

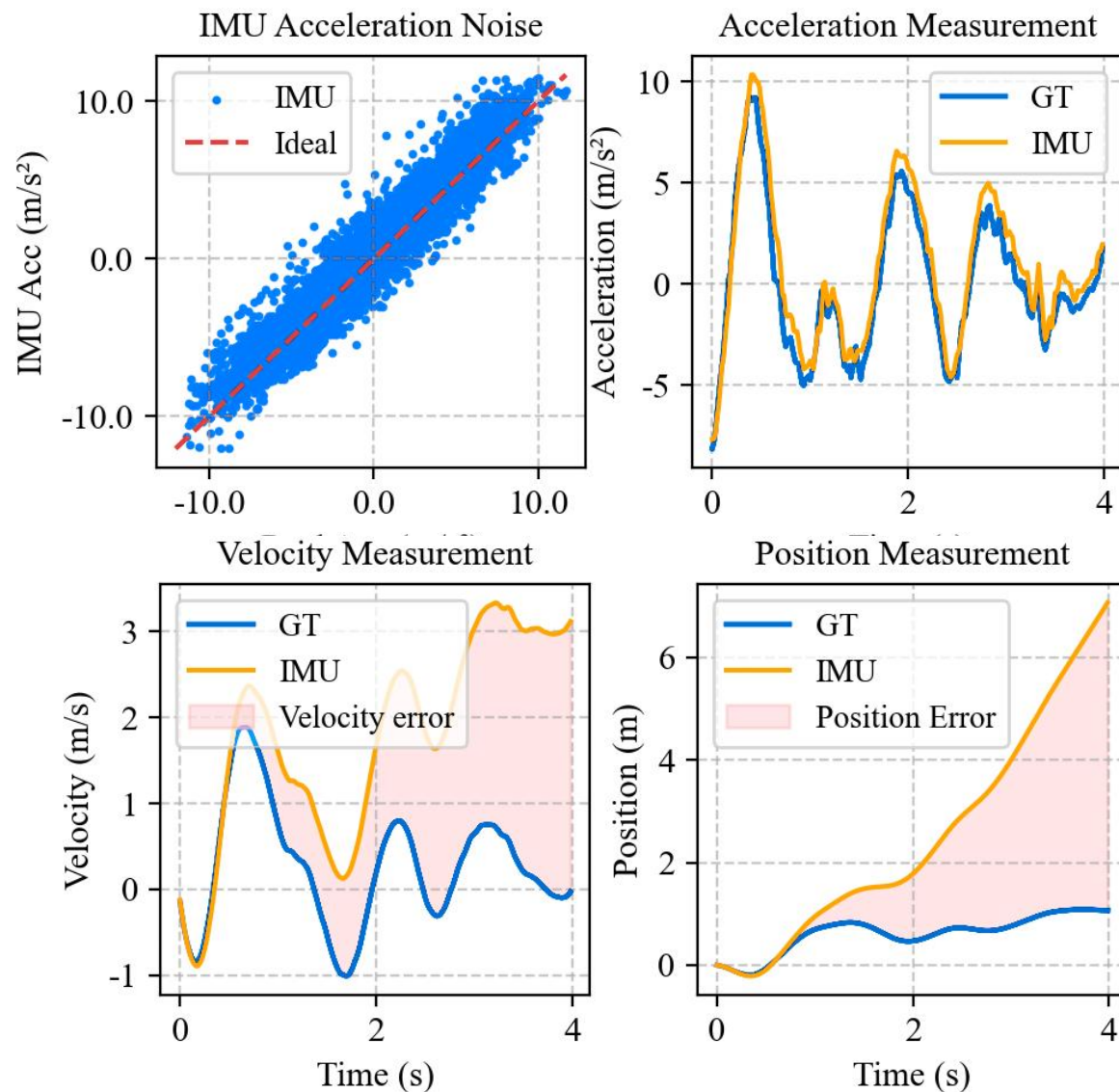
# ToF-IP: Time-of-Flight Enhanced Sparse Inertial Poser for Real-time Human Motion Capture

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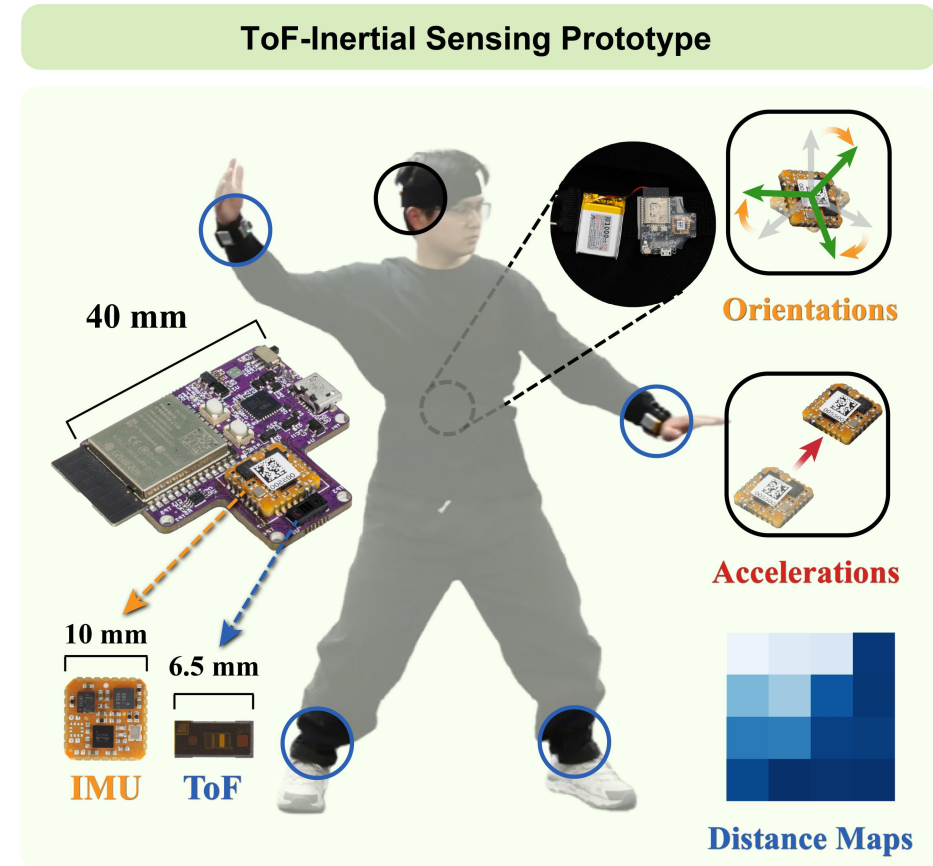
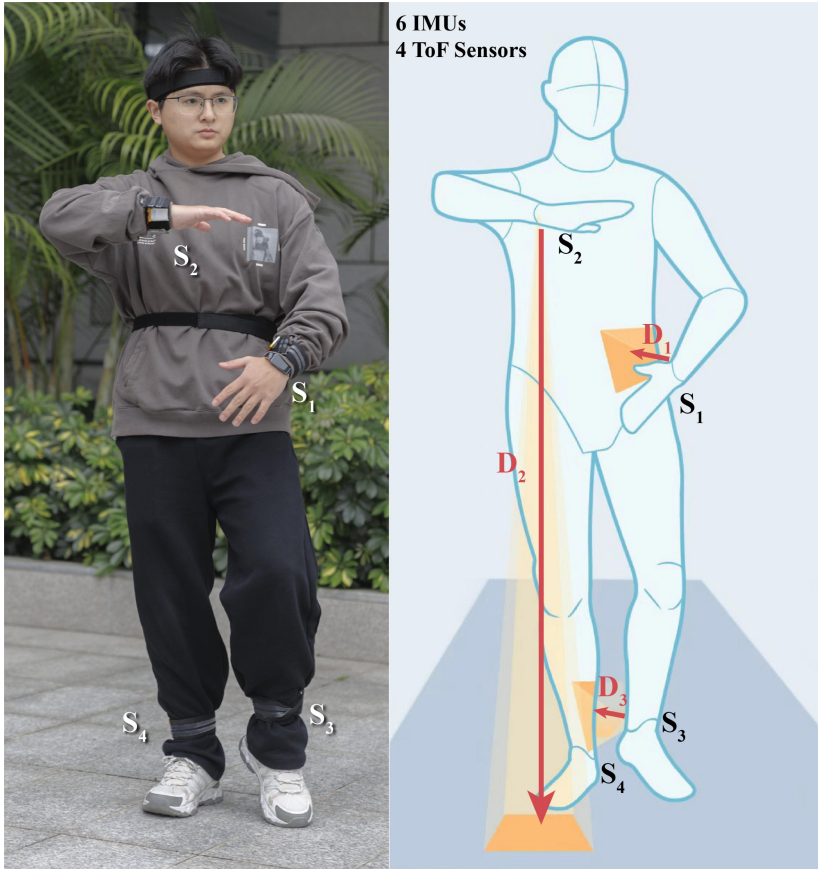
# Why is IMU-only motion capture inaccurate?



- ◆ **Limited Observability:**  
Lack of direct position measurement
- ◆ **Low-SNR in Slow Motions:**  
Noise dominates signals during slow movements
- ◆ **Double Integration Drift:**  
Positions come from double integration of acceleration



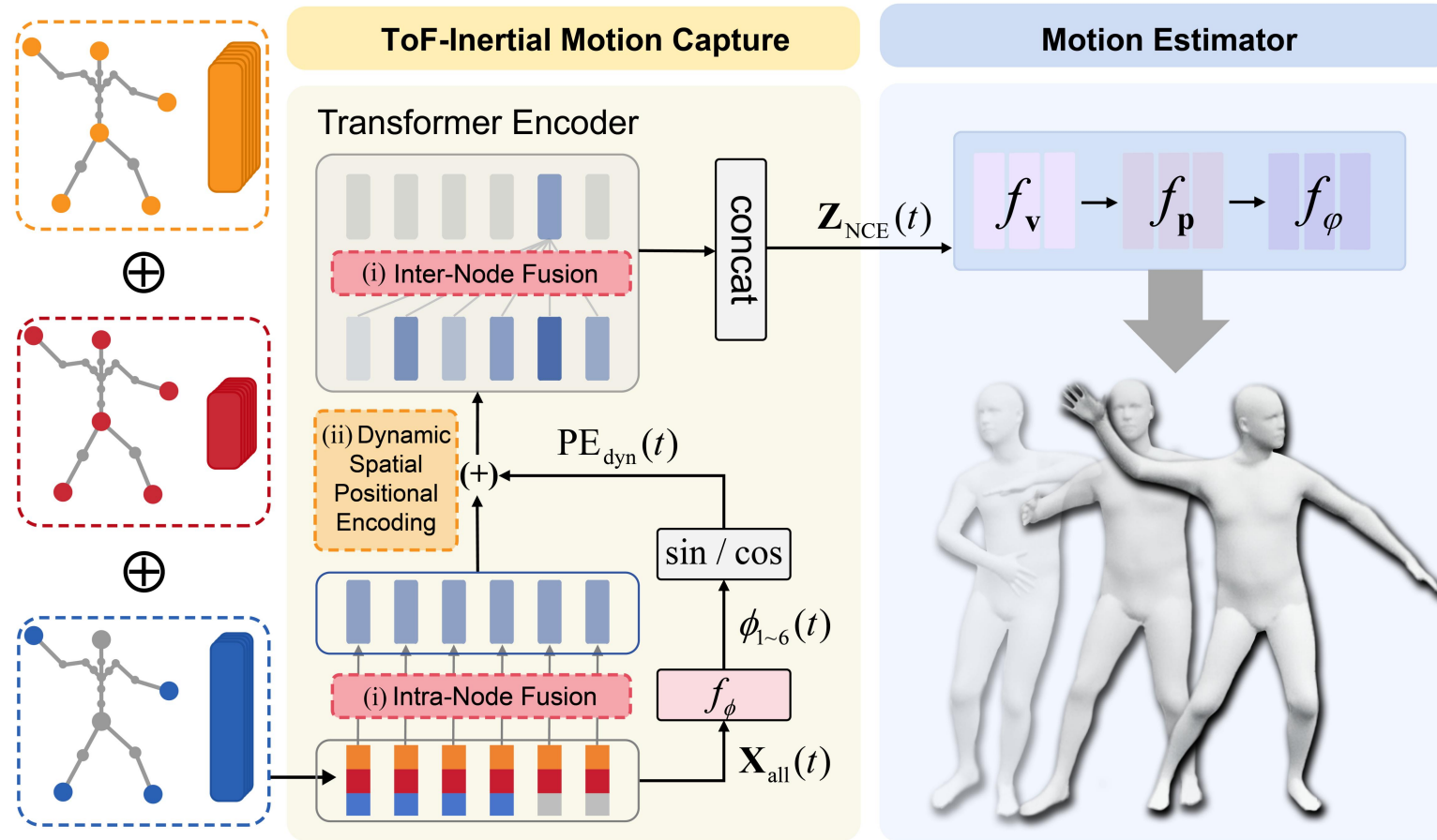
# Hardware in one slide



## Contribution 1:

We design an in-situ enhanced **bimodal wearable sensing platform** for 3D full-body tracking, retaining the conventional layout of 6 sensing nodes. The platform allows for the flexible use of either single IMU sensing or **IMU+ToF bimodal sensing**, with only a **3% increase in volume**.

# Method overview

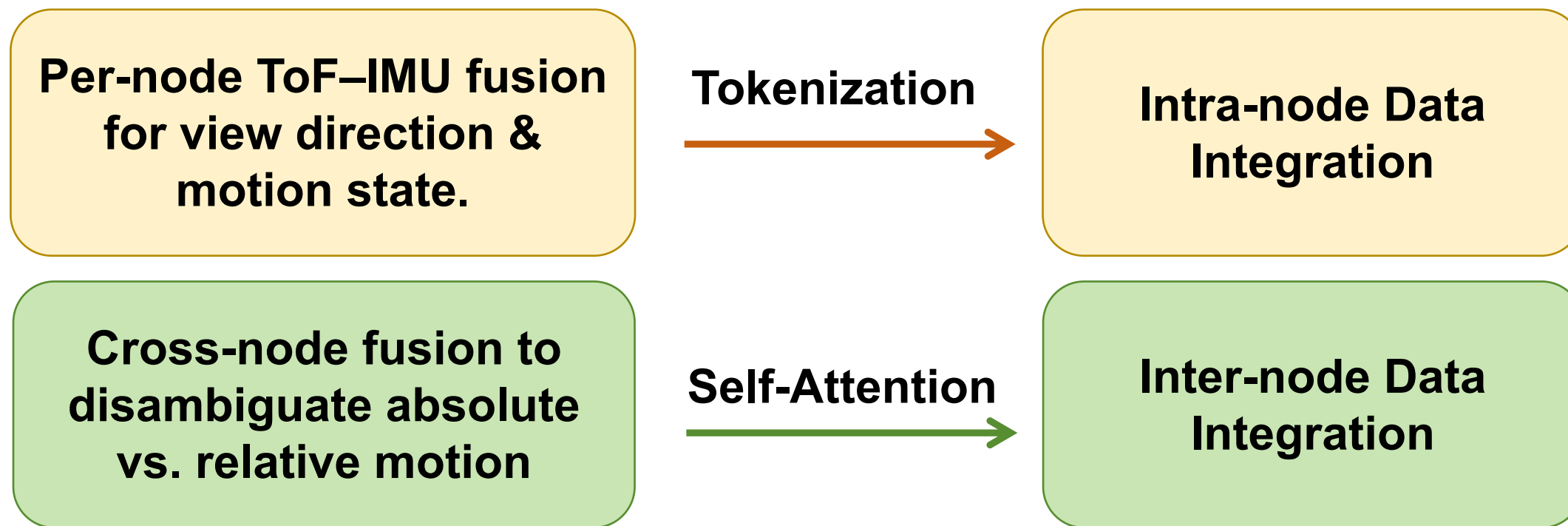


## Contribution 2:

We propose ToF-IP, a novel Transformer-based inertial-ToF motion capture framework that introduces two key innovations on the software side.

# Node-Centric Data Integration

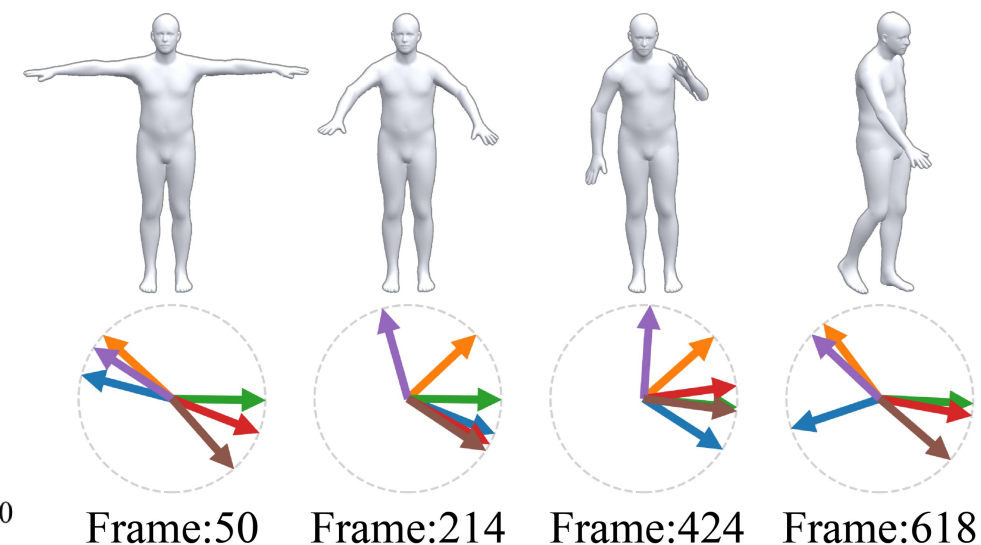
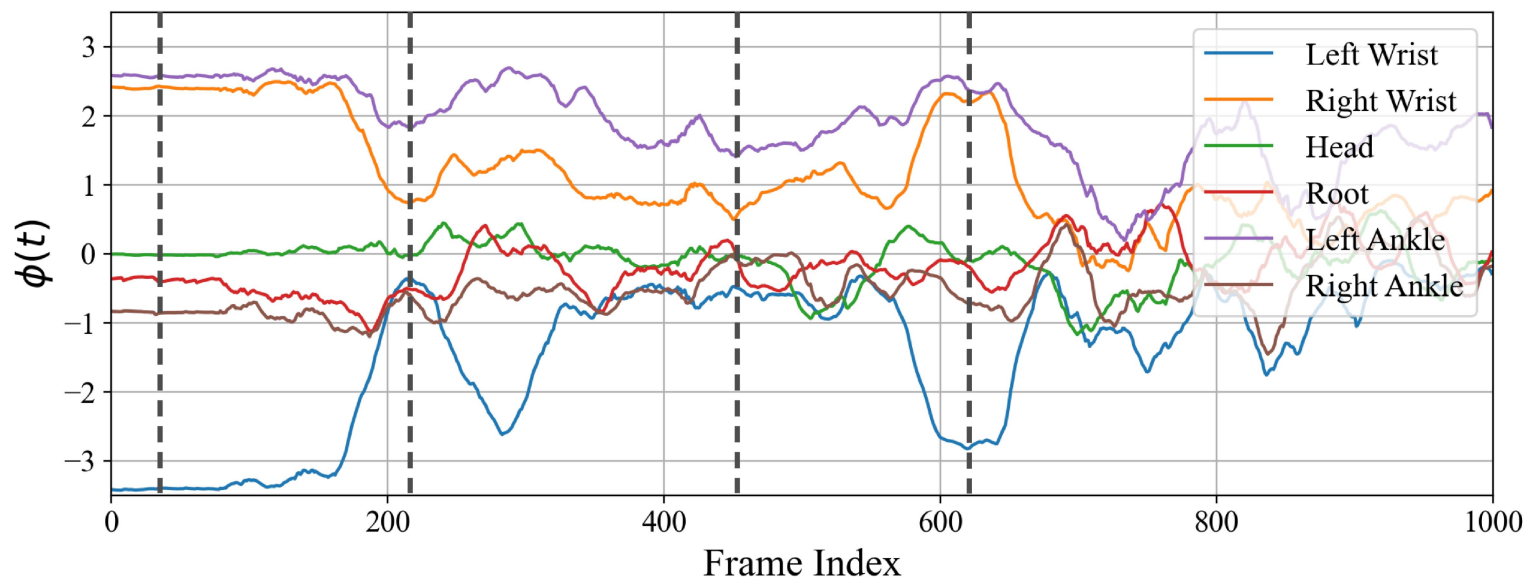
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## Contribution 2.1:

A Node-Centric Data Integration strategy that preserves the structural semantics of multi-sensor data by treating each sensing node as a token and hierarchically integrating intra- and inter-node information via self-attention

# Dynamic Spatial Positional Encoding



## Contribution 2.2:

A Dynamic Spatial Positional Encoding scheme that models the continuously evolving spatial positions of wearable nodes as motion-conditioned functions, enhancing spatial awareness and robustness to body movement variations.

# ToF-IP-DB: Synchronized IMU+ToF Dataset



## ToF-IP-DB:

- 208 minutes
- 749k frames
- 10 participants
- 20+ activities
- Tai Chi
- Baduanjin



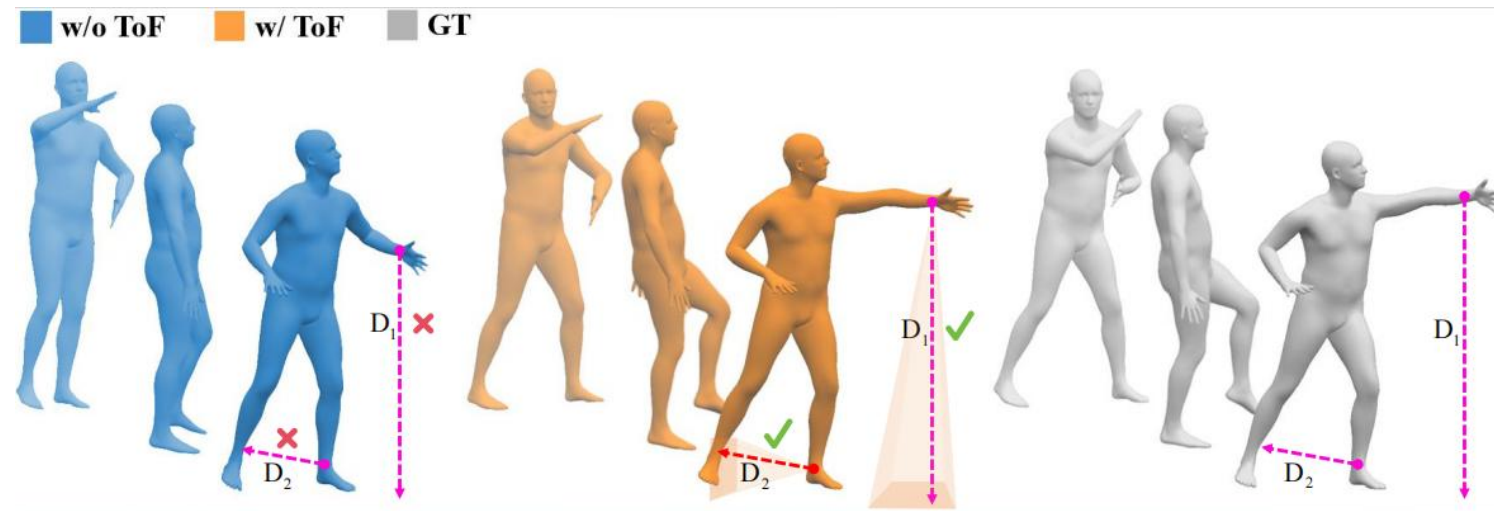
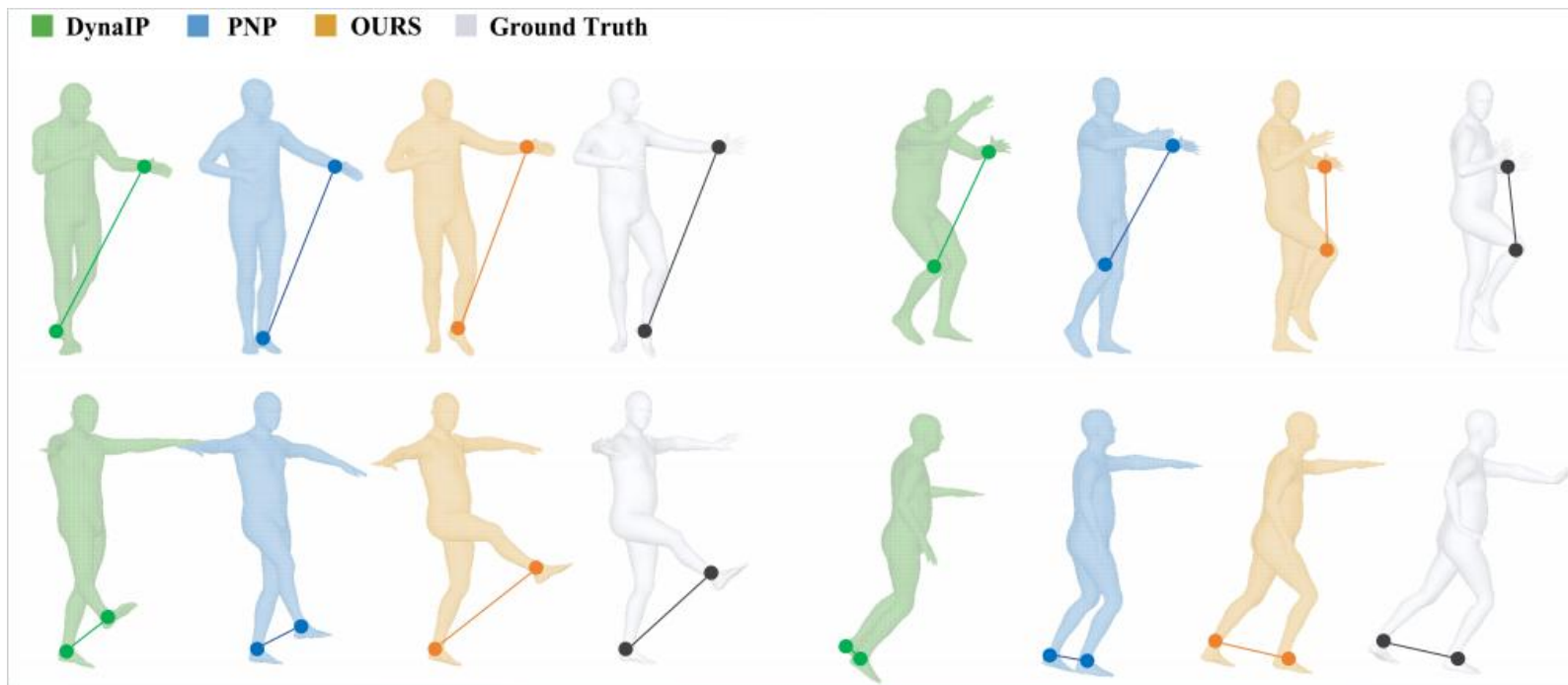
# Experimental Results

Method	ToF-IP-DB					DIP (with synthesis ToF)				
	SIP Err	Ang Err	Pos Err	EndPos Err	Jitter	SIP Err	Ang Err	Pos Err	EndPos Err	Jitter
Transpose	20.73	14.51	7.58	13.58	0.18	17.06	8.86	6.03	8.73	1.11
TIP	20.37	14.58	7.63	13.97	0.17	16.90	9.07	5.63	8.27	1.56
PIP	20.22	13.85	7.32	12.77	0.12	15.33	8.78	5.12	7.78	0.17
DynaIP	19.04	13.33	7.26	13.05	0.16	13.78	7.07	4.98	7.44	0.18
PNP	18.52	13.23	6.86	12.39	0.12	13.71	8.75	4.97	7.49	0.17
ToF-IP(Ours)	<b>17.26</b>	<b>12.09</b>	<b>6.31</b>	<b>11.41</b>	0.12	<b>13.62</b>	<b>6.75</b>	<b>4.59</b>	<b>6.65</b>	0.17

Case	ToF	NCI	ToF-IP-DB					DIP (with synthesis ToF)				
			SIP Err	Ang Err	Pos Err	EndPos Err	Jitter	SIP Err	Ang Err	Pos Err	EndPos Err	Jitter
1	×	×	18.87	13.14	6.88	12.27	0.07	16.34	7.64	5.80	8.49	0.13
2	✓	×	18.95	12.89	6.92	12.39	0.13	16.10	7.50	5.47	8.08	0.17
3	×	✓	17.90	13.18	6.81	12.06	0.13	15.52	7.30	5.30	7.79	0.17
4	✓	✓	<b>17.26</b>	<b>12.09</b>	<b>6.31</b>	<b>11.41</b>	0.12	<b>13.62</b>	<b>6.75</b>	<b>4.59</b>	<b>6.65</b>	0.17



# Experimental Results



# Thank You!

