Department of Electrical & Computer Engineering
ELEC421
Why study Digital Signal Processing?

DSP functionalities are embedded in electronic devices and software that touch many facets of our daily life. DSP functionalities include media players and recorders, speech coders and modems in cellular phones, image processors in TVs and digital cameras, GPS navigators, etc. DSP enables information transmission in telephone and communications infrastructures, measurement and control in medical equipment (pacemakers, hearing aids), and formation and analysis of medical, earth, and planetary images. The list of applications is virtually endless! Moreover, DSP has a long history of providing machine intelligence capabilities.

DSP technologies are built on synergies of signals and systems theory, models of physical processes, computation algorithms, and hardware and software architectures. Continuous advances in these and allied areas enable DSP to go beyond replacing traditional analog electronic systems. DSP has enabled a vast and growing array of applications that would not have been built or even envisioned with analog technology. You can find DSP practitioners working on financial, genomic, and social signal processing. The power of DSP is reflected in the job market: DSP engineers who can execute the design chain from theory to implementation are in demand. In recent years, advances in DSP design tools such as Matlab and high-level language compilers and simulators have made learning and designing sophisticated DSP functions easier and fun.

This course builds on the signals and systems fundamentals acquired in ELEC 323 and 324. The student learns analysis, design, and synthesis of basic DSP systems or “algorithms”. Students study models and techniques that progress from theory to implementations. Students learn the design flow by performing simple but realistic laboratory exercises.

The course begins with a review of sampling theorem and signal digitization, LTI systems, frequency response, and poles and zeroes. New topics such as minimum phase filters and stability check are introduced during the review. A major aim of this course is learning to design DSP functions that can be implemented in real-time using dedicated or programmable hardware. This is accomplished by focusing on a key building block of DSP systems: filters. We study finite impulse response (FIR) and infinite impulse response (IIR) filter realization structures, implementation issues including coefficient sensitivity and complexity, and programming for real-time signal processor implementation. In practice, filters are designed using computer-based optimization tools such as Matlab. To obtain efficient designs, the designer needs a good grounding in basic theory. Thus, we discuss basic properties of linear phase FIR and causal IIR filters. We study FIR filter design using windows and a numerical optimization technique called equipripple design. IIR filter design from continuous time filters using bilinear transformation is then covered. Real filters are designed and tested on a signal processor development system in the laboratory.

Discrete Fourier transform (DFT) is arguably the most important signal analysis tool for all areas of science and technology. DFT is usually implemented using a fast Fourier transform (FFT) algorithm. We study the basic properties of DFT, two basic FFT algorithms, and the application of DFT to spectral analysis and filtering.