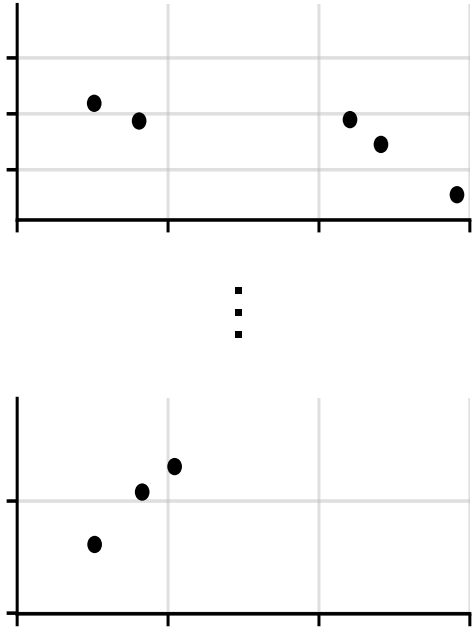
`NeuralProcesses.jl`: Composing Neural Processes with Flux

Wessel P. Bruinsma[1,2,*], Jonathan Gordon[1,*], Richard E. Turner[1]

[1]University of Cambridge, [2]Invenia Labs
[*]Equal contribution

JuliaCon 2020

Setting: Learning to Predict



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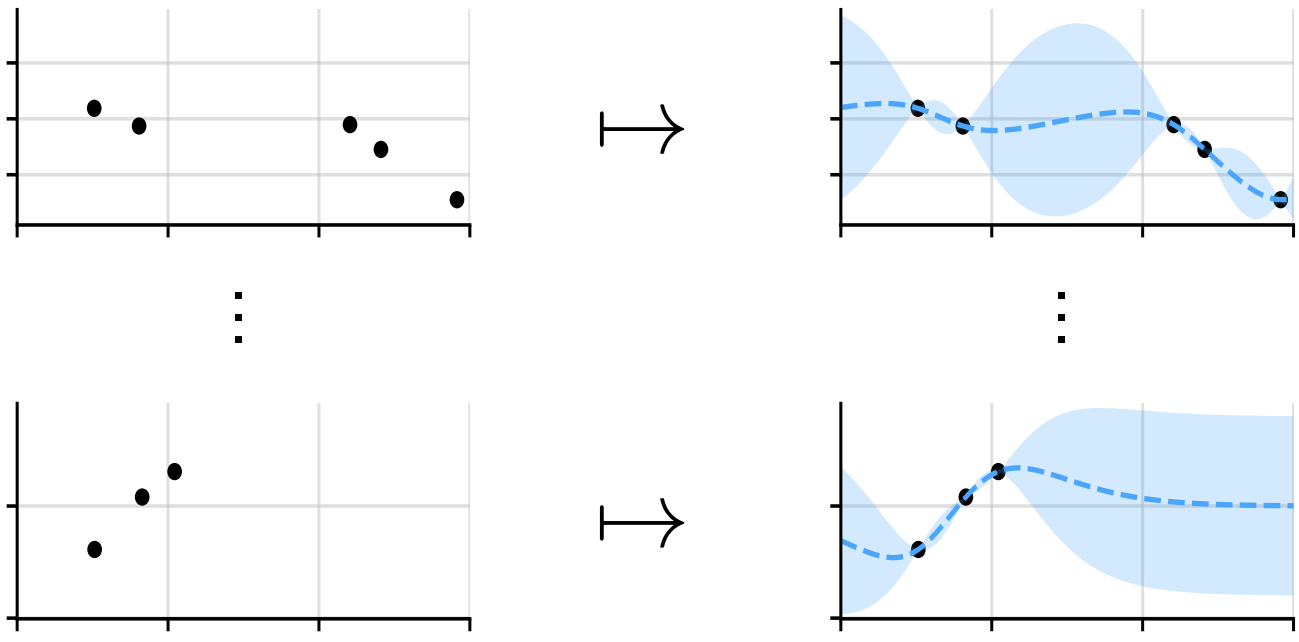

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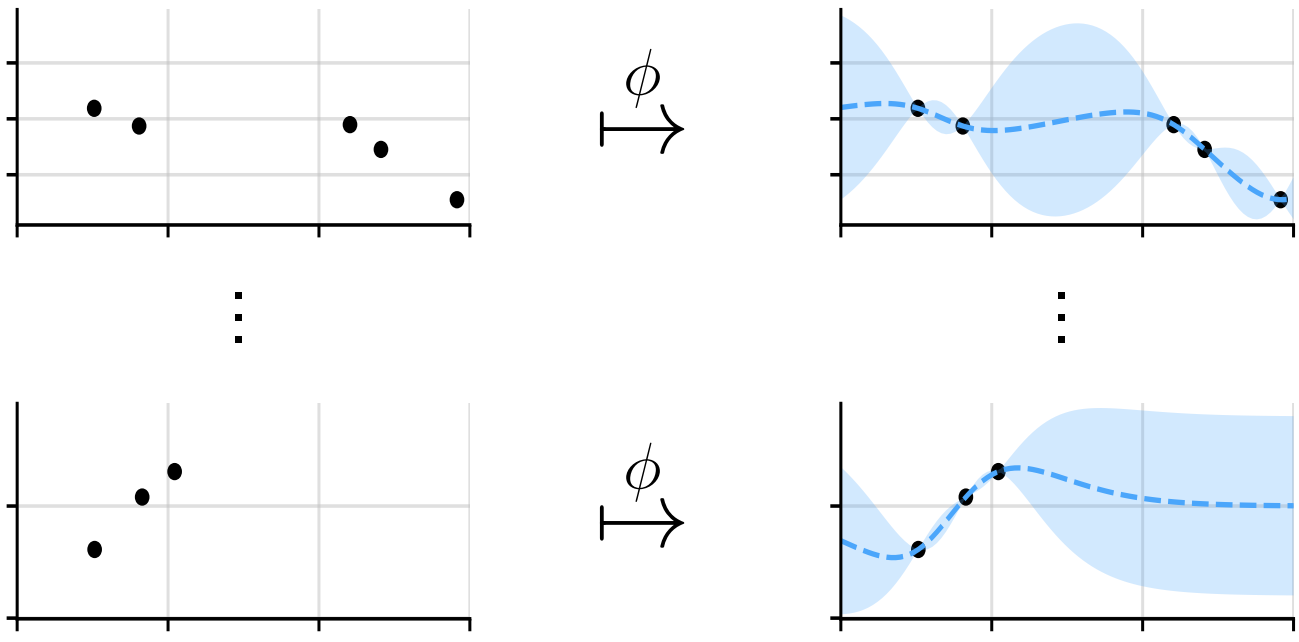
ϕ : data sets $\mathcal{D}$ $\longrightarrow$ predictions $\mathcal{P}$



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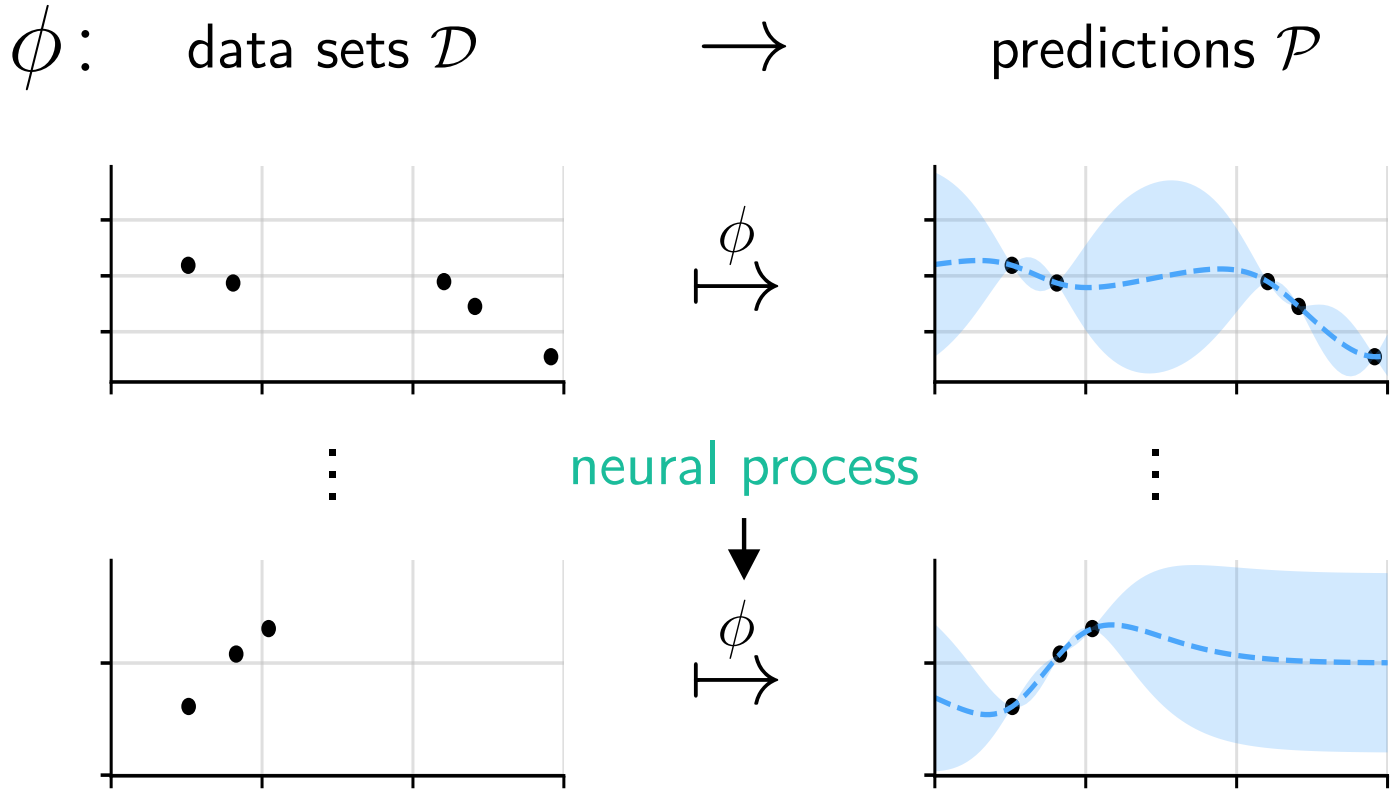

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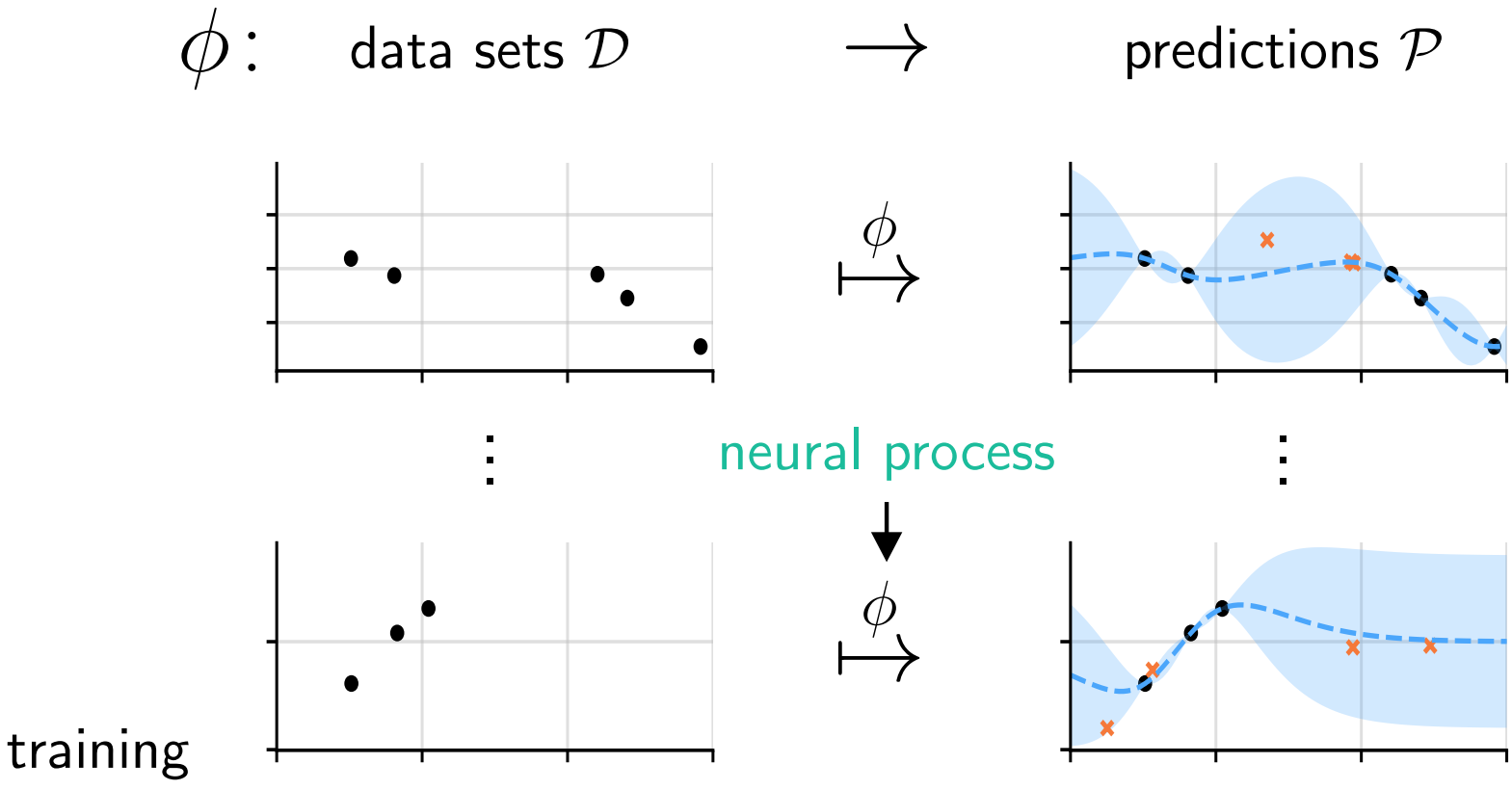

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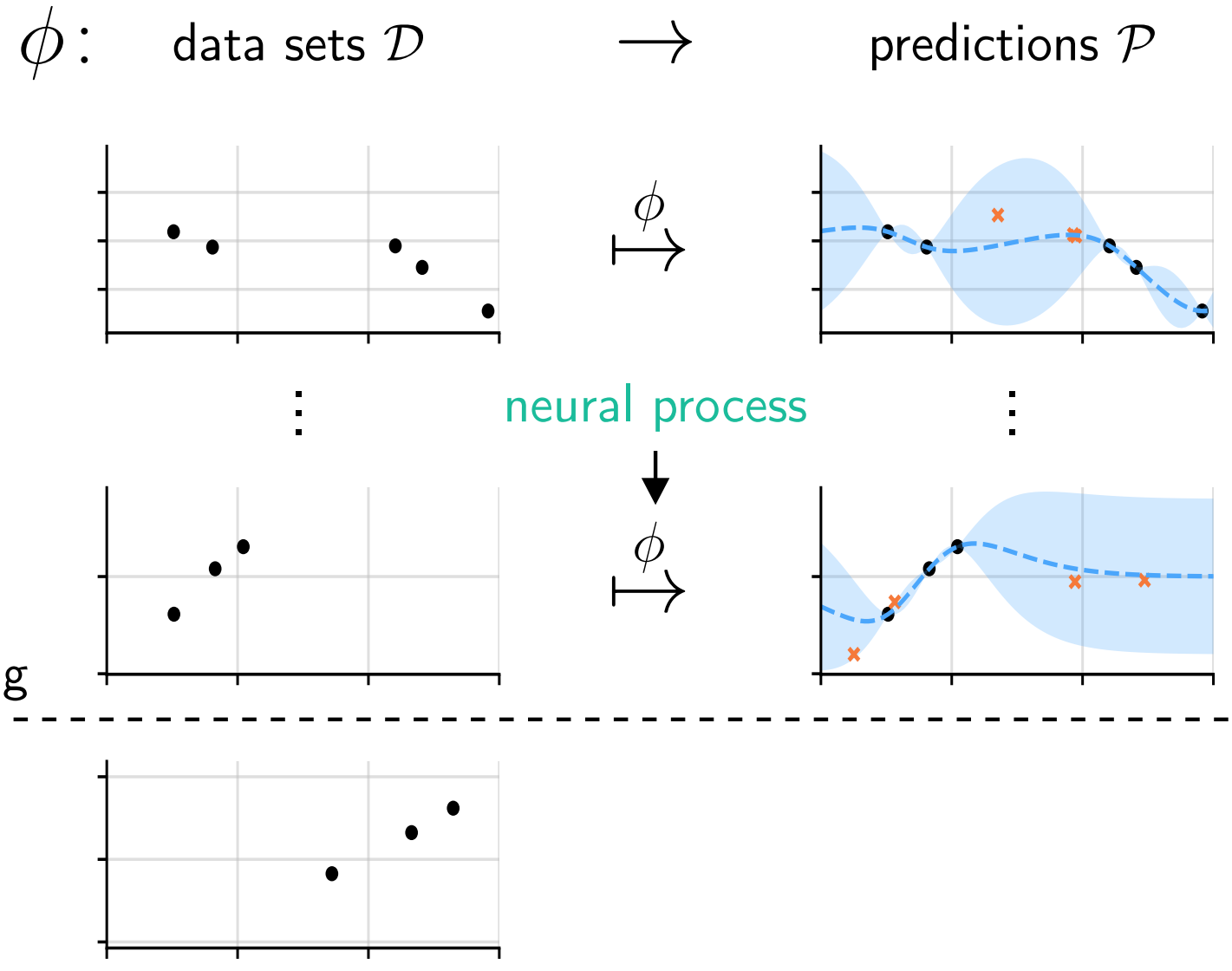

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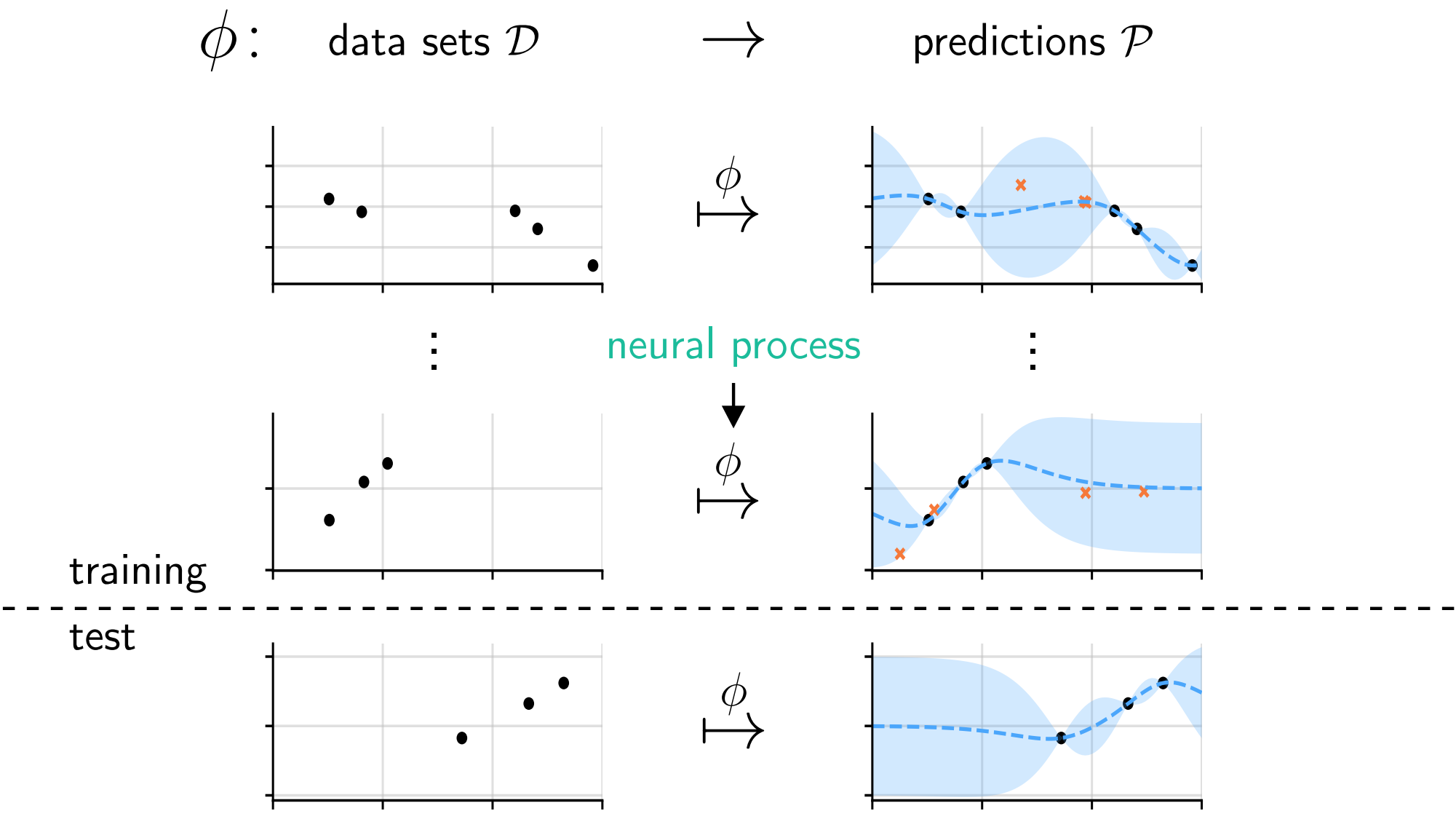

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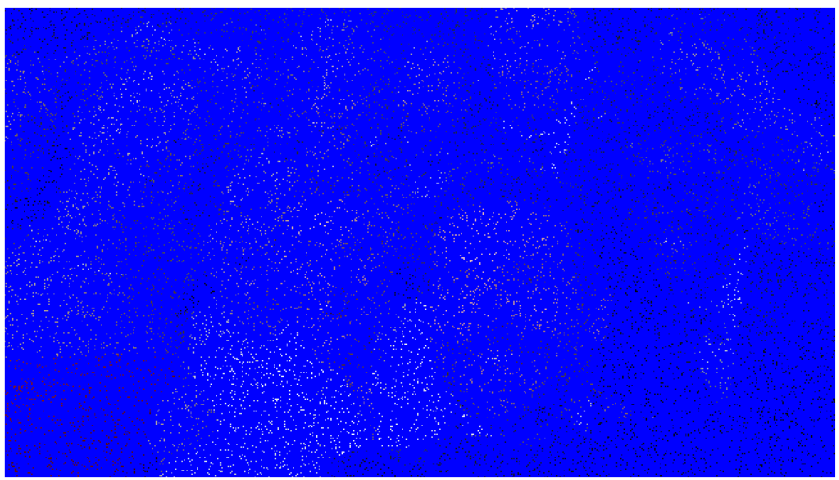

Figure from Gordon et al. (2020).

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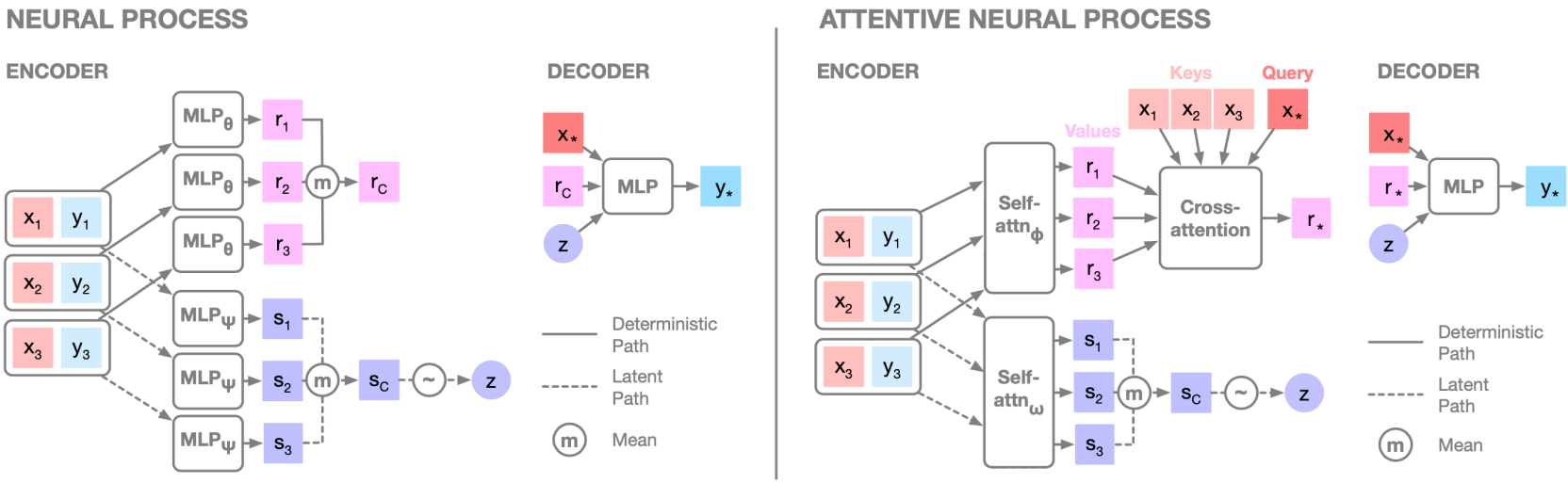

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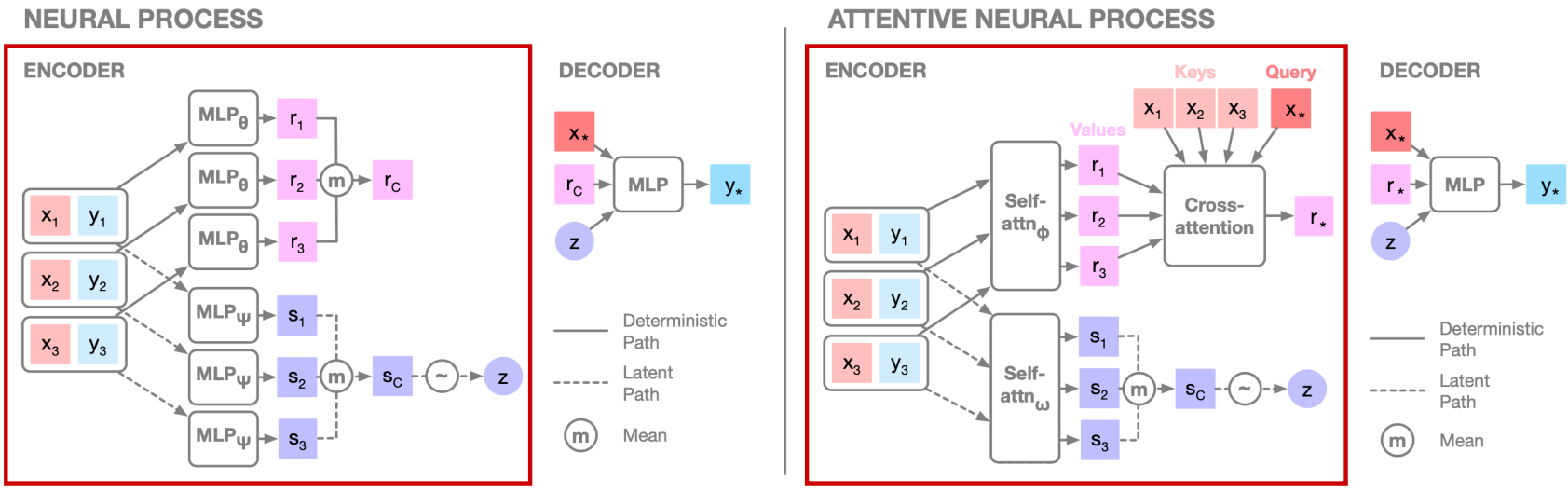

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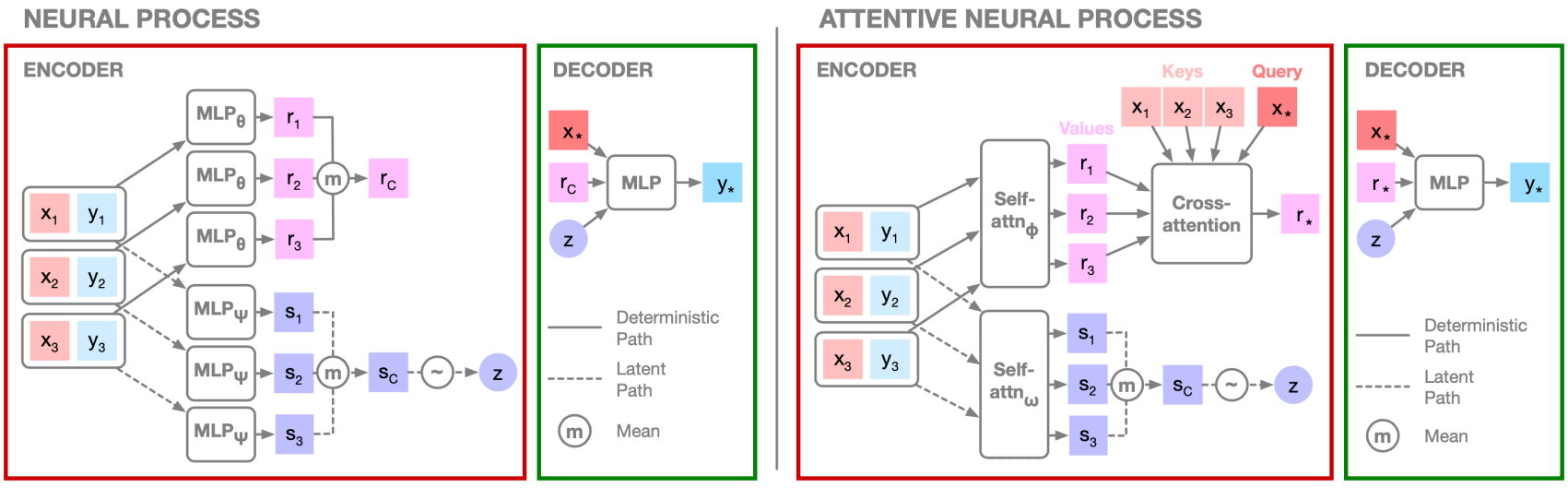

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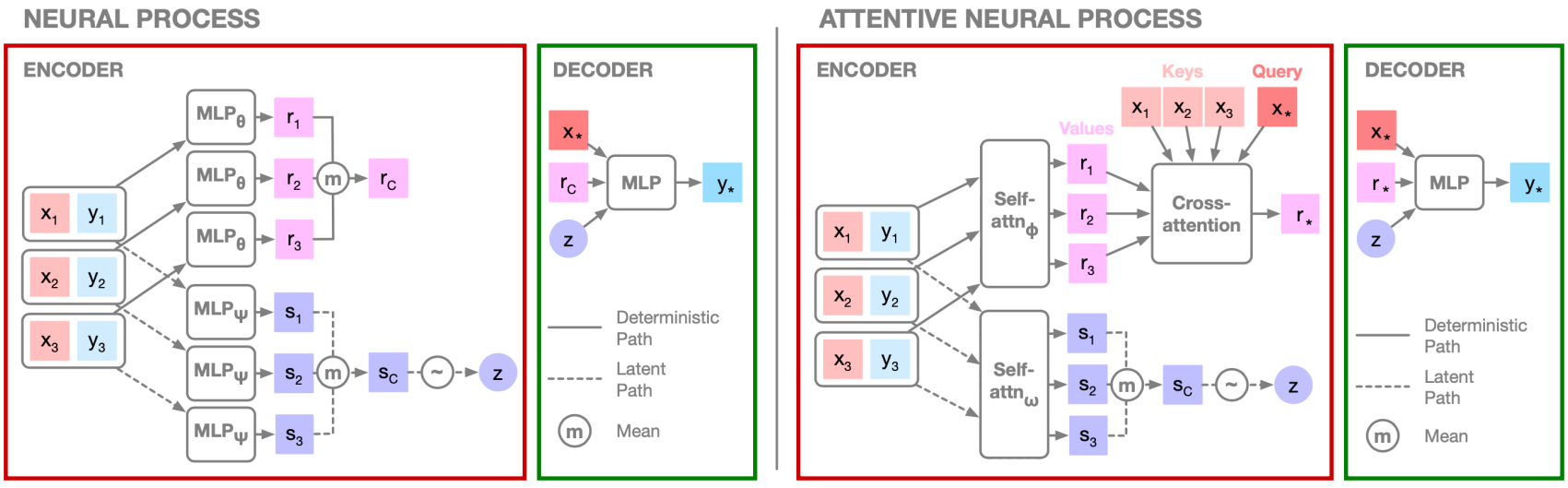

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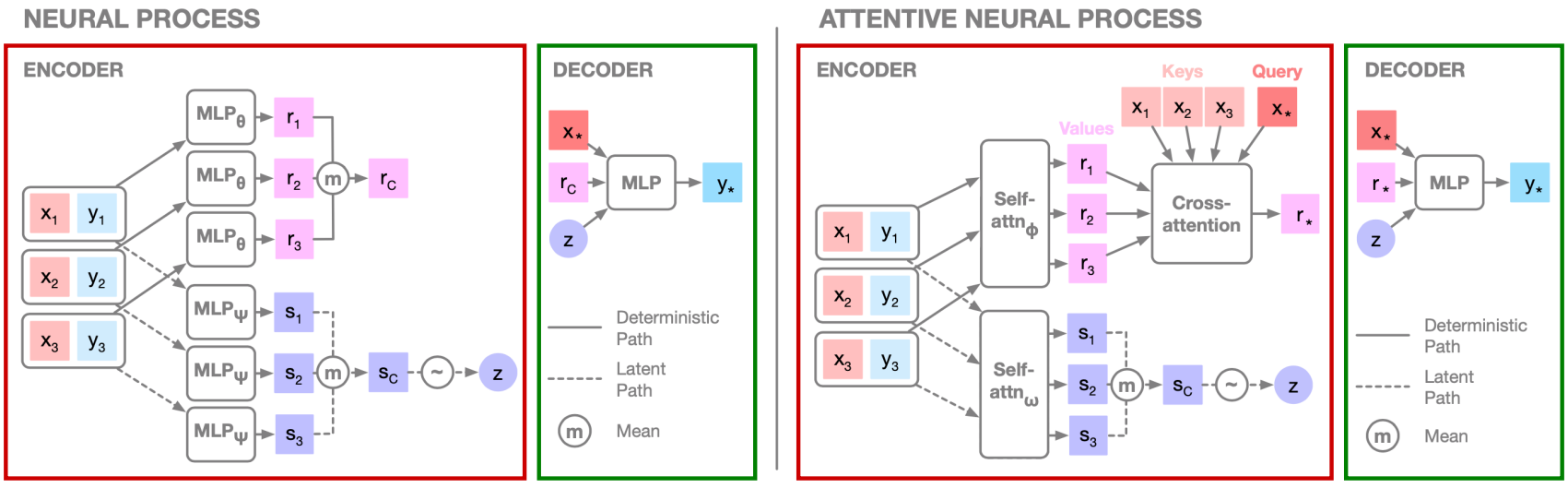

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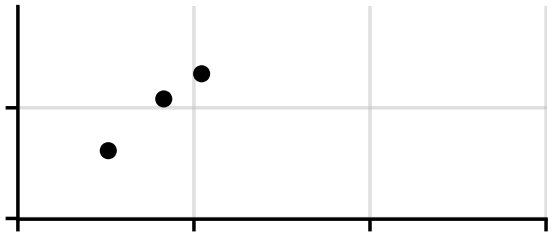
- Implementations similar, but differ in details.
- Calls for a unifying framework: `NeuralProcesses.jl`.

Encoder–Decoder Architectures



$$D = (x_i, y_i)_{i=1}^{n}$$

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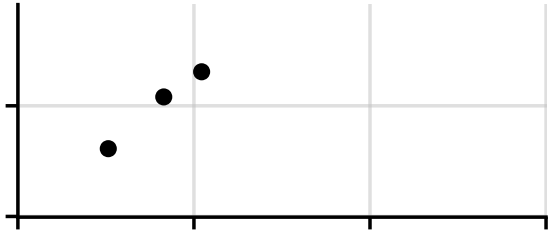

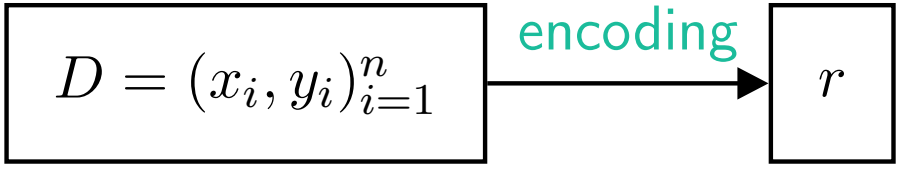

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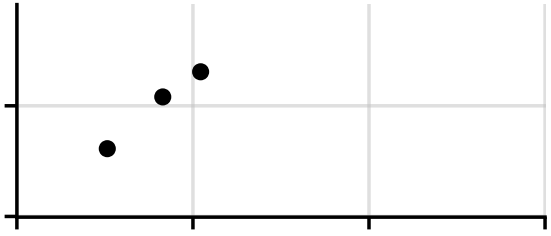

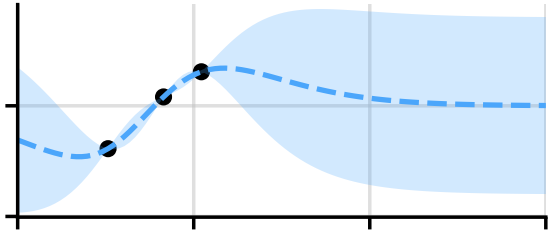

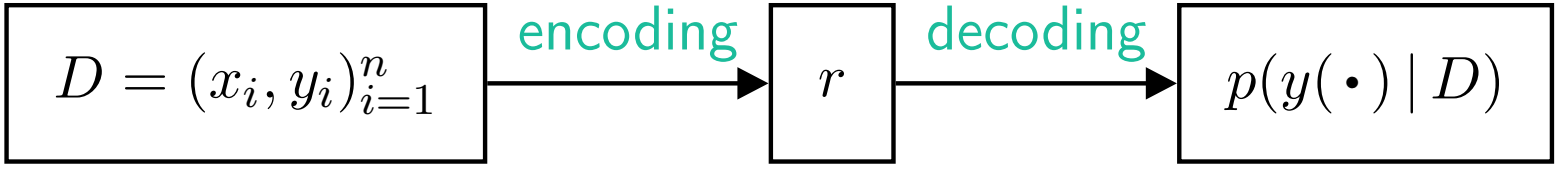

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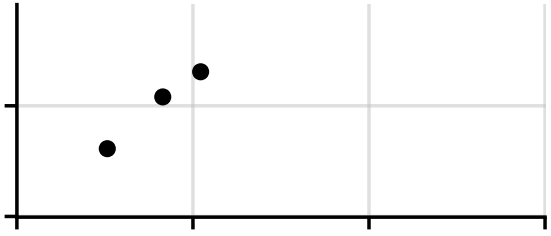

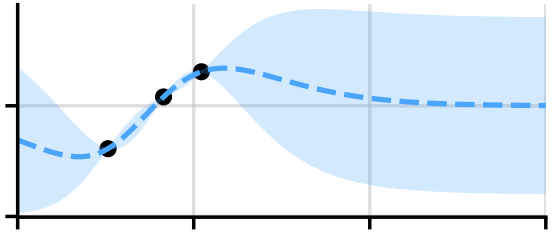

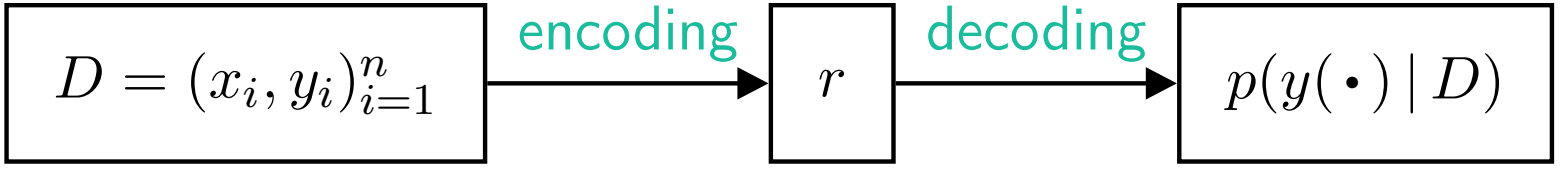

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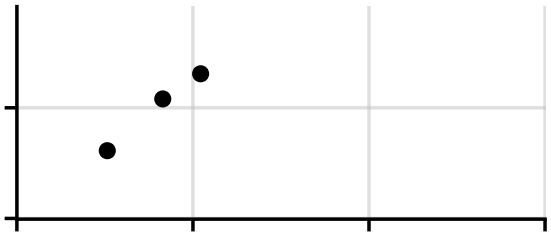

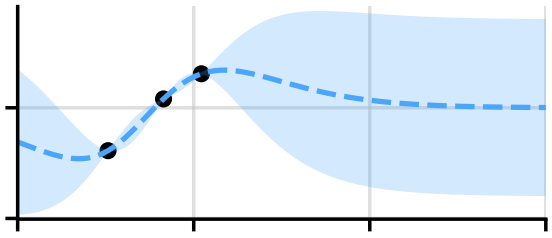

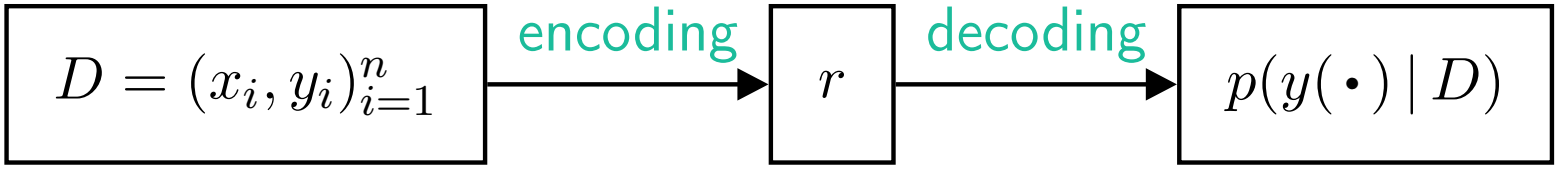

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- Data is a function: $D\colon \{x_1, \ldots, x_n\} \to \{y_1, \ldots, y_n\}$.

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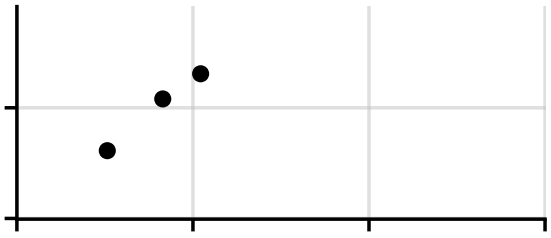

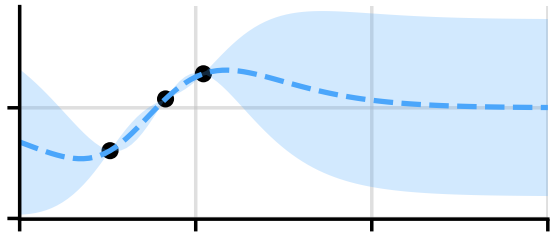

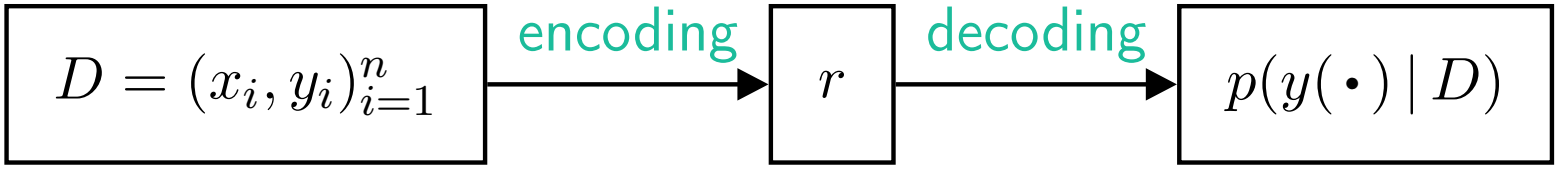

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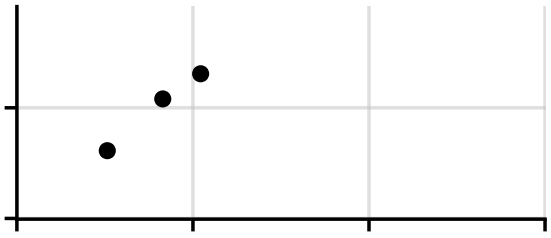

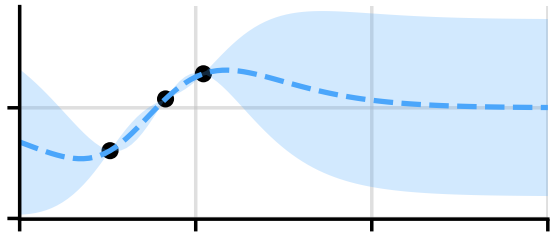

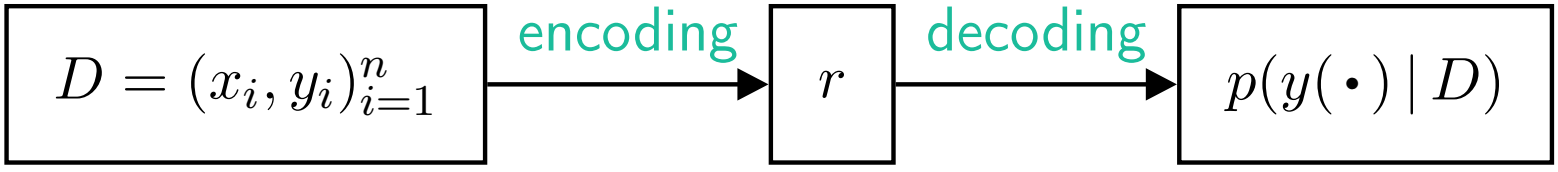

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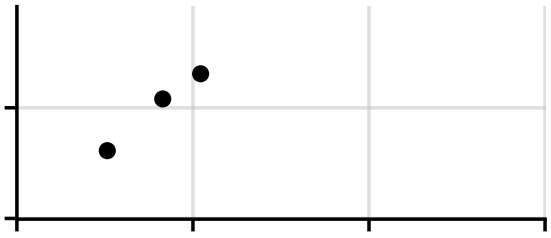

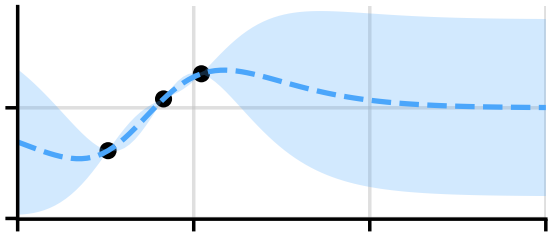

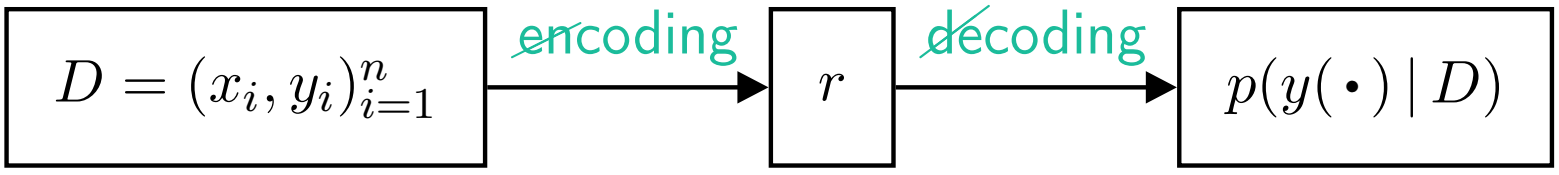

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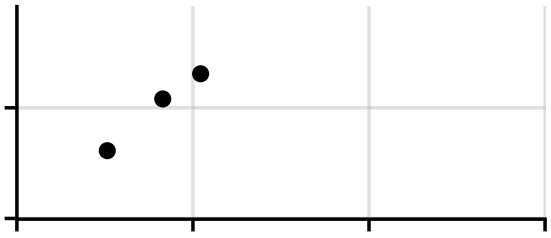

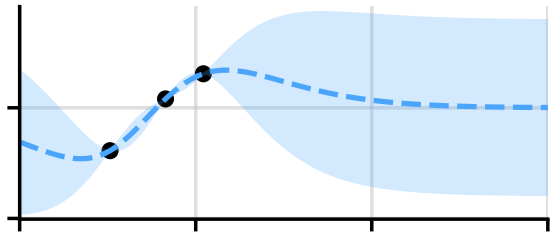

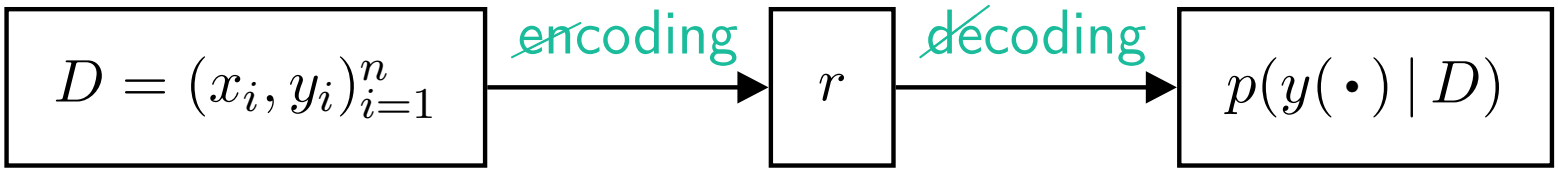

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$\Rightarrow$ fundamental abstraction of `NeuralProcesses.jl`.

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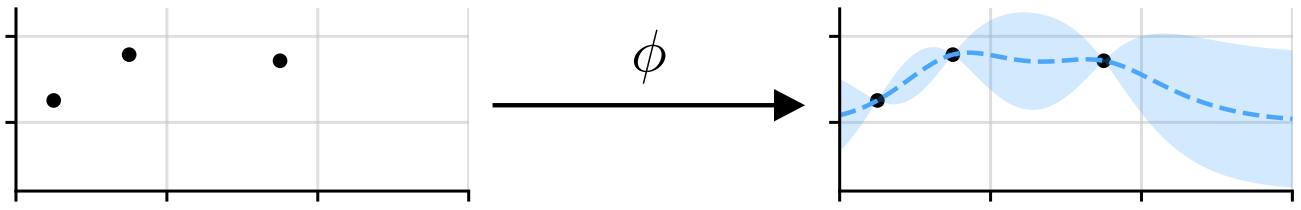

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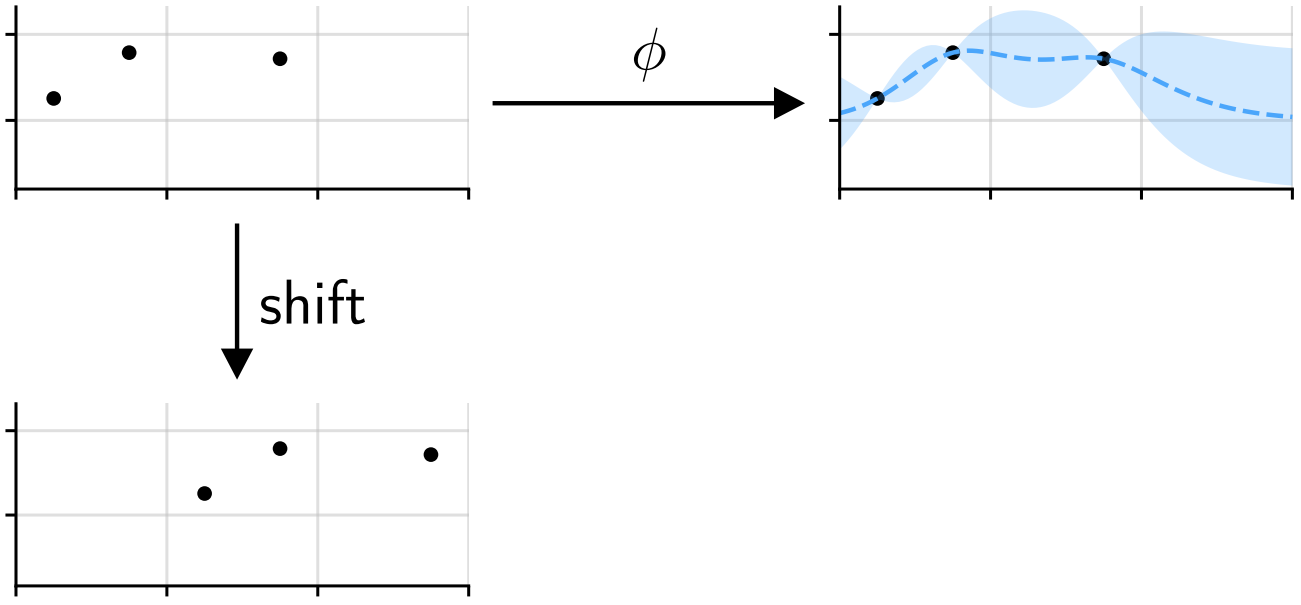

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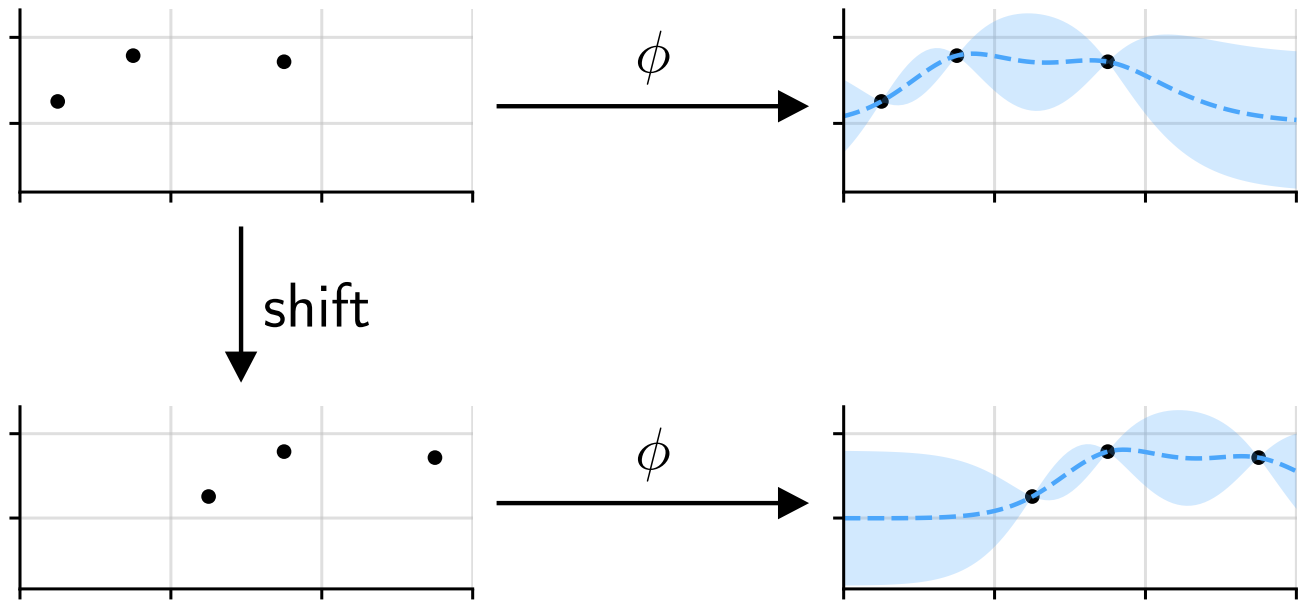

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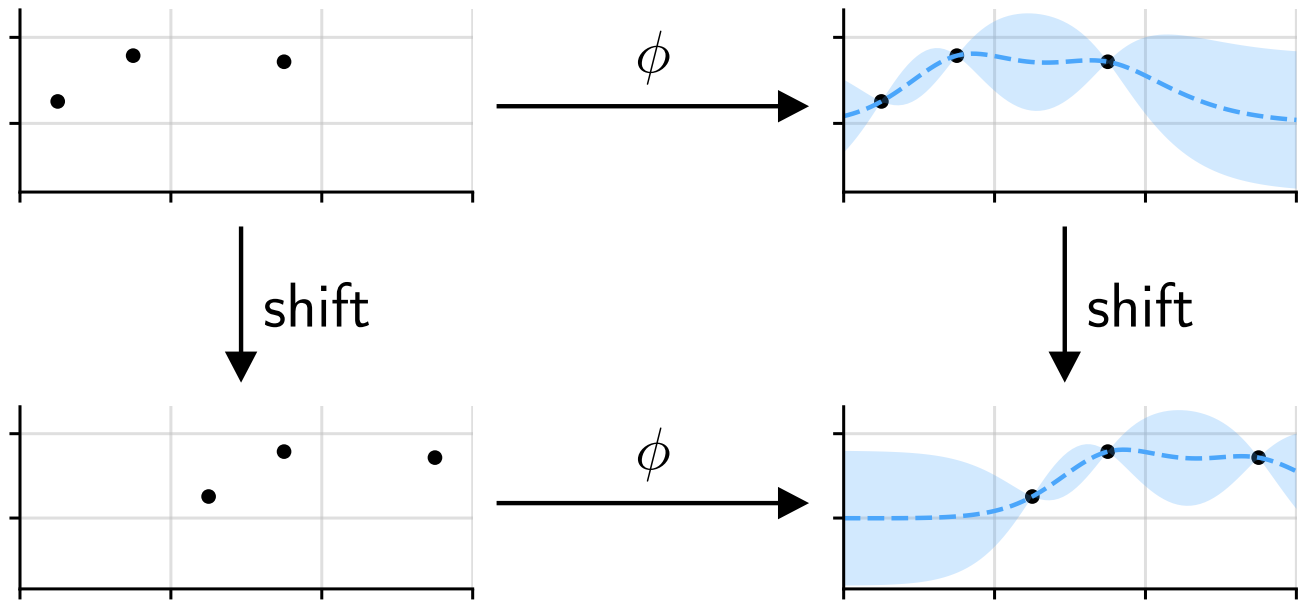

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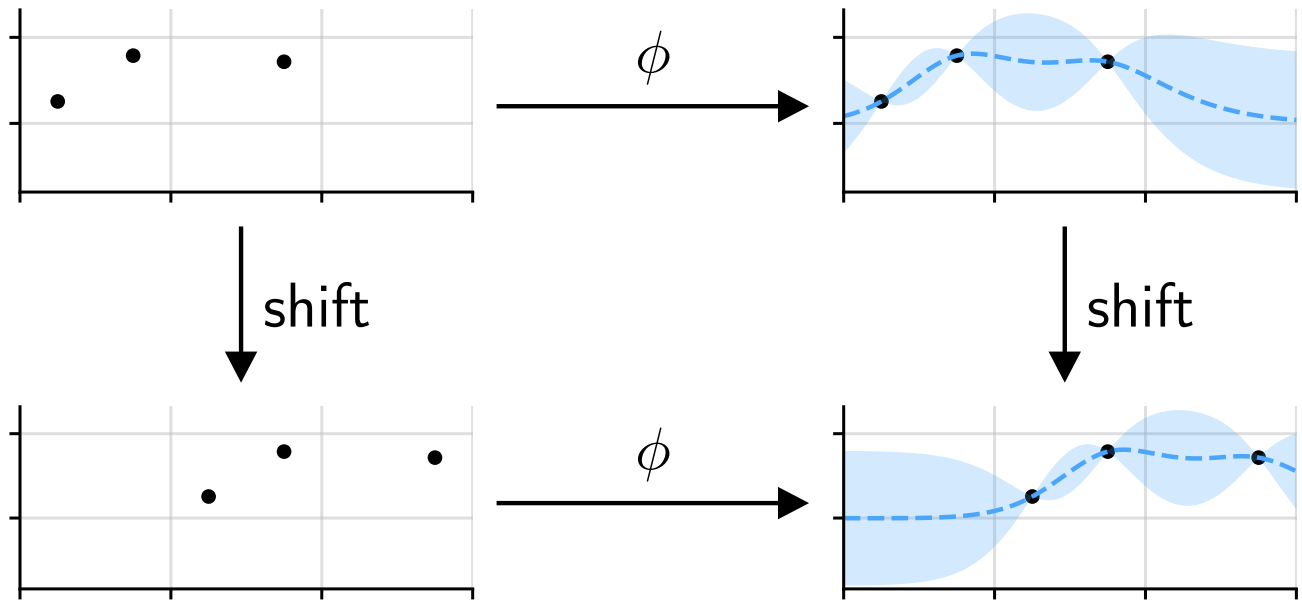
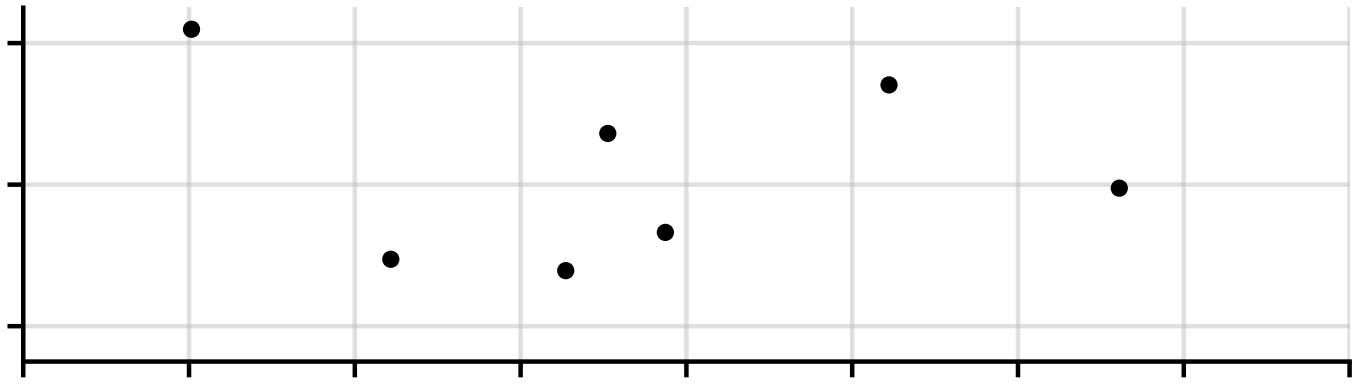


- Leverages the parameter efficiency of CNNs: `Flux.jl`!

The ConvCNP with `NeuralProcesses.jl`



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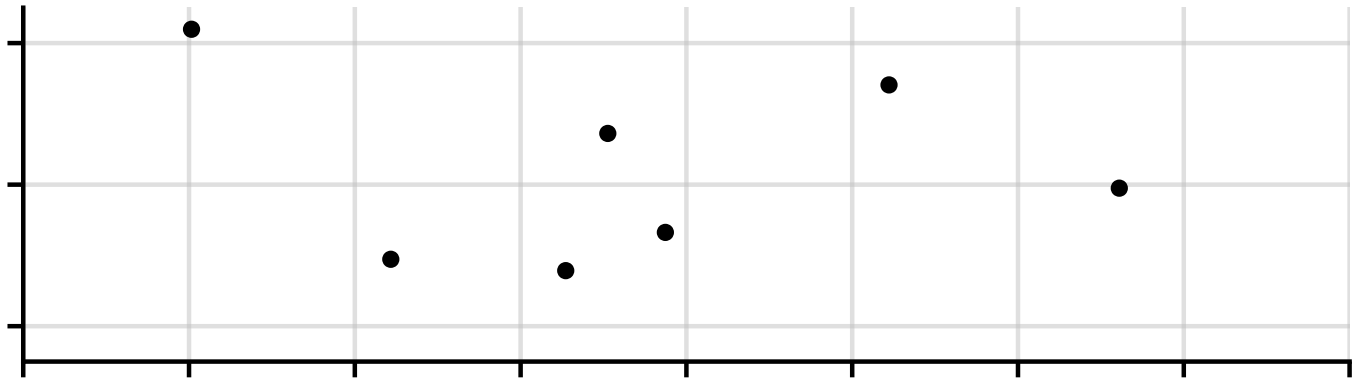

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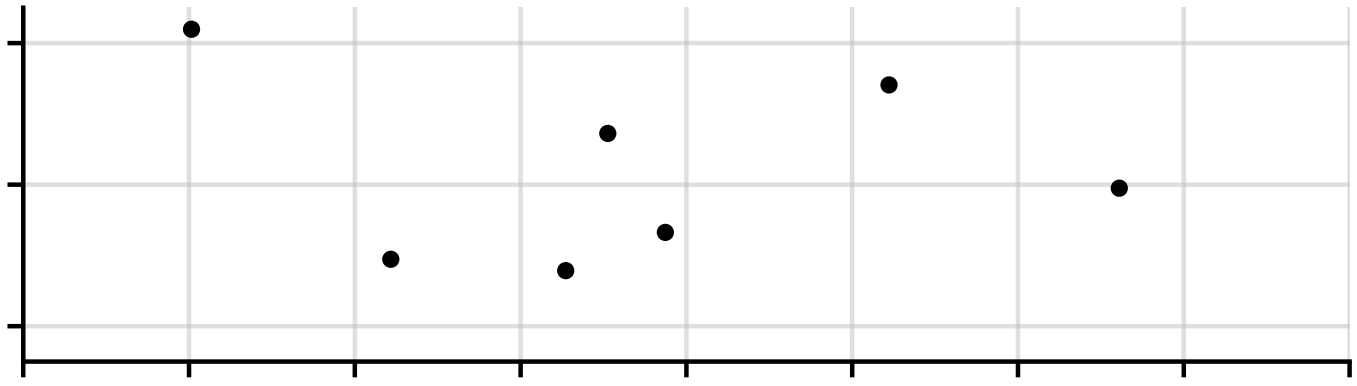

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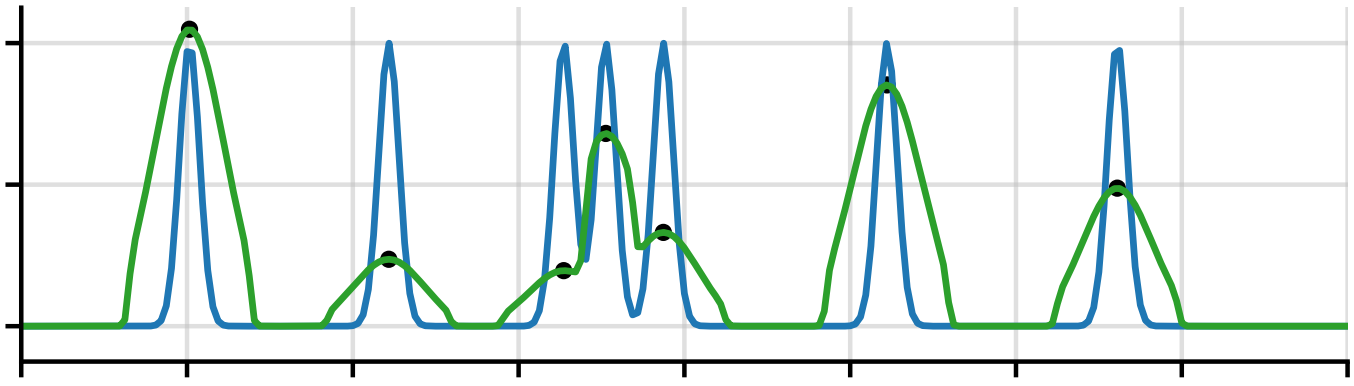

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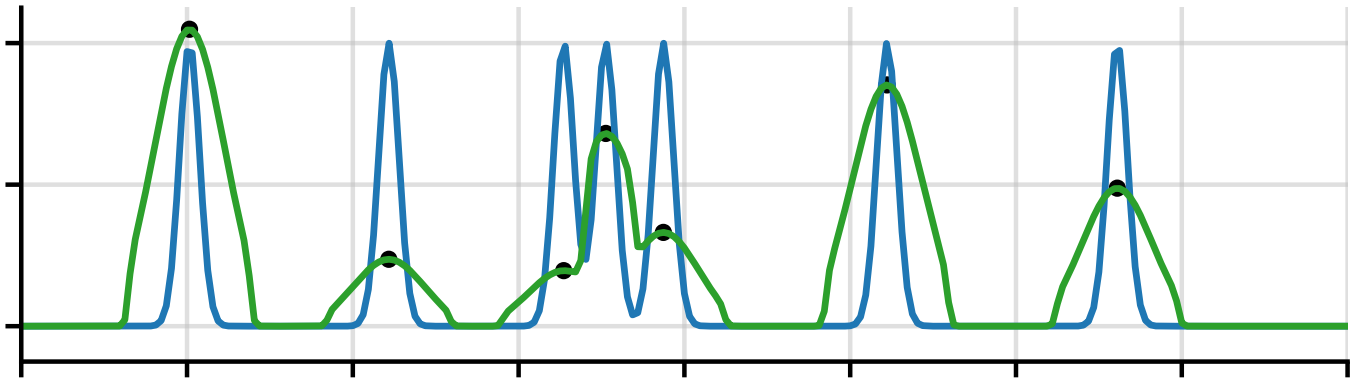

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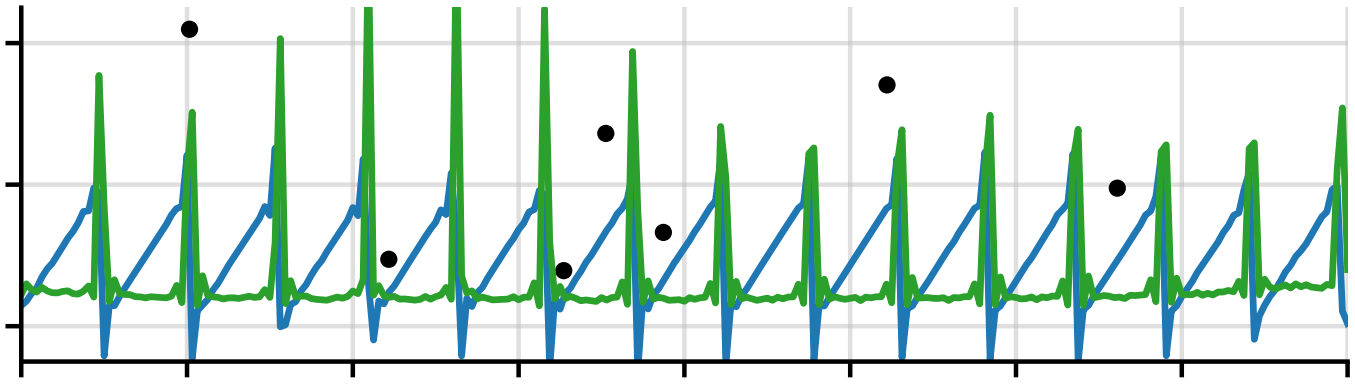

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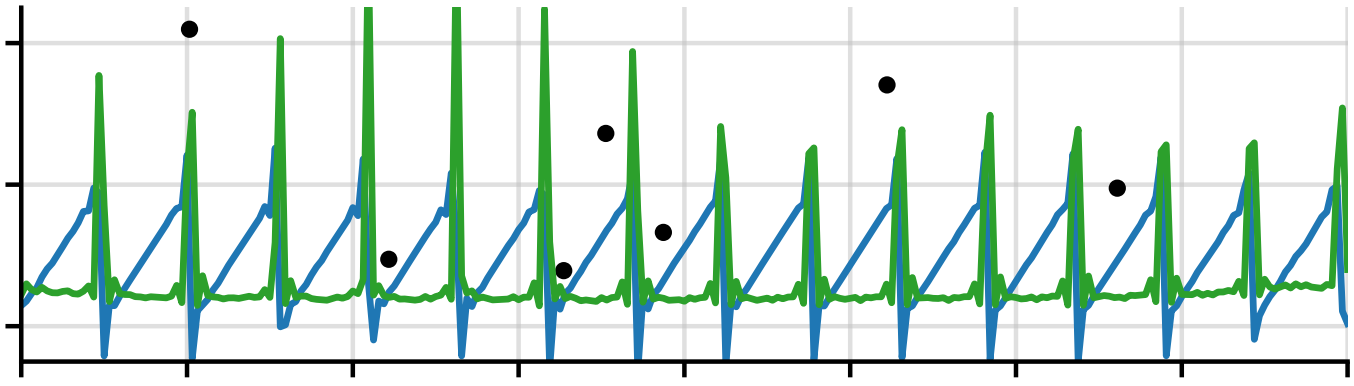
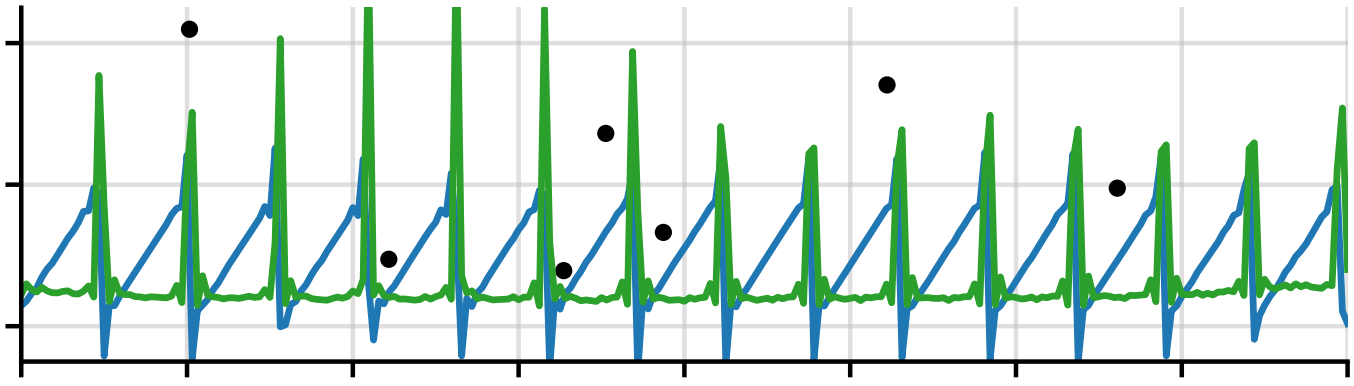
The ConvCNP with `NeuralProcesses.jl`



```
encoder = FunctionalCoder(
    UniformDiscretisation1D(...),
    Chain(
        # See Gordon et al. (2020).
        set_conv(...),
        Deterministic()
    )
)
```

```
decoder = Chain(
    build_conv(...),
    set_conv(...),
    HeterogeneousGaussian()
)
```

The ConvCNP with `NeuralProcesses.jl`



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        # See Gordon et al. (2020).
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    )
)
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```
decoder = Chain(
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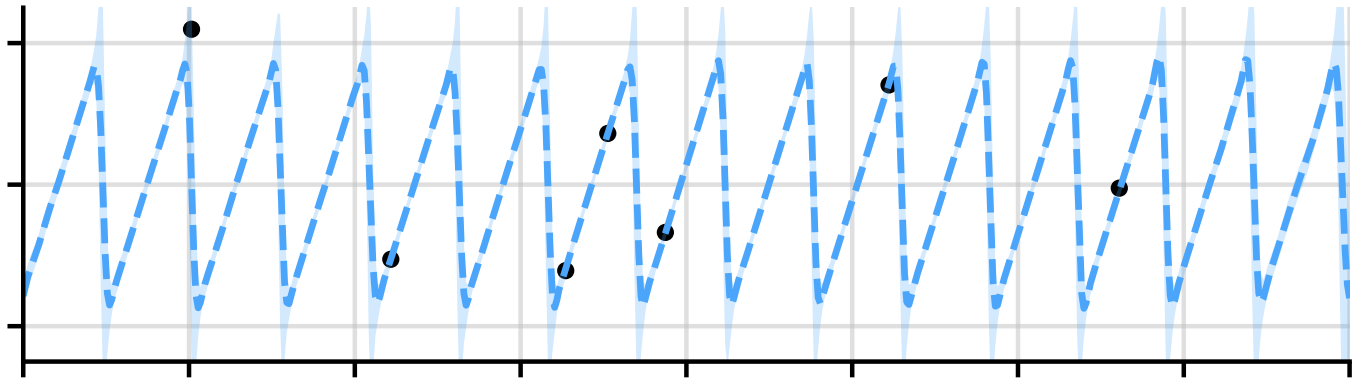
    set_conv(...),
    HeterogeneousGaussian()
)

convcnp = Model(encoder, decoder)
```

The ConvCNP with `NeuralProcesses.jl`



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    UniformDiscretisation1D(...),
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        # See Gordon et al. (2020).
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    )
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    HeterogeneousGaussian()
)

convcnp = Model(encoder, decoder)
```

NeuralProcesses.jl


```
# Gordon et al. (2020)
convcnp = Model(
    FunctionalCoder(
        UniformDiscretisation1D(...),
        Chain(
            set_conv(...),
            Deterministic()
        )
    ),
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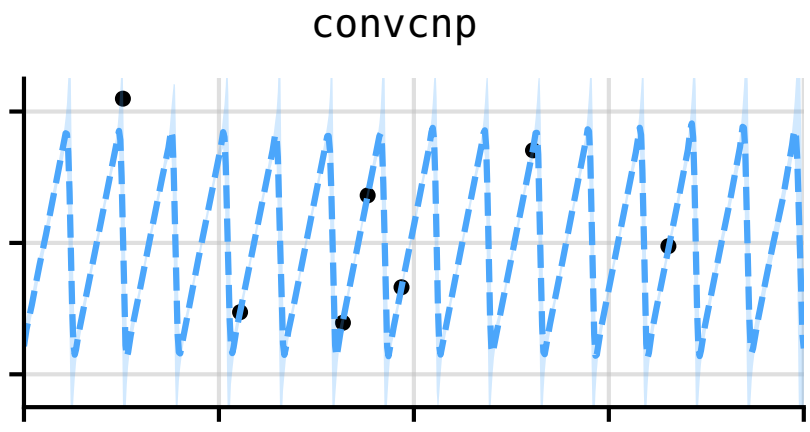
       build_conv(...),
       set_conv(...),
       HeterogeneousGaussian()
    )
)
```



NeuralProcesses.jl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# Gordon et al. (2020)
convcnp = Model(
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        UniformDiscretisation1D(...),
        Chain(
            set_conv(...),
            Deterministic()
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       set_conv(...),
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    )
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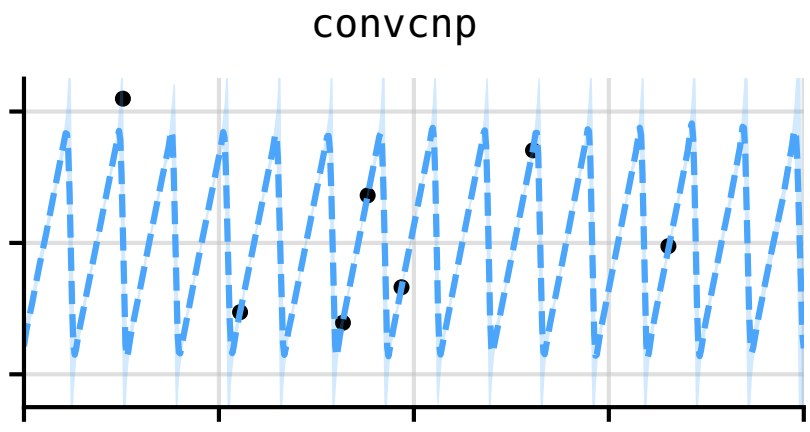

NeuralProcesses.jl


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# Foong et al. (2020)
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            build_conv(...),
            HeterogeneousGaussian()
        )
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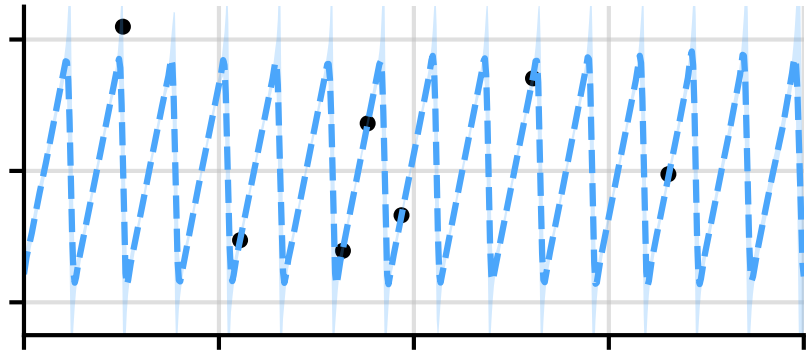
       build_conv(...),
       set_conv(...),
       HeterogeneousGaussian()
    )
)
```

convcnp



NeuralProcesses.jl


```
# Foong et al. (2020)
convnp = Model(
    FunctionalCoder(
        UniformDiscretisation1D(...),
        Chain(
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        )
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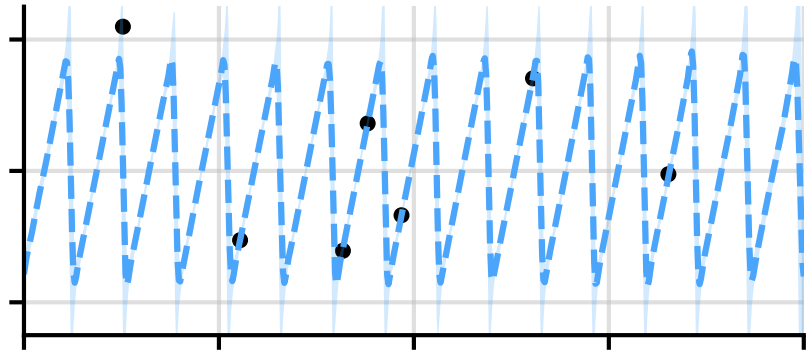
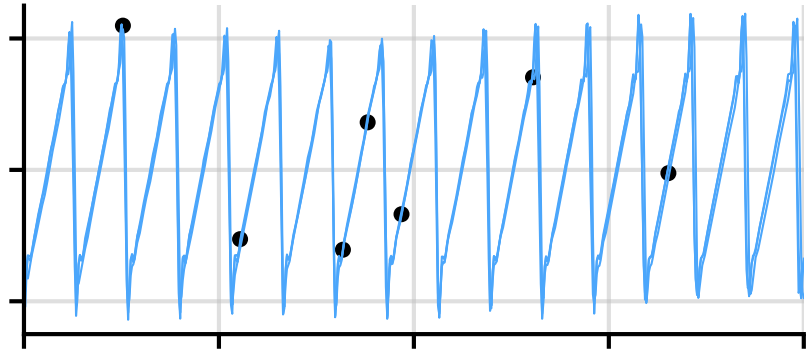
       HeterogeneousGaussian()
    )
)
```

convcnp



convnp



NeuralProcesses.jl


```
# Foong et al. (2020)
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        UniformDiscretisation1D(...),
        Chain(
            set_conv(...),
            build_conv(...),
            HeterogeneousGaussian()
        )
    ),
    Chain(
       build_conv(...),
       set_conv(...),
       HeterogeneousGaussian()
    )
)
```

- Composable building blocks

NeuralProcesses.jl


```
# Garnelo et al. (2018)
np = Model(
    Parallel(
        Chain(
           InputsEncoder(),
           Deterministic()
        ),
        Chain(
           MLPEncoder(...),
           Deterministic()
        ),
        Chain(
           MLPEncoder(...),
           HeterogeneousGaussian()
        )
    ),
    Chain(
       Materialise(),
       batched_mlp(...),
       HeterogeneousGaussian()
    )
)
```

- Composable building blocks

NeuralProcesses.jl


```
# Garnelo et al. (2018)
np = Model(
    Parallel(
        Chain(
           InputsEncoder(),
           Deterministic()
        ),
        Chain(
           MLPEncoder(...),
           Deterministic()
        ),
        Chain(
           MLPEncoder(...),
           HeterogeneousGaussian()
        )
    ),
    Chain(
       Materialise(),
       batched_mlp(...),
       HeterogeneousGaussian()
    )
)
```

- Composable building blocks
- Use `Chain` and `Parallel` to glue things together

NeuralProcesses.jl


```
# Garnelo et al. (2018)
np = Model(
    Parallel(
        Chain(
            InputsEncoder(),
            Deterministic()
        ),
        Chain(
            MLPEncoder(...),
            Deterministic()
        ),
        Chain(
            MLPEncoder(...),
            HeterogeneousGaussian()
        )
    ),
    Chain(
        Materialise(),
        batched_mlp(...),
        HeterogeneousGaussian()
    )
)
```

- Composable building blocks
- Use `Chain` and `Parallel` to glue things together
- Inference and learning are automatic

NeuralProcesses.jl


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        ),
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        ),
        Chain(
            MLPEncoder(...),
            HeterogeneousGaussian()
        )
    ),
    Chain(
        Materialise(),
        batched_mlp(...),
        HeterogeneousGaussian()
    )
)
```

- Composable building blocks
- Use `Chain` and `Parallel` to glue things together
- Inference and learning are automatic

NeuralProcesses.jl


```
# Kim et al. (2019)
anp = Model(
    Parallel(
        Chain(
            InputsEncoder(),
            Deterministic()
        ),
        Chain(
            attention(...),
            Deterministic()
        ),
        Chain(
            MLPEncoder(...),
            HeterogeneousGaussian()
        )
    ),
    Chain(
        Materialise(),
        batched_mlp(...),
        HeterogeneousGaussian()
    )
)
```

- Composable building blocks
- Use `Chain` and `Parallel` to glue things together
- Inference and learning are automatic

NeuralProcesses.jl


```
# Kim et al. (2019)
anp = Model(
    Parallel(
        Chain(
            InputsEncoder(),
            Deterministic()
        ),
        Chain(
            attention(...),
            Deterministic()
        ),
        Chain(
            MLPEncoder(...),
            HeterogeneousGaussian()
        )
    ),
    Chain(
        Materialise(),
        batched_mlp(...),
        HeterogeneousGaussian()
    )
)
```

- Composable building blocks
- Use `Chain` and `Parallel` to glue things together
- Inference and learning are automatic

Thank you for listening :)

Appendix

References

Foong, A. Y. K., Bruinsma, W. P., Gordon, J., Dubois, Y., Requeima, J., & Turner, R. E. (2020). Meta-learning stationary stochastic process prediction with convolutional neural processes. *arXiv preprint arXiv:2007.01332*. eprint: https://arxiv.org/abs/2007.01332

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