SOME STUDIES ON QUANTIFICATION AND FUSION OF DIFFERENTIAL INFORMATION

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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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Snigdha Bhagat

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, जब्ती 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 फ़्यूज़न 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।

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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