ECE516 Syllabus 2021
Intelligent Image Processing

Fundamentals of "Wearables", VR/AR/XR, Intelligent Sensing,
Meta-Sensing, and Image Processing for Wearables, Autonomous
Electric Vehicles, Smart Cities and the Invironment and Environment.

Winter 2021, 39 lectures + 5 labs.
Website: http://wearcam.org/ece516/

Instructor:	Professor Steve Mann (mann@eyetap.org), http://wearcam.org/bio2.htm
TAs:	Zhao Lu (zhao.lu@mail.utoronto.ca)
	Jacky Lau (jkk.lau@mail.utoronto.ca)

Advisors: Arkin Ai (VisionerTech Founder), Raymond Lo (Meta Co-Founder), Chris Aimone (InteraXon CTO and Co-Founder), Ken Nickerson (Kobo Co-Founder), Ajay Agrawal (Rotman CDL Founder), Norm Pearlstine (served as the Editor-in-Chief of the *Wall Street Journal*, *Forbes,* and Time, Inc.), Ryan Jansen (Transpod Co-Founder), Nahum Gershon (Father of Human-Information Interaction), Dan Braverman (MannLab COO/General Counsel), and many others.

Time/Location:	Online, asynchronous + scheduled http://meet.jit.si/ECE516
Lectures:	Online, asynchronous + scheduled http://meet.jit.si/ECE516
Labs:	Online, asynchronous + Instructables + http://meet.jit.si/ECE516
Office Hours:	Scheduled at student's convenience, as a Jitsi video call.

I.   Purpose:

This course is designed to 1) provide instruction and mentorship to students interested in the art and science of understanding the world around us through intelligent sensing and meta-sensing, with an emphasis on intelligent imaging (e.g. computer vision with cameras, sonar, radar, lidar, etc.), and 2) teach the fundamentals of Human/Machine Learning in order to benefit humanity at multiple physical scales from "wearables" (wearable computing), to smart cars, smart buildings, and smart cities.

The emphasis is on fundamentally understanding technology in basic and simple ways that involve actually building devices from first-principles, to develop a deeper understanding than is possible through merely using existing tools in a shallow way.

The primary course deliverable consists of weekly labs which are demonstrations (i.e. for you to show your understanding of the material).

You will learn how to build your own wearable computer vision seeing aid for the blind, so that you can learn (1) how simple + reliable technology can help people, (2) how to implement HuMachine Learning in a way that benefits humanity, (3) understand wearable technologies by building them, and (4) how to take a picture using your eye as a camera.

The emphasis is on Phenomenological Augmented Reality, Wearable Computing, and Humanistic Intelligence, operating at multiple physical scales, i.e. including vehicles as a form of Extended Intelligence.

It is expected that many students will go on to form startup ventures around their prototypes and labs, through ongoing guidance and support.

Guest lecturers and mentors include Founders, CEOs, and CTOs from venture-capital backed companies in the U.S., Canada and China, many of which were founded in Professor Mann's Toronto lab, as well as connections with Mannlab Silicon Valley and Mannlab Shenzhen.

II.   Overall Course Philosophy, Aims and Outcomes:

In this course you will learn how to build your own wearable computer and your own self-driving personal electric car or drone. The emphasis of this course is to teach fundamental physical sciences and engineering so that you can learn how to think (and do) for yourself.

Many universities have become tax-free hedge funds to serve the interests of big corporations and big government. They train students to become a source of cheap labour for big pharma, big data, big science, and big watching (surveillance). They train students to become a small specialized cog in a big machine.

Many courses are no longer taught by professors who are authors of the textbooks or who are authorities on the subject matter, or who even show up to the labs to work directly with the students.

Therefore, what we aim to do in this course is restore the balance in favour of the student, i.e. to empower the student with concepts like "little data" (distributed data like blockchain), "little watching" (also known as sousveillance), and human-in-the-loop AI ("HuMachine Learning") [Minsky, Kurzweil, Mann, 2013], Wearable AI (IEEE Intelligent Systems), and eXtended Intelligence (IEEE CXI).

In this course you will learn how to think for yourself and how to build things yourself without the support of lab technicians and massive infrastructure. These are the skills that startups as well as the top companies are looking for, and the skills you need to create your own startup.

See http://wearcam.org/ece516/philosophy.htm for more on the philosophy of ECE516.

III.   Specific Learning and Evaluational Outcomes*:*

By the end of this course, students will:

• Know how to build a basic wearable device, such as a computer vision system for the blind;

• Understand fundamentals of personal technologies such as a small electric vehicle (e.g. mobility scooter) and fundamentals of sensing and meta-sensing associated with wearables and personal vehicles;

• Deeply understand Human/Machine Learning in the Minsky, Kurzweil, Mann [2013] sense, i.e. Sensory HuMachine Learning, along with associated mathematical transforms, i.e. Comparametric Equations, and Adaptive Chirplet Transform and Intelligent Signal Processing (e.g. to fulfill Haykin's principle of vision systems capable of cognition).

Students will learn how to quickly turn ideas into inventions through a range of time-scales ranging from quick and sloppy "rapid prototyping" (rapid reduction-to-practice) to more well-made (longer time scale) prototypes designed for demonstration to others. Whereas other engineering courses often teach a slower more methodological approach akin to classical music, in this course, students will also learn "tinquiry" (tinkering as inquiry), more akin to jazz music (i.e.. quick improvisation, often making working prototypes to turn ideas into inventions in 90 minutes or less).   Formal large lectures will be given, but there will be ample one-on-one and small-group mentorship and meta-mentorship as well. For meta-mentorship, we offer to help you bring in friends and associates of your own, who you are comfortable with already, as co-mentors.

The course will use the Instructables.com website to help in teaching. The course instructor devotes a lot of time to individual one-on-one mentorship of students, and will respond individually to each "I made it" post. Completing one or more of these Instructables will give students the opportunity to demonstrate aptitude for making things, and to get a sense of what kinds of topics the course instructor is best equipped to help you with.

IV. Course Readings:

The course textbook is "Intelligent Image Processing" by Steve Mann, published by John Wiley and Sons, and available in the University of Toronto bookstore.

Additional readings, articles and publications are located at http://www.eyetap.org/publications and from http://weartech.com, as well as AR Metavision content will also be made available.
From time-to-time additional readings and instructables will be posted on http://wearcam.org and http://www.instructables.com/member/SteveMann/instructables/.

V. Course Evaluation and Grading Procedures, which are tentative due to possible pandemic response changes to COFM (Composition of Final Mark):

- Closely Supervised Individual Term Work: 15% (in-lab reports, testing, participation, etc.);
- Not Closely Supervised Work: 50% (take-home assignments or the portion of lab reports done at home, but all to be presented in the lab!);
- Final exam (or, due to pandemic, may shift toward an at-home exam, project or report): 35%, open-book.

Lab periods are for grading. It is presumed that you will arrive at the lab with a working assignment to show and be graded in the lab (i.e. the prelab is to get it working).

VI. Labs:

The majority of your grade comes from the labs, and the lectures are primarily in service of the labs.

The lab periods are for you to show your work and for you to connect with the professor and TAs and other members of the class. This is your opportunity to show off and see and be seen in the world of smart technologies.

The most important part of this course is the labs, which offer authentic, direct mentorship with a high degree of involvement from the professor and other leading experts in sensing, meta-sensing, and machine learning.

There are 5 labs with projects in these areas:
1. Phase-coherent detection for active computer vision:
     - Active vision systems (sonar, radar, lidar);
     - Sonar vision system for the blind using the amplifier;
     - Fourier transform, wavelet transform, and chirplet transform;
     - Machine learning for computer vision: Radar Vision and LEM neural network;
     - Biosignals and biosensing. In this lab, we will build an ultrasound system to image your own heart. [Analysis of Seismocardiographic Signals Using Polynomial Chirplet Transform...].
     - Brain-Computer Interfaces (InteraXon company co-founded by Mann and his students and others);
     - Fluid User Interfaces and Natural User Interfaces (NUIs);
     - See and photograph sound waves, radio waves, and light waves using a lock-in amplifier.
2. Passive vision: Many courses on computer vision fail to teach the fundamental concepts of what sensing is and does. We'll begin with fundamental principles by exploring first a 1-pixel camera and 1-pixel display, quantigraphic (quantifiable) sensing, and meta-sensing.
     - Begin with fundamental 1-pixel display;
     - Build your own 1-pixel camera;
     - Quantigraphic sensing: Comparametric Equations;
     - Self-driving vehicles, sensing, and meta-sensing;

○ Phenomenological augmented reality with Metavision;
3. Autonomous vehicles: Understanding 3 phase motors and electric vehicles;
4. Tentative: a final project of your own choosing (time and student interest permitting)...

VII. Opportunities

Prof. Mann is widely known as the inventor of HDR (High Dynamic Range) imaging used in more than 2 billion smartphones, and in his role as a founding member of the IEEE Council on Extended Intelligence and the Chair of the Silicon Valley Investment and Entrepreneurship Forum, is well-connected to industry. We have vacancies in Toronto, Silicon Valley, and Shenzhen China, and we seek people who are well-grounded in fundamentals leading to deeply understanding "wearables" and HuMachine-Learning/Extended-Intelligence (HI) for autonomous vehicles and smart cities. Ford Motor Company is collaborating with us and we're looking for people for this as well. Prof. Mann has also helped a number of students get into MIT (his alma mater) and Stanford (where he spent a lot of time living and working).

Doing really well in this course is your chance to impress us and our advisory team and also to build a foundation and make and do things that will impress others. Many students have said that they've learned more in this course than all their other courses put together. Here's your chance to "put your feet on the ground" and build a solid foundation under all of what you do.

Please see http://wearcam.org/ece516/opportunities.htm for summer and fall 2021opportunities in MannLab.com as well as at the University of Toronto, MIT, Stanford, Ford Motor Company, etc.

VIII. Academic Integrity

Each student in this course is expected to abide by the University of Toronto Code of Behaviour on Academic Matters. Any work submitted by a student in this course for academic credit will be the student's own work.

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to other students or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of the work done by someone else, in any form (i.e. mail, digital file, floppy disk, audio recording, or a hard copy).

Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Code can also be extended to include failure of the course and University disciplinary action.

During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and

may lead to failure of the course and University disciplinary action.

IX.   Accommodations for Students with Disabilities

In compliance with the University of Toronto policy and equal access laws, I am available to discuss appropriate academic accommodations that may be required for students with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with Student Disability Services to verify their eligibility for appropriate accommodations.

We are also extremely well-versed in seeing aids for the visually impaired, as well as in electric mobility aids.

X.   Inclusivity Statement

We understand that our members represent a rich variety of backgrounds and perspectives. The engineering department is committed to providing an atmosphere for learning that respects diversity. While working together to build this community we ask all members to:

- Share their unique experiences, values and beliefs
- Be open to the views of others
- Honor the uniqueness of their colleagues
- Appreciate the opportunity that we have to learn from each other in this community
- Value each other's opinions and communicate in a respectful manner
- Keep confidential discussions that the community has of a personal or professional nature
- Use this opportunity together to discuss ways in which we can create an inclusive environment in this course and across the university community

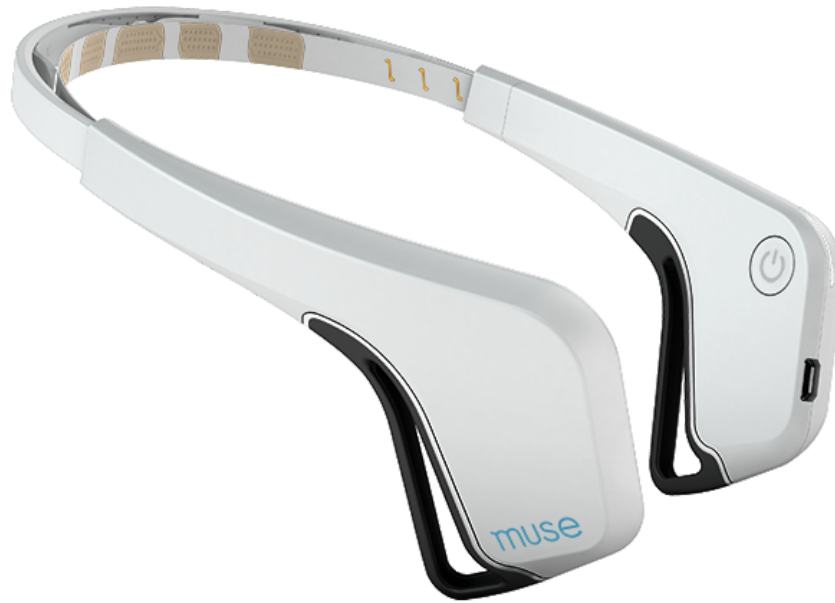# Appendix. Available Course Equipment

VisionerTech VMG-PROV

Related link: https://www.youtube.com/watch?v=T0m0qGA8xhk

Meta 2 Augmented Reality Eyeglasses

Related link: https://www.metavision.com

Muse Headband

Related link: https://www.choosemuse.com

Muse Safilo Eyeglasses

Related link:https://www.youtube.com/watch?v=5CZtoYbfbHU

BlueberryX.com world-and-brain-sensing eyeglass
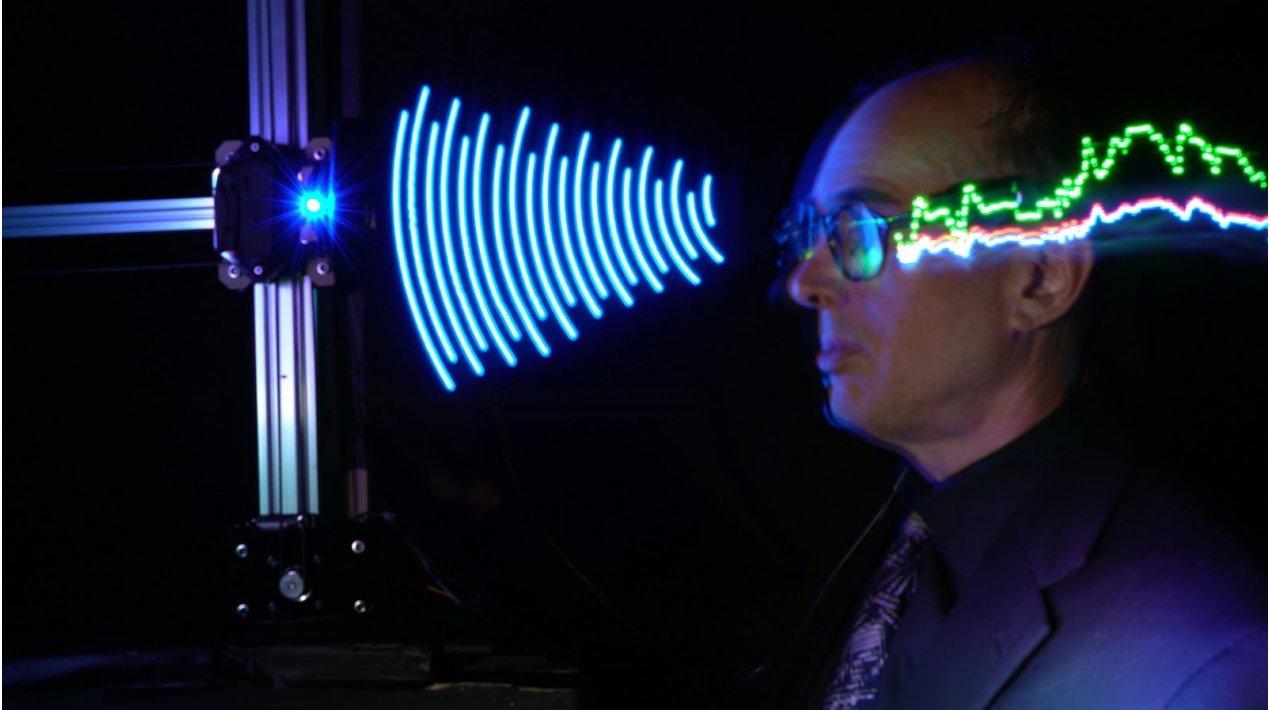
Open EyeTap

Related link: https://www.openeyetap.com
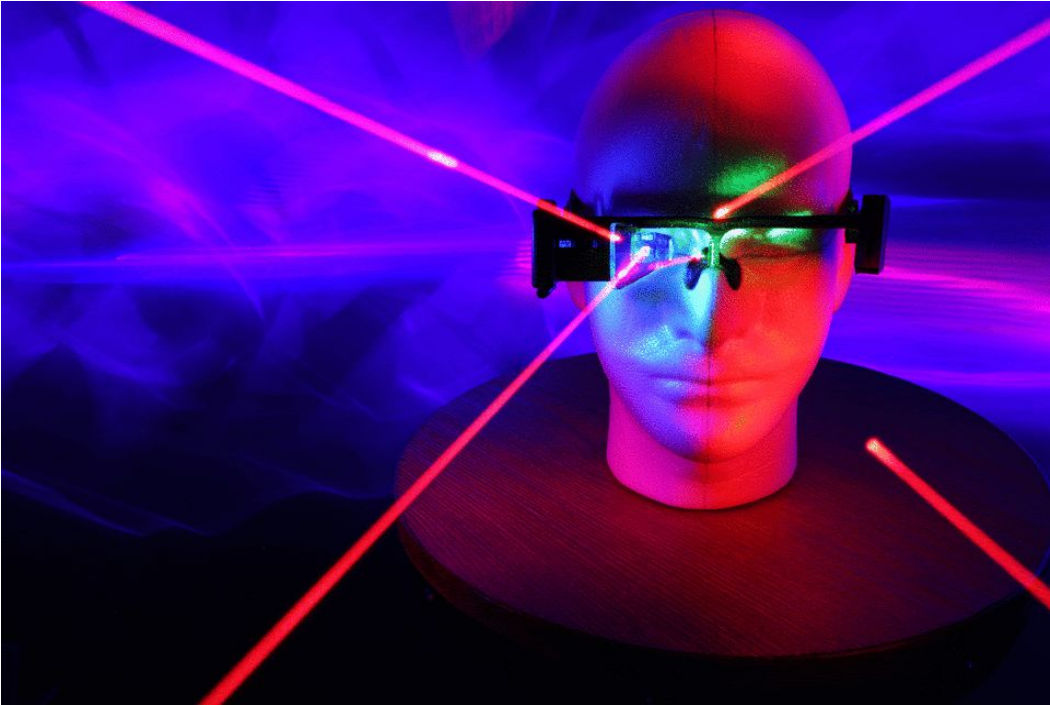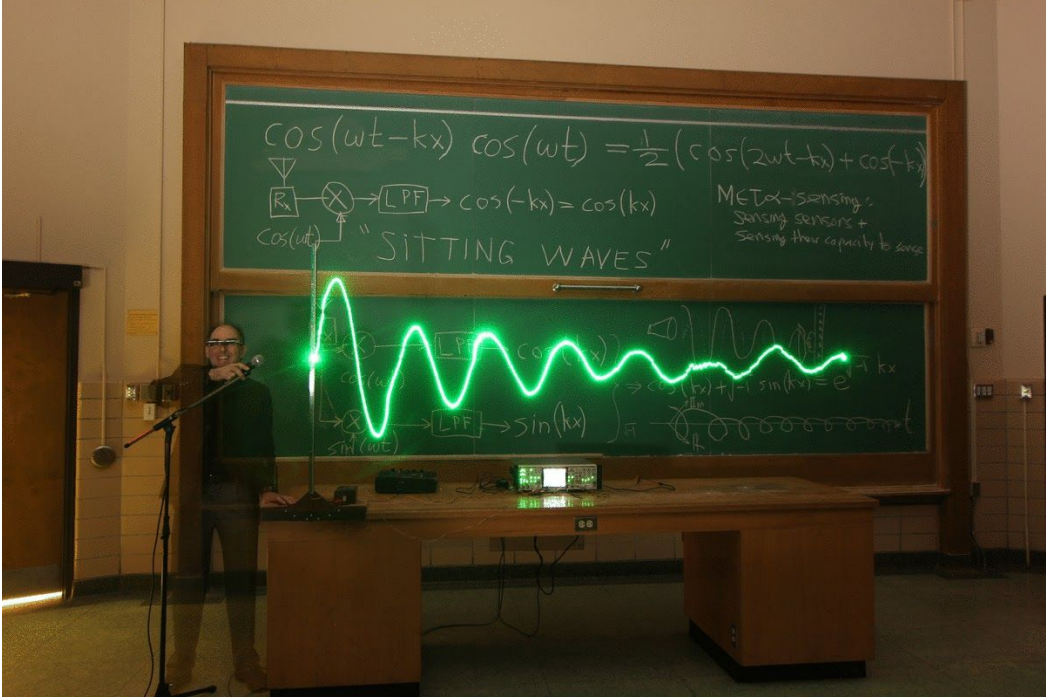
"MannLab x SYSU" Lock In Amplifier & Phenomenological Augmented Reality

Related link: http://www.wearcam.org/par/