Single-Stage Uncertainty-Aware Jersey Number Recognition in Soccer

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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 evidence-based **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).

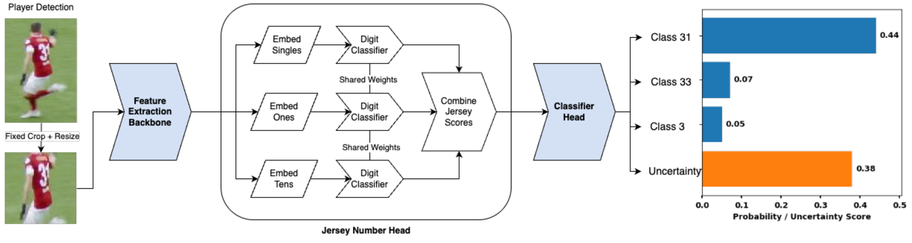
To address these issues, we leverage and contribute to several large-scale datasets:

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	Image*
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.



Ablation Studies on SoccerNet Test Set

Head Type	Acc Total (%)		Acc Visible (%)		Acc Not-Visible (%)	
	Softmax	Dirichlet (Δ)	Softmax	Dirichlet (Δ)	Softmax	Dirichlet (Δ)
Digit-Aware (DA)	80.15 ± 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)	72.49 ± 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)

SoccerNet Challenge Results

Method	Test Acc (%)	Challenge Acc (%)
Gerke et al. (2015)	32.57	35.79
Vats et al. (2021)	46.73	49.88
Li et al. (2018)	47.85	50.60
Vats et al. (2022)	52.91	58.45
Balaji et al. (2023)	68.53	73.77
Koshkina et al. (2024)	87.45	79.31
Ours (ViT-S, SoccerNet)	82.74	-
Ours (ViT-B, SoccerNet)	86.37	83.52
Ours (ViT-B, 200M)	85.46	**85.62**
Ours (ViT-B, SN-finetuned)	**88.27**	85.41