Characterization of dynamic textures for video retrieval

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This report describes the work done by Renaud Péteri at the SZTAKI, Hungary, as an ERCIM Fellow from the 4^{th} *January till the* 4^{th} *October 2004.*

1 Research topic

1.1 Introduction

The amount of available digital images and videos for professional or private purposes is quickly growing. Extracting the useful information from these data is a highly challenging problem and requires the design of efficient content-based retrieval algorithms.
A new issue in texture analysis is its extension to temporal domain, known as dynamic texture. Many real-world textures are dynamic textures whose retrieval from a video database should be based on both dynamic and static features. The ultimate goal is to be able to support video queries involving natural and artificial quasi-periodic processes like fire, water flows, moving crowd, escalator, etc. Combined with search for periodic activities, this could allow for queries like "Find video(s) showing a person digging near a fire and close to a river".

1.2 A method for characterizing dynamic textures

During my stay at the SZTAKI, I have developed with Dmitry Chetverikov a method for extracting features revealing fundamental properties of dynamic textures. Their interpretation enables qualitative requests when browsing videos. The features form two distinct groups: those based on the normal flow and those based on the temporal variation of the maximal regularity. Combining the two groups of the features, one can search for processes with different dynamics and spatio-temporal periodicity.
These two categories are detailed in the following sections.

Criteria based on the normal flow fields.

This first category characterizes the local dynamics of a time-varying texture averaged over time. The corresponding quantitative criteria are based on the normal flow, that derives from the well-known optical flow equation [1]:
- the *divergence*, that reflects converging and diverging fluxes,
- the *rotational*, that reflects circular movements around points (vortex),
- the *peakness* criterion, that discriminates dynamic textures having homogeneous and high motion values from dynamic textures with sparse or low motion values,

- the *orientation* criterion, that reflects a main motion orientation in the dynamic texture. The 1^{st} raw of figure 1 represents 3 kinds of dynamic textures A, C and F, where the orientation criterion has been superimposed. On a rigid and well-oriented motion like the escalator A, the homogeneity value on orientation is high, reflecting a consistent main motion flow. The smoke of sequence F is not well segmented and is very volatile, resulting to a lower value on orientation homogeneity. However, the ascending motion of the smoke is still extractable. The last sequence C of a waving plastic sheet has a very low main orientation value: the plastic sheet has an oscillating motion, resulting from an overall null displacement.

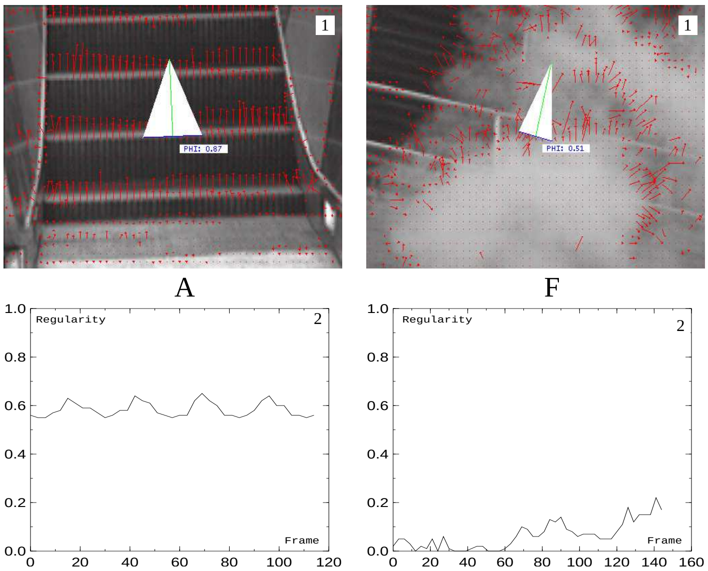

Figure 1: Orientation homogeneity and maximum regularity criteria (*courtesy of the MIT)*). 1^{st} *row: main orientation pointed by the triangle and its homogeneity (base of the triangle).* 2^{nd} *row: values of the maximal regularity areas for each frame.*

Criteria based on the maximal regularity criteria.

The second category describes the temporal variation of the most (spatially) periodic part of the image [2]. The derived criteria discriminate dynamic textures maintaining a spatially coherent structure through time, from those with low values reflecting a close to random spatial arrangement. The 2^{nd} raw of figure 1 represents the temporal evolution of the most regular area value for A, C and F. The dynamic textures A and C have significant and stable regularity values, whereas F appears as a random texture. The derived quantitative criteria are the mean and the standard deviation over time of this most regular area value.

1.3 Conclusion and future prospects

The defined criteria have been applied in [3] on a real dataset browsing a wide range of possible dynamic texture occurrences (a fire, a waving flag, ripples on a river . . .). It is possible to separate different sorts of motion: oriented from isotropic or rotating, as well as spatially regular from random ones. The qualitative criteria are fast to compute and can be used to guide the human query: a request 'water' can

indeed appear in many occurrences in a video (waving, as a vortex or as an oriented flow). One can think of assigning weights to the defined coefficients according to this request.
Current work aims at testing the discriminative aspect of the features in a full classification process. The multi-scale properties in time and space of dynamic textures will also be studied.

2 Scientific production

2.1 Publication

R. Péteri and D. Chetverikov. "Qualitative characterization of dynamic textures for video retrieval". Proc. International Conference on Computer Vision and Graphics, Warsaw, 2004, to appear in Kluwer series on Computational Imaging and Vision.

ABSTRACT: A new issue in texture analysis is its extension to temporal domain, known as dynamic texture. Many real-world textures are dynamic textures whose retrieval from a video database should be based on both dynamic and static features. In this article, a method for extracting features revealing fundamental properties of dynamic textures is presented. Their interpretation enables qualitative requests when browsing videos. Future work is finally exposed.

2.2 Conference and lectures

- I have given an oral presentation of the previous article at the International Conference on Computer Vision and Graphics, held in Warsaw, Poland in September 2004.
- I have also given 2 lectures at the SZTAKI on my research topic, in February and April 2004.

2.3 Web demo

A web demonstration of the work carried out during my stay at the SZTAKI is also available at the address:
`http://porthos.ipan.sztaki.hu/~rpeteri/ipan/dynamic_textures_web/`

References

[1] B.K.P. Horn and B.G. Schunck. Determining optical flow. *Artificial Intelligence*, 17:185–203, 1981.

[2] D. Chetverikov. Pattern regularity as a visual key. *Image and Vision Computing*, 18:pp. 975–986, 2000.

[3] R. Péteri and D. Chetverikov. Qualitative characterization of dynamic textures for video retrieval. In *Proc. International Conference on Computer Vision and Graphics*, Warsaw, Poland, September 2004. To appear in Kluwer series on Computational Imaging and Vision.