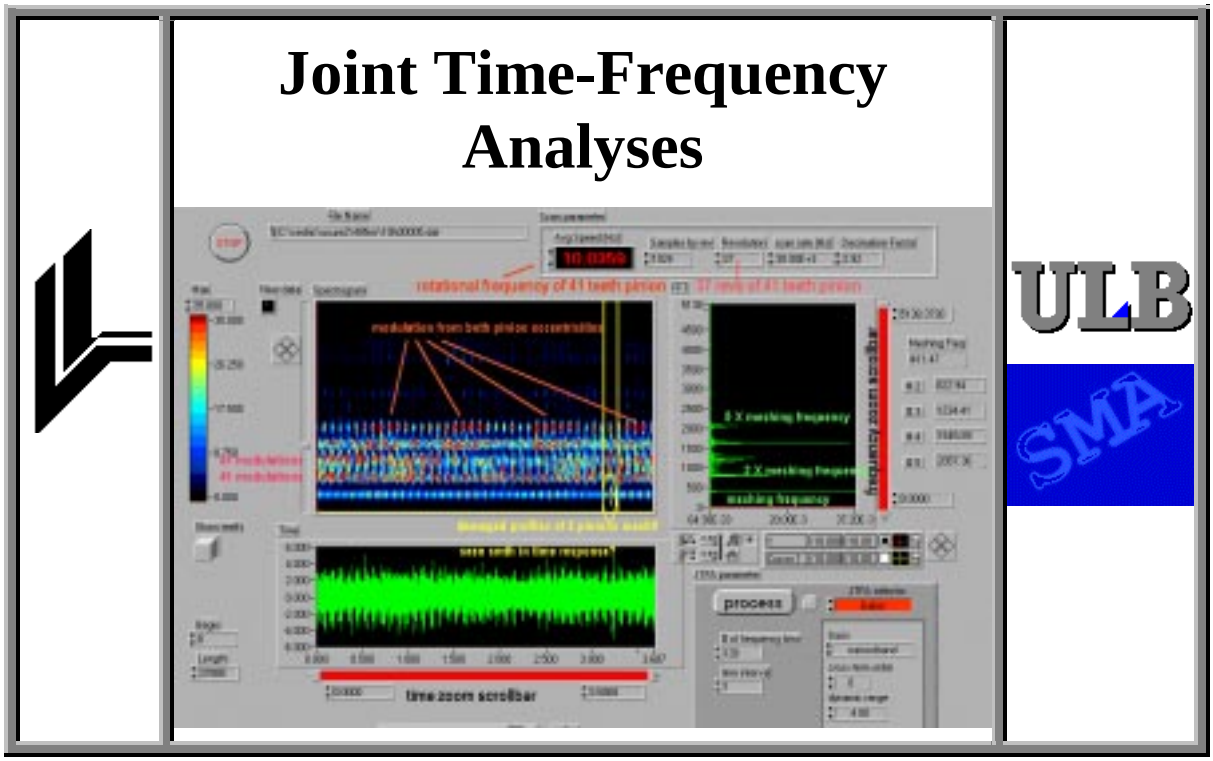
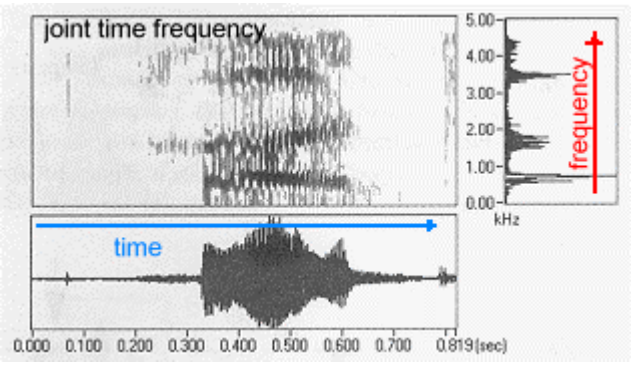


Joint Time-Frequency Analyses.

The Fourier transform has been the most common tool to study a signal's frequency properties. However, based on the Fourier transform and power spectrum alone, it is hard to tell whether or not a signal's frequency contents evolve in time, even though the phase of the Fourier transform relates to time shifting.

On the other hand, except for a few special cases, the frequency contents of the majority of signals encountered in the real world change with time. In those applications, the classical Fourier analysis is no longer adequate. One can find good examples to prove this statement in the analysis of speech signals below.

JTFA in speech analysis



Example of speech recognition JTFA.

'Hood," spoken by a five-year-old boy (Data courtesy of Y Zhao, the Beckman Institute at the University of Illinois). The power spectrum (right) indicates there are four frequency clusters, but it does not tell how they are changed over time. In contrast, the time-dependent spectrum (top left) clearly depicts how those four formants vary with time.

Intuitively, the formant of the speech must be time-varying. Otherwise, the speech will be indistinguishable and thereby cannot be used for our daily communications. It has been recognized for a long time that the conventional power spectrum is not suitable for the study of speech, Doppler frequency, as well as many other signals, in which the spectra evolve with time.

Not only boys speak. Machines also do and the job is to recognize what they want to convey to perform a sound diagnosis of their possible malfunctions. We are then operating in the vibracoustics domain. Instead of ears to process the signal we rely upon accelerometers.

Let us consider gear drives. Meshing pairs of teeth also "talk" at meshing frequencies at the pinion rotational frequencies times the number of teeth and their multiples. If everything is all right, their sound repeats itself at each new meshing. Otherwise the amplitudes of the meshing frequency and its multiples vary during each successive revs. JTFA aims at spotting these abnormal patterns during successive meshings. It lays the basis to find out the possible causes and thus diagnose the gear drive condition.

To this aim, one wants to identify the following causes of malfunctions from a suspicious JTFA analysis

- **which tooth profile might exhibit surface defects**
- **which pair of meshing teeth might exhibit unmatched profiles**
- **eccentricities of pinions**
- **pinions that are mounted perpendicularly to shafts**

Let us take a few examples from the current research and see how JTFA helps.