Brief Biography

Personal Data

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University Education

California Institute of Technology. B.S. and M.S. in Mathematics, 1971

Stanford University. Ph.D. in Computer Science, 1976

Dissertation Title: The Analysis of Hashing Algorithms

Advisor: Donald E. Knuth

Professional Appointments

Xerox Palo Alto Research Center, Computer Science Laboratory. Member of the Research Staff, 1973–1982. Principal Scientist, 1982–1984.

Systems Research Center, Digital Equipment Corporation. Principal Scientist, 1984–1988. Senior Consultant Engineer, 1988–1993.

Massachusetts Institute of Technology. Professor of Computer Science and Engineering, 1989–1991.

Stanford University. Professor of Computer Science, since 1984. Professor of Electrical Engineering (by courtesy), since 2007. Paul Pigott Professor in the School of Engineering, since 2009.

Currently Professor Guibas heads the Geometric Computation group in the Computer Science Department of Stanford University and is acting director of the Artificial Intelligence Laboratory. He is also a member of the Computer Graphics Laboratory, the Institute for Computational and Mathematical Engineering (iCME), and the Bio-X program. In addition, he co-directs of the Max Planck Center for Visual Computing and Communications at Stanford.

Visiting Appointments, Consultancies, Scientific Boards

Selected visiting appointments: University of Patras, Greece (Spring 1988), University of Athens, Greece (Spring 1995), National University of Singapore (Fall 1998, 2006), Athens Information Technology Institute, Greece (Fall 2004), National Institute of Informatics, Tokyo, Japan (Spring 2006), Swiss Federal Institute of Technology (ETH), Zürich (Fall 2008), Google, Inc. (2011-12), Advanced Study Institute at Hong Kong University of Science and Technology (2015), Tsinghua-Berkeley Shenzhen Institute (2016-), Autodesk (2017), Shanghai Jiaotong University (2017-).

Selected consultancies or scientific board memberships: Xerox Palo Alto Research Center (1993-2005), Align Technology (2000-02), Protein Mechanics (2002-05), Microsoft Corporation (2005-07), Nokia Corporation (2007-08), 3D Industries (2014-), Samsung Research America (2016-), DeepMap Inc. (2017-).

Research Activities and Honors

Professor Guibas has a long record of theoretical and experimental work in computer science and applied mathematics. Areas with significant publications include combinatorial algorithms, computational geometry

and geometry processing, computer vision, computer graphics, robotics, sensor networks, topological data analysis, machine learning, and biomedical computation.

Early career: discrete and geometric algorithms. His early work was in discrete algorithms and data structures, including contributions such as Red-Black trees, a search data structure now routinely taught to undergraduates and part of many standard C++ or Java libraries. He went on the become one of the founders of the field of Computational Geometry with many accomplishments that define the field today, including algorithms for the computation of Voronoi and Delaunay diagrams, the quad-edge data structure, topological sweep, fractional cascading, snap-rounding, and kinetic data structures. These results remain some of the classic, most highly cited papers in the field.

Geometry everywhere. He has pursued the use of geometric ideas across many disciplines. His work on the Earth Mover's Distance (EMD) for distributions has found wide applicability in many computer vision tasks, especially image retrieval, and was recently honored with the Helmholtz prize in computer vision. His Metropolis light transport paper in computer graphics made possible practical global illumination algorithms and has been used extensively in the special effects industry. He is currently a world leader in the area of geometry and topology processing, involving the analysis of massive geometric data sets coming from sensors or simulations. Recent accomplishments in geometry processing include the widely used Heat Kernel Signature (HKS) features for 3D models, algorithms for shape and image segmentation, methods for the detection of symmetries and other regular patterns in 3D geometry, the use of topological complexes in surface reconstruction, the capture of shape and motion of deforming bodies from 3D scan data, and a variety of methods for finding correspondences or matchings in 3D geometry.

He has also worked on several related areas, including multi-camera sensor networks for activity understanding, the development of identity management techniques in target tracking based on Fourier group representations and other harmonic analysis ideas, the construction of small libraries of protein fragments to model the 3D structures of folded proteins, and the analysis of massive amounts of mobility (GSP trace) data. Many of these contributions are infused with geometric ideas, even in setting where geometry does not ostensibly apply. For example, sweep methods are well known in geometry (and other areas such as PDEs), but he has extended their use to sensor networks even when no location information is available. In data analysis, he has taken classical ideas from topology and geometry that in themselves may be quite fragile in the presence of sampled representations and replaced them by robust counterparts that seek "persistent" structures in the data, in both low and high dimensions.

Joint data analysis. More recently, Professor Guibas has pursued and is continuing to develop a research program focused on the joint analysis of multiple related data sets. A significant accomplishment along these lines was the development of functional maps and functional networks that link function spaces defined over data sets. Functions are very general mathematical objects and can encode all kinds of information about the underlying data, including features and attributes, parts and hierarchical structures, as well as symmetries and repetitions. Maps and correspondences between related data sets "lift" to functional maps between the corresponding function spaces. As it turns out these functional maps are always linear, allowing us to use powerful numerical tools from linear algebra and optimization. Functional maps then give rise to functional map networks, through which large collections of data can be interconnected so that information can be transported efficiently through the network. These networks create a new discipline of "map processing", where the goal is to clean up noisy maps, just as one does with images in image processing and meshes in geometry processing. Surprisingly, as it turns out, these networks are not only good at transporting information but also at discovering it. Knowledge about the data emerges from the network in completely unsupervised ways, as the network extracts shared structure from the data that invariably has semantic significance.

Deep nets for irregular data. Most recently he has focused on developing deep network architectures suitable for irregular geometric or visual data, such as point clouds, 2D meshes, or other simplicial complexes. Processing or generating such data via deep nets is challenging, as they do not have the regular grid structure exploited by convolutional architectures for weight sharing and other optimizations. This has led to novel

lightweight architectures that have generated significant interest in the computer vision and graphics communities. He is currently working to integrate such "vertical" nets that move information across abstraction layers for one data set with the "horizonal networks" described above that transfer information between corresponding layers in different but related data sets. The latter are synergistic with deep learning networks and can help regularize and denoise their results, reducing the amount of supervision necessary.

ShapeNet. In a related effort, Professor Guibas and collaborators are developing ShapeNet (`https://www.shapenet.org`), a very large repository of 3D models of everyday objects that are richly annotated (currently over 3M). The annotations include geometric (parts, symmetries), semantic (keywords for the shape and its parts), physical (weight, size), and functional (affordances, scene context). In particular, the aim is for ShapeNet to be an encyclopedia of knowledge about objects in the world supported by an ecosystem of algorithms that can then transfer all relevant semantic knowledge to objects as they are seen by sensors, either by training machine learning algorithms using repository data or by direct transport from the repository to similar objects in scenes. The ShapeNet project has demonstrated the ability to very successfully train computer vision algorithms through rendering massive amounts of synthetic imagery from 3D models and has been used towards this end by several hundred different groups around the world.

Metrics and awards. Professor Guibas has authored or co-authored over 450 hundred journal and referred conference papers, as well as a popular textbook on sensor networks. Overall, *Google Scholar* and *Publish or Perish* claim the PI has over 47,000 citations, an h-index of 109 and a g-index of 208. He is a member of the National Academy of Engineering, has been elected an ACM and IEEE Fellow, and is the recipient of the ACM/AAAI Allen Newell award, the ICCV Helmholz prize, and numerous best paper awards. He was named the Paul Pigott Professor of Engineering at Stanford in 2009.

Selected Recent Publications

1. *Discovering structural regularity in 3D geometry*. Mark Pauly, Niloy J. Mitra, Johannes Wallner, Helmut Pottmann, and Leonidas Guibas. *ACM Transactions on Graphics (Siggraph 2008)*, **27**(4), 2008.
2. *Scalar field analysis over point cloud data*. Frédéric Chazal, Leonidas Guibas, Steve Oudot, and Primoz Skraba. *Discrete and Computational Geometry*, **46**(4), pp. 743-775, 2011.
3. *Persistence-based clustering in Riemannian manifolds*. Frédéric Chazal, Leonidas Guibas, Steve Oudot, and Primoz Skraba. *Proceedings of the 27th annual ACM Symposium on Computational Geometry (SoCG '11)*, pp. 97-106, 2011.
4. *A concise and provably informative multi-scale signature based on heat diffusion*. Jian Sun, Maks Ovsjanikov, and Leonidas Guibas. *Computer Graphics Forum*, **28**(5), pp. 1383–1392, July 2009.
5. *Functional maps: a flexible representation of maps between shapes*. Maks Ovsjanikov, Mirela Ben-Chen, Justin Solomon, Adrian Butscher, and Leonidas Guibas. *ACM Transactions on Graphics (Siggraph 2012)*, **31**(4), 2012.
6. *Map-based exploration of intrinsic shape differences and variability*. Raif Rustamov, Maks Ovsjanikov, Omri Azencot, Mirela Ben-Chen, Frederic Chazal, and Leonidas Guibas. *ACM Transactions on Graphics (Siggraph 2013)*, **32**(4), 2013.
7. *Consistent shape maps via semidefinite programming*. Qixing Huang and Leonidas Guibas. *Computer Graphics Forum (Eurographics Symposium on Geometry Processing)*, **32**(5), 2013.
8. *Joint embeddings of shapes and images via CNN image purification*. Yangyan Li, Hao Su, Charles R. Qi, Noa Fish, Daniel Cohen-Or, and Leonidas Guibas. *ACM Transactions on Graphics (Proceedings of Siggraph Asia 2015)*, **34**(6), 2015.
9. *PointNet: deep learning on point sets for 3D classification and segmentation*. Hao Su, Charles Qi, Kaichun Mo, and Leonidas Guibas. *IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)*, 2017.
10. *ComplementMe: Weakly-supervised component suggestions for 3D modeling*. Minhyuk Sung, Hao Su, Vladimir Kim, Siddhartha Chaudhuri, and Leonidas Guibas. *ACM Transactions on Graphics (Proceedings of Siggraph Asia 2017)*, **36**(6), 2017.

Recent Invited Presentations

Professor Guibas has been plenary invited speaker at numerous major international meetings across a range of disciplines, such as *IEEE Computer Vision and Pattern Recognition* (CVPR, 1997), *Algorithmic Foundations of Robotics* (1998), *Mathematics of Image Analysis* (MIA, 2004), *Vision, Modeling and Visualization* (VMV, 2004)), *International Conference on Distributed Computing in Sensor Systems* (DCOSS, 2006), *ACM International Conference on Mobile Computing and Networking* (MobiCom, 2007), *International Symposium on Mobile Ad Hoc Networking and Computing* (MobiHoc, 2007), *EuroGraphics* (2008), *Eurographics Symposium on Geometry Processing* (SGP, 2009), *Canadian Computational Geometry Conference* (CCCG, 2009), *SIAM/ACM Geometric and Physical Modeling* (GPM, 2009), *Voronoi Diagrams in Science and Engineering* (2010), *ACM Multimedia* (2013), *Curves and Surfaces* (2014), *Robotics Science and Systems* (RSS, 2015), and *Eurographics Workshop on 3D Object Retrieval* (2017).

Granted US Patents

US Patent 5748197: Dynamic computation of a line segment arrangement using finite precision arithmetic for use in a processor controlled system; *US Patent 5710877*: User-directed interaction with an image structure map representation of an image; *US Patent 5751852*: Image structure map data structure for spatially indexing an image; *US Patent 6987885*: Systems and methods for using visual hulls to determine the number of people in a crowd; *US Patent 8411081*: Systems and methods for enhancing symmetry in 2D and 3D objects.

Advising and Teaching

Professor Guibas has graduated 41 Ph.D. students and has supervised 29 postdoctoral fellows, many of whom are well-known in computational geometry, in computer graphics, in computer vision, in theoretical computer science, and in ad hoc and sensor networks. His student and postdoc graduates include current faculty at the University of Noth Carolina (J. Snoeyink), U.of Arizona (A. Efrat), Stuttgart Uiversity (S. Funke), Tel Aviv U. (D. Halperin), EPFL (M. Pauly), U. of Louvain, Belgium (B. Adams), Ohio State U. (Y. Wang), U. Mass Amherst (V. Kalogerakis), Technion (M. Ben-Chen), State U. of NY at Stonybook (J. Gao), University College London (N. Mitra), Ecole Polytechnique in Paris (M. Ovsjanikov), U. of Texas at Austin (Q. Huang), U. of Mainz, Germany (M. Wand), Shandong U. (Y. Lee), U. of Graz, Austria (M. Kerber), MIT (J. Solomon), Stanford (C. Piech), and UCSD (H. Su). Many of the rest are employed in the high-tech sector with the research arms of major corporations such as Adobe, Autodesk, Google, Microsoft, etc., government research organizations such as INRIA in France or Max Planck in Germany, or have become entrepreneurs.

In terms of teaching, he has developed at Stanford new courses on Algorithms and Data Structures (CS161), Geometric and Topological Data Analysis (C233), Geometric Algorithms (CS268), Algorithms for Structure and Motion in Biology (CS273), Information Processing for Sensor Networks (CS321), Geometric Modeling and Processing (CS348a), and Deep Learning for 3D Data (CS468). He has also conducted research on how to provide personalized feedback to students in MOOCs (massive open on-line courses), using the data networking techniques described earlier.

Service to the Profession

Guibas has served or is serving on the editorial board of *Journal of Algorithms* (1980-1996), *SIAM Journal on Computing* (1982-1996), *ACM Transactions on Graphics*, (1983-1990), *Journal of Symbolic Computation* (1985-1995), *Applied Mathematics Letters* (1987-1995), *Discrete and Computational Geometry* (1984-), *Algorithmica* (1984-), *Computational Geometry, Theory and Applications* (1990-2010), *Int. J. of Computational Geometry and Applications* (1990-), *ACM Transactions on Sensor Networks* (2003-2011).

He is co-founder of the *ACM International Conference on Information Processing in Sensor Networks*, now in its 15th year, and has bee chair or member of the program committee for several major conferences (multiple

times), including *ACM Principles of Programming Languages Conference*, *IEEE Foundations of Computer Science Conference*, *ACM Symposium on Theory of Computing*, *ACM/SIAM Symposium on Discrete Algorithms*, *ACM Computational Geometry Conference*, *ACM SIGGRAPH Symposium*, *Computer Graphics International*, *Pacific Graphics*, *Solid and Physical Modeling*, *Eurographics Geometry Processing Symposium*, *Eurographics Symposium on Computer Animation*, *IEEE Computer Vision and Pattern Recognition*, *ACM International Conference on Information Processing in Sensor Networks*, *ACM Symposium on Embedded Networked Systems*, *IEEE International Conference on Distributed Computing in Sensor Systems*, *ACM Sigspatial International Conference on Advances in Geographic Information Systems*.

Professor Guibas has been a member of numerous Funding Agency Panels in all areas of Computer Science, in both the US (e.g., NSF) and Europe (e.g, ERC). He has organized several workshops in domestic and international locations on computational geometry, computer graphics, and sensor networks (e.g., Modeling Motion, 2000, Form and Content in Sensor Networks, 2005, Geometric Approaches to Ad Hoc and Sensor Networks, 2006. Functoriality in Geometric Data, 2015). For these activities he was able to generate support from multiple organizations, such as NSF, Schloss Dagstuhl in Germany, the Hong Kong University of Science and Technology Institute for Advanced Study, etc.

Research Funding

Guibas is the recipient of 20 National Science Foundation Grants, of 11 grants from Defense agencies (Air Force Office of Scientific Resaerch, Office of Naval Research, Army Research Office, Defense Advanced Research Projects Agency) and of one from the National Institutes of Health — including several where he is the lead PI of a large teams of investigators. He has also been awarded grants or given gifts by several corporations, including Adobe, Agilent, Amazon, Apple, Autodesk, Google, HTC, Microsoft, Qualcomm, Toshiba, and Toyota.

DoD related projects in the past decade span a variety of topics, including collaborative motion modeling (ONR MURI), topological data analysis (DARPA), multi-target tracking (ARO), information diffusion in sensor networks (ARL Center), networking image collections (ONR MURI), map-based understanding of visual data (AFOSR), and human / autonomous agent collaboration (ONR MURI).