Always Look on the Bright Side of the Field: Merging Pose and Contextual Data to Estimate Orientation of Soccer Players

Adrià Arbués-Sangüesa[1], Adrián Martín[1], Javier Fernández[2], Carlos Rodríguez[2], Coloma Ballester[1], Gloria Haro[1]

[1]Universitat Pompeu Fabra, [2]Futbol Club Barcelona

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Researchers

Adrià Arbués-Sangüesa
PhD Fellow, GPI-UPF

Adrián Martín
Postdoc Fellow, IP4EC-UPF

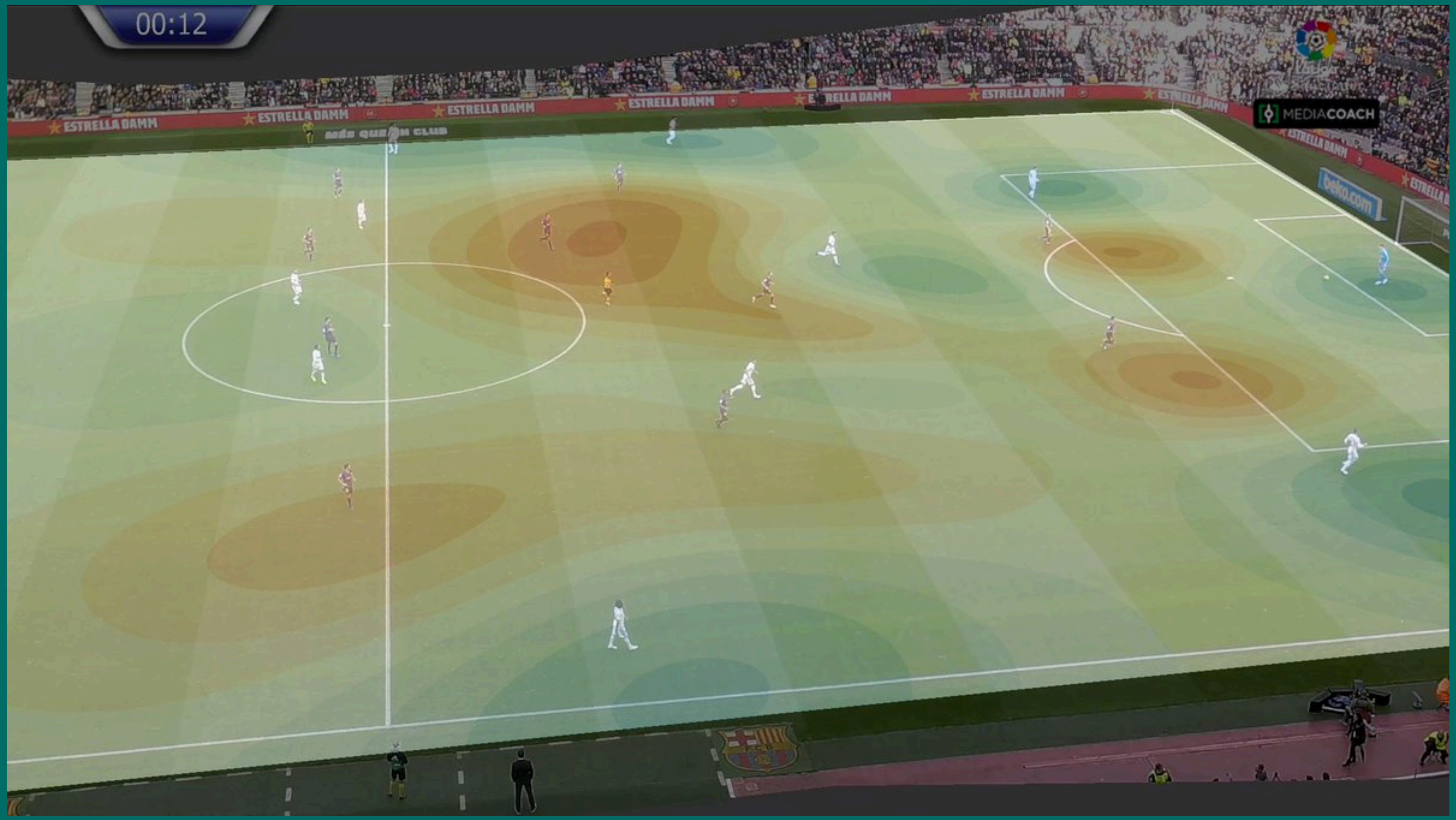
Coloma Ballester
Group Coordinator, GPI-UPF

Gloria Haro
Faculty, GPI-UPF

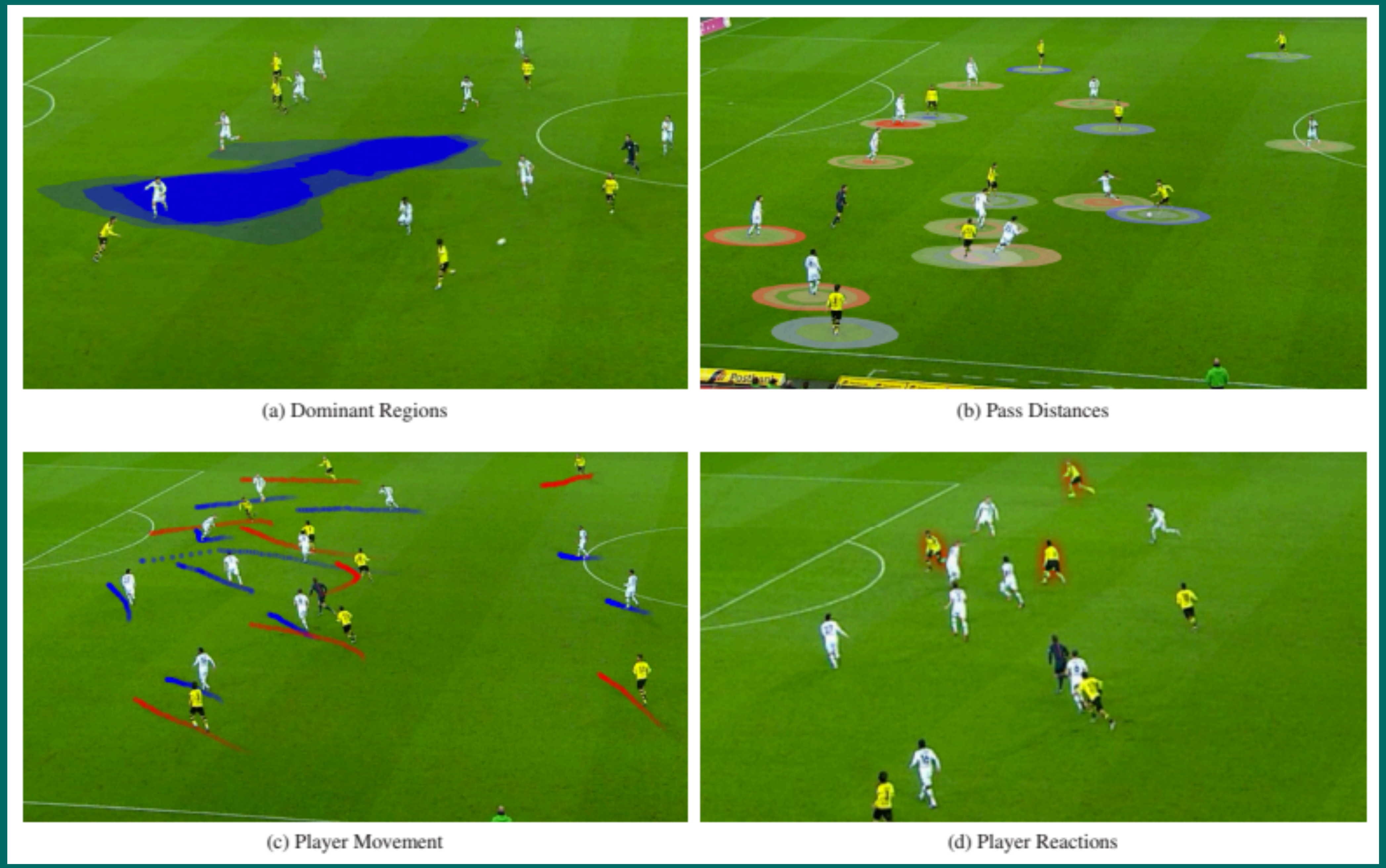
Javier Fernández
Head of Sports Analytics, FCB

Carlos Rodríguez
Data Scientist, FCB

Introduction



[1] Decomposing the Immeasurable Sport: a Deep Learning Expected Posesssion Value Framework for Soccer [Fernández *et al.*]



[2] A Winning Combination: Pairing Video and Movement Data to Enhance Sports Data Analysis [Stein *et al.*]

Introduction

Source: @toppng.com
[Pinterest]

-Yesteryear soccer:

1 Control

2 Look

3 Pass

Introduction

Source: @toppng.com
[Pinterest]

-Yesteryear soccer:

1 Control

2 Look

3 Pass

- Today's faster soccer:

1 **Orient**

2 Control

3 Pass

Introduction

Introduction

Introduction

Problem Statement:

-Player Orientation: missing critical piece of information in soccer analytics.

Goal:

Soccer Video Feed → Player Pose and Position (+ ball) → Time-based set of Orientation / Player

Proposed Method
Pipeline

Proposed Method
Pipeline

Proposed Method
Pipeline

Proposed Method

Proposed Method
OpenPose + SuperResolution

Proposed Method
OpenPose + SuperResolution

OpenPose

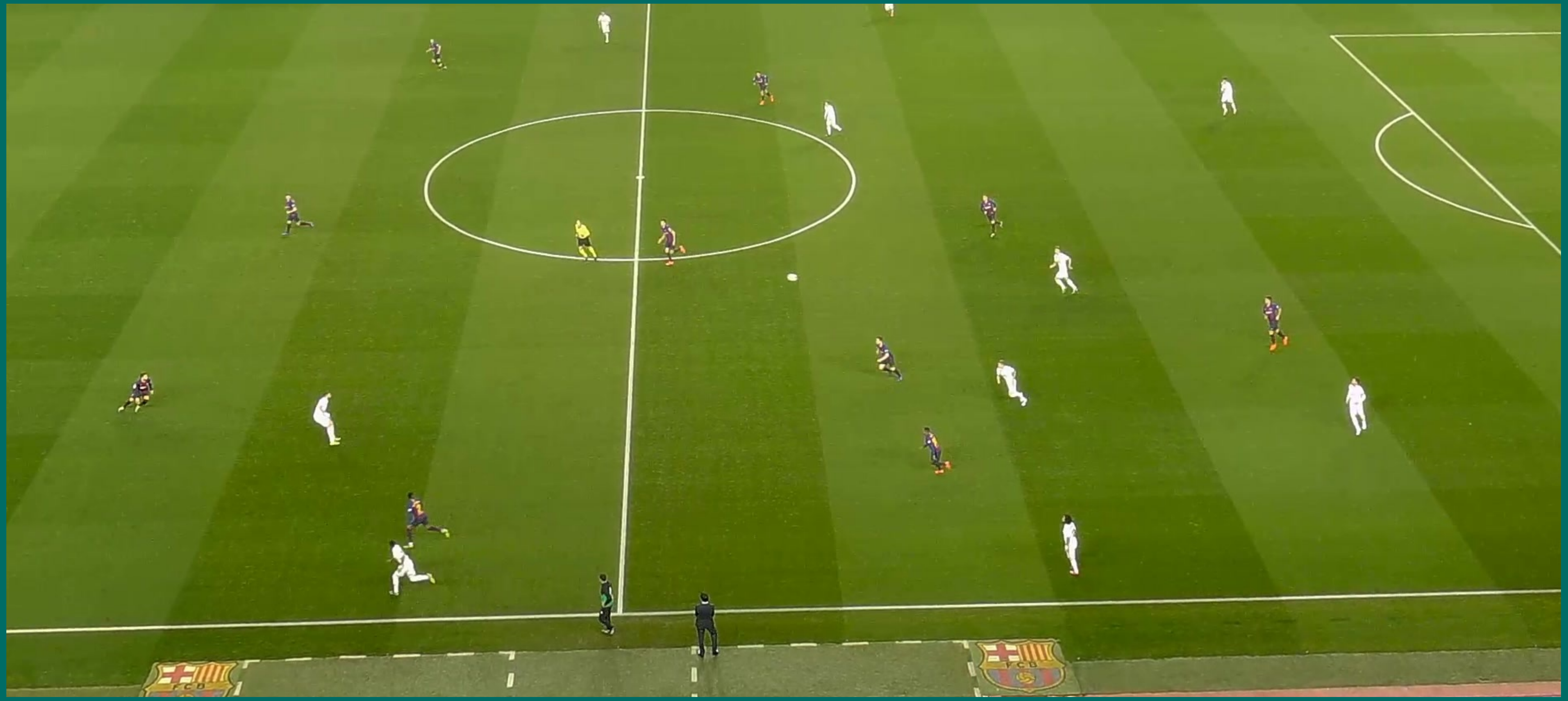
[3] Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields [Cao et al.]

Up to 25 parts detected / person

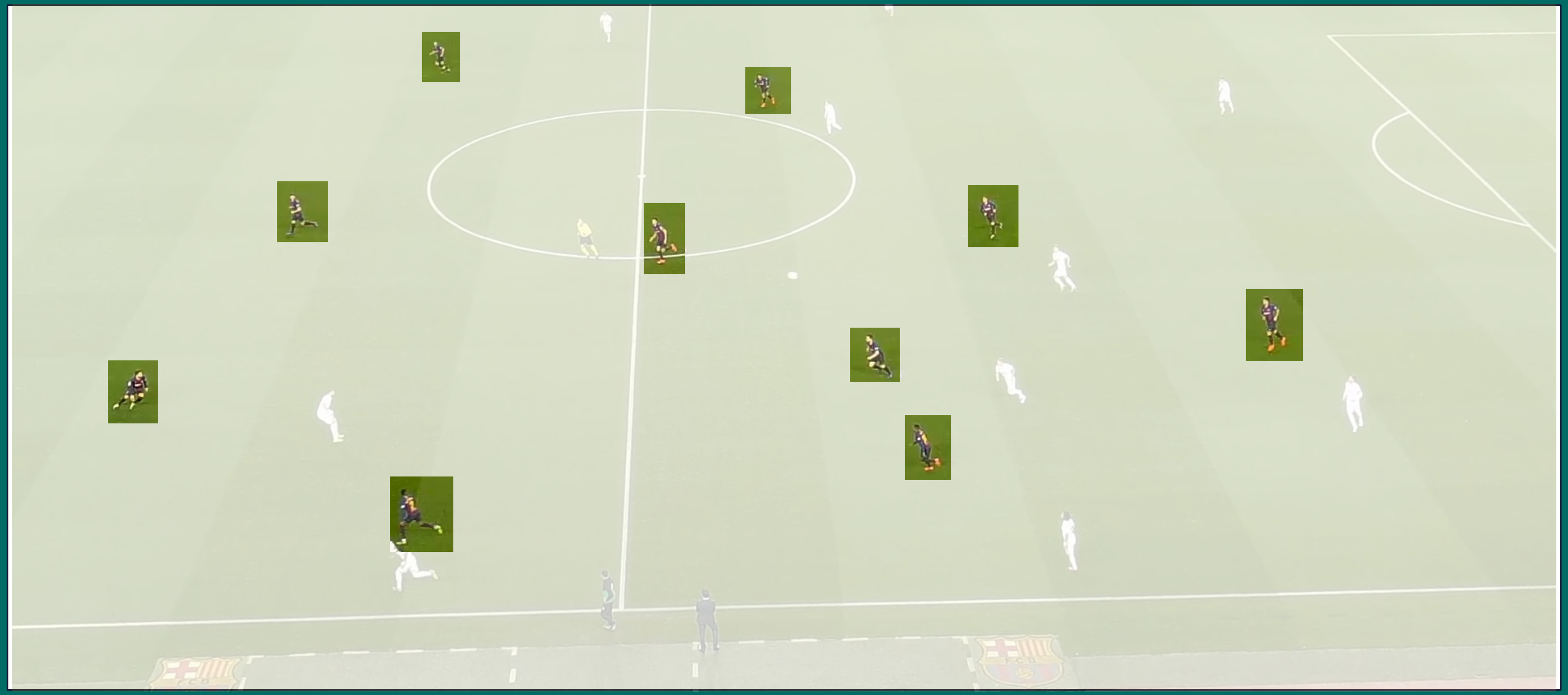
Associated confidence value / part

Output: 1 heatmap / part + PAFs (limbs)

Proposed Method
OpenPose + SuperResolution



Full-HD Frame

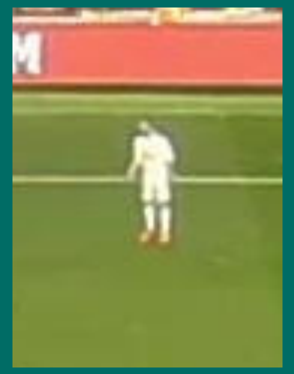


Tiny Pixel Resolution / Player

Not enough for OpenPose to produce a decent result

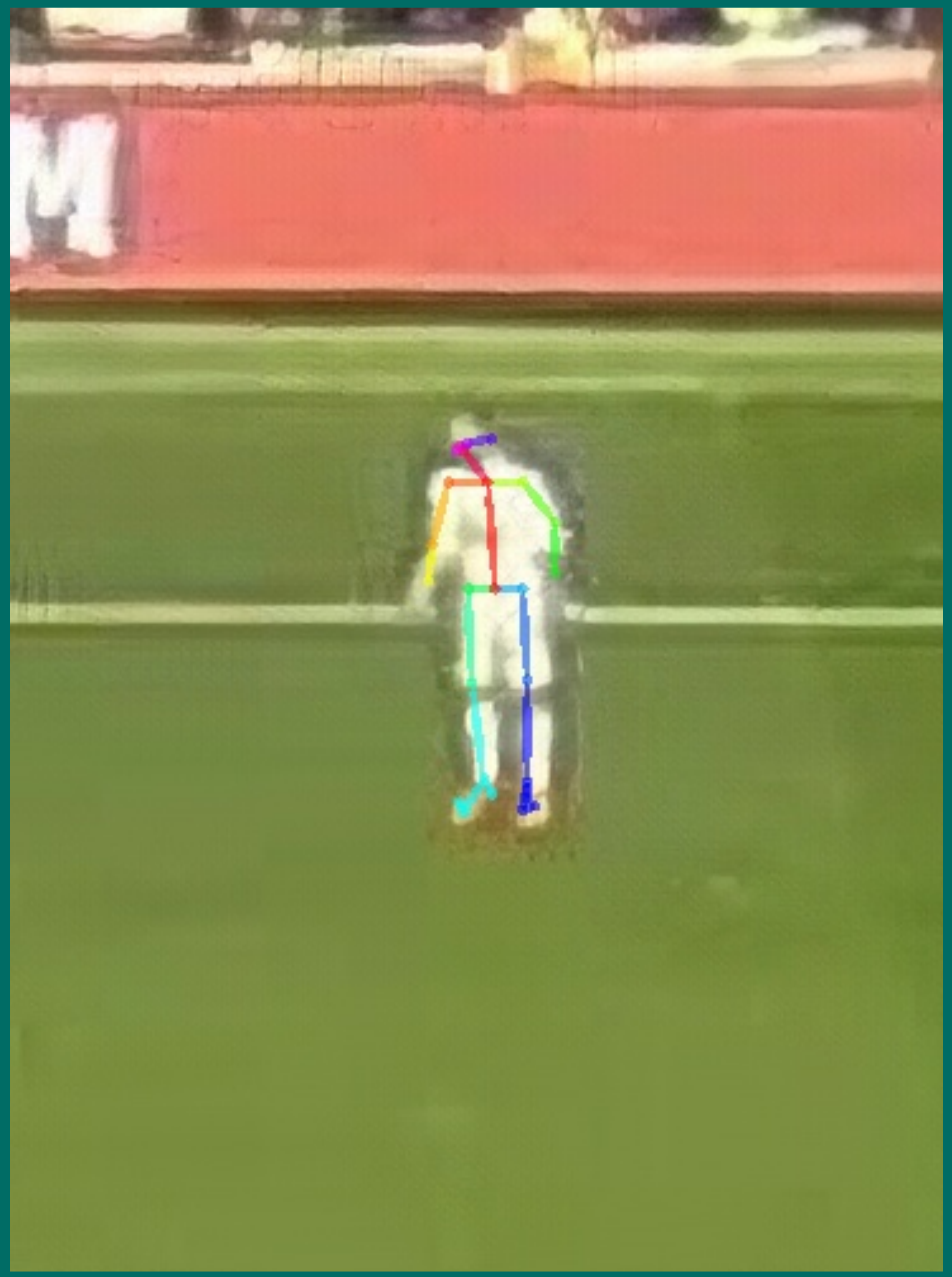
Proposed Method

OpenPose + SuperResolution



Original Crop

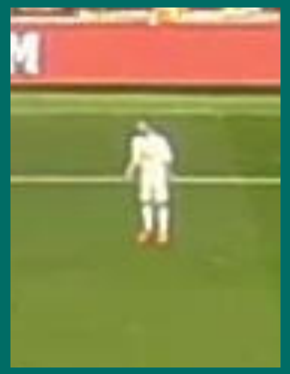
Upscaling by
Bicubical Interpolation



Upscaling by
Convolutional Networks

Proposed Method

OpenPose + SuperResolution



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Upscaling by
Bicubical Interpolation

Upscaling by
Convolutional Networks

[4] Residual Dense Network for Image Super-Resolution [Cardinale *et al.*]

Proposed Method
Shoulder / Hip Orientation

Proposed Method

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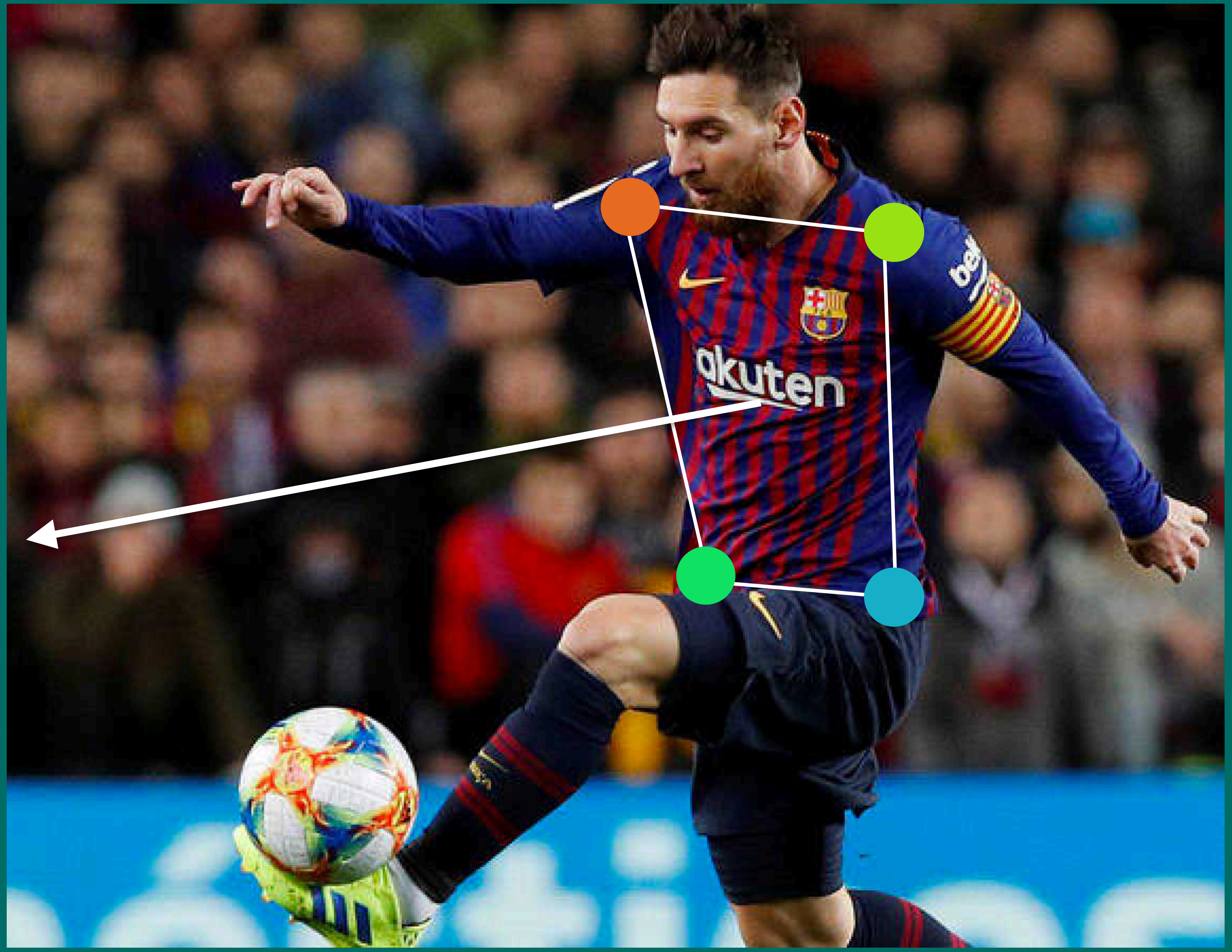
Shoulder / Hip Orientation



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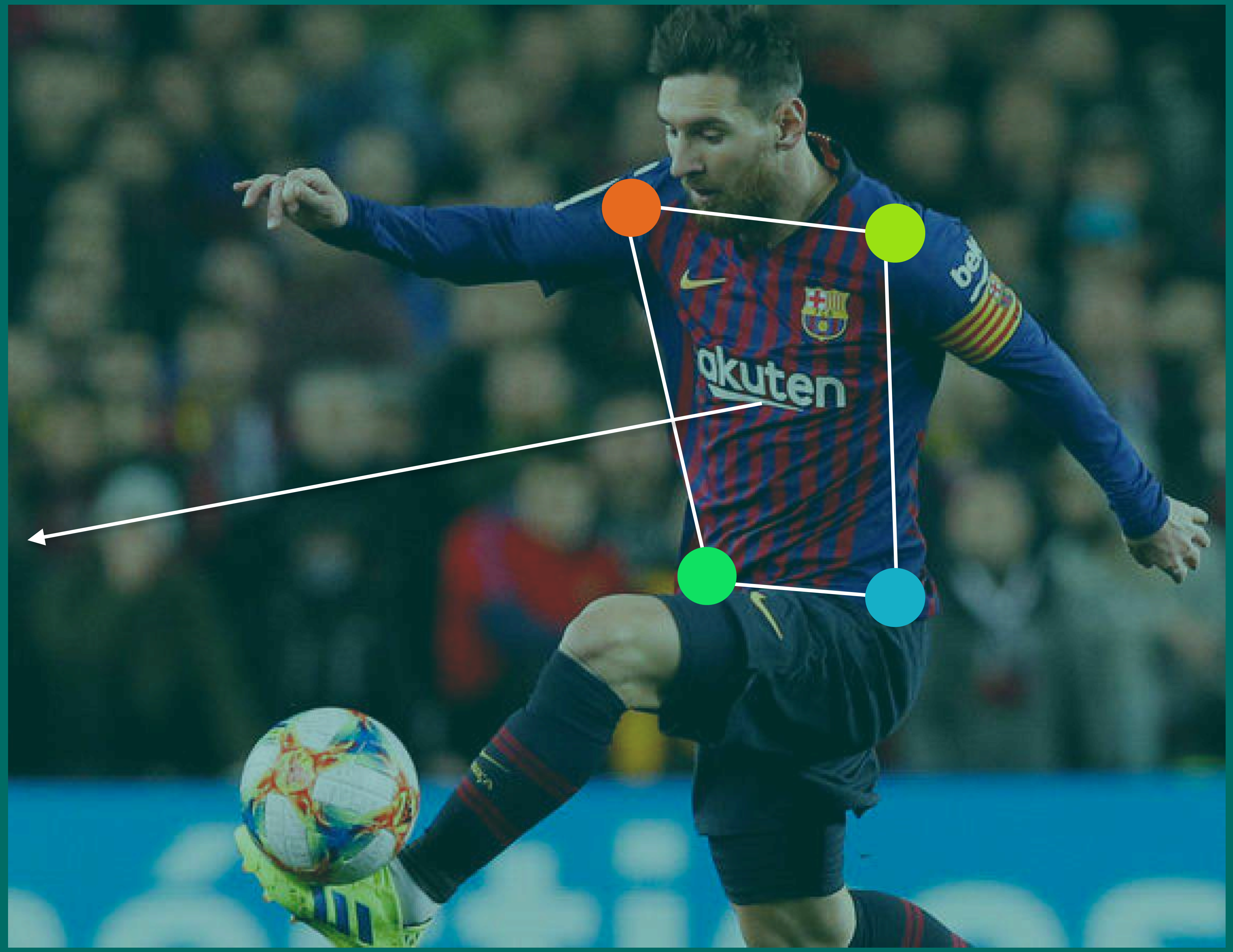
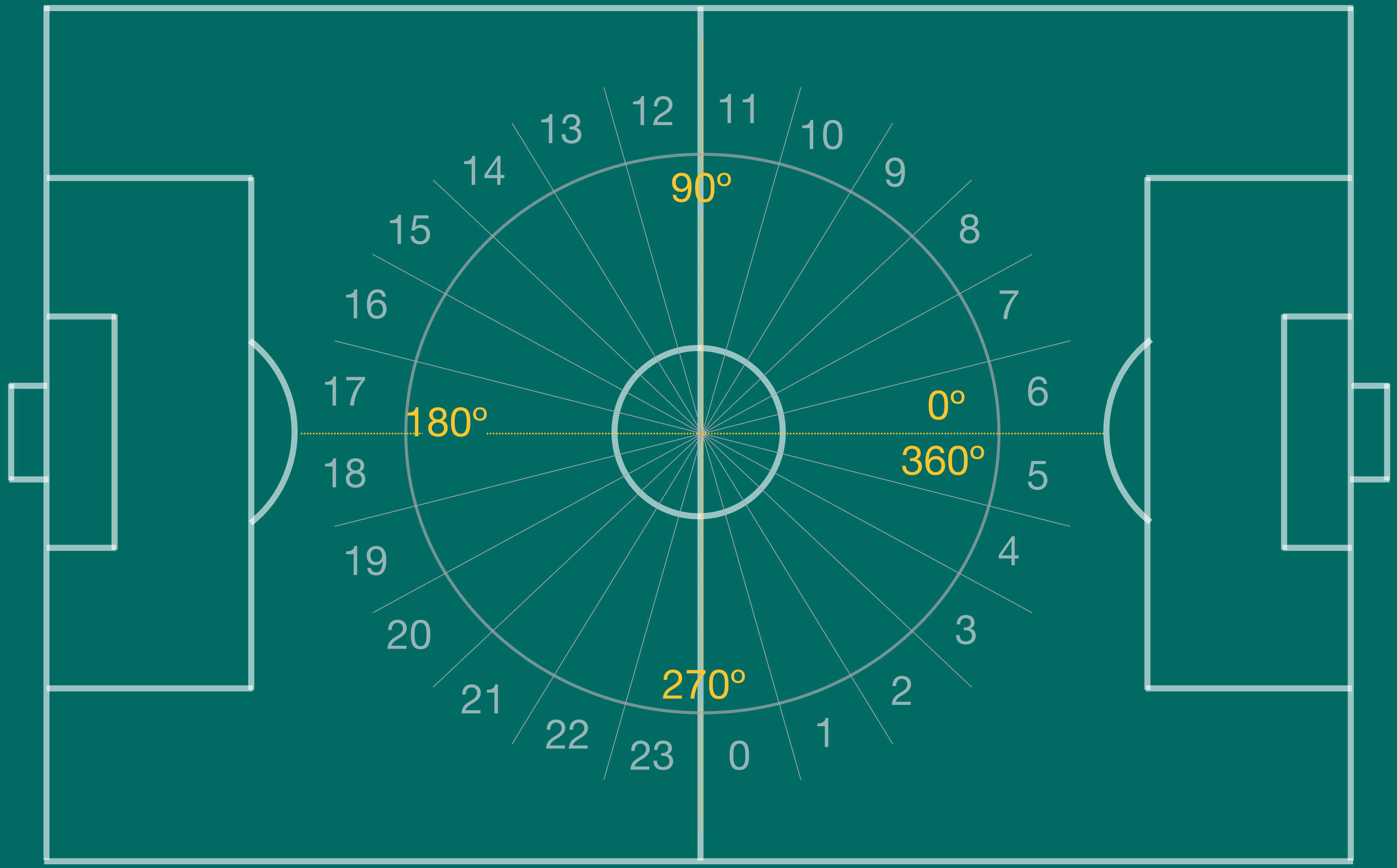
Shoulder / Hip Orientation





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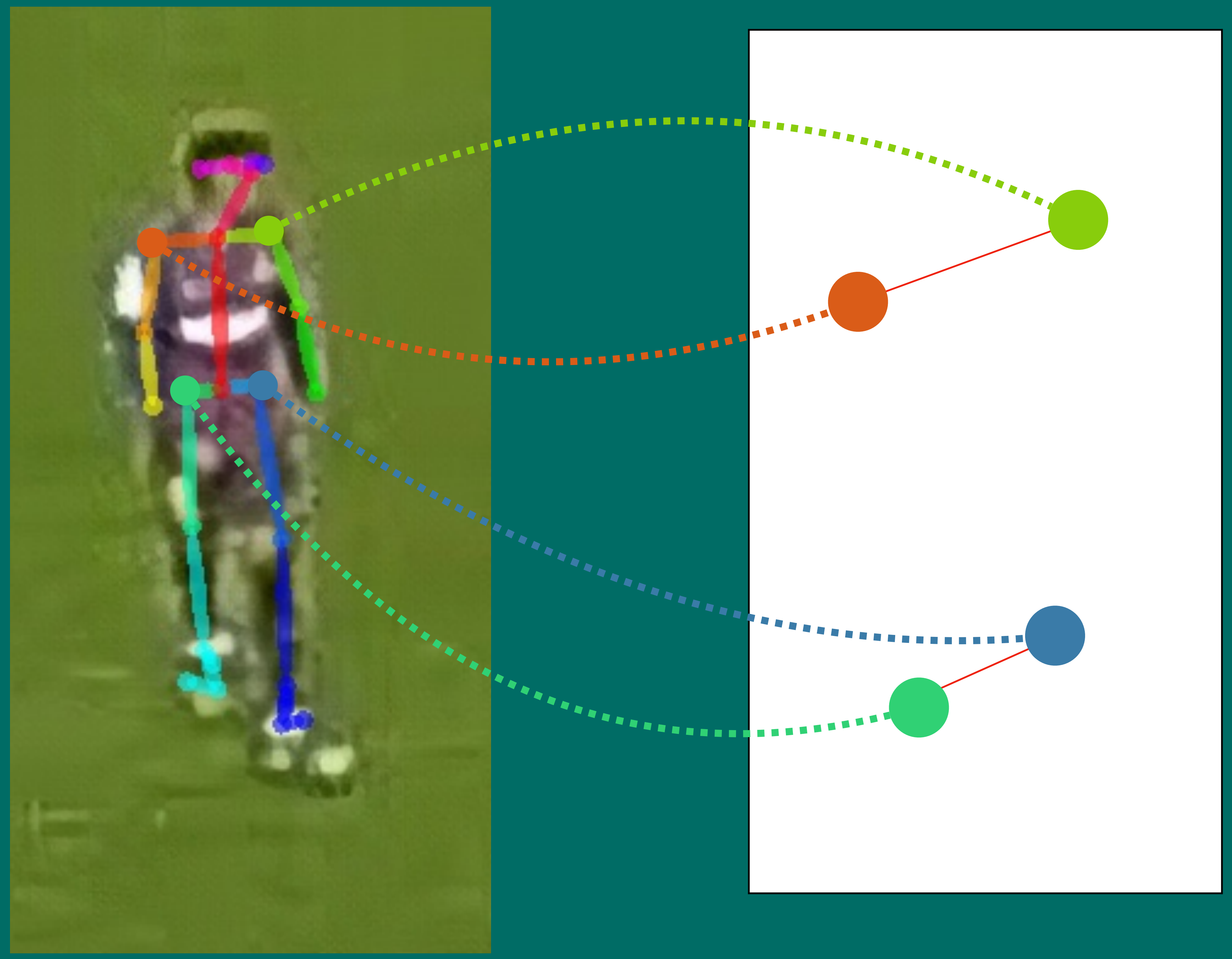
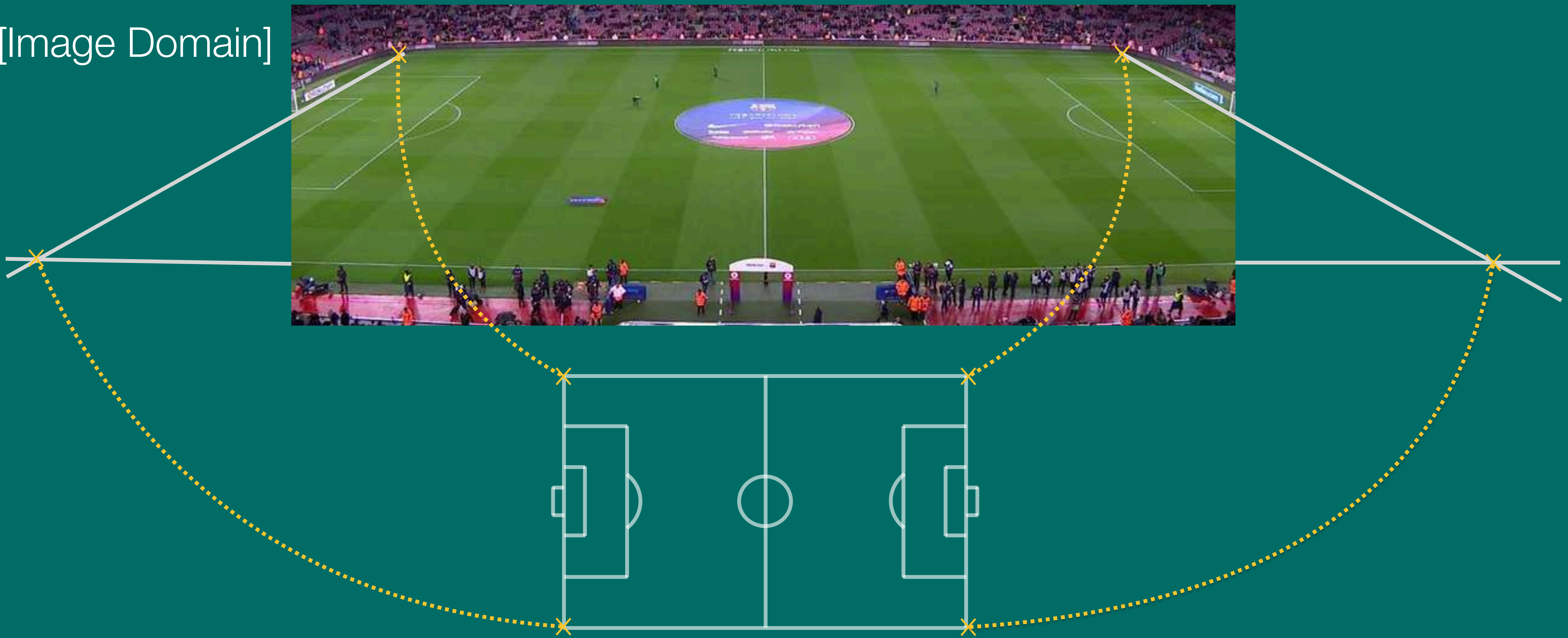


Proposed Method
Shoulder / Hip Orientation, Homography Estimation

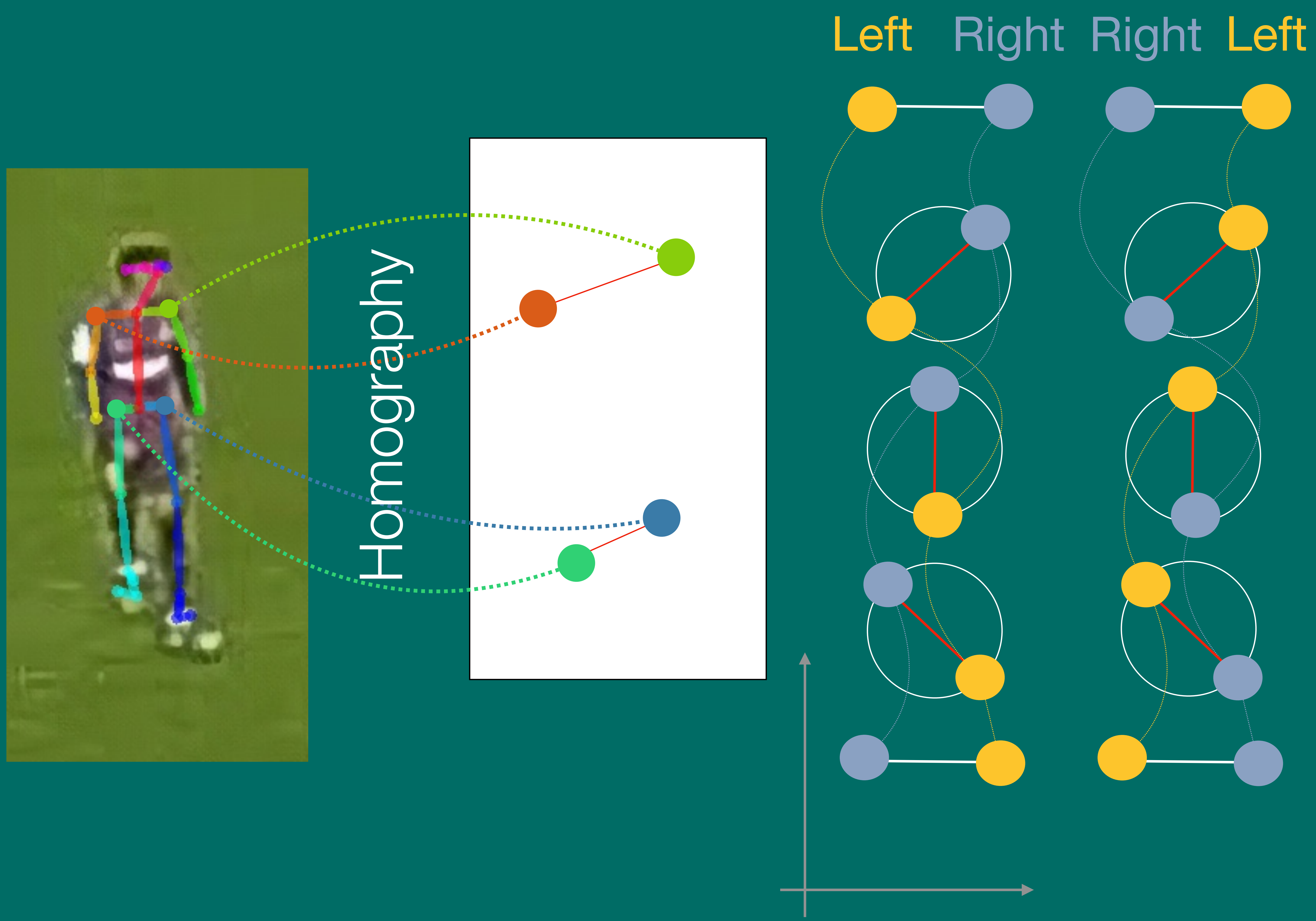
[Image Domain]



[Field Domain]

Proposed Method

Shoulder / Hip Orientation



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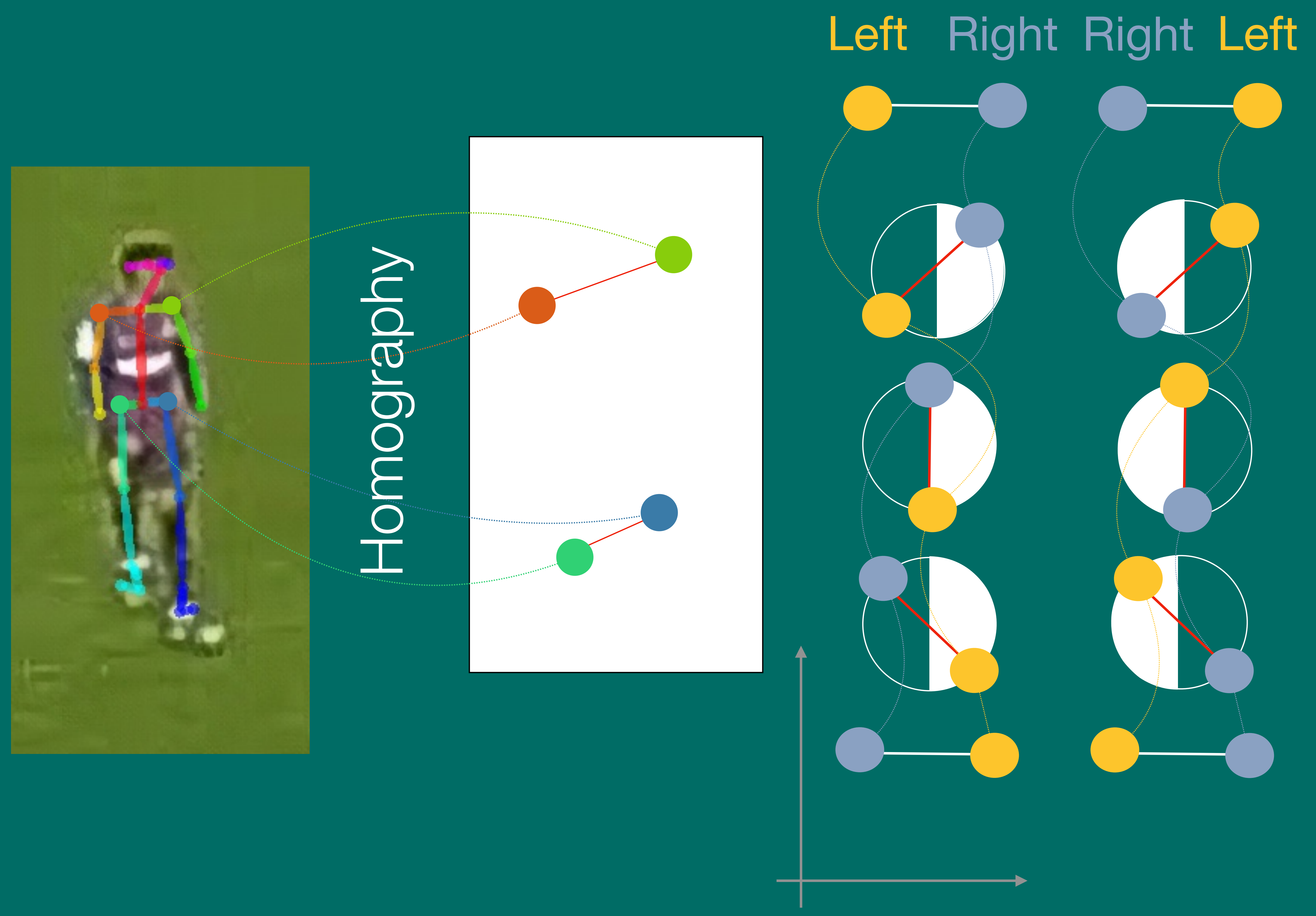

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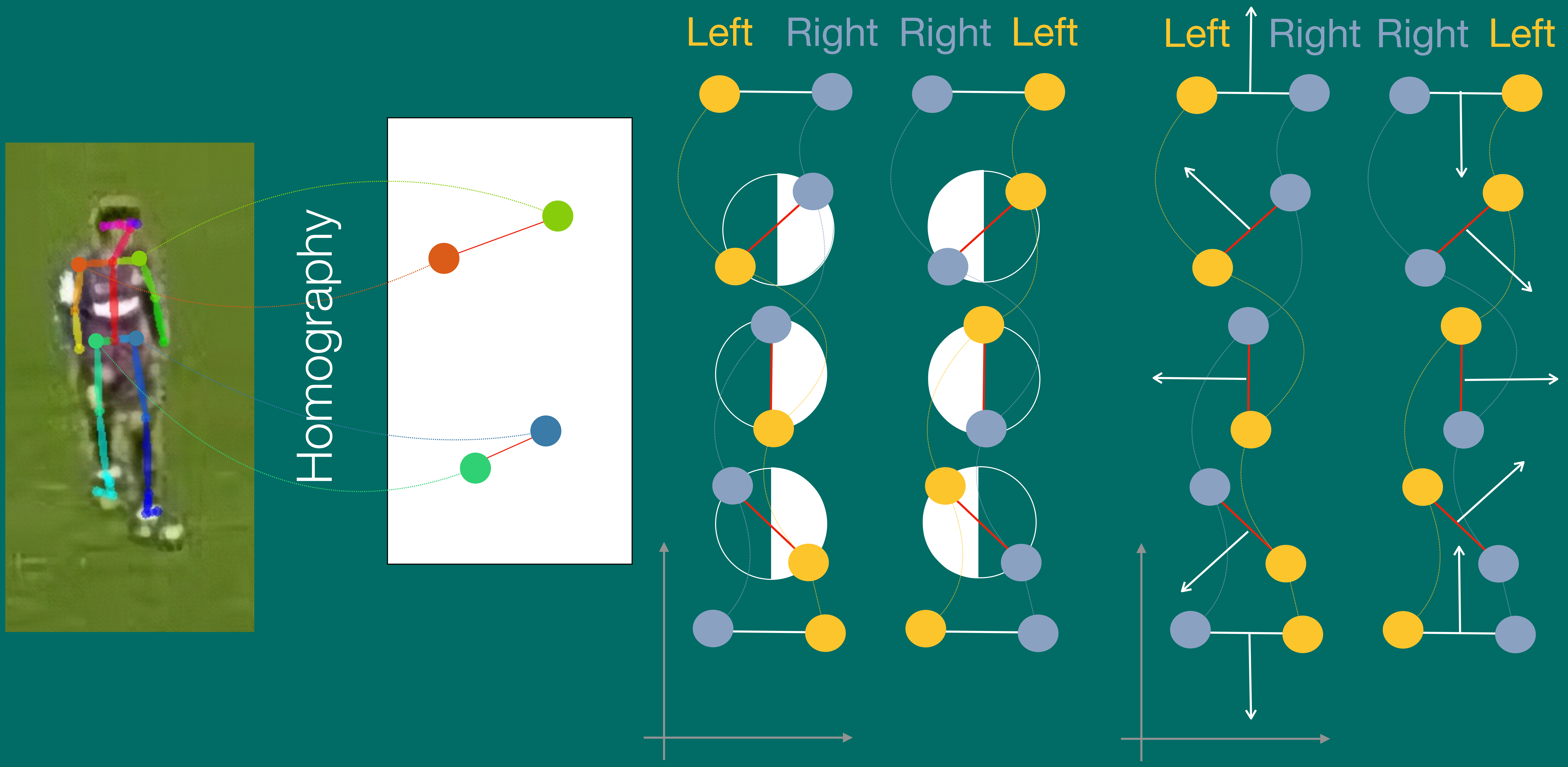
Shoulder / Hip Orientation



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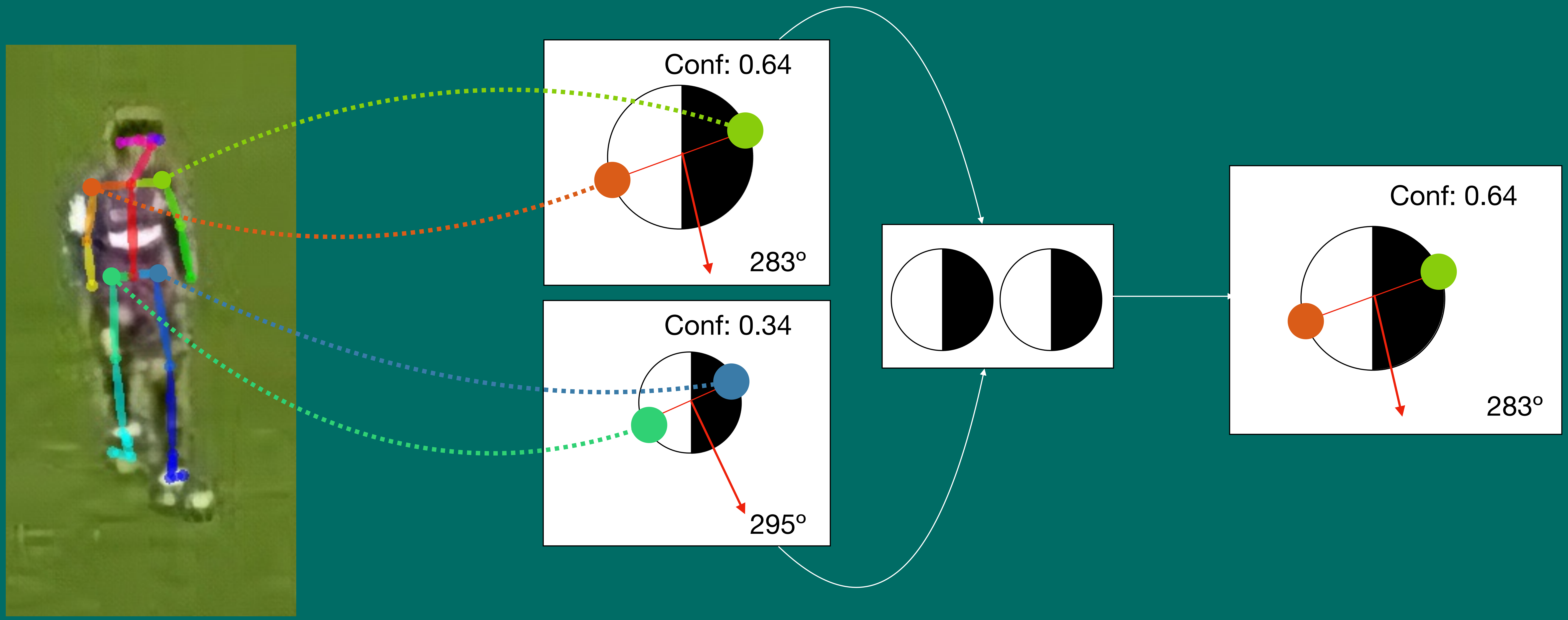
Shoulder / Hip Orientation



Proposed Method
Face Orientation

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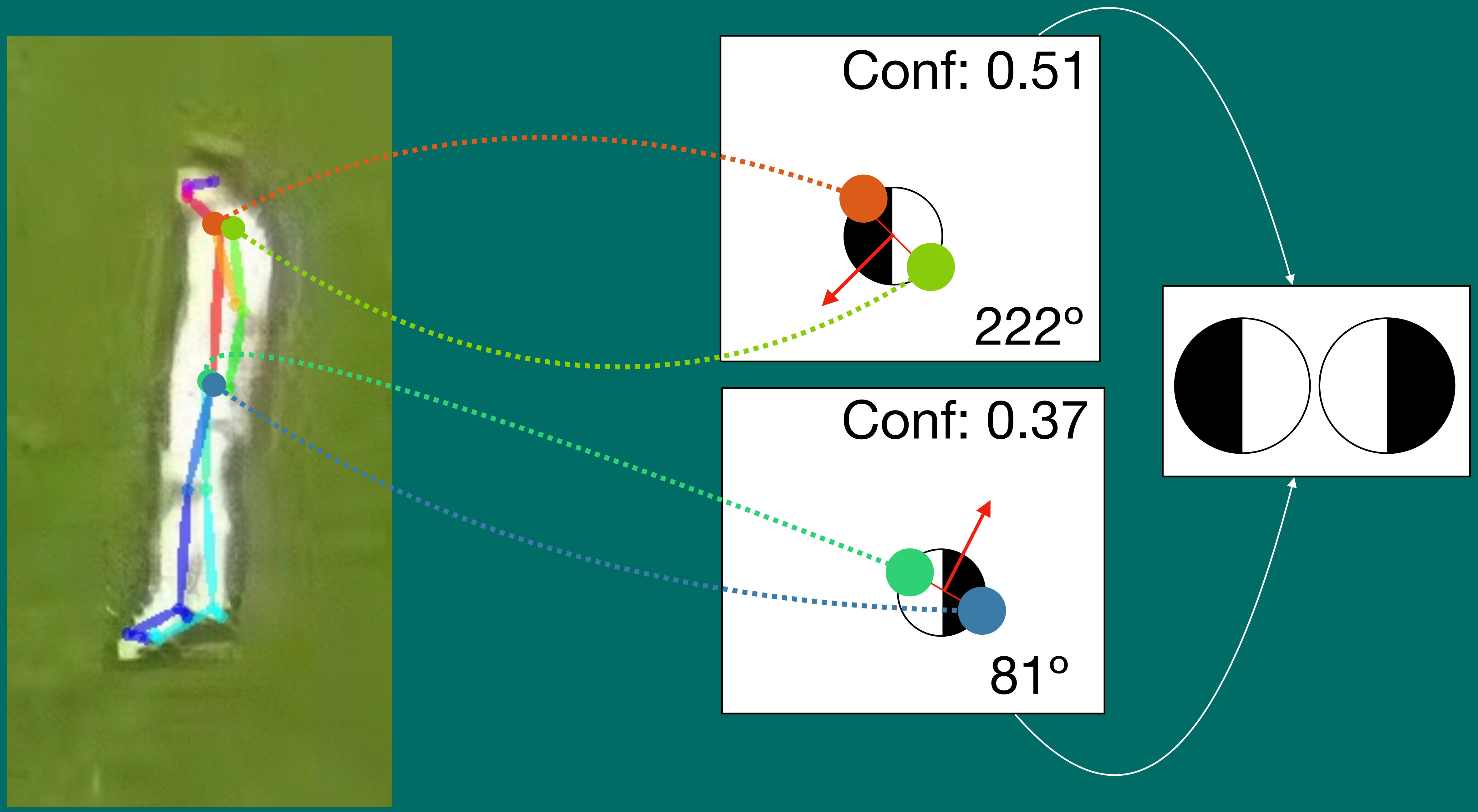
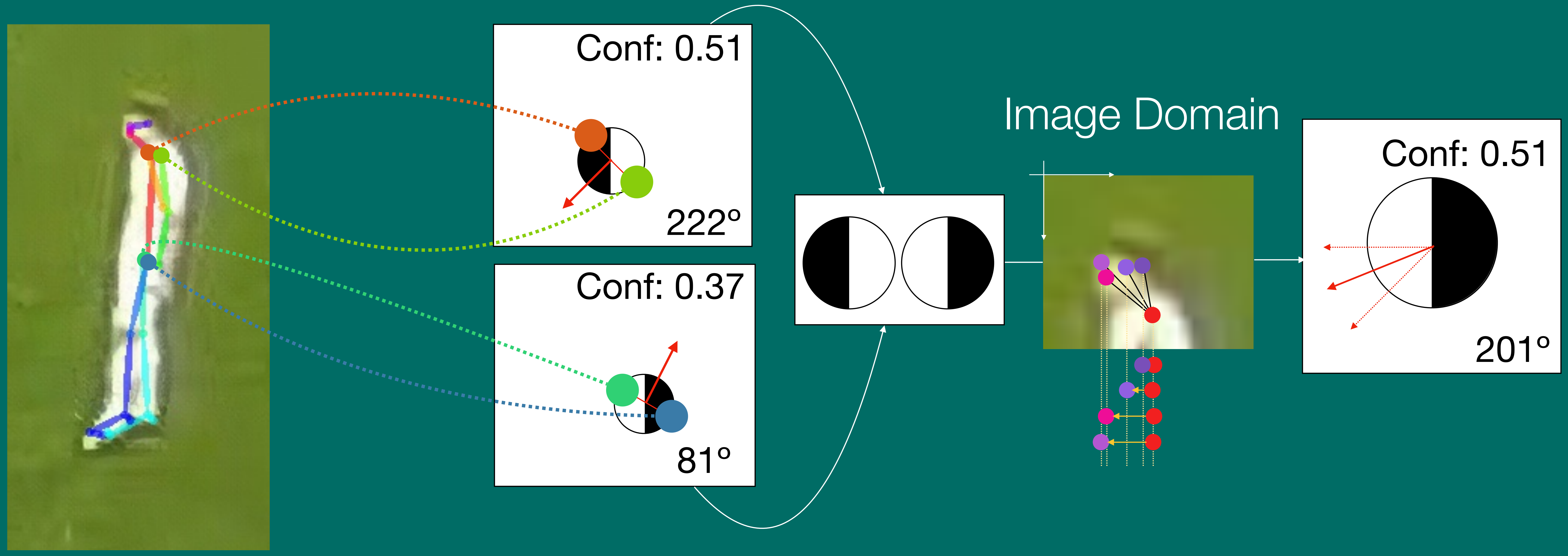
Face Orientation



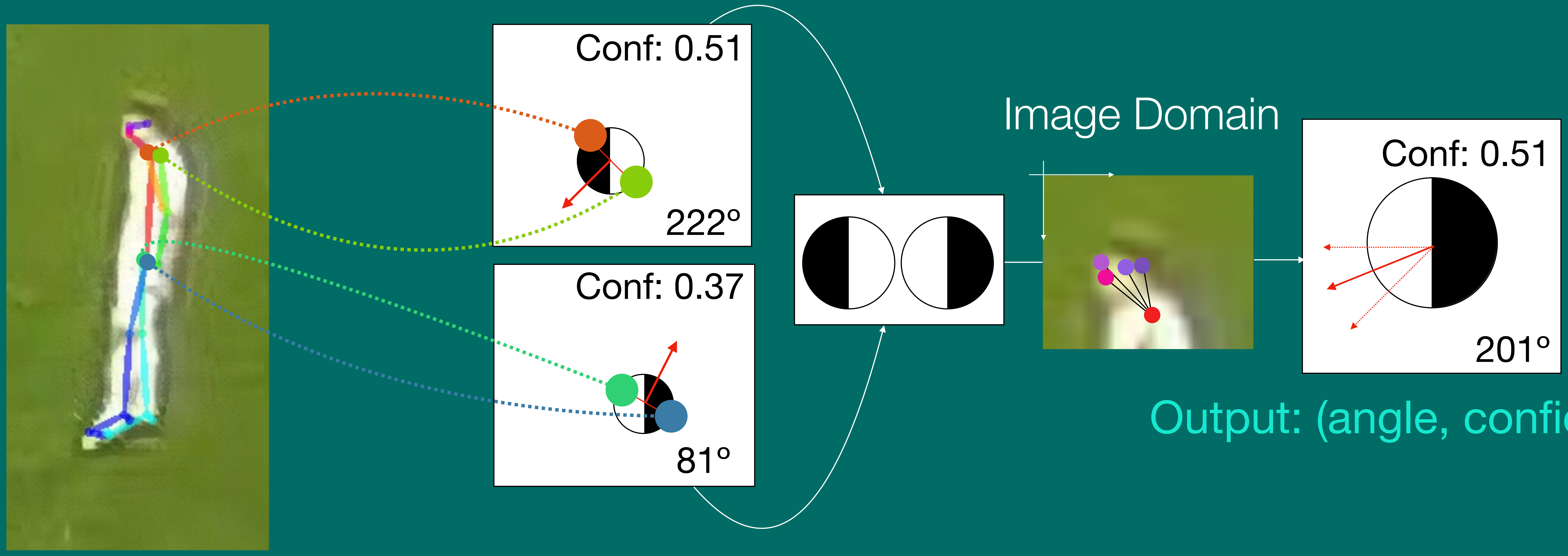
Proposed Method

Face Orientation



Proposed Method

Face Orientation



Output: (angle, confidence)

Proposed Method
Coarse Validation

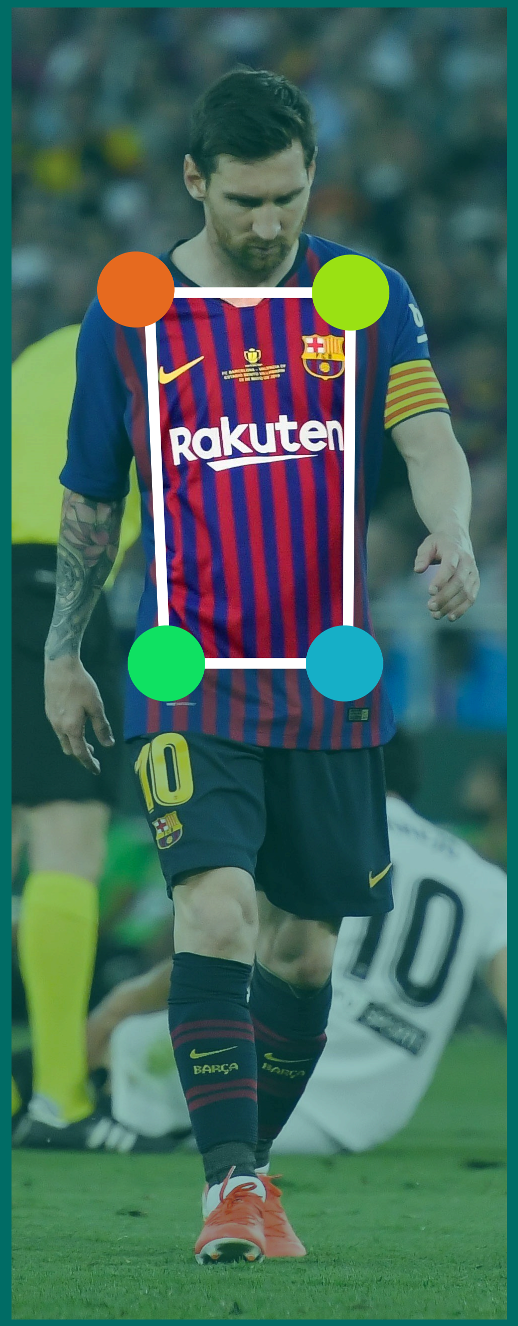
Proposed Method
Coarse Validation

Main Open-Pose
drawback at low-resolution

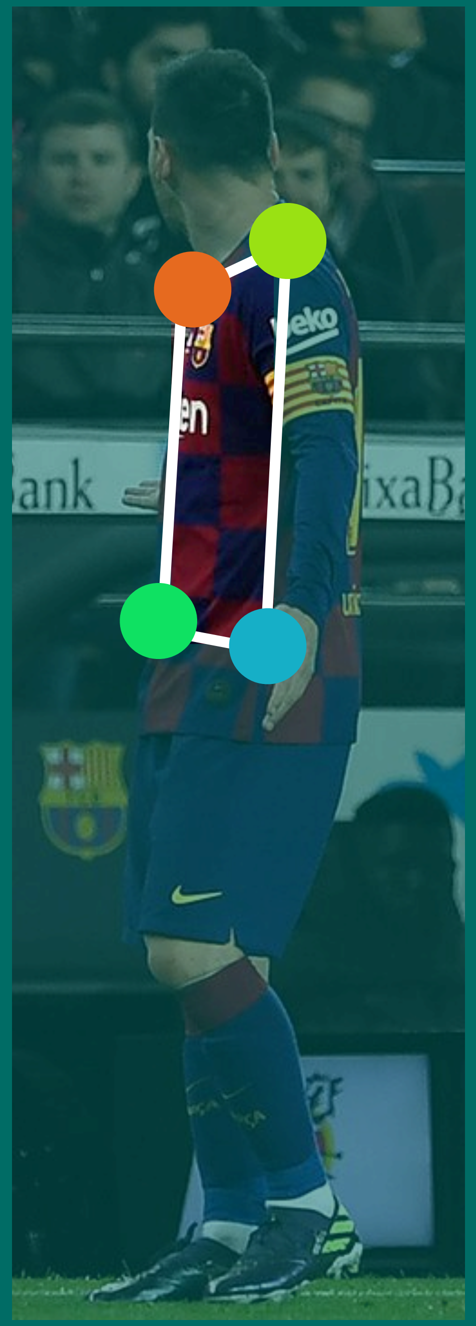
Proposed Method

Coarse Validation

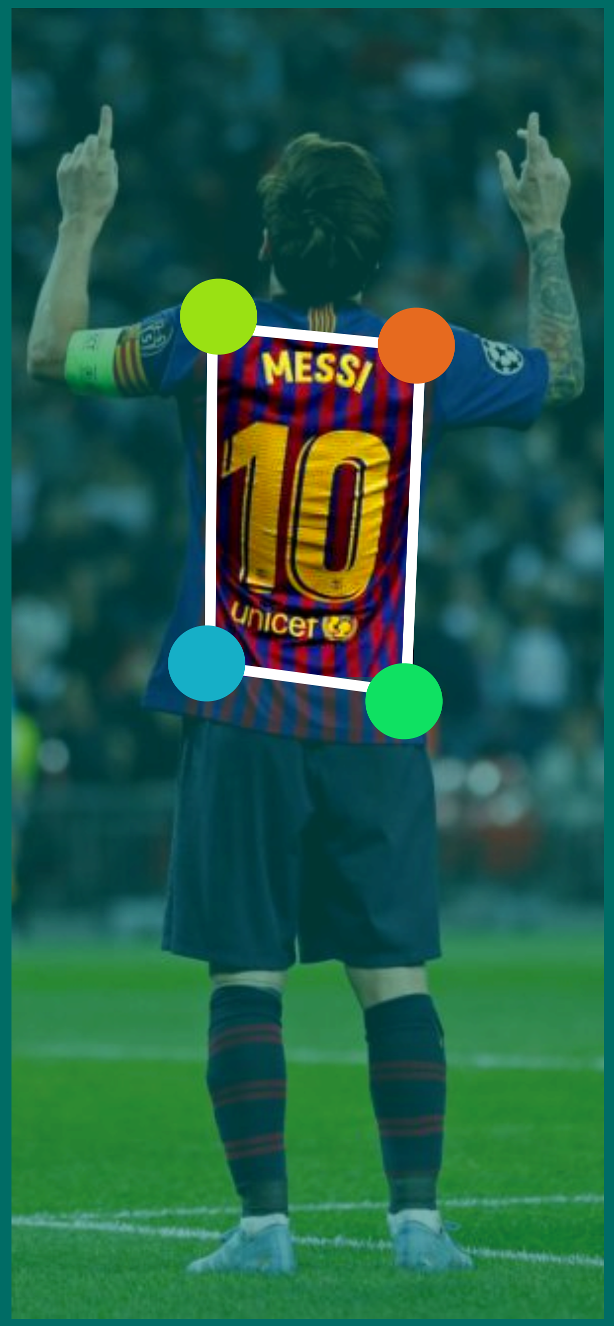
Main Open-Pose
drawback at low-resolution



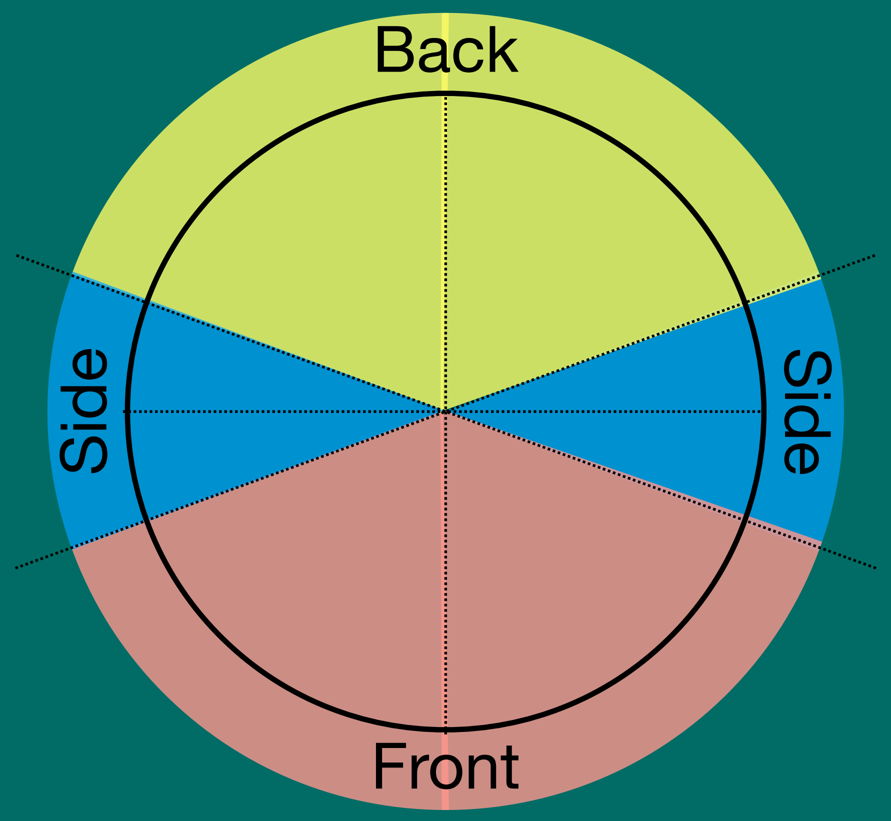
(a) Front



(b) Side



(c) Back

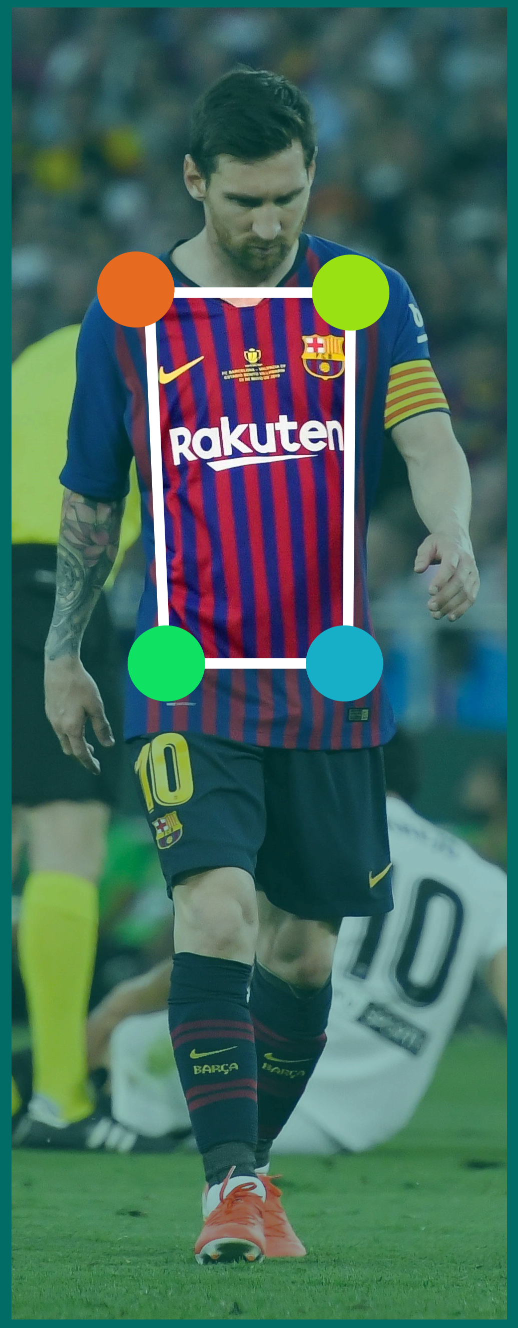


(d) Profile
Orientations

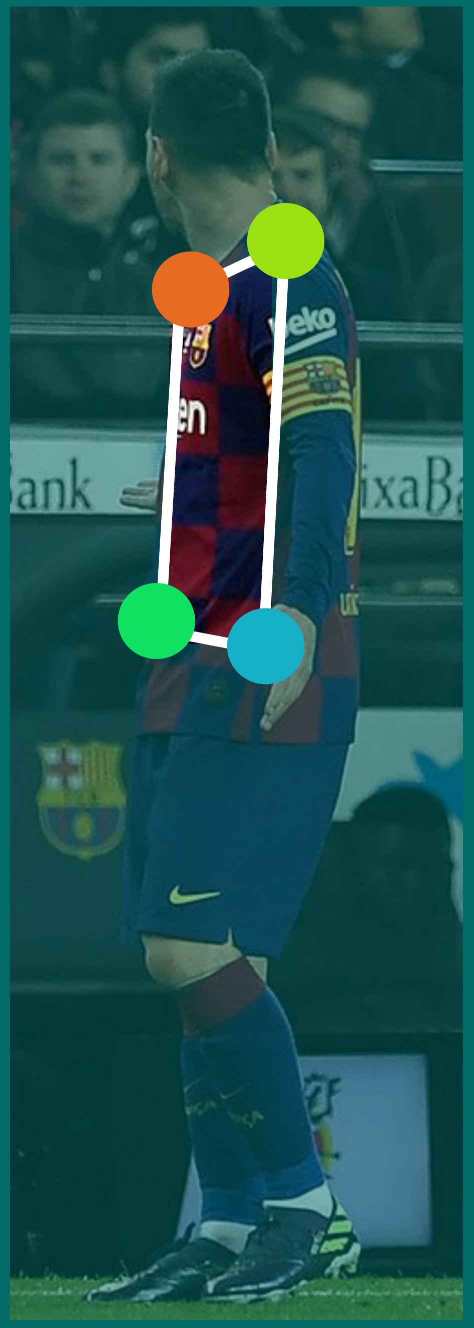
Proposed Method

Coarse Validation

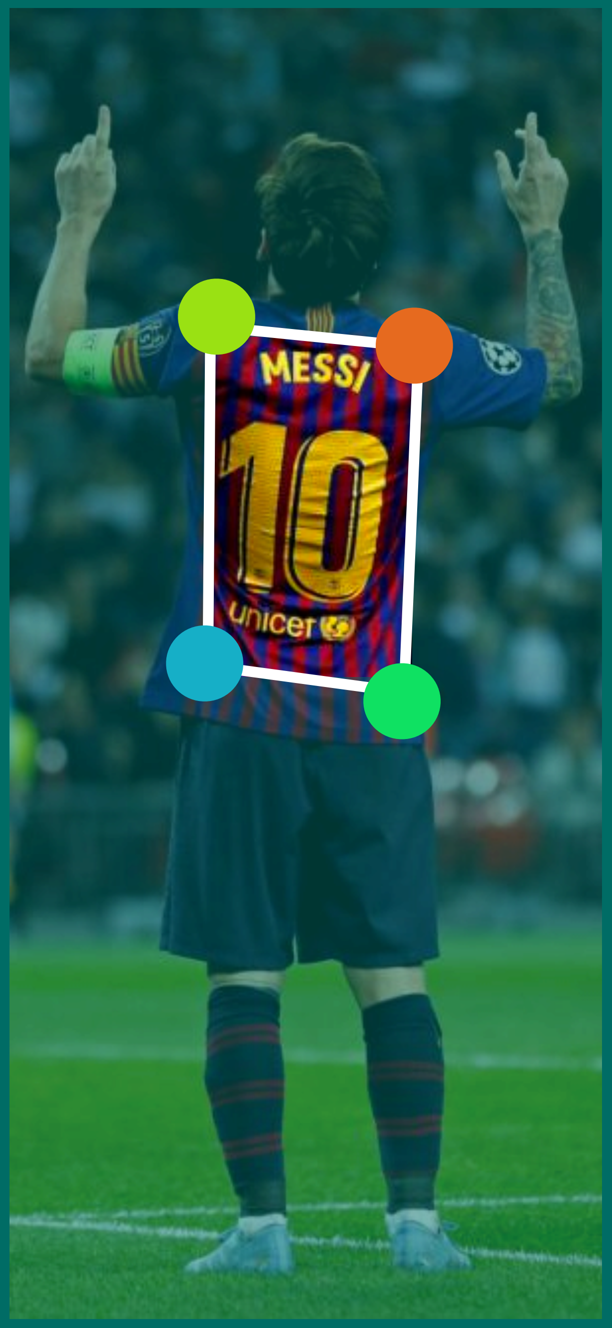
Main Open-Pose
drawback at low-resolution



(a) Front



(b) Side



(c) Back

Extract color (HSV) and geometrical features from the upper-torso

Annotate 14.000 instances with 3 possible labels: front / side / back

Train SVM model to perform a double-check

Proposed Method
Pose Estimation Discretization

Proposed Method

Pose Estimation Discretization

Bin Nº	1	2	3	4	(…)	22	23	24
Included Angles	0-15º	15-30º	30-45º	45-60º	(…)	315-330º	330-345º	345-360º

Orientation Expressed with Probability Vectors (Gaussian Support)

Proposed Method

Pose Estimation Discretization

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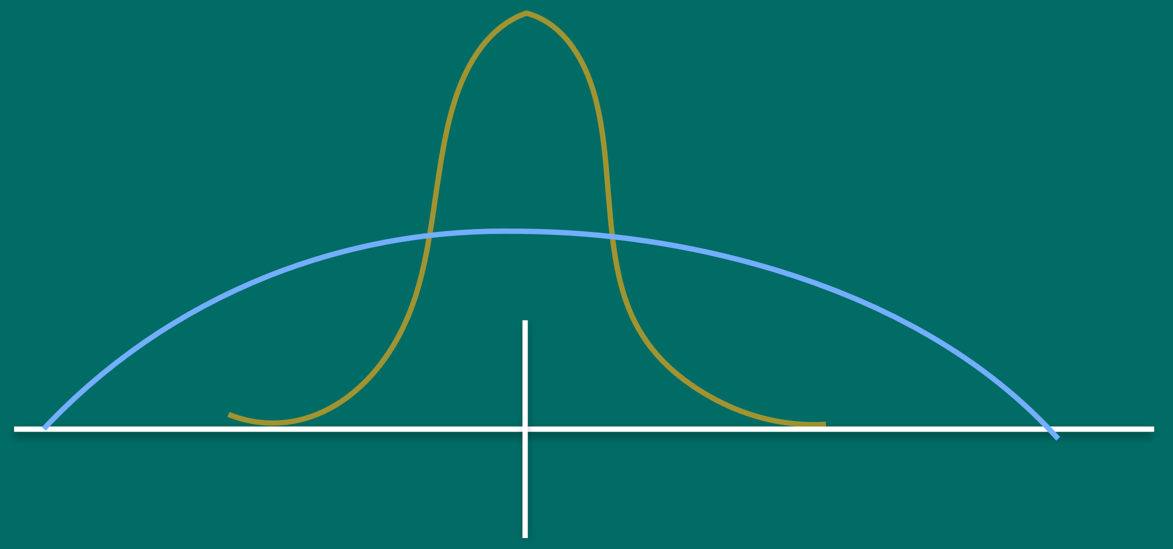
Orientation Expressed with Probability Vectors (Gaussian Support)

Example 1: (angle, confidence) - (50º, 0.8)

Example 2: (angle, confidence) - (155º, 0.4)



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	0	0.1	0.8	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0.1	0.2	0.4	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0

Proposed Method

Pose Estimation Discretization

$$N_P = \max\left(\left\lfloor N_{bins}\left(\frac{1-C_P}{2}\right)\right\rfloor, 1\right)$$

$$or_P = \begin{cases} \left\lfloor \frac{\alpha_P}{360/N_{bins}} + \frac{N_{bins}}{4} \right\rfloor & \text{if } \frac{\alpha_P}{360/N_{bins}} < 18 \\ \left\lfloor \frac{\alpha_P}{360/N_{bins}} + \frac{N_{bins}}{4} \right\rfloor - N_{bins} & \text{if } \frac{\alpha_P}{360/N_{bins}} \geqslant 18 \end{cases}$$

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Ball Orientation

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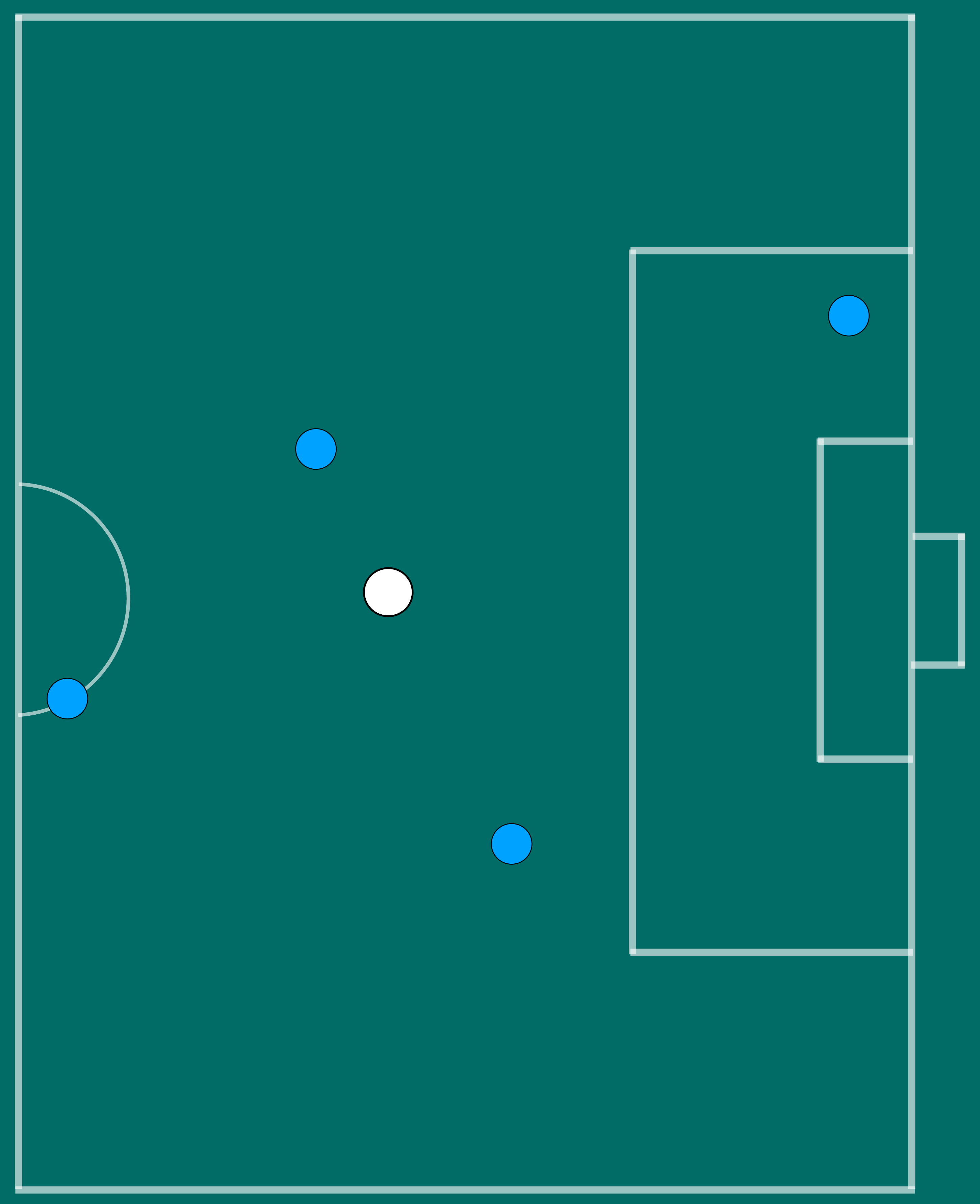

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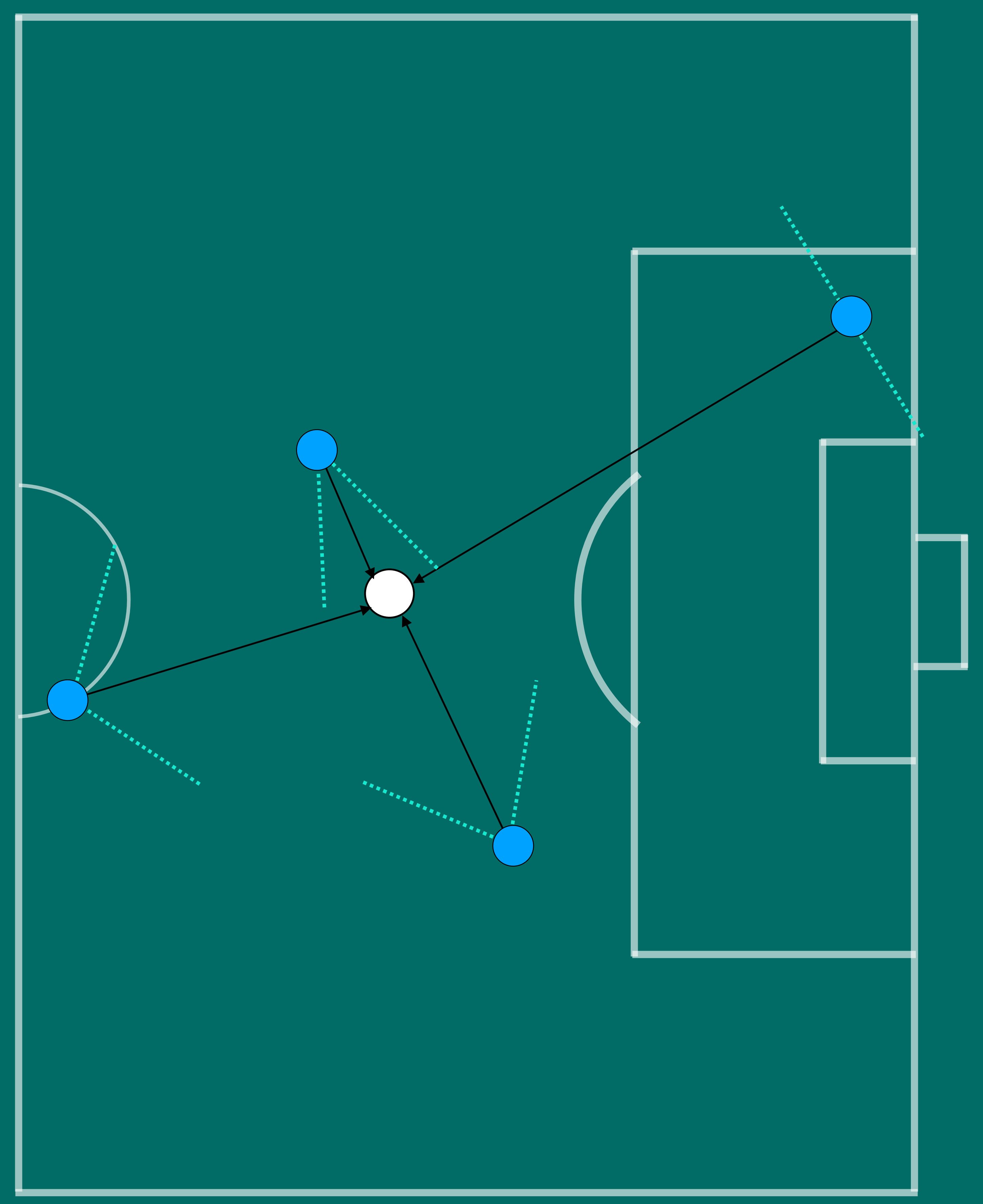

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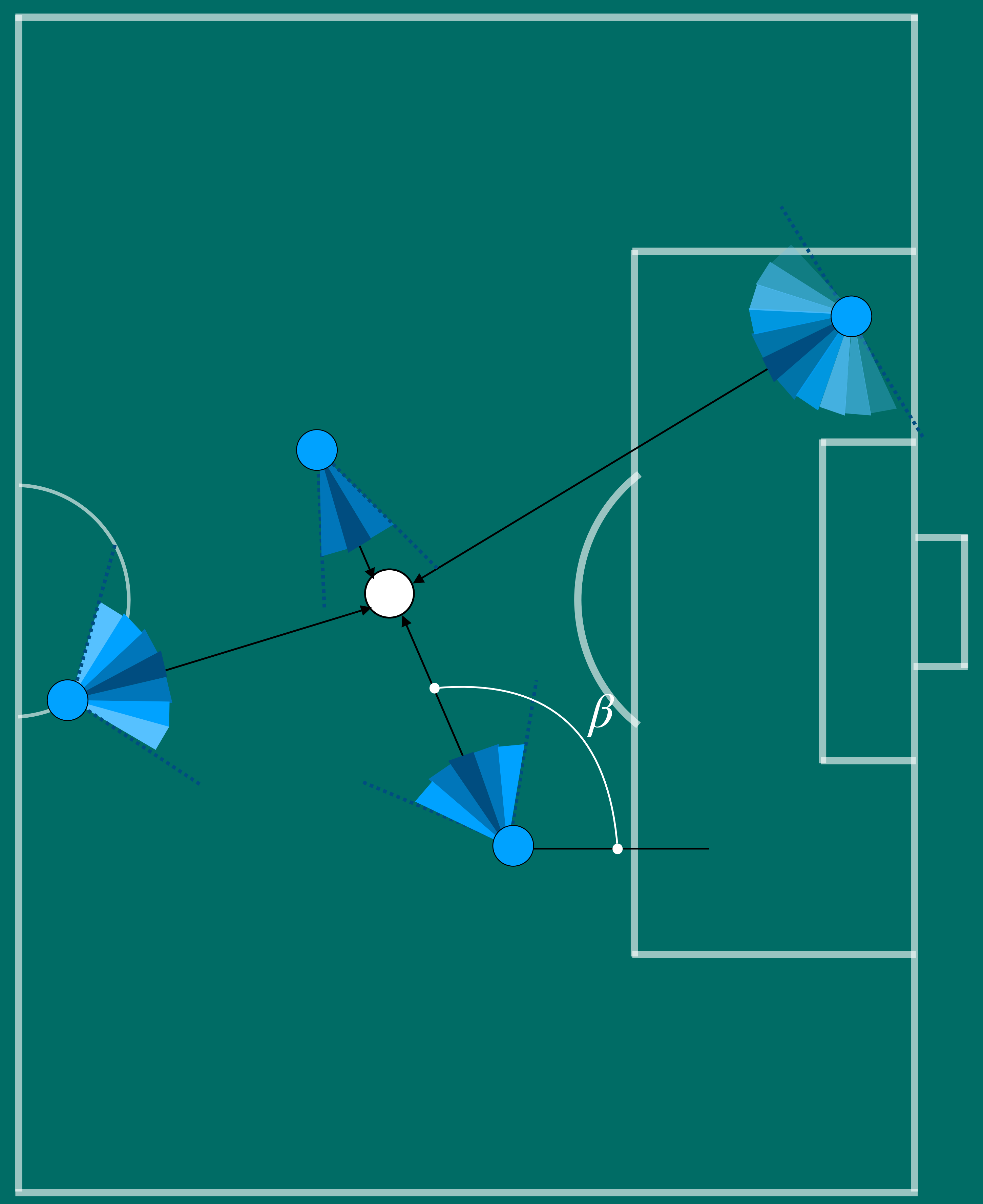
Ball Orientation



Proposed Method
Ball Estimation Discretization

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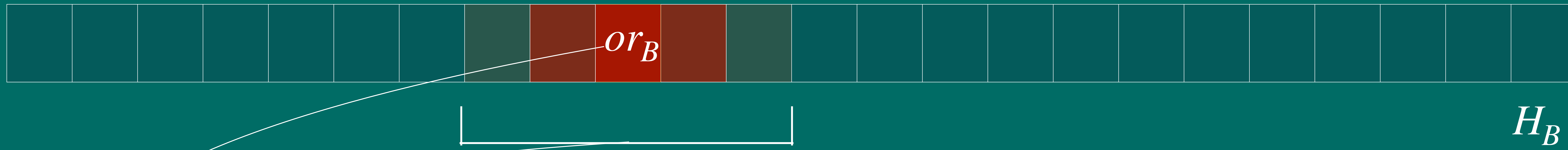
Ball Estimation Discretization



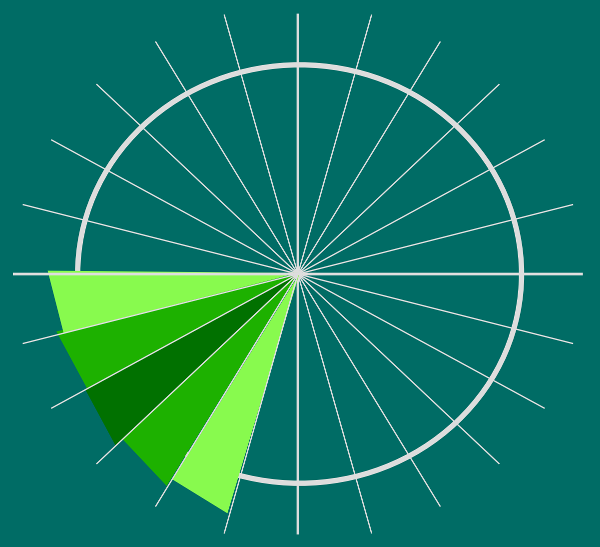
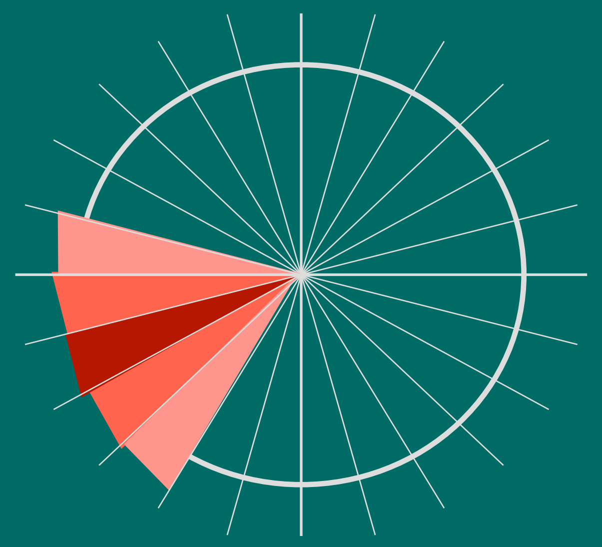
$$N_B = \frac{N_{bins}}{4}\left\lfloor 1 - \frac{MD - \sqrt{(P_x^2 - B_x^2) + (P_y^2 - B_y^2)}}{MD}\right\rfloor + \frac{N_{bins}}{8}$$

$$\text{or}_B = \begin{cases} \left\lfloor \frac{\beta}{360/N_{bins}} + \frac{N_{bins}}{4} \right\rfloor & \text{if } \left\lfloor \frac{\beta}{360/N_{bins}} \right\rfloor < 18 \\ \left\lfloor \frac{\beta}{360/N_{bins}} + \frac{N_{bins}}{4} \right\rfloor - N_{bins} & \text{if } \left\lfloor \frac{\beta}{360/N_{bins}} \right\rfloor \geqslant 18 \end{cases}$$

Proposed Method
Contextual Weighting

Proposed Method

Contextual Weighting

$H_{TOT} = w \cdot ($  $) + (1 - w) \cdot ($  $)$

Pose Orientation

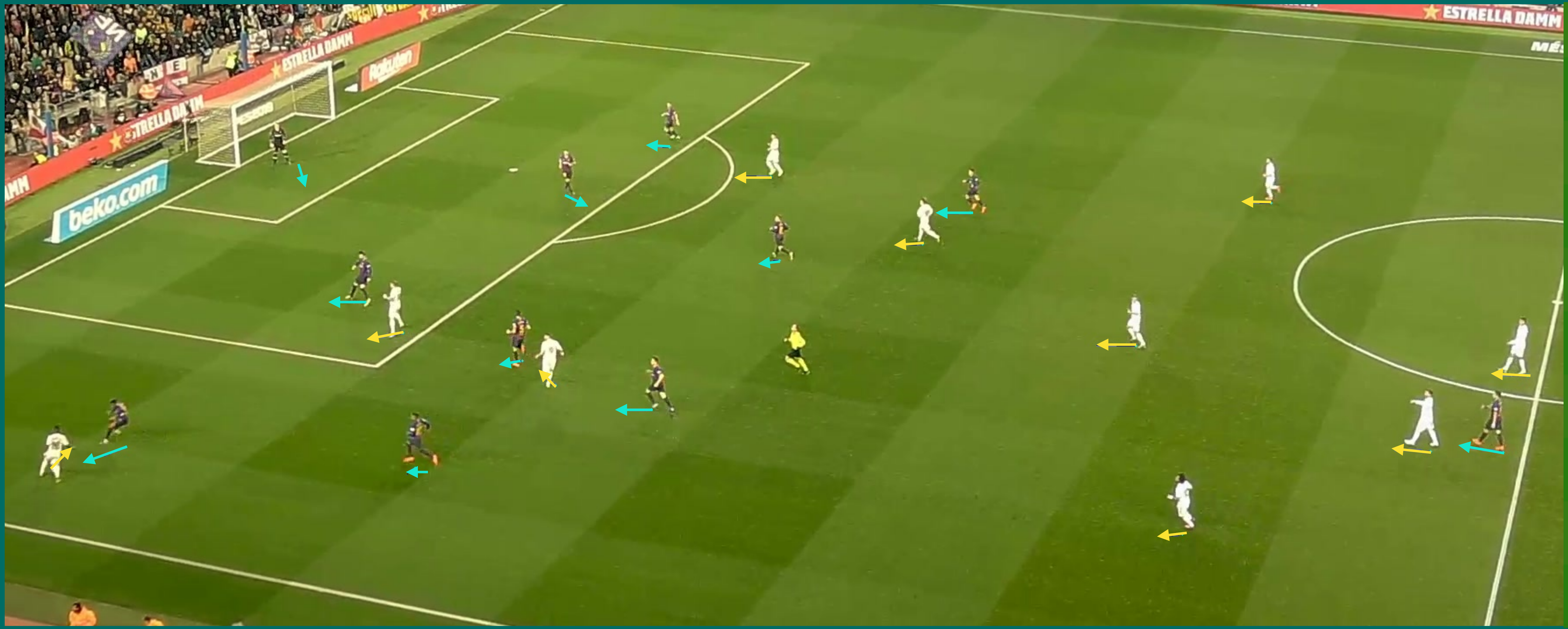
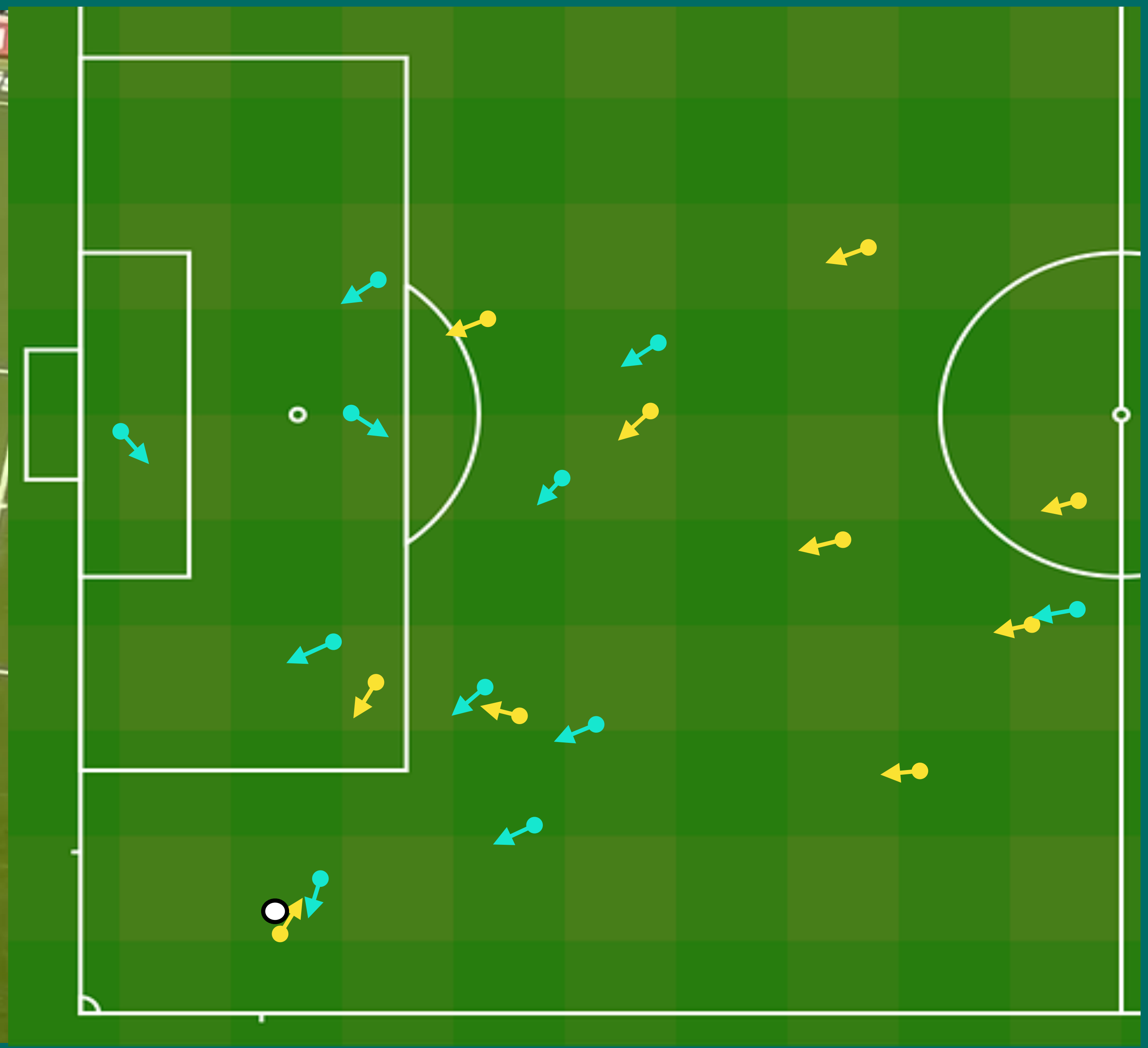
H_P

Ball Orientation

H_B

Final orientation: central value of the bin in H_{TOT} with a higher weight

Proposed Method
Visualization

Results

Dataset

Content:

-La Liga: video footage (25 fps, Full-HD), smoothed tracking data (image and field domains) and corners positions, eventing data.

-Youth games: video footage, raw data from EPTS devices (100 samples/second). Ground-truth orientation.

Validation:

- Subsampling to 1/3 of original frame rate; 2000 frames, 30000 players.

Results

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Results
Metrics

OpenPose + Super-Resolution

Detection Rate: 89.69%

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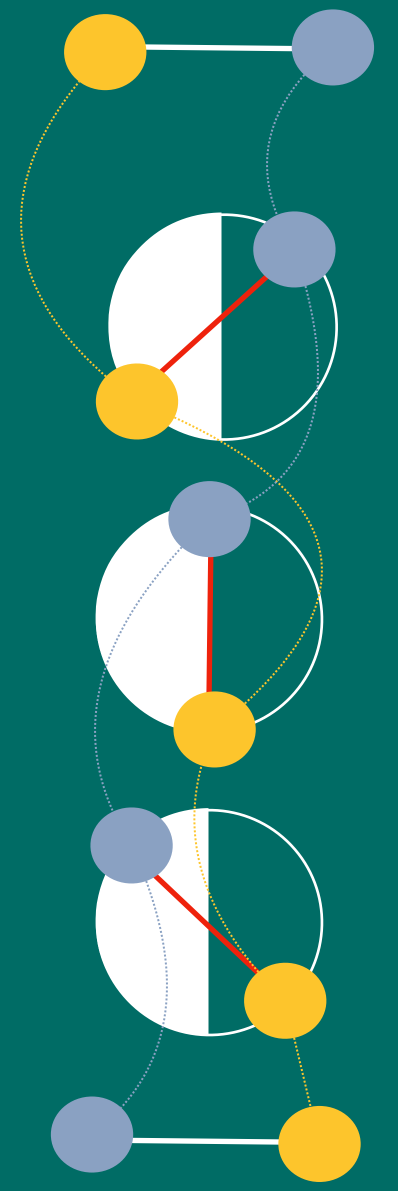
LR-Side



LR Accuracy: 92.43%

Results
Metrics

OpenPose + Super-Resolution

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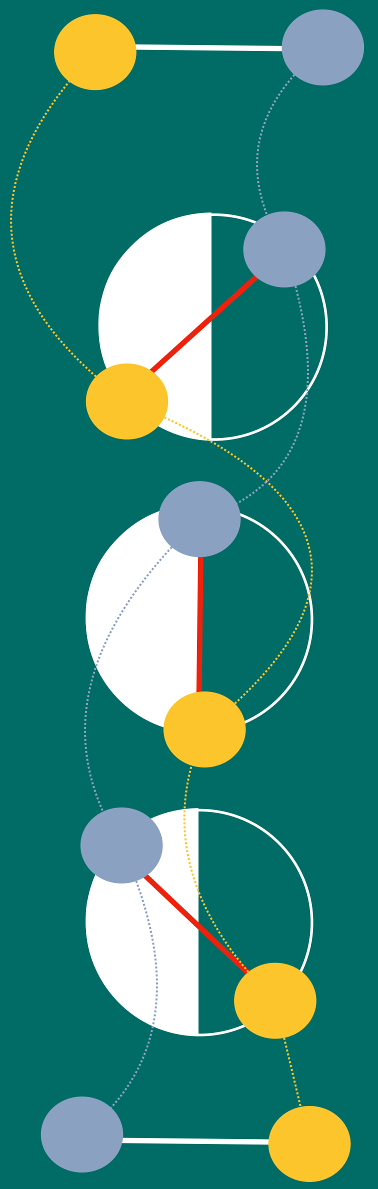

LR Accuracy: 92.43%

Coarse Validation

(80-20 train-test)

Accuracy: 85.91%

Results

Parameter Adjustment

$$OD_{i_t} = \min(|\alpha_{i_t} - \omega_{i_t}|, 360 - |\alpha_{i_t} - \omega_{i_t}|)$$

Best Combination: $H_{TOT} = 0.7 \cdot H_P + 0.3 \cdot H_B$

Mean: 29.78°

Median: 27.66°

Results

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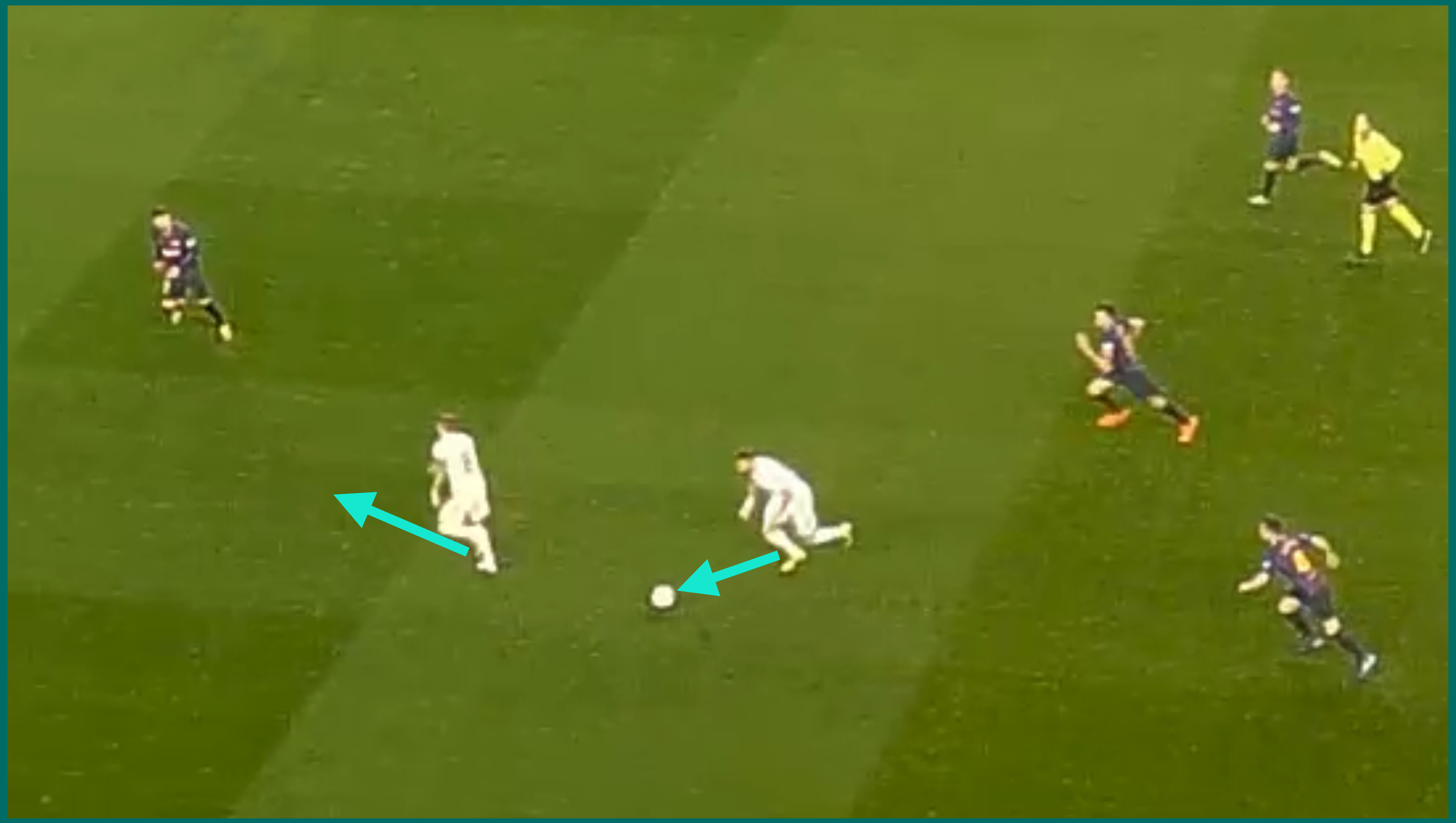
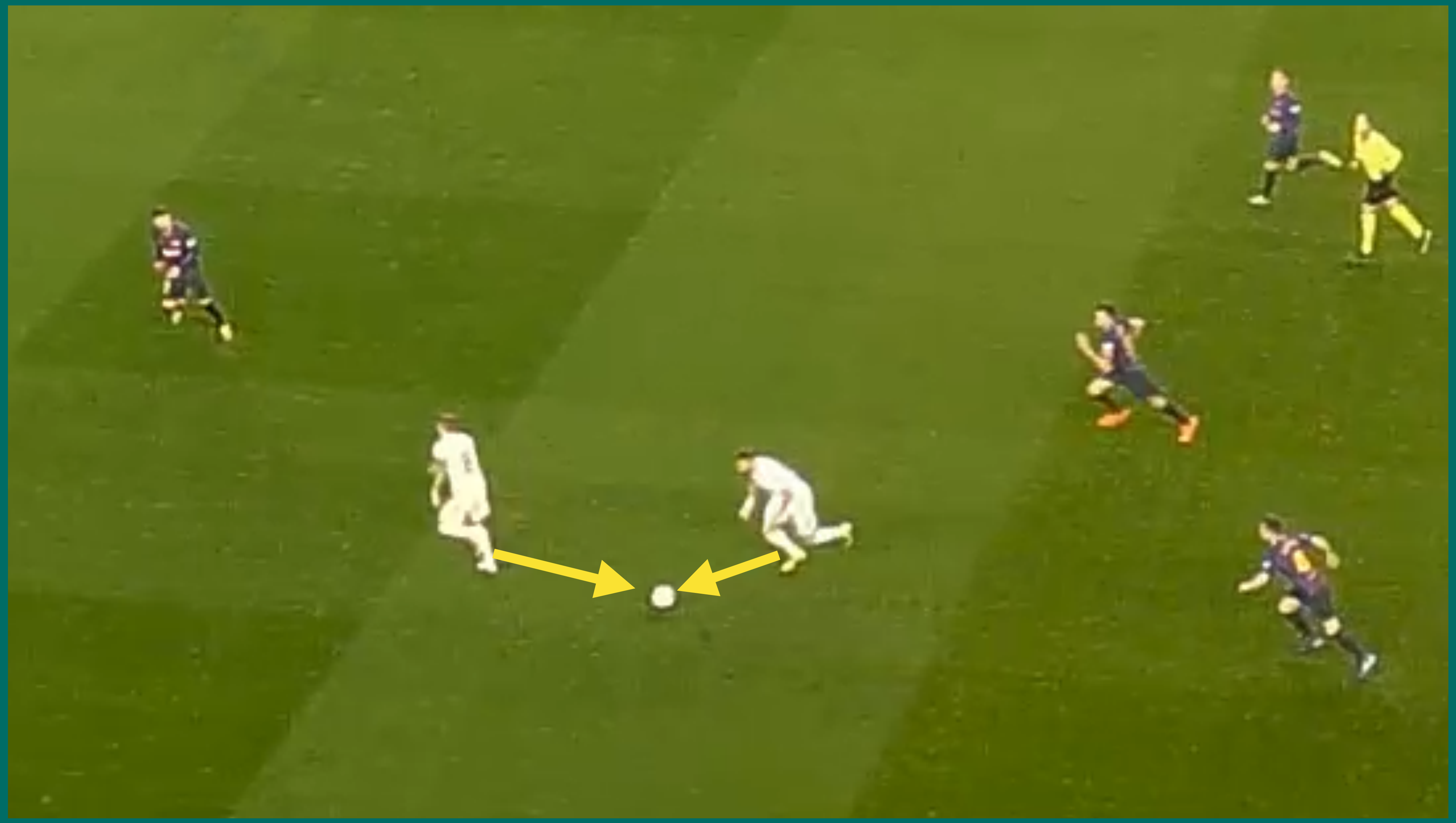
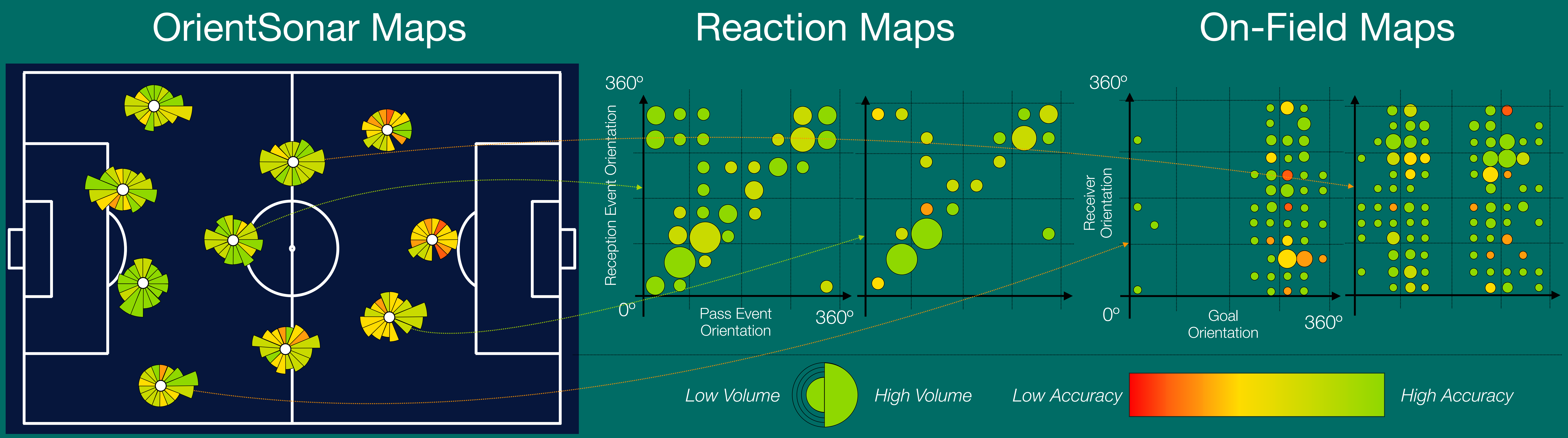




Results

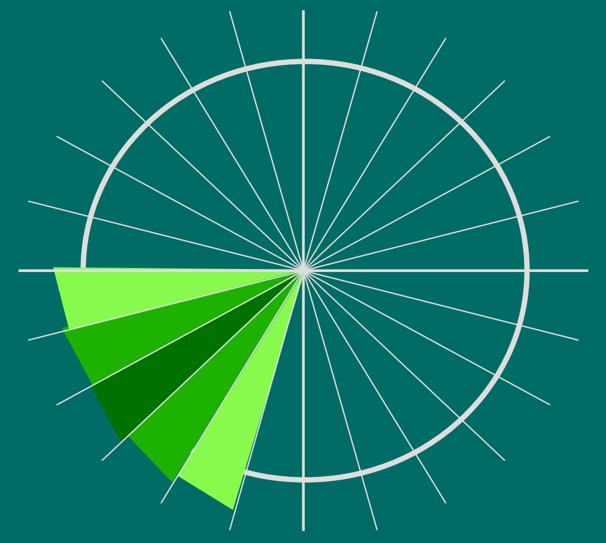
Practical Applications

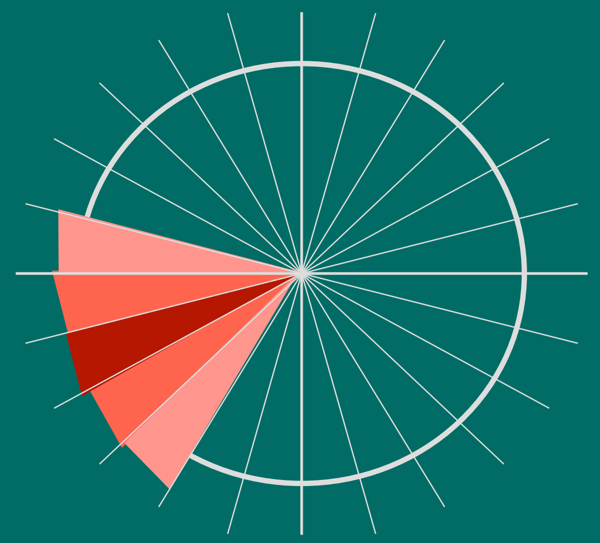


Conclusions

Body orientation estimator for soccer scenarios through the combination of:

Pose Orientation





Ball Orientation

Detection Rate: 89.69%

LR Accuracy: 92.43%

Mean Error: 29.78º

Median Error: 27.66º

Future Work: Quantify the relevance of body orientation

[5] Using Player's Body Orientation to Model Pass Feasibility in Soccer [Arbués-Sangüesa et al.]

References

[1] Decomposing the Immeasurable Sport: a Deep Learning Expected Posesssion Value Framework for Soccer [Fernández et al.] - MIT Sloan Sports Analytics Conference 2019

[2] A Winning Combination: Pairing Video and Movement Data to Enhance Sports Data Analysis [Stein et al.] - IEEE Digital Library 2018

[3] Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields [Cao et al.] - CVPR 2016

[4] Residual Dense Network for Image Super-Resolution [Cardinale et al.] - CVPR 2018

[5] Using Player's Body Orientation to Model Pass Feasibility in Soccer [Arbués-Sangüesa et al.] - Computer Vision in Sports Workshop at CVPR 2020

Thank you for your attention!

adria.arbues@upf.edu