UNIVERSITÀ
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Bayesian Convolutional neural network

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Probabilistic Machine Learning
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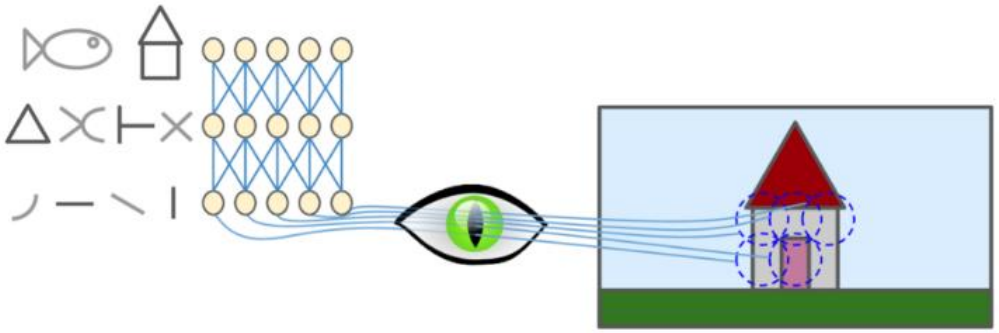
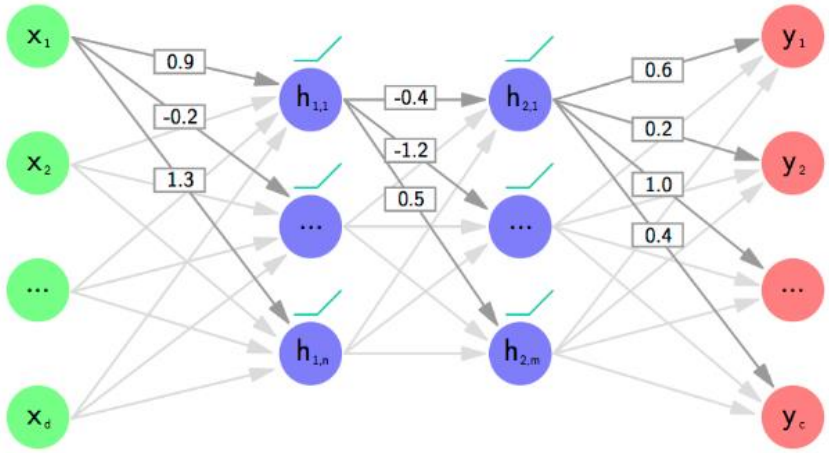
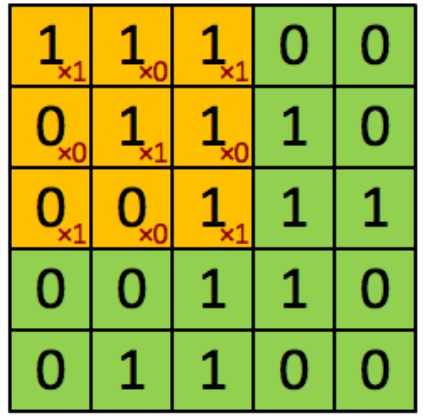
Introduction

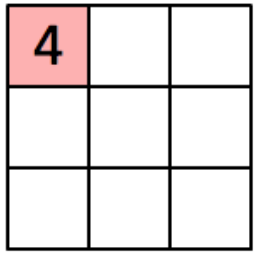
- Artificial Neural Networks
- Layers
- MLP vs Convolutional neural networks
- Convolution Layer







Image



Convolved Feature

The Probabilistic Approach

- Variational Inference
  - The predictive distribution

$$p(y^*|x^*, X, Y) = \int p(y^*|f^*)p(f^*|x^*, w)p(w|X, Y)df^*dw.$$

  - The KL divergence

$$q(y^*|x^*) = \int p(y^*|f^*)p(f^*|x^*, w)q(w)df^*dw.$$

  - Minimising the KL divergence is equivalent to maximising the log evidence lower bound

$$KL_{VI} := \int q(w)p(F|X, w)\log p(Y|F)dFdw - KL(q(w)||p(w))$$

The Probabilistic Approach

- Bayesian approach for Neural Networks
  - Bayes by backprop.

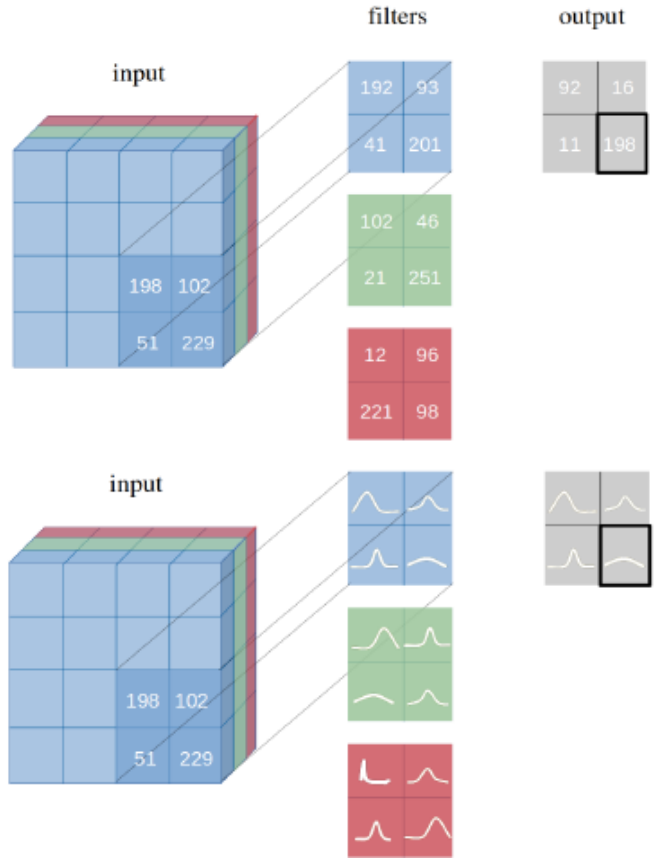
$$\begin{aligned}\theta^{opt} &= \arg\min_{\theta} \mathrm{KL}\left[q_\theta(w|\mathcal{D})\|p(w|\mathcal{D})\right] \\ &= \arg\min_{\theta} \mathrm{KL}\left[q_\theta(w|\mathcal{D})\|p(w)\right] \\ &\quad - \mathbb{E}_{q(w|\theta)}[\log p(\mathcal{D}|w)] + \log p(\mathcal{D})\end{aligned}$$

$$\mathrm{KL}\left[q_\theta(w|\mathcal{D})\|p(w)\right] = \int q_\theta(w|\mathcal{D}) \log \frac{q_\theta(w|\mathcal{D})}{p(w)} dw.$$

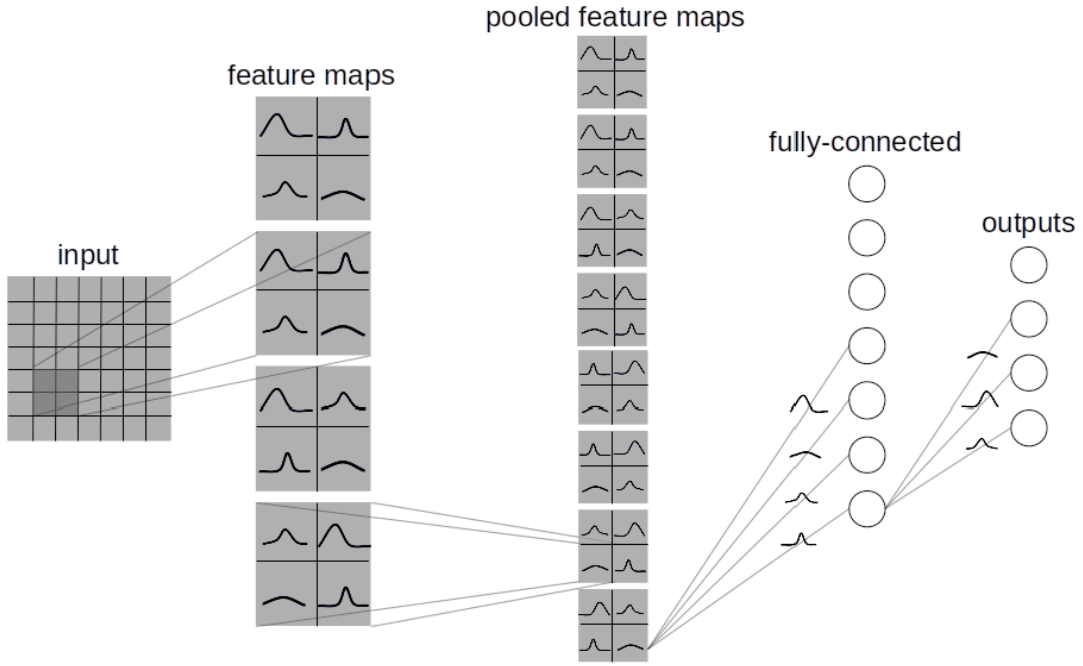
- Some Related work
  - Gal and Ghahramani (2015) framework for modelling Bayesian uncertainty.

Bayesian Convolutional Neural Network

- The Algorithm



- The local reparameterization trick



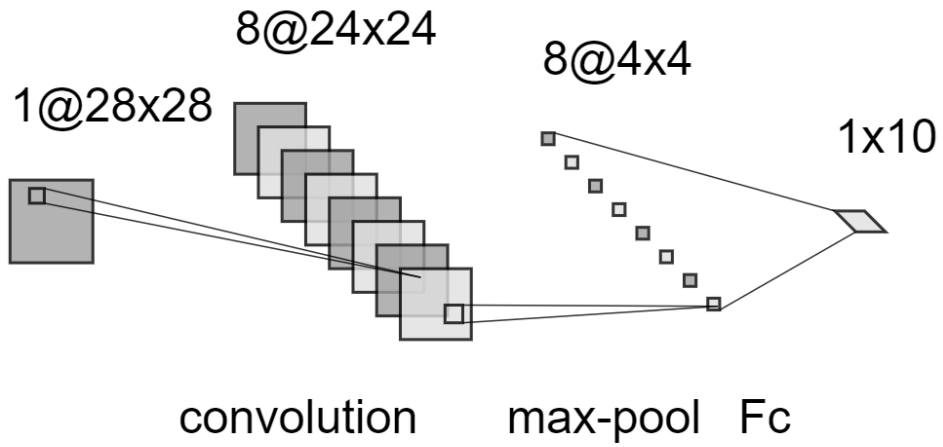
- Applying two sequential convolutional operations (Mean and Variance)
- Model pruning

Bayesian Convolutional Neural Network

- The Data sets
  - MNIST

  - MNIST_corrupted

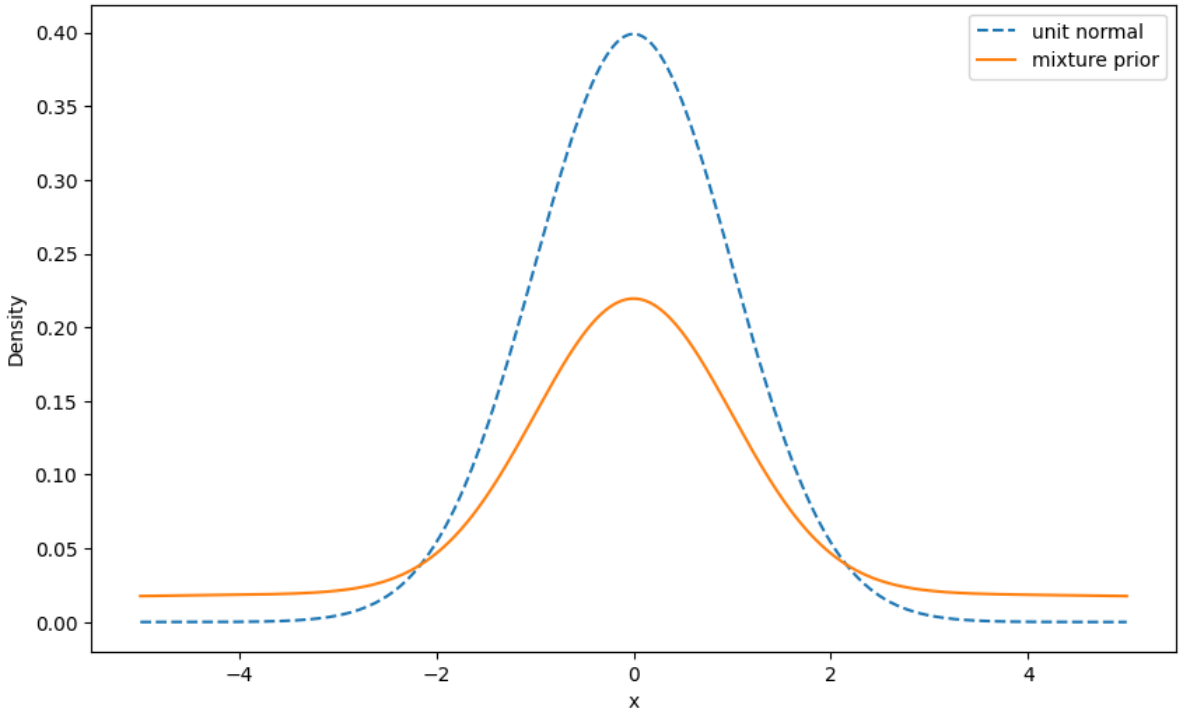
- The deterministic approach

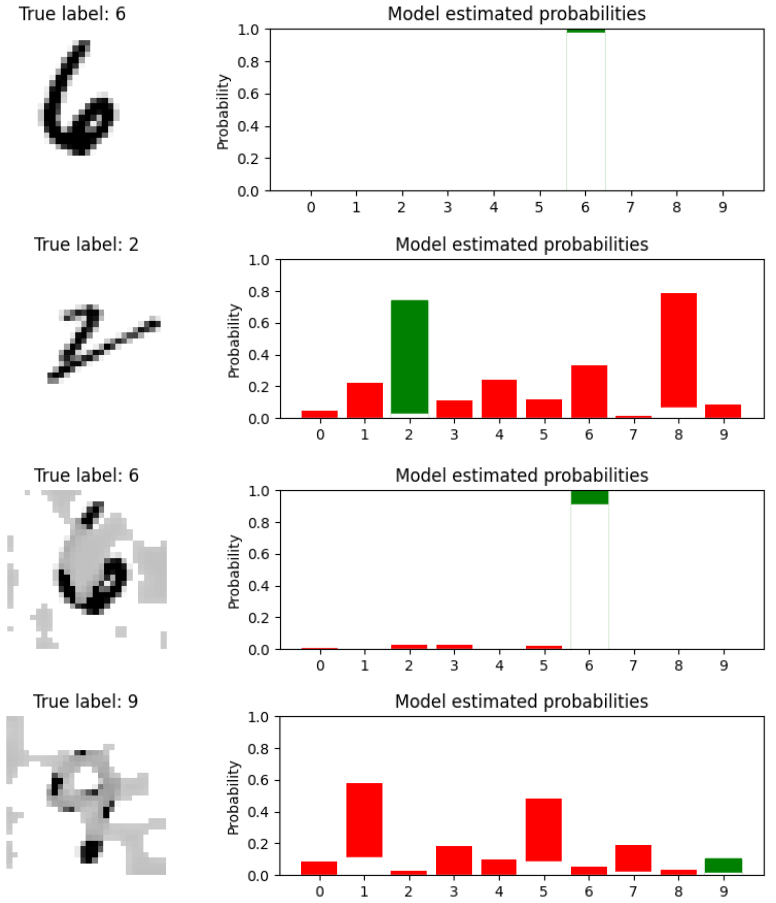


- The probabilistic approach

Bayesian Convolutional Neural Network

- B-CNN





References

[1] Y. Gal and Z. Ghahramani, "Bayesian convolutional neural networks with bernoulli approximate variational inference," 2016.

[2] Z. Ul Abideen, M. Ghafoor, K. Munir, M. Saqib, A. Ullah, T. Zia, S. A. Tariq, G. Ahmed, and A. Zahra, "Uncertainty assisted robust tuberculosis identification with bayesian convolutional neural networks," *IEEE Access*, vol. 8, pp. 22812–22825, 2020.

[3] K. Shridhar, F. Laumann, and M. Liwicki, "A comprehensive guide to bayesian convolutional neural network with variational inference," 2019.