

## EGR 215 Topics in EE Signal and Image Processing

**Signal and Image Processing (SIP) deals with the classification and transformation of signals (variation of a parameter with time) and images (2D signals).** SIP is almost accidentally in Electrical Engineering, as much of the field is really applied math, with signals and images considered abstractly. However, **most signals are electrical**, like the variation in a voltage, and most images are processed using electronic components, including cameras to collect them, CRTs and flat screen displays, and printing technology. (Yes, there is also a mechanical component to printers.)

The field is quite important because we live in an information economy, and information is moved in signals and images.

The roots of signal processing go back to 1822 to the French mathematician Joseph Fourier. A noted Egyptologist, a career civil servant, and secretary of the French Academy of Sciences, Fourier was solving second order multivariate differential equations describing heat transfer when he hit on using a series of sines and cosines with integral frequencies and varying coefficients.

$$y = \frac{1}{2}a_0 + (a_1 \cos x + b_1 \sin x) + (a_2 \cos 2x + b_2 \sin 2x) + \dots + (a_n \cos nx + b_n \sin nx)$$

Fourier also showed how  **$y = f(x)$  could be transformed into a fourier series for arbitrary  $f(x)$** , an elegant mathematical process called the **Fourier Transform** which is still at the heart of much signal processing.

Fourier probably did not realize that the mathematical tools he had developed to transform a periodic signal  $f(t)$  from the **time domain**, where its value is known for every time  $t$ , to the **frequency domain**,  $F(\omega)$ , where its magnitude at each frequency is known, would be essential to the understanding of radio. Suppose, for example, we want to listen to a particular radio station transmitting on a known frequency, along with many, many other stations transmitting at other frequencies. If we think only in terms of the time domain, it is impossible to distinguish our station from others. But if we think in terms of the frequency domain, we need only remove the unwanted frequencies, a process called **filtering**. Filters can be built from electrical components, or can simply be algorithms applied to digitized data.

(Similarly, vibrations of a mechanical part can be understood in the time domain from observation, but often can be better understood in the frequency domain as occurring at resonant or characteristic frequencies, and parts can be designed to modify these frequencies.)