

## Homage to Alain Glavieux

To accomplish the sad duty of paying homage to Alain Glavieux, I have referred to his biography as much as my own memories. Two points of this biography struck me, although I had hardly paid attention to them until now. I first noted that Alain Glavieux, born in 1949, is the exact contemporary of information theory, since it was based on the articles of Shannon in 1948 and 1949. I also noted that his first research at the Ecole Nationale Supérieure de Télécommunications de Bretagne (ENST Brittany) related to underwater acoustic communications.

To work on these communications, first of all, meant to be interested in concrete local problems linked to the maritime vocation of the town of Brest. It also meant daring to face extreme difficulties because the marine environment is one of the worst transmission channels there is. Carrying out effective underwater communications can be conceived only by associating multiple functions (coding, modulation, equalizing, synchronizing) that do not only have to be optimized separately, but must be conceived together. This experience, along with the need for general solutions, which are the only effective ones in overcoming such difficulties, has prepared him, I believe, for the masterpiece of the invention of turbocodes, born from his very fruitful collaboration with Claude Berrou. Better still, no one could understand better than him that iterative decoding, the principal innovation introduced apart from the actual structure of the turbocodes, implies a more general principle of exchange of information between elements with different functions but converging towards the same goal. Admittedly, the idea of dealing with problems of reception using values representing the reliability of symbols and thus lending themselves to such an exchange, instead of simple decisions, had already been exploited by some researchers, like Joachim Hagenauer and myself, but the invention of turbocodes brought the most beautiful illustration conceivable, paving the way for a multitude of applications.

Shannon had shown in 1948 that there exists a bound for the possible information flow in the presence of noise, the capacity of the channel, but had not clarified the means of dealing with it. If the asymptotic nature of the Shannon theorem did not leave any hope to effectively reach the capacity, the attempts to approach it had remained in vain despite the efforts of thousands of researchers. Turbo codes finally succeeded 45 years after the statement of the theorem. They improved the best performances by almost 3 decibels. What would we have read in the newspapers if an athlete had broken the 100 meters record by running it in 5 seconds! If this development remained almost unknown to the general public, it resounded like a thunder clap in the community of information and coding theoreticians.

This result and the method that led to it called into question well anchored practices and half-truths, which time had solidified into dogmas. They revealed that unimportant crude restrictions had in fact excluded the best codes from the field of research. The inventors of turbo codes looked again at the basic problem in the spirit of Shannon himself, not trying to satisfy the posed *a priori* criterion to maximize the minimal distance of the code, but to optimize its real performances. To imitate random coding, a process that is optimal, but unrealizable in practice that Shannon had employed to demonstrate the theorem, Berrou and Glavieux introduced an easily controllable share of risk into coding in the form of an interleaving, whose inversion did not present any difficulty. The turbo codes scheme is remarkably simple and their realization is easy using currently available means, but it should be noted that they would have been inconceivable without the immense progress of the technology of semi-conductors and its corollary, the availability of computers. In fact, computer simulations made it possible to choose the best options and to succeed, at the end of an unprecedented experimental study into the subject, with the first turbo code. Its announced performances were accommodated with an incredulous smile by experts, before they realized that they could easily reproduce and verify them. The shock that resulted from it obliged everyone to revise the very manner of conceiving and analyzing codes. The ways of thinking and the methods were completely renewed, as testified by the true metamorphosis of the literature in the field caused by this invention.

It was certainly not easy to invent turbo codes. From a human point of view it was perhaps more difficult still to have invented them. How, indeed, could he handle the authority conferred by the abrupt celebrity thus acquired? Alain Glavieux was absolutely faithful to himself and very respectful of others. He preferred efficiency to glamour. He was very conscious of the responsibilities arising from this authority and avoided the peremptory declarations on the orientation of research, knowing that, set into dogmas, they were also likely to become blocked. He thus used this authority with the greatest prudence and, just as at the start when he had put his engineering talent to the service of people and of regional developments, he devoted

himself to employ it to the benefit of the students of the ENST Brittany and of the local economy, in particular, by managing the relations of the school with companies. He particularly devoted himself to help incipient companies, schooling them in “seedbed”. He was also concerned with making science and the technology of communication known, as testified, for example, by his role as the main editor of this book. Some of these tasks entailed not very exciting administrative aspects. Others would have used their prestige to avoid them, but he fully accepted his responsibilities. In spite of the serious disease which was going to overpower him, he devoted himself to them until the very last effort.

The untimely death of Alain Glavieux leaves an enormous vacuum. Fruits of an exemplary friendship with Claude Berrou, turbocodes definitively marked the theory and practice of communications, with all the scientific, economic, social and human consequences that it implies. Among those, the experimental sanction brought to information theory opens the way for its application to natural sciences. The name of Alain Glavieux will remain attached to a work with extraordinary implications in the future, which, alas, offers his close relations only meager consolation.

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