Computing and the Environment
Spring 2011

Instructor: Doug Fisher (douglas.h.fisher@vanderbilt.edu)
Class Time: Tuesdays and Thursdays 11:00 AM - 12:15 PM
Class Room: FGH 200
Textbook: Greening Through IT (Tomlinson). MIT Press
Instructor Office Hours: Monday 4:00 - 5:00 PM, Wednesday 2:00 - 3:00, Friday 1:00 - 2:00, or by appointment
Two project papers: one before Spring break, and one due by end of semester (with presentations).

Computing and communication technology is ubiquitous in materially wealthy populations, and is becoming more prevalent across all populations. While the computing sector's direct ecological footprint (e.g., energy required for manufacture and use; toxins from improper disposal) is increasing rapidly, computing holds great promise for (a) offsetting environmental footprints and mitigating degradation in other sectors such as travel (through use of virtual-participation technologies); (b) improving data collection on environmental processes through sensor networks and robotics; (c) for improving evidence-based environmental decision making through artificial intelligence, machine learning, optimization, and visualization; (d) for increasing awareness and activism through social computing; and (e) for environmental and societal modeling and simulation. In conjunction with improvements to the design of computing systems for energy efficiency and recycling, computing has substantial contributions to make towards core challenges of environmental and societal equity and sustainability.

Topics: The course will view computing through a sustainability lens. Topics will include hardware design (e.g., for recycling), algorithm analysis (e.g., for energy implications), and unanticipated consequences of such technology evolution; robotics, computer vision, and acoustics (e.g., for species monitoring); artificial intelligence, machine learning, and optimization (e.g., for design of bio-reserves and smart-grids); agent-based modeling (e.g., for traffic modeling); and social computing (e.g., for activism and collective intelligence). The course is relatively unique in its broad and holistic coverage of the computing sub-disciplines. There will be attention to the social sciences, because trying to understand the environmental implications of computing without attention to human behavior is myopic and ill advised. This treatment will extend to discussion on national and international policy questions concerning computing and the environment.

Format: There will be weekly readings and brief student responses to the reading; in-class discussions; and two student-designed computing-based design/implementation project on environmental/energy/sustainability.

Schedule

Readings by January 18
Attached Files: SustainLeader.final.pdf (218.097 KB)
1. Chapter 1 of Greening through IT textbook (Tomlinson)
2. Leadership in Science and Technology, 17. Sustainability, (Fisher).

Readings by January 25
Attached Files: overview-and-highlights-v7.doc (6.785 MB)
1. Chapter 2 of Greening Through IT2. Computational Sustainability Project Highlights: http://www.cis.cornell.edu/ics/projects/overview.php (or as a WORD file -- see attached)

Readings by February 1
Attached Files: Lucid_IJSHE_DormEnergyFeedback.pdf (314.123 KB)
1. Chapter 3 of Greening Through IT
2. "Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives" (Peterson, et al, 2007)

Readings by February 8
Attached Files: Comparison of Carbon Calculators.pdf (323.564 KB)
RossShantharamTomlinson-BetterCarbon-ISSST2010.pdf (332.942 KB)
1. Chapter 4 of Greening Through IT text (Tomlinson)
2. "Collaborative Filtering and Carbon Footprint Calculation" (Ross, et al 2010).
3. OPTIONAL: "A Comparison of Carbon Calculators" (Padgett, et al 2008)

Readings by February 15
1. Chapters 5 and 6 of Greening through IT2. Discuss student-identified sources and essays due March 4

Readings by February 22
1. Chapters 7 and 8 of Greening through IT2. Discuss student-identified sources and essays due March 4

Readings by March 1
1. Chapter 9 of Greening through IT2. Discuss student-identified sources and essays due March 4

Readings by March 15
Attached Files: Shipping vs streaming.pdf (495.756 KB)

1. Shipping to Streaming: Is this shift green? (see attached -- read for THURSDAY, March 17) Anand Seetharam, Manikandan Somasundaram, Don Towsley, Jim Kurose, Prashant Shenoy Department of Computer Science University of Massachusetts, Amherst MA 01003 USA

Readings by March 22 (Design and algorithms week)

Attached Files: energy complexity martin.pdf (178.383 KB)
energy complexity jain.pdf (109.405 KB)
energy complexity albers.pdf (4.566 MB)

1. In lieu of class on Tuesday, March 22, I want you to virtually attend at least one (90 min) session on the AAAI Symposium on Artificial Intelligence and Sustainable Design (http://www.vuse.vanderbilt.edu/~dfisher/AI-Design-Sustainability.html) -- follow the link to "Program" at this URL (I'd suggest one of the invited speakers early Monday evening Central Time or late Wednesday morning central time). We'll discuss more in class, but see the link to virtual participation option at the site above.
2. Reading for Thursday, March 24 (there is class; Kirstin Early will lead):
2a) Martin, Alain J. 2001. "Towards an Energy Complexity of Computation."Information Processing Letters, 77 (2001): 181 – 187. (preprint attached)
2b) Susanne Albers, "Energy-Efficient Algorithms" Communications of the ACM, 53.5 (2010): 86-96 (see attached)
Other optional readings:
2c) Jain, Ravi, David Molnar, and Zulfikar Ramzan. "Towards a Model of Energy Complexity for Algorithms." Wireless Communications and Networking Conference, 3 (2005): 1884 – 1890. (attached)

Readings by March 29 (Climate Modeling week)

Jonathan Gilligan guest lecture: March 29
Attached Files: History of Climate Modeling.pdf (970.414 KB)
Edwards - Representing the Global Atmosphere - 2001.pdf (111.491 KB)
Computer Modeling.pptx (9.951 MB)
LearningOverview.ppt (283.5 KB)

1. "History of Climate Modeling," Paul N. Edwards http://onlinelibrary.wiley.com/doi/10.1002/wcc.95/pdf (see attached)
2. "Representing the Global Atmosphere: Computer Models, Data, and Knowledge about Climate Change," in C.A. Miller and P.N. Edwards, eds., Changing the Atmosphere: Expert Knowledge and Environmental Governance (MIT, 2001), pp. 31-65. (see attached)

Readings by April 5 (Optimization Week)

Attached Files: corridors-TR-july2010.pdf (10.159 MB)
CPAIOR2010-dilkina-gomes.pdf (192.84 KB)
aid10_brunskilllesh-1.pdf (179.517 KB)

Connected landscape optimization Williams.pdf (357.058 KB)
dilkina-crocs09-final.pdf (85.192 KB)
Incorporating Economic and Ecological Information into the Optimal Design of Wildlife Corridors by Conrad.docx (48.896 KB)
See the exercise attached: Incorporating Economic and Ecological Information into the Optimal Design of Wildlife Corridors by Conrad.docx
1. Incorporating Economic and Ecological Information into the Optimal Design of Wildlife Corridors. Jon Conrad, Carla Gomes, Willem van Hoeve, Ashish Sabharwal, and Jordan Suter. Computing and Information Science Technical Reports,URI:http://hdl.handle.net/1813/17053. Cornell University, Ithaca, NY, 2010. (attached)
2. Routing for Rural Health: Optimizing Community Health Worker Visit Schedules. Emma Brunskill, Neal Lesh (attached)
Other: FYI
Reserve Design
Game: http://www.uq.edu.au/marxan/resgame/index.html#intro
Solving Connected Subgraph Problems in Wildlife Conservation. Bistra Dilkina and Carla Gomes. CPAIOR2010. Proceedings of the 7th International Conference on on Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems, Bologna, Italy, 2010. (attached)
Williams, J. C., and Snyder, S. A. 2005. Restoring habitat corridors in fragmented landscapes using optimization and percolation models. Environmental Modeling and Assessment. 10(3):239–250. (attached)
Wildlife Corridor Design: connections to Computer Science, Bistra Dilkina & Carla P. Gomes (attached)

Readings by April 12 (Machine Learning week)
Attached Files: Tracking climate models.pdf (749.042 KB)
Machine learning in Ecosystems Informatics.pdf (830.122 KB)
1 Tracking Climate Models CLAIRE MONTELEONI*, GAVIN SCHMIDT**, AND SHAILESH SAROHA*** (attached)
2. Machine Learning in Ecosystem Informatics and Sustainability, Thomas G. Dietterich (attached) and Machine learning: http://videolectures.net/ijcai09_dietterich_mleis/ (International Joint Conference on Artificial Intelligence, 2009)

Readings by April 19 (Robotics week)
Attached Files: AAAI08-AUV control.pdf (1.999 MB)
Multi-AUV.pdf (2.138 MB)
Autonomous Fish Tracking by ROV Using Monocular Camera.pdf (425.889 KB)
1. Adaptive Control for Autonomous Underwater Vehicles, Conor McGann, Frederic Py, Kanna Rajan, John Ryan, Richard Henthorn, Monterey Bay Aquarium Research Institute, Moss Landing, California (Proceedings of the Twenty-Third AAAI Conference on Artificial Intelligence (2008)) See attached.
Additional (optional) readings

2. Multi-AUV Control and Adaptive Sampling in Monterey Bay, Edward Fiorelli, Member, IEEE, Naomi Ehrich Leonard, Senior Member, IEEE, Pradeep Bhatta, Member, IEEE, Derek A. Paley, Student Member, IEEE, Ralf Bachmayer, Member, IEEE, and David M. Fratantoni, Member, IEEE, IEEE JOURNAL OF OCEANIC ENGINEERING, VOL. 31, NO. 4, OCTOBER 2006 935
3. Autonomous fish tracking by ROV using Monocular Camera , Jun Zhou Christopher M. Clark , Lab for Autonomous and Intelligent Robotics, Department of Mechanical Engineering , University of Waterloo

Readings by April 26

Attached Files: 2004 Koehler Expected Environmental Impacts of.pdf (102.855 KB)

1. Expected Environmental Impacts of Pervasive Computing, Andreas K¨ohler1 and Lorenz Erdmann, 2004 (attached