EEE4114F DSP project

This document provides an outline for a DSP project to be completed by the end of the course. The project brief is deliberately left quite vague, so you may need to do some exploration to find a meaningful direction. You are also free to take the project in a direction that interests you, both in terms of methods and datasets, if appropriate.

You are expected to investigate, in detail, methods related to solving the problem. There is a design element to the project, and a quantitative evaluation of the performance of the proposed methods must be performed and presented. You are to write up a comprehensive report (of no more than 10 pages) describing your method and results. You should work in groups of two, although you may work alone if you really want to.

The report should have a clear introduction describing the problem being looked at, and basically what was done. A short literature review should follow, outlining the main aspects of theory used. A description of the work you did should be followed by a comprehensive set of results. These results form the main contribution, and should take the form of one or more experiments that were done in order to interrogate a directed and explicit hypothesis. *Results should answer a specific question*, not simply provide data on outcome or performance. I find it useful to remember the components required in an experimental writeup: aim, apparatus, method, results, analysis, and conclusion.

Task 1: Hardware implementation of online filters

The objective here is to design and implement some digital filters for real-time applications. You can investigate methods of filter design and implementation architectures, and explore the costs and benefits of different choices. While you may try to see what you can do with an integer processor, which would be interesting in itself, implementation on a floating-point unit like the STM32F will probably be more straightforward. Ideally the filter should go as fast as possible while using the minimum of resources, and most processors have specialised instructions and extensive software libraries to assist in this objective. Your system should incorporate ADC and DAC functionality so that you can test it in the lab with a signal generator and oscilloscope. If you like you can tailor the project around an application that you identify, which would make the design criteria more specific.

The report should not exceed 10 pages. While it can discuss the software structure or design it is not appropriate to include detailed source code: the project is to assess the *method*, not your specific implementation of it (although that might deserve a mention at a high level).

Task 2: Multirate DSP

According to Wikipedia:

> Linear time-invariant systems typically operate at a single sampling rate, which means that we have the same sampling rate at input and output. In other words, in an LTI system, the sampling rate would not change in the system.
>
> Systems that use different sampling rates at different stages are called multirate systems. The multirate system can have different sampling rates based on desire. Also multirate systems can provide different sampling rates without destroying the signal components.

Conduct an investigation into multirate systems, identify an application, and conduct some meaningful experiments to demonstrate the concepts. These should all then be written up into a project report. Note that the emphasis should be on *hardware or software implementation* — it is not sufficient to just do a "high-school" report that simply rehashes the theory currently out there.

Resources

1. Matlab has good background and tools:
   `https://www.mathworks.com/help/dsp/multirate-and-multistage-filters`
2. The slides for "Lecture 8" at
   `https://users.encs.concordia.ca/~msoleyma/ELEC442/Course%20Notes.ht`

Task 3: Project from Columbia DSP course

Dan Ellis was a professor of electrical engineering at Columbia university. His old DSP course webpage, under a creative commons license, has some excellent project suggestions with pointers towards data for development and testing:
`http://www.ee.columbia.edu/~dpwe/e4810/projects.html`.
You may pick one of these, conduct a meaningful investigation, and report on the result. The web page also contains some useful general information on how to structure a report.