MOTION CAPTURE OPTIMIZATION

Group: GFA23AI20, Project: FA23AI11

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Problem

How can we create animation:

- Manual keyframe before mocap
- Use predefined points with a green background
- Use suit with a lot of IMU sensor

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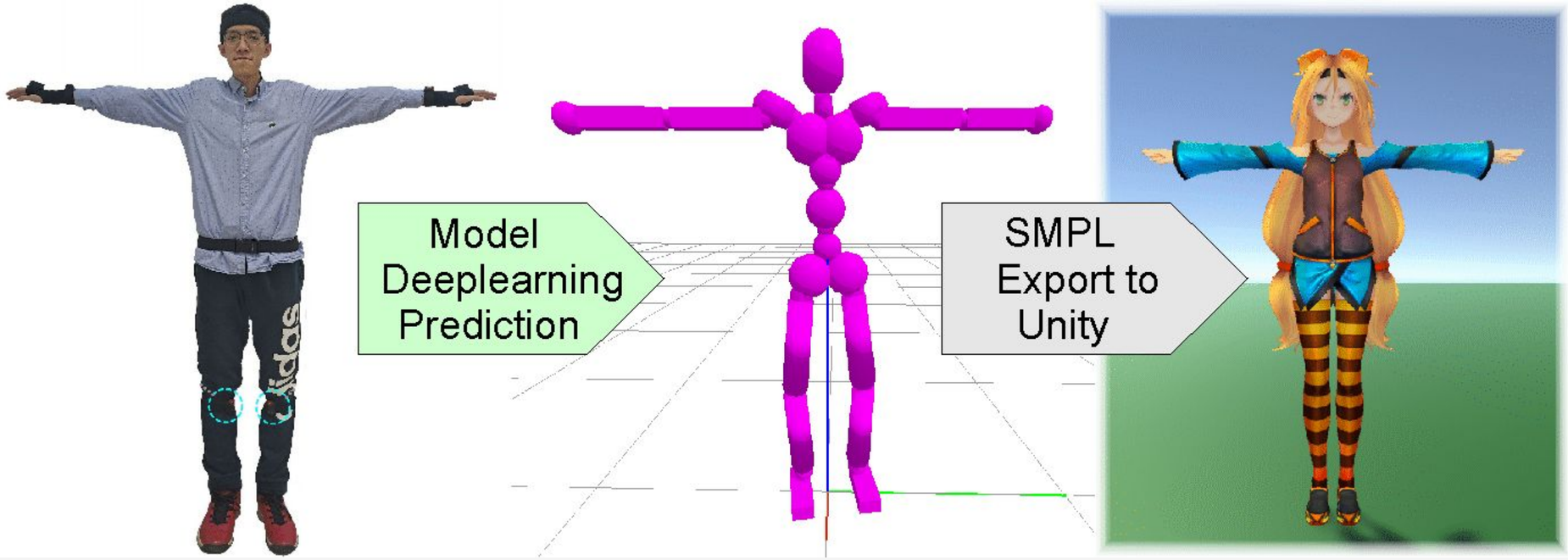
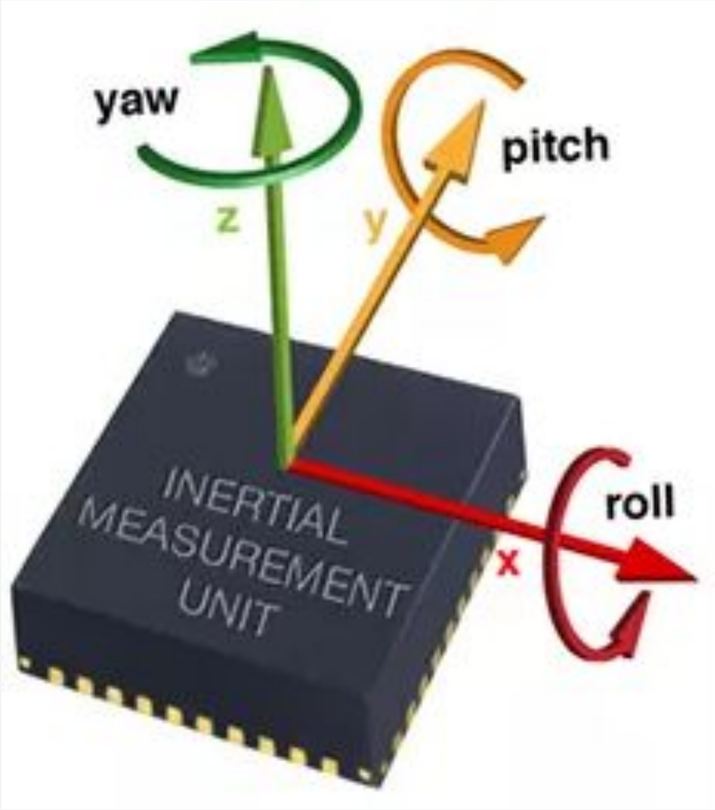
Introduction



Introduction

Data inputs from sensors

- Signals from a set of 6 IMU sensors.
- Response speed: 60 samples/s.
- Acceleration for X, Y, Z (14 bits resolution -8g to 8g)
- Quaternion with W, X, Y, Z (float value, interpolated inside the sensor).
- [{"id": 0, "acc": [X, Y, Z], "quat": [W, X, Y, Z]},
  {"id": 1, "acc": [X, Y, Z], "quat": [W, X, Y, Z]},
  {"id": 2, "acc": [X, Y, Z], "quat": [W, X, Y, Z]},
  {"id": 3, "acc": [X, Y, Z], "quat": [W, X, Y, Z]},
  {"id": 4, "acc": [X, Y, Z], "quat": [W, X, Y, Z]},
  {"id": 5, "acc": [X, Y, Z], "quat": [W, X, Y, Z]}]
- Kalman filter



Data inputs for model

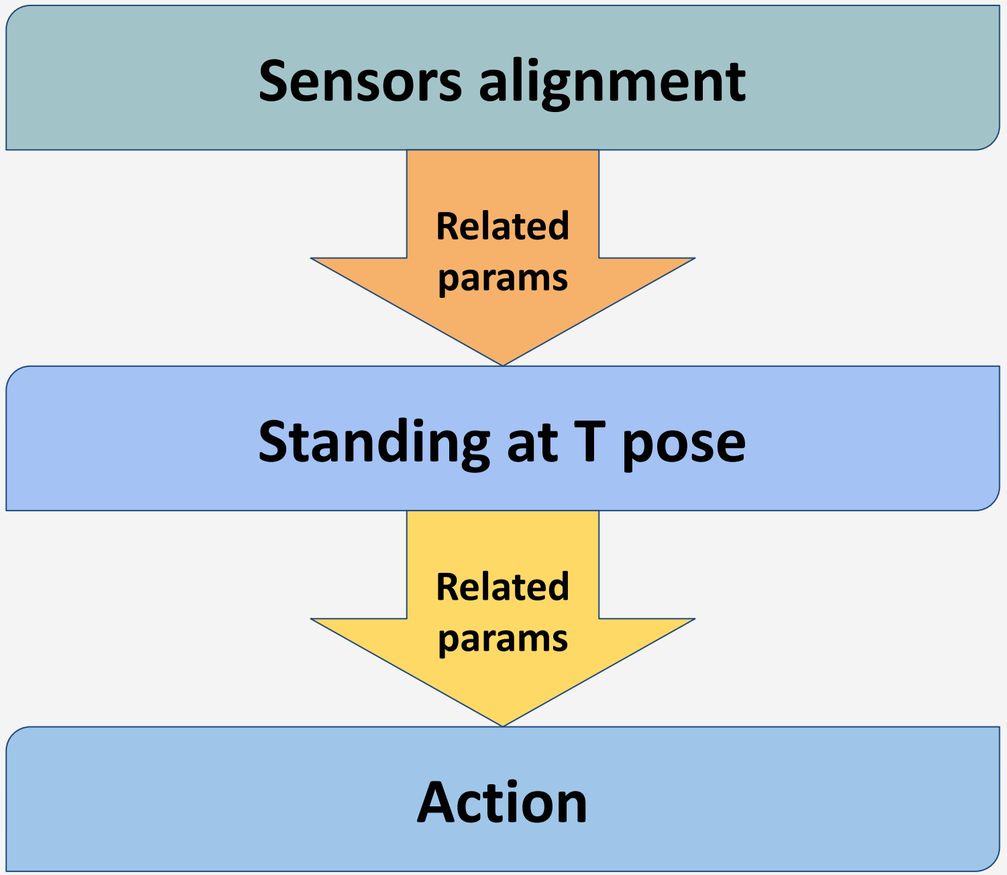
01	Acceleration values	Acceleration values
02	Quaternion values	Rotation matrix values

```
inputs = [
    R01, R02, ... R09,
    ...
    R51, R52, ... R59,
    X0, Y1, Z1,
    ...
    X5, Y5, Z5,
]
shape = (None, 72) = (None, 6*9 + 6*3)
```

$$\mathbf{q} = (\cos(\theta/2), \sin(\theta/2)\vec{a}) = (w, (x, y, z))$$

$$R_{\mathbf{q}} = \begin{pmatrix} 1-2y^2-2z^2 & 2xy-2wz & 2xz+2wy & 0 \\ 2xy+2wz & 1-2x^2-2z^2 & 2yz-2wx & 0 \\ 2xz-2wy & 2yz+2wx & 1-2x^2-2y^2 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Data process flows



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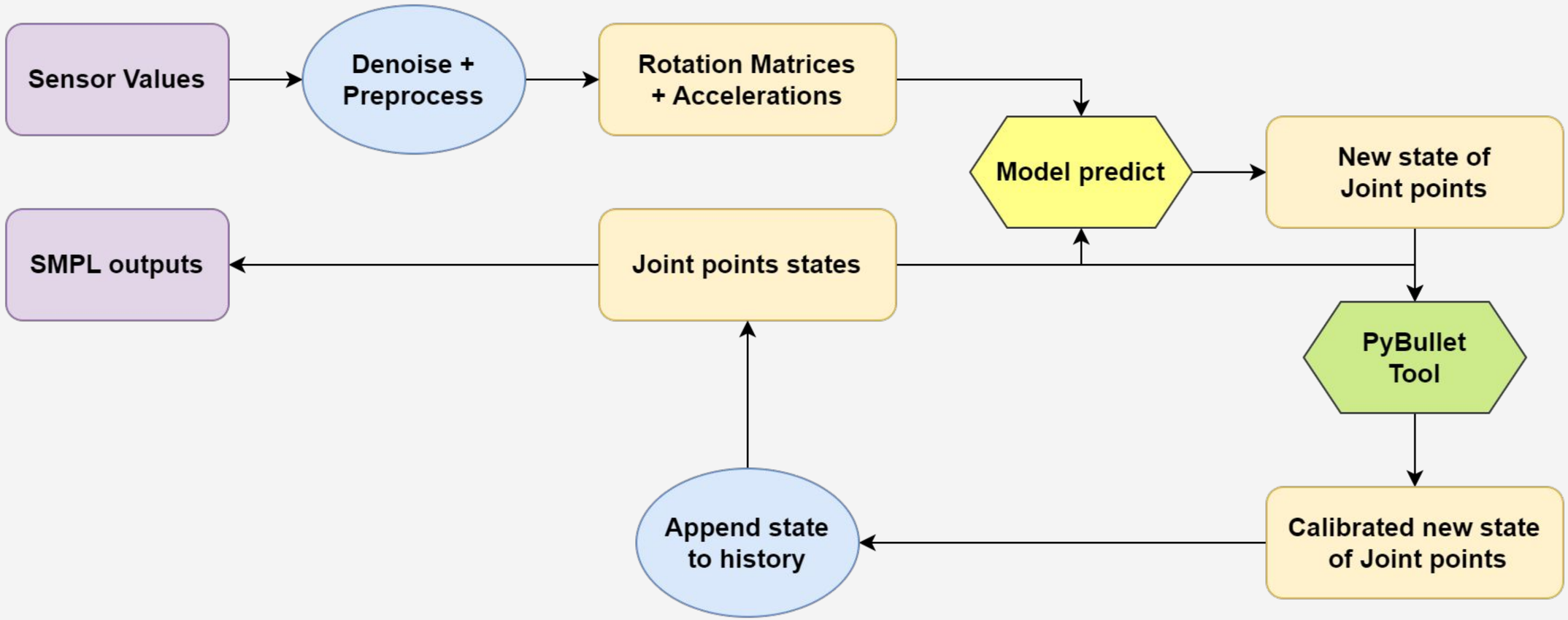
Model Pipeline



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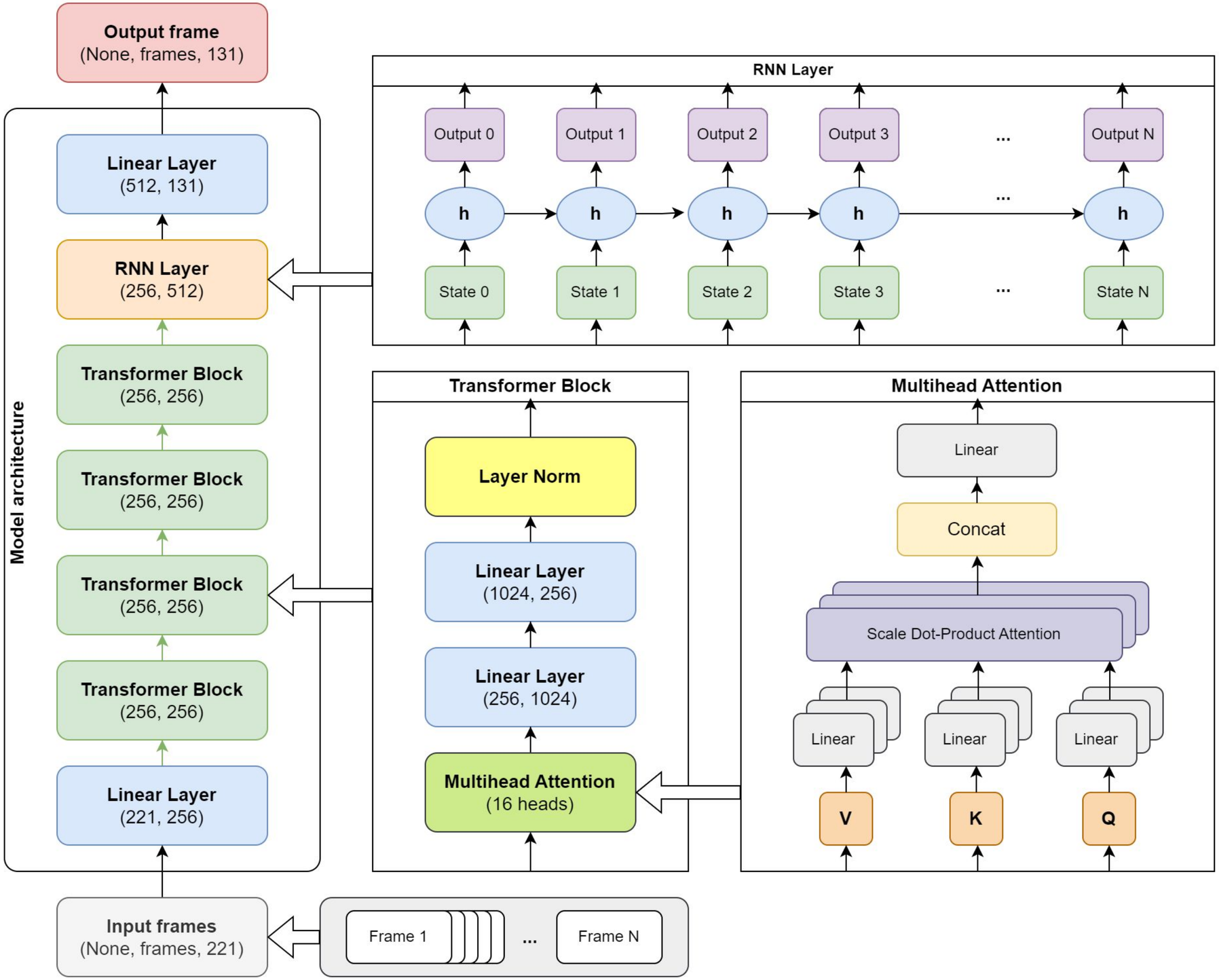
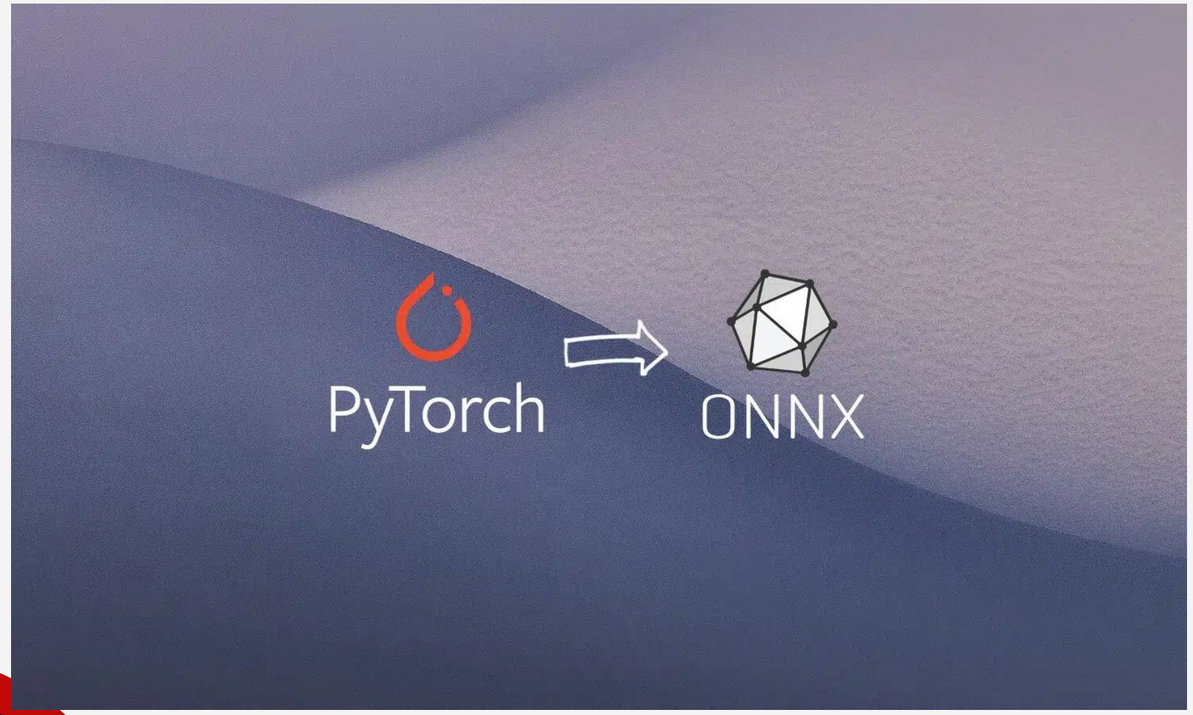
Model Architecture



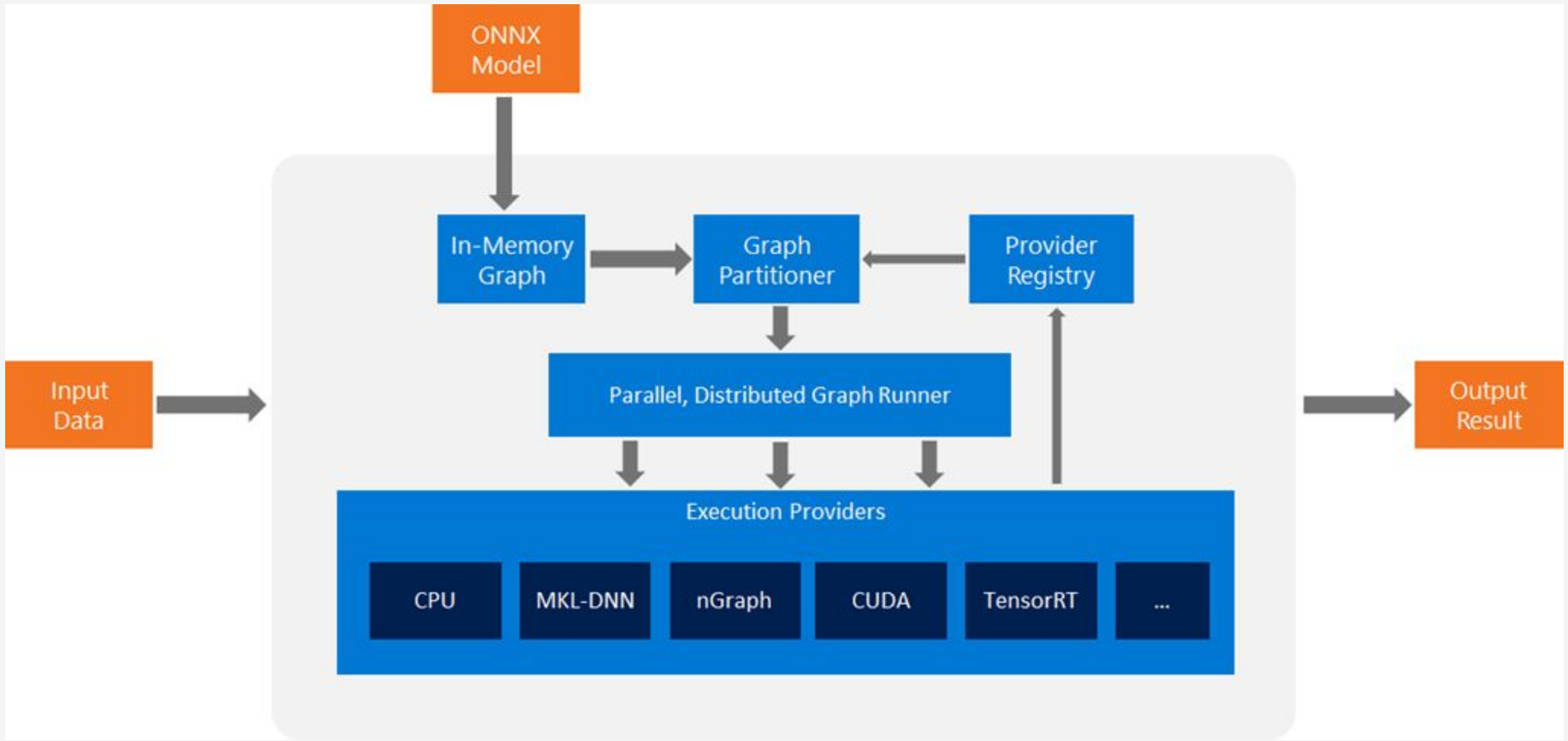
Open Neural Network Exchange (ONNX)



Provide:

- Standard representation graphs
- Standard data types
- Standard functions

ONNX Runtime



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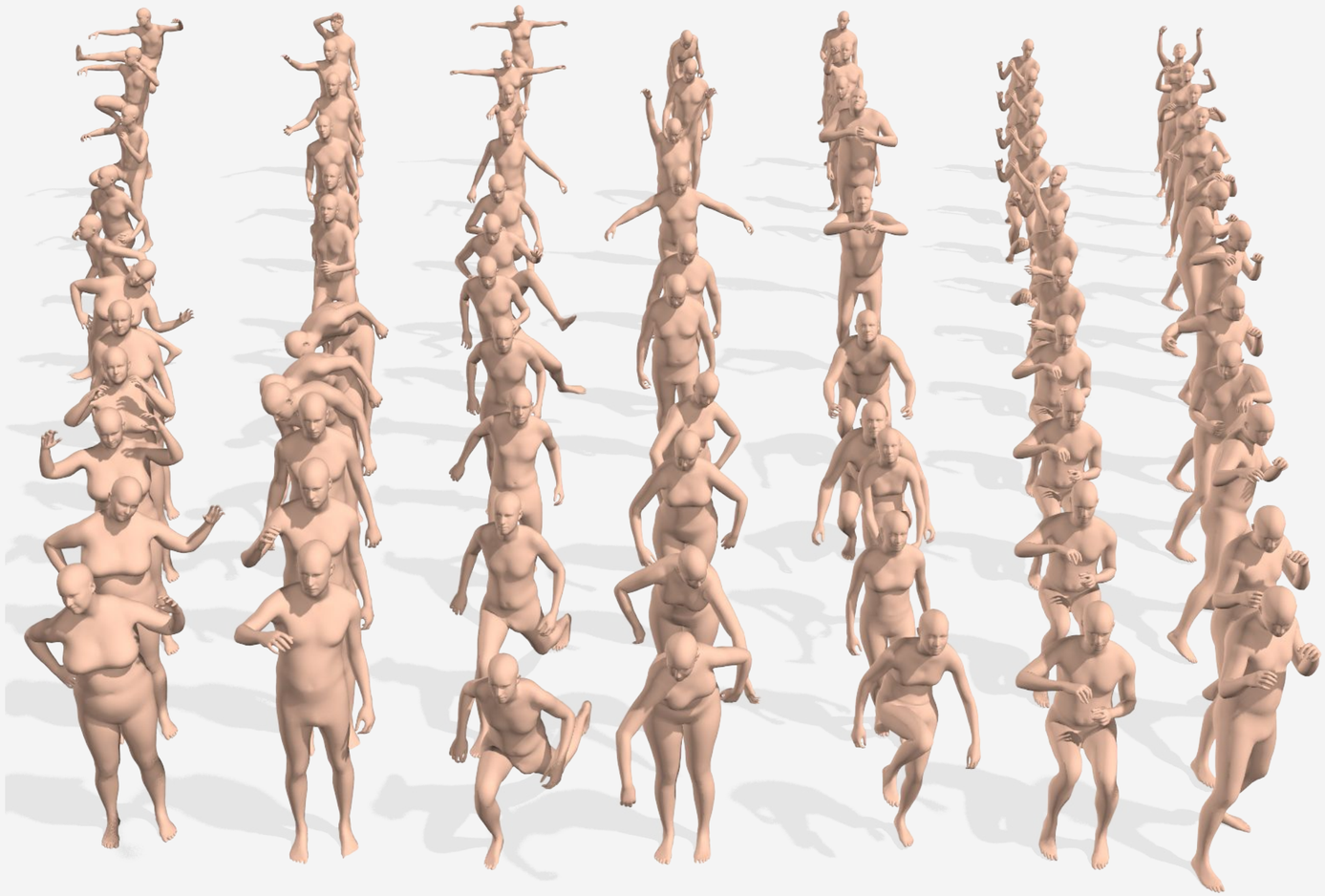
Evaluation datasets



DanceDB - Part of AMASS

Metrics:

- Mean Joint Angle Error
- Mean Root-Relative Joint Position Error
- Root Error 2s/5s/10s

Results

Engine	PyTorch			ONNX FP32			ONNX FP16		
	40	60	120	40	60	120	40	60	120
Joint Angle Error	10.008	9.833	**5.385**	6.609	6.474	6.431	6.604	6.429	6.591
Joint Position Errors	6.144	6.064	3.289	3.370	3.335	3.184	3.358	3.323	**3.193**
Root Errors in 2s	0.022	0.016	0.025	0.012	**0.010**	0.011	0.012	0.010	0.011
Root Errors in 5s	0.032	0.017	0.012	**0.012**	0.013	0.014	0.013	0.014	0.014
Root Errors in 10s	0.047	0.024	0.029	0.011	**0.008**	0.009	0.011	0.009	0.009

Hardware information

Table 5.2 Hardware information used for benchmark.

GPU Name	VRAM	TFLOPS	CPU cores	CPU clock	RAM
Tesla T4	16GB	8.14	2	2.5 GHz	12GB
RTX 2060	6GB	6.45	12	4.3 GHz	16GB
Tesla M40	24GB	6.83	48	2.5 GHz	32GB
GTX 1060	4GB	1.86	8	4.0 GHz	16GB

Model Performance

Table 5.3 Comparison of model performance, benchmark on Tesla T4

Engine	PyTorch			ONNX FP32			ONNX FP16		
Num of frames	40	60	120	**40**	**60**	120	**40**	**60**	120
Model runtime (s)	44.1	46.7	53.5	**17.8**	**19.7**	28.4	**17.7**	**19.3**	27.0
Engine runtime (s)	114.8	126.1	163.7	**63.0**	**74.8**	113.8	**62.7**	**74.2**	111.5
Process speed (fps)	43.6	39.6	30.5	**79.3**	**66.8**	43.9	**79.7**	**67.4**	44.8
Memory usage (MB)	172	176	184	**152**	**156**	184	**156**	**160**	184

Model Performance

Table 5.5 Comparison of model performance, benchmark on Tesla M40

Engine	PyTorch			ONNX FP32			ONNX FP16		
Num of frames	40	60	120	**40**	**60**	120	**40**	**60**	120
Model runtime (s)	52.4	55.5	63.6	**21.2**	**23.4**	33.8	**21.0**	**22.9**	32.1
Engine runtime (s)	86.1	94.6	122.8	**47.3**	**56.1**	85.3	**47.1**	**55.6**	83.6
Process speed (fps)	58.1	52.9	40.7	**105.8**	**89.1**	58.6	**106.3**	**89.9**	59.8
Memory usage (MB)	184	188	200	**168**	**172**	200	**168**	**172**	200

Model Performance

Table 5.6 Comparison of model performance, benchmark on GTX 1060

Engine	PyTorch			ONNX FP32			ONNX FP16		
Num of frames	40	60	120	40	60	120	40	60	120
Model runtime (s)	183.4	194.2	222.7	74.2	81.9	118.1	73.5	80.3	112.2
Engine runtime (s)	210.4	225.5	270.1	95.1	108.1	159.4	94.3	106.4	153.5
Process speed (fps)	23.8	22.2	18.5	52.6	46.3	31.4	53.0	47.0	32.6
Memory usage (MB)	220	256	268	210	224	236	212	216	232

Model Performance

Table 5.4 Comparison of model performance, benchmark on RTX 2060 Super

Engine	PyTorch			ONNX FP32			ONNX FP16		
Num of frames	40	60	120	**40**	**60**	120	**40**	**60**	120
Model runtime (s)	56.1	58.7	66.2	**20.4**	**25.0**	28.7	**20.0**	**23.2**	33.2
Engine runtime (s)	89.9	95.1	123.7	**47.6**	**64.0**	97.5	**49.1**	**58.0**	88.6
Process speed (fps)	55.6	52.6	40.4	**105.0**	**78.1**	51.3	**101.8**	**86.2**	56.4
Memory usage (MB)	176	180	188	**156**	**160**	188	**160**	**164**	188

Demo

You can watch some of my videos [here].

You can find our official repo at [here].

Thank You