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Frederick Phillips Brooks, Jr.

Department of Computer Science
University of North Carolina
Chapel Hill, NC 27599-3175
(919) 962-1931
(919) 962-1799 Fax
brooks@cs.unc.edu
<http://www.cs.unc.edu/~brooks>

413 Granville Road
Chapel Hill, NC 27514-2723
(919) 942-2529

Born 19 April 1931; Durham, NC
Married, three children:
Kenneth P. Brooks, 8/14/58
Roger G. Brooks, 12/25/61
Barbara B. LaDine, 2/24/65

EDUCATION

Ph.D., Harvard University, Applied Mathematics (Computer Science), 1956; Howard H. Aiken, advisor;
dissertation: *The Analytic Design of Automatic Data Processing Systems*
S.M., Harvard University, Applied Mathematics (Computer Science), 1955
A.B. *summa cum laude*, Duke University, Physics, 1953. First in class of 1953.

TEACHING EXPERIENCE

University of North Carolina at Chapel Hill, Department of Computer Science
Kenan Professor of Computer Science, 1975-
Professor of Computer Science, 1964-75
Chairman, 1964-1984; founder

Twente Technical University, Enschede, The Netherlands: Visiting Professor, 1970

Columbia University: Adjunct Assistant Professor, 1960-61

Vassar College: Visiting Instructor, 1958

IBM Systems Research Institute, Voluntary Education Program, and Summer Student Program Teacher, 1957-59

DEVELOPMENT EXPERIENCE

IBM Corporation

Poughkeepsie, New York

Corporate Processor Manager for Development of System/360 Computer Systems, 1961-1965

Manager of Operating System/360, 1964-65

Manager, System/360 Hardware Development, Data Systems Division, 1961-64

Systems Planning Manager, Data Systems Division (8000 series *et al.*), 1960-61

Yorktown Heights, New York: Advisory Engineer, Thomas J. Watson Research Center, 1959-60

Poughkeepsie, New York

Project STRETCH: Advisory Engineer, 1958-59; Staff Engineer, 1956-58; Associate Engineer, 1956

Professional summer jobs at IBM Endicott, Bell Labs, North American Aviation, Marathon Oil Co., 1952-56

COMPUTER DESIGNS

IBM System/360: Manager of whole project, 1961-64

IBM 8000 Series (never produced): Manager of Architecture, 1960-61

IBM 7950 (Harvest): Instruction set-up, adjustments, 1957-58

IBM 7030 (Stretch): Instruction sequencing, interruption, variable-field-length arithmetic, editing, programmable console, 1956-59

A specialized computer for payroll, Ph.D. Dissertation, 1955-56

PATENTS

U.S. 2,981,020 "Alphabetical Read-Out Device"

U.S. 3,048,332 "Program Interruption System" with D.W. Sweeney; also French, German, British patents on same. Broad coverage of mask-controlled interruption, vectored interruption, etc.

HONORS

National Medal of Technology, 1985

A.M. Turing Award, Association for Computing Machinery, 1999

Bower Award and Prize in Science (\$250,000), Franklin Institute, 1995

Allen Newell Award, Association for Computing Machinery, 1994

Eckert-Mauchly Award, Association for Computing Machinery and The Institute of Electrical and Electronics Engineers-Computer Society, 2004

John von Neumann Medal, The Institute of Electrical and Electronics Engineers, 1993

Harry Goode Memorial Award, American Federation of Information Processing Societies, 1989

McDowell Award for Outstanding Contribution to the Computer Art, IEEE Computer Group, 1970

Distinguished Service Award, Association for Computing Machinery, 1987

Honorary Doctor of Technical Science, Swiss Federal Institute of Technology, ETH Zurich, 1991

Distinguished Fellow, British Computer Society, 1994

Royal Academy of Engineering, (U.K.) Foreign Member, 1994

Royal Netherlands Academy of Arts and Sciences, Foreign Member, 1991

National Academy of Science, Member, 2001

National Academy of Engineering, Member, 1976

American Academy of Arts and Sciences, Fellow, 1976

Guggenheim Fellowship for studies on computer architecture and the human factors of computer systems, 1975,
at Cambridge University, England

Computer Pioneer Award, IEEE Computer Society, 1982

Association for Computing Machinery, Fellow (initial inductee), 1994

The Institute of Electrical and Electronics Engineers, Fellow, 1968

Fellow Award, The Computer Museum History Center, 2001

Thomas Jefferson Award, University of North Carolina at Chapel Hill, 1986

Order of the Golden Fleece, University of North Carolina at Chapel Hill

Computer Sciences Distinguished Information Services Award, Information Technology Professionals, 1970

CyberEdge Journal Annual Sutherland Award, April 1997

SERVICE

National Science Board, 1987-1992

Defense Science Board, 1983-86

Chairman, Military Software Task Force, 1985-87

Member, Computers in Simulation and Training Task Force, 1986-87

Member, Artificial Intelligence Task Force, 1983-84

NSF Advisory Committees

Computer and Information Science and Engineering Advisory Committee, 1995-January 1999

Education and Human Resources, 1992-1995 (Chairman, 1994)

National Research Council

Committee to study the High Performance Computing and Communications Initiative, co-chair, 1994-95

Produced the so-called *Brooks-Sutherland Report*

Computer Science and Technology Advisory Board, 1977-80

Division of Mathematical Sciences, Executive Committee, 1967-70

Microelectronics Center of North Carolina

Committee of Institutional Technical Representatives 1980-85 (Chairman, 1981-83); a founder

Triangle Universities Computation Center: Board of Directors (Chairman, 1975-77), 1965-1983; a founder

North Carolina Education Computing Service: Policy Committee, and its predecessor, 1964- ; a founder

IBM Corporation: Science Advisory Committee, 1979-93

Teknowledge Corporation: Technical Advisory Board, 1982-87

Austek Microsystems: Technical Advisory Board, 1984-86

Virtus Corporation

Board of Directors, 1992-99

Association for Computing Machinery, 1953-

National Council, Member-at-Large, 1966-70

Special Interest Group on Computer Architecture, Board of Directors, 1973-75

University of California at Berkeley: Computer Science Visiting Committee, 1996-98

Carnegie-Mellon University

Advisory Committee on the Undergraduate Computer Science Curriculum, 1992-94

School of Computer Science Advisory Board, 2002-

Stanford University: Computer Science Advisory Committee (Chairman, 1976-77), 1972-79

Princeton University: Computer Center Advisory Council (Chairman, 1969-72), 1968-72

Organization for Economic Cooperation and Development (OECD)

Consultant Expert on Technological Gaps in the Computer Industry, 1967-68

Atomic Energy Commission: Mathematics & Computer Sciences Research Advisory Committee, 1967-72

National Institutes of Health: Various special study sections

Executive Office of the President

Special assignment to the President's Science Advisor (studying Soviet computer status), 1959

National Security Agency: Special 6-week assignment on cryptographic research, 1959

Strategic Air Command

Task Force on False Alerts, ~1972

438L Study Group on Intelligence, 1959

UNC

Chancellor's Advisory Committee, 2000-2003; Chair, 2001-2003

Search Committee for Vice-Chancellor for Research and Graduate Studies, Chair, 2000-2001

Search Committee for Vice Chancellor for Information Technology, Chair, 1996-97

Chair, Conference of Chairs, sometime in 1970's

Durham Academy: Board of Trustees, 1973-80; (President, 1977-80)

Trinity School of Durham and Chapel Hill: Advisory Committee, Chair, 1995-2003; Board of Trustees, 2003- (Chair, 2003-)

BIBLIOGRAPHY

BOOKS AND CHAPTERS

Whitton, M., B. Lok, B. Insko, F. Brooks, "Integrating Real and Virtual Objects in Virtual Environments," *Advances in Virtual Environments Technology: Musings on Design, Evaluation, & Applications*, Lawrence Erlbaum Associates. To appear.

Taylor II, R. M., D. Borland, F. P. Brooks, Jr., M. Falvo, M. Guthold, T. Hudson, K. Jeffay, G. Jones, D. Marshburn, S. J. Papadakis, L. C. Qin, A. Seeger, F. D. Smith, D. H. Sonnenwald, R. Superfine, S. Washburn, C. Weigle, M. C. Whitton, P. Williams, L. Vicci and W. Robinett, "Visualization and Natural Control Systems for Microscopy," in *Visualization Handbook*, Edited by C. Johnson and C. Hansen, Harcourt Academic Press, 2004, 875-900.

Brooks, Jr., F. P. "Foreword" in D. Luebke, M. Reddy, J. D. Cohen, A. Varshney, B. Watson, and R. Huebner, *Level of Detail for 3D Graphics*. San Francisco, CA: Morgan Kaufmann Publishers, 2003, ix.

Brooks, Jr., F. P. "The History of IBM Operating System/360," in M. Broy and E. Denert eds., *Software Pioneers: Contributions to Software Engineering*. Berlin: Springer, 2002, 170-178.

Brooks, Jr. F.P. "Aiken and the Harvard 'Comp Lab'", in I. B. Cohen and G. W. Welch (eds.), *Makin' Numbers: Howard Aiken and the Computer*. Cambridge, MA: MIT Press, 1999, 137-142.

Blaauw, G.A., F.P. Brooks, Jr. *Computer Architecture: Concepts and Evolution*. Reading, MA: Addison-Wesley, 1997 (A research monograph and text for practicing architects), 1213 pages.

Brooks, Jr. F.P. "Language Design as Design," in T.J. Bergin and R.G. Gibson, eds, *History of Programming Languages II*. New York and Reading, MA: ACM Press and Addison-Wesley, 1996, 4-16.

Brooks, Jr., F.P. *The Mythical Man-Month: Essays on Software Engineering*, 20th Anniversary Edition. Reading, MA: Addison-Wesley, 1995, 322 pages. (Also in Chinese, Dutch, French, Japanese, Polish, Russian)

Brooks, Jr., F.P. and I.E. Sutherland, co-chairs, E. Bloch, D. Estrin, J. Hennessy, B.W. Lampson, E.D. Lazowska, W.A. Lester, J. Preston, W. Sincoskie, L. Smarr, J.F. Traub. *Evolving the High Performance Computing and Communications Initiative to Support the Nation's Information Infrastructure*. Washington: National Academy, 1995, 119 pages.

Brooks, Jr., F.P., chm., V. Basili, B. Boehm, E. Bond, N. Eastman, D.L. Evans, A.K. Jones, M. Shaw, C.A. Zraket. *Report of the Defense Science Board Task Force on Military Software*. Washington: Dept. of Defense, 1987, 78 pages.

F.P. Brooks, Jr., Pique, M., 1985: "Computer Graphics for Molecular Studies" in *Molecular Dynamics and Protein Structure: Proceedings of a Workshop held 13-18 May 1984 at the University of North Carolina*, Jan Hermans, ed., Published by Chapel Hill, University of North Carolina, Distributed by Polycrystal Book Service, 1985, pg. 109.

Brooks, Jr., F.P. *The Mythical Man-Month: Essays on Software Engineering*. Reading, MA: Addison-Wesley, 1975. (Also in Japanese, Russian, German, and Dutch.)

Brooks, Jr., F.P., K.E. Iverson. *Automatic Data Processing, System/360 Edition*. New York: Wiley, 1969. (Also in Polish)

Brooks, Jr., F.P., K.E. Iverson. *Automatic Data Processing*. New York: Wiley, 1963.

Brooks, Jr., F.P. In *Planning a Computer System*. W. Buchholz, ed. New York: McGraw-Hill, 1962. Author of Chapters 2, 10; co-author with W. Buchholz, G.A. Blaauw of Chapters 4, 7.

Brooks, Jr., F.P. In *Reference Manual for the IBM 7030 Data Processing System*, IBM Form A-22-6530, 1960. Author of several chapters.

TECHNICAL PAPERS (Major papers marked*)

*Brooks, Fred, J. Cannon-Bowers, H. Fuchs, L. McMillan, M. Whitton, "A New VE Challenge: Immersive Experiences for Team Training," *Proceedings of HCI International 2005*, (Las Vegas, Nevada, July 2005). To appear.

Whitton, Mary, B. Lok, B. Insko, F. Brooks, "Integrating Real and Virtual Objects in Virtual Environments," *Proceedings of HCI International 2005*, (Las Vegas, Nevada, July 2005). To appear.

Whitton, M., Cohn, J., Feasel, J., Zimmons, P., Razzaque, S., Poulton, S., McLeod, B., Brooks, F., "Comparing VE Locomotion Interfaces," in *Proceedings of IEEE Virtual Reality 2005*, (Bonn, Germany March, 2005), 123-130, IEEE Computer Society.

Burns, E., Razzaque, S., Panter, A. T., Whitton, M. C., McCallus, M. R., & Brooks, F. P. "The Hand is Slower than the Eye: A quantitative exploration of visual dominance over proprioception," *Proceedings of IEEE Virtual Reality 2005*, (Bonn, Germany March 2005), 3-10, IEEE Computer Society.

Lok, Benjamin, Samir Naik, Mary Whitton, and Frederick Brooks, 2004: "Experiences in Extemporaneous Incorporation of Real Objects in Immersive Virtual Environments," *Beyond Glove and Wand Based Interaction Workshop Manual*, 107-110, IEEE Virtual Reality 2004, Chicago, IL.

*Lok, Benjamin, Samir Naik, Mary Whitton, and Frederick P. Brooks, Jr. 2004: "Effects of Handling Real Objects and Avatar Fidelity on Cognitive Task Performance and Sense of Presence in Virtual Environments," *Journal on Presence: Teleoperators and Virtual Environments*, **12**, 6: 615-628.

Brooks, Jr., F.P. 2003: "Truth vs. Beauty," Panel Presentation during Special Session "Truth Before Beauty: Guiding Principles for Scientific and Medical Visualization," *ACM SIGGRAPH'03*, San Diego, CA, July 30, 2003.

*Lok, B., S. Naik, M.C. Whitton, F.P. Brooks, Jr. 2003: "Incorporating Dynamic Real Objects into Immersive Virtual Environments," *Proceedings of ACM SIGGRAPH 2003 Symposium on Interactive 3D Graphics* (Monterey, CA, April 28-30, 2003), 31-40, ACM, New York. Five best papers were selected for presentation at SIGGRAPH 2003. The abstract is in those proceedings, *ACM Transactions on Graphics* **22**,3: 701.

- *Lok, B., F.P. Brooks, Jr., S. Naik, M.C. Whitton 2003: "Effects of Handling Real Objects and Self-Avatar Fidelity on Cognitive Task Performance in Virtual Environments," *Proceedings of IEEE Virtual Reality 2003* (Los Angeles, CA, March 22-26, 2003), 125-132, IEEE Computer Society.
- *Meehan, M., S. Razaque, M.C. Whitton, F.P. Brooks, Jr. 2003: "Effect of Latency on Presence in Stressful Environments," *Proceedings of IEEE Virtual Reality 2003* (Los Angeles, CA, March 22-26, 2003), 141-148, IEEE Computer Society.
- Brooks, Jr., F.P. 2003: "Three Great Challenges for Half-Century-Old Computer Science." *Journal of the ACM*, **50**, 1: 25-26.
- *Brooks, Jr., F.P. 2002: "Studies in Virtual Environments." Keynote address for the Fifth Presence Workshop (Porto, Portugal, October 9-11).
- *Brooks, Jr., F.P. 2002: "STRETCH-ing Is Great Exercise: It Gets You in Shape to Win." Keynote address at STRETCH Development Reunion (Poughkeepsie, New York, September 28), *Annals of the History of Computing*. To appear.
- *Meehan, M., B. Insko, M.C. Whitton, F.P. Brooks Jr., 2002: "Physiological Measures of Presence in Stressful Virtual Environments," *ACM Transactions on Graphics*, **21**, 3: 645-652. (Proc. of ACM SIGGRAPH 2002, San Antonio, TX).
- Brooks, Jr., F.P. 2002: "Understanding Virtual Environments: Passive Haptics for Presence and Training," *SIGGRAPH '02 Course Notes*.
- Brooks, Jr., F.P. 2002: "Understanding Virtual Environments: The VE Design Process - A Checklist," *SIGGRAPH '02 Course Notes*.
- Brooks, Jr., F.P. 2001: "The History of IBM Operating System/360," Proceedings of SD&M Software Pioneers Conference, Bonn, Germany.
- *Brooks, Jr., F.P. 2000: "The Design of Design," Turing Award address at SIGGRAPH '00, (July 2000). *Communications of the ACM*. To appear.
- Guthold, M., M.R. Falvo, W.G. Matthews, S. Paulson, S. Washburn, D. Erie, R. Superfine, F.P. Brooks, R.M. Taylor II 2000: "Controlled Manipulation of Molecular Samples with the nanoManipulator," *IEEE/ASME Transactions on Mechatronics* **5**, 2 June 2000: 189-198.
- Guthold, M., M.R. Falvo, W.G. Matthews, S. Paulson, A. Negishi, S. Washburn, R. Superfine, F.P. Brooks, Jr., R.M. Taylor II 1999: "Investigation and Modification of Molecular Structures Using the nanoManipulator," *Journal of Molecular Graphics & Modeling*, **17**, 3: 187-197.
- *Brooks, Jr., F.P. 1999: "What's Real About Virtual Reality?" *IEEE Computer Graphics and Applications*, **19**, 6: 16-27.
- Falvo, M.R., G. Clary, A. Helser, S. Paulson, R.M. Taylor II, V. Chi, F.P. Brooks, Jr., S. Washburn, R. Superfine 1999: "Nanomanipulation Experiments Exploring Frictional and Mechanical Properties of Carbon Nanotubes," *Microscopy and Microanalysis*, **4**, 5: 504-512.
- Falvo, M.R., G.J. Clary, A. Hesler, R.M. Taylor II, V. Chi, F.P. Brooks, Jr., S. Washburn, R. Superfine 1999: "Rolling and Sliding on the Nanometer Scale," *Nature*, **397**, 6716: 236-238.
- Guthold, M., G. Matthews, A. Negishi, R.M. Taylor II, D. Erie, F.P. Brooks, Jr., R. Superfine 1999: "Quantitative Manipulation of DNA and Viruses with the nanoManipulator Scanning Force Microscope," *Surf. Interf. Analysis* **27**: 437-443.
- Brooks, Jr., F.P. 1999: "Fourteen years of interactive walkthroughs," *SIGGRAPH'99 Course #20 Notes*, pp. H1-H21.

- *Usoh, M., K. Arthur, M.C. Whitton, R. Bastos, A. Steed, M. Slater, F.P. Brooks, Jr., 1999: "Walking>Walking-in-Place>Flying in Virtual Environments," *Proc. of SIGGRAPH 1999* (Los Angeles, CA, August 8-13, 1999), New York, 1999, pp. 359-364.
- *Aliaga, D., J. Cohen, A. Wilson, H. Zhang, C. Erikson, K. Hoff, T. Hudson, W. Stuerzlinger, E. Baker, R. Bastos, M. Whitton, F.P. Brooks, Jr., D. Manocha 1999: "MMR: Massive Model Rendering System using Geometric and Image-Based Simplification," *Proc., 1999 Symposium on Interactive 3D Graphics*, April 1999.
- Arthur, K., T. Preston, R.M. Taylor II, F.P. Brooks, Jr., M.C. Whitton, W.V. Wright 1998: "Designing and Building the PIT: a Head-Tracked Stereo Workspace for Two Users," 2nd International Immersive Projection Technology Workshop, Ames, Iowa, May 1998.
- Taylor II, R.M., J. Chen, S. Okimoto, N. Llopis-Artime, V. Chi, F.P. Brooks, Jr., M. Falvo, S. Paulson, P. Thiansathaporn, D. Glick, S. Washburn, R. Superfine 1997: "Pearls Found on the way to the Ideal Interface for Scanned-probe Microscopes," *Proc. IEEE Visualization '97*, Phoenix, AZ, October 19-24: 467-470, 579.
- *Falvo, M.R., G. J. Clary, R.M. Taylor II, V. Chi, F.P. Brooks, Jr., S. Washburn, R. Superfine 1997: "Bending and buckling of carbon nanotubes under large strain," *Nature*, **389**, 6651: 582-584.
- Falvo, M.R., S. Washburn, R. Superfine, M. Finch, F.P. Brooks, Jr., V. Chi, R.M. Taylor II 1997: "Manipulation of Individual Viruses: Friction and Mechanical Properties," *Biophys. Journal* **72** (March 1997): 1396-1403.
- Superfine, R., M.R. Falvo, S. Paulson, S. Washburn, R.M. Taylor II, G.J. Clary, V. Chi, F.P. Brooks, Jr. 1997: "Manipulation of Nanometer Objects: Friction, Mechanical Properties, and Devices," *Proceedings of the International Conference on Novel Materials*, Puri, India, March 3-7, 1997.
- *Miné, Mark R., F.P. Brooks, Jr., C.H. Sequin 1997: "Moving Cows in Space: Exploiting Proprioception as a Framework for Virtual Environment Interaction," *Computer Graphics, Proceedings Annual Conference Series*, ACM SIGGRAPH, Los Angeles, CA, 19-26.
- *Cohen, Jonathan, A. Varshney, D. Manocha, G. Turk, H. Weber, P. Agarwal, F.P. Brooks, Jr., W. Wright 1996: "Simplification Envelopes," *Computer Graphics, Proceedings Annual Conference Series*, ACM SIGGRAPH, New Orleans, LA, 119-128.
- *Brooks, Jr., F.P. 1996: "The Computer Scientist as Toolsmith II." Keynote/Newell Award address at SIGGRAPH 94, (July 1994). *Communications of the ACM*, March 1996, Vol. 39, No. 3: 61-68. Also *Computer Graphics (Proc. of SIGGRAPH '94)*, **28**, 4 (November): 281-287.
- Falvo, M., R. Superfine, S. Washburn, M. Finch, R.M. Taylor II, V.L. Chi, F.P. Brooks, Jr. 1996: "The Nanomanipulator: A Teleoperator for Manipulating Materials at the Nanometer Scale," *Proceedings of the International Symposium on the Science and Technology of Atomically Engineered Materials*, Richmond, VA, October 1995, P. Jena, S.N. Khana, and B.K. Rao, eds., World Scientific Publishing, 579-586, 1996.
- Varshney, A., F.P. Brooks, Jr., D.C. Richardson, W.V. Wright, D. Manocha 1995: "Defining, Computing, and Visualizing Molecular Interfaces," *Proceedings: Visualization '95*, Atlanta, October 1995, Los Alamitos, CA: IEEE Computer Society: 36-43.
- *Varshney, A., F.P. Brooks, Jr., W.V. Wright 1994: "Computing Smooth Molecular Surfaces," *IEEE Computer Graphics and Applications*, **14**, 5 (September 1994): 19-25.
- *Surles, M.C., J.S. Richardson, D.C. Richardson, F.P. Brooks, Jr. 1994: "Sculpting Proteins Interactively: Continual Energy Minimization Embedded in a Graphical Modeling System," *Protein Science*, **3**: (February 1994): 210.
- Varshney, A., F.P. Brooks, Jr. 1993: "Fast Analytical Computation of Richards's Smooth Molecular Surface," *Proceedings: Visualization '93*, San Jose, CA, (October 1993): 300-307.

*Bergman, L.D., J.S. Richardson, D.C. Richardson, F.P. Brooks, Jr. 1993: "VIEW – An Exploratory Molecular Visualization System with User-Definable Interaction Sequences," *Computer Graphics* (Proceedings of SIGGRAPH 93), August 1993: 117-126.

*Taylor II, R.M., W. Robinett, V.L. Chi, F.P. Brooks, Jr., W.V. Wright, R.S. Williams, E.J. Snyder 1993: "The Nanomanipulator: A Virtual-Reality Interface for a Scanning Tunneling Microscope," *Computer Graphics* (Proceedings of SIGGRAPH 93), August 1993: 127-134. Fuchs, H., G. Bishop, W. Bricken, F.P. Brooks, Jr., M. Brown, C. Burbeck, N. Durlach, S. Ellis, M. Green, J. Lackner, M. McNeill, M. Moshell, R. Pausch, W. Robinett, M. Srinivasan, I. Sutherland, D. Urban, E. Wenzel 1992: "Research Directions in Virtual Environments," *Computer Graphics*, **26**, 3 (August 1992): 153-177.

Robinett, W., R.M. Taylor II, V.L. Chi, W.V. Wright, F.P. Brooks Jr., R.S. Williams, E.J. Snyder 1992: "The nanoManipulator: An Atomic-Scale Teleoperator," Proceedings of SIGGRAPH '92. Course notes for Course #9: "Implementation of Immersive Virtual Environments, August 1992, 2.1-2.8.

Brooks, Jr., F.P. 1991: "Modeling: Today's Biggest Graphics Problem," Panel presentation for "Computer Graphics: More Unsolved Problems." SIGGRAPH 91, July 1991, Las Vegas.

Brooks, Jr., F.P. 1990: "Force and Volume Visualization Methods for Molecular Studies." Invited address at the Ninth Annual Conference of the Molecular Graphics Society, Uppsala, Sweden, July 2-6. Abstract in *Journal of Molecular Graphics*, **8**, 4 (December 1990): 228-229.

*Brooks, Jr., F.P., M. Ouh-Young, J.J. Batter, P. J. Kilpatrick 1990: "Project GROPE – Haptic Displays for Scientific Visualization," *Proceedings of SIGGRAPH '90*, (Dallas, Texas, August 6-10, 1990). In *Computer Graphics*, **24**, 4 (August 1990) ACM SIGGRAPH, New York, 1990, pp. 177-185.

Minsky, M., M. Ouh-Young, O. Steele, F.P. Brooks, Jr., M. Behensky 1990: "Feeling and Seeing: Issues in Force Display," *Computer Graphics* (Proceedings of 1990 Symposium on Interactive 3D Graphics), **22**, 2 (March 1990): 235-244.

*Airey, J., J. Rohlf, F.P. Brooks, Jr. 1990: "Towards Image Realism with Interactive Update Rates in Complex Virtual Building Environments," *Computer Graphics, Proceedings of 1990 Symposium on Interactive 3D Graphics*, **24**, 2: 41-50, Snowbird, UT, March 1990. (Best paper award)

*Brooks, Jr., F.P. 1989: "UNC Walkthrough Project," *SIGGRAPH '89 Course #29 Notes*, "Implementing and Interacting with Real-Time Microworlds," pp. 1-1 to 1-4, 4-1 to 4-9.

Ouh-young, M., D.V. Beard, F.P. Brooks, Jr. 1989: "Force Display Performs Better Than Visual Display in a Simple 3-D Docking Task," *Proceeding of IEEE Robotics and Automation Conference*, Scottsdale, AZ, May 14-18: 1462-1466.

Chung, J.C., M.R. Harris, F.P. Brooks, Jr., H. Fuchs, M.T. Kelley, J. Hughes, M. Ouh-young, C. Cheung, R.L. Hallaway, M. Pique 1989: "Exploring Virtual Worlds with Head-Mounted Displays," *Non-Holographic True 3-D Dimensional Display Technologies, SPIE Proceedings*, **1083**, Los Angeles, CA, January 15-20.

Ouh-young, M., M. Pique, M. Harris, J. Hughes, N. Srinivasan, F.P. Brooks, Jr. 1988: "Force Display in Molecular Docking," Abstract in *Journal of Molecular Graphics*, **6**, 4 (December 1988): 224.

Brooks, Jr., F.P. 1988: "VIEW – Visualization Impromptu Evaluation Workbench," Invited address at the Seventh Annual Conference of the Molecular Graphics Society, San Francisco, CA, August 10-12. Abstract in *Journal of Molecular Graphics*, **6**, 4 (December): 223.

*Brooks, Jr., F.P. 1988: "Grasping Reality Through Illusion – Interactive Graphics Serving Science." Invited keynote address at Conference on Human Factors in Computing Systems, Washington, D.C., May 17. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, May 1-11. E. Solloway, D. Frye, and S. Sheppard, eds. Reading, MA: Addison Wesley, 1988.

- *Brooks, Jr., F.P. 1987: "The Newly Burning Bush." Invited address at Hypertext 87 in Chapel Hill, NC.
- *Brooks, Jr., F.P. 1986: "Walkthrough— A Dynamic Graphics System for Simulating Virtual Buildings," *1986 Workshop on Interactive 3D Graphics*. S. Pizer and F. Crow, eds. University of North Carolina at Chapel Hill, October 1986.
- *Brooks, Jr., F.P. 1986: "People Are Our Most Important Product," *Software Engineering: The Educational Needs of the Software Community*. R.E. Fairley and N. Gibbs, eds. New York: Springer-Verlag, 1987. (Keynote address, Software Engineering Education Workshop, Software Engineering Institute, 1986.)
- *Brooks, Jr., F.P. 1986: "No Silver Bullet— Essence and Accidents of Software Engineering," *Information Processing 86*. H.J. Kugler, ed. Amsterdam: Elsevier Science Publishers B.V. (North Holland): 1069-1076. (Invited paper, International Federation of Information Processing (IFIP) Congress '86, Dublin, Ireland, September 1986.) Reprinted in *Computer*, **20**, 4 (April 1987) 10-19. Also reprinted in *The Mythical Man-Month, Anniversary Edition*, Frederick P. Brooks, Jr., Addison-Wesley, 1995.
- Brooks, Jr., F.P. 1985: "The Technical Feasibility of Software for the Strategic Defense Initiative," 8th International Conference on Software Engineering, London, August 1985.
- Fuchs, H., J. Goldfeather, J.P. Hulquist, S. Spach, J.D. Austin, F.P. Brooks, Jr., J.G. Eyles, J. Poulton 1985: "Fast Spheres, Shadows, Textures, Transparencies, and Image Enhancement in Pixel-Planes," *Computer Graphics*, **19**, 3 (July 1985): 111-120.
- *Brooks, Jr., F.P. 1985: "UNC Graphics Sampler," Videotape, 1985 SIGGRAPH Conference, July 1985.
- *Brooks, Jr., F.P. 1984: "UNC Graphics Sampler," Videotape, 1984 SIGGRAPH Conference, July 1984.
- *Brooks, Jr., F.P. 1984: "Growing versus Building Software," *7th International Conference on Software Engineering*, March 25. Invited paper.
- Brooks, Jr., F.P. 1983: "Office Automation: Which Way Forward?— A Taxonomy of Office Functions," *Proceedings of the SHARE European Association (25th) Anniversary Meeting*, September 26-30: 247-252. Invited lecturer.
- *Brooks, Jr., F.P. 1982: "Views of Unseen Worlds— Visualizing Abstractions Through Computer Graphics." Keynote Lecture for *Science Magazine's* conference "Computers in Science," December 1982.
- *Pique, M., J.S. Richardson, F.P. Brooks, Jr. 1982: "What Does a Protein Look Like?" Invited videotape presented at 1982 SIGGRAPH Conference, July 1982.
- *Britton, E., J.S. Lipscomb, M. Pique, W.V. Wright, F.P. Brooks, Jr. 1981: "The GRIP-75 Man-Machine Interface." Invited videotape presented at 1981 SIGGRAPH conference, August 1981.
- Fuchs, H., S. Pizer, J.S. Cohen, F.P. Brooks, Jr. 1980: "A Three-Dimensional Display for Medical Images from Slices," *Information Processing in Medical Imaging (Proc. VIth International Conference on Information Processing in Medical Imaging, Paris, France, July, 1979)*, INSERM 1980.
- Brooks, Jr., F.P. 1978: "Response on APL." Videotape presented at ACM's History of Programming Languages Conference; Los Angeles, CA, June 1-3.
- *Brooks, Jr., F.P. 1977: "The Computer 'Scientist' as Toolsmith: Studies in Interactive Computer Graphics," *Information Processing '77*. B. Gilchrist, ed. North-Holland Pub. Co., Amsterdam: 625-634. (Invited paper, International Federation of Information Processing Congress '77, Toronto, Canada, August 1977.)
- Brooks, Jr., F.P. 1975: "Man-Machine Interface," *Computers and Communications: Implications for Education*. R.J. Seidel and M. Rubins, eds. New York: Academic Press, 1977: 371-373. (Proceedings of the Conference on Computer Technology in Education for 1985 at Airlie House, Warrenton, Virginia, September 15-18)

- *Brooks, Jr., F.P. 1976: "An Overview of Microcomputer Architecture and Software," *Proceedings of Second Euromicro Symposium on Microprocessing and Microprogramming*, North-Holland Pub. Co., Amsterdam: 1-3a. (Invited keynote address at Euromicro '76, Venice, Italy, October 1976.)
- Brooks, Jr., F.P. 1976: "What next in Data Processing?" *Data Management*, **14**, 7 (July 1976): 21. (Invited article)
- *Rossman, G.E., C.G. Bell, F.P. Brooks, Jr., M.J. Flynn, S.H. Fuller, H. Hellerman 1975: "A Course of Study in Computer Hardware Architecture," *Computer*, **8**, 12: 44-63.
- Brooks, Jr., F.P. 1974: "The Mythical Man-Month," *Datamation*, December 1974, 44-52.
- *Batter, J.J., F.P. Brooks, Jr. 1972: "GROPE-1: A Computer Display to the Sense of Feel," *Information Processing 71*, North-Holland Publishing Co., Amsterdam: 759-763. (Invited paper, IFIP Congress '71, Ljubljana, Yugoslavia, 1971.)
- Brooks, Jr., F.P. 1971: "Six Years of Experience with PL/I in University Teaching and Research," *Proceedings of IBM Germany Science Seminar* (Stuttgart, Germany).
- Brooks, Jr., F.P. 1971: "Computer Structures" – Past, Present, and Future: A Position Paper," Abstract in *AFIPS Conference Proceedings*, **39**: 395.
- Brooks, Jr., F.P. 1971: "Why is the Software Always Late?" *Data Management*, **9**: 18-21.
- *Prokop, J.S., F.P. Brooks, Jr. 1970: "Decision Making with Computer Graphics in an Inventory Control Environment," *AFIPS Conference Proceedings*, **37**: 599-607.
- Brooks, Jr., F.P. 1970: "Computer-Man Communication: Using Computer Graphics in the Instructional Process," *Advances in Computers*, 10. W. Frieberger, ed. New York: Academic Press: 149-173.
- Brooks, Jr., F.P. 1970: "Architecture and Structure of Information Systems," *Proceedings of the First International Conference on Man and Computer* (Institut de la Vie, Paris).
- Brooks, Jr., F.P. 1969: "Mass Memory in Computer Systems," *IEEE Transactions on Magnetics*, *MAG-5* (1969): 635-639. (Invited paper presented at Intermag Conference, Amsterdam.)
- *Oliver, P., F.P. Brooks, Jr. 1969: "Evaluation of an Interactive Display System for Teaching Numerical Analysis," *AFIPS Conference Proceedings*, **35**: 525-533.
- *Brooks, Jr., F.P., J.K. Farrell, T.M. Gallie 1969: "Organizational, Financial, and Political Aspects of a Three-University Computing Center," *Proceedings of IFIP Congress 1968* (Edinburgh): 923-927.
- *Parker, Jr., L.T., T.N. Gallie, F.P. Brooks, Jr., J.K. Farrell 1969: "Introducing Computing to Smaller Colleges and Universities – A Progress Report," *Communications of the ACM*, **12**: 319-323.
- Stevens, W.Y., F.P. Brooks, Jr. 1967: "Color Display System," *IBM Technical Disclosures Bulletin*, **10**, 1 (August 1967).
- Brooks, Jr., F.P. 1966: "Programming Systems and Programming Languages," *Proceedings of the Third Australian Computer Conference*, 3 (Canberra, Australia): 265-268.
- *Brooks, Jr., F.P. 1965: "The Future of Computer Architecture," *Proceedings of the IFIP Congress 1965*, 1 (New York): 87-91.
- *Brooks, Jr., F.P. 1964: *An Introduction to System/360 by Dr. F.P. Brooks, Jr.*, Campus Films, 50 minutes, color.
- *Blaauw, G.A., F.P. Brooks, Jr. 1964: "Outline of the Logical Structure," Part I of "Structure of System/360," *IBM Systems Journal*, **3**: 119-135.

*Amdahl, G.M., G.A. Blaauw, F.P. Brooks, Jr. 1964: "Architecture of the IBM System/360," *IBM Journal of Research and Development*, **8**: 87-101.

Brooks, Jr., F.P. 1963: "Recent Developments in Computer Organization," In *Advances in Electronics and Electronic Physics*, 18. L. Martin, ed. New York: Academic Press: 45-65.

Brooks, Jr., F.P. 1962: "Advanced Computer Organization: Addressing," *Proceedings of IFIP Congress 1962 (Munich)*: 564.

Beckman, F.S., F.P. Brooks, Jr., W.J. Lawless 1961: "Developments in the Logical Organization of Computer Arithmetic and Logical Units," *Proceedings of the IRE*, 49: 53-66. (Invited review paper for special computer issue.)

*Brooks, Jr., F.P. 1960: "The Execute Operations: A Fourth Mode of Instruction Sequencing," *Communications of the ACM*, **3**: 168-170.

*Brooks, F.P., Jr., G.A. Blaauw, W. Buchholz 1959: "Processing Data in Bits and Pieces," *IRE Transactions on Electronic Computers*, EC-8: 118-124.

*Brooks, Jr., F.P. 1957: "A Program-Controlled Program Interruption System," *Proceedings of the Eastern Joint Computer Conference*: 128.

*Brooks, Jr., F.P., A.L. Hopkins, Jr., P.G. Neumann, W.V. Wright 1957: "An Experiment in Musical Composition," *IRE Transactions on Computers*, EC-6: 175-182. Reprinted in S.M. Schwanauer and D.A. Levitt, eds. *Machine Models of Music*, MIT Press (1993): 23-42.

Brooks, Jr., F.P. 1956: "Management Problems of the Business Computer Installation," *IRE Transactions on Engineering Management*, EM-3: 60-63.

*Brooks, Jr., F.P. 1956: *The Analytic Design of Automatic Data Processing Systems*. Doctoral Dissertation, Harvard University, May 1956.

OTHER

Brooks, Jr., F. P., "Making and Measuring Effective Virtual Environments," Keynote speech at IEEE Virtual Reality 2005, Bonn, Germany, March 12-16, 2005.

Brooks, Jr., F. P., "Collaboration and Telecollaboration in Design," Turing Lecture at The British Computer Society / Institution of Electrical Engineers Meeting, London, England, January 20, 2005.

Brooks, Jr., F. P., "Human Motion in Virtual Environments for Team Training," Keynote speech at NATO Intelligent Motion and Interaction Within Virtual Environments Conference, London, UK, September 15-17, 2003.

Brooks, Jr., F.P., "Project Lessons Learned the Hard Way," Keynote speech at ASYNC 2003, Vancouver, Canada, May 12-16, 2003.

Meehan, M., M. Whitton, S. Razzaque, P. Zimmons, B. Insko, G. Combe, B. Lok, T. Scheuermann, S. Naik, J. Jerald, M. Harris, A. Antlye, F. P. Brooks, Jr. 2002: "Physiological Reaction and Presence in Stressful Virtual Environments." Exhibit and Demonstration in Emerging Technology in *Conference Abstracts and Applications*, SIGGRAPH 2002 (San Antonio, TX): 75.

Machover, C., et al., *The History of Computer Graphics*, film produced by SIGGRAPH and premiered at SIGGRAPH'99, Los Angeles, CA, August 8-14, 1999.

Brooks, Jr., F.P. , "What's Real about Virtual Reality?" Keynote speech at IEEE Virtual Reality '99 Conference in Houston, TX, March 13-17, 1999.

Brooks, Jr., F.P., "Is There Any Real Virtue in Virtual Reality?" Public lecture co-sponsored by the Royal Academy of Engineering and the British Computer Society, London, November 30, 1994.

Varshney, A., F.P. Brooks, Jr., W.V. Wright, "Interactive Visualization of Weighted Three-dimensional Alpha Hulls," 3rd Annual Video Review of Computational Geometry: Tenth Annual Symposium on Computational Geometry, Stony Brook, NY, June 6-8, 1994.

Brooks, Jr., F.P., Testimony before the U.S. Senate Subcommittee on Science, Technology, and Space, of the Committee on Commerce, Science, and Transportation, with videotape of demonstrations from UNC-Chapel Hill research, May 1991.

Brooks, Jr., F.P., Interview videotaped and excerpted, with illustrations from Walkthrough demonstrations, in the *SIGGRAPH Video Review*, vol. 60 (August 1990).

Brooks, Jr., F.P., Review of *Computer Structures: Readings and Examples* by C. Gordon Bell and Allen Newell. New York: McGraw-Hill, 1971. *Computing Reviews* 12: 245-248, 1971.

Brooks, Jr., F.P., *The IBM System/360 Computer Family*, film, IBM Corporation, Armonk, NY, 1 hr., 1964.

Brooks, Jr., F.P., P. Calingaert, "A Functional Unit Notation for Punched Card Systems." The Computation Laboratory of Harvard University, March 1956.

Numerous other reviews in *IRE Transaction on Electronic Computers* and *Computing Reviews*.

Numerous unpublished lectures to universities, ACM chapters, business groups.