R·V ReSpo-Vision



Introduction

TL;DR: We reframe jersey number recognition as a classification task with principled **uncertainty** quantification. Our end-to-end model uses a digit-compositional architecture and an evidencebased **Dirichlet** framework. This achieves **85.62%** accuracy on **SoccerNet Challenge** (83.52%) using public datasets) with simple Bayesian tracklet-level averaging.

Motivation

- Player identification in sports critically relies on recognizing jersey numbers.
- Recognition is hindered by challenging real-world conditions: motion blur, low resolution, occlusions, and varied player orientations.
- Robustly reading **partially visible numbers** remains a key unsolved challenge.
- Existing **public datasets** lack the diversity needed to train robust, generalizable models.
- Complex multi-stage methods are difficult to integrate into larger systems focused on Game State Reconstruction (GSR).

To address these issues, we leverage and contribute to several large-scale datasets:



Dataset	Tracklets	Images	Annotation	Visibility
SoccerNet Train	1,427	733,000	Tracklet	Tracklet (Image*)
SoccerNet Test	1,211	564,500	Tracklet	Tracklet
SoccerNet Challenge	1,426	748,600	Tracklet	Tracklet
SoccerNet ReID	-	350,986	Image*	Image*
200M	594,977	1,071,564	Tracklet	lmage*
Copa America (CA)	33,730	89,728	Tracklet	Image*

Bold text indicates our public contributions (new dataset or new labels), (*) indicates pseudo-labels.

Main Contributions

- Digit-Compositional Architecture: We propose novel jersey number heads that leverage digit compositionality, learning structural relationships between numbers to outperform independent classifiers.
- Uncertainty-Aware Predictions: We integrate a Dirichlet-based evidential framework that provides robust uncertainty estimates, significantly boosting accuracy over softmax baselines.
- Single-Stage Approach: We propose a unified, end-to-end trainable model that directly recognizes jersey numbers from player crops, without a separate jersey detection stage or OCR.
- New Datasets for Robust Evaluation: We introduce the Copa America (CA) dataset, featuring unique jersey designs crucial for validation and testing model generalization. We also provide pseudo-labels for the large-scale SoccerNet ReID dataset to foster further public research.

Single-Stage Uncertainty-Aware Jersey Number **Recognition in Soccer**

Łukasz Grad^{1,2}

Digit

Classifie

Digit

Classifier

Digit

¹University of Warsaw, Poland



Jersey Number Head

Ablation Studies on SoccerNet Test Set

	Ac	c Total (%)	Acc	: Visible (%)	Acc Not-Visible (%)		
Head Type	Softmax	Dirichlet (Δ)	Softmax	Dirichlet (Δ)	Softmax	Dirichlet (Δ)	
Digit-Aware (DA)	$\textbf{80.15} \pm \textbf{1.16}$	83.24 ± 0.94 (+3.09)	83.72 ± 0.85	85.83 ± 1.17 (+2.11)	71.55 ± 2.46	77.00 ± 1.07 (+5.45)	
Tied DA with Multiplicative Emb. (TDA-M)	78.70 ± 0.22	82.91 ± 0.25 (+4.21)	81.85 ± 0.82	85.71 ± 0.70 (+3.86)	71.08 ± 2.29	76.15 ± 0.86 (+5.07)	
TDA-M with Per-Digit Bias	77.81 ± 0.59	82.11 ± 1.92 (+4.30)	80.49 ± 1.52	84.11 ± 3.65 (+3.62)	71.36 ± 2.40	77.28 ± 2.28 (+5.92)	
TDA with Additive Emb. (TDA-A)	75.81 ± 0.73	73.03 ± 0.80 (-2.78)	77.18 ± 1.66	71.11 ± 0.53 (-6.07)	$\textbf{72.49} \pm \textbf{1.55}$	77.65 ± 1.55 (+5.16)	
Independent (Baseline)	73.47 ± 1.25	78.48 ± 0.55 (+5.01)	74.61 ± 0.97	79.05 ± 1.94 (+4.44)	70.70 ± 1.95	77.09 ± 3.26 (+6.39)	

																			,	Uncerta	ainty - 0.00
Pred: 11 Prob: 0.78	Pred: 11 Prob: 0.96	Pred: 11 Prob: 0.89	Pred: 11 Prob: 0.62	Pred: 34 Prob: 0.52	Pred: 7 Prob: 0.21	Pred: 11 Prob: 0.07	Pred: 11 Prob: 0.02	Pred: 7 Prob: 0.04	Pred: 11 Prob: 0.51	Pred: 11 Prob: 0.09	Pred: 10 Prob: 0.01	Pred: 3 Prob: 0.02	Pred: 10 Prob: 0.01	Pred: 10 Prob: 0.01	Pred: 10 Prob: 0.01	Pred: 11 Prob: 0.93	Pred: 11 Prob: 0.99	Pred: 11 Prob: 0.99	Pred: 11 Prob: 0.98		
		11		42	3		TA	1				2	X	÷.	4		1		U)		- 0.10
									SU.	1					<u>I</u> (A		- 0.20
Pred: 9 Prob: 0.02	Pred: 18 Prob: 0.18	Pred: 18 Prob: 0.19	Pred: 9 Prob: 0.07	Pred: 7 Prob: 0.05	Pred: 4 Prob: 0.03	Pred: 9 Prob: 0.03	Pred: 5 Prob: 0.06	Pred: 6 Prob: 0.08	Pred: 18 Prob: 0.03	Pred: 9 Prob: 0.01	Pred: 8 Prob: 0.01	Pred: 8 Prob: 0.02	Pred: 8 Prob: 0.02	Pred: 7 Prob: 0.01	Pred: 7 Prob: 0.02	Pred: 7 Prob: 0.01	Pred: 7 Prob: 0.02	Pred: 9 Prob: 0.01	Pred: 23 Prob: 0.80		
																					- 0.30
Pred: 4	Pred: 4	Pred: 4	Pred: 4	Pred: 4	Pred: 4	Pred: 4	Pred: 4	Pred: 4		- 0.40											
																					- 0.50
Pred: 14 Prob: 0.36	Pred: 14 Prob: 0.81	Pred: 14 Prob: 0.96	Pred: 2 Prob: 0.04	Pred: 4 Prob: 0.02	Pred: 17 Prob: 0.19	Pred: 10 Prob: 0.04	Pred: 14 Prob: 0.90	Pred: 10 Prob: 0.17	Pred: 14 Prob: 0.96	Pred: 14 Prob: 0.95	Pred: 14 Prob: 0.94	Pred: 8 Prob: 0.05	Pred: 14 Prob: 0.86	Pred: 14 Prob: 0.95	Pred: 14 Prob: 0.96	Pred: 14 Prob: 0.94	Pred: 10 Prob: 0.01	Pred: 8 Prob: 0.01	Pred: 8 Prob: 0.01		- 0.60
Ż							N		k								R				- 0.70
Pred: 10 Prob: 0.01	Pred: 10 Prob: 0.02	Pred: 10 Prob: 0.01	Pred: 7 Prob: 0.01	Pred: 10 Prob: 0.01	Pred: 4 Prob: 0.02	Pred: 10 Prob: 0.01	Pred: 6 Prob: 0.01	Pred: 8 Prob: 0.01	Pred: 6 Prob: 0.01	Pred: 7 Prob: 0.02	Pred: 8 Prob: 0.02	Pred: 2 Prob: 0.03	Pred: 10 Prob: 0.01	Pred: 8 Prob: 0.01	Pred: 7 Prob: 0.01	Pred: 8 Prob: 0.01	Pred: 10 Prob: 0.01	Pred: 9 Prob: 0.07	Pred: 10 Prob: 0.01		- 0.60
					Ż	浅		İ	K		k	K	Ŝ	1			1	Í	K		- 0.90

²ReSpo.Vision, Poland





1.00



GT: 9	GT: 4	GT: 23	GT: 4	GT: 11	GT: 14	GT: 34	GT: 7	GT: 9	GT: 14	GT: 27	GT: 23	Uncertainty
Pred: 9	Pred: 4	Pred: 23	Pred: 4	Pred: 11	Pred: 14	Pred: 34	Pred: 7	Pred: 9	Pred: 14	Pred: 27	Pred: 23	
R	R	23		H I		Ē				Ţ		0.00
GT: 50	GT: 14	GT: 4	GT: 4	GT: 16	GT: 26	GT: 26	GT: 33	GT: 33	GT: 5	GT: 20	GT: 5	- 0.10
red: 50	Pred: 14	Pred: 4	Pred: 4	Pred: 16	Pred: 26	Pred: 26	Pred: 33	Pred: 33	Pred: 5	Pred: 20	Pred: 5	
	ų,		i	5	2	26	A	Real Property in the second se	5	5 V	Â	- 0.20
GT: 26	GT: 36	GT: 26	GT: 3	GT: 26	GT: 25	GT: 14	GT: 50	GT: 93	GT: 33	GT: 25	GT: 20	
red: 16	Pred: 16	Pred: 26	Pred: 9	Pred: 26	Pred: 25	Pred: 14	Pred: 50	Pred: 33	Pred: 18	Pred: 25	Pred: 20	
18	Ì	10			5 7	H		1	A			- 0.30
GT: 16	GT: 20	GT: 34	GT: 32	GT: 10	GT: 11	GT: 16	GT: 15	GT: 50	GT: 25	GT: 26	GT: 36	
red: 16	Pred: 20	Pred: 34	Pred: 32	Pred: 10	Pred: 11	Pred: 16	Pred: 16	Pred: 50	Pred: 8	Pred: 24	Pred: 36	
1	1		32	k		ALL DE	Ĵ			2		- 0.40
GT: –1	GT: 10	GT: 20	GT: 36	GT: 7	GT: 34	GT: 10	GT: 55	GT: 44	GT: 9	GT: 36	GT: 20	- 0.50
Pred: 9	Pred: 10	Pred: 20	Pred: 26	Pred: 31	Pred: 34	Pred: 10	Pred: 69	Pred: 44	Pred: 5	Pred: 36	Pred: 25	
	1 and a start	AL N	\$ V	÷.	R	煄 ,		R	ì		1	- 0.60
GT: 33	GT: 15	GT: 14	GT: 31	GT: 24	GT: 4	GT: 38	GT: 24	GT: 16	GT: 25	GT: 7	GT: 22	
red: 20	Pred: 15	Pred: 14	Pred: 31	Pred: 25	Pred: 14	Pred: 36	Pred: 24	Pred: 16	Pred: 20	Pred: 10	Pred: 29	
	A			A	1	36		Ì		-	Ĩ	- 0.70
GT: 44	GT: 62	GT: 10	GT: 56	GT: 25	GT: 93	GT: 17	GT: 50	GT: 4	GT: 50	GT: 50	GT: 5	
red: 14	Pred: 9	Pred: 10	Pred: 30	Pred: 8	Pred: 8	Pred: 7	Pred: 50	Pred: 4	Pred: 5	Pred: 5	Pred: 7	
A				Å	-	1	1	À			R	- 0.80
GT: 15	GT: 93	GT: 26	GT: -1	GT: 38	GT: –1	GT: –1	GT: –1	GT: –1	GT: 33	GT: 4	GT: 25	- 0.90
Pred: 2	Pred: 8	Pred: 20	Pred: 20	Pred: 15	Pred: 10	Pred: 7	Pred: 7	Pred: 10	Pred: 10	Pred: 10	Pred: 10	
A C			入入	No.	意し	1						- 1.00

SoccerNet Challenge Results

	Test Acc (%)	Challenge Acc (%)
	32.57	35.79
	46.73	49.88
	47.85	50.60
	52.91	58.45
	68.53	73.77
	87.45	79.31
	82.74	-
	86.37	83.52
	85.46	85.62
ed)	88.27	85.41

