# Notes on Variational Autoencoders

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## Introductory Notes

*Generative modeling* is a broad area of machine learning which deals with the models of distributions , defined over datapoints in some potentially high-dimensional space . For instance, images are a popular kind of data for which we might create generative models. Each “datapoint” (image) has thousands or millions of dimensions (pixels), and the generative model’s job is to somehow capture the dependencies between pixels, e.g., that nearby pixels have similar color, and are organized into objects. Exactly what it means to “capture” these dependencies depend on exactly what we want to do with the model. One kind of generative model simply allows us to compute numerically. In the case of images, values which look like real images should get high probability, whereas images that look like random noise should get low probability. However, models like this are not necessarily useful: knowing that one image is unlikely does not help us synthesize one that is likely.

Instead, one often cares about producing more examples that are *like* those already in a database, but not exactly the same. We could start with a database of raw images and synthesize new, unseen images. We could start with database of raw images and synthesize new, unseen images. We might take in a database of 3D models of something like plants and produce more of them to fill a forest in a video game. We could take handwritten text and try to produce more handwritten text. We can formalize this setup by saying that we get examples distributed according to some unknown distribution , and our goal is to learn a model which we can sample from, such that P is as similar as possible to .

Training this type of model has been a long-standing problem in the machine learning community and most approaches before variational autoencoders have had one of three serious drawbacks.

*First*, they might require strong assumptions about the nature of the data. *Second*, they might make severe approximations leading to suboptimal models. *Third*, they might rely on computationally expensive inference procedures like Markov Chain Monte Carlo.

## Preliminaries: Latent Variable Models

## Appendix

## References

[Tutorial on Variational Autoencoders, Carl Doersch, Carnegie Mellon, UC Berkeley, 2021](https://github.com/dimitarpg13/information_theory_and_statistical_mechanics/blob/main/literature/articles/variational_autoencoders/Tutorial_on_Variational_Autoencoders_Doersch_2021.pdf)

[Introduction to Variational Autoencoders, Diedrik P. Kingma, Max Welling, 2019](https://github.com/dimitarpg13/information_theory_and_statistical_mechanics/blob/main/literature/articles/variational_autoencoders/An_Introduction_to_Variational_Autoencoders_Kingma_2019.pdf)

[Auto-Encoding Variational Bayes, Diedrik P. Kingma, Max Welling, 2022](https://github.com/dimitarpg13/information_theory_and_statistical_mechanics/blob/main/literature/articles/variational_autoencoders/Auto-Encoding_Variational_Bayes_Kingma_2022.pdf)