CLOUD MOTION ESTIMATION IN SEVIRI IMAGE SEQUENCES

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1. INTRODUCTION

Determining the apparent motion from time-varying image sequences is a challenging issue in many image processing applications (i.e. medical imaging, video coding, object tracking, assisting in autonomous navigation, modeling the evolution of clouds, ice or oceanic features, etc.).

2. PROBLEMS

In the last decades, different strategies have been developed for the estimation of the optical flow, nevertheless, there does not exist yet a robust methodology providing optimum results when applied to the problem of tracking cloudy zones in remote sensing sequences, mainly, due to: (i) the presence of uniform areas without structures, (ii) the different motions appearing at different heights, (iii) the high deformation of the cloudy structures, which can split or merge, (iv) the image degradation due to atmospheric noise, and (v) the fact that gradients are weak and fuzzy, generating several unconnected border lines and making it difficult to identify structures.

Besides that, an in-deep quantitative survey of motion estimation techniques has not yet been carried out. Much of the image motion literature presents examples for a few preferred image sequences which can only be mainly judged qualitatively. As a consequence, a detailed assessment of the performance of those techniques in the remote sensing scenario is essential to select those algorithms providing the most accurate flow fields.

3. METHODOLOGY

Region matching techniques have been the most popular approaches to estimate motion. Though the MCC (Maximum Cross-Correlation) metric is almost exclusively used (see figure 1) in flow estimation by a majority of authors [1]-[5], a number of other metrics exists. The three basic metrics are: (i) the sum of absolute differences (SAD), (ii) the sum of square differences (SSD), and (iii) the cross-correlation (CC), while the rest are derived by combinations of normalization and zero-meaning. In these cases the closest match is given by the minima of the SAD, SSD and variants, or by the maxima of the CC and its variants. In this work, a total of 12 metrics have been implemented: SAD, NSAD (normalized sum of absolute differences), ZSAD (zero-mean sum of absolute differences), NZSAD (normalized zero-mean sum of absolute differences), SSD, NSSD (normalized sum of square differences), ZSSD (zero-mean sum of square differences), NZSSD (normalized zero-mean sum of square differences), CC, NCC (normalized cross-correlation), CCCoef (cross-correlation coefficient), and NCCCoef (normalized cross-correlation coefficient), usually applied under the name of MCC.

We have conducted a detailed study of these region matching techniques, using two databases. One with <u>synthetic sequences</u> generated by the application of geometric transformations on real images plus the inclusion of intensity variations and additive and impulsive noise degradation; and the other database with <u>real sequences</u> using images from the 12 available channels of the SEVIRI sensor on board the MSG (Meteosat Second Generation) satellite

In addition to the quantitative assessment and to improve the efficiency of the motion estimation procedure, a new methodology has been developed based on a preliminary stage that segments the cloudy structures to initialize the optimum motion estimation parameters: (i) The adequate template window size is retrieved from the cloud mask after analyzing the size of the cloudy structures to be able to estimate. (ii) The search window is related to the maximum displacement between features in the consecutive images of the sequence. So, the image difference of cloud masks allows the determination of the maximum motion within the image for that sequence. (iii) A study region mask is also generated around gradient areas and disables the calculation of motion vectors in unwanted and uniform zones where a reliable template matching is not possible. Likewise, a post-processing stage has been included to eliminate unreliable vectors according to magnitude and angular considerations, based on neighbourhood coherence.

4. CONCLUSIONS

After the extensive study of 12 region-based matching metrics to precisely assess their performance, using databases with 20 synthetic sequences and 50 real sequences, we can conclude that region matching techniques are robust with regard to intensity variations or spatial displacements within the image. In particular, the best performances were achieved by the ZSAD, ZSSD, NZSSD, and NCC metrics. It is important to emphasize the fact that the most prevalent method (MCC or NCCCoef metric) provides acceptable results but with larger errors when compared with the other metrics across the three databases. On the other hand, the new methodology improves the overall performance and decreases computation times.

5. REFERENCES

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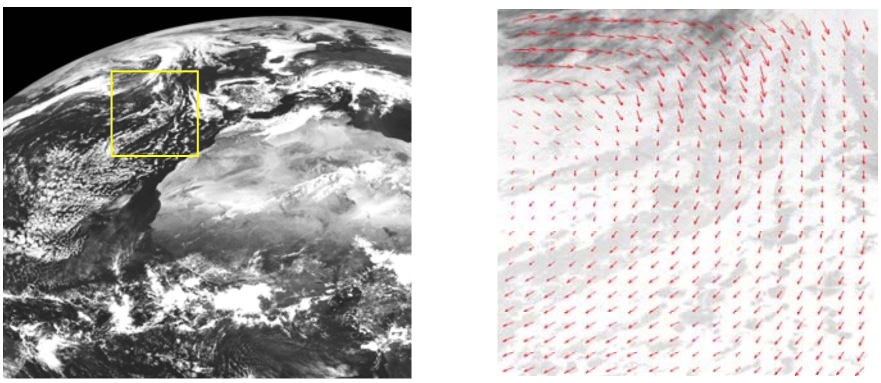

(a) (b)

Figure 1. Example of estimated motion vectors for a sequence of May, 4th 2007 (11:45 and 12:15 am): (a) Area of interest, and (b) motion vectors for the complete area using the MCC metric.