Registration of Multispectral Satellite Images with Orientation-Restricted SIFT

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Different bands of remotely sensed images contain unique information due to the different reflection properties of the surfaces for these modalities. These images might be acquired from various cameras having different parameters and images from different bands need to be registered to facilitate combining of distinct information contained in each band.

For the registration of multi modal images some commonly used techniques are region based [1], moment based [2], region and feature based [3] and cross-correlation and FFT based [4] methods. *Scale Invariant Future Transform (SIFT)* is a recent, effective and popular feature based technique [5] and it has largely replaced the well-known Förstner, Harris and Lucas-Kanade corner detectors that have commonly been used for feature-based registration in the last decades. SIFT essentially consists of two stages. First, good features that can be used for matching in the second stage are determined in both images through scale and rotation invariant transform. Then, the best match between feature points in the given images is obtained via comparison of the characteristic feature vectors accompanying the feature points. These characteristic feature vectors mainly include the histogram of the intensity gradient spatial directions around the feature points.

For multimodal images, feature detection step of SIFT for different image modalities can be carried out in the same manner because the location of the feature points such as corners in images of different modalities are likely to be the same. The accompanying feature vectors that will be used for matching, however, need to be modified because feature vectors of the corresponding points are unlikely to have similar intensity characteristics in multimodal images. GOM-SIFT (Gradient Orientation Modification SIFT) technique has been developed to offset this effect [6] by feature orientation reversal, treating the intensity changes in both directions (dark-to-light or light-to-dark) in the same manner.

In this paper, we acknowledge the fact that there could be more variation in the intensity changes between multimodal images than simple gradient negation as in GOM-SIFT. To allow for more variation, we construct the feature vectors by merging the histogram bins corresponding to opposite directions. For example, the histogram bin containing the 45°-90° edge direction and the bin containing the 225°-270° information are merged in a single bin because an edge with these directions correspond to the same edge albeit with different gradient direction. This also reduces the feature vector size by one half. As a result, one needs to match shorter feature vectors for registration. We called this method 'Orientation-Restricted SIFT' or OR-SIFT.

OR-SIFT compares favorably with SIFT and GOM-SIFT when there are same number of best matches. SIFT generates the lowest number of true matches. GOM-SIFT boosts the number of features extracted. However GOM-SIFT is not invariant to rotation and its performance degrades with increased rotation whereas SIFT and OR-SIFT are invariant both to rotation and scaling.

When there is a constant scale factor between the images, the matching performance can be increased by restricting the scale differences between the corresponding features [6]. We further improved the robustness of our approach by imposing scale-restriction when appropriate.

In *Figure 1*, two QUICKBIRD images (NIR and red bands) of the same region are shown. The non-linear intensity differences between the NIR band image and red band image can be easily observed in these images. All feature points that are detected by SIFT and are correctly matched by the proposed OR-SIFT are indicated by isolated green dots in the figure. In this way, correct matches are omitted and only the incorrect ones are shown by lines combining the feature pair. For this patch, of the 191 matches made, GOM-SIFT [6] results in 171 correct matches while OR-SIFT results in 181 matches. The true match ratio increases from 89.52% to 94.76% with the proposed method.

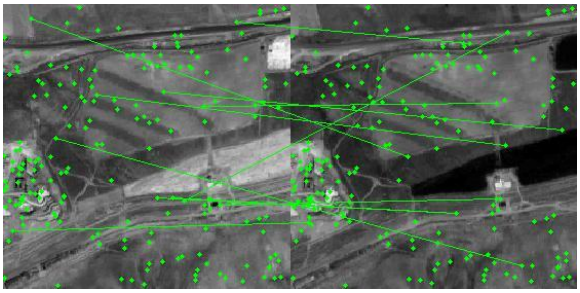

Figure 1- NIR band image (left) and red band image (right), correctly matched features are shown by green dots and incorrect matches are connected with lines.

Total performance is increased by 0.5 to 2 percent with OR-SIFT on the used test images. OR-SIFT uses a descriptor vector of size 64 where GOM-SIFT's descriptor is of size 128. This reduces the matching time by 15% on two images having 2500 features each. Alternatively, by keeping the descriptor sizes the same, i.e 128 bins, 3% increase in the number of correct matches is obtained.

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