Satellite image analysis using PDE techniques.

Álvarez L., Castaño C., García M., Krissian K., Mazorra L., Salgado A., Sánchez J.
Departamento de Informática y Sistemas
Universidad de Las Palmas de Gran Canaria, Campus de Tafira
35017 Las Palmas de Gran Canaria, Spain
http://www2.dis.ulpgc.es/~lalvarez/ami

The European organization EUMETSAT provides multi-channel satellite image sequences, including visible channels, temperature channels and water vapor channels. We use a combination of these channels to perform the following tasks: 2D flow computation, altitude estimation and noise reduction, 3D position computation and 3D visualization of the clouds and of the vector flow.

The 2D flow is computed using a PDE based optical flow technique described in [1]. It consists in minimizing an energy defined as a weighted sum of 2 terms: a data term and a regularization term. The data term assumes that the images are similar at the corresponding points and the regularization term assumes a smoothness of the fluid flow. The regularization term uses the approach proposed by Nagel and Enkelmann [2], with the following improvements: (i) the formulation avoids inconsistencies caused by centering the brightness term and the smoothness term in different images, (ii) it uses a coarse to fine linear scale-space strategy to avoid convergence to physically irrelevant local minima, and (ii) it creates an energy functional that is invariant under linear brightness changes. Other approaches introduce a second order div-curl regularization to better preserve the vorticity and divergence structures [3], or use block-based matching methods [4].

An approximation of the height of the clouds is computed from an estimation of the temperature based on the infrared channel.

The noise reduction filters are applied independently within each classification area. We mainly use 2 types of filters: a validation data filter and an energy based smoothing filter which yields to a linear PDE (heat equation).

The 3D visualization is based on OpenGL, using our software AMILab available at http://serdis.dis.ulpgc.es/~krissian/HomePage/Software/AMILab/.

Fig. 1 illustrates the different tasks and their inputs.

Fig. 2 shows on the left the 3D layer decomposition obtained using the EUMETSAT original information. On the right, we display the effect our noise reducing filters applied to both the classification image and the temperature channel and the estimated flow for the highest class of clouds. The vertical component of the vectors represents the evolution of the clouds altitude. A video that illustrates our results is available at http://serdis.dis.ulpgc.es/~krissian/HomePage/Demos/Fluid/Video/CVPR_VIDEO_AMI.mpg

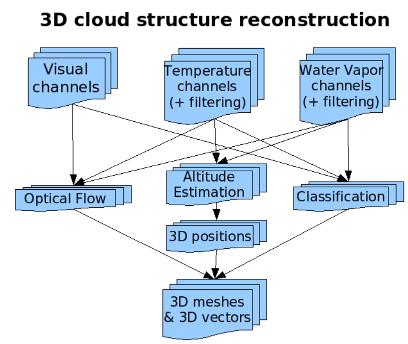

Fig. 1
PROCESSING AND VISUALIZATION OF THE SATTELITE DATA

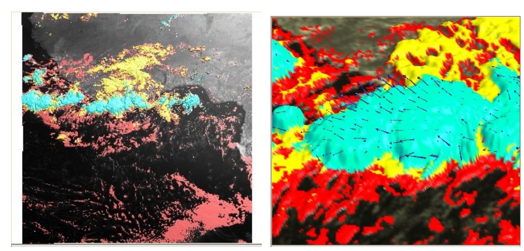

Fig. 2
LEFT: COLORING THE CLOUDS, RIGHT: DISPLACEMENT FIELD AS 3D VECTORS.

ACKNOWLEDGEMENTS

We would like to acknowledge the Laboratoire de Météorologie Dynamique (CNRS, UMR 8539, France) for providing the experimental data. This work was funded by the European research project FLUID, number FP6-513663.

REFERENCES

[1] L. Alvarez, J. Weickert and J. Sánchez “Reliable Estimation of Dense Optical Flow Fields with Large Displacements”, IJCV, 39(1):41-56, 2000.
[2] H.-H. Nagel, W. Enkelmann “An investigation of smoothness constraints for the estimation of displacement vector fields from image sequences”, IEEE Trans. Pat. Anal. and Mach. Intell., vol. 8, 565-593, 1986.
[3] T. Corpetti, E. Mémin and P. Pérez “Dense Estimation of Fluid Flows”, IEEE Trans. on Pat. Anal. and Mach. Intell., 24(3):365-380, Mars 2002
[4] A. Szantai, F. Désalmand and M. Desboi “A method for the construction of cloud trajectories from series of satellite images”, Int. J. Remote Sensors, 23(8), 1699-1732, 2002.