بسم الله الرحمن الرحيم

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شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

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جامعة عين شمس

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قسم

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Abstract

Remote sensing applications have been enriched by the spectral information captured by hyperspectral cameras despite its limited spatial resolution. In each pixel, multiple ground materials generally mix to form the spectrum recorded. Hyperspectral Unmixing (HU) or Spectral mixture analysis is a challenging problem in determining the underlying material spectra, called endmembers from hyperspectral sensors and the abundances fraction of each pure material in each pixel.

The problem of Hyperspectral Unmixing (HU) has already been extensively researched. Different Hyperspectral Unmixing algorithms have been developed. In this thesis, a comprehensive investigation of HU methods was conducted. There are different categories for HU methods; the machine learning-based method offers more accurate estimation results compared to other traditional and statistical methods.

In this thesis, three different HU methods were proposed. First, a Deep Convolutional Autoencoder Network (DCAE) was presented to resolve the unmixed hyperspectral pixels. The proposed architecture composed of two sub-networks, namely: encoder and decoder. The encoder sub-network extracts a significant non-redundant feature vector. On the other hand, the decoder sub-network contains only one-layer to mimic the linear unmixing model. By utilizing the decoder layer weigh, one can extract both the endmembers and their abundance maps. Several experiments were performed to assess the proposed DCAE performance using synthetic and real hyperspectral datasets. The results demonstrated the significant performance of the proposed DCAE and that it outperforms benchmark unmixing methods even in a noisy environment in terms of both Root Mean Square Error (RMSE), and Mean Square Error (MSE). The achieved results of the proposed DCAE in terms of mean absolute error were

0.0097, 0.001, 0.0141, and 0.0145 for Samson, Cuprite, Urban, and Jasper Ridge datasets, respectively.

Second, a blind hyperspectral nonlinear unmixing method was proposed in [3]. The proposed autoencoder architecture composed of encoder and decoder. The encoder network contains three layers and the proposed decoder network has four fully connected layers, each with the number of neurons equal to the dimension of the end members. Several experiments were conducted using nonlinear synthetic dataset sampled from the USGS library, and the performance was evaluated using both SAD and SID metrics. The experiments evaluated the performance in terms of accuracy assessment, weight initialization techniques, learning rate, and robustness to the noise. The results verified that the proposed autoencoder outperforms traditional endmember extraction algorithms in nonlinear cases. After that, we introduced the application of hyperspectral image unmixing algorithm in the Internet of things (IoT) environment.

Finally, a novel band selection approach that extends the work proposed in [3]. The proposed band selection approach consists of two main steps. The unmixing step utilized the aforementioned nonlinear deep autoencoder unmixing method to extract accurate material spectra. In the cluster stage, the variance for each obtained endmember was calculated to construct a variances vector. Next, classical K- means was adopted to cluster the variances vectors. Finally, only one spectral band for each cluster was selected. To evaluate the effectiveness and generality of the proposed method, various experiments were conducted on seven benchmarks hyperspectral dataset. Results shows the proposed approach had suppressed mentioned methods by an average of 4% in terms of overall accuracy.

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List of Abbreviations

Abbreviation	Stands for
HSI	**H**yper**s**pectral **I**mage
HU	**H**yperspectral **U**nmixing
ANN	**A**rtificial **N**eural **N**etwork
VIS	**V**isible range
NIR	**N**ear-**I**nfrared **R**ange
SWIR	**S**hort-**W**avelength **I**nfrared
MIR	**M**id-wavelength **I**nfrared
TIR	**T**hermal **I**nfrared (TIR)
PPI	**P**ixel **P**urity **I**ndex
MV	**M**inimum **V**olume
LMM	**L**inear **M**ixing **M**odel
MNF	**M**aximum **N**oise **F**raction
BMM	**B**ilinear **M**ixing **M**odels
OPF	**O**ptimum-**P**ath **F**orest
DCAE	**D**eep **C**onvolutional **A**utoencoder
ReLU	**R**ectified **L**inear **U**nit
ASC	**S**um-to-one Constraint
SID	**S**pectral **I**nformation **D**ivergence
MSE	**M**ean **S**quare **E**rror
RMSE	**R**oot **M**ean **S**quare **E**rror
SAD	**S**pectral **A**ngler **D**istance
SID	**S**pectral **I**nformation **D**ivergence
VCA	**V**ertex **C**omponent **A**nalysis

Chapter 1

Introduction