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SOPD-Daniel Lemire, Ph.D.

Contributions to Science and Technology

Current work (March 2002)

Daniel Lemire is currently doing research on data thinning and Computer Aided Geometric Design (CAGD) at Acadia University. He has worked for years experience in telehealth and data processing. He is currently interested in building efficient summaries for large XML files and helping data mining applications scale better on large databases through data thinning.

Among his recent contributions to CAGD is his work on High Resolution Subdivision Schemes [1]. The purpose of this work is to propose and study a new truly local data interpolation scheme which can be one order of magnitude better at approximating polynomials than the existing schemes in some cases. Among applications of such work are pyramidal transforms which can be used for efficient progressive data transfers and analysis.

Hermite Subdivision Schemes (2000-2001)

Hermite Subdivision Schemes are a CAGD and data processing technique. Daniel Lemire's work [2] has lead to a new type of mathematical analysis for the regularity of Hermite Subdivision Schemes based on the Fourier transform.

Citation: S. Dubuc, J.-L. Merrien, A 4-Point Hermite Subdivision Scheme, Mathematical Methods in CAGD: Oslo 2000, T. Lyche & L.L.Shumaker (eds), 2001

Post-Doctoral Fellowships (1998-1999)

Daniel Lemire got two post-doctoral fellowships: one with professor A.-R. LeBlanc and the other one with professor P. Matthieu both at the "Institut de génie biomédical" ("Biomedical Engineering Institute") and at the "Centre de recherche de l'Hôpital Sacré-Coeur" (Sacré-Coeur Hospital Research Center). He worked on data processing applications in a medical context (ECG, NMR, EMG...).

The following contributions were made:

- A new approach to detect myocardial ischemia (lack of oxygen in one's heart) was proposed [4][7]. Myocardial ischemia is a common cause of death in North America and proper monitoring of the patients is important. The most common monitoring technique involve ECGs and a simple average over a small section

of the heartbeat. We were the first to propose wavelets as a tool to measure ischemia. Having several perpendicular measures of the same physiological phenomenon typically allows one to improve accuracy.

- During his post-doctoral years, Daniel Lemire contributed substantially to the JSci - A science API for Java project. Indeed, all of the processing and visualization software was written in Java. To this day, a large number of classes contributed to JSci are used in various Java projects through the world. Reference: http://maths.dur.ac.uk:8000/~dma3mjh/jsci/.

Thesis (1995-1998)

Daniel Lemire got his Ph.D. in 1998 from the "École Polytechnique de Montréal" (largest engineering school in Canada) with professors Gilles Deslauriers and Serge Dubuc. He worked on wavelets and applications. His thesis was on "iterative schemes and wavelets". He also got his M.Sc. from the University of Toronto were he worked with professor Catherine Sulem on "a priori estimates for nonlinear systems".

The following contributions were made:

- New non-separable filters for image processing were proposed [12]. It is hoped that these new filters might lead to image processing algorithm with reduced blocking artifacts.
- New boundary-aware wavelet filters were proposed [11]. This work is important for two reasons: we discovered a mathematically simpler approach to filter design and these new filters provide a new tool for engineers. Indeed, most wavelet filters generate (small) artifacts at the beginning and at the end of signals while these filters can be considered "perfect" filters with regard to the boundaries.

Contributions to Clients

Since 1998, over 200,000$ in research contracts were granted by the following companies: THEM Geophysics Inc., FalconBridge, Waid, CIRA, Infinition, and Kheops. The 3 most significant projects are described below.

MedicalGate Association (France) 2000-2001

Daniel Lemire served as a technology architect for Medical Association, a non-profit group of doctors, biologists and pharmacists. We successfully developed a medical records management system through XML descriptors (Multimedia Medical Format) with backward compatibility with systems such HPRIM. At the time, the proposed DTD was certainly one of the first concrete attempt at using XML for medical record management in France, if not the first. The project has since been open-sourced and is part of an ongoing attempt at creating an efficient XML-based medical information management system.

It is hoped that this work will serve as a foundation for future work in electronic medical record processing.

Waid/CIRA/Serveur national de radiologie (France) 1999-2000

Daniel Lemire was the consulting scientist for the first wavelet-based image server for the "Serveur national de radiologie" in France ("National Radiology Server") [5][9]. Serving medical images (DICOM) on the web is a major undertaking since the average radiologist will generate over 4 gigabytes of raw data per day. In 2000, Daniel Lemire spent part of the summer at Aix-en-Provence as the guest scientist for this project. The result of this work is known as the "waaves" format and it is currently in use in France for storing and retrieving digital radiology images. It is one of the few radiology image file format using wavelets in the world and might have been the first. As far as technology is concerned, we were involved in making available a file format that is not normally used on the web .

This work has lead to an improved encoding of radiology images and easier management through an embedded "imagette" (thumbnail) system based on quad-tree encoding.

THEM Geophysics Inc./FalconBridge/CAMIRO (Canada) 1998-2000

Over several years, Daniel Lemire worked with THEM Geophysics Inc. with funding from FalconBridge and CAMIRO (Canadian Mining Industry Research Organization) on improving geophysical data processing for the THEM system [3]. The THEM system is the only Canadian airborne EM system for exploring rough terrains. The signal-to-noise ratio was improved by at least 100% using better mathematical modeling. The software has been used successfully in Northern Canada and Sudan in exploration contracts worth several millions of dollars. It is impossible to estimate the exact value of such software, but geophysical data processing packages are typically sold for over 100,000$ for one license and it should be noted that no commercial solution was found to outperformed the software developed specifically for THEM Geophysics Inc.

Contributions Outreach and Influence

Media

- Daniel Lemire was invited to the TV show "C'est mathématiques!" ("It's mathematics!") on "Canal Z" (Winter 2001) to discuss Canadian innovations in geophysical data processing. "Canal Z" is the major French TV channel in Canada featuring technology and science programs. "C'est mathématiques!" has been on the air for several years.
- Daniel Lemire gave an interview for the "Bulletin de l'AMQ" (Bulletin of the "Quebec Mathematical Society") on the theme "consulting in the industry as a mathematician" (Autumn 2001). The "AMQ" is the only major Mathematical Society in Quebec and has thousands of members who all receive the "Bulletin de l'AMQ".

Referee

Daniel Lemire has been a referee for a few international journals including IEEE Transactions in Medical Imaging, IEEE Transactions in Signal Processing and others.

Web

Daniel Lemire owns his own domain name on the web “ondelette.com” which stands for “wavelet.com”. This web site host the “Wavelet forum” on http://www.ondelette.com/indexen.html (“ondelette” is French for “wavelet”) and meant as a resource for researchers and students interested in wavelets.

Professorship

Daniel Lemire has been a professor at Acadia University during the school year 2001-2002. (Reference: http://www.ondelette.com/acadia/ .)

- He was a member of the special committee on the new master in Industrial Mathematics. The master in Industrial Mathematics should be offered in 2003 for the first time.
- He has taught to over 100 students during that one year including some of the most advanced engineering and computer science students at Acadia University (courses “Advanced Calculus” and “Numerical Methods 2”).
- As a guest lecturer, during the summer of 2001, Daniel Lemire taught to over 150 students at the “Université de Sherbrooke” in Quebec (courses “Data Structures” and “Algorithmic”).

Contributions to Teamwork

Acadia University

As a professor at Acadia University, Daniel Lemire has been a member of the committee for the upcoming master (M.Sc.) in industrial mathematics. He also contributed to several internal teaching documents including solutions for Calculus and he updated a teaching reference on Series.

Consultant

As a consultant Daniel Lemire was typically part of team including a least one system programmer and often other scientists. Moreover, clients expected good teamwork with their own technical teams.

APPENDIX

Publications

[1] Daniel Lemire, High Resolution Subdivision Schemes, Curves and Surfaces, Saint-Malo, France, June-July 2002 (accepted on March 2002).

[2] Serge Dubuc, Daniel Lemire, Jean-Louis Merrien, Fourier analysis of 2-point Hermite interpolatory subdivision schemes, Journal of Fourier Analysis and Applications, Volume 7, Issue 5, 2001.

[3] Daniel Lemire, Recent mathematical advances in EM modeling for mineral exploration, Canadian Mining Industry Research Organization (CAMIRO), Toronto, Ontario, 2001 (guest talk).

[4] Daniel Lemire, Chantal Pharand, Jean-Claude Rajaonah, Bruno Dubé, A.-Robert LeBlanc, Wavelet time entropy, T wave morphology and myocardial ischemia, IEEE Transactions in Biomedical Engineering, vol. 47, no. 7, July 2000.

[5] Daniel Lemire, Intégration Web de formats propriétaires par le Java, congrès WebTek, Québec, mars 2000. (“Web integration for proprietary formats using Java”)

[6] Gilles Deslauriers, Serge Dubuc et Daniel Lemire, Une famille d’ondelettes biorthogonales sur l’intervalle obtenue par un schéma d’interpolation itérative, Ann. Sci. Math. Québec 23 (1999), no.1, 37-48.(“A family of biorthogonal wavelets obtained by a interpolatory iterative scheme”)

[7] Daniel Lemire, Chantal Pharand, Jean-Claude Rajaonah, Bruno Dubé, A.-Robert LeBlanc, Wavelet Time Entropy and T Wave Morphology, CMBEC 25, London, June 1999.

[8] Alain Béliveau et Daniel Lemire (1999), Géophysique, traitement du signal et analyse numérique, congrès Géologie Québec, gouvernement du Québec, Québec. (“Geophysics, signal processing, and numerical analysis”)

[9] Alain Béliveau et Daniel Lemire, White paper on Fast Wavelet Transform and Image Compression, white paper for CIRA (France), March 1999.

[10] Gilles Deslauriers, Serge Dubuc et Daniel Lemire, Interpolation itérative et ondelettes, 66e Congrès de l’Acfas, Université Laval, May 1998.

[11] Gilles Deslauriers, Serge Dubuc et Daniel Lemire, Dérivées de l'interpolation itérative de Lagrange et les ondelettes b-adiques de Cohen-Daubechies-Feauveau, Rapport technique EPM/RT-97/28, École Polytechnique de Montréal, Montréal, April 1997. ("Technical Report: Derivatives of the Lagrange interpolation scheme and b-adic Cohen-Daubechies-Feaveau wavelets")

[12] Gilles Deslauriers, Serge Dubuc, Daniel Lemire (1997), Traitement d'images par ondelettes non séparables, Colloque des sciences mathématiques du Québec, UQTR, Trois-Rivières. ("Image Processing using Non Separable Wavelets")

[13] Gilles Deslauriers, Serge Dubuc, Daniel Lemire (1996), Interpolation des moments, Colloque des sciences mathématiques du Québec et de l'Atlantique, Université de Moncton, Moncton. ("Moment interpolation")