

Self-Evaluation for Period July 2010-June 2013
Ken Goldberg, Professor, UC Berkeley

Summary

This report describes technical research and creative work, teaching, and service activities over the past three years. Links to papers, artworks, cv, and online interfaces are available at: <http://goldberg.berkeley.edu>

My students and I pursue technical research on four topics: (1) "Algorithmic Automation", algorithmic and control-theoretic approaches to problems in motion planning and manufacturing; (2) "Cloud Robotics", where the Internet provides resources on demand for processing and memory via networks; (3) "Medical Robotics", radiation therapy planning and delivery for prostate cancer and supervised autonomy of selected surgical subtasks such as retraction and suturing; and (4) "Social Information Filtering," algorithms and interfaces that collect, visualize, and analyze numerical, textual, and video data based on techniques from robotics and automation. A 0% faculty appointment in the UCSF Radiation Oncology Department is based on my ongoing medical robotics research with UCSF faculty.

During the review period I created and exhibited two solo art installations, one at the Contemporary Jewish Museum in San Francisco and one at the Nevada Museum of Art in Reno. I co-wrote 3 short documentary films and a feature documentary film on the global and personal implications of social media technology and hosted 25 visiting speakers in the Art, Technology, and Culture (ATC) public lecture series. A 0% faculty appointment in the UC Berkeley Art Practice Department is based on this creative work.

I am a dedicated mentor for junior faculty, postdocs, grads, and undergraduates. My students and postdocs hold faculty positions at Stanford, UW, UNC, Texas A&M, WPI, and Utah. I'm active in teaching and outreach, reorganizing a Freshman Seminar on Industrial Engineering to include field trips and student projects, and co-founding the African Robotics Network, which is developing an "Ultra-Affordable" robot an order of magnitude less expensive than existing products for K-12 education. My primary service contributions have been as Editor-in-Chief of the *IEEE Transactions on Automation Science and Engineering (T-ASE)*, Director of the UC Berkeley CITRIS *Data and Democracy Initiative (DDI)* and as Executive Committee member of the *Berkeley Center for New Media*, a highly cross-disciplinary campus center that has 130 affiliated faculty members from 35 campus departments.

During the review period I've been fortunate to serve as craigslist Distinguished Professor of New Media and have received four awards: the 2011 IEEE Robotics and Automation Distinguished Service Award, a 2012 NSF/ Mozilla Ignite Challenge Award, the 2012 IEEE CASE Best Applications Paper Award, and the 2013 Disruptive Innovation Award from the Tribeca Film Festival. In addition to technical lectures, I gave presentations for public audiences on robotics, film, and art, and presented over 80 invited talks and plenary lectures.

In the years ahead, I look forward to mentoring junior faculty colleagues and students, pursuing technical research, creating art and films, and extending collaboration and dialogues across academic and geographic cultures.

Introduction

My primary challenge is containing my curiosity. I've been curious about art, rockets, butterflies, and robots since I was a kid. My wife Tiffany Shlain, a documentary filmmaker, and our daughters, Odessa (10) and Blooma (4), are also extremely curious so they are not helping matters. Working as a professor at UC Berkeley has only exacerbated my condition.

I've always been interested in environments where abstraction meets materiality. Maybe it was my background growing up as one of the only Jewish kids in the steel town of Bethlehem Pennsylvania. My mother, an artist and reading specialist, taught me about the Jewish concept of G-d, an abstraction that cannot be visualized or verbalized, and my father, a metallurgist and engineer, helped me build a go-kart and taught me about the materiality of machines. In college and grad school I focused on robotics and automation, where engineers wrestle with the Mind-Body Problem.

I'm passionate about art and technology. Although C.P. Snow characterized the many differences between the "Two Cultures," I've discovered they have much in common. Both the Humanities and the Sciences require years of training and demand rigor. They both thrive on creativity and counter-intuitive ideas. I'm extremely fortunate to work at UC Berkeley, a mecca for scholars from both cultures, where I help build bridges between them. I lead a research lab focusing on robotics and automation and create artwork that addresses the impact of technology on nature and culture.

Sabbatical in Spring 2012

In Spring 2012 I was on Sabbatical. I continued research and advising and served as Chair of the BCNM Faculty Search Committee (where Prof. Eric Paulos was hired, jointly between BCNM and EECS). I was invited to speak in Ghana (I was born in Nigeria), where I discovered a great interest in robots for education. After discussions with Prof. Ayorkor Korseh of Ashesi University in Accra, we co-founded the African Robotics Network (AFRON), a community of institutions, organizations and individuals engaged in robotics in Africa. AFRON seeks to promote communication and collaborations that will enhance robotics-related education, research, and industry on the continent. AFRON now has 380 members from 51 countries including regular members from Ghana, Nigeria, Kenya, Algeria, South Africa, Egypt, and Ethiopia, as well as affiliated members from the US, Switzerland, UK, France, Germany, Portugal, and Argentina. With support from the IEEE Robotics and Automation Society, AFRON is leading the "Ultra Affordable Educational Robot" Project: to collaboratively design robots that can inspire young children worldwide about Science, Technology, Engineering, and Math. The first phase, in Summer 2012, was the "\$10 Robot" Design Challenge. In September 2012, ten highly innovative and inexpensive designs (and six Honorable Mentions) were announced at Maker Faire New York and reported in *WiRed*, *IEEE Spectrum*, *Popular Mechanics*, and *Slashdot* and featured in a design exhibit at UC Berkeley. Phase I of the project received a "Tribeca Disruptive Innovation Award" in New York in May 2013.

Technical Research Overview

I Direct the Berkeley Automation Sciences Lab in Etcheverry Hall, a research group including one postdoc, 5 graduate students, and 10-15 undergraduates. We pursue technical research on the

topics listed in the Summary above. During the review period our work was primarily supported by two NSF grants: (1) *Multilateral Manipulation by Human-Robot Collaborative Systems* (NSF Award IIS-1227406, Subcontract to UC Berkeley: IIS-1227536) a four-year project under the National Robotics Initiative (\$3,535,000 shared by 6 co-PIs starting Oct 2012) and (2) *Robust Intelligent Manipulation and Apprenticeship Learning for Robotic Surgical Assistants* (NSF Award 0905344) a four-year project (\$1,359,881 shared by 5 co-PIs starting Aug 2009).

Technical Research: Algorithmic Automation

I coined the term “Algorithmic Automation” in 2008 to describe a systematic approach to automation that formalizes objectives, constraints, admissible inputs, outputs and operators so that planning algorithms can accept part specifications as input and return a sequence of operators that meet desired objectives or a report that no such sequence exists. This allows the functionality of industrial automation to be designed independent of the underlying implementation to provide the foundation for formal specification and analysis, algorithmic design, consistency checking and optimization. Algorithmic Automation facilitates integrity, reliability, interoperability, and maintainability of automation. I presented a number of invited talks on this subject; in May 2011, I organized and co-chaired an international workshop on Uncertainty in Automation at the IEEE International Conference on Robotics and Automation in Shanghai and in June 2013, I was invited to present a keynote at the ACM Symposium on Computational Geometry: “Putting the Turing into Manufacturing: Recent Results in Algorithmic Automation”. The extended abstract was published as [IIIA12].

Pieter Abbeel and I collaborated on a geometric approach to robotic clothes folding [IA53, ID115]. We define a quasi-static cloth model and parameterize fold sequences that use gravity to manipulate cloth represented as polygons. We develop a model-based optimization approach for visually inferring the pose of a clothing article from a single image, such that the resulting polygon is suitable for these folding primitives. We present an algorithm which, given a 2D cloth polygon and a desired sequence of folds, outputs a motion plan for executing the corresponding *g-folds* using a minimal number of robot grippers, and evaluate the algorithm with experiments on the PR2 robot in our lab.

Pieter and I also worked with our students to develop an efficient approach to part grasping and fixturing with extra contacts to minimize the maximum applied force. We present a novel formula for the quality functions and a discretization technique that evaluates them with bounded error, and showed that the result is a submodular coverage problem [ID118]. In other work, we developed new approaches to robot motion planning, using “environment-guided” random trees [ID119], and Linear-Quadratic Gaussian (LQG) state-space models to generate plans that maximize the probability of reaching a desired goal for robots with uncertainty in state and motion [ID116, IA49]. The latter paper was cited over 50 times in the two years since it was published. Also related to planning, we considered the classic A* algorithm from artificial intelligence, and developed an anytime version, Anytime Non-parametric A* (ANA*) eliminates the subjective parameter and is relevant for robot applications. We evaluated ANA* with a number of experiments and found that it significantly improves over previous methods. We presented a paper on it at the AAAI Annual Conference [ID117].

Technical Research: Cloud Robotics

My interest in networked robots began in 1994, when I led the research team that developed the first robot remotely operated over the Internet. Networked Telerobotics is now an active research area. In 2010, James Kuffner at Google introduced the term "Cloud Robotics" to describe a related approach to robotics that takes advantage of the Internet as a resource for massively parallel computation and real time sharing of vast data resources. The Google autonomous driving project exemplifies this approach: the system indexes maps and images that are collected and updated by satellite and trucks and crowdsourcing from the network to facilitate accurate localization. Another example is Kiva Systems' approach to warehouse automation and logistics using large numbers of mobile platforms to move pallets using a local network to coordinate platforms and update tracking data. Related concepts include "Internet of Things", and General Electric's concept of the "Industrial Internet".

As described in our survey of related work in Cloud Robotics and Automation [III06], I believe that the Cloud has potential to improve robot performance in five ways: 1) Big Data: indexing a global library of images, maps, and object data, 2) Cloud Computing: parallel grid computing on demand for statistical analysis, learning, and motion planning, 3) Open-Source / Open-Access: humans sharing robot code, data, algorithms, and hardware designs, 4) Collective Robot Learning: robots sharing trajectories, control policies, and outcomes that can be analyzed with statistical machine learning methods and 5) Crowdsourcing and call centers: offline and on-demand human guidance for evaluation, learning, and error recovery.

I applied Cloud Robotics to motion planning [ID120] and grasping. We developed a statistical approach to address tolerance zones of uncertainty in shape of parts, which is extremely difficult to model analytically. In [ID121], we developed a sampling model to estimate lower bounds on achieving force closure with zero-slip push grasps that take advantage of memory and parallel computing in the cloud. We extended this to compute estimates of part tolerance bounds in cases where part slip is considered [ID123]. We also began a collaboration with James Kuffner on using Google's online image-analysis engine (Google Goggles) to recognize and plan grasps for parts [ID125]. This is an active and exciting research topic for the lab and is being funded by grants from Google and Cisco.

Technical Research: Medical Robotics

During the review period, my students and I published three journal papers and two conference papers in this area. Working closely with researchers and physicians at UCSF and Johns Hopkins, we considered several challenges associated with brachytherapy, a treatment for prostate cancer where radioactive seeds are inserted with needles to destroy tumors while sparing healthy tissue. A fundamental challenge is to compute spatial dose arrangements that maximize exposure to diseased tissue while minimizing damage to healthy tissue. We published two papers in the journal *Medical Physics* that apply relaxation and Mixed Integer Programming [IA50, IA52], to develop needle models and algorithms for accurately reaching targets inside the human body [IA51, ID116]. Our paper that explores how a robot can help humans guide needles accurately, [ID124] *Initial Experiments toward Automated Robotic Implantation of Skew-Line Needle Arrangements for HDR Brachytherapy*, received the Best Applications Paper Award at the IEEE International Conference on Automation Science and Engineering (CASE), Seoul, Korea in August, 2012.

Pieter Abbeel and I installed a Raven surgical robot in our lab and are now installing a da Vinci surgical robot from Intuitive Surgical for research in Belief Space Planning and Control. We are actively involved in collaborations with Doug Boyd, a tele-surgery pioneer at UC Davis Medical Center. Results from my NIH R01 research project on Steerable Needles are summarized in [IA51] and produced a US Patent 7,822,458 [IIA07] granted in October 2010: Distal Bevel-Tip Needle Control Device and Algorithm. Inventors: R. Webster, A. Okamura, N. Cowan, G. Chirikjian, K. Goldberg, and R. Alterovitz. Joint between Johns Hopkins and UC Berkeley.

Technical Research: Social Information Filtering

Social Media has tremendous potential for innovation and problem solving, but existing tools such as blogs, wikis, and comment lists are often overwhelmed by extreme viewpoints and the sheer volume of responses. I'm interested in "crowdsourcing" and new approaches to visualizing social networks that can address these issues.

When Mike Franklin, David Patterson and other EECS faculty launched the Algorithms, Machines, and People (AMP) Lab in 2012 to develop new techniques and software for Big Data, they included me as a faculty participant. The AMP lab is an extremely stimulating environment with semi-annual retreats with researchers from industry. It supports several of my students for work on interfaces and parallel algorithms for text analysis and clustering. In [ID127] we use a Spectral Clustering model to formulate a distributed implementation of Laplacian Eigenmaps using AMP Lab's SPARK that we call Distributed Spectral Dimensionality Reduction (DSDR). We evaluate DSDR to visualize conceptual clusters of terms in textual data from short documents written by online contributors to a State Department website. We compare DSDR with PCA, multi-dimensional scaling, ISOMAP, and Locally Linear Embedding based on the Dunn Separation Index and computation times, finding that DSDR is faster and better preserves high-dimensional cluster structure. We are now doing studies with bigger data sets and working on a stochastic model of the tradeoffs between processing time and confidence in estimating average values for "dirty" data where data is corrupted by noise and cleaned by crowdsourcing.

During the review period my students and I revised and extended "Opinion Space," an interface we initially designed in 2009 to help communities exchange ideas and identify those that are most insightful. Opinion Space is based on a game model and incorporates techniques from deliberative polling, collaborative filtering, and multidimensional visualization. It uses dimensionality reduction to generate an intuitive graphical map that displays patterns, trends, and insights as they emerge. Opinion Space has been used by the U.S. State Department since March 2010 to collect ideas and suggestions on foreign policy questions on their website.

My students and I developed prototypes in collaboration with General Motors, Unilever, and Humana. In 2011 one of the students working on the project, David Wong, completed his Masters degree and we co-founded Hybrid Wisdom Labs as a small startup with office space in the Skydeck Incubator on Shattuck Ave. We worked with professional designers to revise the interface and UC Berkeley filed for a patent on some of the algorithms we developed. One year later, the internet company Survey Monkey acquired key assets of Hybrid Wisdom Labs and David is now a Senior Engineer there. I'm working on non-profit applications of Opinion Space with organizations such as Occupy Wall Street and IEEE. In [ID126], my students and I report on a new study using Opinion Space to collect and evaluate suggestions for novel applications of social media to enhance K-12 learning. Textual suggestions were broadly classified into three

categories: collaboration, diversity, and evaluation. We report demographic correlations and present the ideas that the ranking algorithm found most effective and/or novel.

I'm also working on algorithms and interfaces that use crowdsourcing to analyze video data. In [IE18], we report results from a two-year project with ornithologists and citizen scientists using the NSF funded: "Collaborative Observatory for Natural Environment" that we set up at the Welder Wildlife Refuge in Texas. This included a publicly accessible collaborative robot camera with an interactive online interface that allowed motivated birdwatchers to observe, record, and collectively classify (using a voting model) images of birds (and other animals) that visited a feeding station we set up at the remote site. The system was online continuously for two years during which a dedicated cadre of online participants collected and classified over 29,000 images.

In 2011, motivated by the clashes between student protesters and campus police at UC Berkeley and the UC Davis pepper spraying of students, I began work on the "Rashomon" project. Protests and news events are increasingly documented with digital video and photos posted online on sites like YouTube, Vimeo, and Facebook. It is often difficult to obtain a comprehensive view of contested events from these fragmented sources so viewers often draw contradictory conclusions by seeing only parts of the available material. We are developing an online toolkit to facilitate rapidly assembly and public review of "Multi-Perspective Timelines" where videos are time-aligned and displayed simultaneously. Initial experiments with iPhone and Android video show that temporal metadata embedded in the digital files can be used to do a very close alignment. Once they are closely aligned, audio signals from video can be processed to further refine the alignment. This toolkit has potential to benefit the public, citizen journalists, and ideally courts or commissions charged with investigating disputed incidents. Our goal is to allow the public to gain a much better understanding of contested events from user-generated photos and video than is currently possible. This project is funded in part by the Knight Foundation and organized by the UC Berkeley CITRIS Data and Democracy Initiative in collaboration with Witness.org, the Guardian Project, the Berkeley Human Rights Center, and the UC Santa Cruz Digital Arts & New Media Program. In Oct 2012 the Rashomon Project interface was selected as one of Eight Winning Ideas by the National Science Foundation / Mozilla Ignite Challenge and has been reported in *New Scientist*, *NPR*, and *the UK's Journalism.co.uk*.

Related research in robotics and social media for remote shared telepresence resulted in a US Patent 7,937,285 [IIA08] granted in May 2011: Remote Collaborative Control and Direction. Inventors: K. Goldberg, J. Donath, E. Paulos, D. Pescovitz, K. Dobson, M. Lee, A. Levandowski, D. Song, D. Spiegel, D. Tang. Joint between MIT and UC Berkeley.

Creative Work: Art and Screenwriting

As an artist, I consider the impact of technology on nature, perception, and culture. My artwork, is represented by the Catharine Clark Gallery in San Francisco. During the review period I created two museum installations. The first was a responsive audio installation at the Contemporary Jewish Museum in San Francisco. "*Are We There Yet?*" [IIE10] was supported with a major competitive award by the Creative Work Fund and was a collaboration with San Francisco designer Gil Gershoni. Questioning is at the core of Jewish cultural and spiritual identity. Jewish mothers teach that "it never hurts to ask," and a Yiddish proverb states "One who doesn't ask, doesn't know." Gershoni and I worked with UC Berkeley students to develop a robot vision technology that tracked each visitor in a reactive sound environment (described in detail in

[ID122]). The system presented visitors with questions from a variety of sources including the Talmud, literature, and popular culture. Launched in advance of the exhibition, a companion website let visitors learn about the show, suggest questions for the installation, and visually explore the suggestions of others. The installation, on exhibit from April-July 2011, received positive reviews on *NPR*, *SF Chronicle*, *Huffington Post*, and *CNN*.

The second installation, "*Bloom*," [IIE11] was commissioned by the Nevada Museum of Art and is dedicated to Color Field painter Kenneth Noland (1924-2010). *Bloom* is an internet-based Earthwork that transforms live seismic data into an exuberant display of color. A seismometer at the Hayward Fault continuously measures the Earth's motion and transmits this data over the Internet to the installation, where the data is processed in real time using custom software to produce an abstract field of unpredictable circular blooms. In contrast to the distractions of contemporary life, *Bloom* strives to be a meditation on growth and geological endurance. This project, a collaboration with the UC Berkeley Seismology Department, Google visual designers Fernanda Viégas and Martin Wattenberg, and my PhD student Sanjay Krishnan, was on exhibit from Feb-June 2013 and acquired by the Museum for their permanent collection. It is available for viewing online via the Seismology Department website.

One of my greatest pleasures is collaborating with my wife, award-winning film director Tiffany Shlain. We share interests in technology and culture; during the review period we co-wrote the screenplays for one feature documentary and three short documentary films. The feature, *Connected: An Autobiography about Love, Death and Technology*, was selected to premier at the 2011 Sundance Film Festival. The film was summarized as: "*an exhilarating stream-of-consciousness ride through the interconnectedness of humankind, nature, progress and morality at the dawn of the 21st century. For centuries we've been declaring independence. With insight, curiosity, and humor, the film explores whether it's time to declare our interdependence.*" This film showed in theaters in six major cities, on PBS television, and is available on Netflix. It won 15 awards and was selected by the US State Department as one of the films to represent America in the 2012 America Film Showcase.

One short documentary, *Facing the Future* (2013), is a parody of Facebook. Another short documentary, *A Declaration of Interdependence* (2011), was selected by the National Gallery of Art and the Black Maria Film Festival. Tiffany and I wrote the script based on the 1776 version (which emphasized Independence rather than Interdependence) and posted it online. We invited people around the world to video record themselves reading the script in their native language and email the results to us. We also asked artists to interpret the words and ideas. The film incorporates selected submissions and is available online, where it has been translated into 65 languages.

The third short doc, *Brain Power: From Neurons to Networks* (2012), is based on emerging research on how to best nurture children's brains from Harvard University's Center on the Developing Child and University of Washington's I-LABS. It explores the parallels between a child's brain development and the development of the Internet, offering insights into the best ways to shape both. Made through a new crowd-sourcing creativity process we call "Cloud Filmmaking": using the connections between neurons, networks, and people around the world. *Brain Power* won Best Short Educational Film from The International Family Film Festival in 2013.

Teaching

I benefited from mentoring in my past and now enjoy mentoring junior faculty. I work closely with Pieter Abbeel here at Berkeley and regularly advise and write letters of recommendation for my past students and postdocs and junior faculty from other institutions. It's a pleasure teaching and advising the superb students at Berkeley. Three of my PhD students completed their dissertations during the review period:

- Dr. Siamak Faridani. *Models and Algorithms for Crowdsourcing Discovery*. UC Berkeley IEOR Dept, Dec 2012.
- Dr. Timmy Siau. *Integer Programs for High Dose Rate Brachytherapy Needle and Dose Planning that Directly Optimize Clinical Objectives*. UC Berkeley, CEE Dept, Dec 2012.
- Dr. Ephrat Bitton. *Geometric Models for Collaborative Search and Filtering*. UC Berkeley IEOR Dept, May 2011.

I also actively recruit and advise undergrads in my lab and supervise their independent study projects. The lab group meets weekly for research discussions over pizza. I'm currently advising four PhD candidates, Animesh Garg of IEOR, Zoe McCarthy and Sanjay Krishnan of EECS, and Ben Kehoe of ME. I have 12 undergraduates working on research in the lab.

In the IEOR Department, I regularly teach undergraduate courses. During the Review Period I taught three semesters of IEOR 115, Design and Analysis of Databases. This is an upper-division project course where student teams work with local organizations (from UCOP to a local solar heating company) to analyze needs and design and implement prototype database systems as team projects. At the end of the semester, student teams present their analysis and database designs to their clients in a public presentation, including Entity-Relationship diagrams, relational schemas, queries in relational algebra and SQL, and normalization analysis, and demonstrate a fully functional system using MS Access. I also taught one semester of a graduate course, IEOR 215, Database Systems.

I taught three semesters of IEOR 24, *Introduction to IEOR*, a Freshman Seminar that introduces students to our field. During the review period I revamped this seminar adding student research projects and field trips in addition to guest lectures by other faculty.

During the review period I taught four semesters of NW MEDIA 201, a 3-unit graduate seminar, Questioning New Media. This seminar is held in conjunction with the Art, Technology, and Culture Colloquium, a lecture series I've been organizing since 1997 which brings internationally-known speakers to campus to present work on advanced topics in art and new media. During the review period I curated and organized 25 evening ATC lectures, which are free of charge and open to the public, with speakers including Sophie Calle, Christopher Alexander, and Stelarc. In 2011 I coordinated publication of a book cataloging the first 13 years and 130 speakers of the series [IE17]. A full list of speakers and abstracts is available at: <http://atc.berkeley.edu>

In the Questioning New Media seminar, students enhance skills in questioning and challenging assumptions about new media: how to think critically about advanced topics in new media, how to use new media resources such as the internet to research pioneering work in new media, how to formulate incisive questions about new media, and how to evaluate and create effective presentations on topics in new media. This course is a requirement for BCNM's PhD-level Designated Emphasis in New Media.

With regard to K-12 education and outreach, as described above in the section on the Spring 2012 Sabbatical, I'm co-Chair of the African Robotics Network (AFRON) and working closely with the co-founder to develop an "Ultra-Affordable" robot for K-12 education. In 2011 I curated the art exhibit, *Teen Age*, at the Catharine Clark Gallery in SF, selecting artworks by collaborative teams that include at least one person under 18 and one person over 21. In 2011, I served as a soccer coach for my 10-year-old daughter's team, where after a 0-9 season I was advised to keep my day job ;).

Service : External

I'm active in the IEEE Robotics and Automation Society (RAS), which has over 11,000 members worldwide. In 2011, I received the IEEE RAS Distinguished Service Award. I currently chair the committee that selects the annual recipient of the IEEE Technical Field Award in Robotics and Automation, the highest honor in our field. I've also been active as a member of the steering committee of the biannual Workshop on Algorithmic Foundations of Robotics (WAFR), the Editorial Advisory Board of the Springer-Verlag Advanced Robotics Book Series, and the Advisory Board of IEEE Spectrum, the monthly magazine for 350,000 members.

My primary service activity has been as Editor-in-Chief of the *IEEE Transactions on Automation Science and Engineering (T-ASE)*. We publish the abstractions, algorithms, theory, methodologies, models, systems, and case studies that can be applied across industries to advance efficiency, quality, productivity, and reliability for society. As EiC, I oversee all aspects of the journal and reviews by 9 Senior Editors and 50 Associate Editors. When I was appointed in October 2011, I re-organized the journal's administration, formalized the Duties of Editors and AEs, and appointed six new Editors and 25 new Associate Editors from industry, Europe, and under-represented minorities. The journal covers a range of topics so I developed a taxonomy by reviewing its published papers and identifying two sets of categories: Ten Primary Methodologies (e.g., Logistics, Theoretical Foundations) and Ten Primary Applications (e.g. Manufacturing, Healthcare). These are now used to classify papers and balance the Editorial Board. I worked to increase awareness of the journal by writing Editorials on topics such as "What is Automation?" and "A Secret to Advancing Research and Increasing Citations to Your Papers" (spoiler: include Supplemental Materials such as data and code). I actively recruited leading authors from major conferences to submit. In my first year as EiC, the journal's Impact Factor rose 15% and annual submissions rose 40%, from 350 to 525.

During the Review Period I presented 82 invited lectures on robotics, automation, social media, and art at universities and public and private organizations as listed on my cv, including a public interview with cyberpunk author William Gibson.

Service: Campus

I enjoy service on campus. In addition to organizing the monthly public lectures for the Art, Technology, and Culture Colloquium, I served as a member of the Academic Senate LIBR (Library) Committee and as a member of the Regents Lectures Committee. In Dec 2012 I was appointed as Chair of the Regents Lecture committee and led the design of a new website for the series, solicited nominations, and coordinated the Committee that selected 10 for recommendation to the Chancellor. In Oct 2012 I presented a Homecoming lecture on the

Opinion Space project for the College of Engineering and served as moderator for the Hewlett Challenge Celebration of 100 new Chaired Professors in November 2012. I served on the IEOR Dept Advisory Board committee and Chaired the IEOR Search Committee in Spring 2013 that resulted in the hire of Asst. Professor Anil Aswani. In Spring 2012, I was on Sabbatical but Chaired the BCNM Faculty Search that resulted in the hire of Asst. Professor Eric Paulos.

I serve on the Advisory Committee for the Berkeley MasterCard Scholars program, which fully supports 15-20 undergraduate scholars from needy backgrounds in mainland Africa for 4 years of study at Cal including living and traveling expenses.

I am actively involved with the College of Engineering's Center for Information Technology in the Interest of Society (CITRIS), where I serve as co-founder and Faculty Director of the *Data and Democracy Initiative (DDI)*. DDI undertakes research and develops tools to support the evolving, dynamic relationships between digital media and democratic practices, for example novel mobile, Internet and social media applications to enhance online deliberation, participatory decision-making, and rapid mobilization. DDI seeks to enhance individual and collective awareness, understanding, and engagement for people of diverse backgrounds on critical social, political, and economic issues. During the review period I worked with Paul Wright, staff Director Camille Crittendon, and other faculty to build the program, host several public events, and establish an Advisory Board including Lt. Governor Gavin Newsom and over 30 Affiliated Faculty from UC Berkeley, UC Santa Cruz, UC Davis, and UC Merced.

Further information on diversity-enhancing efforts is in "Diversity Statements" and sample scanned documents are in "Non-Confidential Documents" at the APBears file. A full CV is available at: <http://goldberg.berkeley.edu/>

Respectfully submitted,

Ken Goldberg
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