EE225B Projects

Spring 2008

You need to do a term project of your choice to satisfy the requirements of the course. The report is due on Friday May 9th in class together with a copy of your presentation. I need both electronic and hard copies of the report and the presentation. In your project report you should include some background material as to what problem you are trying to address, who has done what before you, and clearly identify your objectives for the project. If you are doing a project which is related to or part of a different project, e.g. your MS or PhD thesis, at the time of proposal, you need to delineate what pieces have already been done and what pieces remain to be done. Be specific about what you plan to accomplish this semester for this course.

The project report should be brief report, preferably no longer than 10 pages double space. I strongly recommend that you form groups of 2 – 4 students so that you can do a larger scale, more meaningful project.

The proposals for your project or your literature review are due on Feb. 22nd in class. Friday May 9th, class will be devoted to presentations of projects.

The suggested topics for papers and project are as follows.

1. ***Wireless Video***

Quality of Service (QoS) continues to be an issue in today's packet switched networks, regardless of whether they are wireline or wireless. Video has strict real time requirements such as delay and jitter. As such a late packet is as good as a dropped packet.

In the wireless arena WLANs are becoming increasingly more ubiquitous. Entire cities such as San Francisco and Philadelphia are getting covered by WLAN thanks to providers such as Google and Earthlink. As popularity of video applications increases thanks to YouTube, Myspace and other internet social networking sites, communicating video over heterogeneous set of devices becomes increasingly important. In particular, what are the bag of tricks one has to use in order to optimize the user experience?

Here are few suggestions for class projects:

- 802.11e: has been suggested as a way to add QoS to wireless LANs. But recent studies have shown that using 802.11e by itself cannot guarantee delay requirements for situations in which voice and data are used simultaneously in an 802.11 network. However, Teresa Tung in her 2006 PhD thesis in EECS at UC Berkeley has recently introduced techniques at the Access Point (AP) that alleviates this situation for voice/data applications co-existing on a 802.11 network. Extend these techniques to video and use NS2 simulations to demonstrate its performance.
- Error locating codes: can be used to detect location of errors in a string of bits. This could be useful in video communication applications where corrupted

packets are usually sent to the application layer regardless of whether they have been received free of errors or not. The reason is that video applications can tolerate a certain amount of loss and still "look good" to the end user. Investigate error location codes most suitable in wireless video applications, implement them in Matlab or C and demonstrate their effectiveness by packetizing bit streams from an MPEG-4 or H.264 encoder freely available on the internet. What would be the best packetization strategy if the packets were to be used in conjunction with error locating codes?

- Use MPEG-4 or H.264 encoder in conjunction with NS2 and a state of the art link adaptation algorithm to simulate video transmission over an 802.11 network. Then compare the resulting video quality with what one would obtain if traditional link adaptation techniques such as ARF or AARF are used. For the state of the art link adaptation algorithms take a look at the latest paper by Wong, Yang, Lu and Bhargavan in Mobicom 2006.
- Design your own link adaptation algorithm for 802.11b networks that would optimize a video related metric. Most link adaptation techniques attempt optimize throughput without any consideration for delay. For video, not only delay is important, but also partial packet recovery is important. How would you design the link adaptation algorithm that works best for video? Implement and simulate it with NS and H.264 video codec to demonstrate its effectiveness.
- Examine the use of 802.11N as a way to transmit wireless video. What is the optimal packet size at the MAC Layer for maximizing throughput? How about link adaptations for 802.11N? Would it be different or similar to 802.11a, b, g? What are the implications of 802.11N as far as video is concerned?

2. ***Sparse Signal Approximation, Compressed Sampling and Applications to Video and Image Representation:***

The matching pursuits algorithm has been introduced as a way of doing residual coding for video compression systems, with extraordinarily good results. As an example, look at:

R. Neff, and A. Zakhor, "Very low bit-rate video coding based on matching pursuits" IEEE Transactions on Circuits and Systems for Video Technology, Feb. 1997, Vol.7, No. 1, pp. 158 - 171.

Yet, matching pursuits is one of many signal expansion algorithms along overcomplete set of basis functions. For instance Donoho and his colleagues have come up with other such schemes in their recent papers:

S. Chen, D. L. Donoho, "Examples of basis pursuit" Proceedings of the SPIE, vol.2569, pt.2, (Wavelet Applications in Signal and Image Processing III, San Diego, CA, USA, 12-14 July 1995.) SPIE-Int. Soc. Opt. Eng, 1995. p.564-74.

Shaobing Chen and D. Donoho, (Edited by: Singh, A.) "Basis pursuit", Proceedings of 1994 28th Asilomar Conference on Signals, Systems and Computers, Pacific Grove, CA, USA, 31 Oct.-2 Nov. 1994. p.41-4 vol.1

Scott Shaobing Chen, D. L. Donoho, M. A. Saunders, "Atomic decomposition by basis pursuit", SIAM Journal on Scientific Computing, vol.20, (no.1), SIAM, 1998. p.33-61.

http://www-stat.stanford.edu/~donoho/Reports/index.html

Tipping, Rao and Delgado have also come up a new sparse representation called, Sparse Bayesian Learning (SBL). This technique requires applying large matrix inversions where the size of the matrix is N squared by N squared and an NxN image. Finally most recently Donoho, Candes and Baranuik have proposed compressed sampling as a way for sparse signal representation.

In previous years, a group of students in EE225B implemented SBL, BP and MP and compared their performance over a set of images. However, the largest size images SBL could be run on was 32x32 due to storage limitations. In doing so, they showed that SBL outperformed the other two algorithms.

Here are some projects to consider in this area:

- Extend SBL so that it runs on arbitrary size images e.g. 512 x 512 without requiring excessive memory.
- Assuming the largest block size you can run SBL on is 32x32, apply it to large images such as 512x512 and compare its performance to MP and BP and possibly the best of "compressed sensing".
- Start with H.264 encoder, remove the transform coding part of it, and replace it with SBL, Matching Pursuits, and Basis Pursuit and compare the performance of the three approaches. Compute the PSNR to compare the performances for a video sequence of 100 frames.
- Start with compressed sensing approaches of Baranuik, Candes, or Donoho, and compare their performance to that of MP, BP and SBL for typical images.

3. *Video Similarity Search*

With the explosion of the amount of video data on the web, a number of techniques have been developed to detect nearly identical videos in a database. This is particularly useful when content owner wants to know whether or not its video has been unlawfully distributed. Two examples of such papers include:

Efficient video similarity measurement with video signature

Cheung, S.-S. Zakhor, A.
Dept. of Electr. Eng. & Comput. Sci., Univ. of California, Berkeley, CA, USA; **Circuits and Systems for Video Technology, IEEE Transactions on**; Publication Date: Jan 2003; Volume: 13, Issue: 1; On page(s): 59- 74

Fast similarity search and clustering of video sequences on the world-wide-web

Cheung, S.-S.   Zakhor, A.
Univ. of California, Berkeley, CA, USA; **Multimedia, IEEE Transactions on**
Publication Date: June 2005; Volume: 7, Issue: 3; On page(s): 524- 537

Possible projects are as follows:

- Propose ways to extend the above techniques to audio similarity search; Make sure your proposed technique is scalable.
- How would you extend the signature method to still images only? Address scalability and implementation issues.

4. *Network of Cameras*

Sensor networks are becoming an increasing important area of research in recent years. One of the most critical issues in all sensor network technology is power. As such in monitoring applications where one is interested in detecting and tracking targets, low cost, low power sensors are usually used to wake up more sophisticated sensors such as cameras. Here are few projects in the area of network of cameras.

- An important issue in a network of camera problem is calibration of the cameras with respect to each other. The computer vision community has introduced several techniques for calibration, but all of them ignore the communication cost between the cameras. Implement a state of the art network of camera calibration scheme, and characterize its communication requirements. Propose ways of minimizing communication bandwidth during the calibration process.
- Design algorithms that would enable a network of cameras track an object, follow it and hand it off to the next camera for which the object is in the field of view. Consider this problem for both stationary cameras and those that are capable of panning, zooming and tilting. You might have to address camera calibration issues in the process.
- Propose ways to compress fields of views of multiple cameras that are looking at a common scene. Assume there is a lot of overlap between the cameras and that their respective images are highly correlated. Would you gain in compression if the relative poses of the cameras are communicated to each other ahead of time? What are the tradeoffs between upfront communication and compression efficiency?

5. *Super-Resolution Techniques for Video Format Conversion, de-interlacing and upsampling*

It is difficult to convert standard definition (SD) television images into good quality high quality High Definition (HD) images. Up-conversion is now a central issue for broadcast and television industries. The challenge of up-conversion is to compute missing pixels of HD images from pixels of input SD images in order to produce HD video sequences that are sharp and detailed. This is called super resolution process because the resolution of images are apparently increased with an appropriate recombination of the information available. Another issue is the existing noise in SD images. Here are possible projects:

- Implement state of the art SD to HD conversion algorithm and suggest few ways to improve upon it. You might want to look at the bandlet scheme used at:

  http://www.letitwave.fr/rubriques/7%20TECHNOLOGY/WhitePaper_LIW.pdf