Robert B. MacCurdy
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Education

Cornell University   Cornell University/Ithaca College
    M.S. Mechanical Engineering, August 2013   B.S. / B.A. cum laude, May 1999
    PhD Mechanical Engineering, May 2015   Electrical Engineering / Physics

Research Interests

Automated Design & Fabrication of Robots

My research vision, summarized as **Robots Creating Robots**, is to transform the way that robots are designed and fabricated. Building robots via conventional practice requires painstaking design and assembly steps that rely heavily on human intuition and individual expertise. I develop algorithms and fabrication techniques that automate the design and production of customized robots in order to accelerate this process, with the goal of automatically designing robots that "walk out of the printer".

Automated Biological & Ecological Sensing

Understanding biological systems requires observations, yet monitoring free-ranging organisms, including humans, presents technical hurdles that limit the quantity and quality of scientific data, impacting applications ranging from wetland management to eldercare. I design and deploy small, robust, long-lived biosensing instruments that overcome these challenges, with a focus on problems where automation innovations will allow human efforts to scale.

Research Experience

- Postdoctoral associate: MIT Computer Science and Artificial Intelligence Lab
    - Research topic: "Printable Robotics" – I am creating algorithms and assemblers to automate the design and fabrication of customized robots.
    - Supervisor: Daniela Rus
- Graduate student researcher: Cornell Creative machines Lab 2009-2015
    - Thesis title & topic: "Multicellular Machines" – I developed materials, printers and algorithms to automatically design and fabricate functional electromechanical systems by integrating ideas from modular robotics, additive manufacturing, design automation and digital materials.
    - Adviser: Hod Lipson. Committee members: David Winkler, Ephrahim Garcia, Rajit Manohar
- Research engineer: Cornell University Laboratory of Ornithology 1999-2009
    - Designed, built, and deployed systems that enable continuous, unattended in-situ wildlife monitoring
    - Wrote grant proposals, managed projects, reported activities to funding agencies, presented work at conferences and published results
    - Led research expeditions to remote locations in Peru, Argentina, Ghana, various deepwater marine sites
    - Supervised teams of 2 to 4 employees, created job descriptions, recruited and hired staff
    - Specified, sought funding for and created lab & engineering shop space: basic infrastructure as well as test & development HW/SW

Grants/Awards

- NSF OTIC. "Aquatic Energy Harvesting and Intelligent Systems for Wildlife and Environmental Sensing". (**funded: $633,706**). Oct 2015 – Oct 2018. PI: Michael Shafer. I am a technical adviser and wrote sections of the proposal.
- Dolores Zohrab Liebmann Fund Fellowship. (**funded: $47,500**). Aug 2014 - May 2015.
- NWO (Dutch NSF). "Shorebirds in space. Development and application of individual tracking tools for all relevant temporal and spatial scales" TOP Grant (**funded: €749,000**). Jan 2012 - Jan 2015. PI: Theunis Piersma. I wrote the radio-tracking sections, as part of an ongoing collaboration.
- NSF Graduate Research Fellowship. (**funded: $132,000**). May 2011 - May 2014.
- DARPA M3. "Field-Programmable Actuation Arrays". (declined). August 2012. PI: Hod Lipson. I wrote technical sections and performed proof-of-concept simulations.
- ZKO (Dutch). "Responses of protected avian migrants to ecosystem regime shifts in their most important staging area, the Wadden Sea: contrasting a declining shellfish-eating with an increasing worm-eating shorebird" (declined). Jan 2008. PI: Theunis Piersma. I wrote the radio-tracking sections, as part of an ongoing collaboration.
- Gordon and Betty Moore Foundation. "Amazonian Radio Tracking Network" req#402 (**funded: $1,064,347**). Oct 2004 - Jan 2009. PI: Kurt Fristrup. I designed the system, led the research team after the original PI (Kurt Fristrup) left Cornell, published our results, and submitted written and oral progress reports to the Moore Foundation staff.

Publications

- **Journal Articles**
  - MacCurdy, R. & Lipson, H. "Hybrid Printing: Modular 3D Printing of Integrated Electromechanical Systems" (in-submission)
  - MacCurdy, R.; McNicoll, A. & Lipson, H. "A System for 3D Printing Functional Machines with Digital Materials" (in-submission)
  - Cellucci, D., MacCurdy, R., Lipson, H., Risi, S. "1D Printing of Recyclable Robots", (in-submission)
  - Maggini, I., Kennedy, L., Macmillan, A., Elliott, K., MacCurdy, R., Pritsos, C., Dean, K., Guglielmo, C. "Trouble on takeoff: light feather oiling impairs escape performance of shorebirds" (in-review, Ecotoxicology and Environmental Safety)
  - MacCurdy, R., Bijleveld, A., Gabrielson, R., Cluderay, J., Spaulding, E., Oudman, T., van Gils, J., Dekinga, A., Piersma, T., Winkler, D. "Automatic, intensive wildlife radiotracking" (in-submission)
  - Bijleveld, A., MacCurdy, R., Chan, Y., Penning, E., Gabrielson, R., Cluderay, J., Spaulding, E., Dekinga, A., Holthuijsen, S., ten Horn, J., Brugge, M., van Gils, J., Winkler, D., Piersma, T. "Understanding spatial distributions: Negative density-dependence in prey causes predators to trade-off prey quantity with quality" *Proc. R. Soc. B*, 2016, 283, 20151557
  - Shafer, M., MacCurdy, R., Shipley, J., Winkler, D., Guglielmo, C., and Garcia, E. "The case for energy harvesting on wildlife in flight," *Smart Materials and Structures, IOP Publishing, 2015, 24, 025031*
  - MacCurdy, R., McNicoll, A., Lipson, H., "Bitblox: A Printable Digital Material for Electromechanical Machines", *International Journal of Robotics Research*, Vol. 33 (10), pp1342-1360, 2014
  - Piersma, T., MacCurdy, R., Gabrielson, R., Cluderay, J., Dekinga, A., Spaulding, E., Oudman, T., Onrust, J., van Gils, J., Winkler, D., Bijleveld, A. "Fine-scale measurements of individual movements within bird flocks: the principles and three applications of TOA-tracking", *Limosa*, Vol. 87, pp 156-167, 2014.
  - Cheney, N.; MacCurdy, R.; Clune, J. & Lipson, H. "Unshackling evolution: evolving soft robots with multiple materials and a powerful generative encoding". *ACM SIGEVOlution*, ACM, 2014, 7, 11-23
  - Bridge, E. S., Kelly, J. F., Contina, A., Gabrielson, R. M., MacCurdy, R., & Winkler, D. W. "Advances in tracking small migratory birds: a technical review of light-level geolocation", *Journal of Field Ornithology*, *84*(2), 121-137, 2013.
  - Valsalam, V., Hiller, J., MacCurdy, R., Lipson, H., Miikkulainen, R., "Constructing controllers for physical multilegged robots using the ENSO neuroevolution approach", *Evolutionary Intelligence*, Vol 5, Num. 1, pp45-56, 2012.
  - Clark, R., MacCurdy, R., Jung, J., Shaff, J., Rutherford-McCouch, S., Aneshansley, D., Kochian, L., "3-Dimensional Root Phenotyping with a Novel Imaging and Software Platform", *Plant Physiology,* pp.110.169102v1-pp.110.169102, 2011.
  - MacCurdy, R., Gabrielson, R., Spaulding, E., Purgue, A., Cortopassi, K., Fristrup, K., "Automatic animal tracking using matched filters and TDOA", *Journal of Communications,* Vol 4, Issue 7, pp 487-495, 2009.

- **Conference Proceedings**
  - MacCurdy, R., Lipton, J., Li, S., Rus, D. "Printable Programmable Viscoelastic Materials for Robots", *Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2016)*, pp 2628 - 2635
  - MacCurdy, R., Katzschmann, R., Yim, Y., Rus, D. "Printable Hydraulics: A Method for Fabricating Robots by 3D Co-Printing Solids and Liquids", *Proceedings of 2016 IEEE International Conference on Robotics and Automation (ICRA 2016),* pp 3878 - 3885
  - DelPreto, J., Katzschmann, R., MacCurdy, R., Rus, D. "A Compact Acoustic Communication Module for Remote Control Underwater", *Proceedings of the Tenth ACM International Workshop on Underwater Networks (WUWNET),* 2015
  - MacCurdy, R and Lipson, H. "Hybrid printing of photopolymers and electromechanical assemblies", *Solid Freeform Fabrication Symposium*, August 3-6, 2014, Austin, Texas.
  - Cheney, N., MacCurdy, R., Clune, J., Lipson, H. "Unshackling Evolution: Evolving Soft Robots with Multiple Materials and a Powerful Generative Encoding", *Proceedings of the conference on genetic and evolutionary computation (GECCO)*, 2013
  - Shafer, M., MacCurdy, R., Garcia, E. "Testing of vibrational energy harvesting on flying birds," *ASME SMASIS*, 2013.
  - Lipton, J., MacCurdy, R., Lipson, H., et al., "Fab@Home Model 3: A more robust, cost effective and accessible open hardware fabrication platform", *Solid Freeform Fabrication Symposium*, August 6-8, 2012, Austin, Texas.
  - Shafer, M., MacCurdy,R., Garcia, E., Winkler D., "Harvestable vibrational energy from an avian source: theoretical predictions vs. measured values," *Proceedings of SPIE Active and Passive Smart Structures and Integrated Systems*, 2012.
  - Reissman, T., MacCurdy, R., Garcia, E., "Electrical power generation from insect flight", *Proceedings of SPIE Active and Passive Smart Structures and Integrated Systems*, 2011

- o MacCurdy, R., Gabrielson, R., Spaulding, E., Purgue, A., Cortopassi, K., Fristrup, K., "Real-Time, Automatic animal tracking using direct sequence spread spectrum" *Proceedings of European Wireless Technology Conference*, EuWiT, Amsterdam, 2008
  - o MacCurdy, R., Reissman, T., and Garcia, E., "Energy Management of Multi-Component Power Harvesting Systems", *Proceedings of SPIE Conference on Smart Materials and Structures*, #6928, 2008
  - o Reissman, T., MacCurdy, R., Garcia, E., "Experimental Study of the Mechanics of Motion of Flapping Insect Flight Under Weight Loading", *Proceedings of ASME SMASIS Conference*, SMASIS, #661, 2008
  - o MacCurdy, R., Reissman, T., Winkler, D., and Garcia, E., "A methodology for applying energy harvesting to extend wildlife tag lifetime", *Proceedings of ASME IMECE Conference*, IMECE, #68082, 2008
  - o Miller, S., MacCurdy, R., Kidd, W., Hudson, J. "Stabilization and Control of a Micro-scale Helicopter" *AIAA Region I Student conference*, March 2008
- **Book chapter**
  - o MacCurdy, R., Gabrielson, R., Cortopassi, K., "Automated Wildlife Radio Tracking - Chapter 33", *Handbook of Position Location: Theory, Practice, and Advances*, Wiley, 2011.
- **Acknowledged as research equipment developer**
  - o Parks, S. E. 2003. "Acoustic communication in the North Atlantic right whale (Eubalaena glacialis)." PhD thesis, Woods Hole, MA: MIT-WHOI Joint Program in Oceanography, 2003.
  - o Parks, S. E., Hamilton, P. K., Kraus, S. D. & Tyack, P. L. 2005. "The gunshot sound produced by male North Atlantic right whales (Eubalaena glacialis) and its potential function in reproductive advertisement." *Marine Mammal Science*, 21, 458-475.
  - o Parks, S. E. & Tyack, P. L. 2005. "Sound production by North Atlantic right whales (Eubalaena glacialis) in surface active groups." *Journal of the Acoustical Society of America*, 117, 3297-3306.
  - o Thompson, M., Payne, K., Schwager, S. "Heard but not seen: an acoustic survey of the African forest elephant population at Kakum Conservation Area, Ghana", *African Journal of Ecology*, Volume 48, Issue 1, pp 224–231, March 2010

Patents
- "Printable Programmable Viscoelastic Materials", MacCurdy, R., Rus, D., Lipton, J. Status: pending; Provisional application filed with USPTO May 2016
- "Printable Hydraulics – A method for fabricating actuated 3D-printed assemblies via co-deposition of solids and liquids". MacCurdy, R., Rus, D. Status: pending; Application filed with USPTO and PCT November 2016
- "System and Methods for 3D Printing". MacCurdy, R. & Lipson, H. Status: pending; Provisional application filed with USPTO April 2014; PCT application April 2015
- "Digitally controlled tracking device and related methods". MacCurdy, R., Powell, S., Gabrielson, R., Winkler, D. Status: pending; Provisional application filed with USPTO Oct 2013; PCT application filed April 2015
- "System and methods for actuation using electro-osmosis". MacCurdy, R., Lipson, H. Status: **USPTO Patent Issued: 11-8-16, #9,487,387**; International PCT application filed Aug 2013
- "System and methods for electrowetting based pick and place assembly". Apoorva, Lipson, H., MacCurdy, R. Status: pending, International PCT application filed July 2013
- "System and methods for moving objects individually and in parallel". Perich, C., Macner, A., Lipson, H. Steen, P., MacCurdy, R. **USPTO Patent Issued: 3-31-15, #8,992,183**

Invited Talks
- "Automated radio tracking via time-of-arrival", Joseph W. Jones Ecological Research Center, Newton GA, December 2015
- "Multicellular Machines", Harvard Graduate School of Design Symposium on Informal Robotics, October 2015
- "Multicellular Machines", MIT Active Matter Summit, May 2015
- "Automated tracking of small animals for long periods: optimizing tag energy efficiency and receiver capabilities", US Geological Survey, Fort Collins CO, June 2014
- "Cellular Machines: A Bio-inspired approach to electromechanical design and fabrication", Washington State University Mechanical Engineering Department Seminar, April 2014
- "Design, development, and deployment of a time of arrival tracking system" Minerva Center: Advanced Tracking Systems for Movement Ecology Research in the Hula Valley, Kfar-Blum Israel, November 2012
- "Advanced Animal Tagging" International Society for Behavioral Ecology, Sept 2008
- "Recent Cornell work on Advanced Animal Tags" MIGRATE Conference, April 2008
- "The BRP RF Initiative: Radio Tracking and Telemetry" presentation to Lab of Ornithology Board of Directors, May 2006
- "Building tools to study animal behavior", Ithaca College Physics Department, May 2005

Awards, Honors, Achievements
- Winner "Virtual Creatures Competition": Genetic and Evolutionary Computation Conference (GECCO) 2014

- NSF Young Professional Workshop on Exploring New Frontiers in Cyber-Physical Systems (**travel award: $500**). March 2014.
- First Prize in AAAI Video Competition for video: "Unshackling Evolution: Evolving Soft Robots with Multiple Materials and a Powerful Generative Encoding", 2013
- Advised student team that won 1st place award at the AIAA Region I-NE Student Conference, 2009
- Runner-up for Best Paper prize at the European Wireless Technology Conference in Amsterdam, 2008.
- "Conservation Project of the Year" award from SERDP for project titled: Acoustical Monitoring of Threatened and Endangered Species in Inaccessible Areas, 2003.
- Built recording devices and led field expedition that captured the first recordings of isolated and endangered population of forest elephants in Ghana.
- Academic awards: Sigma Pi Sigma, Oracle Honor Society

Student Mentoring
- Jingyu Li, Undergraduate, Soft deformable body simulation, 2016-
- Landon Carter, Undergraduate, Automatic generation of CAD solid models, 2016-
- Youbin Kim, Undergraduate, Coauthored a conference paper on Printed Hydraulics, 2015-present
- Anthony McNicoll, Undergraduate, Coauthored a journal paper on Cellular Machines, drafting a second, 2012-2015
- Alex Volkov, Undergraduate, Electroosmotic pumps, 2013-2014
- James Wang, Master's of Engineering, Relaxation-based mechanical simulation on GPU, 2012-2013
- Nick Chartrain, Undergraduate, Characterization of wax actuators, 2012-2013
- Jean Rouge, Master's of Engineering, Relaxation-based mechanical simulation on distributed CPUs, 2011-2012
- Jeff Ames, Master's of Engineering, Relaxation-based mechanical simulation on distributed CPUs, 2011-2012
- Sima Mitra, Undergraduate, Coauthored a conference paper on 3D printing, 2010-2011
- Aldo Garcia, Undergraduate, Coauthored a conference paper on 3D printing, 2010-2011
- Jon Kaufman, Undergraduate, Coauthored a conference paper on 3D printing, 2010-2011

Teaching, Volunteer Activities
- Robotic ScareGull Project – Advised a team of 7th and 8th grade students at Dewitt Middle School in the design, construction and installation of an animatronic ScareGull intended to prevent gull predation on a tern nesting colony in Maine.
  - Taught simple physics concepts (force, torque, work, power)
  - Taught electromechanical design and construction principles (reinforced joints, electrical wire gauge, design for reliability)
  - Taught software programming on a microcontroller (timed loops, debugging strategy, real-time operation)
  - Four of the students traveled with me to Eastern Egg Rock Island in Maine where we installed the finished prototype. Video of the installation is available on YouTube: http://youtu.be/6gb3vjCCkT8
- Micro Vehicle INU – Supervised a team of MEng students that built an autonomous micro-helicopter.
  - Created the project, and managed it for two years
  - Built the hardware and software framework
  - Advised students as they implemented various subsystems.
  - Taught circuit design, embedded programming, micro-circuit assembly, and feedback control theory.
  - The team's paper and presentation won the 1st place award at the AIAA Region I-NE Student Conference in 2009.
- Course TA – Two semesters for MAE 3780 Mechatronics at Cornell
- Wind Energy – Consulted the Town of Caroline on volunteer basis to establish a 6MW wind generation capacity. I assisted the Town with turbine site selection based on wind resource availability, turbine parameters and electrical grid interconnection accessibility.
- Ithaca Science Center – Developed Electricity & Magnetism exhibit materials and volunteered during outreach activities
- Web page design – I taught web page creation workshops for middle and high school students. The courses were intended for students with minimal computer literacy and culminated with each student creating their own personal web page.
- Peer reviewer for GECCO and RAS conferences

Media Coverage: PBS, Scientific American, Discovery, New York Times, The Economist, Wall Street Journal, Popular Science, ABC News, IEEE Spectrum, National Science Foundation News, Cornell Engineering Magazine, nanoWerk, KurzweilAI, Engadget, Gismodo, Tech News Daily, Biotechnologia, EETimes, International Business Times, Live Science, CNET, DamnGeeky, World of Birds

Professional Societies: IEEE, ASME, AIAA, SPIE

Recreation: Expert Downhill Skier and Instructor, Snowboarding, Mountain Biking, Backpacking, Rock Climbing & Mountaineering, Windsurfing, Kite-boarding, Canoeing, Kayaking, Hockey

References:
Prof. Daniela Rus (Postdoctoral supervisor)
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