Research activity report 2009-2012

by J.-F. Bercher

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Introduction

This short report describes my research activity and the results obtained since the beginning of 2009, date of the previous report and research activity evaluation. At ESIEE, the research activity is evaluated every three or four years by two anonymous and external referees, and based on their advices, the research activity can be encouraged by a lowering of the teaching duties (from 400h per year to 300h per year). These two external referees are here sincerely acknowledged (they should know that I will not have access to their report, and that I regret it since this is always useful and instructive).

The readers of the present report may obtain its electronic version at http://www.esiee.fr/∼bercherj/Documents/RapActivite0912.pdf. This electronic version includes hypertext links to all referenced papers (PDF links in the bibliography).

Since the beginning of 2008, I am a member of the laboratoire d'Informatique Gaspard Monge (LIGM, UMR CNRS 8049), équipe « Signal et Communications ». Pointers on information on our team are here and here. The LIGM is part of the Laboratoire d'excellence Bezout.

There are two main axes of results presented in this report.

1) The first axis (historically the second) concerns what I call radiotechnique, that is the analysis and technological developments of transmitters or receivers in the context of high speed communications. For several reasons, this axis is now in extinction, though it is still productive as a result of previous efforts. My research in this area will probably end with the defense of Amandine Lessellier's Phd, targeted in the beginning of 2013.
2) My second axis of research (now main axis) concerns Information theory and information processing, and more precisely the study of information measures and their interrelations, with applications to the analysis of signals or complex systems and to statistical physics.

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I. Topics in Radiotechnique

A. A frequency BAW-based frequency reference

For present as well as prospective applications in telecommunications, it is required to have a very high frequency oscillator. It is often also desirable to have a stable oscillator, with respect to aging, temperature, etc; in such a case, the oscillator is termed a frequency reference. The study and design of such a frequency reference has been considered during the preparation of the PhD thesis of Pierre Guillot. This thesis has been prepared under the direction of Corinne Berland and myself, in the context of a collaboration with NxP semiconductors. The design and actual realization of the oscillator has been presented in [4], [16]. These papers actually describe the design of a 500 MHz oscillator in a 65 nm CMOS process and based on a 2 GHz bulk acoustic wave (BAW) resonator. A digital frequency control is implemented using a switched capacitor bank in parallel to the resonator. The tuning range is up to 500 kHz with a minimum step of 200 Hz. The oscillator core uses a differential topology and is designed for low phase noise (2128 dBc/Hz at 100 kHz offset) at low power consumption (0.9 mW). It is followed by a low-noise divider, which provides a 500 MHz output with a phase noise of 2139 dBc/Hz at 100 kHz offset from the carrier. The characterization and control of the whole system require to estimate the different parameters and track their changes. For this, we have proposed and implemented a state model and a joint estimation-correction procedure based on Kalman filtering. Though these results are still (and will probably remain) unpublished, we have demonstrated the high efficiency of the solution. The PhD thesis of Pierre Guillot has been defended on 2011-10-17 and obtained with the highest honors.

B. Adaptive Gain and Delay Mismatches Corrections in Advanced Transmitters Architectures

Actual performances of advanced transmitters architectures may be limited by small impairments of analog components or mismatches between pair of components. In some of our previous work (joint with Corinne Berland), we have proposed several signal processing methods to cope with these problems. The main idea is to use an adaptive algorithm, driven by an error between the ideal output and the actual one, and insert a digital correction of the analog impairments. This idea was applied to the correction of a delay between the envelope and phase in a polar architecture. With Corinne Berland and Olivier Venard, we have continued and improved these results and also applied them to the LInear amplification with Nonlinear Component (LINC) transmitter architecture. In the paper [17], we have presented the application of a gradient algorithm on impairments correction for polar and LINC transmitters, with in particular the description of the two aspects of the approach: identification and correction. The large improvements obtained using such solutions was demonstrated for both transmitters.

The case of the LINC transmitter was considered more deeply in the paper [6]. Indeed, the LINC is an efficient solution for high efficiency amplification of signals, but this solution suffers both from gain impairment and delay mismatch between the two signal paths. A mismatch in propagation time between the paths degrades the quality of the transmit signal but also disrupts the convergence of the gain correction algorithm resulting in a degradation of its performance. In the paper, we have proposed an adaptive algorithm based on a gradient descent formulation for the identification and correction of these delays. We have demonstrated its effectiveness when applied prior to the gain adjustment procedure.

C. *Broadband digitization*

With Olivier Venard, we have the joint direction of the PhD thesis of Amandine Lesellier. This thesis is a partnership between NXP Semiconductors and ESIEE. The goal is to provide a solution to multi-channel reception for cable network. This is linked to the general problematic of broadband digitization. The state of the art has been reviewed in [18]. We have studied an architecture called RFFB involving a bank of analog filters and a bank of ADCs. We have proposed an interesting solution to broadband digitization and compared this solution to a challenging wideband ADC, by NXP, using a cost function depending on the surface and on power consumption. This work has been presented at EuMW [19]. This architecture has the major advantage that all the components are feasible, even the ADCs, and it is possible to switch-off subbands to save power. We have also investigated Hybrid Filter Banks as a possible alternative. In particular, we have developed an efficient optimization algorithm to find the best synthesis filters and reach our targets of distortion and aliasing rejection. An identification of analog filters is also suggested to cope with the issue of sensitivity to analog errors, which has been presented at Newcas [20]. Finally, a physical realization proves the concept of aliasing rejection and confirms the theoretical issues of this architecture [21]. The defense of Amandine's thesis is targeted to the beginning of 2013.

II. Topics in information theory and statistical physics

Since my PhD time, I am interested in studying entropies, and more generally information measures, from the viewpoint of general characterizations as well as from the viewpoint of applications. More precisely, our current work examine the properties and interrelations between extended entropies, such as Rényi's and Tsallis', generalized q-Gaussian distributions and a generalized version of Fisher information. Before commenting on the main results, I recall some facts and main definitions.

A. *Basic facts and definitions*

For the analysis of complex systems, generalized entropies, which reduce to the standard one as a particular case, have been proposed. In particular, the thermodynamics derived from Tsallis entropy, the nonextensive thermodynamics, has received a high attention and there is a wide variety of applications where experiments, numerical results and analytical derivations fairly agree with the new formalisms.

Let us recall that if x is a vector of $\Omega \subseteq \mathbb{R}^n$, and $f(x)$ a probability density defined with respect to the Lebesgue measure, then the information generating function is the quantity $M_q[f] = \int_\Omega f(x)^q \mathrm{d}x$, for $q \geq 0$. The Tsallis entropy is given by $S_q[f] = \frac{1}{1-q}\left(M_q[f] - 1\right)$, while the Rényi entropy is given by $H_q[f] = \frac{1}{1-q}\log M_q[f]$.

In this context, the role devoted to the standard Gaussian distribution is extended to **generalized q-Gaussian** distributions, which include the standard Gaussian as a special case. These generalized q-Gaussian distributions form a versatile family that can describe problems with compact support as well as problems with heavy tailed distributions. They are also analytical solutions of actual physical problems and appear in other fields, namely as the solution of non-linear diffusion equations, or as the distributions that saturate some sharp inequalities in functional analysis. If x is a random vector of $\mathbb{R}^n$, and let $|x|$ denote its Euclidean norm. For $\alpha \in (0, \infty)$, γ a real positive parameter and $q > (n-\alpha)/n$, the generalized Gaussian with scale parameter γ has the radially symmetric probability density

$$G_\gamma(x) = \begin{cases} \frac{1}{Z(\gamma)}\left(1-(q-1)\,\gamma|x|^\alpha\right)_+^{\frac{1}{q-1}} & \text{for } q \neq 1 \\ \frac{1}{Z(\gamma)}\exp\left(-\gamma|x|^\alpha\right) & \text{if } q = 1 \end{cases} \tag{1}$$

where we use the notation $(x)_+ = \max\{x, 0\}$, and where $Z(\gamma)$ is the partition function such that $G_\gamma(x)$ integrates to one.

In the context of nonextensive statistics, but also in other contexts such as multifractals, Chernoff bounds for the probability of error in binary hypothesis testing, and surprisingly entropy estimation, a useful tool that I have studied is notion of **escort distribution**. If $f(x)$ is an univariate probability density with respect to $\mu(x)$, then we define its escort distribution of order q, $q \geq 0$, by

$$f_q(x) = \frac{f(x)^q}{\int f(x)^q \mathrm{d}\mu(x)}, \tag{2}$$

provided that $M_q[f] = \int f(x)^q \mathrm{d}\mu(x)$ is finite.

Another important information measure is the Fisher information, which appears as the Riemannian metric that can be defined on a smooth statistical manifold. Furthermore, the Fisher information serves as a measure of the information about a parameter in a distribution. It has intricate relationships with maximum likelihood and has many implications in estimation theory, as exemplified by the Cramér-Rao bound which provides a fundamental lower bound on the variance of an estimator. It is also used as a method of inference and understanding in statistical physics and biology, as promoted by Frieden. In our works, we use a generalized Fisher information which is defined as follows. Let $f(x)$ be a probability density function defined over a subset Ω of $\mathbb{R}^n$. Let $|x|$ denote the Euclidean norm of x and ∇f the gradient operator. If $f(x)$ is continuously differentiable over Ω, then for $q \geq 0$, $\beta > 1$, the **generalized (β, q)-Fisher information** is defined by

$$\phi_{\beta,q}[f] = \int_\Omega f(x)^{\beta(q-1)+1}\left(\frac{|\nabla f(x)|}{f(x)}\right)^\beta \mathrm{d}x \tag{3}$$

$$= E\left[f(x)^{\beta(q-1)}\,|\nabla \ln f(x)|^\beta\right] = E\left[|\nabla \ln_{q*} f(x)|^\beta\right] \tag{4}$$

with $q_* = 2 - q$, and $\ln_{q*}$ is the deformed q logarithm.

B. Results on generalized entropies and escort distributions

In the paper [8], we have discussed the interest of escort distributions and Rényi entropy in the context of source coding. This is quite interesting since this gives an operational signification to the Rényi entropy, and furthermore shows that escort distributions can be a useful tool even in applied situations. We recalled a source coding theorem by Campbell relating a generalized measure of length to the Rényi-Tsallis entropy. We show that the associated optimal codes can be obtained using simple considerations on escort-distributions. We proposed a new family of measure of length involving escort-distributions and we showed that these generalized lengths are also bounded below by the Rényi entropy. Furthermore, we obtained that the standard Shannon codes lengths are optimum for the new generalized lengths measures, whatever the entropic index. Finally, we showed that there exists in this setting an interplay between standard and escort distributions. These kind of results can be easily extended to the Tsallis entropy. This is commented in [9].

In the MaxEnt approach within nonextensive statistics, there has been numerous discussions regarding the choice of a 'correct' form of the constraints, either as a standard mean or an escort-average, and on the connections between the solutions and associated thermodynamics. In particular, dualities and equivalences between the two settings have been described. In [10], we have considered this question. We have introduced and discussed two families of two-parameter entropies and divergences, derived from the standard Rényi and Tsallis entropies and divergences. These divergences and entropies are found as divergences or entropies of escort distributions. Exploiting the nonnegativity of the divergences, we derived the expression of the canonical distribution associated to the new entropies and a observable given as an escort-mean value. This canonical distribution is a two-parameter version of the generalized q-Gaussian distribution, extending the versatility of this distribution. It includes the standard solutions of the nonextensive thermostatistics as particular cases. Actually, the proposed generalized maximum entropy problem includes the standard approaches of nonextensive thermostatistics and provides a continuum of problems and solutions between them. In addition, this approach suggests that it is possible to adopt different indexes for the q-entropy and for the escort-mean constraint. In passing, we also defined a generalized two-parameter divergence, which includes as particular cases two recently proposed divergences.

A natural question is the relationship between escort distributions and extended entropies, in one hand, and the status of generalized entropies versus the standard one. We have examined these questions, and perhaps given some possible hints, in [11], which elaborated on [24]. In this paper, we have presented a simple probabilistic model of transition between two states, which leads naturally to a generalized escort distribution. This generalized escort distribution enables to describe a path, the escort-path, that connects the two states. Then, we have connected several information measures, and studied their evolution along the escort-path. In particular, we have obtained that the Rényi information divergence appears naturally as a characterization of the transition, and that the notion of escort mean values, as used in nonextensive thermostatistics, receives a clear interpretation. We have studied the properties and the evolution of Fisher information along the escort-path. In particular, we have shown that the thermodynamic divergence on the escort-path is a simple function of Jeffreys divergence. We have also considered the problem of inferring a distribution on the escort-path, subject to a moment constraint on its escort. Looking for the distribution as the minimizer of the thermodynamic divergence, we have shown that this procedure is equivalent to the minimization of Rényi divergence subject to a q-moment constraint, which gives a rationale for this approach. Finally, we have recalled that generalized Gaussian distributions arise as solutions of the previous problem.

Beyond the intrinsic interest of our geometric contruction, which enables to connect several quantities of information theory, we have also pointed out possible connections with finite thermostatistics. Furthermore, we have indicated that our findings interrelates several ingredients of the nonextensive statistics. Let us also add that the literature usually points out that the standard entropy (or divergence) is a particular case of generalized Rényi or Tsallis entropies. Our setting suggests a possible additional layer where the generalized quantities are derived from a construction involving the classical information measures.

C. Results on Fisher information and generalized q-Gaussians

1) Minimum of Fisher information for distributions with bounded supports: It is well known that the distribution with a fixed variance that minimizes the Fisher information on $\mathbb{R}$ is the standard Gaussian distribution. However, there are many situations where the variables at hand are known to belong to some subset of $\mathbb{R}$. For instance, the random variable may be known, on physical grounds, to have only non negative outcomes, e.g. the variable represents an energy. Variables may also be known to have a distribution with a support restricted to a given interval: this is the case of normalized variables defined as a percentage or of the measurements obtained from a physical device with a (necessarily) finite output range. It is thus interesting to look for the distributions defined on a bounded support, with minimum Fisher information and a fixed variance; this means, by the Cramér-Rao bound for the localization parameter, that these distributions are the most difficult to localize. In the work [5], we have completely solved the problem of minimizing the Fisher information on restricted supports with a fixed variance. The problem has been stated under the form of a general second order linear differential equation. We have shown that the general form of the solutions involves Whittaker functions. We have derived the explicit expressions of the solutions on $\mathbb{R}^+$ and on an interval. We have first studied the set of solutions on $\mathbb{R}^+$ and shown that the distribution with minimum Fisher information is a scaled chi distribution. On the interval $[-1, +1]$, we have characterized the solutions, investigated their behavior, and shown that the distribution with minimum Fisher information is a squared cosine function. We also characterized the behavior of the minimum Fisher information as a function of the imposed variance.

2) The generalized (β,q)-Fisher information: It is well known that the Gaussian distribution has a central role with respect to classical information measures and inequalities. For instance, the Gaussian distribution maximizes the entropy over all distributions with the same variance. Similarly, the Stam inequality shows that the minimum of the Fisher information over all distributions with a given entropy also occurs for the Gaussian distribution. Finally, the Cramér-Rao inequality shows that the minimum of the Fisher information over all distributions with a given variance is attained for the Gaussian distribution. It is thus natural to inquire for similar results for extended entropies and an associated generalized Fisher information.

In the paper [12] we followed the route opened by Lutwak, Yang and Zhang (2005) who defined a generalized Fisher information wit q-Gaussians extremals. In our work, we presented the extension of their main results to the multi-dimensional case. Almost at the same time, Lutwak et al. have published a similar extension of their results (and some more advanced results). In [12], we also drew attention of the readers to a possible generalized Fisher information that fits well in the formalism of nonextensive thermostatistics. Just as the maximum Rényi or Tsallis entropy subject to an elliptic moment constraint is a generalized q-Gaussian, we showed that the minimization of the generalized Fisher information also leads a generalized q-Gaussian. This yields a generalized Cramér-Rao inequality. In addition, we showed that the generalized Fisher information naturally pops up in a simple inequality that links the generalized entropies, the generalized Fisher information and an elliptic moment. Finally, we gave an extended Stam inequality. In this series of results, the extremal functions are the generalized q-Gaussians. Thus, these results are a interesting complement to the classical characterization of the generalized q-Gaussian and introduce a generalized Fisher information as a new information measure associated with Rényi or Tsallis entropies. Some related results have also been presented, earlier, in [25] (in french).

In this work, I learned many things on inequalities in information theory, in multidimensional calculus, for instance on the theory of rearrangements.

3) Generalized Cramér-Rao inequalities, generalized Fisher information and characterizations of generalized q-Gaussian distributions: In the previous work and subsection, the generalized Fisher information has been introduced as the information attached to the distribution. However, in estimation theory, the Fisher information is defined with respect to a general parameter and characterize the information about this parameter, as well as the estimation performances, as exemplified by the classical Cramér-Rao bound in estimation theory. Hence, it was of interest to look at general estimation problems that could involve a similar generalized Fisher information. In nonextensive thermostatistics, the notion of escort distributions is an important ingredient related to the generalized entropies.

In [13], we have thrown a bridge between concepts in estimation theory and tools of nonextensive thermostatistics. Using the notion of escort distribution, we have established an extended version of the Cramér-Rao inequality for the estimation of a parameter. This new Cramér-Rao inequality includes the standard one, as well as Barankin-Vajda versions as particular cases. Furthermore, in the case of a location parameter, we have obtained extended versions of the standard Cramér-Rao inequality, which are saturated by the generalized q-Gaussians. This means that among all distributions with a given moment, the generalized q-Gaussians are also the minimizers of extended versions of the Fisher information, just as the standard Gaussian minimizes Fisher information over all distributions with a given variance. This result yields a new information-theoretic characterization of these generalized Gaussian distributions. We also have identified and interpreted some prior results. Finally, we have indicated that these findings suggest some new estimation procedures, recovering in particular a recent Maximum L_q-likelihood procedure.

However, a quite frustrating point is that these results were limited to the univariate case, while the multidimensional case is obviously of high importance. We have been able to overcome this restriction in [14] (currently under review) where we show that and how the previous results can be extended to the multidimensional case. More than that, we consider an even wider context where moments of the error are computed with respect to two different probability distributions. In addition, we give the results for general norms. The main results are as follows.

Let $\theta \in \Theta \subseteq \mathbb{R}^n$ be a multidimensional parameter that we wish to estimate using data x. We show that for $\hat{\theta}(x)$ an estimator of θ, if $f(x;\theta)$ and $g(x;\theta)$ are two probability densities, and if α and β are Hölder conjugates of each other, then

$$E\left[\left\|\hat{\theta}(x)-\theta\right\|^{\alpha}\right]^{\frac{1}{\alpha}} I_{\beta}[f|g;\theta]^{\frac{1}{\beta}} \geq |n+\nabla_{\theta}.B_f(\theta)|\,, \tag{5}$$

where $\|.\|$ is a general norm on $\mathbb{R}^n$, $\nabla_{\theta}.B_f(\theta)$ represents the divergence of the bias between $\hat{\theta}(x)$ and θ, and $I_{\beta}[f|g;\theta]$ stands for a generalized Fisher information that measures the information in f about θ, and is taken with respect to g. In particular, if f and g is a pair of q-escort distributions, we obtain

$$E_{\bar{q}}\left[\left\|\hat{\theta}(x)-\theta\right\|^{\alpha}\right]^{\frac{1}{\alpha}} I_{\beta,q}\left[f|g;\theta\right]^{\frac{1}{\beta}} \geq \left|n+\nabla_{\theta}.E\left[\hat{\theta}(x)-\theta\right]\right|, \tag{6}$$

where $I_{\beta,q}\left[f|g;\theta\right]$ is the generalized (β,q)-Fisher information, and $E_q[.]$ denotes the q-expectation which is used in nonextensive statistics. These results are the multidimensional extensions, with an arbitrary norm, of our previous q-Cramér-Rao inequalities. In the monodimensional case and $q=1$, these inequalities reduce to the Barankin-Vajda Cramér-Rao inequality, and to the standard Cramér-Rao inequality for $\alpha=\beta=2$. In addition, in the case of a location parameter, we show that

$$E\left[\|x\|^{\alpha}\right]^{\frac{1}{\alpha}} I_{\beta,q}\left[g\right]^{\frac{1}{\beta}} \geq n \tag{7}$$

which reduces again to our previous results in the univariate case. Examining carefully the cases for equality in (7), we exhibit that the lower bound is attained by generalized q-Gaussian distributions, and we prove that these generalized Gaussian are the unique extremal functions, provided that the dual norm is strictly convex.

In this work, I learned a lot on general norms and their duals (following a suggestion of D. Yang), also on Banach spaces and the Hahn-Banach theorem. I was quite proud to have obtained, in passing but as a key ingredient, a general Hölder-type inequality for vector-valued functions, which involves arbitrary norms.

This work on generalized Fisher information, entropies and q-Gaussians has been continued in [15] (under review). In that paper, we present several variational characterizations of the generalized q-Gaussian distributions, where the generalized Fisher information play a fundamental role. The new findings include (i) a new generalized Stam inequality, which lower bounds the product of the entropy power and of the extended Fisher information, (ii) the definition of several information functionals minimized by the generalized q-Gaussians, (iii) the derivation of an extended de Bruijn inequality which intimately links the q-entropies to the generalized Fisher information through a doubly nonlinear diffusion equation, which generalizes the standard heat equation.

Let $f(x,t)$ a probability distributions satisfying the doubly nonlinear equation. Then, we get

$$\frac{\mathrm{d}}{\mathrm{d}t} S_q[f] = \left(\frac{m}{q}\right)^{\beta-1} M_q[f]^{\beta}\, I_{\beta,q}[f]. \tag{8}$$

where $M_q[f] = \int f^q$ and $S_q[f] = \frac{1}{1-q}\left(M_q[f]-1\right)$ is the Tsallis entropy. A remarkable point is that the extended Fisher information naturally pops up in this identity, generalizing the role of the standard Fisher information in the classical de Bruijn identity. Of course, the classical de Bruijn identity is recovered from the extended de Bruijn identity for $\alpha = \beta = 2$, and $q = m = 1$.

We also established several properties of the generalized Fisher information which might be useful for thermodynamics considerations. In particular, we have considered the combination of two independent systems and shown that, though non additive, the generalized Fisher information of the combined system is upper bounded. In the case of mixing, we have shown that the generalized Fisher information is convex for $q \geq 1$. Finally, we have shown that the minimization of the generalized Fisher information subject to moment constraints leads to a Legendre structure analog to the Legendre structure of thermodynamics.

III. Miscellaneous

Copulas : In a joint work with Ali Djafari and Doriano-Boris Pougaza [22], [23], [7], we have considered the similarities between the problem of reconstruction in Tomography and the fact that a whole probability density can be reconstructed from its marginals (the projections) and from its copula. The main idea was to examine the link between the notion of copulas in statistics and X-ray Computer Tomography (CT) for small number of projections. This link brings up possible new approaches for image reconstruction in CT. We first presented the bivariate copulas and the image reconstruction problem in CT. We highlight the connection between the two problems that consist in i) determining a joint bivariate pdf from its two marginals and ii) the CT image reconstruction from only two horizontal and vertical projections. In both cases, we have the same inverse problem for the determination of a bivariate function (an image) from the line integrals. We have indicated the potential of copula-based reconstruction methods, introducing the MBP (Multiplicative Back Projection) and CopBP (Copula Back Projection) methods.

Committees

I have been a member of the PhD committees of

- Pierre Guillot (october 17, 2011) as a co-PhD adviser (With C. Berland); this PhD thesis was relevant to section 63 of the French CNU (Electronics)
- Doriano Boris Pougaza (december 16, 2011) as a co-PhD adviser (With A. Djafari); this PhD thesis was relevant to section 61 of the French CNU (signal Processing)

I have also served as an expert (reviewer/“Rapporteur”) for the analysis of the following thesis:

- The thesis in mathematics (CNU section 26) of Philippe Regnault, defended on november 10, 2011. This thesis was on the estimation of entropy with the analysis of the underlying Shannon geometry, and the estimation of the entropy of Markov processes
- The Habilitation à diriger des Recherches of Steeve Zozor (section CNU 61; signal processing) defended on june 20, 2012. The habilitation dealt in particular with uncertainty relationships in statistical physics, spherically invariant signals, etc
- The thesis of D. Manzano, on a European PhD thesis in Physics prepared at the University of Granadaand entitled “Information and Entanglement Measures in Quantum Systems with Applications to Atomic Physics” (march 2010)

Habilitation à diriger des Recherches

I have defended myself an Habilitation à diriger des Recherches [1] in december 2009. The manuscript and the presented work was entitled “Entropies et Radiothechnique”. The committee included F. Chapeau-Blondeau, J.-M. Brossier, A. Djafari, P. Gamand, G. Baudoin.

Working Groups

- I participate to a working group on “Bruit et Non-linéaire”, with my colleagues of Grenoble and some others of EPFL. The working group meets one or two times per year for scientific exchanges and presentations.
- I also participate to a group with a growing activity, the groupe de travail “Entropies, Mots et Statistiques”, mainly animated by Valérie Girardin. I have organized last year two meetings of the group at Marne-la-Vallée.

MaxEnt workshop

I have co-organized, with Ali Djafari and Pierre Bessière, the 2010 MaxEnt workshop (30th International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering), which was held on Chamonix, France, July 4-9, 2010. A selection of the presented papers has been published as a book [2].

Book chapters

I have authored a chapter in a textbook on Antennas [3], published in late 2009. I am also the author of a chapter entitled “Entropies et critères entropiques” which will be published by Hermès in 2013 in the book “Méthodes d’inversion appliquées au traitement du signal et de l’image”.

Bibliometry

With all possible cautions – figures depend heavily on the scientific field; a polemic paper without scientific sound receives a high number of citations; the impact factor should be reported to the number of authors, and so on, some figures can be found in my Google scholar page. During the period 2009-12, I had been passionnate with the study of information measures and their extensions, and I had some luck with the findings and the related publications. However, it is unlikely that I could maintain this level of production in the next period.

IV. (Possible) future work

Future work will, probably, continue on the information theory and statistical physics side. I will insist on the study of the interplay between the different information measures, and perhaps on the characterization of generalized q-Gaussians. Further work should for example examine whether a principle of minimum generalized Fisher information, together with the underlying Legendre structure, could lead to interesting predictions. As is well-known, the Weyl-Heisenberg uncertainty principle in statistical physics corresponds to the standard Cramér-Rao inequality for the location parameter. Thus it would certainly be of interest to investigate on the possible meanings of the uncertainty relationships that could be associated to the extended Cramér-Rao inequalities. In their last work Lutwak et al. (2012) have introduced an abstract, implicit, notion of generalized Fisher information matrix attached to a probability density. It would be of interest to examine whether this notion could be extended and interpreted in the estimation theory framework. I also intend to look at potential applications of the generalized Cramér-Rao inequalities to actual estimation problems; e.g. examine the problem of estimating any function of the parameter and the associated bound, consider problems like estimation of parameters of densities with infinite moments, measure the quality of estimation with respect to a quantized version of the original distribution. On the side of generalized entropies, I plan to look at the more abstract entropies that could be defined using Young functions.

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