

課題番号 P-7

## Space and Time Efficient Computation in Image Processing: Theoretical Foundations and Implementation

### [1] Organization

Leader: *Valentin E. Brimkov* (Mathematics Department, Buffalo State College, State University of New York, USA)

Representative at RIE: *Kamen Kanev* (Research Institute of Electronics, Shizuoka University)

Participants:

*Reneta P. Barneva* (Department of Computer Science, SUNY Fredonia, USA)

*Francois de Vieilleville* (Department of Mathematics, University of Savoie, France)

*Daniel D. Cunningham* (Mathematics Department, Buffalo State College, State University of New York, USA)

*José Ramón Dorronsoro* (Telecommunications and Computing Department, Escuela Politécnica Superior, Universidad Autónoma of Madrid (UAM) and Instituto de Ingeniería del Conocimiento (IIC), UAM, Spain)

*Antoine Deza* (Department of Computing and Software, Faculty of Engineering, McMaster University, Canada)

*Elka Korutcheva* (Universidad Nacional de Educación a Distancia, Spain)

*Kostadin Koroutchev* (Universidad Autónoma of Madrid, Spain)

### [2] Progress of the Research

In the eight month project period (June 15, 2009 – March 16, 2010) the project team extended the research initiated in the framework of a successful kick-off mini-project conducted from December 18, 2008 to March 15, 2009. Team members performed research activities on several problems as outlined in the project description. In certain periods of time, they had intensive discussions by email and Skype in order to coordinate the joint research activities. During the project period the following research meetings were held:

- November 25-27, 2009 - Prof. Brimkov, Prof. Barneva, and Prof. Kanev met at the International Workshop on Combinatorial Image Analysis (IW CIA2009) in Cancun, Mexico, and discussed the ongoing collaborative research activities and future joint work.

- July 14, 2009 - Prof. Deza and Prof. Kanev met at the Canada-Japan Workshop on

Discrete and Computational Geometry in Tokyo, Japan and discussed the ongoing collaborative research activities and future collaboration.

- August 16-17, 2009 - Prof. Deza visited RIE to give a talk at the 163rd Monday Morning Forum and had a collaborative research meeting with Prof. Kanev.

Project members were also involved in organizing a Cooperative Research Seminar on space and time efficient computation in image processing. The seminar took place on January 7, 2009 at RIE and the following talks were given by the project participants:

- Prof. Kanev organized the seminar and made a short opening speech

- Prof. Barneva introduced one of the partner universities – SUNY, explained the ongoing collaborations, and focused on the perspectives for fostering further exchanges of faculty and students

- Prof. Brimkov reported on the progress of the collaborative research on space and time efficient computation in image processing

- Prof. Koroutchev presented the ongoing collaborative research on information acquisition and retrieval in very large image databases (VLIDB)

After the seminar interested parties had a number of discussions about possible cooperation of their educational institutions regarding student exchange and other joint education activities. They also discussed topics of common interest with other RIE faculty and got acquainted with the remarkable past and current achievements of scientists from Shizuoka University.

In the course of the research, both theoretical and experimental studies have been carried out. This effort resulted in obtaining a series of results on space and time efficient computation regarding the theoretical foundations of this research area as well as related applications. Overall, most of the project tasks have been accomplished, and some unexpected new results have been obtained.

### [3] Results

(3.1) Research results

The theoretical foundations of CLUSPI functionality were considered. We presented the encoding and decoding schemes using shift-register sequences. Some theoretical challenges were considered: searching noisy patterns, finding the maximal length of a unique pattern with a gap, considering the search in the framework of CRCW-PRAM model, and others.

We proposed and discussed a novel method for enhancing books and other printed materials with layers of digital data blended with their page content. In document digitizing, a patented Cluster Pattern Interface (CLUSPI) is used for providing orientation and position feedback that establishes connections with an electronic multimedia dictionary employing pictures, multilingual word explanations, and pronunciation samples. The work was mainly oriented to young children and aimed to enhance their reading comprehension and develop their language learning skills.

We extended further our approach exploring independently developed sign language dictionary resources and considering for inclusion in an integrated multilingual multimedia dictionary with video support. Print-based interfaces for direct access to digital content were implemented and a novel concept for dynamic linking to printed documents based on mapping of printed and digital content was proposed. Printed texts in different languages and language independent images were used as interface components for addressing diverse multimedia content including sign language and lip reading multimedia resources. Finally, enabling learning and its social dimensions were discussed in the context of the contemporary technological advancements and innovative educational methods and approaches.

It has been shown that by using a modification of previously developed probabilistic method for finding the most unusual part of a 3D digital images, one can detect the temporal intervals and areas of interest in signals/video records and mark the corresponding objects that behave in an unusual way. The method can be successfully applied in Intensive Care hospital Units (ICU), where EEG video recording is a standard practice to ensure that a potentially life-threatening event can be detected even if its indications are present only in a fraction of the observed signals.

Most of the obtained results are available in a form of research papers, published in reputable journals or proceedings of international or

national conferences.

### (3.2) Future work

Some of the results, already reported at international conferences will be extended and submitted for consideration and publication in special issues of reputable scientific journals.

We believe that obtained results will provide a solid foundation for future work on related problems. For this, relevant frameworks and sources of funding are to be sought.

Possibilities for expanding the research collaboration and initiating faculty and student exchange between different departments, potentially leading to official exchange agreement between SUNY, UAM, and Shizuoka University will be explored.

### [4] Publications

- (1) Koroutchev, K., E. Korutcheva, K. Kanev, A. Rodriguez Albarino, J. L. Muniz Gutierrez, F. Farinas Balseiro, Detection of unusual objects and temporal patterns in EEG video recordings, in the Proceedings of ISVC, Las Vegas, Lecture Notes in Computer Science, No 5875, Springer (2009) 965-974
- (2) Barneva, R.P., V.E. Brimkov, K. Kanev, Theoretical Issues of Cluster Pattern Interfaces, Petra Wiederhold, R.P. Barneva (Eds.), Combinatorial Image Analysis, Lecture Notes in Computer Science, No 5852, Springer (2009) 302-315.
- (3) Barneva R.P., V.E. Brimkov, K. D. Kanev, Combining ubiquitous direction-sensitive digitizing with a multimedia electronic dictionary for enhanced understanding, International Journal on Imaging Systems and Technology (Wiley), Vol. 19 (2) (2009) 39-49.
- (4) Kanev, K., R.P. Barneva, V.E. Brimkov, D. Kaneva, Interactive printouts integrating multilingual multimedia and sign language electronic resources, Journal of Education Technology Systems, Vol. 38(2) (2009-2010) 123-143.
- (5) Kanev, K., R.P. Barneva, V.E. Brimkov, D. Kaneva, Print-based interaction interfaces for multilingual multimedia and sign language electronic resource integration. Proc. ICSoft 2009, 4th International conference on Software and Data Technologies, Sofia, Bulgaria, 26-29 (July 2009) Vol. 2, 223-228.
- (6) Koroutchev K., E. Korutcheva, Rare segments in temporal signals and video recordings, ICTP Preprint, IC-056/2009

## Travelling report

Name: Kamen Kanev  
Affiliation: Research Institute of Electronics, Shizuoka University, Japan  
Period of time: July 13, 2009 – July 15, 2009  
Destination: Tokyo University, Japan  
Purpose: To discuss the collaborative project research, to attend the Canada-Japan Workshop on Discrete and Computational Geometry co-organized by Prof. Deza, and to give a talk entitled „A Cluster Pattern Approach for Improved Carpet Encoding of Surfaces“

Name of receiver: Prof. Antoine Deza

Name: Antoine Deza  
Affiliation: Department of Computing and Software, Faculty of Engineering, McMaster University, Canada  
Period of time: August 16, 2009 – August 17, 2009  
Destination: Shizuoka University, Japan  
Purpose: To discuss the collaborative project research and to give a talk entitled „A Combinatorial Optimization Approach to the Peg Solitaire Game“ at RIE

Name of receiver: Prof. Kamen Kanev

Name: Valentin Brimkov  
Affiliation: Mathematics Department, Buffalo State College, State University of New York, USA  
Period of time: January 2, 2010 – January 10, 2010  
Destination: Shizuoka University, Japan  
Purpose: To discuss the project organization and research and to participate in a Collaborative Research Seminar organized at RIE.

Name of receiver: Prof. Kamen Kanev

Name: Reneta Barneva  
Affiliation: Department of Computer Science, SUNY Fredonia, USA  
Period of time: January 2, 2010 – January 10, 2010  
Destination: Shizuoka University, Japan  
Purpose: To discuss the project organization and research and to participate in a Collaborative Research Seminar organized at RIE.

Name of receiver: Prof. Kamen Kanev

Name: Kostadin Koroutchev  
Affiliation: Universidad Autónoma of Madrid, Spain  
Period of time: January 2, 2010 – January 9, 2010  
Destination: Shizuoka University, Japan  
Purpose: To discuss the project organization and research and to participate in a Collaborative Research Seminar organized at RIE.

Name of receiver: Prof. Kamen Kanev