

### **Activities carried on by Simone Milani.**

During the academic years 2003/2004, 2004/2005 e 2005/2006 dott. Simone Milani has attended the PhD course in Electronic and Telecommunication Engineering, XIX ciclo, at the Department of Information Engineering, University of Padova, Italy.

#### Learning activity

Advanced courses for PhD students attended at the University of Padova

- “Selected Topics in Optimization”, prof. M. Pavon, a.a. 2003/2004
- “Writing for PhD students”, prof. S. Guth, a.a. 2003/2004
- “Poisson, Renewal and Semi-Markov Processes”, prof. M. Zorzi, 2003/2004
- “Network Architecture to support QoS over the Internet” (corso di teledottorato), prof. S. Giordano, a.a. 2003/2004
- “Multimedia Systems for the Cultural Heritage” (corso di teledottorato), prof. V. Cappellini, a.a. 2003/2004
- “Traffic Models for Network Performance Evaluation” (corso di teledottorato), prof. Schembra e Lombardo, a.a. 2003/2004
- “Principles of Image and Video Compression” (corso di teledottorato), prof. D. Taubman, a.a. 2003/2004.
- “Introduction to Coding Theory”, prof. F. Fagnani, a.a. 2004/2005
- “Applied Linear Algebra”, prof. H. Wimmer

Advanced courses for PhD students attended at other institutes

- “Statistical Learning Theory”, prof. M. Wainwright, Dept. of Electrical Engineering and Computer Science, University of California, Berkeley, 09/2004-12/2004

Attended PhD schools

- Scuola per Dottorandi in Ingegneria dell’Informazione, prof. G. Zarone, Napoli, 16-20 Febbraio 2004
- Summer School on Information Engineering (SSIE 2005), prof. S. Pupolin, Bressanone, 26-30 Giugno 2005

Attended Seminars:

- “Modelli fisici per l’audio in interfacce multimodali”, F. Avanzini, Padova (DEI Colloquia), Mar. 25<sup>th</sup>, 2004
- “The Enjoyment of Computing Theory”, Andrei Chi-Chih Yao, Padova (DEI Distinguished Lecture), May 7<sup>th</sup>, 2004.
- “Entropy and Relative Entropy in the Mathematical, Physical and Engineering Sciences”, prof. M. Pavon (organizer), Padova, June 24-26, 2004
- “Subspace Methods for Visual Learning and Recognition”, Horst Bischof & Ales Leonardis, Wien, Austria, Sept. 6, 2004
- “Near-Instantaneously Adaptive Wireless Video Communications”, Lajos Hanzo, Wien, Austria, Sept. 6, 2004
- “Wireless Communications Systems: A Journey from 1st Generation to 3rd Generation and Beyond”, U. S. Jha, Abano Terme (PD), Italy, Sept. 12<sup>th</sup>, 2004.

- STreaming Day 2004, Agrate Brianza (MI), Sept. 24<sup>th</sup>, 2004.
- Workshop Primo-Pavia, Torino, Italy, 11-12 Novembre 2004
- “JPEG2000: Compression standard for interactive imaging”, D. Taubman, Padova (DEI Colloquia), Sep. 23<sup>rd</sup>, 2004
- “Highly Scalable Video Compression, with Motion Compensated Multi-Resolution Wavelet Lifting”, D. Taubman, Padova (DEI Colloquia), Nov. 25<sup>th</sup>, 2004
- “Modelli ed algoritmi per problemi di packing bidimensionali”, M. Monaci, Padova (DEI Colloquia), 12 Maggio 2005
- “L'uso della voce eufonica negli insegnanti”, R. De Santi, Padova (DEI Colloquia), 22 Giugno 2006
- “Energy Conservation in Adaptive Filtering”, Ali Sayed, Florence, Italy, Sept. 4<sup>th</sup>, 2006
- STreaming Day 2006, Pisa, Italy, Sept. 11<sup>th</sup>, 2006.

#### Held Seminars:

- “Rate control algorithms for H.264/AVC”, FIRB PRIMO Meeting, Pavia, Italy, Dec. 16<sup>th</sup>, 2003.
- “Joint source-channel video coding for H.264 using FEC”, STreaming Day 2004, Agrate Brianza (MI), Sept. 24, 2004
- “An improved context adaptive binary arithmetic coder for the H.264/AVC standard”, STreaming Day 2006, Pisa, Italy, Sept. 11, 2006
- “Achieving high compression efficiency with distributed video coding”, Video Processing Lab, University of California – San Diego (UCSD), CA, USA, Feb. 5<sup>th</sup>, 2007.

#### Attended International Conferences

- “The 12th European Signal Processing Conference (EUSIPCO 2004), Wien, Austria, September 6-10, 2004
- “The 7th Symposium on Wireless Personal Multimedia Communications (WPMC 2004)”, Abano Terme (PD), Italy, Sep. 12-15, 2004.
- “International Conference on Telecommunication and Computer Networks (IADAT-tcn2004)”, San Sebastian, Spain, Dec. 2004.
- “The 14th European Signal Processing Conference (EUSIPCO 2006)”, Sep. 4-8, 2006, Florence, Italy.
- “IS&T/SPIE Annual Symposium on Electronic Imaging Science and Technology – Visual Communications and Image Processing (VCIP 2007)”, Jan. 28 - Feb. 1, 2007, San Jose, CA, USA.

#### Periods of research activity spent abroad

- University of California, Berkeley, Dept. of Electrical Engineering and Computer Science, 08/2005-06/2006, exchange student in the EAP program.

#### Teaching activity (lessons, exercise practice, laboratories):

- 9 Lab lessons on Digital Signal Processing with MATLAB within the course “Elaborazione Numerica dei Segnali (n.o.)” (“Digital Signal Processing”), prof. G. A. Mian, a.a. 2004/2005

- 3 Lab lessons on Digital Signal Processing with MATLAB within the course “Elaborazione Numerica dei Segnali (n.o.)” (“Digital Signal Processing”), prof. G. M. Cortelazzo, a.a. 2006/2007

#### Research Activity:

The research activity has been focused on coding algorithms for video sequences that are to be transmitted over packet networks. In this work, three aspects were considered: the compression gain, the robustness to channel errors and information losses, and the computational complexity. Thanks to its high coding performance, the video coding standard H.264/AVC was chosen as the starting point of the whole investigation. Its compression gain was improved adopting an enhanced version of its arithmetic coder CABAC. By changing its contexts structure using a graph, it is possible to obtain a 10% reduction in the size of the coded bit stream at a given quality for some sequences. In addition, a good coding efficiency can also be obtained controlling the produced bit rate with an appropriate algorithm. An innovative solution was proposed modelling the number of coded bits as a function of the percentage of null DCT coefficients and of the energy of the transmitted residual signal. The solution permits a sufficiently accurate rate control at a low computational cost.

Then, the thesis concerns the problem of making the transmission of video sequences robust over channels affected by losses. A possible solution consists in including redundant packets in the stream using cross-packet FEC codes based on a matrix structure. This coding scheme requires an effective optimization of matrix size, and to this purpose, different optimization techniques were analyzed together with a joint source-channel rate control algorithm.

Finally, the investigation concerned Distributed Source Coding techniques applied on Video signals to enable a robust transmission of video sequences. Within this work, a DSC coder was designed implementing an entropy coding algorithm that permits obtaining comparable performance with respect to H.264/AVC.

All the algorithms were designed considering the required computational complexity and choosing those techniques that require a limited amount of computation.

The research activity was concluded with the PhD Thesis

“Source and Joint Source-Channel Coding for Video Transmission over Lossy Networks”

Tutor: prof. G. A. Mian

#### Publications:

Proceedings of conferences:

- D. Alfonso, D. Bagni, L. Celetto, and S. Milani "Constant Bit-Rate Control Efficiency With Fast Motion Estimation in H.264/AVC Video Coding Standard", Proc. European Signal Processing Conference (EUSIPCO), Sept. 6-10, 2004, Vienna, Austria
- S. Milani, G.A. Mian, D. Alfonso, L. Celetto, “A (rho,Eq)-Domain Based Low-Cost Rate Control Algorithm for the H.264 Encoder”, Proc. of the Seventh symposium on Wireless Personal Multimedia Communications (WPMC), Sep. 12-15, 2004, Abano Terme(PD), Italy.
- O. Campana and S. Milani, "A Multiple Description Coding Scheme For The H.264/AVC Coder", Proc. of the International Conference on Telecommunication and Computer Networks (IADAT-tcn2004), San Sebastian, Spain, December 2004, pp. 191-195.

- N. Zandonà, S. Milani, A. De Giusti, “Motion-Compensated Multiple Description Video Coding”, Proc. of the International conference on Multimedia, Image Processing, and Computer Vision 2006 IADAT-micv2006, Madrid, Spain, March 30th-April 1st, 2005.
- S. Milani, G.A. Mian, L. Celetto, “Joint optimization of source-channel video coding using the H.264 coder and FEC codes”, Proc. of the 13th European Signal Processing Conference (EUSIPCO 2005), Antalya, Turkey, September 4-8, 2005,
- S. Milani, G.A. Mian, L. Celetto, “A  $p$ -Domain Based Joint Optimization of Source-Channel Video Coding”, Proc. of Wireless Reconfigurable Terminals and Protocols (WiRTeP), Rome, Italy, April 10-12, 2006.
- O. Campana, A. Cattani, A. De Giusti, S. Milani, N. Zandonà and G. Calvagno, “Multiple Description Coding Schemes for the H.264/AVC Coder”, Proc. of Wireless Reconfigurable Terminals and Protocols (WiRTeP), Rome, Italy, April 10-12, 2006,
- S. Milani, G.A. Mian, “An Improved Context Adaptive Binary Arithmetic Coder for the H.264/AVC standard”, Proc. of European Signal Processing Conference (EUSIPCO), Sep. 4-8, 2006, Florence, Italy.
- S. Milani, J. Wang, K. Ramchandran, “Achieving high compression efficiency with distributed video coding”, to appear in the Proc. of IS&T/SPIE Annual Symposium on Electronic Imaging Science and Technology – Visual Communications and Image Processing (VCIP 2007), Jan. 28 - Feb. 1, 2007, San Jose, CA, USA.

Submitted works:

- S. Milani, L. Celetto, and G. A. Mian, “A Rate Control Algorithm for the H.264 Encoder”, submitted to IEEE Trans. on CSVT.