Before and after Shannon: a historical look at the context of information in some 'information engineering' disciplines

Chris Bissell (Keynote Speaker), The Open University

In this talk I shall say very little about Claude Shannon, immensely influential and important though his contributions were. I shall begin by looking at four of his lesser known communications engineering precursors from the 1920 and 1930s (Hartley, 1928; Küpfmüller, 1924, 1928; Nyquist, 1924, 1928; and Kotelnikov, 1933) – the work of the German Karl Küpfmüller and the Russian Vladimir Kotelnikov almost certainly being unknown to Shannon. Shannon himself wrote in the late 1940s of the sampling theorem that it was "common knowledge in the communication art, but in spite of its evident importance it seems not to have appeared explicitly in the literature of communication theory." But Shannon was only partly correct. Ideas about sampling were indeed common knowledge in the late 1940s, and the theorem in various forms had appeared in the mathematical literature. But the theorem had also been published in the 'literature of communication theory' as early as 1933 – but in a collection of papers submitted to a conference in Stalinist Russia – and in Russian (the conference did not, in the event, take place). Other engineers had also published related work in English, German and possibly other languages.

Early ideas about information transmission centre on such notions as:

- Bandwidth utilisation, or how fast can we signal over a given channel?
- How fast must we sample a given signal to preserve the information?
- The quantification of information as a logarithmic measure
- The problem of noise

All the workers mentioned above considered aspects of the first three points, but Shannon was the first to address the fourth in a rigorous manner. The contributions have become rather confused, in particular by the misleading use of terms such as 'Nyquist rate' and 'Nyquist sampling theorem' in the English language literature. The first part of the talk will attempt to clarify this early history.

I shall then turn to some of the practical consequences of how qualitative as well as quantitative notions of information greatly influenced the fields of filter design, control engineering and signal processing. In each area there was a realisation that the essence of design was the nature of the information flow within a system and/or a system model. And each discipline developed individual – even idiosyncratic – but extraordinarily powerful, and mostly graphical, techniques to manage the 'information dimension' of their areas of activity. Particularly important in each area was the ability to switch between various types of models: block diagrams, signal flow diagrams, circuit diagrams, mathematical models, design charts and so on, in the confidence that information was either preserved (often in a strict mathematical isomorphism sense); or otherwise, that only aspects that could be reasonably neglected were indeed neglected. These techniques were elaborated in the period up to the 1950s; but more recently they became incorporated into computer-aided design software as part of the user interface – a testimony to their representational power.