DECISION LEVEL FUSION OF HIGH RESOLUTION SATELLITE DATA FOR URBAN AREA ANALYSIS

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Abstract- In the field of multi-source data fusion, fusion of multispectral and panchromatic remote sensing data in urban area has attracted more attention. Multi-source data has been remarkably increased for classification. This is because, the different sources may provide more information, and fusion of different information can produce a better understanding of the observed site. This paper addressed the use of a decision fusion methodology for the combination of multispectral and panchromatic data in urban area. The proposed method applied a support vector machine (svm)-based classifier fusion system for fusion of the multi-source data in the decision level. First, radiometric feature are extracted on multispectral data. Then, svm based rbf kernel classifiers are applied on each feature data, and on the panchromatic data. After producing multiple of classifiers, two comparative data fusion techniques are applied as a classifier fusion method to combine the results of svm classifiers form the data sets. Experimental results show that the proposed data fusion method improved the classification accuracy and kappa coefficient in comparison to the single data sets. The results revealed that the overall accuracies of svm classification on the multi spectral and the panchromatic data separately are 60.3% and 59.1%, while our decision fusion methodology with majority voting technique receive the accuracy up to 88.6%, and dempster shaf er receive the accuracy up to 94.7%.

Index Terms- Multi-source data fusion, Urban area, Feature extraction, SVM, RBF Kernel, Majority Voting, Dempster Shafer.

I. INTRODUCTION

Nowadays, various sensor technologies allow to measure different aspects of objects on Earth, and a wide spectrum of data can be available for the same observed area. Information from different sensors may provide complementary data, and can produce a better interpretation of the observed area, which is not possible with single sensor. However, the insufficiency of an individual sensor to provide a complete, and precise information about objects on Earth makes multi-source data fusion a subject of interesting research [1][2]. During the last decade, a lot of research studies have been carried on multi-source data fusion, to integrate data from different sensors. In a recent paper, Vahideh et al. [2] use Dempster Shafer Theory to fuse an airborne LiDAR with a multispectral SPOT 5 image for enhancement of feature extraction. In another paper [3], Bogaert and Fasbender proposed a data fusion approach based on Bayesian theory, to enhance image sharpness using Panchromatic and multispectral image. Bigdeli et al. [1] proposed a technique for fusion of Hyperspectral and LIDAR data in the decision level, using support vector machine (SVM)-based classifier fusion system. In [4] the authors propose a building extraction approach by fusion of Panchromatic image, Multispectral image and Digital Surface Model (DSM) generated from WorldView-2 stereo imagery. However, from the problems addressed in the literature, it is evident that no technology can be always enough performant for reliable image interpretation. Therefore, this paper proposes two comparative data fusion approach, the first is based on Majority Voting data fusion, the second, Dempster Safer data fusion, for combining high spatial panchromatic data and multispectral information, for enhancement of features extraction in urban area.

II. METHODOLOGY

A SVM based classifier fusion for fusion of Panchromatic and Multispectral data is presented in Fig.1.

![Flowchart of the proposed data fusion method on Panchromatic and Multispectral image.](image)

**2.1 Proposed fusion method**

This paper describes our approach for decision fusion of Panchromatic and Multispectral data. To generate more features, a radiometric feature extraction strategy is applied on the Multispectral data. Support vector machine (SVM) is used as a supervised
classification strategy on the feature spaces of the Multispectral data, and on the panchromatic image. Finally, two different decision fusion strategies are used and compared, to fuse the classifiers result of Panchromatic and Multispectral data.

![Data sets](image)

### 2.1.1 Phase 1: Feature extraction

The main step of classification process on the Multispectral data is the extraction of useful information to discriminate between different objects. The radiometric features extraction used on the Multispectral data are listed in Table 1.

#### Table 1. Different spectral features on the Multispectral data.

<table>
<thead>
<tr>
<th>Radiometric Indices</th>
<th>Formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normalised difference vegetation index</td>
<td>NDVI = (NIR - Red) / (NIR + Red)</td>
</tr>
<tr>
<td>Brightness Index</td>
<td>B1 = ± Green² + Red² + NIR²</td>
</tr>
<tr>
<td>Index Surfaces Built</td>
<td>ISU = a<em>b</em>R/NIR, a=100, b=25</td>
</tr>
<tr>
<td>Normalized Difference Water Index</td>
<td>NDWI = (Green - NIR) / (Green + NIR)</td>
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</tbody>
</table>

![Radiometric features extraction](image)

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### 2.1.2 Phase 2: Supervised classification

A SVM-based classifier fusion system for fusion of Panchromatic and Multispectral data is presented in this section. We applied a SVM classifier for classification of each feature space which is produced in the previous step. In machine learning the RBF kernel, or (Gaussian) radial basis function kernel, is a popular kernel function, commonly used in support vector machine classification [5].

$$K(x - x') = \exp (-\lambda ||x - x'||^2) \quad (1)$$

A comparative Analysis of Classification Techniques was performed in [6]. The classification methods tested are unsupervised (K-Means, MeanShift), and supervised (Feed Forward Neural Net, Radial-Basis Functions, Support Vector Machines). They conclude that RBF supervised methods produce a best results for building block extraction. Currently, the RBF (Gaussian) kernel is widely used than polynomial kernels, which maps data to an infinite dimensional space, this might be because under such training and testing cost, and because of its good performance, a polynomial kernel may not give higher accuracy [5].

We used SVM based RBF kernel on the feature spaces of the Multispectral data, and on the panchromatic image.

![Classification map](image)

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### 2.1.3 Phase 3: Decision level fusion

Decision-level fusion consists of combining information at a higher level of abstraction. In this level of fusion, images are processed individually for
information extraction, then the information obtained is combined using decision fusion methods to produce a final fused decision [1]. We use two different techniques of data fusion, Majority Voting, and Dempster Shafer, and then we compare the results.

Majority voting data fusion

Voting-based fusion is one of the most important techniques in decision fusion, and has been applied in different applications [1]. Applications of majority voting methods to combine classifiers can be found in [7][8][9][10]. The fusion of the five input classification maps represented in Fig.4 using majority voting fusion, leads to the classification map illustrated in Fig.5. Thus, it appears that this fusion highlights the more relevant classes among the five different input classifications.

\[ m_{1,2}(\emptyset) = 0 \]  (2)

\[ m_{1,2}(A) = (m_1 \oplus m_2)(A) = \frac{1}{1-K} \sum_{B \cap C=A} m_1(B)m_2(C) \]  (3)

\[ K = \sum_{B \cap C=\emptyset} m_1(B)m_2(C) \]  (4)

Dempster Shafer data fusion

Dempster Shafer theory has been already employed in different application areas such as classifiers combination, remote sensing, image processing, pattern recognition, etc. In order to combine information coming from different sources, Shafer [11] has created the evidence theory on the bases formulated by Dempster. This technique is described in [2][11][12]. The interest of Dempster Shafer theory is to combine pieces information from various sources. Dempster Shafer theory considers every class and union of the classes to estimate probability mass functions to provide an efficient way of feature extraction from multi-sensor data, this combination is also called the orthogonal sum, is defined as follows:

The combination also called the joint mass is calculated from the two sets of masses \( m_1 \) and \( m_2 \). \( K \) is a measure of the amount of conflict between the two mass sets. The result of the fusion of the input classification maps represented in Fig.4, is illustrated in Fig.6.

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The first step of our methodology was designed to produce radiometric feature extraction on the Multispectral data. The radiometric feature extracted from Multispectral data, which is listed in Table 1, produced more spectral information on this data (see Fig.2). After feature extraction, for the task of data classification, one-against-one SVM based RBF Kernel is applied on The Multispectral data set, and on the Panchromatic image. After classification of all the data set, Majority Voting technique is applied as classifier fusion approach on the outputs of classifiers. In the same way we applied Dempster Shafer technique, to compare the results of the classifiers fusion methods.

Table 2 represent the overall accuracy (OA) and kappa coefficient of the different fusion of classification strategies on the Multispectral and Panchromatic data. It can be observed that fusion strategy exhibited the best accuracy, with an OA of 94.7% with Dempster Shafer technique, which improved the accuracy of SVM on Panchromatic and Multispectral data up to 35.6 and 34.4%, respectively. A further enhancement was reached with the Majority Voting technique, through which the overall accuracy grew to 29.5% and 28.3% on the Panchromatic and Multispectral data, respectively. The reasonable cause of these results is that the spatial information of Panchromatic data and spectral information of Multispectral data together could improve classification accuracy.

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III. DISCUSSION

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CONCLUSION

In this paper, the performance of a decision fusion of Multispectral and Panchromatic imageries is assessed. After the extraction of radiometric features on the Multispectral image, SVM classifiers were applied independently on each data set. Finally, a decision fusion method was applied to fuse classifiers of Multispectral and Panchromatic data. The main important aim of the proposed method is related to the effectiveness of fusion of Multispectral and Panchromatic data in decision level. Based on the results, we conclude that fusion of classifiers on these two data could improve classification accuracy. Our proposed method applied a classifier fusion to fuse decisions of Panchromatic and Multispectral data. The proposed method utilized a powerful classifier fusion method based on Dempster Shafer theory that shows more improvement in terms of classification accuracy. Multispectral images provide a detailed description of the spectral signatures of classes but this information is in low resolution, whereas Panchromatic data give detailed information about but no information on the spectral signatures. Consequently, the high spatial resolution information is very effective for the separation of species, and the spectral information of Multispectral data was very effective for discrimination of different spectral information.

REFERENCES