Modulated Neural ODEs

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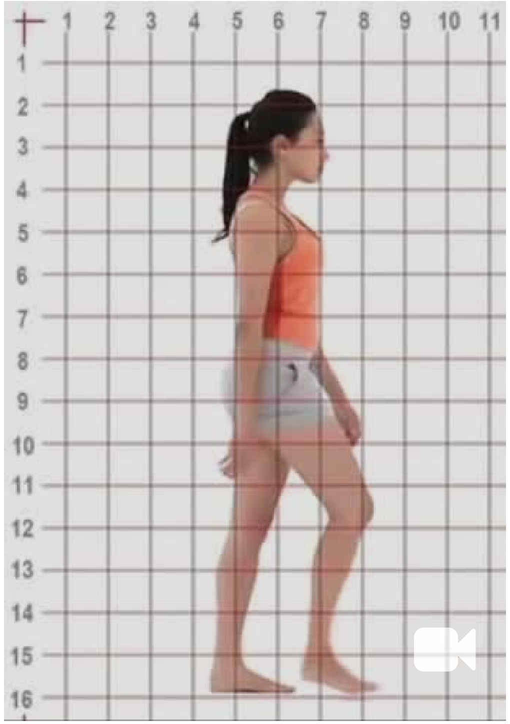
Modulated NODEs

Key Idea:

*does setting apart **dynamic states** from underlying **static factors of variation** improve existing model performance?*



length of limbs ⟷ influence dynamics ⟷ length, mass

color of clothes ⟷ influence reconstruction ⟷ color of a ball

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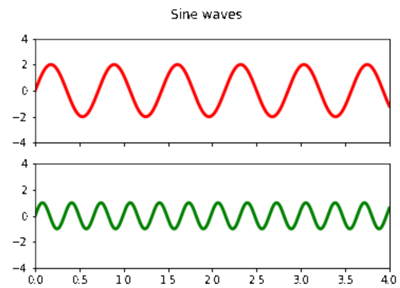
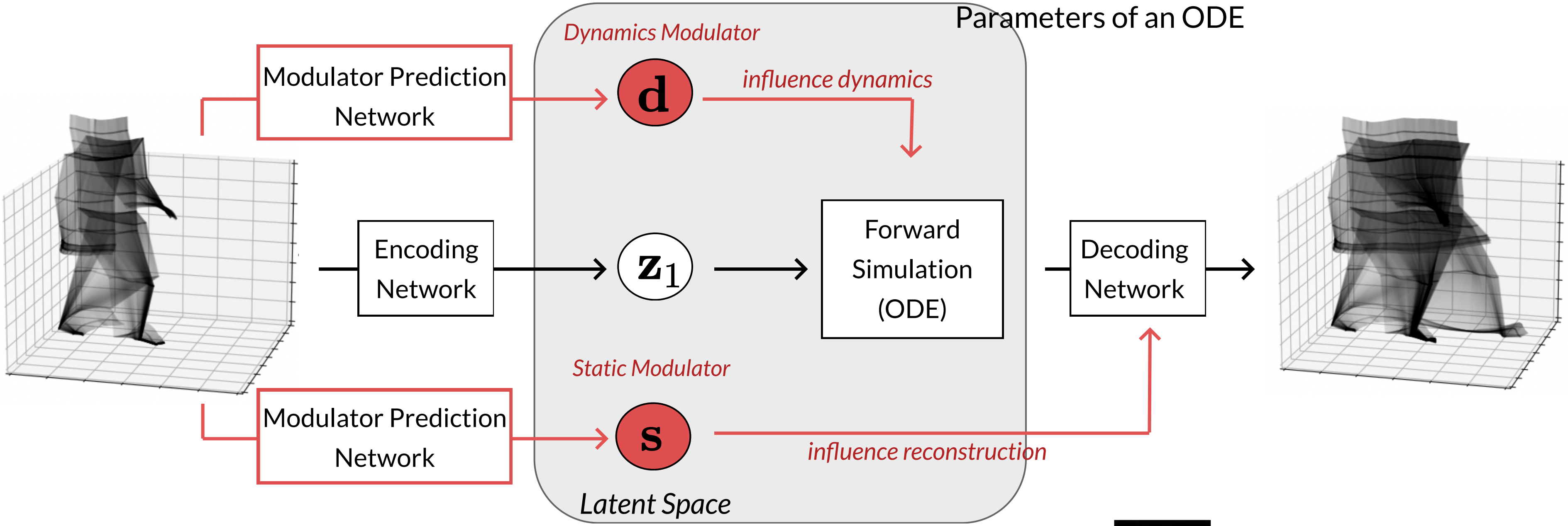


Parameters of an ODE

ours

MoNODE (2023)



Style of a digit

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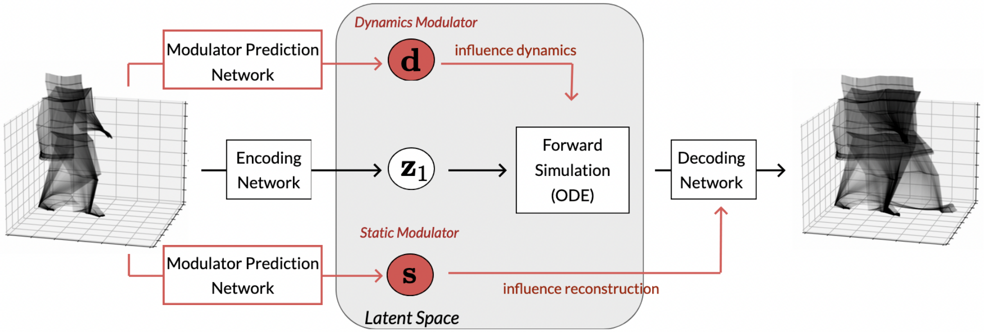

Generative Model

$\mathbf{d} \sim p(\mathbf{d})$ *// dynamics modulator*

$\mathbf{s} \sim p(\mathbf{s})$ *// static modulator*

$\mathbf{z}_1 \sim p(\mathbf{z}_1)$ *// latent ODE state*

$$\mathbf{z}_i = \mathbf{z}_1 + \int_{t_1}^{t_i} \mathbf{f}_\theta(\mathbf{z}(\tau); \mathbf{d})\, d\tau$$

$$\mathbf{x}_i \sim p_{\mathbf{x}_i}(\mathbf{x}_i \mid \mathbf{z}_i \,; \mathbf{s}).$$

ELBO (Chen, 2018)

implicit, point-estimates

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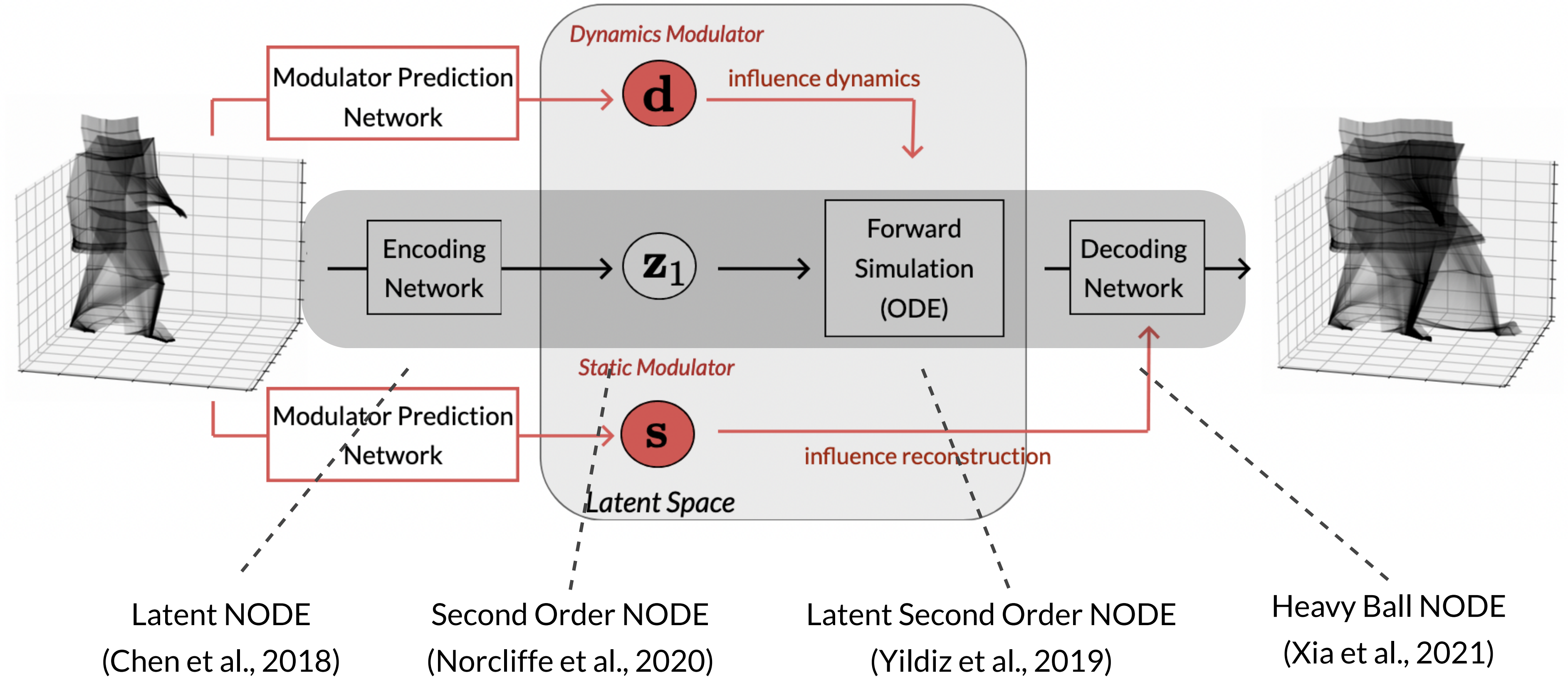
A general framework



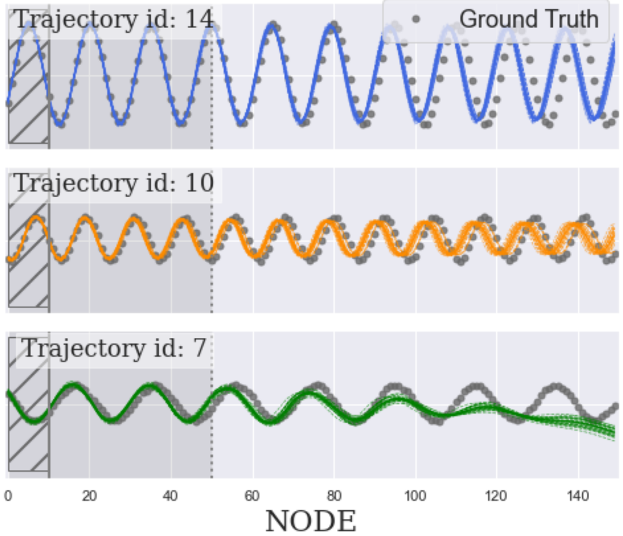
can be applied to most x-NODE

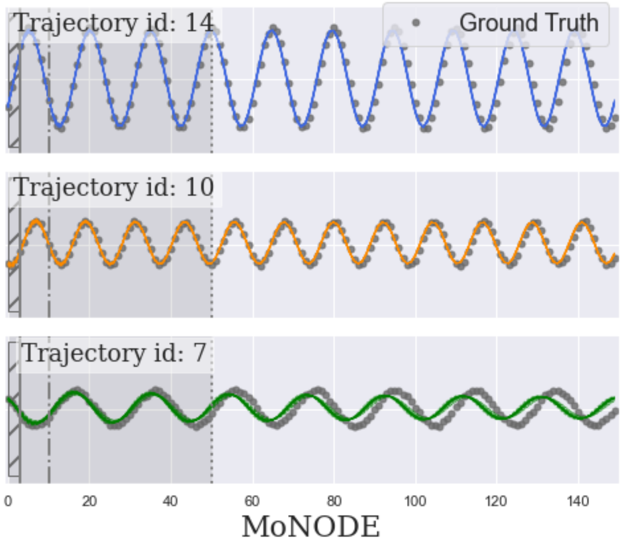
A **general** framework that improves forecasting and generalization

Sinusoidal Data

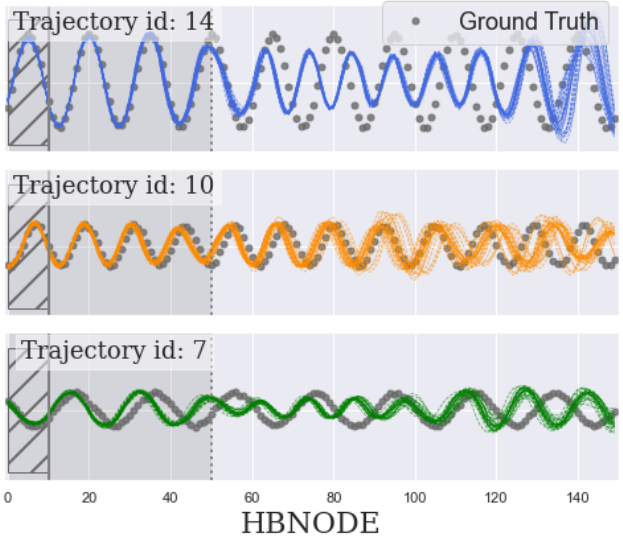
ours Mo-xNODE

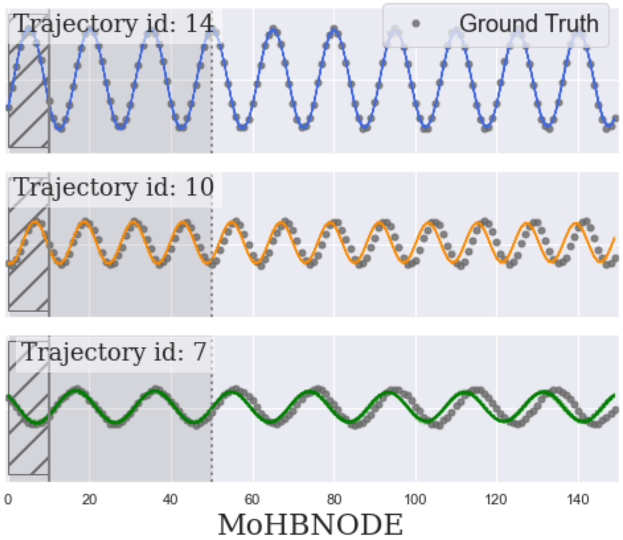
Latent NODE
(Chen et al., 2018)





Heavy Ball NODE
(Xia et al., 2021)



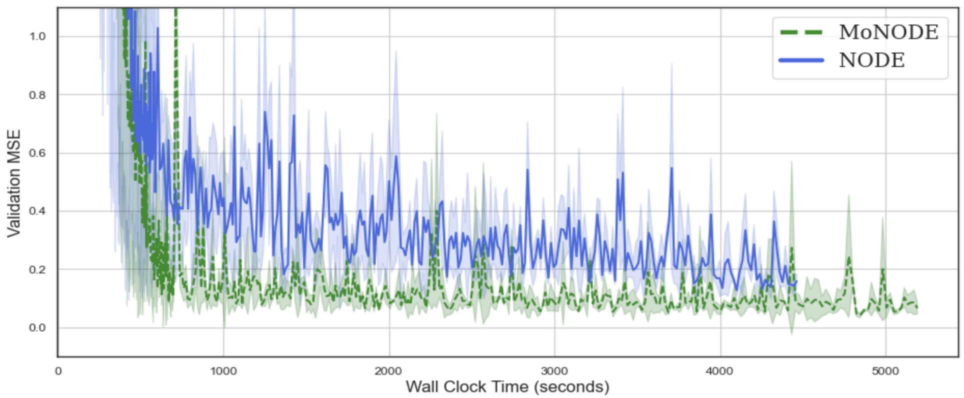


Modulated NODEs

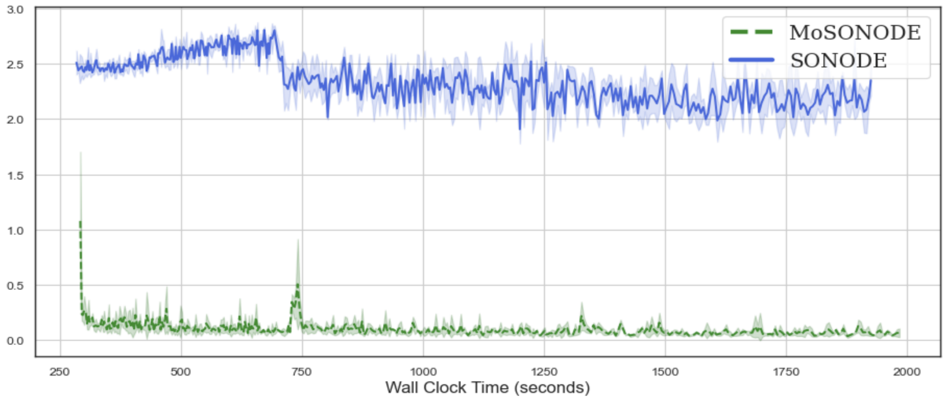
A **general** framework that is easier to train

Sinusoidal Data

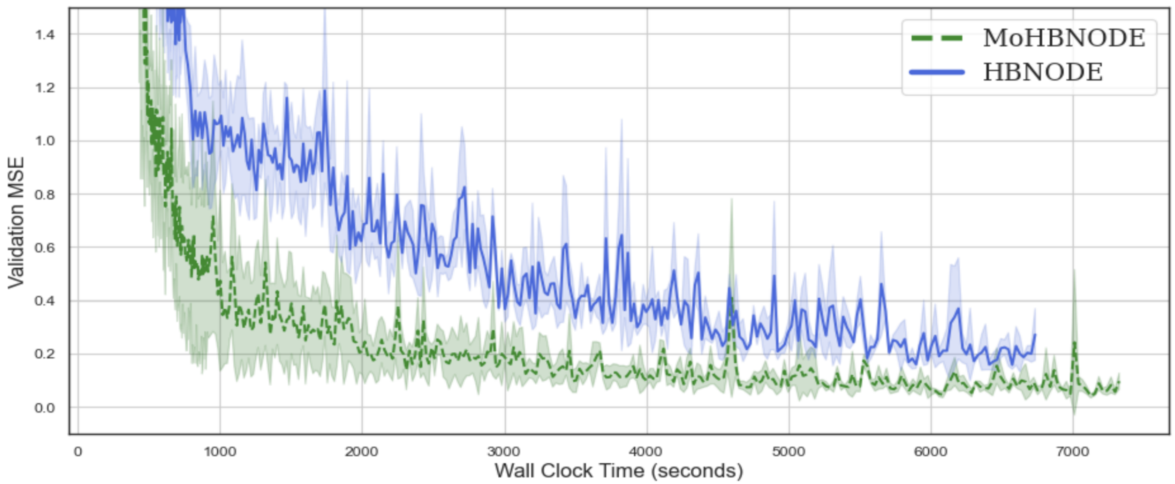
*ours: **Mo**-xNODE*



NODE (Chen et al., 2018)



SONODE (Norcliffe et al., 2020)



HBNODE (Xia et al., 2021)

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A **general** framework that disentangles underlying factors

PP parameters

$$\underbrace{d}_{\text{dynamics modulator}} \sim \quad \frac{dx}{dt} = \alpha x - \beta xy, \qquad \frac{dy}{dt} = \delta xy - \gamma y$$

dynamics modulator

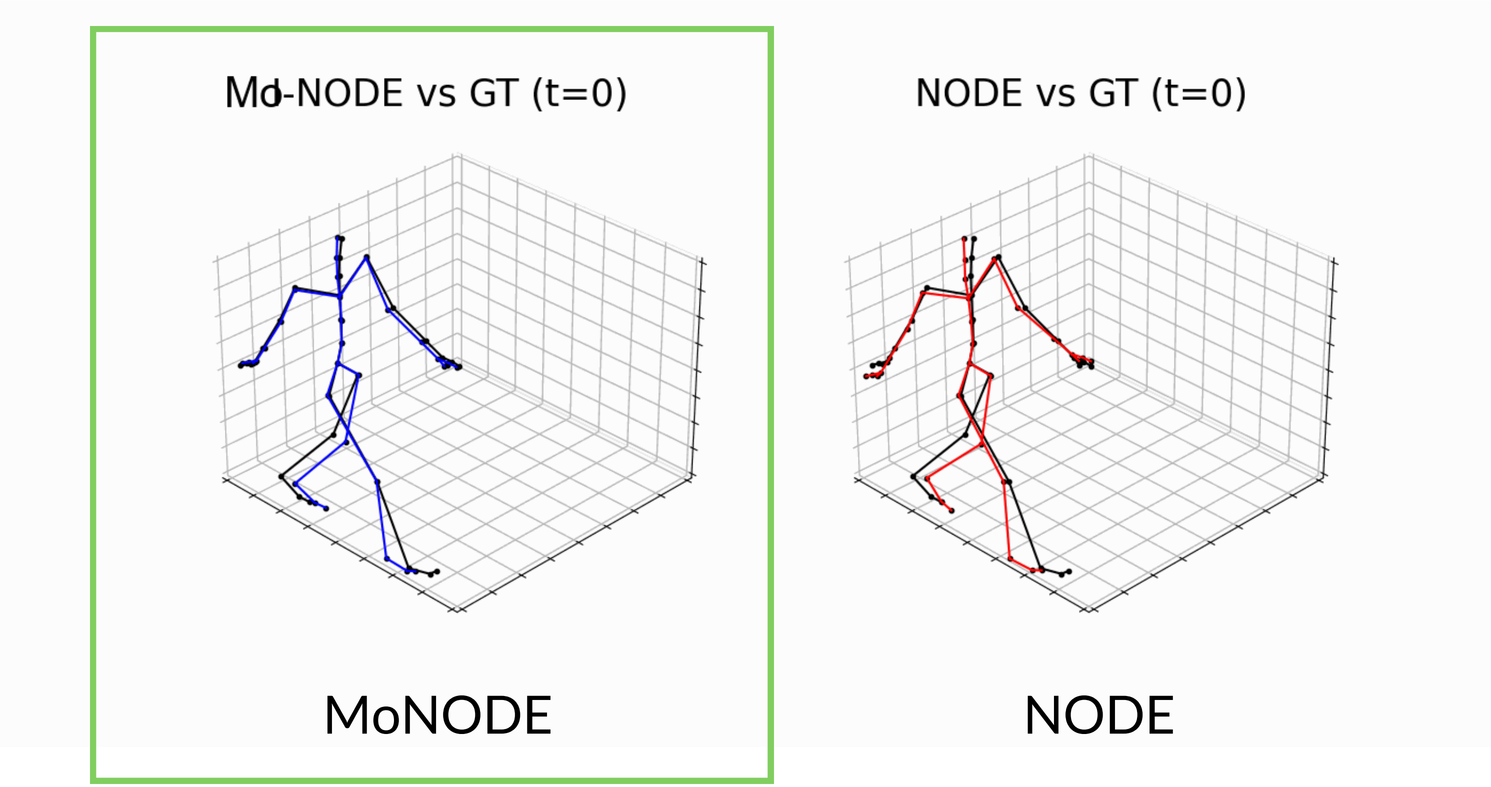
Table 2. R^2 scores to predict the unknown Factors of Variation from inferred latents. Higher is better.

	NODE	MoNODE
Sine	0.90	0.99
PP	-1.35	0.39
BB	-0.29	0.58

that improves performance on real world data

Table 3. Test MSE and standard deviation. Lower is better.

	Bouncing Ball	Rot.MNIST	Mocap	Mocap-shift
NODE	0.0199(0.001)	0.039 (0.003)	72.2(12.4)	61.6(6.2)
MoNODE	0.0164(0.001)	0.030 (0.001)	57.7(9.8)	58.0(10.7)



Thank you for your attention

All experiments and models publicly available at:

https://github.com/IlzeAmandaA/MoNODE

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