PitcherNet: Powering the Moneyball Evolution in Baseball Video Analytics

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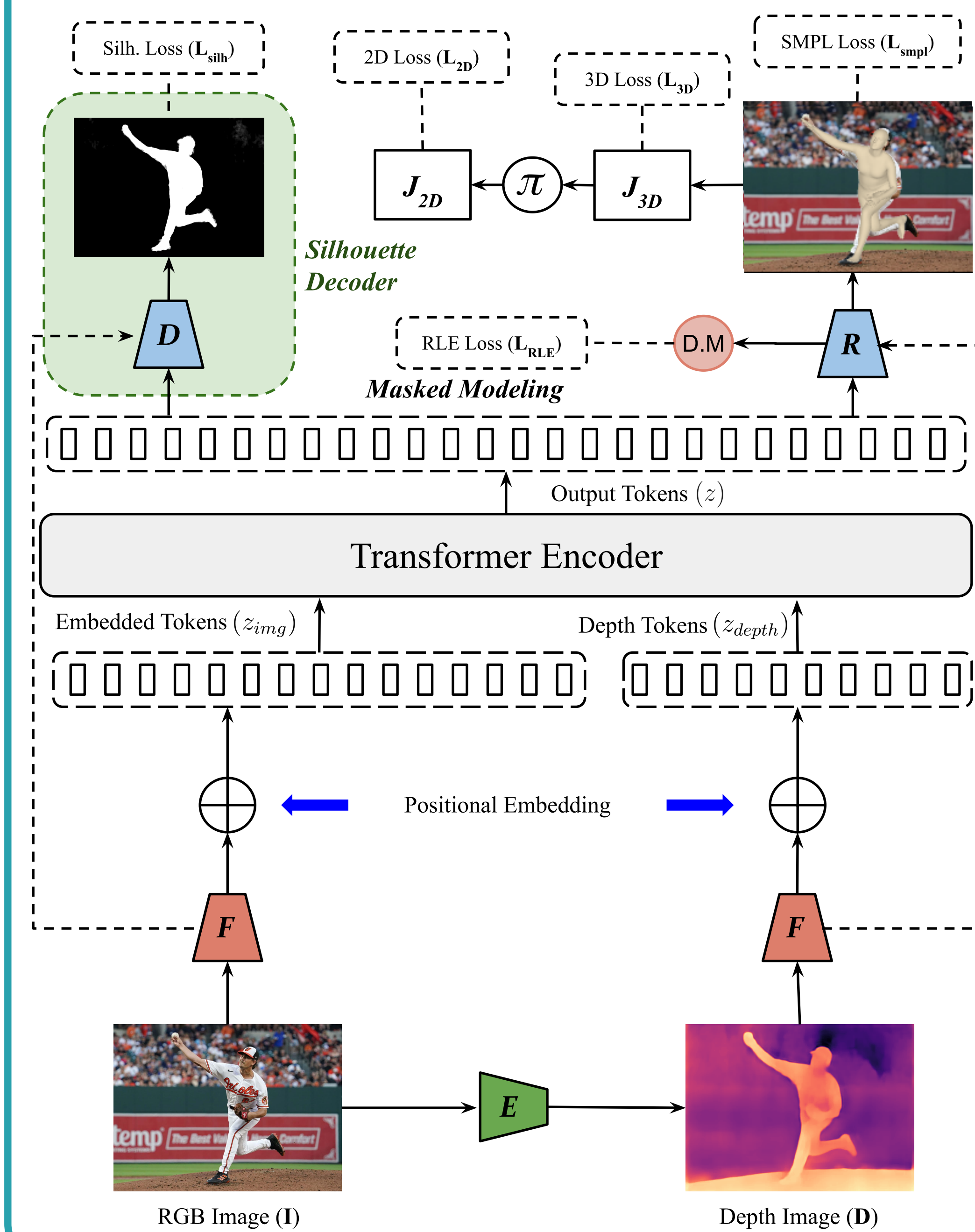
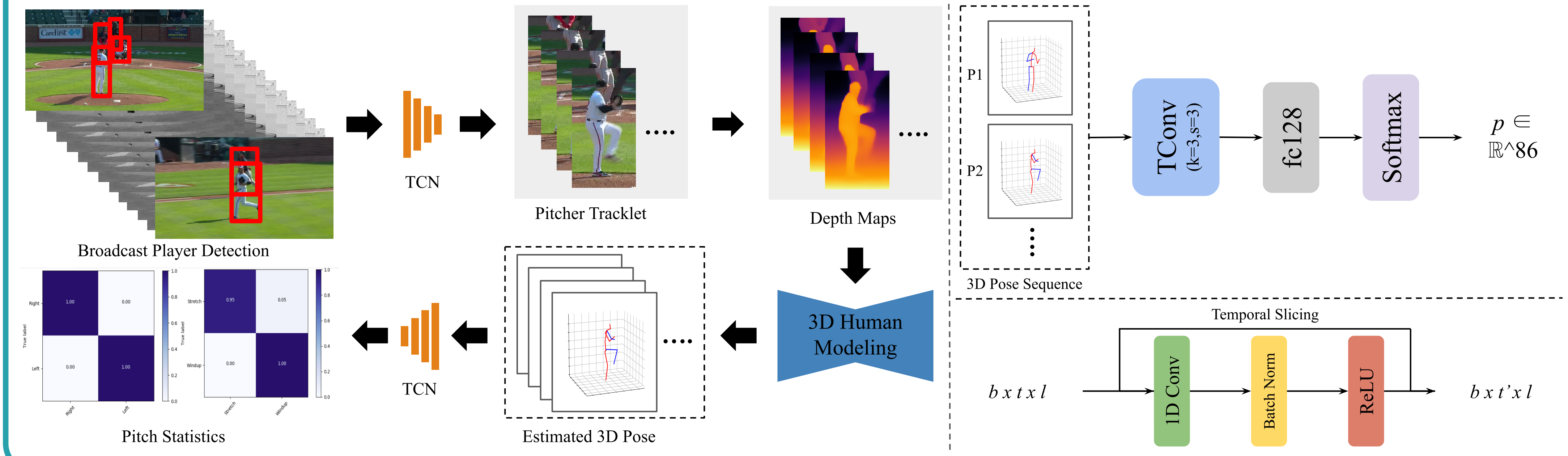**CVPR** JUNE 17-21, 2024 · SEATTLE, WA

Key Contributions

- ❖ PitcherNet- A novel automated system, which enables accurate prediction of baseball pitch statistics from low-quality broadcast videos.
- ❖ Role classification network which aims in classifying players by decoupling actions from player kinematics.
- ❖ D2A-HMR 2.0- A robust generalizable 3D human modeling approach with ability to handle motion blur.
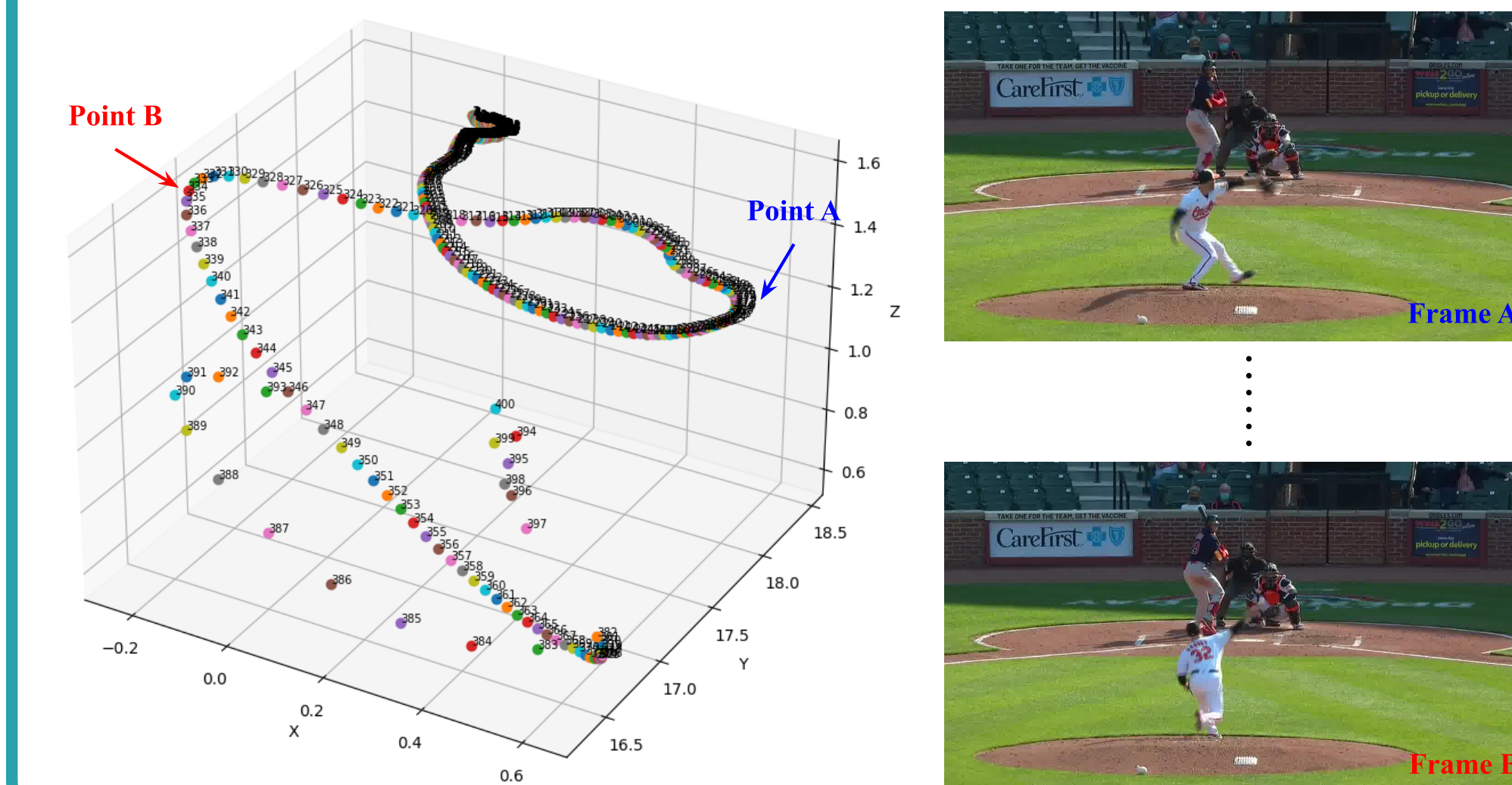
3D Human Modeling

Methodology

We introduce PitcherNet, a pioneering deep learning system that tackles low-resolution video limitations through efficient 3D human modeling for robust player alignment and reliable pitch statistics analysis from estimated kinematic data.

Pitch Statistics

Trajectory of the right wrist joint in 3D space:

Pitch Position (PP):
$$PP(windup, set) = \sigma(TCN(X)), \text{where } X \in R^{100 \times 18 \times 3} \quad (1)$$

Release Point (P_{rel}):
$$P_{rel} = argmax(v(i)|i \in [P_b - n/2, P_b + n/2]) \quad (2)$$

Pitch velocity (v_p):
$$v_p = \omega \times l = \{(atan(w_y^r, w_x^r) - atan(w_y^{r-1}, w_x^{r-1})) \times T\} \times l \quad (3)$$

Release Extension (E_{rel}):
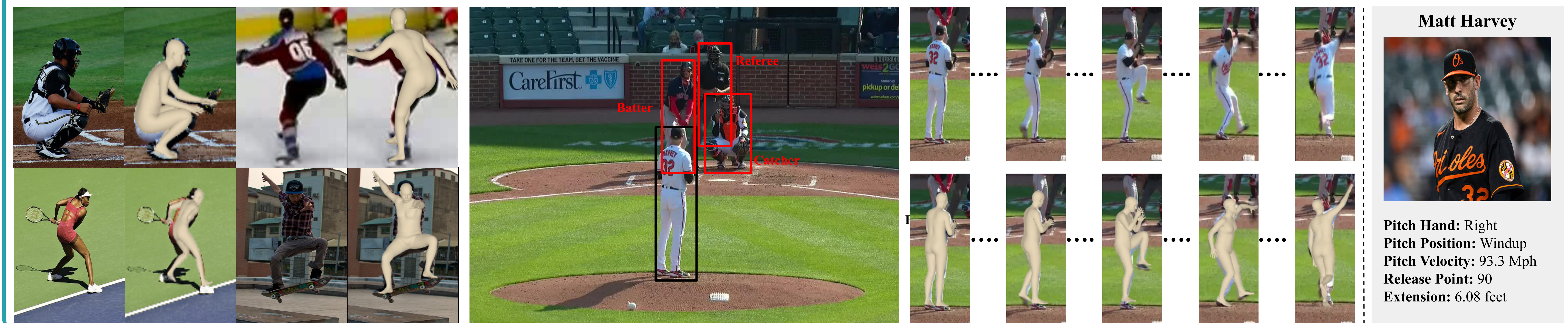$$E_{rel} = \sqrt{(w_x - a_x)^2 + (w_y - a_y)^2 + (w_z - a_z)^2} \quad (4)$$

Loss Functions

Overall objective function for the 3D model:
$$\mathcal{L}_{model} = \lambda_{RLE}\mathcal{L}_{RLE} + \lambda_{SMPL}\mathcal{L}_{SMPL} + \lambda_{2D}\mathcal{L}_{2D} + \lambda_{silh}\mathcal{L}_{silh} + \lambda_{3D}^r\mathcal{L}_{3D} \quad (5)$$

Objective function for the TCN model:
$$L(p_t) = -\sum_{t=1}^{t=N} \alpha_t * (1 - p_t)^\gamma * \log_b(p_t) \quad (6)$$

Quantitative Results

❖ 3D Human modeling

Method	Human3.6M		3DPW	
	mPJPE	PA-mPJPE	mPJPE	PA-mPJPE
HMMR	-	58.1	116.5	72.6
TCMR	62.3	41.1	95.0	55.8
VIBE	65.6	41.4	93.5	56.5
SPIN	62.5	41.1	96.9	59.2
PyMAF	57.7	40.5	92.8	58.9
ROMP	-	-	105.6	53.5
HMR-EFT	63.2	43.8	85.1	52.2
PARE	76.8	50.6	82.0	50.9
ProHMR	-	41.2	95.1	59.5
Pose2Mesh	64.9	47.0	89.2	58.9
METRO	54.0	36.7	77.1	47.9
Ours	53.2	35.9	78.7	46.9

❖ Handedness and Pitch Position Prediction

Method	Handedness			Pitch Position		
	$A \uparrow$	$F1 \uparrow$	$Prec. \uparrow$	$A \uparrow$	$F1 \uparrow$	$Prec. \uparrow$
LSTM	85.0	85.7	90.0	81.3	82.5	85.0
Ours	100.0	100.0	100.0	97.5	97.4	95.0

❖ Release Point and Pitch Velocity Prediction

Method	Release Point			Pitch Velocity		
	$A_1 \uparrow$	$A_2 \uparrow$	$A_5 \uparrow$	$A_{1\%} \uparrow$	$A_{2\%} \uparrow$	$A_{5\%} \uparrow$
LSTM	31.3	46.4	63.5	5.1	13.1	22.2
TCN	43.4	51.5	77.6	10.1	18.1	48.4
Ours	80.8	85.8	97.9	43.4	68.6	94.9

❖ Release Extension Prediction

	$A_{5\%} \uparrow$	$A_{8\%} \uparrow$	$A_{10\%} \uparrow$
LSTM	4.0	7.1	11.1
TCN	14.1	19.1	25.2
Ours	24.2	31.3	37.3

Qualitative Results

Matt Harvey

Pitch Hand: Right
Pitch Position: Windup
Pitch Velocity: 93.3 Mph
Release Point: 90
Extension: 6.08 feet