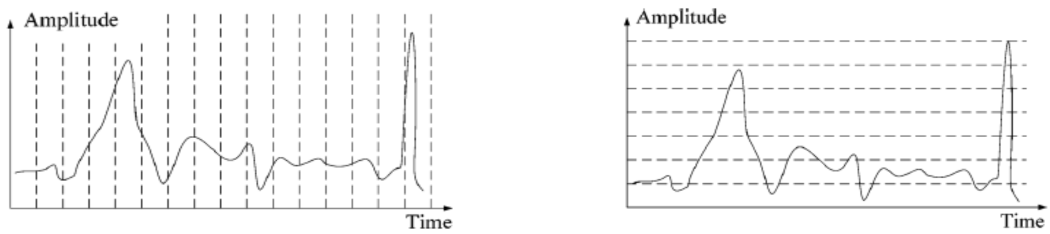
# DESCRIPTION FOR THE GENERAL PUBLIC

Signal processing is one of the most prominent and fundamental fields in engineering including such important areas like speech/image processing, biomedical engineering, wireless communication, statistical data processing, and radar systems, to name a few. The objectives of signal processing are to analyze accurately, code efficiently, transmit rapidly, and to reconstruct at the receiver the salient features and the shape of the original signal. All these tasks critically depend on a proper digital representation of the measured analog signal. The digital representation is needed for the efficient information transmission, representation, storage and compression. In fact, modern telephone systems, consumer electronics, medical imaging, speech processing all operate in the digital domain. Therefore, digital signal processing (DSP) critically relies on a sampling mechanism that converts analog signals to discrete sequence of numbers, while preserving as much information about the signal as possible. Hence, it is desirable to minimize the number of discrete samples while maintaing an acceptable reconstruction distortion. The obtained number of samples is directly related to power efficiency since the power consumption for an analog-to-digital converter is proportional to its sampling frequency. Also in the transmission process (via communication channels) the reduced number of samples improve power and bandwidth efficiencies.

Classical digital signal acquisition systems represent signals at pre-defined equally spaced instances that are in general signal-independent. The critical sampling frequency allowing a perfect signal reconstruction from the samples must be at least twice the highest frequency (bandwidth) in the signal. This describes the celebrated *Shannon-Nyquist* theory that has had a major influence on signal processing and its applications. A uniform sampling at the Shannon-Nyquist rate may produce a large number of redundant samples. Indeed, many real life signals change abruptly and may reveal sparsity in either time or frequency domains and the global signal bandwidth is not an adequate measure of local variations of the signal. For such signals, a promising approach is based on the concept of the event-driven sampling and representation. In this paradigm some particular events dictate the sampling instances, i.e., samples are generated only when the signal satisfies some pre-defined event. As a result, we obtain a non-uniform adaptive signal representation with the number of samples being much smaller than it is generated according to the Shannon-Nyquist theory. Fig.1 (b) depicts an illustration of an important event-based sampling, where an event means “the input signal crosses a given amplitude level“.




(a) (b)

Figure 1: Signal sampling paradigms: (a) Classical uniform sampling. (b) Event-driven sampling based on amplitude level-crossings.

On the other hand, in Fig.1(a) we show the traditional uniform sampling, where the samples are collected at preset times controlled by a sampling clock. In contrast, sampling by level-crossings is free of a sampling clock and is potentially a more energy efficient way to acquire signals.

Motivated by a wide range of modern DSP applications, this project aims at developing a fundamental methodology for signal acquisition from a sequence of events characterizing the signal shape and variability. This will be carried out for time-domain signals of both the deterministic and stochastic nature as well as for higher dimensional objects representing images and multi-channel signals. Moreover, we plan to examine a broader class of event-driven systems where the sampling strategy for efficient information transmission according to pre-defined events is essential. This includes distributed sensor networks where the problem of decentralized detection/estimation plays important role.