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Multi-Source Image Fusion Techniques and Their Applications and Limitations

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ABSTRACT

Image Fusion is a technique of combining the relevant Important Information from a set of images, into a single image, wherein the resultant fused image will be more informative and complete as well as clear than any of the input images. This paper discusses the implementation of Simple Image Fusion algorithms. There are three categories of Simple image fusion algorithms –Average Method, Select Max-Min Method and Principal Component Analysis Method

INTRODUCTION

Image fusion is a process of combining more than one Image into single composite Image that is more informative and more suitable for visual perception. Objective of Image fusion is to reduce the uncertainty and redundancy in the resultant fused Image & maximizes the relevant information to an application or task important. Image Fusion is a mechanism to improve the quality of information from a set of images. By the process of image fusion the good information from each of the given images is Fused to gather to form a resultant image whose quality is Superior to any of the input images.

OBJECTIVE

An image containing the better quality in terms of following evaluation metrics:

Many Image capturing devices are used to capture the image for the particular scenes. Then they are analyzed and assessed for the particular applications. Examples,

- Images have b een captured by the earth observation satellites are analyzed for environmental monitoring, land cover classification, weather forecasting, Object Classification etc.
- Medical Images like MRI, analyzed for medical diagnosis.
- Multiple images are analyzed for surveillance applications. Due to the technological limitations related to the radiometric resolution of the image detectors, limited on-board storage capacity of the image capturing devices, Images are not having very high spatial and spectral resolution. However, in practice, a number of applications require high spatial and high spectral resolution at the same time to improve classification results, strengthen reliability, and better visual interpretation. Image fusion is a powerful solution to provide

SIMPLE IMAGE FUSION ALGORITHMS

The primitive fusion schemes perform the fusion right on the source images. One of the simplest of these image fusion methods just takes the pixel-by-pixel gray level average of the source images. This simplistic approach often has serious side effects such as reducing the contrast.

Averaging Algorithm

When the images are captured with cameras where extrinsic and/or intrinsic parameters are different, we need to first register them. Although medical scanners that can capture registered multimodality images are becoming available, today, in order to fuse medical images it is required to first register them. Here, we assume that two input images are already registered and the resultant image is obtained by averaging every corresponding pixel in the input images.

Fig. 1 Example of a fused image with averaging method

Min-Max Algorithm

A selection process if performed here wherein, for every corresponding pixel in the input images, the pixel with maximum/minimum intensity is selected, respectively, and is put in as the resultant pixel of the fused image.

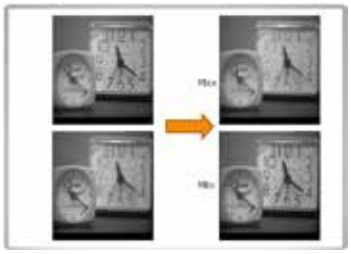

Fig. 2 Example of a fused image with Min-Max Method

Principal Component Analysis Algorithm

- PCA is useful for finding new, more informative, uncorrelated features; it reduces dimensionality by rejecting low variance features. Also Use for Analysis of expression data. PCA is only powerful if the biological question is related to the highest variance in the data set.
- Eigen Vectors show the direction of axes of a fitt d ellipsoid
- Eigen Values show the significance of the corresponding axis
- The larger the Eigen value, the more separation between mapped data
- For high dimensional data, only few of Eigen values are significant

What is PCA?

- Finding Eigen Values and Eigen Vectors
- Deciding on which are significant
- Forming a new coordinate system defined by the significant Eigen vectors
- lower dimensions for new coordinates
- Mapping data to the new space
- Compressed Data

PCA for Image

Each image is represented as a 1-D data Γi
Finding Eigen values/vectors is expensive

Table 1. Turk/Pent land Trick for PCA

$$\text{average picture} : \Psi = \frac{1}{M}\sum_{i=1}^{M}\Gamma_i$$

$$\Phi_i = \Gamma_i - \Psi$$

$$\text{Covariance Matrix} : C = \frac{1}{M}\sum_{i=1}^{M}\Phi_i\Phi_i^T = A\ ^T$$

$$\text{image} : N \times N \rightarrow C : N^2 \times N^2$$

$$\text{Trick} : A\ ^T : N^2 \times N^2 \text{ but } A^T A : M \times M$$

$$A^T \mathcal{M}_i = \lambda_i v_i \rightarrow A\ ^T \mathcal{M}_i = \lambda_i \mathcal{M}_i$$

$$v_i : \text{eigenvector of } A^T A \rightarrow \mathcal{M}_i : \text{eigenvector of } A\ ^T$$

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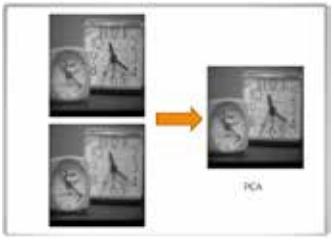
Fig. 1 Example of a fused image with PCA Method



LIMITATION OF SIMPLE ALGORITHMS

- Applied blindly throughout whole Images.
- More suitable to only optical images.
- Resultant fused image will be depends upon the kind of input source images.

MATLAB

This research has been completely developed with MATLAB ®. This high-performance language for technical computer, integrates computation, visualization, and programming in an easy-to-use environment. Better function available in the MAT Lab's. One of the reasons of selecting MATLAB in this research is because it fits perfectly in the necessities of an image processing research due to its inherent characteristics and functionality. MAT Lab's basic data element is an array that does not require dimensioning. This is helpful to solve problems with matrix and vector formulations as well as Image Processing. And an image is nothing but a matrix or set of matrices which define the pixels value of the image and intensity value of the image, such a grey scale value in black and white images, and Red, Green and Blue or Hue, Saturation and Intensity values(HSI) in color images. In addition, MATLAB® includes an Image Processing Toolbox which supports a wide range of image processing operations, including:

- Geometric operations
- Neighborhood and block operations
- θLinear filtering and filter design
- Transforms
- Image analysis and enhancement
- Binary image operations
- Region of interest operations

MAGE QUALITY MEASUREMENT

Objective Evolution Measures Requiring a Reference Image

For certain applications, it is possible to generate an ideal fused image. This ideal fused image is then used as a reference to compare with the experimental fused results. Some typical quality metrics which are used for these comparisons are listed:

The root mean square error(RMSE)

$$RMSE = \sqrt{\frac{1}{N * M}\sum_{x=1}^{N}\sum_{y=1}^{M}[R(x,y) - F(x,y)]^2}$$

The correlation(CORR)

$$CORR = \frac{2 * \sum_{x=1}^{N}\sum_{y=1}^{M} R(x,y)F(x,y)}{\sum_{x=1}^{N}\sum_{y=1}^{M} R(x,y)^2 + \sum_{x=1}^{N}\sum_{y=1}^{M} F(x,y)^2}$$

The peak signal to noise ratio(PSNR)

$$PSNR = 10 * log_{10}\left(\frac{L^2}{\frac{1}{NM}\sum_{x=1}^{N}\sum_{y=1}^{M}[R(x,y) - F(x,y)]^2}\right)$$

The mutual information(MI)

$$MI = \sum_{i_1=1}^{L}\sum_{i_2=1}^{L} h_{R,F}(i_1,i_2) log_2 \frac{h_{R,F}(i_1,i_2)}{h_R(i_1)h_F(i_2)}$$

The universal quality index(QI)

$$QI = \frac{\sigma_{xy}}{\sigma x \sigma y}\frac{2 * \bar{x}\bar{y}}{(\bar{x})^2 + (\bar{y})^2}\frac{2 * \sigma_x \sigma y}{\sigma_x^2 + \sigma_y^2}$$

Objective Evolution Measures Not Requiring a Reference Image

As stated previously, quantitatively accessing the performance in practical applications is a complicated issue because it is usually very difficult to access the truth (i.e., the ideal composite images is normally unknown). Several simple quantitative evaluation methods which do not require a reference image are listed below.

The standard deviation (SD)

$$\sigma = \sqrt{\sum_{i=0}^{L}(i - \bar{i})^2 h(i)}, \quad here\ \bar{i} = \sum_{i=0}^{L} i\, h(i)$$

The entropy (H)

$$H = -\sum_{i=0}^{L} h(i)\ log_2\ h(i)$$

Cross Entropy

$$CE(X,Y;F) = \frac{CE(X;F) + CE(Y;F)}{2}$$

CONCLUSION

In This Paper various Image Fusion Algorithm discussed. In Averaging Method consider average intensity value of images. In Min-Max Method Consider Min Intensity value for Minimum and Highest Intensity value for Maximum. Both methods applied but results are not appropriate so output image is not clear as per are requirement. We need to new approach or method that gives us best image quality. The method considers the intensity value that is best of one of the input images.so in future work we just pick up any one method and represent that method in new approach that give us best result compare to exiting one.

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