

Elias Daniel Guestrin, PhD

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EXPERTISE AND INTERESTS

My interests include, but are not limited to, the general areas of mathematical modeling and computer vision, and the more specific area of eye tracking.

Over the last 15 years, my main focus has been on the development of novel, cutting-edge video-based remote eye tracking technologies. These technologies use one or more video cameras to determine where a person is looking in space, without making physical contact with the person. My work on eye tracking involved mathematical modeling, numerical simulations with MATLAB, selection of imaging sensors, optics and illumination, camera interfacing and calibration, machining, electronics design and implementation, algorithm development and implementation (image processing, gaze estimation, calibration, etc.), numerical methods for equation solving and optimization, C/C++ multi-threaded programming, experimental validation, and writing of scientific articles.

Before that, I worked for a few years in the area of control systems, primarily on model-based controller design. My work on control systems also involved mathematical modeling and numerical simulations with MATLAB, as well as signal conditioning, acquisition and processing, system identification, controller design, real-time programming, electronics design and implementation, experimental validation, and writing of scientific articles.

In summary, the core of my R&D work for about 19 years has covered the process from the development of mathematical models of physical phenomena to the implementation of functional systems based on such models.

WORK AND RESEARCH EXPERIENCE

Senior Researcher (Independent Contractor) Sep 2015-Dec 2015

University of Toronto, Toronto, ON, Canada – Institute of Biomaterials & Biomedical Engineering, Eye Movements & Vision Research Laboratory

Provided research support for the development of advanced gaze estimation systems.

Research Scientist Mar 2015-Aug 2015

EyeCheck Solutions Inc., Kitchener, ON, Canada

Worked on projects related to eye screening and optical measurements for prescription eyeglasses.

Director of Advanced R&D Jun 2014-Dec 2014

Eyediya Technologies Inc., Toronto, ON, Canada

Worked on low-cost and low-power yet robust and accurate eye tracking solutions.

Senior Postdoctoral Fellow Nov 2013-Apr 2014

University of Toronto, Toronto, ON, Canada – Department of Electrical & Computer Engineering, and Institute of Biomaterials & Biomedical Engineering, Eye Movements & Vision Research Laboratory

Contributed to the foundations of a low-cost / low-power eye tracking platform for mobile devices.

Independent Researcher Aug 2013-Oct 2013

Developed a model for visible-spectrum eye tracking under natural head movements.

Independent Contractor (short term, part-time)

May 2013-Aug 2013

University of Toronto, Toronto, ON, Canada – Department of Electrical & Computer Engineering, and Institute of Biomaterials & Biomedical Engineering, Eye Movements & Vision Research Laboratory

Assembled and tested five single-camera eye trackers to be used in various research projects.

Postdoctoral Fellow

Aug 2009-Aug 2011

Toronto Rehabilitation Institute, Toronto, ON, Canada – Research Department, Rehabilitation Engineering Laboratory

Developed gaze-based assistive technologies for severely motor-impaired individuals.

Graduate Student / Postdoctoral Fellow

Sep 2000- Sep 2011

University of Toronto, Toronto, ON, Canada – Department of Electrical & Computer Engineering, and Institute of Biomaterials & Biomedical Engineering, Eye Movements & Vision Research Laboratory

Developed novel, cutting-edge video-based remote eye tracking technologies. These technologies use one or more video cameras to determine where a person is looking in space, without making physical contact with the person. The major milestones of my work on eye tracking include the development of:

- A general 3-D mathematical model for video-based point-of-gaze estimation that contributed significantly to shift the remote eye tracking field from 2-D black-box mapping techniques sensitive to head movements to 3-D model-based gaze estimation methods that are insensitive to head movements.
- The first remote eye tracker reported in the literature that could estimate the point-of-gaze accurately in the presence of head movements using only eye images captured by a single camera without moving parts (minimal system complexity). It had accuracy better than 1° of visual angle, comparable to the best commercial remote eye trackers.
- The first remote eye tracker successfully demonstrated with infants. It could accurately measure relative eye movements without personal calibration and estimate the point-of-gaze after completing a single-point personal calibration routine (minimal subject cooperation); in contrast, commercial eye trackers use multiple calibration points (typically 5-9 points). The point-of-gaze estimation accuracy was 0.4-0.6° of visual angle in the presence of head movements. This technology can enable applications with infants and mentally challenged individuals, which are very difficult or impossible with commercial eye trackers.

Exchange Research Student

Apr 1999-Jun 1999

Universitat Politècnica de Catalunya, Barcelona, Spain – Department of Electronic Engineering

Developed virtual instrumentation with LabVIEW to monitor 3-phase power systems.

Undergraduate Research Student

Mar 1997-Aug 2000

Universidad Tecnológica Nacional - Facultad Regional Paraná, Argentina

Developed a DC servomotor, including modeling, system identification, controller design (proposed a novel formula for tuning PID controllers), and hardware/software implementation.

EDUCATION

University of Toronto, Toronto, ON, Canada
Department of Electrical & Computer Engineering, and Institute of Biomaterials & Biomedical Engineering

PhD degree

May 2003-Oct 2009

Thesis: "[Remote, non-contact gaze estimation with minimal subject cooperation](#)"
Supervisor: Prof. Moshe Eizenman

MASc degreeThesis: "[A novel head-free point-of-gaze estimation system](#)"

Supervisor: Prof. Moshe Eizenman

Sep 2000-Apr 2003

Universidad Tecnológica Nacional - Facultad Regional Paraná, Argentina**Electronics Engineering degree** (graduated with honors)

Thesis: "Position control with a DC motor"

Supervisor: Prof. Eduardo J. Adam

Apr 1992-Apr 1999

SCHOLARSHIPS, FELLOWSHIPS, AWARDS AND PRIZES**Postdoctoral Fellowships**

Postdoctoral fellowship award, Ontario Neurotrauma Foundation (CAD\$ 45,000 / year)

Aug 2009-Aug 2011

Graduate Scholarships and Fellowships

Ontario Graduate Scholarship (CAD\$ 15,000)

Sep 2007-Aug 2008

Ontario Graduate Scholarship (CAD\$ 15,000)

Sep 2006-Aug 2007

Ontario Graduate Scholarship (CAD\$ 15,000)

Sep 2005-Aug 2006

Edward S. Rogers Sr. Graduate Scholarship, Department of Electrical & Computer Engineering, University of Toronto (CAD\$ 12,000)

Sep 2004-Aug 2005

Edward S. Rogers Sr. Graduate Scholarship, Department of Electrical & Computer Engineering, University of Toronto (CAD\$ 12,000)

Sep 2003-Aug 2004

University of Toronto Fellowship (CAD\$ 4,000)

May 2003-Aug 2003

University of Toronto Fellowship (CAD\$ 7,333)

Sep 2000-Apr 2001

Three-year fellowship from the Post-Graduation Program for Faculty Staff, Universidad Tecnológica Nacional, Argentina (equivalent to approx. CAD\$ 21,600/year at the start of the fellowship). *Access to this fellowship was interrupted in Nov 2001 due to the 2001 Argentine economic/financial crisis.*

Sep 2000-Nov 2001

Undergraduate Scholarships

Exchange scholarship for research in the Department of Electronics Engineering of the Polytechnic University of Catalonia (Barcelona, Spain), Program of Inter-University Cooperation of the Spanish Agency for International Cooperation (ranked first among all program applicants from Universidad Tecnológica Nacional, Argentina).

Apr-Jun 1999

Research scholarships to work on a research project about robust control, model-based control and system identification at Universidad Tecnológica Nacional – Facultad Regional Paraná, Argentina (led to undergraduate thesis, [J1], [C1]-[C4]).

Mar 1997-Feb 1999

Awards and Prizes

Best paper award, 2009 IEEE Toronto International Conference - Science and Technology for Humanity (IEEE TIC-STH 2009), Toronto, ON, Canada [C12].

2009

Student paper award from IEEE Argentina, 8th Workshop on Information Processing and Control, Mar del Plata, Argentina (VIII RPIC – Reunión de Trabajo en Procesamiento de la Información y Control) [C2]

1999

Argentine Mathematics Olympiad, Latin-American Centre of Mathematics and Computer Science.

Finalist of the Second Level	1989, 1990
First Prize of the First Level	1988

PUBLICATIONS

Refereed Journal Papers

- [J3] J. J. Kang, M. Eizenman, **E. D. Guestrin**, and E. Eizenman, "[Investigation of the cross-ratios method for point-of-gaze estimation](#)," *IEEE Transactions on Biomedical Engineering*, vol. 55, no. 9, pp. 2293–2302, Sep 2008. **{Cited by 32}**
- [J2] **E. D. Guestrin** and M. Eizenman, "[General theory of remote gaze estimation using the pupil center and corneal reflections](#)," *IEEE Transactions on Biomedical Engineering*, vol. 53, no. 6, pp. 1124–1133, Jun 2006. **{Cited by 295}** (An [erratum](#) to this article was published in the *IEEE Transactions on Biomedical Engineering*, vol. 53, no. 8, p. 1728, Aug 2006.)
- [J1] E. J. Adam and **E. D. Guestrin**, "[Identification and robust control of an experimental servo motor](#)," *ISA Transactions*, vol. 41, no. 2, pp. 225-234, Apr 2002. **{Cited by 19}**

Refereed Conference Papers

- [C16] X. Zhao, **E. D. Guestrin**, D. Sayenko, T. Simpson, M. Gauthier, and M. R. Popovic, "[Typing with eye-gaze and tooth-clicks](#)," in *Proc. of the Seventh Symposium on Eye Tracking Research and Applications (ETRA 2012)*, Santa Barbara, CA, USA, Mar 2012, pp. 341-344. **{Cited by 11}**
- [C15] **E. D. Guestrin** and M. Eizenman, "[Non-contact calibration-free eye-tracker](#)," presented at the 34th Canadian Medical and Biological Engineering Conference (CMBEC34), Toronto, ON, Canada, Jun 2011 (in *Proc. of FICCDAT 2011*, Toronto, ON, Canada, Jun 2011).
- [C14] **E. D. Guestrin** and M. Eizenman, "[Remote point-of-gaze estimation with single-point personal calibration based on the pupil boundary and corneal reflections](#)," in *Proc. of the IEEE Canadian Conference on Electrical and Computer Engineering 2011 (CCECE 2011)*, Niagara Falls, ON, Canada, May 2011, pp. 971-976. **{Cited by 6}**
- [C13] **E. D. Guestrin** and M. Eizenman, "[Listing's and Donders' laws and the estimation of the point-of-gaze](#)," in *Proc. of the Sixth Symposium on Eye Tracking Research and Applications (ETRA 2010)*, Austin, TX, USA, Mar 2010, pp. 199-202. **{Cited by 4}**
- [C12] M. Eizenman, D. Model, and **E. D. Guestrin**, "[Covert monitoring of the point-of-gaze](#)," in *Proc. of the 2009 IEEE Toronto International Conference - Science and Technology for Humanity (IEEE TIC-STH 2009)*, Toronto, ON, Canada, Sep 2009, pp. 551-556. **{Cited by 4}** (Best paper award.)
- [C11] D. Model, **E. D. Guestrin**, and M. Eizenman, "[An automatic calibration procedure for remote eye-gaze tracking systems](#)," in *Proc. of the 31st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2009)*, Minneapolis, MN, USA, Sep 2009, pp. 4751-4754. **{Cited by 8}**
- [C10] **E. D. Guestrin** and M. Eizenman, "[Remote point-of-gaze estimation requiring a single-point calibration for applications with infants](#)," in *Proc. of the Fifth Symposium on Eye Tracking Research and Applications (ETRA 2008)*, Savannah, GA, USA, Mar 2008, pp. 267-274. **{Cited by 54}** (This symposium accepted 18 out of 44 submitted full papers, i.e., 41 % acceptance rate.)
- [C9] **E. D. Guestrin**, M. Eizenman, J. J. Kang, and E. Eizenman, "[Analysis of subject-dependent point-of-gaze estimation bias in the cross-ratios method](#)," in *Proc. of the Fifth Symposium on Eye Tracking Research and Applications (ETRA 2008)*, Savannah, GA, USA, Mar 2008, pp. 237-244. **{Cited by 12}** (This symposium accepted 18 out of 44 submitted full papers, i.e., 41 % acceptance rate.)
- [C8] **E. D. Guestrin** and M. Eizenman, "[Remote point-of-gaze estimation with free head movements requiring a single-point calibration](#)," in *Proc. of the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2007)*, Lyon, France, Aug 2007, pp. 4556-4560. **{Cited by 27}**

* As reported by Google Scholar ([link to Google Scholar profile](#))

- [C7] **E. D. Guestrin** and M. Eizenman, "[Remote point-of-gaze estimation for studies of selective attention and mood disorders](#)," presented at the *30th Canadian Medical and Biological Engineering Conference (CMBEC30), Toronto, ON, Canada, Jun 2007* (in *Proc. of FICCDAT 2007, Toronto, ON, Canada, Jun 2007*).
- [C6] J. J. Kang, **E. D. Guestrin**, W. J. MacLean, and M. Eizenman, "[Simplifying the cross-ratios method of point-of-gaze estimation](#)," presented at the *30th Canadian Medical and Biological Engineering Conference (CMBEC30), Toronto, ON, Canada, Jun 2007* (in *Proc. of FICCDAT 2007, Toronto, ON, Canada, Jun 2007*). **{Cited by 10}**
- [C5] **E. D. Guestrin** and M. Eizenman, "[Remote point-of-gaze estimation with free head movements](#)," in *Proc. of the 3rd European Medical and Biological Engineering Conference (EMBEC'05), Prague, Czech Republic, Nov 2005*, pp. 3746-3751. **{Cited by 1}**
- [C4] E. J. Adam, C. J. Valsecchi, and **E. D. Guestrin**, "Autoajuste en-línea de controladores PID para procesos integradores con retardo," in *Proc. of the X RPIC – Reunión de Trabajo en Procesamiento de la Información y Control – San Nicolás de los Arroyos (Buenos Aires), Argentina, Oct 2003*, vol. 2, pp. 594-599. (In Spanish.)
- [C3] E. J. Adam, C. J. Valsecchi, and **E. D. Guestrin**, "Ajuste de controladores PID para procesos integradores con retardo", in *Proc. of AADECA'02, Buenos Aires, Argentina, Sep 2002*. (In Spanish.)
- [C2] **E. D. Guestrin**, O. Sanz de Acedo Pollan, and E. J. Adam, "Nuevo método de ajuste de controladores PID para plantas de segundo orden con un integrador y tiempo muerto", in *Proc. of the VIII RPIC – Reunión de Trabajo en Procesamiento de la Información y Control – Mar del Plata (Buenos Aires), Argentina, Sep 1999*, vol. 3, pp. 1-9 – 8-9. (In Spanish; **Student paper award from IEEE Argentina.**)
- [C1] E. J. Adam and **E. D. Guestrin**, "Identificación y control robusto de un servo de corriente continua", in *Proc. of the VIII RPIC – Reunión de Trabajo en Procesamiento de la Información y Control – Mar del Plata (Buenos Aires), Argentina, Sep 1999*, vol. 1, pp. 1-2 – 7-2. (In Spanish.)

Conference Abstracts

- [A1] M. Eizenman, **E. D. Guestrin**, and C. A. Westall, "[Binocular remote gaze estimation system for infants](#)," in *Proc. of the 2008 Annual Meeting of the Association for Research in Vision and Ophthalmology (ARVO), Fort Lauderdale, FL, USA, Apr 27-May 1, 2008*.

Theses

- [T3] **E. D. Guestrin**, "[Remote, non-contact gaze estimation with minimal subject cooperation](#)," PhD Thesis, Department of Electrical & Computer Engineering, and Institute of Biomaterials & Biomedical Engineering, University of Toronto, Toronto, Ontario, Canada, 2010. **{Cited by 4}**
- [T2] **E. D. Guestrin**, "[A novel head-free point-of-gaze estimation system](#)," MSc Thesis, Department of Electrical & Computer Engineering, and Institute of Biomaterials & Biomedical Engineering, University of Toronto, Toronto, Ontario, Canada, 2003. **{Cited by 4}**
- [T1] **E. D. Guestrin**, "Control de posición con un motor de corriente continua," undergraduate engineering thesis, Universidad Tecnológica Nacional - Facultad Regional Paraná, Argentina, 1999. (In Spanish; title translated into English: "Position control with a DC motor".)

TEACHING

University of Toronto, Department of Electrical & Computer Engineering

Teaching assistant (labs), <i>Fundamentals of Electricity and Electric Circuits</i>	Spring 2005
Teaching assistant (tutorials), <i>Linear Systems and Communications</i>	Fall 2002
Teaching assistant (tutorials), <i>Electrical Fundamentals</i>	Spring 2002
Teaching assistant (tutorials), <i>Linear Systems and Communications</i>	Fall 2001

Universidad Tecnológica Nacional – Facultad Regional Paraná, Argentina

Teaching assistant (tutorials), <i>Signals and Systems Analysis</i>	Apr 2000-Aug 2000
Teaching assistant (tutorials and labs), <i>Control Systems</i>	Aug 1999-Aug 2000
Course instructor/lecturer, <i>Control Systems</i>	Aug 1998-Aug 1999
Teaching assistant (tutorials and labs), <i>Control Systems</i>	Apr 1998-Aug 1998

SUPERVISION

Supervision of an undergraduate thesis student (Xiaoyu (Amy) Zhao). Thesis: “A novel eye-gaze tracking and brain-computer interface system for assisting severely motor impaired individuals with cursor control”.	Sep 2009-Apr 2010
Supervision of 8 (eight) summer research students at Prof. Eizenman's Eye Movements and Vision Research Laboratory, University of Toronto.	Summers 2003-2008
Supervision of an exchange research student from Spain (Oscar Sanz de Acedo Pollan [C2]) at Universidad Tecnológica Nacional – Facultad Regional Paraná, Argentina, as part of the Program of Inter-University Cooperation of the Spanish Agency for International Cooperation.	Aug-Oct 1998

PROFESSIONAL SERVICES

Reviewer for IEEE Transactions on Human-Machine Systems	Feb 2016
Reviewer for IEEE Transactions on Multimedia	Dec 2013
Reviewer, Seventh Symposium on Eye Tracking Research and Applications (ETRA 2012), Santa Barbara, CA, USA	Mar 2012
Reviewer, Sixth Symposium on Eye Tracking Research and Applications (ETRA 2010), Austin, TX, USA	Mar 2010
Session chair, Fifth Symposium on Eye Tracking Research and Applications (ETRA 2008), Savannah, GA, USA	Mar 2008