ECE516 (formerly known as ECE1766)

Personal Cybernetics and Intelligent Imaging Systems

Course instructor: S. Mann;
Teaching assistants:

- R. Janzen: EA302
- R. Lo: EA302
- David Chartash = chartash (at) ecf (dot) utoronto (dot) ca

Schedule for January 2012:

Hour-long lectures starting Mon 2pm, and Thursday 1pm:

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<td>Mon</td>
<td>14:00</td>
<td>BAB024</td>
<td>Mann, Steve</td>
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<td>ECE516H1S</td>
<td>Thu</td>
<td>13:00</td>
<td>WB119</td>
<td>Mann, Steve</td>
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Important dates:

- Mon2012jan09: first ECE516 lecture;
- Sun2012jan22: last day to courses for engineering undergraduates;
- 2012jan16: last day for ECE graduate students to add a course;
- 2012feb20: last day for ECE graduate students to drop a course.

Each year this course is taught, times can be verified from the official schedule at: APSC 2010 Winter Undergraduate Timetable (this URL seems to have remained constant for a number of years now). Three hour labs starting Thu at 2pm:

**ECE516H1S Thu 14:00 BA3135 or EA302** Mann, Steve and Janzen, Ryan

BA3135 is ECE DigMic LabA, but we may hold the labs, or at least some of the labs, in EA302 (Engineering Annex 302), depending on what topics the class is most interested in, etc., and what resources are needed to meet these interests.

Text-schedule summary block (cut-and-paste the below into your own reminder);

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Course structure

Each year I restructure the course in order to match the interest of the students enrolled, as well as to capture opportunity of new developments. Here's some recent news items (the first one's from your fellow student, Kalin):

- Eyeglasses that overlay data and imagery
- Epson Moverio BT-100 3D Glasses

Final exam schedule will likely appear here, toward the end of the term.

In the year 2012 ECE516H1, INTELLIGENT IMAGE PROCESSING, X, April 25, 2012, 2:00 PM, BA-3012

Links to some useful materials

http://wearcam.org/ece516/
Course "roadmap" by lab units and corresponding book chapters:

PDF: PostScript (idraw)

Labs are organized according to these six units (the first unit on KEYER, etc., includes more than one lab, because there is some intro material, background, getting started, etc.).

Organization of the course follows exactly like the six chapters in the course TEXTBOOK.

location of this course textbook in university of toronto bookstore:

Kevin reported as follows:

I just stopped by the UofT Bookstore, and to help the rest of the students, I thought you could announce that the book is located in the engineering aisle, and exactly to the left of the bookstore computer terminal behind some Investment Science books.

Course summary:

ECE516 is aimed primarily at third and fourth year undergraduates, and first year graduate students. 4th year undergraduates often take this course as their "other technical elective" (fourth year elective). It is often also offered as a Professional Development Course for those in industry who are looking for a new, exciting, and relevant field of study. The classes are comprised of lectures and labs (labs have both a tutorial component and a grading component, etc.) starting in January, along with a final exam in April.

The course provides the student with the fundamental knowledge needed in the rapidly growing field of Personal Cybernetics ("minds and machines", e.g. mind-machine interfaces, etc.) and Personal Intelligent Image Processing. These topics are often referred to colloquially as "Wearable Computing", "Personal Technologies", "Mobile Multimedia", etc.
The course focuses on what will become the most important aspects of truly personal computation and communication. Very quickly we are witnessing a merging of communications devices (such as portable telephones) with computational devices (personal organizers, personal computers, etc.).

The focus of this course is on the specific and fundamental aspects of visual interfaces that will have greatest relevance and impact, namely the notion of a computationally mediated reality, as well as related topics such as brain-computer interfaces (BCI), as explored in collaboration with InteraXon, a spinoff company started by former students from this course.

A computationally mediated reality is a natural extension of next--generation computing. In particular, we have witnessed a pivotal shift from mainframe computers to the personal/personalizable computers owned and operated by individual end users. We have also witnessed a fundamental change in the nature of computing from large mathematical calculations, to the use of computers primarily as a communications medium. The explosive growth of the Internet, and more recently, the World Wide Web, is a harbinger of what will evolve into a completely computer--mediated world in which all aspects of life, not just cyberspace, will be online and connected by visually based content and visual reality user interfaces.

This transformation in the way we think and communicate will not be the result of so--called ubiquitous computing (microprocessors in everything around us). Instead of the current vision of "smart floors", "smart lightswitches", "smart toilets", in "smart buildings" that watch us and respond to our actions, what we will witness is the emergence of "smart people" --- intelligence attached to people, not just to buildings.

And this will be done, not by implanting devices into the brain, but, rather, simply by non--invasively "tapping" the highest bandwidth "pipe" into the brain, namely the eye. This so--called "eye tap" forms the basis for devices that are currently built into eyeglasses (prototypes are also being built into contact lenses) to tap into the mind's eye.

Eye Tap technology causes inanimate objects to suddenly come to life as nodes on a virtual computer network. For example, while walking past an old building, the building may come to life with hyperlinks on its surface, even though the building is not wired for network connections in any way. These hyperlinks are merely a shared imagined reality that wearers of the Eye Tap technology simultaneously experience. When entering a grocery store, a milk carton may come to life, with a unique message from a spouse, reminding the wearer of the Eye Tap technology to pick up some milk on the way home from work.

Eye Tap technology is not merely about a computer screen inside eyeglasses, but, rather, it's about enabling what is, in effect, a shared telepathic experience connecting multiple individuals together in a collective consciousness.

Eye Tap technology will have many commercial applications, and emerge as one of the most industrially relevant forms of communications technology. The WearTel (TM) phone, for example, uses Eye Tap technology to allow individuals to see each other's point of view. Traditional videoconferencing merely provides a picture of the other person. But most of the time we call people we already know, so it is far more useful for use to exchange points of view. Therefore, the miniature laser light source inside the WearTel eyeglass--based phone scans across the retinas of both parties and swaps the image information, so that each person sees what the other person is looking at. The WearTel phone, in effect, let's someone "be you", rather than just "see you". By letting others put themselves in your shoes and see the world from your point of view, a very powerful communications medium results.

The course includes iPhone and Android phone technologies, and eyeglass-based "eyePhone" hybrids.

Text:

- Intelligent Imaging Processing (published by John Wiley and Sons, November 2, 2001)
- online materials and online examples, using the GNU Octave program, as well as other parts of the GNU Linux operating system (most of us use Ubuntu, Debian, or the like).
- additional optional references: publications, readings, etc., that might be of interest.

Organization of the textbook

http://wearcam.org/ece516/
The course will follow very closely to the textbook which is organized into these six chapters:

1. **Personal Cybernetics**: The first chapter introduces the general ideas of "Wearable Computing", personal technologies, etc. See [http://wearcam.org/hi.htm](http://wearcam.org/hi.htm).
2. **Personal Imaging**: (cameras getting smaller and easier to carry), wearing the camera (the instructor's fully functioning XF86 GNUX wristwatch videoconferencing system, [http://wearcam.org/wristcam/](http://wearcam.org/wristcam)); wearing the camera in an "always ready" state.
3. **Mediated Reality and the EyeTap Principle.**
   - Collinearity criterion:
     - The laser EyeTap camera: Tapping the mind's eye: infinite depth of focus
     - Contact lens displays, blurry information displays, and vitrionic displays
4. **Comparametric Equations, Photoquantigraphic Imaging, and comparagraphics** (see [http://wearcam.org/comparam.htm](http://wearcam.org/comparam.htm)).
5. **Lightspace**:
   - lightvector spaces and anti-homomorphic imaging
   - application of personal imaging to the visual arts
6. **VideoOrbits and algebraic projective geometry** (see [http://wearcam.org/orbits](http://wearcam.org/orbits)): Computer Mediated Reality in the real world; Reality Window Manager (RWM).

### Other supplemental material

1. **Chording keyer (input device) for wearable/portable computing or personal multimedia environment**
2. **fluid user interfaces**
3. **previously published paper on fluid user interfaces**
4. **University of Ottawa: Cyborg Law course** See also, the [University of Ottawa site, and article on legal and philosophical aspects of Intelligent Image Processing](http://wearcam.org/)
5. **photocell experiment**
6. "Recording 'Lightspace' so shadows and highlights vary with varying viewing illumination", Optics Letters, Vol. 20, Iss. 4, 1995 ("margoloh")
7. **Example from previous year's work: data from final lab, year 2005: lightvectors and lightspace** (See readme.txt file).

### Lecture, lab, and tutorial schedule from previous years

Here is an example schedule from a previous year the course was taught.

Each year we modify the schedule to keep current with the latest research as well as with the interests of the participants in the course. If you have anything you find particularly interesting, let us know and we'll consider working it into the schedule...

1. **Week1 (Tue. Jan. 4 and Wed. Jan. 5th)**: Humanistic Intelligence for Intelligent Image Processing
   - Humanistic User Interfaces, e.g. "LiQUIface" and other novel inputs that have the human being in the feedback loop of a computational process.
2. **Week2**: Personal Imaging; concomitant cover activity and VideoClips; Wristwatch videophone; Telepointer, metaphor-free computing, and Direct User Interfaces.
3. **Week3**: Atmel AVR, handout of circuitboards for keyers, etc.; [wiring instructions are now on this www site at http://wearcam.org/septambic/](http://wearcam.org/septambic/)
4. **Week4**: EyeTap part1; technology that causes the eye itself to function as if it were both a camera and display; collinearity criterion; Calibration of EyeTap systems; Human factors and user studies.
5. **Week5**: Eyetap part2; Blurry information displays; Laser Eyetap; Vitronics (electronics in glass); Vitrionic contact lenses.
7. Week7: READING WEEK: NO LECTURE THIS WEEK
8. Week8: Comparametric Equations part2.
10. Week10: Lightspace and anti-homomorphic vectorspaces.
11. Week11: VideoOrbits, part1; background
12. PDC intensive course may also be offered around this time;
13. Week12: VideoOrbits, part2; Reality Window Manager (RWM); Mediated Reality; Augmented Reality in industrial applications; Visual Filters; topics for further research (graduate studies and industrial opportunities).
14. Week13; review for final exam;
15. Final Exam: standard time frame usually sometime between around mid April and the end of April.

Course Evaluation (grading):

- Closely Supervised Work: 40% (in-lab reports, testing, participation, field trials, etc.).
- Not Closely Supervised Work: 25% (take-home assignments or the portion of lab reports done at home)
- Final exam: 35%. Exam is open book, open calculator, but closed network connection.

This course was originally offered as ECE1766; you can see previous version (origins of the course), http://wearcam.org/ece1766.htm for info from previous years.

To see the course outline of other previous years, visit, for example, http://wearcam.org/ece1766_1998.html

Resources and info:

- AVR info
  - avr_kit.tar (shell script that installs GCC AVR and SP12 for those of you using the parallel port approach...)

- Example from ECE385:

Supplemental material:

- the cyborGLOGGER community at http://glogger.mobi
- the EyeTap site, at www.eyetap.org.org
- related concepts like sousveillance, and collective intelligence...
- here's an interesting article about decentralization
- "the electronic device owned now by the most college students is the cell phone. Close behind is the laptop."
- A new name for cyborglogging and sousveillance: "lifecasting".
- Microsoft's interest in our work

Here's one of our neckworn sensory cameras, designed and built at University of Toronto, 1998, which later formed
the basis for Microsoft's sensecam.

CyborGLOG of Lectures from previous year

(...on sabbatical 2009, so last year the course was not offered. Therefore, the must up-to-date previous course CyborGLOG was from 2008.)

- **Tue 2008 Jan 08:**
  My eyeglasses were recently broken (damaged) when I fell into a live three-phase power distribution station that was for some strange reason setup on a public sidewalk by a film production company. As a result, my eyeglasses are not working to well. Here is a poor quality but still somewhat useful (understandable) capture of the lecture as transmitted live (archive) (please forgive the poor eyesight resulting from temporary replacement eyewear).

  Another point of view is here.

- **Thu 2008 Jan 10:**
  - walking to the classroom plus the first half of lecture; and also...
  - second half of lecture and walking out of the classroom.

- **Tu 2008 Jan 15:**
  - walking to the classroom plus most of the lecture; and also...
  - end part of lecture (questions answered on chalk board).

- **Th 2008 Jan 17:**
  - first half of lecture
  - second half of lecture

- **Tu 2008 Jan 22:** lecture
- **Th 2008 Jan 24:** lecture
- **Tu 2008 Jan 29:** lecture
- **Th 2008 Jan 31:** walking to lecture with Ryan's presentation on AVR
- **Tu 2008 Feb 05:** lecture
- **Th 2008 Feb 07:** lecture
- **Tu 2008 Feb 12:** lecture
- **Th 2008 Feb 14:** lecture
- **2008 Feb 18-22:** reading week, no lectures or labs
- **Tu 2008 Feb 26:** lecture
- **Th 2008 Feb 28:** lecture
- **Tu 2008 Mar 04:** lecture
- **Th 2008 Mar 06:** lecture
- **Tu 2008 Mar 11:** lecture
- **Th 2008 Mar 13:** lecture
- **Tu 2008 Mar 18:** lecture
- **Th 2008 Mar 20:** lecture
- **Tu 2008 Mar 25:** lecture
- **Th 2008 Mar 27:** lecture
- **Tu 2008 Apr 01:** lecture
- **Th 2008 Apr 03:** lecture

CyborGLOG of Labs

- **Fr 2008 January 18th:**
  1. first half of lab
  2. second half of lab
- **Fr 2008 January 25:**
  - lab
  - soldering banana connectors
• Fr 2008 February 01: Snow storm; university officially closed but I still made myself available to people who came and wanted some help:
  o Meeting with students who showed up to the EA302 lab on the day the university was closed due to snow storm...
  o Meeting with Ryan and the students who wanted to work with fluidsynth...
  o Ryan and I discussing AVR pinout for driving three 7-segment LEDs

• Fr 2008 February 08:
  o lab

• Fr 2008 February 29:
  1. first part of lab
  2. second part of lab
  3. last part of lab

• Fr 2008 March 07:
  1. first part of lab
  2. second part of lab, then visit to Decon

• Fr 2008 March 14: Individual group evaluations (not in the public 'glog)
• Fr 2008 March 21: Good Friday (now lab)
• Fr 2008 March 28: lab

Other background readings:

• photocell experiment
• Computational photography
• Candocia's research
• Candocia's paper in
• some of these papers show up also in scientific commons, e.g. take a look at the second paper listed in scientific commons, or any of the other papers on comparometrics, or range-range estimates.
• background estimation under rapid gain change

Christina Mann's fun guide: How to fix things, drill holes, install binding posts, and solder wires to terminals
Material from year 2007:

Lab 2007-0: Demonstration of an analog keyboard

Example of analog keyboard; continuous fluidly varying input space:

Lab 2007-1, Chapter 1 of textbook: Humanistic Intelligence

In lab 1 you will demonstrate your understanding of Humanistic Intelligence, either by making a keyer, or by programming an existing keyer, so that you can learn the overall concept.

Choose one of:

- Build a keyer that can be used to control a computer, camera, music player, or other multimedia device. Your keyer can be modeled after the standard Twiddler layout. You can take a look at http://wearcam.org/ece516/musikeyer.htm to get a rough sense of what our typical keyers look like. See also pictures from last year's class, of various keyers that were made, along with the critiques given of each one. Your keyer should have 13 banana plugs on it: one common and 12 others, one of these 12 for each key. If you choose this option, your keyer will be graded for overall engineering (as a crude and simple prototype), ergonomics, functionality, and design.
- Modify one or more of the programs on an existing keyer to demonstrate your understanding of these keyers. Many of our existing keyers use the standard Twiddler layout, and are programmed using the C programming language to program one or more Atmel ATMEGA 48 or ATMEGA 88 microcontrollers. If you choose this project, please contact Prof. Mann or T.A. Ryan Janzen, to get a copy of the C program, and to discuss a suitable modification that
demonstrates your understanding of keyers.

- Assemble a "blueboard" (we supply printed circuit board and pre-programmed chips). Should have experience soldering DIPs, etc.. The blueboard is the standard interface for most wearable computers and personal cybernetics equipment, and features 15 analog inputs for 12 finger keys and 3 thumb keys. If you choose this option, please contact Prof. Mann or T.A. Ryan Janzen, to determine materials needed.
- Implement a bandpass filter. You can do this using a suitable personal computer that has a sound card, that can record and play sound (at the same time). You can write a computer program yourself, or find an existing program written by someone else that you can use. Your filter should monitor a microphone input, filter it, and send the output to a speaker. The filter should be good enough that it can be set to a particular frequency, for example, 440Hz, and block sounds at all but that frequency. Any sound going into the microphone should be audible at that specific frequency only, i.e. you should notice a musical or tonal characteristic in the output when the input is driven with arbitrary or random sound.

Ideally we would have at least one person doing each part of this project so that we can put a group together for the entire result (keyer).

Lab 1 results:

- Greg's bandpass filter was based on CLAM
- JAMES: perfboard-based keyer
- MOHAMAD's bandpass filter based on FPGA
- Jono (Jonathan, Iceman)'s keyer
- David's blueboard interface/adapter
- PENG's keyer
- BRYAN's keyer, considering foam pipe
- Anthony's keyer on perfboard, with ribbon cable
- Rachenne made keyer on perfboard, with the 13 plugs.
- Philip's pipe-based keyer

OKI Melody 2870A spec sheet

The OKI Melody 2870A spec sheet is here.

Lab 2007-2, Chapter 2 of textbook: Eyeglass-based display device

In this lab we will build a simple eyeglass-based display device, having a limited number of pixels, in order to understand the concept of eyeglass-based displays and viewfinders.

This display device could function with a wide range of different kinds of wearable computing devices, such as your portable music player.

Link to ECE516 Lab 2, 2007

Lab 2007-3, Chapter 3 of textbook: EyeTap (will also give intro to photocell)

Presentation by James Fung:
Lab 2007-4, Chapter 4 of textbook: Photocell experiment

photocell experiment and a recent publication describing it.

Example of linear regression

Today there were two really cool projects that deserve mention in the ECE516 Hall of Fame:
David's comparametric analysis and CEMENTing of telescope images:

Peng's tone generator:

Lab 2007-5, Chapter 5 of textbook: Lightvectors

Lab 2007-6 and 7

Final projects: something of your choosing, to show what you've learned so far.

No written or otherwise recorded report is required.

However, if you choose to write or record some form of report or other support material, it need not be of a formal nature, but you must, of course, abide by good standards of academic conduct, e.g. any published or submitted material must:

- properly cite reference source material (e.g. where any ideas that you decide to use came from);
- properly cite collaborations with others. You are free to do individual projects or group projects, and free to discuss and collaborate even if doing individual projects, but must cite other partners, collaborators, etc..

If you choose not to provide a written report, but only to demonstrate (verbal report, etc.), in the lab, you still need to state your source and collaboration material.

It is expected that all students will have read and agree to the terms of proper academic conduct. This usually happens and is introduced in first year, but for anyone who happens to have missed it in earlier years, it's here: How Not to Plagiarize. It's written mainly to apply to writing, but the ethical concept is equally applicable to presentations, ideas, and any other
representation of work, research, or the like.

Year 2006 info:

Keyer evaluation is posted:

Lab 2

EyeTap lab: Explanation of how eyetap works; demonstration of eyetap; demonstration of OPENvidia.

C.E.M.E.N.T. lab

Comparametrics lab: Recover the damage done by the Elipses of Evil, on the Axes of Good:
Exam schedule in previous years

Check the official site by following the most current hyperlink; in previous years (example, 2006 below) the exam schedule was given at the following URL: [ECE516H1 INTELLIGENT IMAGE PROCESSING X April 17, 2006 9:30 AM BA-3004](http://wearcam.org/ece516/)
Last day of class:

In previous year the last day of classes was April 13. Generally the last day of classes falls sometime close to mid-April, and then there's the final exam.

Course poster