# Utilizing variational autoencoders in the Bayesian inverse problem of photoacoustic tomography

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## Abstract

Photoacoustic tomography (PAT) is a biomedical imaging modality based on the photoacoustic effect. In PAT, the imaged target is illuminated with a short pulse of light. Absorption of light creates localized areas of thermal expansion, resulting an increase of pressure. This initial pressure distribution relaxes as ultrasound waves that are measured on the boundary of the target. In the inverse problem of PAT, the initial pressure distribution is estimated from a set of measured ultrasound data.

In PAT, machine learning has been applied to a wide range of problems such as pre- and post processing, and partially or fully solving the inverse problem. However, as with conventional reconstruction approaches, most of the machine learning based approaches provide images of the underlying initial pressure distribution but do not offer insight in quantifying the reliability of the solution. In this work, we study a machine learning based approach to the Bayesian inverse problem of PAT [1]. The approach is based on the variational autoencoder (VAE) and the recently proposed extension to the VAE called the uncertainty quantification VAE (UQ-VAE) [2]. The proposed method provides photoacoustic images together with estimates of their reliability taking into account measurement noise, forward model and prior distribution. The approach is studied using 2D simulations and the results are compared to the solution of the Bayesian inverse problem of PAT.

[1] T. Sahlström and T. Tarvainen, Utilizing variational autoencoders in the Bayesian inverse problem of photoacoustic tomography, *SIAM Journal on Imaging Sciences*, Accepted for publication (2022).

[2] H. Goh, S. Sheriffdeen, J. Wittmer, and T. Bui-Thanh, Solving bayesian inverse problems via variational autoencoders, *Proceedings of Machine Learning Research*, 145:386–425, 2021.