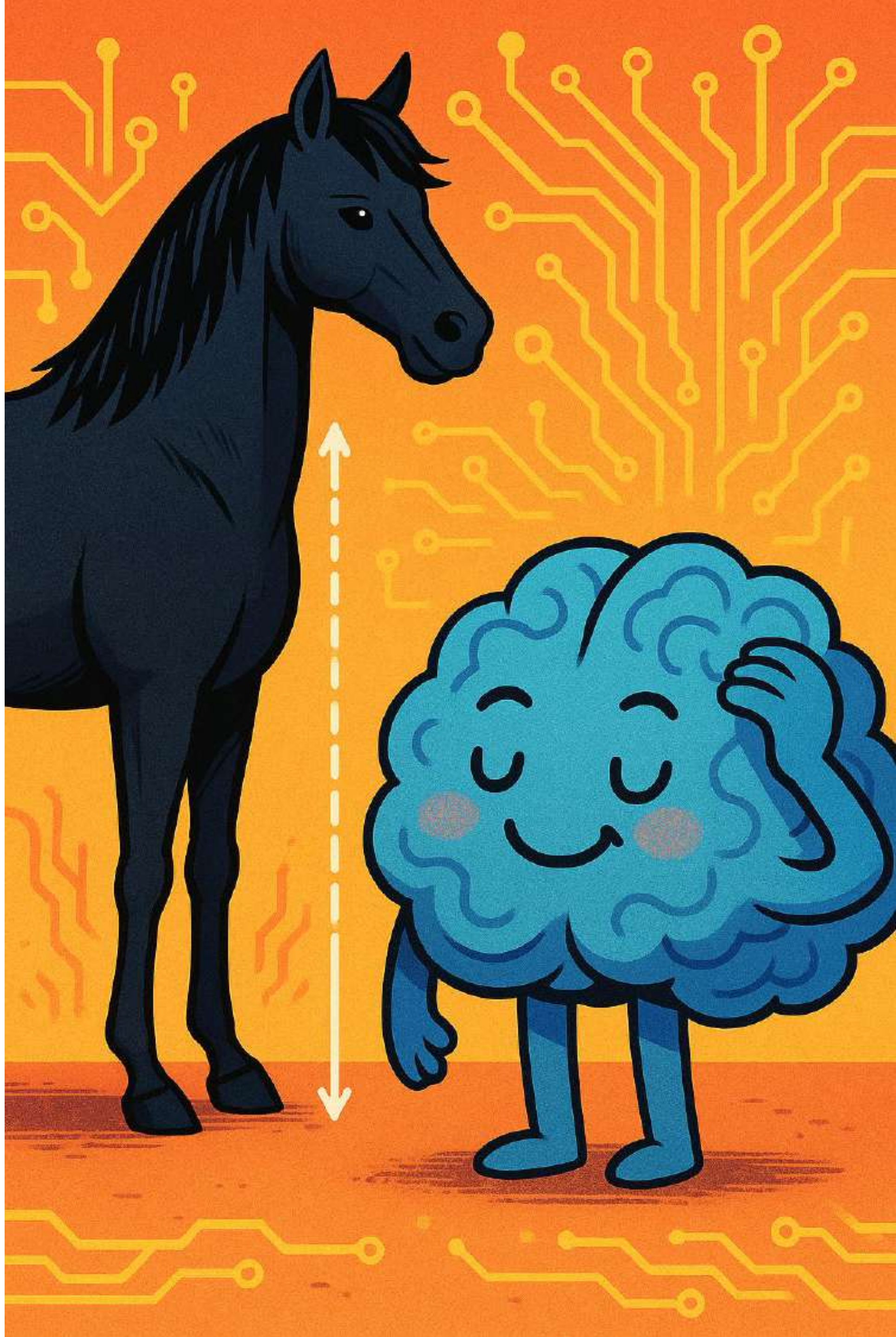
Computer vision algorithms are able to automatically elaborate images and videos to extract patterns

Convolutional Neural Networks capture anatomical details providing an automatic framework to estimate horse morphometry:

- Speed up the evaluation
- Facilitate large-scale studies

Tools as **DeepLabCut** greatly facilitate the automatic estimation of animals traits

Nath, T., Mathis, A., Chen, A. C., Patel, A., Bethge, M., & Mathis, M. W. (2019). Using DeepLabCut for 3D markerless pose estimation across species and behaviors. *Nature protocols*, *14*(7), 2152-2176.



Research proposal

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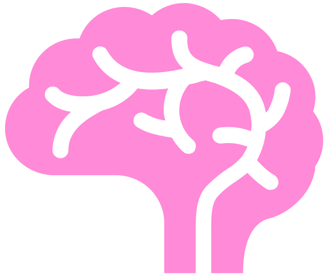
Neural network



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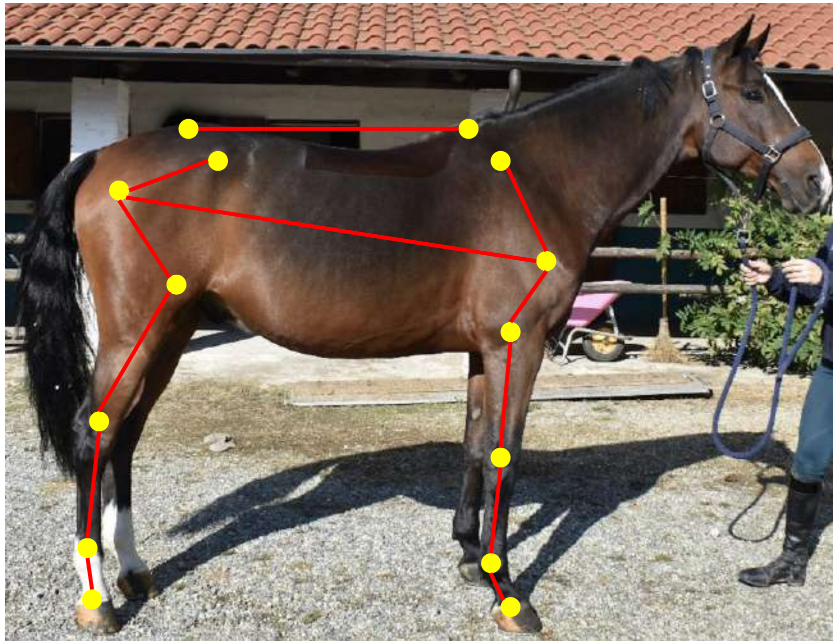
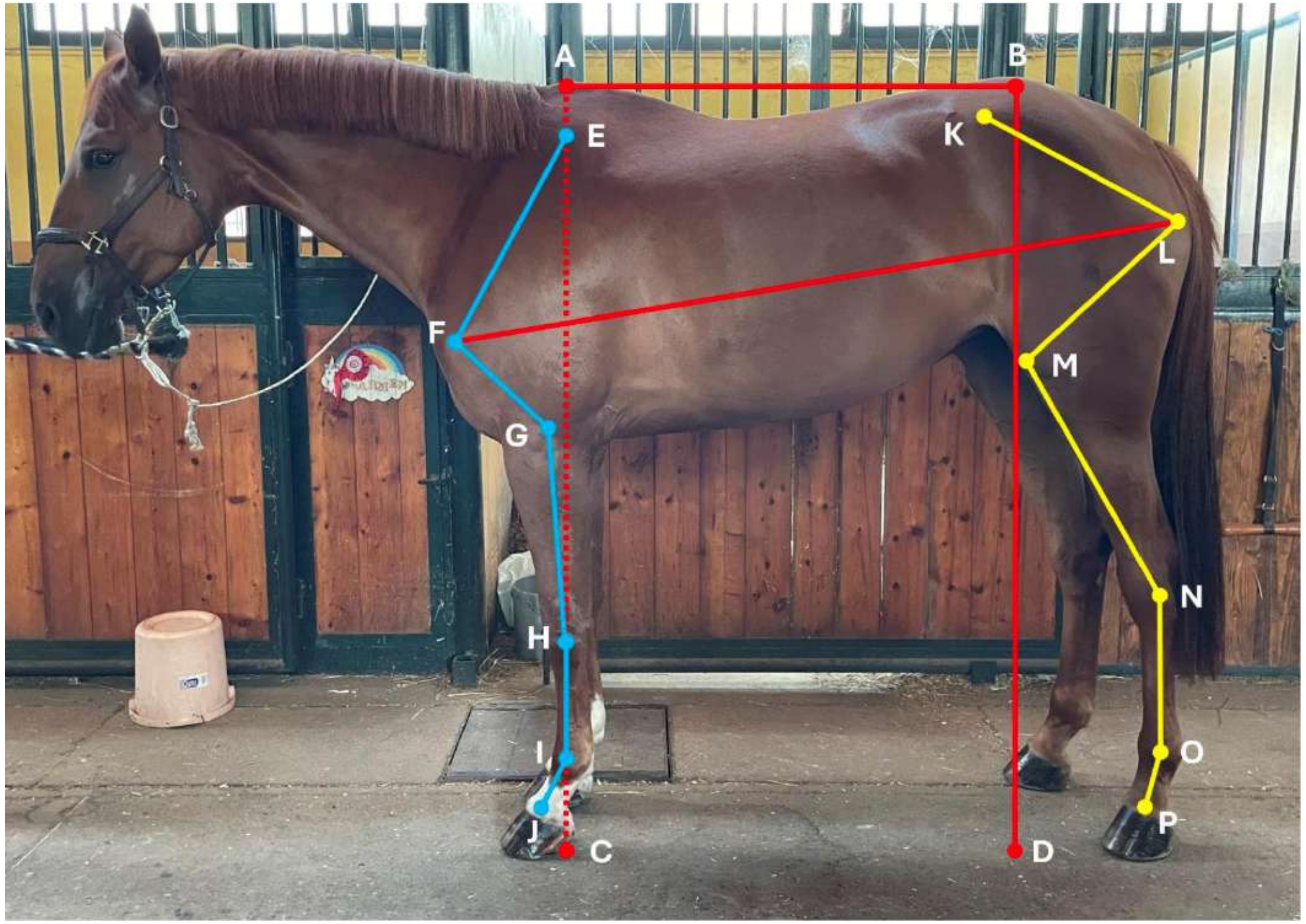


The keypoints



Keypoints

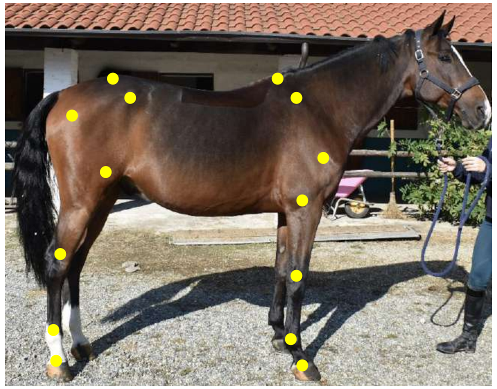
- A. Withers
- B. Croup
- C. Withers terrain
- D. Croup terrain
- E. Scapula
- F. Point of shoulder
- G. Elbow
- H. Carpus
- I. Front fetlock
- J. Front coronary band
- K. Ilium
- L. Ischium
- M. Patella
- N. Hock
- O. Hind fetlock
- P. Hind coronary band

Body dimensions

- A-B: Withers to croup
- A-C: Withers height
- B-D: Croup height
- F-L: Point of shoulder to ischium
- E-F: Shoulder length
- F-G: Shoulder to elbow
- G-H: Elbow to carpus
- H-I: Front cannon bone
- I-J: Front pastern
- K-L: Ilium to Ischium
- L-M: Ischium to patella
- M-N: Patella to hock
- N-O: Hind cannon bone
- O-P: Hind pastern

Research pipeline

1. Data collection



Two datasets:

A. 800 images

B. 100 images + measurements

Each image has been labeled

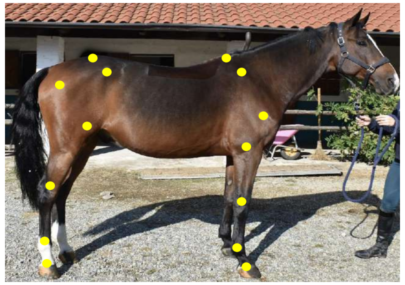
2. Neural network (NN)

Resnet50

+

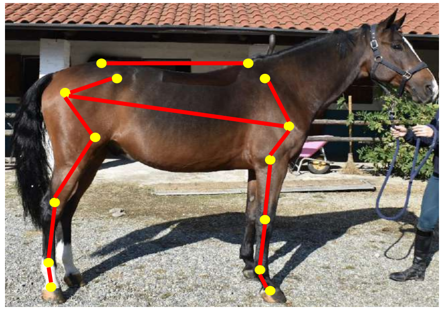
up convolution

3. NN training



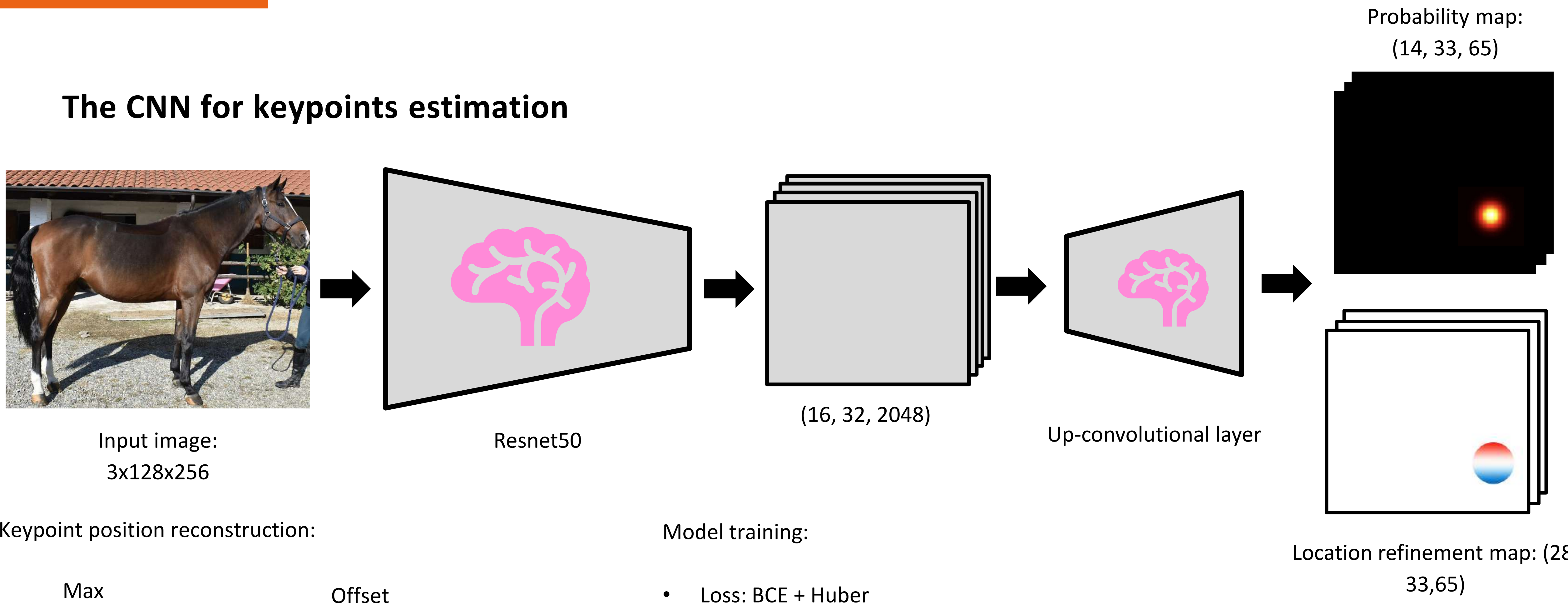
The NN is trained <u>ONLY</u> on Dataset A

4. NN testing

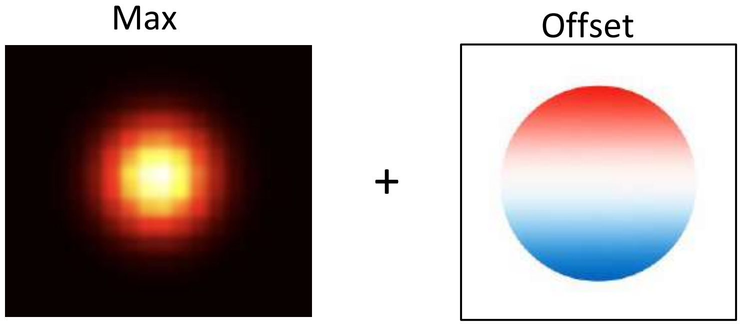


- Predict keypoints on Dataset B
- Reconstruct the morphometry
- Compare to real measurements

The CNN for keypoints estimation



Keypoint position reconstruction:



Model training:

- Loss: BCE + Huber
- Scheduler: linear + cosine annealing
- Optimizer: AdamW
- 10 fold cross-validation

Validation and testing results

Mean euclidean distance (mED)

$$\text{mED} = \frac{1}{N}\sum_{i=1}^{N}\sqrt{(x_i - \hat{x}_i)^2 + (y_i - \hat{y}_i)^2}$$

Mean average precision (mAP)

$$\text{mAP} = \frac{1}{T}\sum_{t=1}^{T}\text{AP}(\text{OKS} \geq \tau_t), \quad \tau_t \in \{0.50, 0.55, \ldots, 0.95\}$$

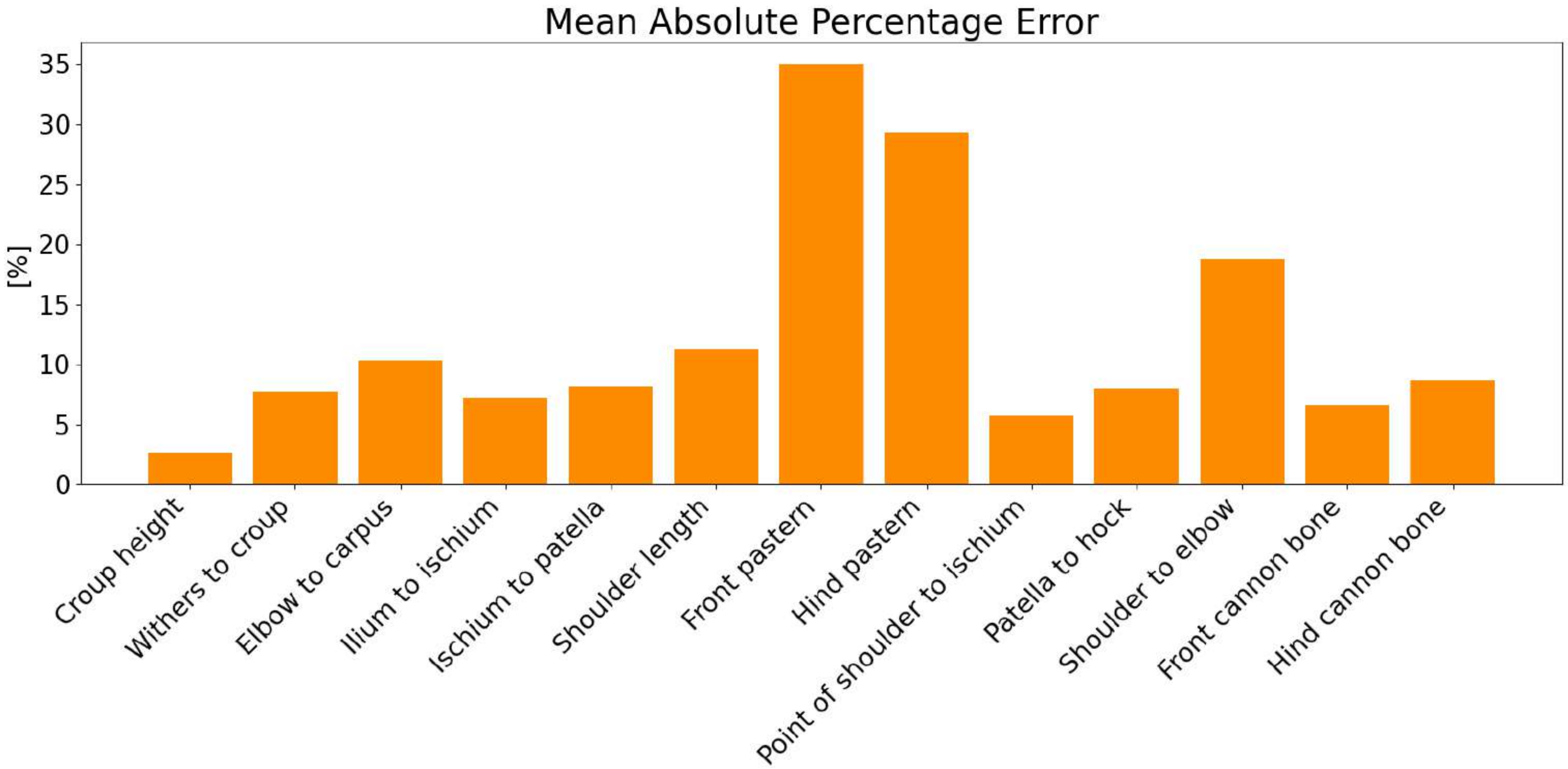
$$\text{OKS} = \frac{\sum_i \exp\left(-\frac{d_i^2}{2s^2k_i^2}\right) \cdot \delta(v_i > 0)}{\sum_i \delta(v_i > 0)}$$

Validation set	Test set
mED: 1.68 pixels	mED: 1.96 pixels
mAP: 92.5%	mAP: 86.5%

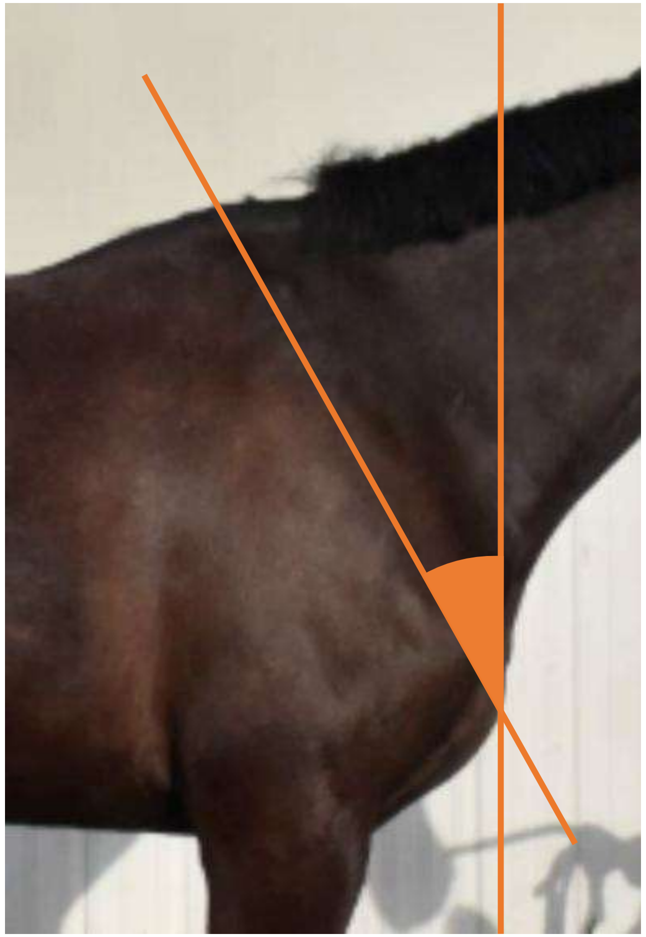
Morphometry reconstruction

MAE: 4.52 cm

MAPE: 11.39 %



Angular measurement: shoulder orientation

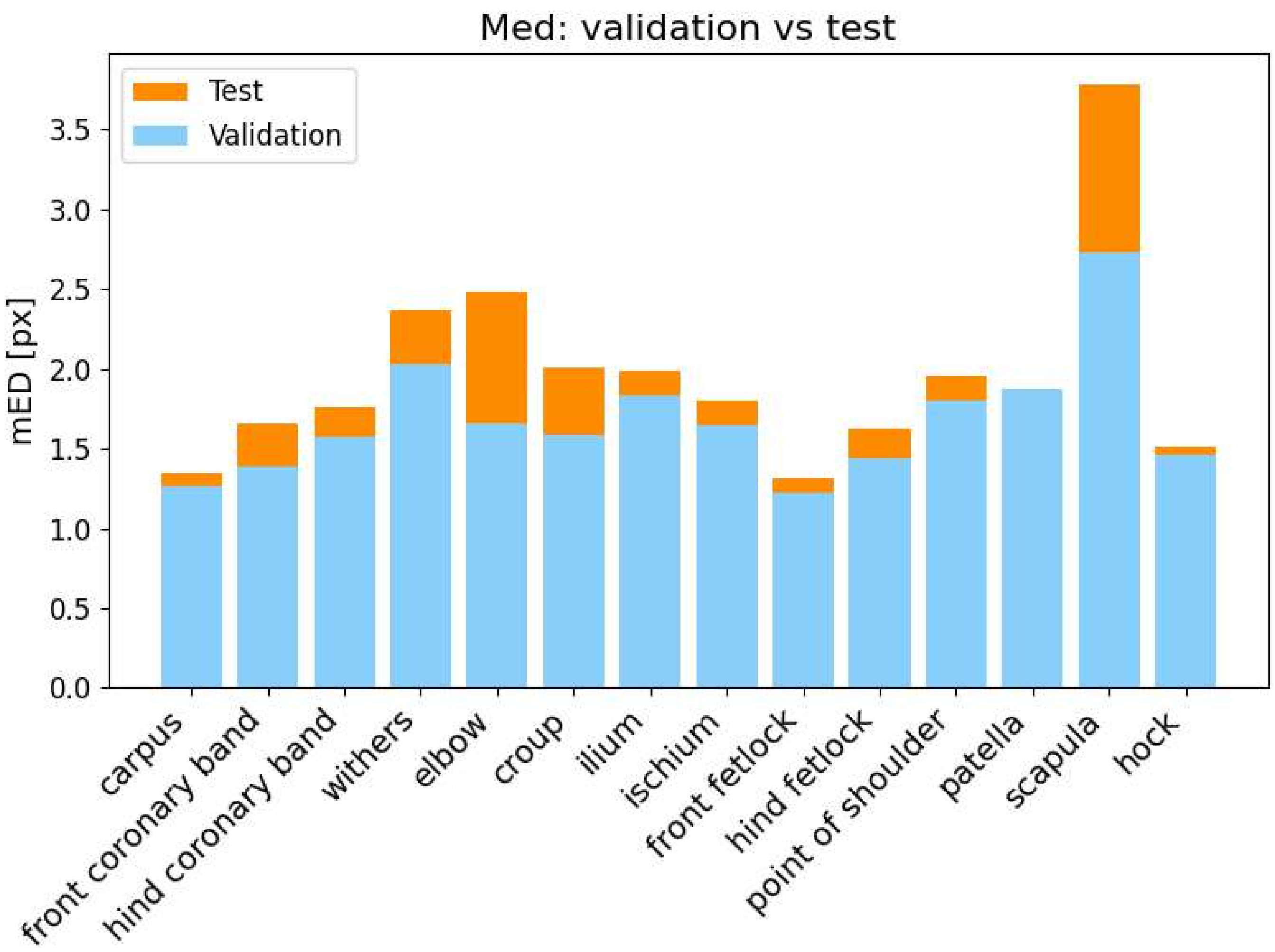


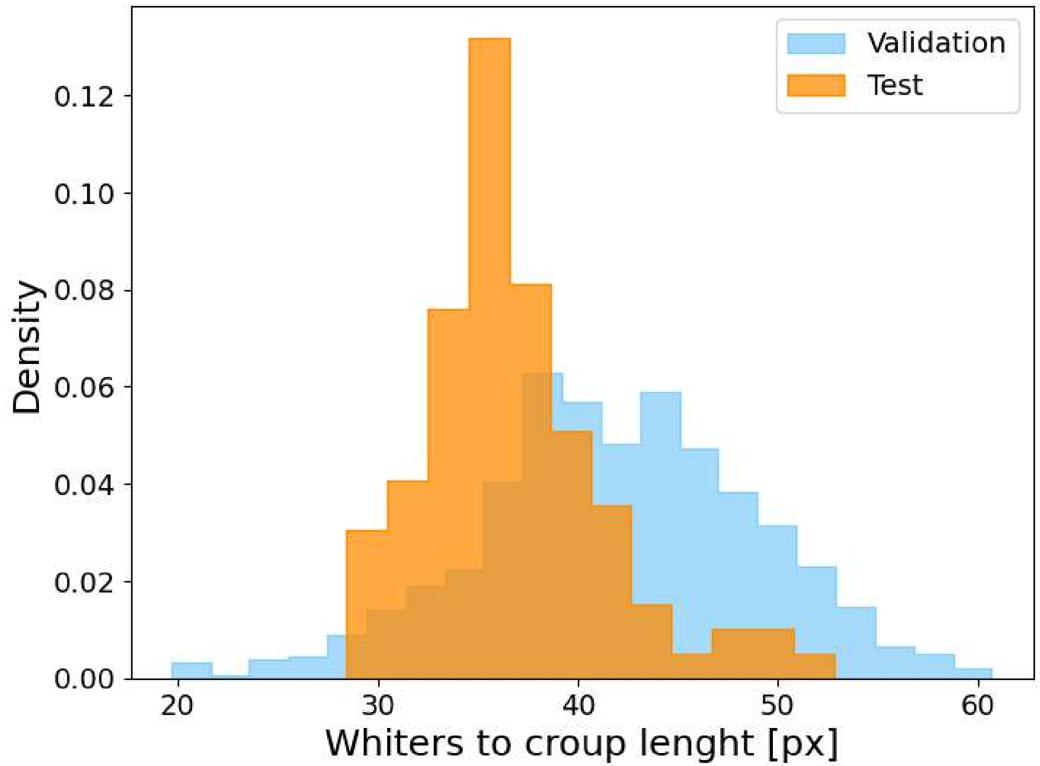
The shoulder orientation is related to a natural aptitude for jumping.

The sloping of the shoulder facilitates the forward movement of the scapulohumeral joint during the jump.

Validation	Test
MAE: 3.15°	MAE: 3.22°
MAPE: 8.92 %	MAPE: 10.40 %

Limitations: validation vs test





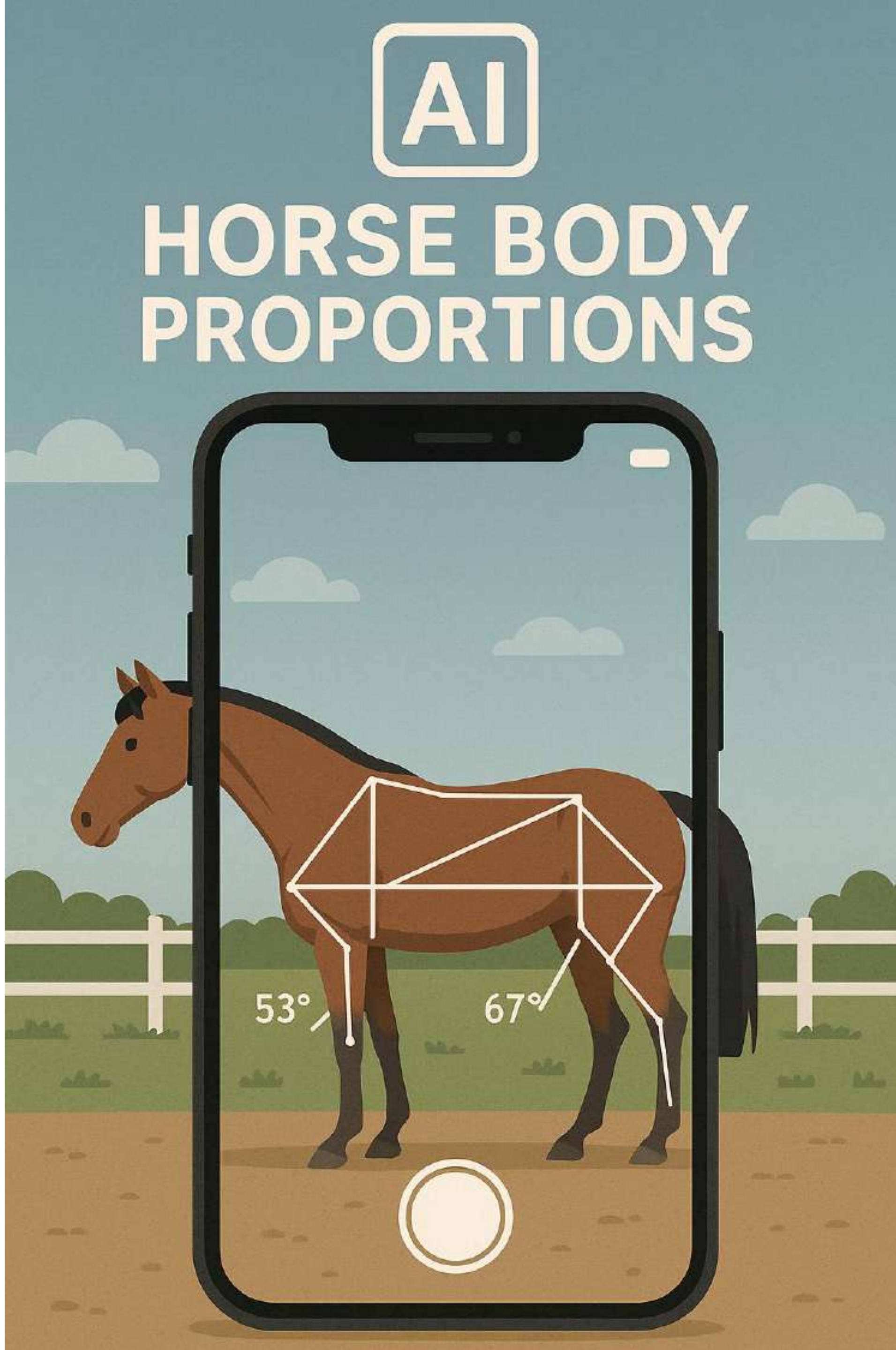
Next steps

1. Refine the keypoints prediction:

- Improve test image quality and definition

- Re-define keypoints locations

2. Deploy the neural network into a mobile application and test its performance with expert evaluators



Thank you for the attention!

marco.zanchi@unito.it

clara.bordin@unito.it

tommaso.danese@unito.it

laura.ozella@unito.it

emanuela.valle@unito.it

UNIVERSITÀ
DI TORINO