

# Curriculum Vitae

## Robert Glenn Scharein

December 4, 2007

Mailing Address: *available upon an email request*

Phone: *available upon an email request*

email: [rob@knotplot.com](mailto:rob@knotplot.com)

web: [knotplot.com](http://knotplot.com) [hypnagogic.net/rob](http://hypnagogic.net/rob)

Citizenship: Canadian

## 1 Academic information

**Ph.D. (Computer Science)**, The University of British Columbia, 1998

Research areas: topological drawing, computer graphics and art, graphical user interface design, mathematical and scientific visualization, computational knot theory, biomedical imaging, computer vision

Dissertation *Interactive Topological Drawing* available at [knotplot.com/thesis](http://knotplot.com/thesis)

**M.Sc. (Astronomy)**, The University of British Columbia, 1985

Research areas: automated image analysis, theoretical and observational cosmology, general relativity, radio astronomy

Scholarships: 1984–1986 N.S.E.R.C. Postgraduate Scholarship, 1981–1983 N.S.E.R.C. 1967 Science Scholarship

**B.Sc. (Honours Physics)**, The University of Manitoba, 1981

Research areas: physics of low temperature metals, nuclear and atomic physics, general relativity

Awarded the Allen Medal for highest standing in Honours Physics graduating class

## 2 Relevant Skills & Experience

### 2.1 Research areas

**generative art and design** — Created an innovative method of interactive computer aided design, called *topological drawing*, that has been useful in generating new architectural and sculptural forms.

**experimental mathematics and biology** — Active in collaborations with mathematicians, biologists, and physicists in problems related to polymer physics and molecular biology.

**real time computer graphics** — Implemented many simulation and animation applications using OpenGL and other graphics libraries. These tools were designed to work consistently across different computer architectures (SGI, Linux, Microsoft Windows and MacOSX).

**virtual environments** — Developer of several sophisticated applications to work in 3D virtual environments, either “fishtank” virtual reality, or immersive virtual reality (such as a CAVE). Excellent knowledge of CAVElib and other VR toolkits. Good understanding of VRML, X3D, and related technologies.

**visualization** — Thorough knowledge of visualization techniques, especially of mathematical objects in three and four dimensions. Developer of the software KnotPlot ([knotplot.com](http://knotplot.com)), widely used by knot theorists, knot enthusiasts, teachers, and others to simulate, interact with, and visualize mathematical knots. Also developed other software to create and visualize polyhedra, planar tilings, mazes and labyrinths, and 3D architectural models.

**image processing / computer vision** — Developed and implemented algorithms for automated image analysis of 3D confocal microscope imagery. Experience implementing computer vision (high & low level) algorithms.

**document processing** — Created software packages for automated document classification and analysis.

**computer human interaction** — Developed graphical user interfaces for both the standard desktop and 3D virtual environments. The latter also involved gestural input with the use of a six degree of freedom input device.

## 2.2 Electronic Media Design

**publishing technologies** — Moderate to expert knowledge of electronic publishing technologies, including PDF, XHTML, CSS, CGI-scripting, XML, SVG, MathML, among others.

**KnotPlot Site** — A visual exploration of knotting and tangling, located at [knotplot.com](http://knotplot.com), The KnotPlot Site was named site of the week at American Scientist Online, July 06, 2004, [www.americanscientist.org/template/AssetDetail/assetid/34991](http://www.americanscientist.org/template/AssetDetail/assetid/34991) and has won recognition from other journals (editor's choice at *Science* and *Scientific American*) and science museums. It is the first link in the Canadian Mathematical Society's *Knot a Braid of Links* list of "cool math sites of the week" ([www.cms.math.ca/Kabol/knotlinks.html](http://www.cms.math.ca/Kabol/knotlinks.html))

**knowledge representation** — Some experience with digital knowledge representation, especially in mathematics (eg. OpenMath).

## 2.3 Mentoring

I have a long experience with mentoring both graduate and undergraduate students in Computer Science. However, two recent groups of non-CS students proved to be a valuable mentoring experience (for both sides).

**Affectionate Computing Group** — This group met regularly at NewMIC<sup>1</sup> and in the Interactivity Lab at SFU/Surrey, under the research direction of Thecla Schiphorst (SFU/Surrey) and Alan Boykiw (NewMIC/Emily Carr Institute). Members of the group were approximately six students from Emily Carr (final year design program), and several students from SFU/Surrey. The term "affectionate computing" (due to Thecla Schiphorst) was used to describe the wide ranging interests and focus of the group. These included the design of wearable computing equipment, novel input devices, and the general rethinking of how we interact with technology.

**BCIT Students** — This team consisted of five students from the British Columbia Institute of Technology and was under the guidance of Alan Boykiw (Emily Carr) and myself. We had a number of goals, but finally settled on designing a low cost (under \$150) wand interface to KnotPlot. This was successfully integrated with KnotPlot using some interface software that the students wrote. The device worked very well, and we have plans at some point to extend this work. Some images and movies from the students' final presentation can be found at [www.cecm.sfu.ca/~scharein/projects/tracker](http://www.cecm.sfu.ca/~scharein/projects/tracker)

## 2.4 Software Development

**programming languages** — Expert knowledge of C/C++, PostScript, Java, JavaScript,  $\text{\TeX/L\AT\TeX}$ , and META FONT. Moderate knowledge of PHP, Python, Lisp, Scheme, and Prolog.

**mathematics** — Developer of KnotPlot, a large software system widely used for research in experimental knot theory and for teaching purposes (from high school math courses to graduate courses in topology to courses in art design). KnotPlot is freely downloadable from [knotplot.com/download](http://knotplot.com/download)

**web-based tools for physics and astronomy** — Developed a suite of applets for instructional use in undergraduate physics and astronomy courses. Some of these were designed to be "open-ended", in the sense that a fair amount of play and experimentation could be performed, even by one already familiar with the physical concepts being simulated. The applets are online at [www.astro.ubc.ca/~scharein/applets](http://www.astro.ubc.ca/~scharein/applets) and are still being used in several courses in the Dept. of Physics and Astronomy at UBC.

## 2.5 Science and Math outreach

During my graduate career up to the present, I've given demonstrations and lectures to hundreds of students (ranging in age from pre-school to university) and to the general public. Most, but not all, of these demonstrations have centred around KnotPlot and knot theory. Knots prove to be an good subject to engage young people and interest them in mathematics, being very familiar everyday objects.

---

<sup>1</sup>The New Media Innovation Centre, in Vancouver (now closed)

## 3 Recent, Current, and Future Projects

### 3.1 The Knot Project

The Knot Project uses widespread cultural familiarity with knotting, braiding, and weaving to introduce beautiful and scientifically important mathematics to people who might otherwise not be open to thinking mathematically. The team consists of myself and two US colleagues (Greg Buck and Jonathan Simon). We have been working since 1997 to design and build a large scale museum exhibit on knots. This would include all aspects of knotting and tangling: mathematical and physical knots, fishing and climbing knots, hair braiding, macramé, and tangled extension cords. In addition to the exhibit, we also plan a film, extensive science outreach (web-based and other), and computer games related to the Knot Project. The Knot Project has generated considerable interest from science museums (most notably the Museum of Science in Boston) and preliminary funding from the National Science Foundation has been obtained. We've also worked with a film crew and have discussed film ideas with a leading director of historical and scientific films.

General information on the Knot Project can be found at the web site [knots.org](http://knots.org) and some exhibit plans and the motivation for the project at [knots.org/exhibit](http://knots.org/exhibit)

### 3.2 Software Development

**Advanced Visualization Suite (AVS)** — This is a collection of applications designed to work across a wide range of computer visualization platforms, from visually rich display environments (eg. immersive virtual reality in a CAVE) to the average desktop computer. It was also my goal to enable these applications to allow sophisticated remote collaboration between two or more users. Most of the initial work for the AVS was done during my time at NewMIC (2003) and was successfully running in the Immersive Media Lab (IML) there. Of all the tools in the AVS, the most sophisticated is an virtual reality version of KnotPlot, *caveKnotPlot*. Videos of *caveKnotPlot* running in the CAVE at NewMIC can be found at the web site [www.cecm.sfu.ca/~scharein/projects/caveKnotPlot](http://www.cecm.sfu.ca/~scharein/projects/caveKnotPlot) and more information about the AVS is at ([www.cecm.sfu.ca/~scharein/avs.html](http://www.cecm.sfu.ca/~scharein/avs.html)).

**coKnotPlot** — A collaborative version of KnotPlot. Initial versions of coKnotPlot were implemented in early 2004 using the networking software SWAN, developed by Panthesis Incorporated. coKnotPlot provides a rich form of collaboration (i.e. more than sharing the same view). Remote users can inhabit the same data space, but see different views of the data. Several different interaction modes were under exploration and need more study and testing.

**NP** – NP for “new perspectives”, this project is in its early stages. NP proposes a new kind of gaming environment, one that allows for unusual, possibly non-Euclidean, or perhaps even “impossible” perspectives. The motivation is to liberate gaming environments from the traditional Euclidean space-time model, and to explore what happens when much more general kinds of spaces are allowed, for example, the spaces envisioned by Escher, Tanguy, Dali, or a Chinese landscape painting. The latter was one of my main interests during my involvement with Xing Xing (see Section 4.3). A problem is finding formal descriptions of abstract worlds, so that they may be implemented on a computer. A prototype using one approach to this problem was implemented at NewMIC in the virtual reality lab.

## 4 Relevant Work Experience

### 4.1 Research

**Freelance Graphics and Visualization Specialist** — Hypnagogic Software, February 2005 to present. Worked on various projects including statistical analysis of textual documents. Continued research in experimental knot theory and molecular biology.

**Visiting Scholar** — Department of Mathematics, The University of Iowa, July/August 2006, Obermann Center for Advanced Studies, The University of Iowa, May/June 2005.

Project *Computer visualization and identification of DNA knots and links*, collaboration with Isabel K. Darcy ([www.math.uiowa.edu/~idarcy](http://www.math.uiowa.edu/~idarcy)) and Stephen D. Levene ([www.utdallas.edu/biology/faculty/research/levene.html](http://www.utdallas.edu/biology/faculty/research/levene.html))

Obermann Center: [www.uiowa.edu/~obermann](http://www.uiowa.edu/~obermann) [news-releases.uiowa.edu/2005/june/060305obermann-awards.html](http://news-releases.uiowa.edu/2005/june/060305obermann-awards.html)

**Collaboration and Visualization Researcher** — WestGrid ([westgrid.ca](http://westgrid.ca)), December 2003 – September 2004.

Duties included developing distributed visualization tools as well as integrating these tools into WestGrid's Access Grid ([www.accessgrid.org](http://www.accessgrid.org)) environment. Implemented a collaborative version of KnotPlot, coKnotPlot.

**Research Scientist** — New Media Innovation Centre (NewMIC), January 2003 – November 2003.

Developed the Advanced Visualization Suite (AVS) for the Immersive Media Lab at NewMIC, including an immersive virtual reality version of KnotPlot, caveKnotPlot. Also conducted extensive research on astronomical virtual observatories.

AVS: [www.cecm.sfu.ca/~scharein/avs.html](http://www.cecm.sfu.ca/~scharein/avs.html)

caveKnotPlot: [www.cecm.sfu.ca/~scharein/projects/caveKnotPlot](http://www.cecm.sfu.ca/~scharein/projects/caveKnotPlot)

**Research Associate** — Centre for Experimental and Constructive Mathematics (CECM), Simon Fraser University, April 2001 - present (currently adjunct).

On going research in computational knot theory and mathematical visualization.

**Postdoctoral Fellow** — The Pacific Institute for the Mathematical Sciences, January 1999 – October 1999.

Continued doctoral research in experimental knot theory.

## 4.2 Teaching and Curriculum Development

**Sessional Lecturer** — Department of Electrical and Computer Engineering, The University of British Columbia, January 2002 – April 2002.

Project-based final year computer graphics course, Supervised about a dozen different project groups (two to four students each). Projects involved visualizing a physical or engineering concept from the students' other courses.

**Sessional Lecturer and/or Lab Instructor** — Department of Computer Science, The University of British Columbia, January 2001 – December 2001, January 1999 – December 1999.

Fourth year computer graphics course.

**Research Assistant/Associate** — Department of Physics and Astronomy, The University of British Columbia, October 1997 – April 2002.

Developed WWW site and numerous Java applets for use in astronomy and physics tutorials (located at [www.astro.ubc.ca/~scharein/applets](http://www.astro.ubc.ca/~scharein/applets)).

**Faculty** — Department of Mathematics and Science, Douglas College, September 1988 – December 1988.

Instructor for first year physics course.

## 4.3 Consulting

**Project Consultant** — January 2003 – April 2004.

Consultant for a group of BCIT students who developed a low cost 3D input device for KnotPlot, using computer vision techniques, [www.cecm.sfu.ca/~scharein/projects/tracker](http://www.cecm.sfu.ca/~scharein/projects/tracker)

**Chief Scientist** — Xing Xing Computer Graphics Inc, May 2000 – June 2001.

Xing Xing is a developer of computer games with an Asian theme. We were in the process of designing several games based on the history of the Yuan Ming Yuan garden (the Old Summer Palace) in Beijing. I consulted with Xing Xing during their pre-funding phase. Information on an earlier product from Xing Xing can be found at [www.cs.ubc.ca/spider/wang](http://www.cs.ubc.ca/spider/wang).

## 5 Selected Publications

Gregory Buck, Robert G. Scharein, Jeffrey Schnick, and Jonathan Simon. Accessibility and occlusion of biopolymers, ray tracing of radiating tubes, and the temperature of a tangle. *Physical Review E*, 2007 (accepted).

Alexandre A. Vetcher, Alexander Y. Lushnikov, Junalyn Navarra-Madsen, Robert G. Scharein, Yuri L. Lyubchenko, Isabel K. Darcy, and Stephen D. Levene. DNA topology and geometry in Flp and Cre recombination. *J Mol Biol.*, 357(4):1089–1104, 2006.

Isabel K. Darcy and Robert G. Scharein. TopoICE-R: 3D visualization modeling the topology of DNA recombination. *Bioinformatics*, 22(14):1790–1791, 2006.

Gregory Buck, Jonathan Simon, and Robert G. Scharein. Physical knot theory. *Scientific American*. (accepted).

Eric J. Rawdon and Robert G. Scharein. Upper bounds for equilateral stick numbers. *Contemporary Mathematics*, 304:55–75, 2002.

Robert G. Scharein and Kellogg S. Booth. Interactive knot theory with KnotPlot. In *Multimedia Tools for Communicating Mathematics*, pages 277–290. Springer-Verlag, Berlin, Heidelberg, 2002.

Robert G. Scharein. *Interactive Topological Drawing*. PhD thesis, Department of Computer Science, The University of British Columbia, 1998.

Vsevolod Katritch, Jan Bednar, Didier Michoud, Robert G. Scharein, Jacques Dubochet, and Andrzej Stasiak. Geometry and physics of knots. *Nature*, 384(6605):142–145, 14 November 1996.

Robert G. Scharein, Kellogg S. Booth, and James J. Little. 3-D neuron tracing from confocal microscope data using a head-coupled display. In *SPIE Symposium on 3-D Microscopy*, February 1994.

Robert Glenn Scharein. AOLP: an automatic object location program. Master’s thesis, Department of Geophysics and Astronomy, University of British Columbia, 1984.

## 6 Invited Conference Presentations

*Experimental knot theory with KnotPlot* — Knots in Vancouver: Workshop in Knot Theory and 3-manifolds, Vancouver, BC, July 2004 [www.pims.math.ca/science/2004/KT3Mwksp](http://www.pims.math.ca/science/2004/KT3Mwksp)

*Experimental knot theory with KnotPlot* — Experimental Mathematics Workshop, Oakland, California, March 2004 [crd.lbl.gov/~dhbailey/expmath/workshop.html](http://crd.lbl.gov/~dhbailey/expmath/workshop.html)

*Tying Topology Tools Together* — 5th International Congress on Industrial and Applied Mathematics (ICIAM 2003) Sydney, Australia, July 2003, [www.iciam.org/iciam2003](http://www.iciam.org/iciam2003)

*caveKnotPlot, coKnotPlot, audKnotPlot* — AMS Special Session on Physical Knot Theory, San Francisco, California, March 2003

*Topological Drawing Applications in Architecture* — NEXUS 2002: Relationships Between Architecture and Mathematics, Óbidos, Portugal, June 2002, [www.emis.unne.edu.ar/journals/NNJ/2002](http://www.emis.unne.edu.ar/journals/NNJ/2002)

*Topological Drawing using KnotPlot* — Electronic Media in Mathematics, Coimbra, Portugal, September 2001

*Interactive Knot Theory with KnotPlot* — Multimedia Tools for Communicating Mathematics, Lisbon, Portugal, November 2000

*Interactive topological drawing* — First Canada–China Mathematical Congress, Beijing, China, August 1999

*The Knot Project: Linking the cultural and scientific ways of knowing* — Association of Science and Technology Centers (ASTC) annual meeting, Edmonton, Alberta, October 1998 (presentation together with Greg Buck)

Plenary talk on relationship of my work to that of artist and knot tyer Clifford Ashley — Ashley Retrospective & IGKT Meeting International Guild of Knot Tyers (North American Branch), New Bedford Whaling Museum, New Bedford, Massachusetts, August 1997

*Using KnotPlot for Experiments in Knot Theory* — Workshop on Computational and Algorithmic Methods in Three Dimensional Topology, Mathematical Sciences Research Institute, Berkeley, California, March 1997, [www.msri.org/activities/events/9697/comp\\_top](http://www.msri.org/activities/events/9697/comp_top)

## 7 Exhibits and Artistic Projects

Cover art for *Quadrature*, Magazine de mathématiques pures et épicées, Octobre–Décembre 2004

Computer animation and other artwork for the film *porridge pulleys and Pi* directed by George Paul Csicsery and produced by Mathematical Sciences Research Institute (MSRI), 2004, [www.msri.org](http://www.msri.org)

*Mathematics and Knots* — Knot exhibit, together with Paul Hamilton and Keith Taylor, Gordon Snelgrove Art Gallery, University of Saskatchewan, January 2002 [math.usask.ca/~taylor/knots](http://math.usask.ca/~taylor/knots)

Cover art and other graphics for article by Ivars Peterson, *Science News*, 8 December 2001

Cover art for the Newsletter of the Korean Mathematical Society, November 2000

Cover art and other illustrations for the book *Life by the Numbers* by Keith Devlin, John Wiley & Sons, 1998

Artwork for premiere issue of *Illumine*, published by The University of Iowa, April 1998.

Computer graphics for special issue on knots entitled *La Science des Nœuds* appearing in *Dossier Pour la Science* (Édition Française de Scientific American), April 1997.

Illustrations for article by Gregory Buck. Why “Knot”? *Odyssey*, 6(7):8–12, October 1997.

Cover art for *Science Lessons* by William H. New. Oolichan Books, Lantzville, British Columbia, 1996.

Computer graphics for U.B.C. Continuing Studies Calender, Winter session, 1995/96.

Live multi-media jazz improvisation, together with Roland Haynes, Tom Berryhill, Jeff Koftinoff, and Malcolm Warwick. Real-time driving of KnotPlot graphics via a MIDI stream originating from the keyboard player. Had one public performance. Centre for Image and Sound Research (CI★SR), Vancouver B.C., November 1994, (details at [www.cecm.sfu.ca/~scharein/projects/jazz](http://www.cecm.sfu.ca/~scharein/projects/jazz))

## 8 References

Dr. André Roberge  
President and Vice-Chancellor  
Université Sainte-Anne  
Church Point, N.S. B0W 1M0

email: [andre.roberge@usainteanne.ca](mailto:andre.roberge@usainteanne.ca)  
web: [www.usainteanne.ca/a\\_propos/admin.php](http://www.usainteanne.ca/a_propos/admin.php)  
Phone: 902 769 2114  
Fax: 902 769 3120

Dr. Dale Rolfsen  
Professor  
Department of Mathematics  
The University of British Columbia  
Room 121, 1984 Mathematics Road  
Vancouver, B.C. V6T 1Z2

email: [rolfsen@math.ubc.ca](mailto:rolfsen@math.ubc.ca)  
web: [www.math.ubc.ca/~rolfsen](http://www.math.ubc.ca/~rolfsen)  
Phone: 604 822 6324  
Fax: 604 822 6074

Dr. Jonathan Simon  
Professor  
Department of Mathematics  
University of Iowa  
Iowa City, Iowa 52242

email: [jsimon@math.uiowa.edu](mailto:jsimon@math.uiowa.edu)  
web: [www.math.uiowa.edu/~jsimon](http://www.math.uiowa.edu/~jsimon)  
Phone: 319 335 0768  
Fax: 319 335 0627