PP-RAI'2024

Pixel-level Hyperspectral Image Analysis using RBMs and Quantum Devices

Dawid Mazur[1], Tomasz Rybotycki[2,3,4], Piotr Gawron[2,3]

[1] AGH University of Cracow, Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering [2] AGH University of Cracow, Center of Excellence in Artificial Intelligence;
[3] Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences; [4] Systems Research Institute of the Polish Academy of Sciences

18–20 April 2024

Abstract

We explore the possibility of using restricted Boltzmann machines (RBMs) as a tool for pixel-level multi- or hyperspectral image analysis. Our approach relies on the work done in the QBM4EO project, wherein the researchers used the same techniques — latent Bernoulli auto-encoders (LBAEs) and RBMs for satellite image analysis. By pixel-level processing, we show further potential applications for RBMs and quantum devices for analyzing Earth observations images.

Introduction

Using quantum techniques for image processing is an idea that emerged at the beginning of this century. With the recent advancements in quantum technologies, it is getting much attention. Especially in hyperspectral image analysis.

ARVIS Dataset

The dataset consists of hyperspectral images captured by the Airborne Visible / Infrared Imaging Spectrometer (AVIRIS) sensor on June 12, 1992. The research conducted with this dataset emphasized residue, as reflected in the documentation of residue conditions in the fields. The area observed includes significant portions of the Indian Creek and Pine Creek watersheds.

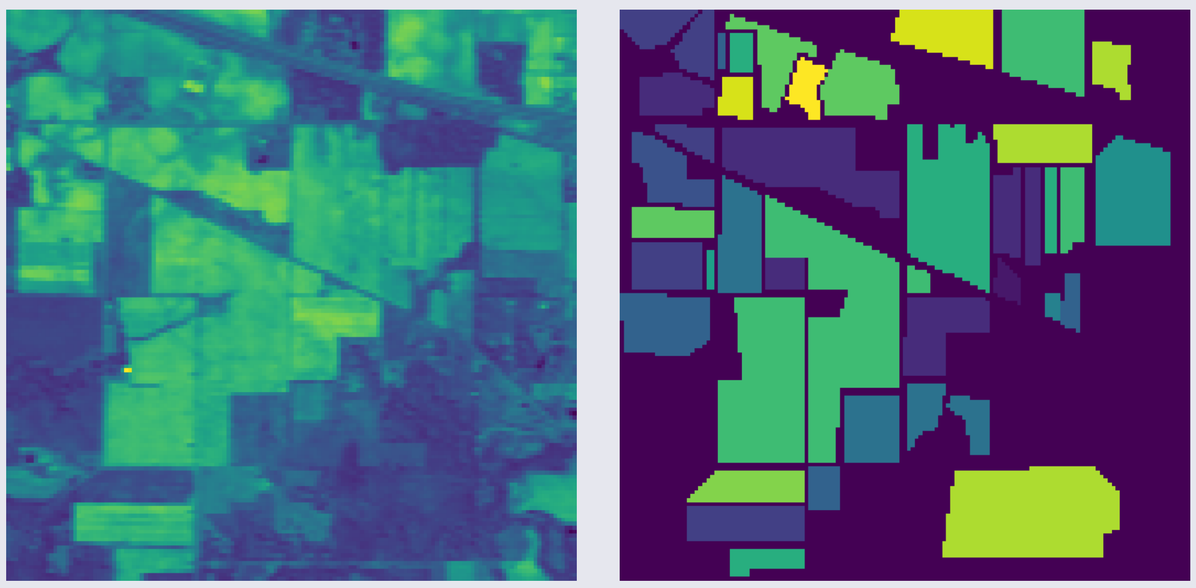

Figure: A 123-band image from the AVIRIS dataset (left) and its (noisy) ground truth segmentation (right).

The dataset consists of a hyperspectral image with dimensions of 220 bands, width 145, and height 145, totaling 21,045 pixels, and includes seventeen classes.

Results

We analyzed the model learning curve to ensure it was not overtrained. As of now, we used classical training algorithms.

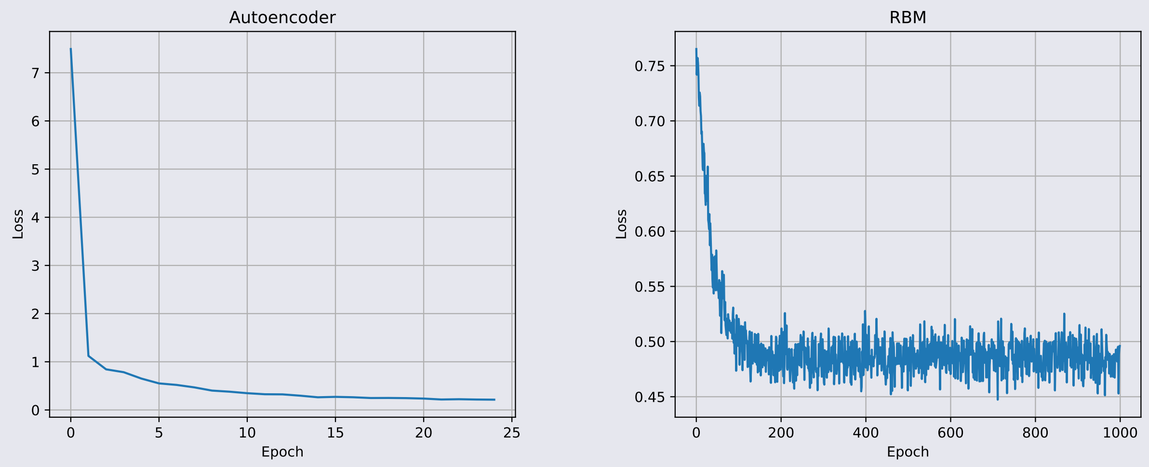

Figure: Learning curve of LBAE and RMB parts of our model.

The Rand score of our model on the ARVIS dataset is 0.713.

Conclusions

We plan to fine-tune our model and compare our approach with the state-of-the-art methods. Finally, we intend to train our model using a quantum annealer.

Aknowledgements

The authors would like to thank the authors of the QBM4EO project[a]. The project is co-financed by the funds of the Polish Ministry of Education and Science under the program entitled International Co-Financed Projects. We gratefully acknowledge the funding support by the program "Excellence initiative research university" for the AGH University in Kraków as well as the ARTIQ project: UMO-2021/01/2/ST6/00004 and ARTIQ/0004/2021.

[a] https://feralqubits.github.io/qbm4eo-lp/

Model and Method

We explore the idea of using RBMs for hyperspectral image analysis. By processing the image pixel by pixel, encoding the spectrum using LBAE, and grouping the encoded data using RBMs, we strive to assign labels to previously unseen hyperspectral pixels.

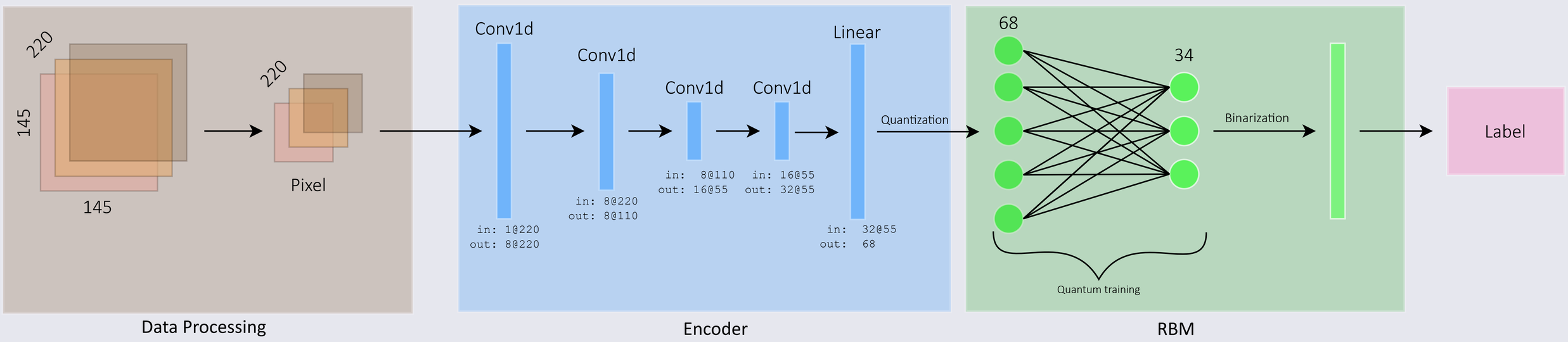

Figure: Our model. Preprocessed data is fed to the encoder. Its quantized output is then sent to the visible layers of the RBM, which labels the pixels.