Variational autoencoders for artefact detection and imputation in physiological signals

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Big Data in the Intensive Care Unit

- ICU is data-dense with constant patient monitoring
- Attributes of big data: volume, variety, velocity, veracity

Physiological signals:

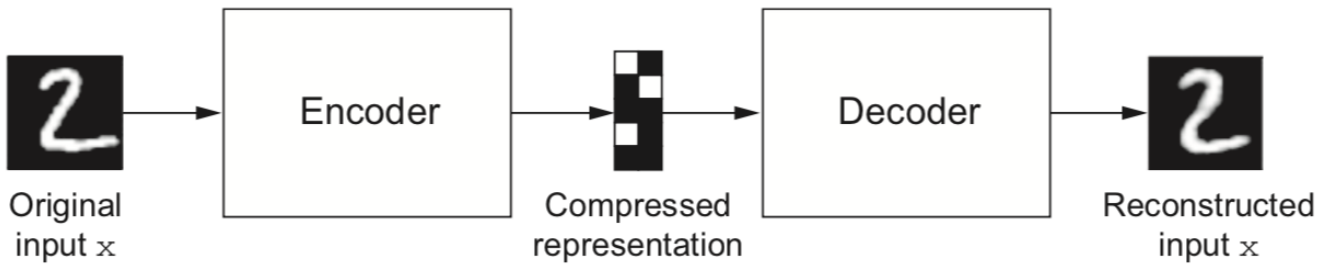
- e.g. arterial blood pressure (ABP), intracranial pressure (ICP)
- Basis for clinical care and research

Broad goal:

- Transforming data so it's more interpretable/useful for clinicians

Autoencoders

- Network maps inputs to themselves (self-supervised learning) through an 'information bottleneck' lower-dim latent space



- Maximum likelihood problems: fragility, overconfidence

Bayesian learning

Bayesian learning

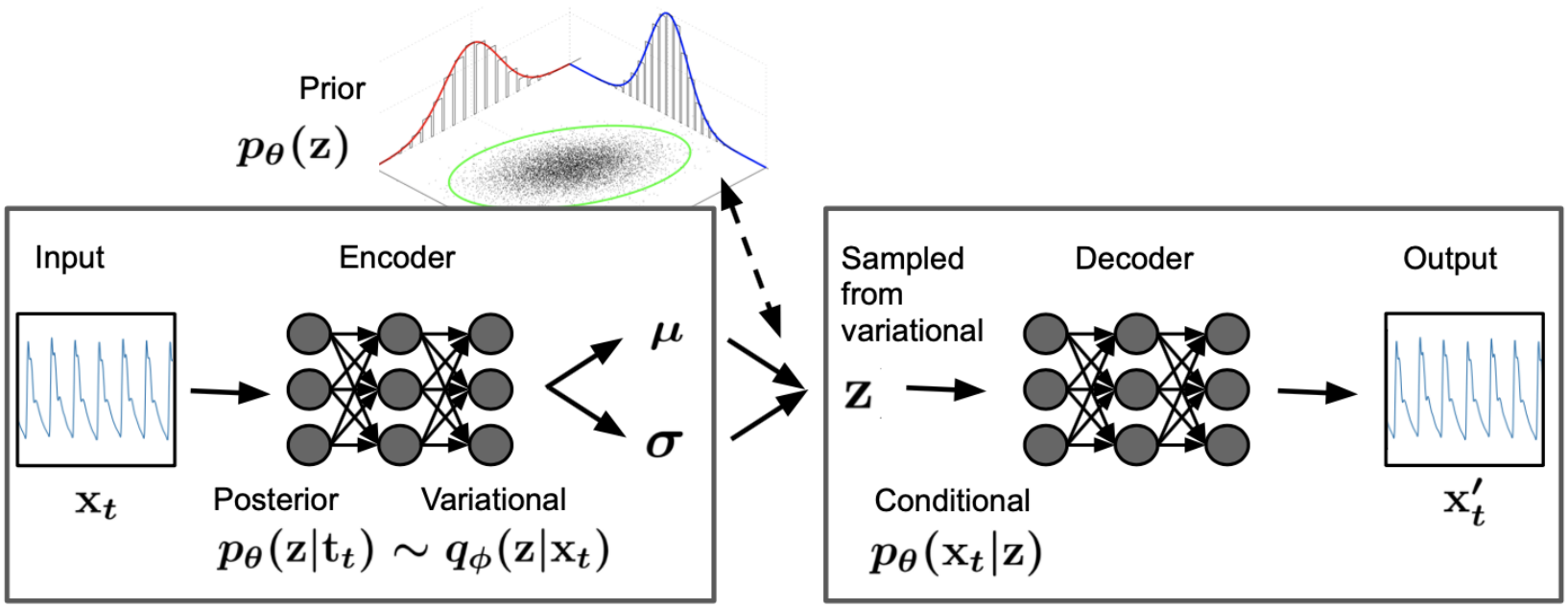
$$p(\theta|\mathcal{X},\mathcal{Y}) = \frac{1}{p(\mathcal{Y}|\mathcal{X})} p(\theta) p(\mathcal{Y}|\mathcal{X},\theta)$$

- Distribution rather than point estimate, so gain uncertainty
- Fundamental flaw: posterior (and marginal) intractable
- Variational Bayes: optimising an approximation to posterior

Autoencoding Bayes: a Variational Autoencoder

Probabilistic autoencoder:

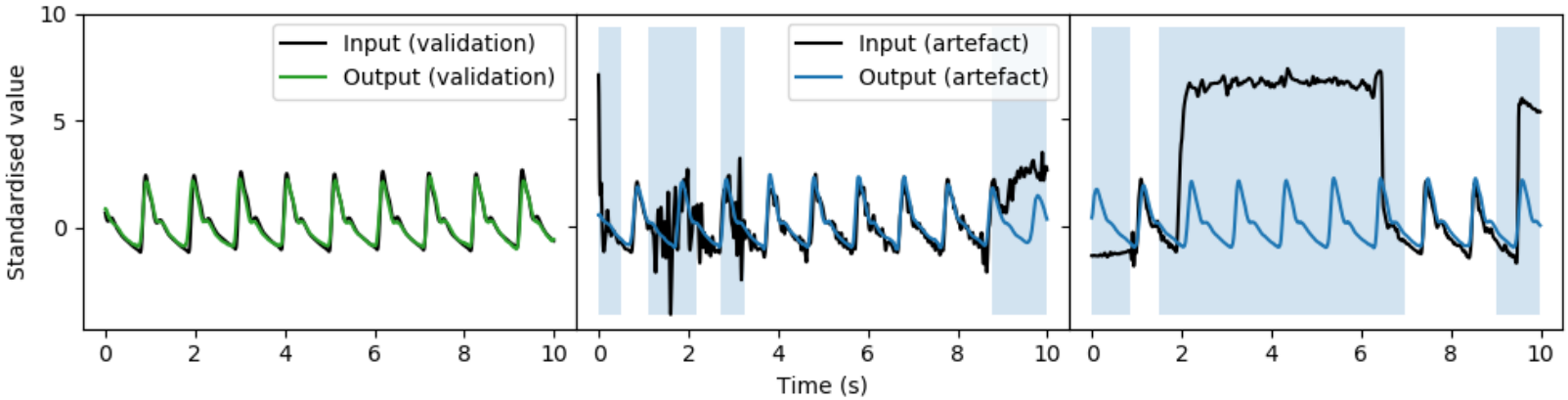
- Assume the data generated by a random process, dependent on unobserved variables (features) $\mathbf{z}$ and distribution $p_\theta(\mathbf{x}_t|\mathbf{z})$



Motivation and Results

Problems: detection of artefacts, imputation of missing data

- Critical in alerting, derived measures associated with outcome



Variational autoencoder approach

- No explicit training for artefact detection
- Input containing artefact has low reconstruction prob/high error
- Sampling from latent distribution to generate synthetic data
- Self-supervised: does not require costly human annotation

Acknowledgements and References

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[1] J. V. Stone, *Artificial Intelligence Engines: A Tutorial Introduction to the Mathematics of Deep Learning*. Sebtel Press, Apr. 2019.

[2] D. P. Kingma and M. Welling, "Auto-Encoding Variational Bayes," *arXiv*, Dec. 2013.