Scientific Report

First name / Family name	Fabien Racapé
Nationality	French
Name of the *Host Organisation*	Fraunhofer - Heinrich-Hertz-Institute
First Name / family name of the *Scientific Coordinator*	Patrick Ndjiki-Nya
Period of the fellowship	01/04/2013 to 31/03/2014

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During my fellowship, I conducted my research at the Fraunhofer - Heinrich-Hertz-Institute, under the supervision of Dr. Ndjiki-Nya. The objective was to develop a texture synthesis module that can be easily integrated into specific video applications. Even if the framework we developed is generic, the video compression application has been targeted.

Natural textures that can be highly dynamic in videos are difficult to predict via classical prediction modes. Their transmission requires a lot of data not to lose quality. Hence, some frameworks called perception-oriented compression schemes have been studied over the past 10 years, in which textures are not transmitted but synthesized at the decoder side. Texture synthesis algorithms, used in these schemes, can be classified into two main categories: parametric and non-parametric methods. The first category builds a model with a minimum of parameters which aims at approximating the probability density function of the source signal. The second mostly builds the output texture on the fly by finding best matching patches in the input texture. It is difficult to evaluate and compare these perception-oriented compression frameworks, since no existing metrics enable to objectively assess the quality of such decoded and synthesized videos. Considering the state-of-the-art, the question of choosing between parametric and non-parametric schemes remains open.

In the hosting team, a perception-oriented compression scheme using a non-parametric method already was previously developed. It was then legitimate to try a parametric method to explore its possibilities and to create a competitive tool that can be used for certain types of textures. The basic idea was to explore possible efficient synthesizers that could be selected by the encoder in the same way as a prediction mode is selected in standard codecs. We developed an improved 2D+t parametric texture completion framework based on the autoregressive (AR) model or more precisely the spatiotemporal autoregressive (STAR) model. In the classical scheme, a Gaussian noise is used to drive the synthesis. However, when trying to synthesize highly dynamic textures (fast moving water, grass, leaves…) the genuine method fails. We thus propose to replace Gaussian noise by a new innovation term that provides much better visual results. Moreover, this new term is deterministic which is essential in the video coding context. Indeed, the encoder can select this synthesis mode while exactly knowing the result at the decoder side, which is not the case when introducing randomness.

Existing frameworks directly use texture synthesis algorithms to complete the regions that are selected to be synthesized. However, these algorithms are built to synthesize *stationary* or nearly stationary textures, which is hardly ever the case in natural scenes. We propose here to split the source signal into *cartoon* and *texture* via texture separation. The cartoon part is a filtered version of the source signal which is piecewise smooth and easy to predict with classical compression modes. It is then classically encoded. The texture is the difference between the source signal and the cartoon. Thus, it contains less structures, which appear in the cartoon and tends to be nearly stationary. Although stationarity is never reachable, this texture signal has better statistical properties to be synthesized. We have demonstrated that avoiding the transmission of residuals of dynamic regions drastically reduces bitrate, using the most recent HEVC reference software. The visual quality of our resulting synthesized textures outperforms existing methods, in particular in the case of highly dynamic textures.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Accepted:
Fabien Racape, Martin Köppel, Dimitar Doshkov and Patrick Ndjiki-Nya *Adaptive 2D-AR framework for texture completion*, "ICASSP2014 - Image, Video, and Multidimensional Signal Processing, Florence, Italy, may, 2014.

Abstract:
Texture extrapolation techniques enable to fill large holes of missing information. Many applications can be targeted such as image and video coding, channel block losses, object removal and filling of 3D disocclusions. For more than two decades, many approaches have been developed, even though each contains pros and cons which force to choose the best compromise for the targeted application. In this paper, we propose to continue exploring and improving a popular parametric completion method using the autoregressive (AR) model. In this framework, the training area is automatically optimized. A consistency criterion also enables to assess and regularize the model. Moreover, a post-processing step enables to remove the remaining seam artefacts. A comparison with the state-of-the-art is provided for both subjective quality and complexity which remains a major constraint for texture completion.

Submitted:
Fabien Racape, Dimitar Doshkov, Martin Köppel and Patrick Ndjiki-Nya, *2D+t Autoregressive Framework for Video Texture Completion*, IEEE International Conference on Image Processing 2014 (ICIP 2014), Paris, France, oct, 2104.

Abstract:
In this paper, an improved 2D+t texture completion framework is proposed, providing high visual quality of completed dynamic textures. A Spatiotemporal Autoregressive model (STAR) is used to propagate the signal of several available frames onto frames containing missing textures. A Gaussian white noise classically drives the model to enable texture innovation. To improve this method, an innovation process is proposed, that uses texture information from available training frames. The proposed method is deterministic, which solves a key problem for applications such as synthesis-based video coding. Compression simulations show potential bitrate savings up to 49% on texture sequences at comparable visual quality. Video results are provided online to allow assessing the visual quality of completed textures.

To be Submitted:
Fabien Racape, Sebastian Bosse, Dimitar Doshov, Patrick Ndjiki-Nya. *Joint texture Separation and Synthesis for Video Compression.* Transaction on Circuits and Systems for Video Technology

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

ABCDE Seminar, Athens, Greece. 31st October 2013 – 2nd November 2013.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

1st exchange:
Hosting institute: Polytechnic University of Catalonia (UPC), Barcelona, Spain
Dates: 27/09/13-05/10/13

I did my first exchange in the Image Processing Group, led by Pr. Ferran Marquez and Pr. Philippe Salembier. I met and discussed with their team and in particular with Guillem Palou, who works on video representation. Their work on Trajectory Binary Partition Tree is of high interest, considering the connections with my work on the evolution of dynamic textures in videos. I gave a presentation of my work to invited people from the department.

2nd exchange:
Hosting institute: French Institute for Research in Computer Science and Automation (INRIA), Rennes, France.
Dates: 5/2/13-16/2/13

I did my second exchange in the SIROCCO team, led by Dr. Christine Guillemot. During the visit, I gained knowledge on their recent research work. They especially published an outstanding review on image Inpainting. Very interesting research is also carried on sparse representations, trying to find non-classical means to encode videos. I also presented my work to the team.