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HMD-Poser: On-Device Real-time Human Motion Tracking from Scalable Sparse Observations

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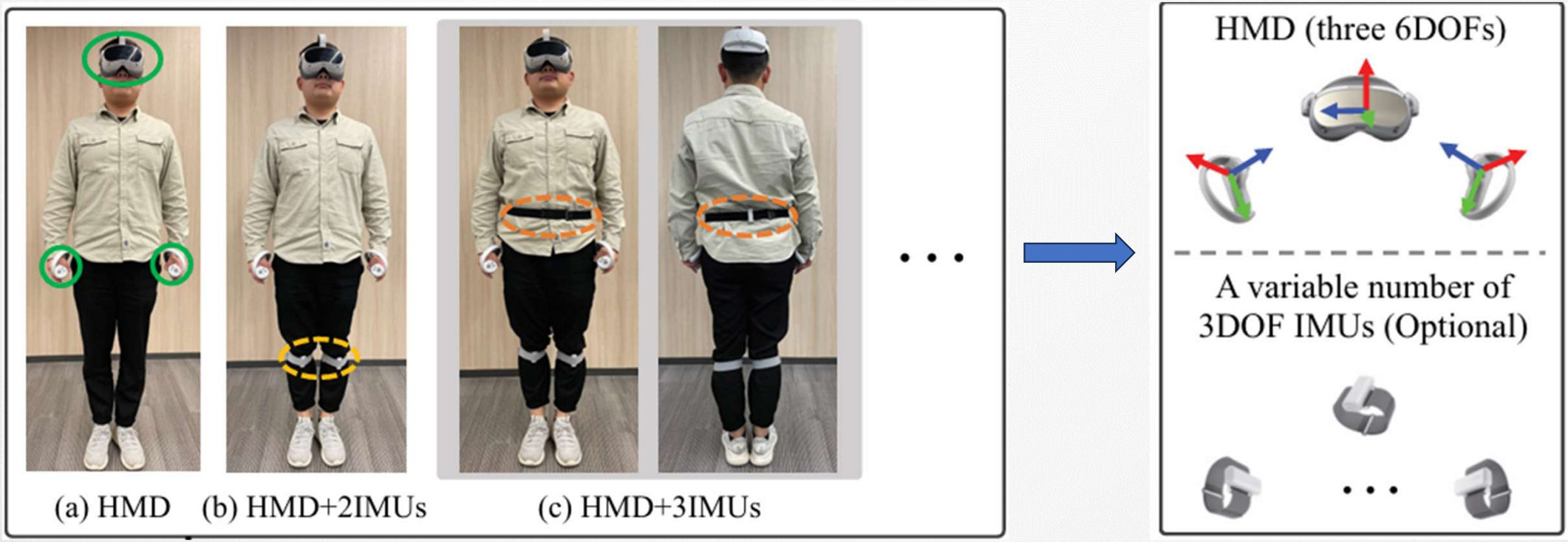
Introduction

Sparse Observations

Motion Tracking

Virtual Avatar

Introduction



Scalable Sparse Observations

Introduction

For only HMD(including hand controllers):

When estimating the user’ s lower-body motions, is inherently an **under-constrained problem** with such sparse tracking signals.

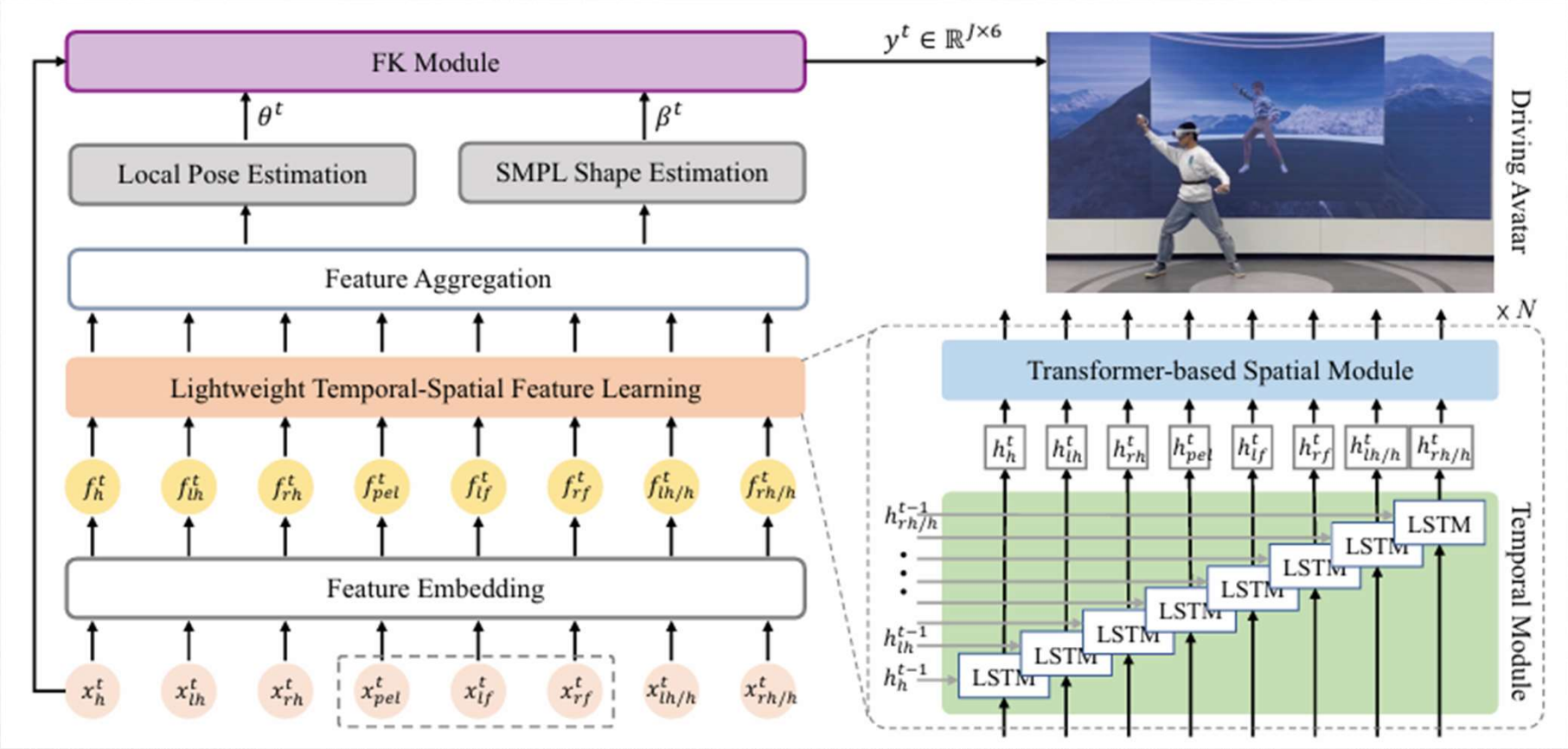
For IMU sensors:

Prone to **positional drift** due to the **inevitable accumulation errors** of IMU sensors

Introduction

Driving an Avatar on HMD in Real-time

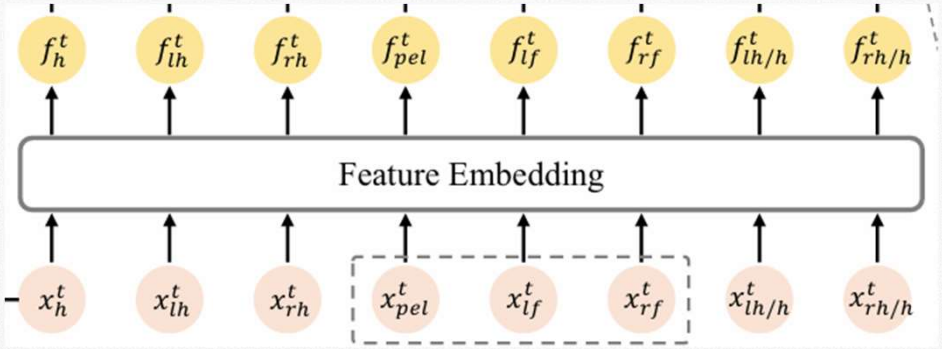
Method



Overview of HMD-Poser

Method

Feature Embedding Module



Input :

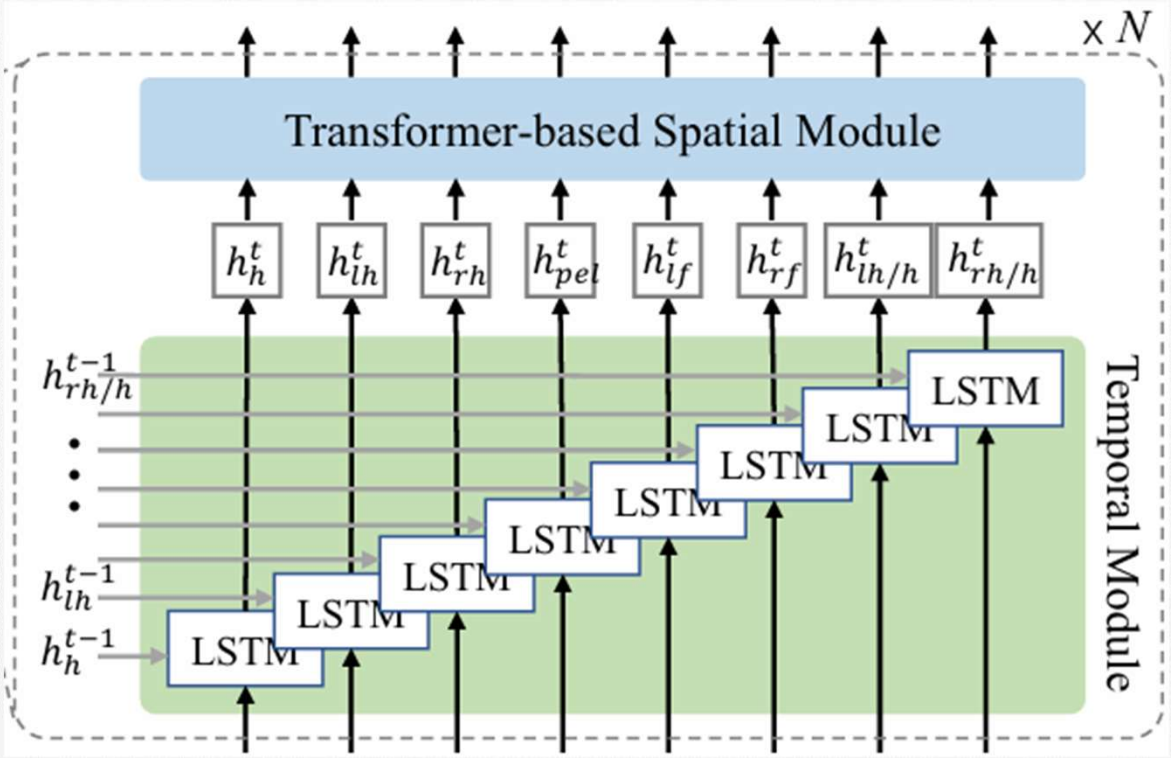
Use a concatenated vector of position, linear velocity, rotation, and angular velocity to obtain the representation for the **head** x_h^t, the **left hand** x_{lh}^t, and the **right hand** x_{rh}^t .

adopt a concatenated vector of rotation, angular velocity, and acceleration to obtain the representation for the **pelvis** x_{pel}^t, the **left leg** x_{lf}^t, and the **right leg** x_{rf}^t.

$$x^t = [x_h^t, x_{lh}^t, x_{rh}^t, x_{pel}^t, x_{lf}^t, x_{rf}^t, x_{lh/h}^t, x_{rh/h}^t]$$

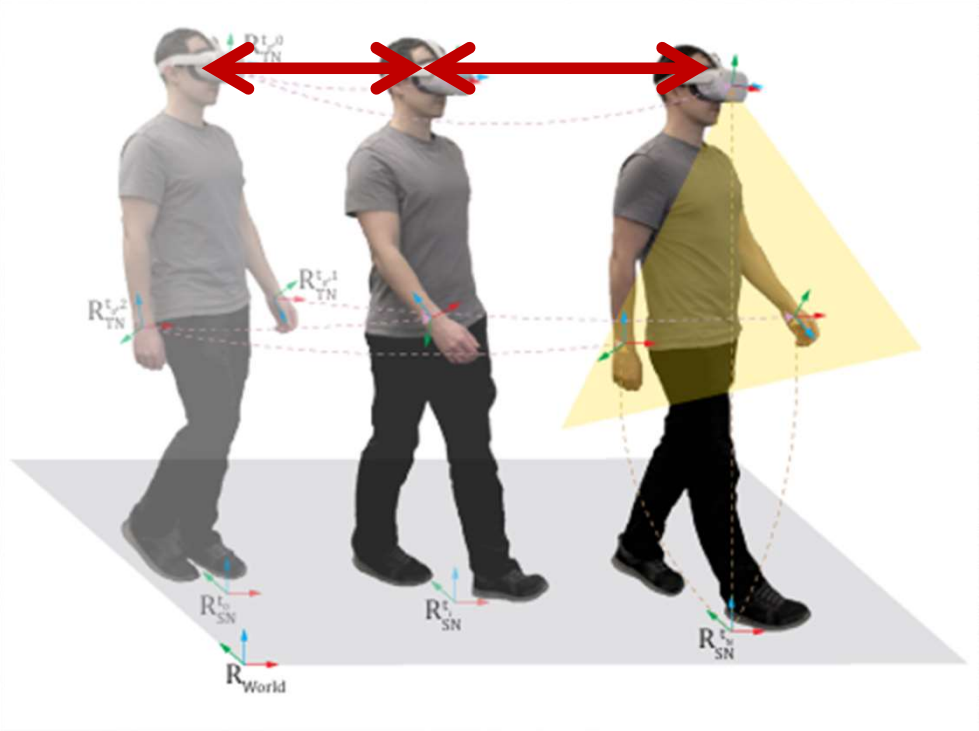
Method

lightweight temporal-spatial feature learning (TSFL) network

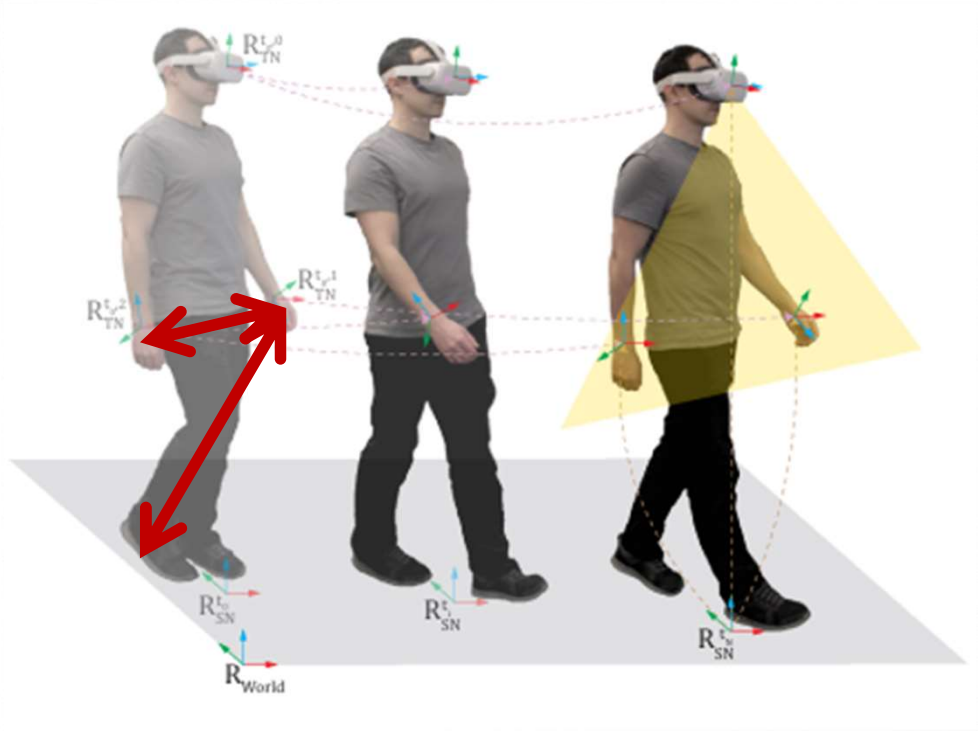


Method

temporal correlation

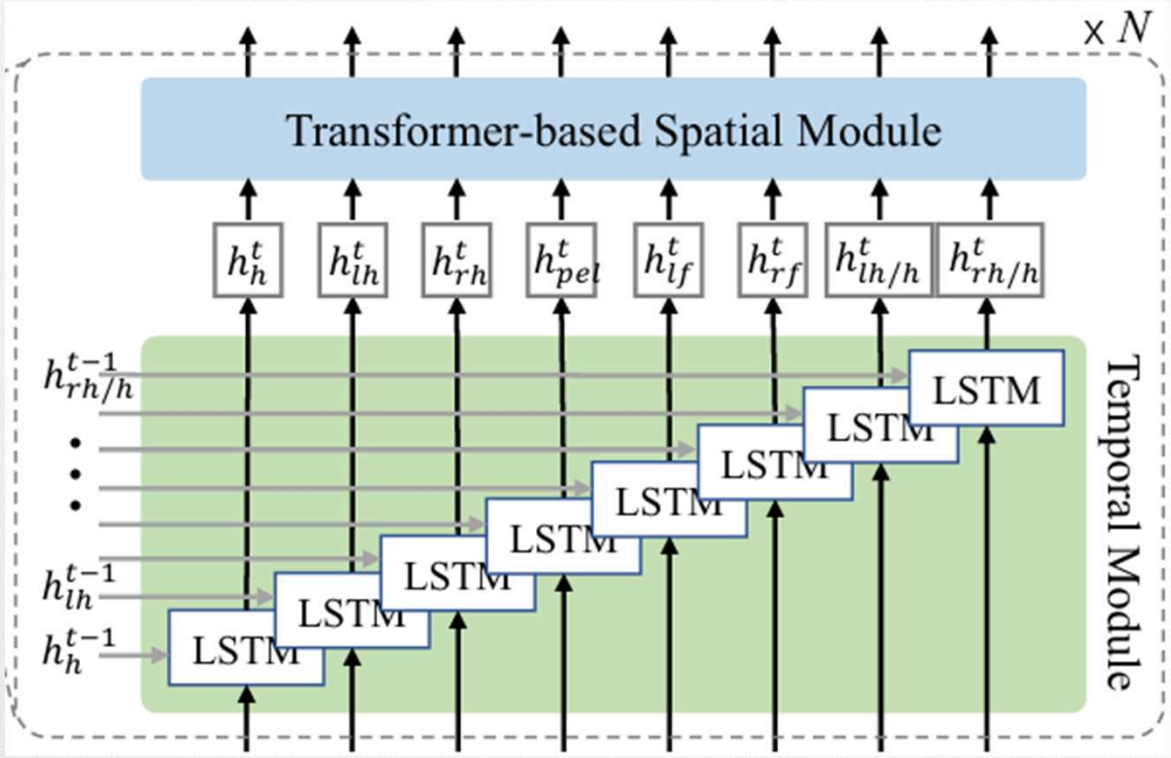


spatial correlation



Method

lightweight temporal-spatial feature learning (TSFL) network



LSTM: learn temporal correlation

Transformer: learn spatial correlation

Time Complexity

Only Transformer : $o(M^2d + Md^2)$

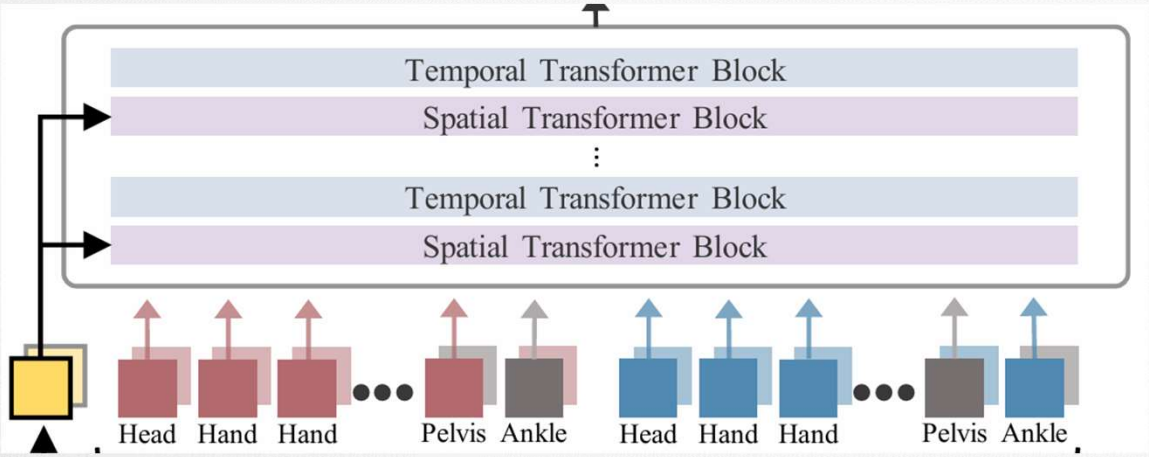
TSFL: $o(d^2)$

M :sequence of length

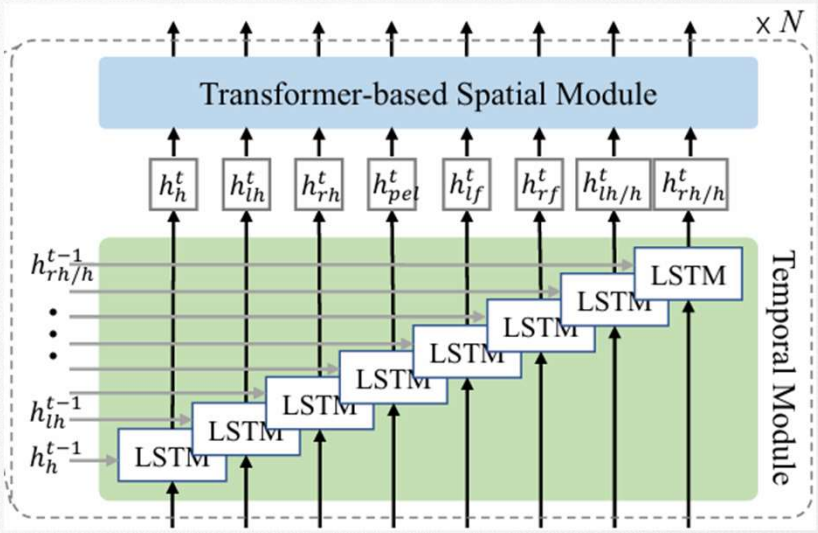
d :dimension of the hidden state

Method

Only Transformer : $o(M^2d + Md^2)$

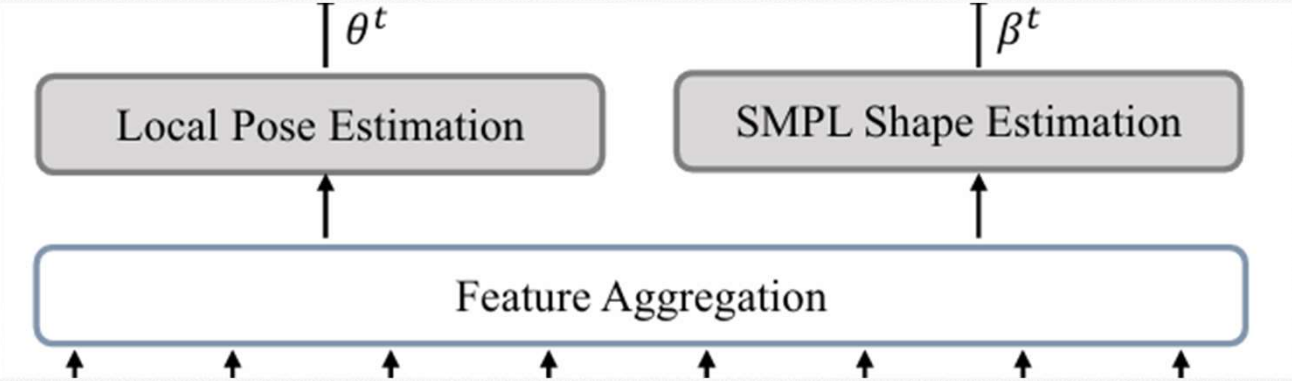


TSFL: $o(d^2)$



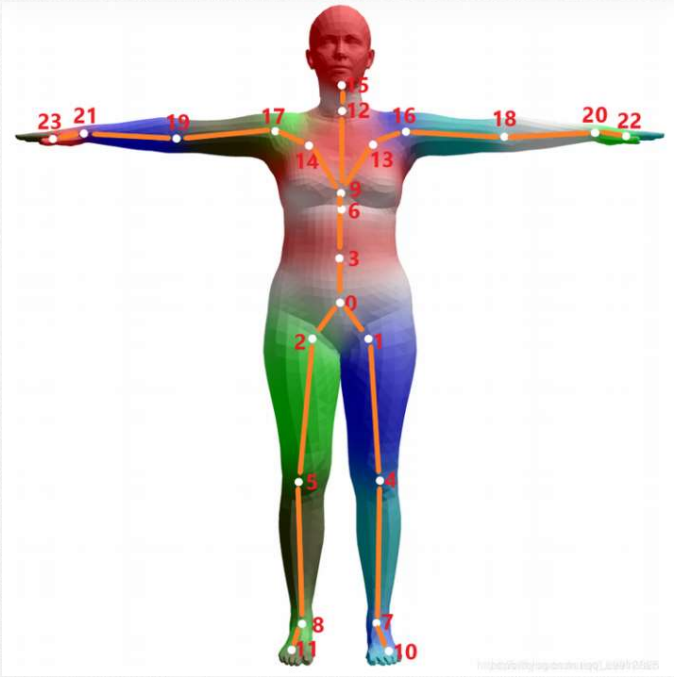
Method

regress the local pose parameters θ and the shape parameters β

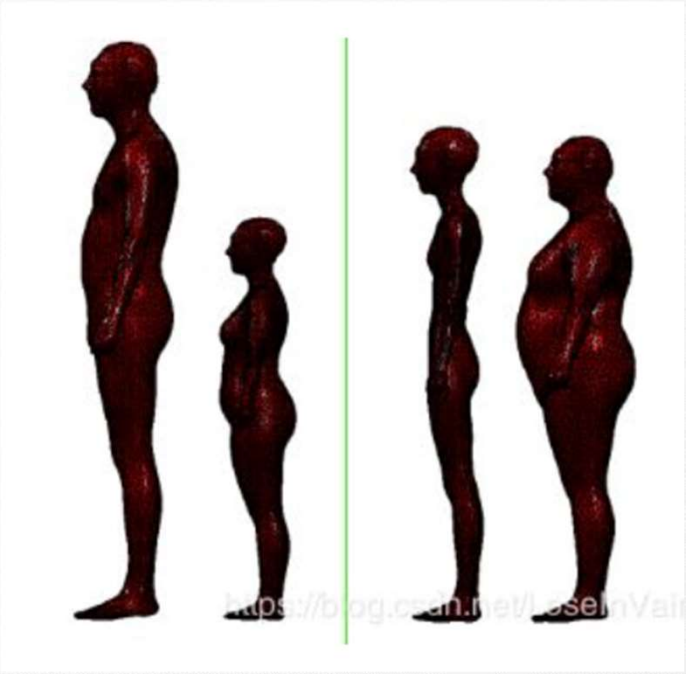


Method

pose parameters θ



shape parameters β



Skinned Multi-Person Linear (SMPL) Model
参数化人体蒙皮模型

Method

Loss Design

Overall Loss : $L = \alpha_{ori}L_{ori} + \alpha_{lrot}L_{lrot} + \alpha_{grot}L_{grot} + \alpha_{joint}L_{joint} + \alpha_{smooth}L_{smooth}$

Where $L_{ori}, L_{lrot}, L_{grot}, L_{joint} and L_{smooth}$ are root orientation loss, local pose loss, global pose loss, joint position loss and joint position loss

set α_{ori}, α_{lrot}, α_{grot}, α_{joint} and α_{smooth} to 1.0 , 5.0 , 1.0 , 1.0 and 0.5, respectively

Smooth Loss : $L_{smooth} = \frac{1}{(T-2)\times(3J)} \sum_{t=1}^{T-1} \sum_{i=0}^{3J} \left| a_i^t - \hat{a}_i^t \right|_1$

Where a_i^t and $\hat{a}_i^t$ are the computed and the ground-truth acceleration at time t, respectively, and T is the sequential length in the training and J is the number of joints.

Experiments

Quantitative.

Method	MPJRE↓	MPJPE↓	MPJVE↓	Jitter↓	H-PE↓	U-PE↓	L-PE↓	R-PE↓
AvatarPoser [16]	2.94	5.84	26.60	13.97	4.58	3.24	9.59	5.05
AGRoL [9]	2.70	5.73	19.08	7.65	4.29	3.16	9.44	5.15
AvatarJLM [59]	2.81	5.03	20.91	6.94	2.01	3.00	7.96	4.58
Transpose [50]	3.05	4.57	22.41	7.98	3.83	3.05	6.76	4.62
PIP [51]	2.45	4.54	19.02	8.13	4.54	3.15	6.53	4.54
HMD-Poser: HMD	2.28	3.19	17.47	6.07	1.65	1.67	5.40	3.02
HMD-Poser: HMD+2IMUs	1.83	2.27	13.28	5.96	1.39	1.51	3.35	2.74
HMD-Poser: HMD+3IMUs	**1.73**	**1.89**	**11.03**	**5.35**	**1.27**	**1.46**	**2.46**	**2.37**

Experiments

Quantitative.

Method	MPJRE↓	MPJPE↓	MPJVE↓	Jitter↓	H-PE↓	U-PE↓	L-PE↓	R-PE↓
AvatarPoser [16]	4.68	6.62	33.16	10.79	3.93	2.97	11.89	5.30
AGRoL [9]	4.38	6.74	24.14	6.33	3.53	3.02	12.11	5.86
AvatarJLM [59]	4.45	5.96	27.50	6.91	2.30	2.97	10.28	5.22
Transpose [50]	4.31	5.29	28.18	5.16	7.38	3.86	7.36	4.80
PIP [51]	3.61	4.16	22.22	6.89	4.28	2.97	5.89	4.30
HMD-Poser: HMD	4.27	5.44	30.15	5.62	2.56	2.44	9.77	4.83
HMD-Poser: HMD+2IMUs	3.66	3.68	20.29	6.22	**1.65**	**2.14**	5.92	4.51
HMD-Poser: HMD+3IMUs	**3.49**	**3.13**	**16.17**	**4.93**	1.81	2.17	**4.51**	**3.88**

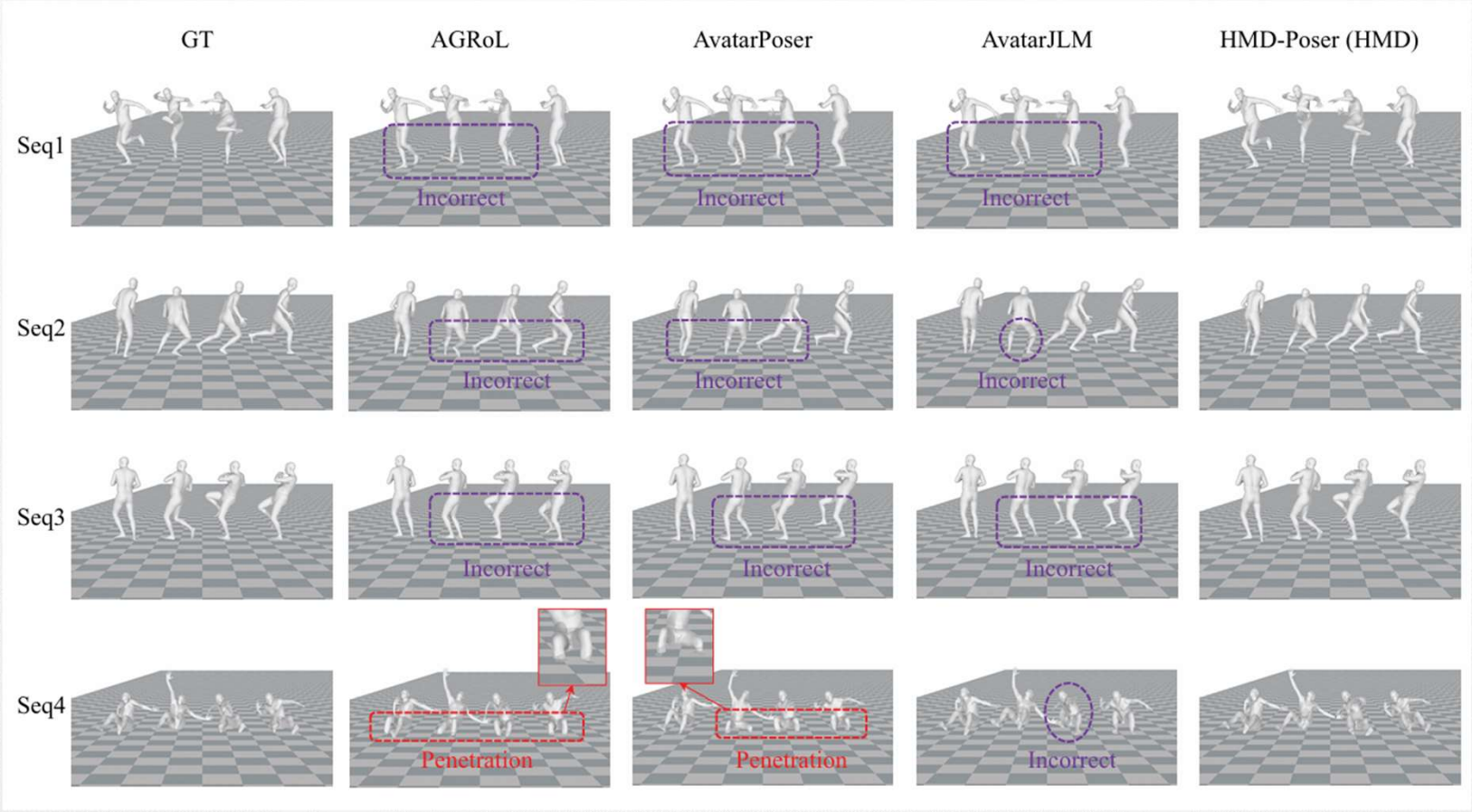
Experiments

Quantitative.

Method	FPS (GPU)↑	FPS (HMD)↑
AvatarPoser [16]	114.1	-
AGRoL [9]	60.8	-
AvatarJLM [59]	1.9	-
Transpose [50]	123.0	-
PIP [51]	62.5	-
HMD-Poser (Ours)	**205.7**	**90.0**

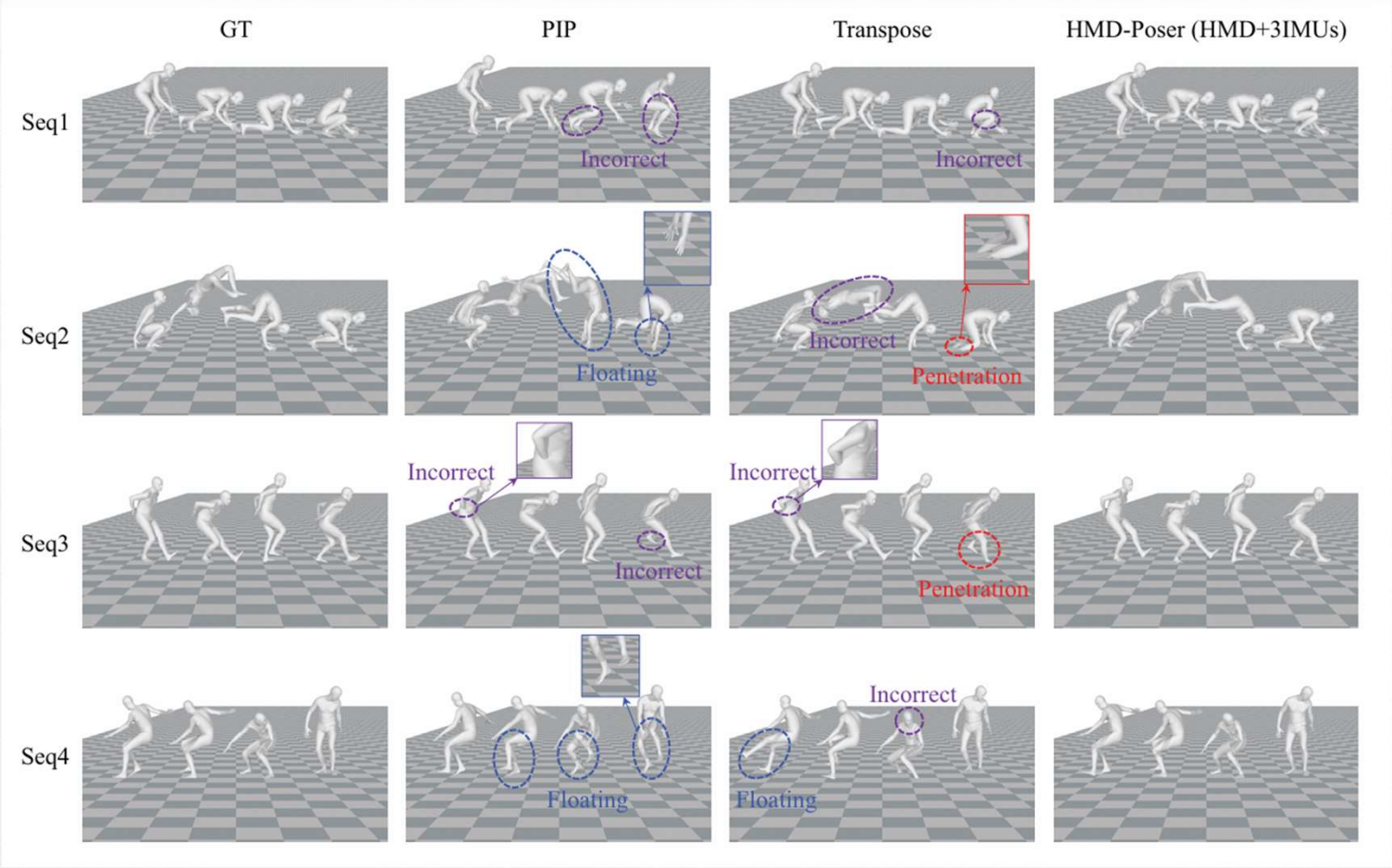
Experiments

Qualitative



Experiments

Qualitative



Experiments

Ablation Study

Method	MPJRE	MPJPE	H-PE	Jitter
w/o $\{x^t_{lh/h}, x^t_{rh/h}\}$	2.45	3.43	2.36	6.25
with $\{x^t_{lh/h}, x^t_{rh/h}\}$	**2.28**	**3.19**	**1.65**	**6.07**

Table 3. Evaluating the effect of adding hand representations relative to the head coordinate frame to input representation.

Method	MPJRE	MPJPE	H-PE	Jitter
w/o ShapeHead	2.32	5.08	4.25	6.11
with ShapeHead	**2.28**	**3.19**	**1.65**	**6.07**

Table 4. Evaluating the effect of the shape regression head. The default shape is used when there is no shape regression head.

Thank you for watching!