

SOME STUDIES ON QUANTIFICATION AND FUSION OF DIFFERENTIAL INFORMATION

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SOME STUDIES ON QUANTIFICATION AND FUSION OF DIFFERENTIAL INFORMATION

by

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THESIS CERTIFICATE

This is to certify that the thesis entitled “Some Studies on Quantification and Fusion of differential Information” being submitted by Snigdha Bhagat to the Department of Electrical Engineering, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy is the record of the bonafide research work carried out by her under my supervision. In my opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted either in part or in full to any other university or institute for the award of any degree or diploma.

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ABSTRACT

KEYWORDS: Information Fusion, Multi-modal image fusion, Matrix Pencil, Generative Adversarial Modelling, Residual Networks, Signal matched multi-rate filter bank, Image Super-resolution

Multi-modal image fusion has been one of the active areas of research due to its extensive practical application in surveillance, military and especially object detection in bad weather conditions. Since fog, rain and other weather conditions reduce the visibility in general, it causes the visible image not to gather the information required, and that is where infrared images come into the picture.

In this work, we propose a set of techniques to quantify differential information of one pattern over the other and subsequently fuse information in limited and optimal data scenarios. In this regard we propose a novel approach for quantification of differential information, of one pattern over the other and observe that this leads to the solution of matrix pencil equation. This mathematical formulation has been tested on a variety of applications like image classification, audio classification, seizure detection, the transformation of patterns and fusion in a constrained scenario.

Multi-modal image fusion techniques have been proposed for limited data and optimal data scenario. A novel adversarially constrained residual neural network, with symmetric skip connections, has been proposed for infrared and visible image fusion. The architecture has been trained and tested on the TNO dataset for military applications.

In the case of single instance data availability, a novel spatially constrained adaptive multi-rate filter bank structure has also been presented. Its efficacy has been tested for multi-modal fusion and image super-resolution on the TNO dataset and SupER database, respectively.

सार

मल्टी-मोडल इमेज फ्यूजन निगरानी, सैन्य और विशेष रूप से खराब मौसम की स्थिति में वस्तु का पता लगाने में व्यापक व्यावहारिक अनुप्रयोग के कारण अनुसंधान के सक्रिय क्षेत्रों में से एक रहा है। चूंकि कोहरा, बारिश और अन्य मौसम की स्थिति सामान्य रूप से दृश्यता को कम करती है, यह दृश्य छवि को आवश्यक जानकारी एकत्र नहीं करने का कारण बनती है, और यही वह जगह है जहां अवरक्त छवियां चित्र में आती हैं।

इस काम में, हम एक पैटर्न की दूसरे पर अंतर जानकारी को मापने के लिए तकनीकों का एक सेट प्रस्तावित करते हैं और बाद में सीमित और इष्टतम डेटा परिदृश्यों में जानकारी को फ्यूज करते हैं। इस संबंध में, हम एक पैटर्न के दूसरे पर अंतर जानकारी की मात्रा का ठहराव के लिए एक उपन्यास दृष्टिकोण का प्रस्ताव करते हैं और देखते हैं कि यह मैट्रिक्स पेंसिल समीकरण के समाधान की ओर जाता है। इस गणितीय सूत्रीकरण का परीक्षण विभिन्न प्रकार के अनुप्रयोगों जैसे छवि वर्गीकरण, ऑडियो वर्गीकरण, जल्दी का पता लगाने, पैटर्न के परिवर्तन और विवश परिदृश्य में संलयन पर किया गया है।

सीमित डेटा और इष्टतम डेटा परिदृश्यों के लिए मल्टी-मोडल इमेज फ्यूजन तकनीकों का प्रस्ताव किया गया है। एक उपन्यास प्रतिकूल रूप से विवश अवशिष्ट तंत्रिका नेटवर्क, सममित के साथ

स्किप कनेक्शन, इन्फ्रारेड और दृश्यमान छवि संलयन के लिए प्रस्तावित किया गया है। सैन्य अनुप्रयोगों के लिए टीएनओ डेटासेट पर वास्तुकला को प्रशिक्षित और परीक्षण किया गया है। एकल आवृत्ति डेटा उपलब्धता के मामले में, एक उपन्यास स्थानिक रूप से सीमित अनुकूली बहु-दर फ़िल्टर बैंक संरचना भी प्रस्तुत की गई है। इसकी प्रभावकारिता का परीक्षण क्रमशः TNO डेटासेट और सुपर डेटाबेस पर मल्टी-मोडल फ्यूजन और इमेज सुपर-रिज़ॉल्यूशन के लिए किया गया है।

Contents

ACKNOWLEDGEMENTS	i
ABSTRACT	iii
LIST OF TABLES	viii
LIST OF FIGURES	xi
ABBREVIATIONS	xii
1 Introduction	1
1.1 Motivation	1
1.2 Objective and Scope	2
1.2.1 Quantification of Differential Information	4
1.2.2 Autoencoder based Image Fusion	7
1.2.3 Image fusion using an adaptive multi-rate filter bank structure . . .	24
1.3 Organisation of thesis	51
1.4 Conclusion	53
2 Mathematical Preliminaries	54
2.1 Introduction	54
2.2 Matrix Pencil: A brief overview	54
2.3 Deep Neural Networks: A brief overview	55
2.3.1 Variational Autoencoders	58
2.3.2 Generative Adversarial Networks: The rise of imagination in machines	64
2.4 Multi-rate filter bank structure	69
2.4.1 Multi-dimensional Filtering	71
2.4.2 Multi-dimensional Sampling	73
2.4.3 Multi-dimensional Multi-rate Filter Bank	75

2.5	Conclusion	77
3	A novel approach for Quantification of Differential Information	78
3.1	Introduction	78
3.2	Matrix Pencil for capturing Differential Information of stochastic signals .	79
3.2.1	Discussion	86
3.3	Generation of Transformation Independent Basis for deterministic signals .	87
3.3.1	Discussion	90
3.4	Results	92
3.4.1	Binary Classification using Matrix Pencil	92
3.4.2	Multi-class Classification of Stochastic Signals using Matrix Pencil .	96
3.4.3	Multi-class Classification of Deterministic Signals using Matrix Pencil	102
3.4.4	Seizure Detection	105
3.4.5	Transformation of one pattern to another	108
3.4.6	Fusion of patterns	111
3.5	Conclusion	112
4	Multi-modal Image fusion using symmetric skip autoencoder via an Adversarial Regulariser	113
4.1	Introduction	113
4.2	Mathematical Preliminaries	116
4.2.1	Autoencoder constrained by Adversarial Regulariser	116
4.2.2	Residual Networks	117
4.3	Proposed Architecture for multi-modal image fusion	119
4.3.1	Problem Formulation	119
4.3.2	Network Architecture	121
4.4	Experimentation and Results	122
4.4.1	Experimental Conditions	122
4.4.2	Performance Assessment	123
4.4.3	Discussion and Conclusion	135
5	Multi-modal data fusion and Image super resolution via an adaptive multi-rate filter bank structure	137

5.1	Introduction	137
5.2	Adaptive Multi-rate filter bank for Image Fusion	138
5.2.1	Cost function	139
5.2.2	Iterative estimation of structure parameters	140
5.2.3	A Novel Frequency Extrapolation Module	147
5.2.4	Non uniform interpolation	152
5.3	Results and Conclusion	156
5.3.1	Multi-modal Data Fusion	156
5.3.2	Image Super-resolution	158
5.4	Conclusion	162
6	Conclusion and Future Scope	166
6.1	Conclusion	166
6.2	Future Scope	169

List of Tables

1.1	Comparison of state of art multi-modal fusion techniques	3
3.1	Classification accuracy (in percentage) for binary classification on MNIST database	95
3.2	Classification accuracy (in percentage) for binary classification on Google speech recognition database	96
3.3	Classification accuracy (in percentage) for Multi-class Classification for MNIST image dataset	98
3.4	Classification accuracy (in percentage) for Multi-class Classification for Google speech command dataset	99
3.5	Classification accuracy (in percentage) for Multi-class Classification for modified feature set for MNIST image dataset	100
3.6	Classification accuracy (in percentage) for Multi-class Classification for modified feature set for Google speech command dataset	100
3.7	Comparison of classification results on Google speech command dataset with other state of art algorithms (in percentage)	100
3.8	Comparison of classification results on MNIST database with other state of art algorithms (in percentage)	101
3.9	Number of eigen vectors for Classification of deterministic signals	103
3.10	Classification accuracy (in percentage) for Multi-class Classification of deterministic signals	104
3.11	Statistical analysis of seizure detection on CHB-MIT Dataset	107
4.1	Objective score of proposed fusion method on 7 benchmark image pairs. VIF = visual information fidelity; SSIM = structural similarity; MI = mutual information; EN = entropy	131
4.2	Performance metric evaluation for state of art algorithms	132
5.1	Objective score of proposed fusion method on 7 benchmark image pairs. VIF = visual information fidelity; SSIM = structural similarity; MI = mutual information; EN = entropy	158
5.2	Quantitative evaluation results - PSNR and SSIM scores on Set5 benchmark dataset at an interpolation factor of 4	160

5.3	Quantitative evaluation results - PSNR and SSIM scores on Set5 benchmark dataset at an interpolation factor of 2	160
5.4	Qualitative Metric Scores for Multiple Image Super resolution with interpolation factors of 2,3 and 4	163

List of Figures

1.1	Where and How is Multi-modal Image Fusion employed?	2
1.2	Multi-scale transform based fusion technique[MML19]	10
1.3	Sparse representation based image fusion scheme[LKF ⁺ 17]	18
1.4	The basic CCD types: (a) conventional CCD, (b) super CCD with a non rectangular pixel layout, and (c) orthogonal-transfer CCD.	26
1.5	Sub-pixel image capturing mechanism (a) A double classical CCD linear array to generate square sampling grids (b) Sub-pixel shift of sampling grids in both row and column	29
1.6	Basic premise of SR	30
1.7	An overview on state of art of Image super-resolution	31
1.8	Image Acquisition Model	32
1.9	Image Observational Model [PPK03]	33
1.10	Aliasing relationship between LR image and HR image	35
1.11	Non -uniform interpolation based SR scheme[YH17]	38
1.12	Non uniform interpolation	40
1.13	Iterative Back Projection	42
1.14	(a) Transpose Convolution operator (b) Sub-pixel Layer	45
1.15	Network Design Strategies[WCH20]	46
2.1	Taxonomy of Deep Generative Models[Goo16]	58
2.2	Basic components of autoencoder model[Doe16]	60
2.3	Latent attributes of a vanilla autoencoder network	60
2.4	Latent attributes of a variational autoencoder network	61
2.5	Schematic diagram of an autoencoder network	64
2.6	Schematic of the Turing Test[SCA00]	65
2.7	Overall Block Diagram of GAN architecture	66
2.8	Training stages of GAN architecture	67
2.9	M-channel multirate filter bank	70

2.10	Frequency domain support represented by dark grey regions of ideal filters $f_1[n]$ and $f_2[n]$	72
2.11	Sampling lattice for generator matrices I_1 , I_2 and I_3 respectively	74
2.12	Fundamental lattice of $\Lambda(S)$ for Quincunx Sampling lattice I_2	74
2.13	Quincunx Sampling lattice, black dots indicate the sampling points in $\mathbb{Z}^2$ space and the gray area indicates the fundamental lattice $F_\Lambda(M)$	75
2.14	Multirate Filter Bank(a) Analysis Side (b) Synthesis side [Hay99]	76
3.1	Categories of scenes in Super database. Starting from top left: Books and Papers, Newspapers, Banknotes, Bookshelf, Porsche, Tea - Bottles, Games, Truck - Buddha - Duck, Pencils, Coffee, Loader, Dolls, Globe, Magnified Globe	102
3.2	Euclidean distance time series for subjects from CHB-MIT dataset	108
3.3	(a) Data sample from class 1 (b) Data sample from class 2 (c) Transformation output	109
3.4	From left to right: Data Sample from class 1, Data sample from class 2, Transformation output. (a) Sawtooth signal (b) Square signal (c) Sawtooth to Square transformed signal (d) Sinusoidal signal (e) Square signal (f) Sinusoidal to Square transformed signal (g) Square signal (e) Sinusoidal signal (f) Square to Sinusoidal transformed signal	110
3.5	Fusion of information	112
4.1	Single Residual Block	117
4.2	Overall Structure	118
4.3	Visual Information Fidelity Model	126
4.4	Fusion Autoencoder Module(Generator)	129
4.5	(a) Network Architecture of Discriminator Module (b) Bottleneck Block without downsampling operation (c) Bottleneck Block with downsampling operation (d) Transbasic Block without upsampling operation (e) Transbasic Block with upsampling operation (f) Agent Layer (g) Final Deconv Layer	130
4.6	Subjective results of the proposed algorithm on TNO dataset, left to right Visual Image, Infrared image and Fused Image	133
4.7	Qualitative metric evaluation results on infrared and visible image pairs from TNO database. From left to right: Bench, Bunker, Tank, Kaptein. From top to bottom: Visible, Infrared, LP, NSCT, SCNN, FPDE, DDCTPCA, CBF, HMSD, Wavelet, FusionGAN, DDcGAN, Proposed algorithm	134
5.1	Proposed SR framework	138
5.2	Weight update for parameters of Delay Unit	141

5.3	Weight update for parameters of Sampling Matrix	142
5.4	Weight update for parameters of Analysis Filter	144
5.5	Weight update for parameters of Synthesis Filter	146
5.6	Schematic of the iterative algorithm	149
5.7	Magnitude of $G_0(f_x, f_y)$ displayed at log-scale	150
5.8	Magnitude of $g_0(x, y)$ in image space	150
5.9	Magnitude of $G'_0(f_x, f_y)$ displayed at log-scale	151
5.10	Subplots 1-27 show the profile(1st col) , spectrum(2nd col) and reconstruction(3rd col) and different rows show results for iterations 0, 1, 10, 50, 100, 500, 1000, 2000 and 5000 respectively.	154
5.11	Image Fusion using Multi-rate filter bank structure : From Left to right Infrared Image, Visible Image, Fused Image	157
5.12	State of art Subjective Quality comparison for "baby" image in Set5 database with interpolation factor = 2	161
5.13	State of art Subjective Quality comparison for "head" image in Set5 database with interpolation factor = 2	161
5.14	Subjective Quality for Multiple Image Super resolution with Global Pan Outlier Photometric Translation	163
5.15	Variation of PSNR with number of input images for interpolation factor = 3	164
5.16	Variation of SSIM with number of input images for interpolation factor = 3	164

ABBREVIATIONS

IITD	Indian Institute of Technology, Delhi
MRFB	Multi-rate Filter Bank
GAN	Generative Adversarial Network
MNIST	Modified National Institute of Standards and Technology database
KLT	Karhunen-Loeve Transform
VAE	Variational Autoencoder
KL	Kullback–Leibler
DBN	Deep Belief Networks
ELBO	Evidence Lower Bound
LTI	Linear Time Invariant
SLOCC	Stochastic Local Operation and Classical Communication
SEM	Singularity Expansion Method
SVD	Singular Value Decomposition
PCA	Principal Component Analysis
RASTA	Relative Spectral Analysis
PLP	Perceptual Linear Prediction
MFCC	Mel-frequency Cepstral Coefficient
CNN	Convolution Neural Network
PAN	Panchromatic
MS	Multi-spectral
LiDAR	Light detection and Ranging
MST	Multi-scale Transform
TLBO	Teaching Learning Based Optimisation
DWT	Discrete Wavelet Transform
DCT	Discrete Cosine Transform
DFT	Discrete Fourier Transform
NSCT	Non - Subsampled Countourlet Transform

OMP	Orthogonal Matching Pursuit
TV	Total Variation
IR	Infrared Image
SEM	Singularity Expansion Method
K-SVD	K-means Singular Value Decomposition
S-OMP	Simultaneous orthogonal matching pursuit
VIF-Net	Visible and Infrared image fusion network
SR	Super-resolution
LR	Low-resolution
HR	High-resolution
PPI	Pixels per Inch
CCD	Charged Couple Devices
CMOS	Complementary metal-oxide Semiconductor
MAP	Maximum a Posteriori
ML	Maximum Likelihood
POCS	Projection onto Convex Sets
MRF	Markov random field
IBP	Iterative Back-Projection
ProSR	Progressive Super-resolution
LapSRN	Laplacian Super-resolution Network
DenseNet	Dense connection Neural Network
MAE	Mean Absolute Error
MSE	Mean Square Error
ELBO	Evidence Lower Bound
OSU-T	OSU Thermal Database
SSIM	Structural Similarity Index
VIF	Visual Information Fidelity
OSU-T	OSU Thermal Database
MI	Mutual Information
EN	Entropy
RMSE	Root Mean Square Error
MBE	Mean Bias Error

LSE	Least Squares Error
APOCS	Alternating projections onto convex sets
PSWF	Prolate spheroidal wave function
IFT	Inverse Fourier Transform
FT	Fourier Transform
SISR	Single Image Super-resolution
MISR	Multiple Image Super-resolution
PSNR	Peak Signal to Noise Ratio
AN	Attention Network
PMSRN	Progressive Multi-scale Residual Network
DRL	Densely Residual Laplacian
CSNLA	Cross Scale Non Local Attention
NEDI	New Edge Directed Interpolation
HPBN	Hierarchical Back Projection Network