FLD: Fourier Latent Dynamics for Structured Motion Representation and Learning

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Motivation

Limited demonstrations

sparse reference

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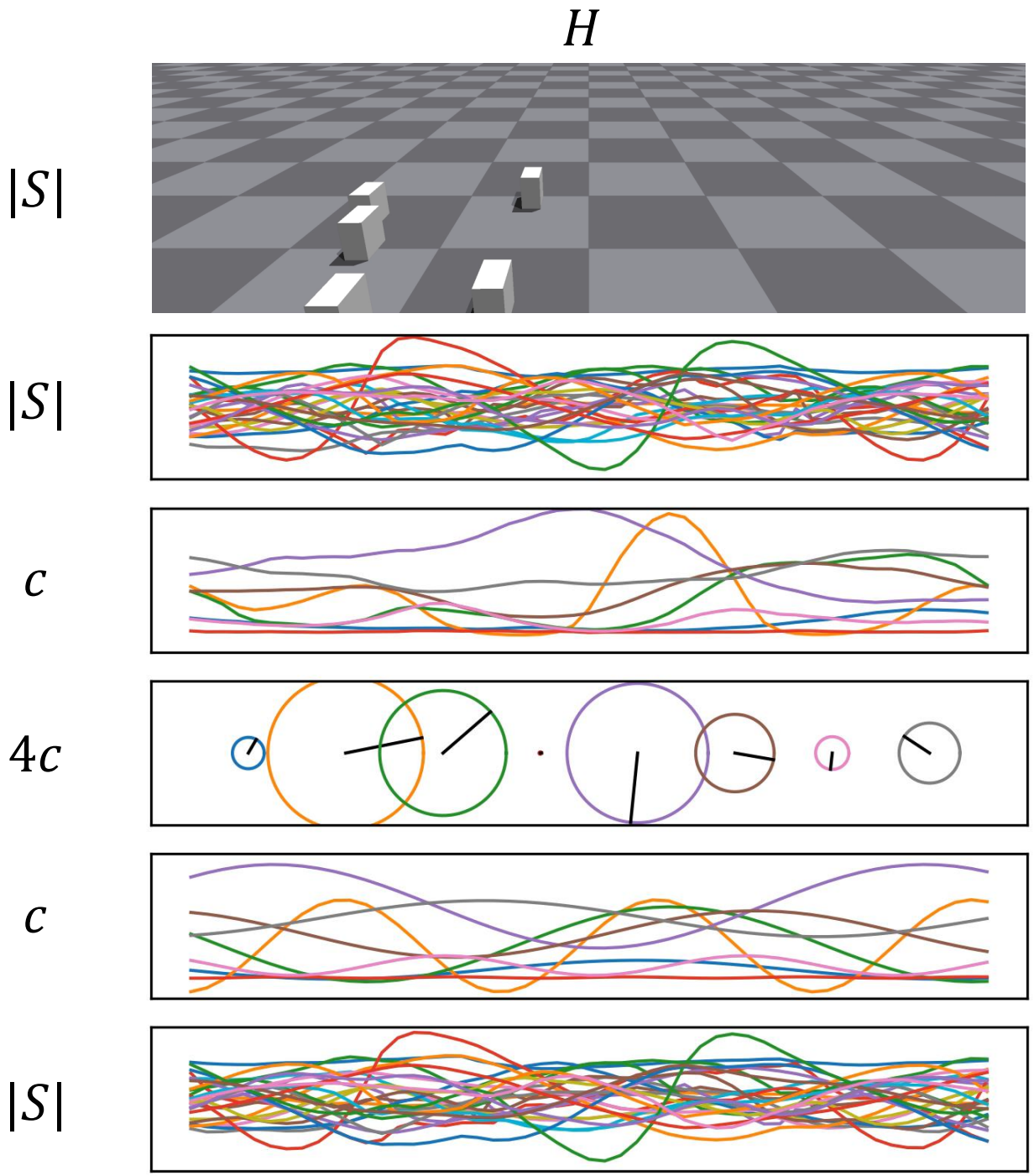
Limited demonstrations

sparse reference


H
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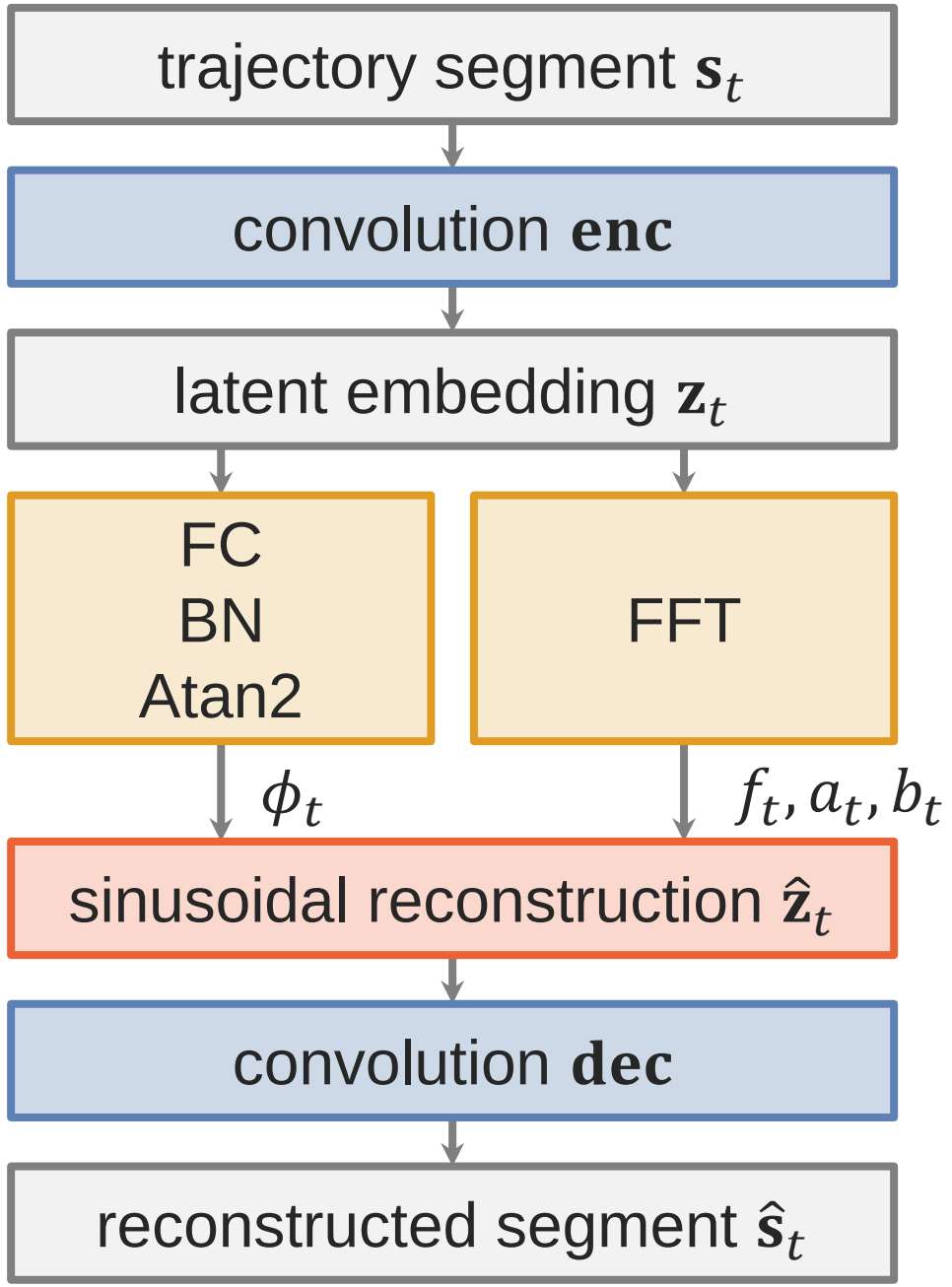
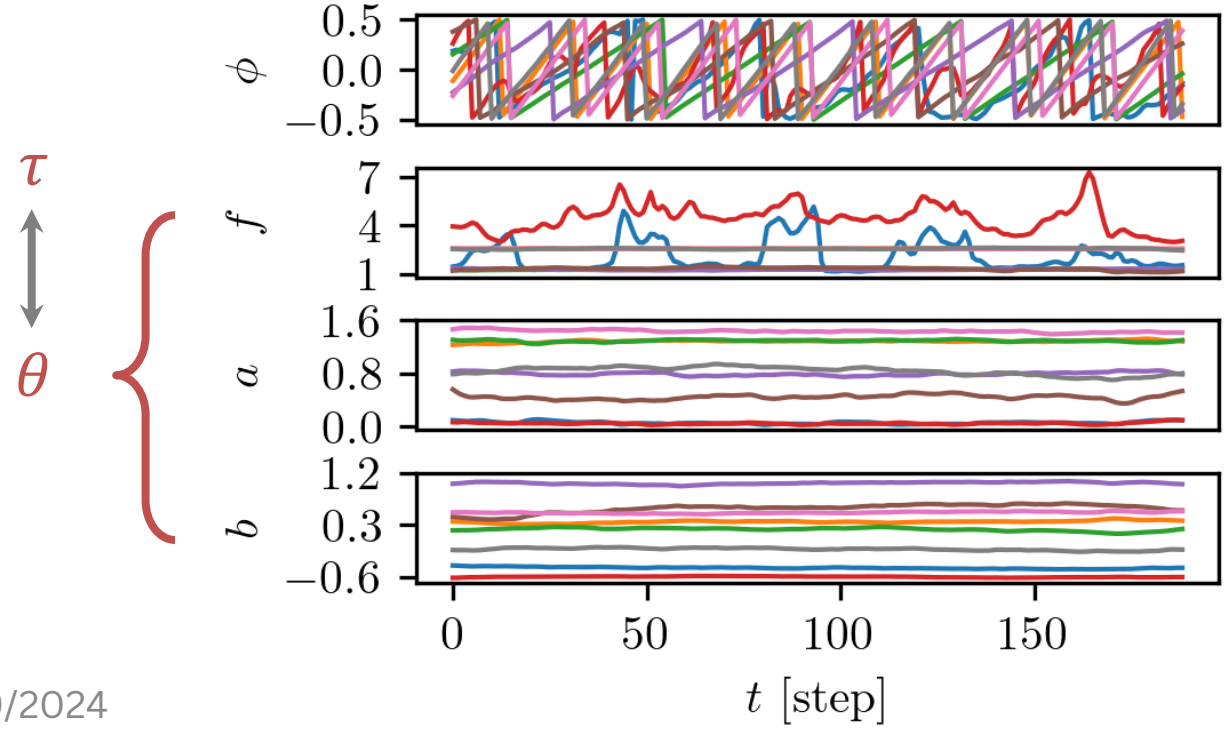
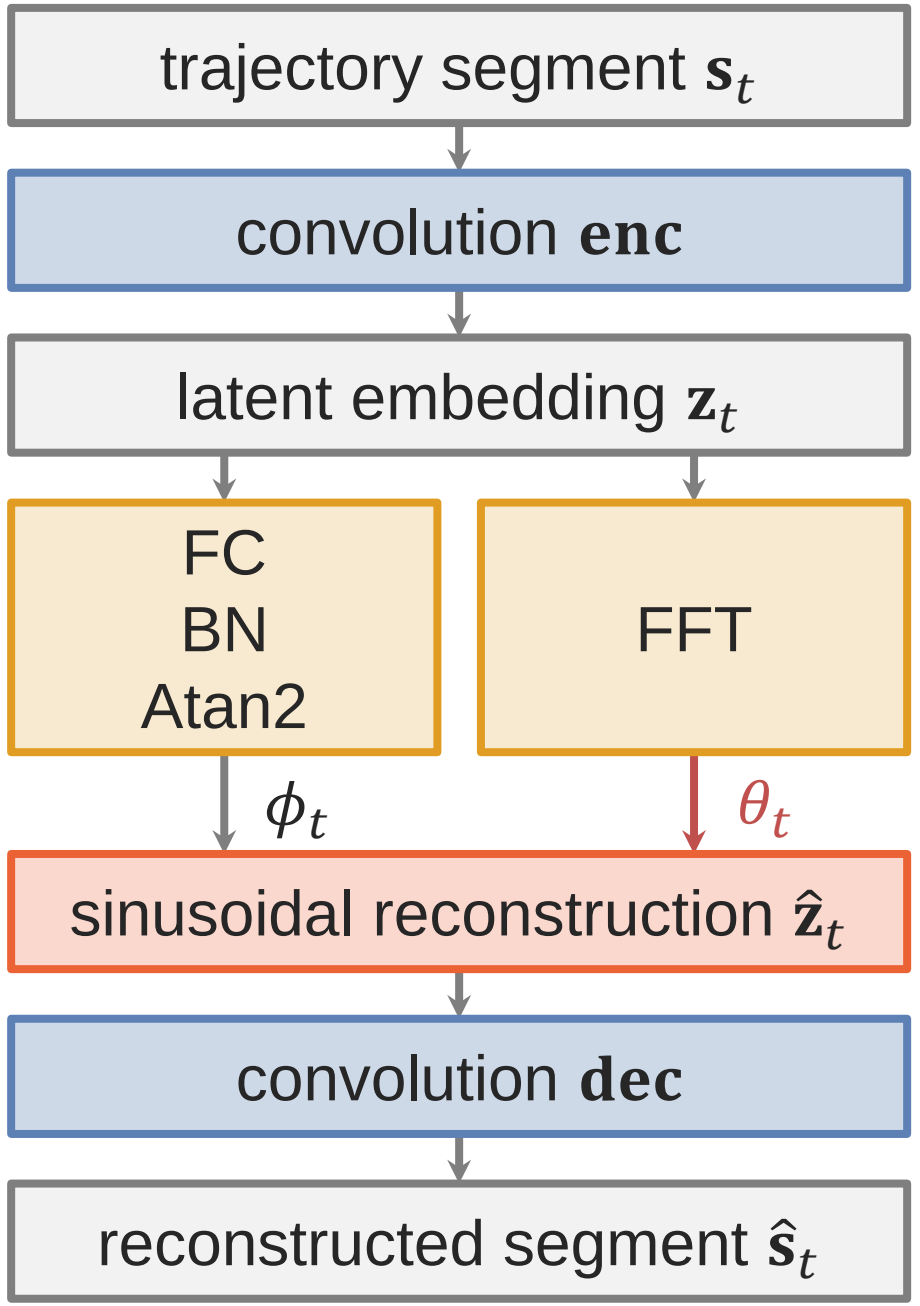

trajectory segment $\mathbf{s}_t$
convolution **enc**
latent embedding $\mathbf{z}_t$
FC
BN
Atan2
FFT
ϕ_t
f_t, a_t, b_t
sinusoidal reconstruction $\hat{\mathbf{z}}_t$
convolution **dec**
reconstructed segment $\hat{\mathbf{s}}_t$

Motion Representation

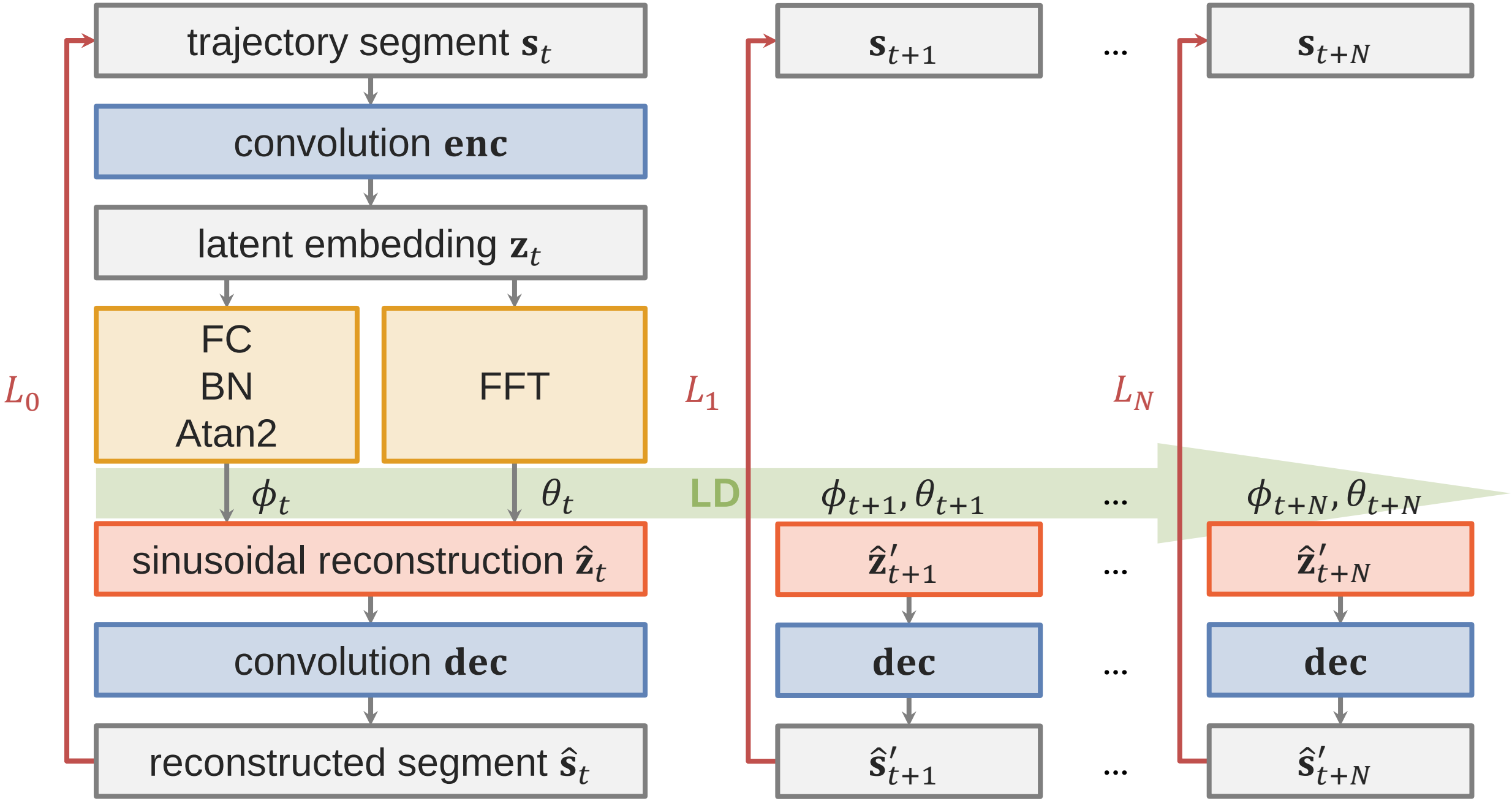
Quasi-constant parameterization

- motion similarity
- time invariance





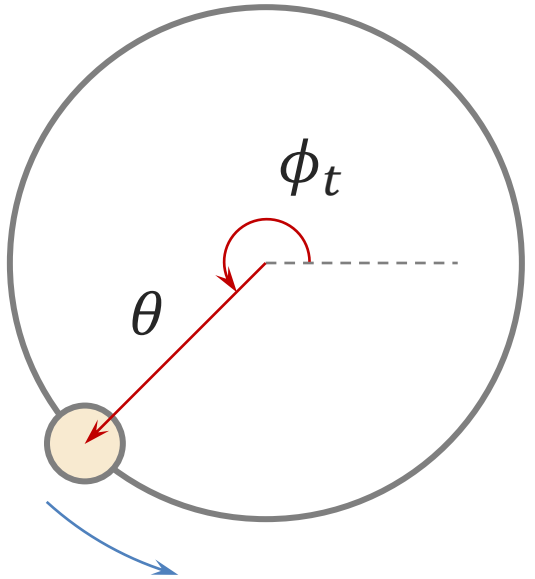
Fourier Latent Dynamics
FLD


trajectory segment $\mathbf{s}_t$
convolution **enc**
latent embedding $\mathbf{z}_t$
FC
BN
Atan2
FFT
L_0
L_1
L_N
ϕ_t
θ_t
LD
ϕ_{t+1}, θ_{t+1}
ϕ_{t+N}, θ_{t+N}
sinusoidal reconstruction $\hat{\mathbf{z}}_t$
convolution **dec**
reconstructed segment $\hat{\mathbf{s}}_t$
$\mathbf{s}_{t+1}$
$\mathbf{s}_{t+N}$
...
$\hat{\mathbf{z}}'_{t+1}$
$\hat{\mathbf{z}}'_{t+N}$
dec
$\hat{\mathbf{s}}'_{t+1}$
$\hat{\mathbf{s}}'_{t+N}$

Motion Representation

Latent manifold

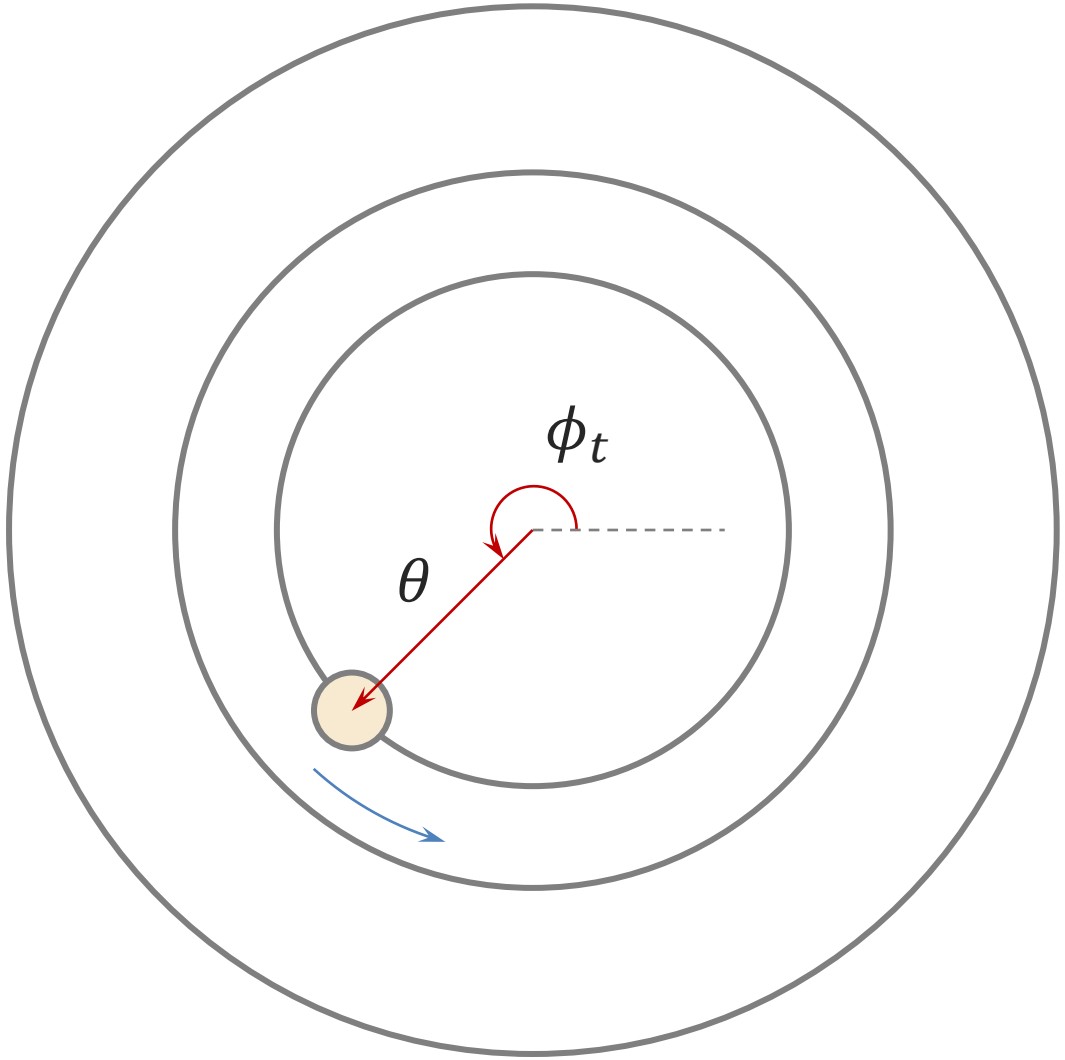
- quasi-constant parameterization



Motion Representation

Latent manifold

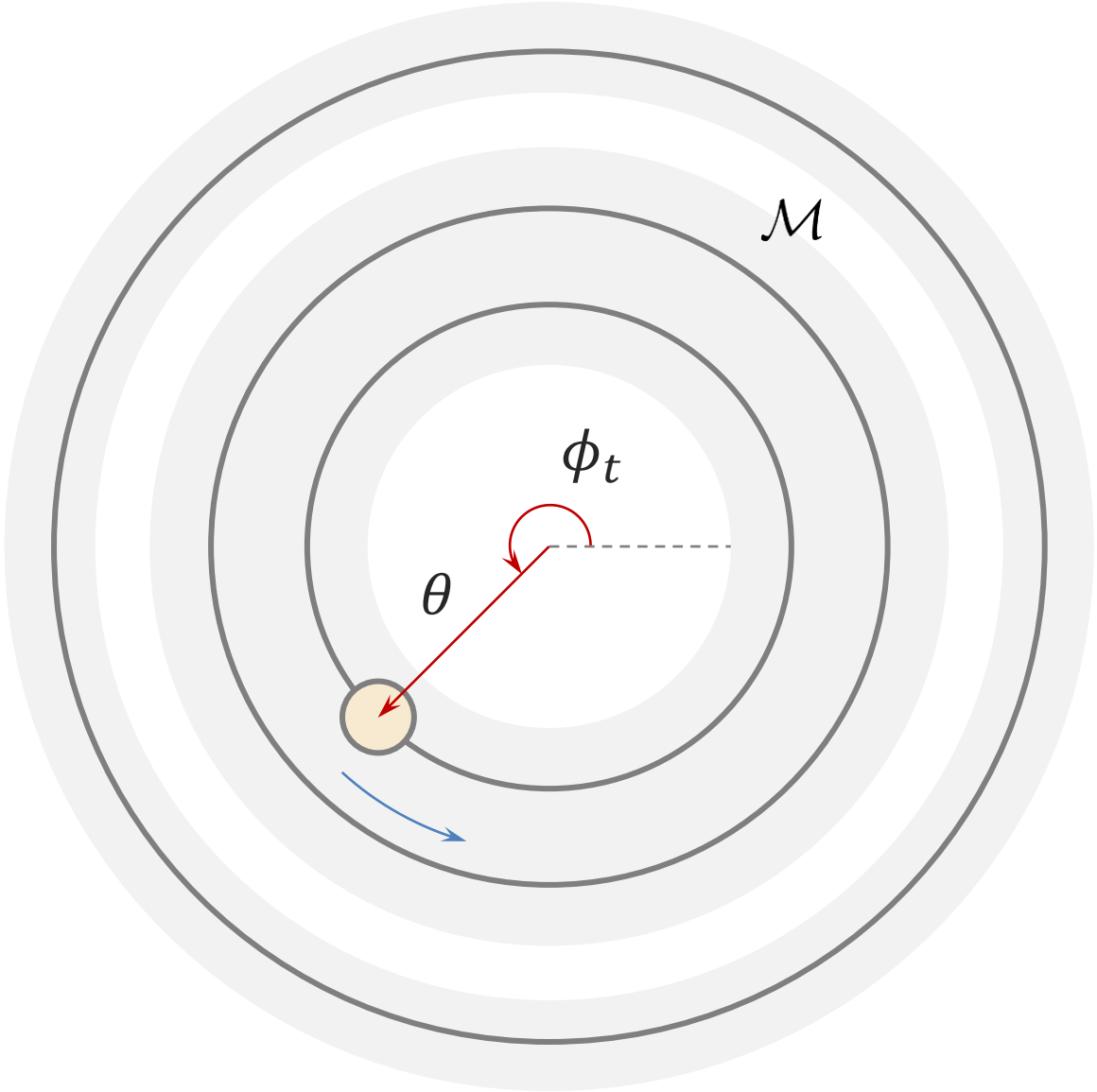
- quasi-constant parameterization



Motion Representation

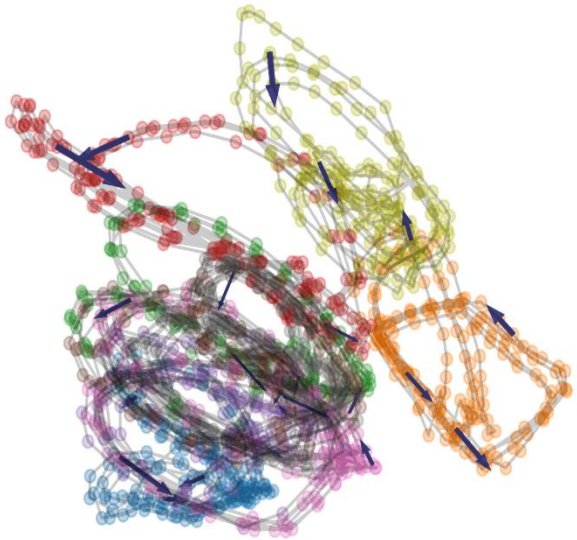
Latent manifold

- quasi-constant parameterization

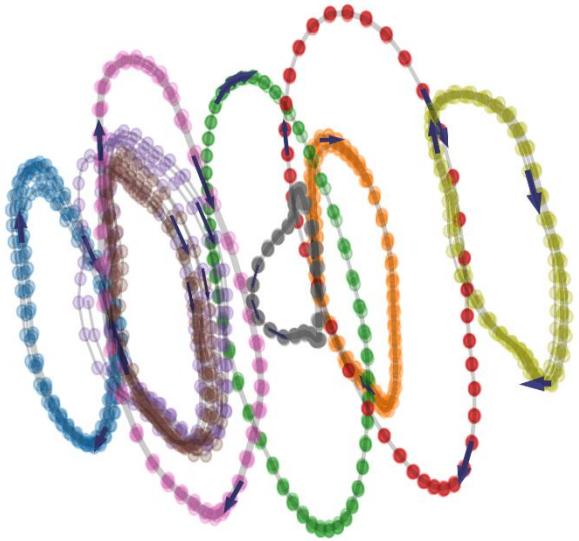


Motion Representation

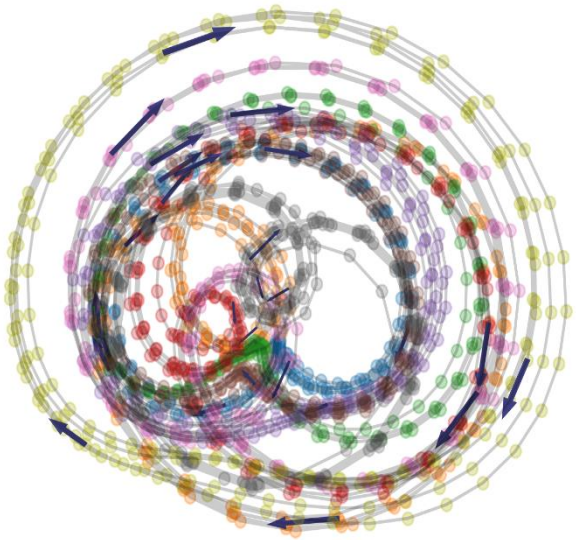
original



VAE



PAE



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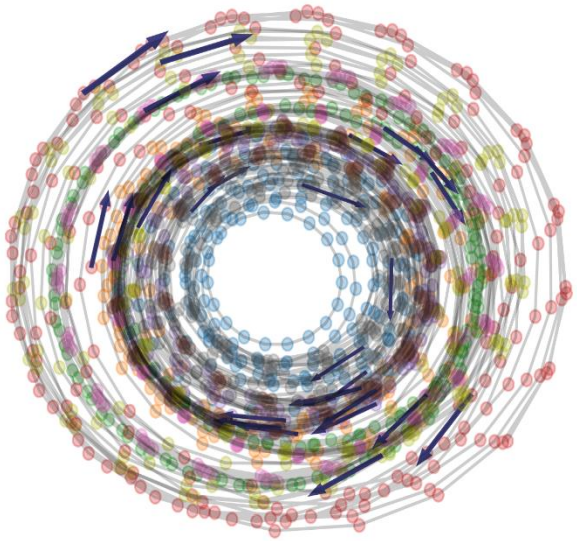
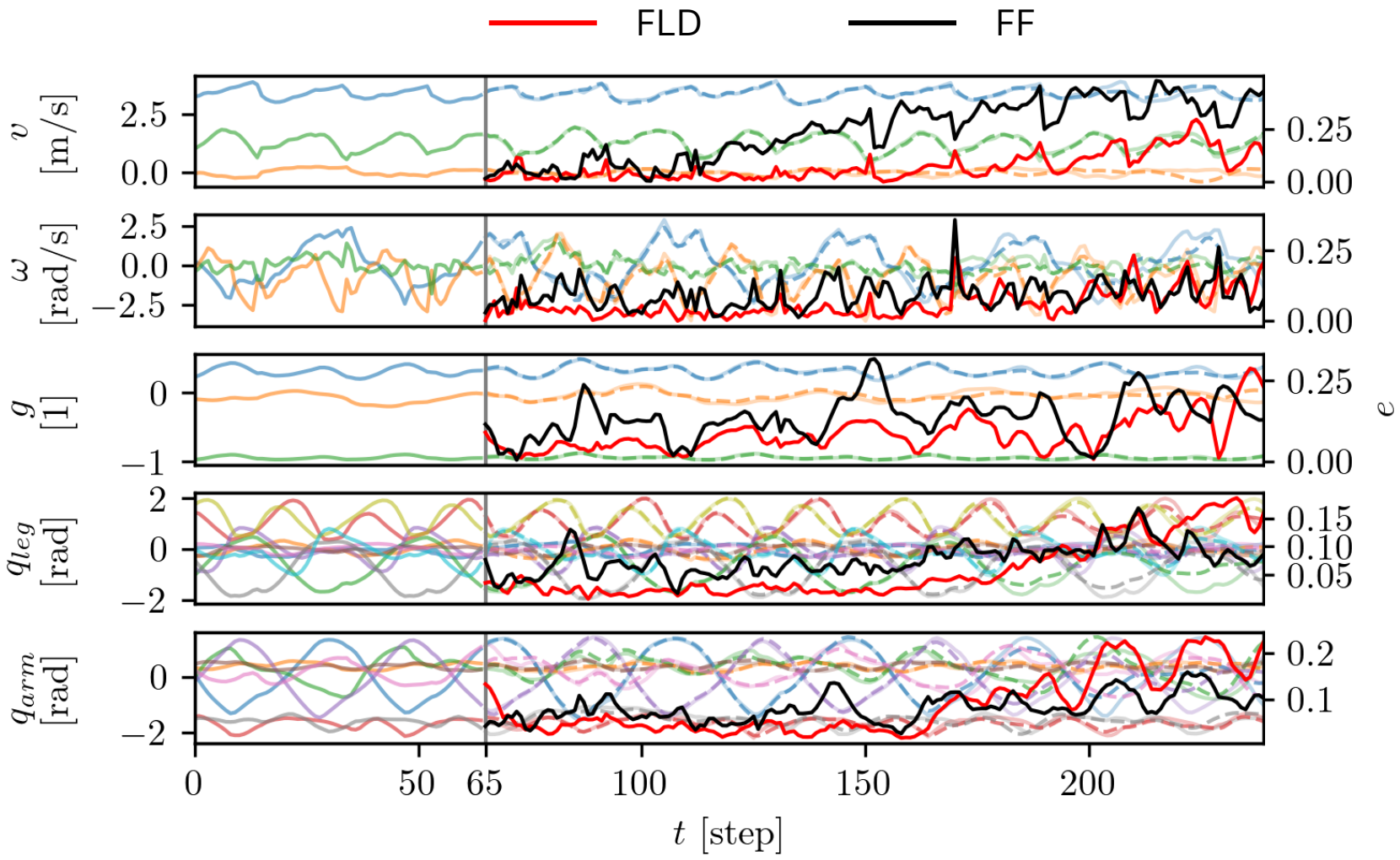


parameters to represent a state trajectory τ in space S

$|S| \times |\tau|$ $\quad$ $c \times (|\tau| - H + 1)$ $\quad$ $4c \times (|\tau| - H + 1)$ $\quad$ $4c$

Motion Representation

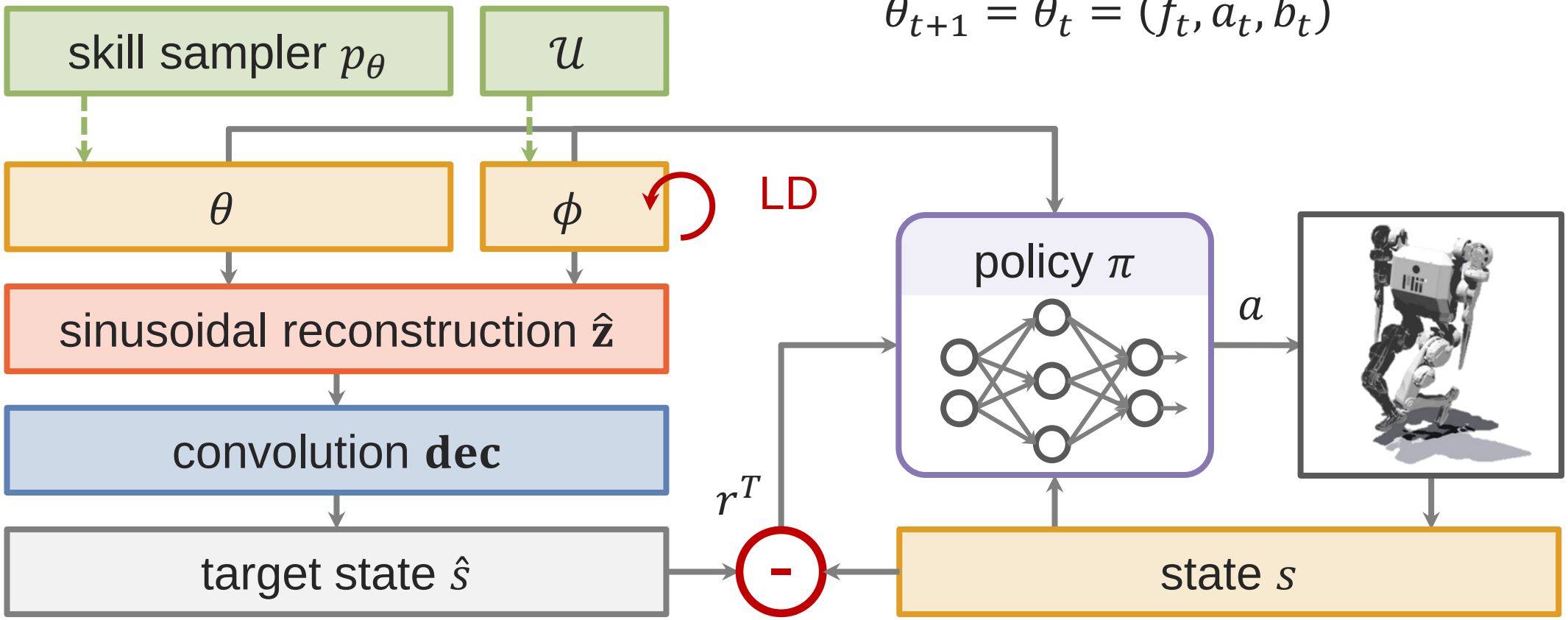
stride



Motion Learning

$$\phi_{t+1} = \phi_t + f_t \Delta t$$

$$\theta_{t+1} = \theta_t = (f_t, a_t, b_t)$$



Motion Learning

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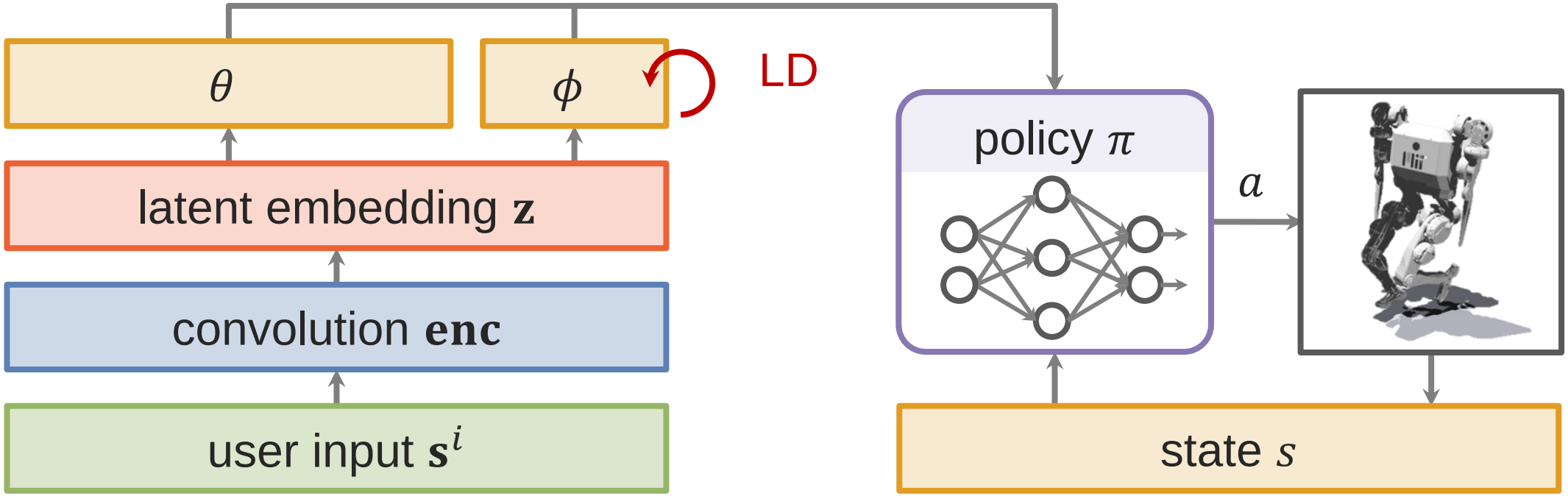
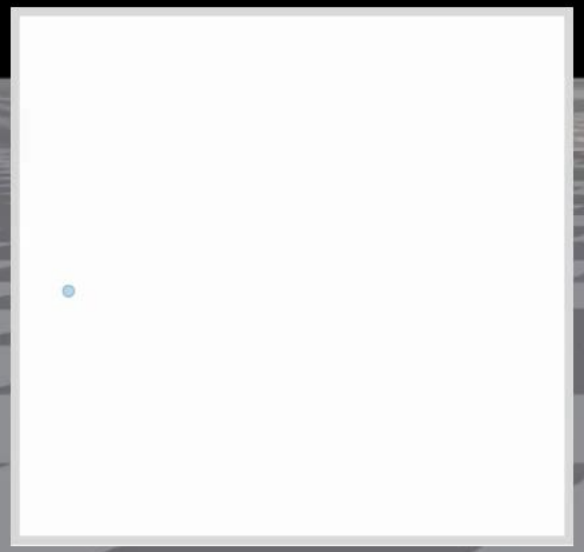
$$\theta_{t+1} = \theta_t = (f_t, a_t, b_t)$$

Real-time tracking



latent manifold



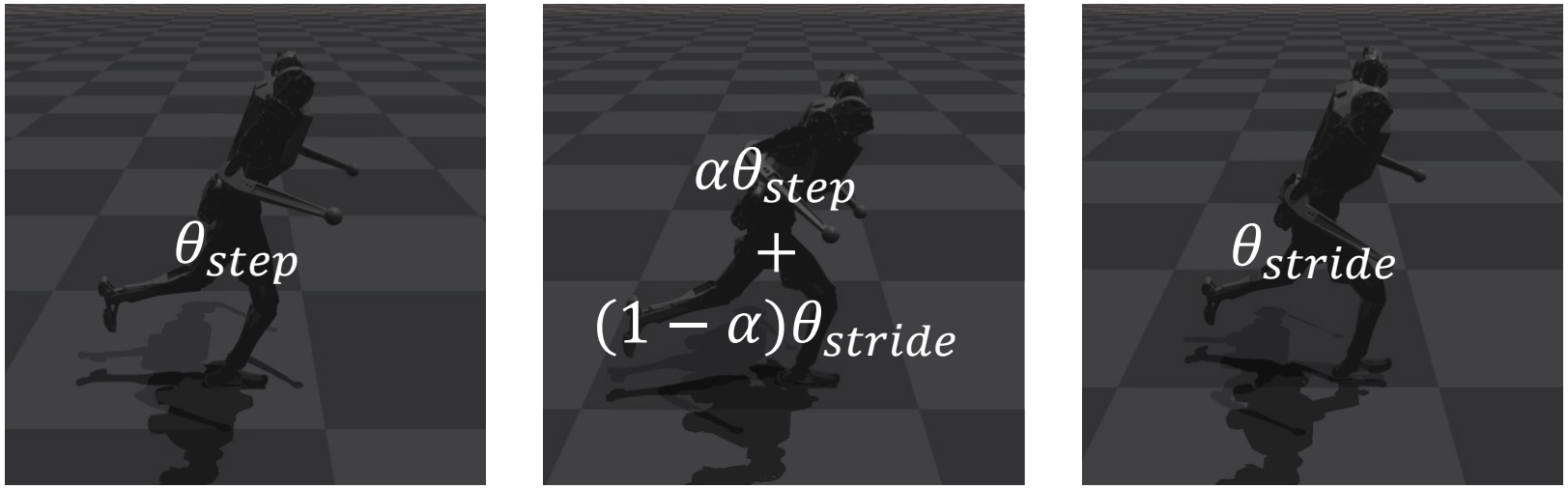
tracking target

Motion Learning

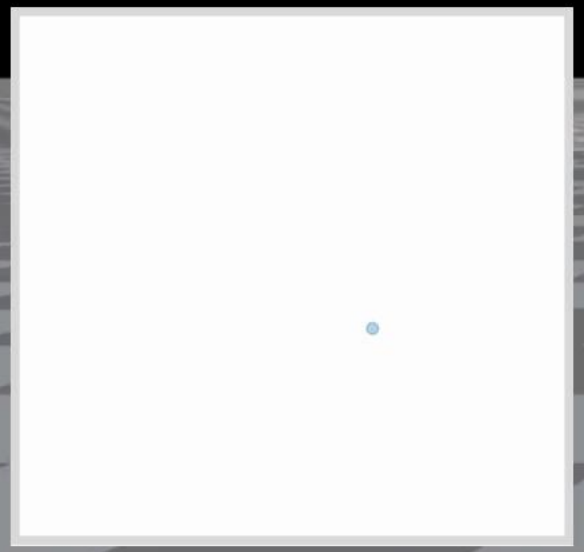
Parameterization space θ

- motion similarity
- time invariance

Spatial-temporal relationships



phase manifold



tracking target

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