Natural Sciences and Engineering Research Council of Canada | Conseil de recherches en sciences naturelles et en génie du Canada

Date 2012/07/29

Notification of Intent to Apply for a Discovery Grant

Avis d'intention de présenter une demande de subvention à la découverte

APPLICANT / CANDIDAT

Family name / Nom de famille	Given name / Prénom	Initial(s) of all given names / Initiale(s) de tous les prénoms	Personal identification no. (PIN) / N° d'identification personnel (NIP)
Bridson	Robert	RE	**Valid/Valide** 214193

Department / Département	Institution / Établissement
Computer Science	British Columbia

E-mail address / Adresse de courriel
rbridson@cs.ubc.ca

Degrees Diplômes	Discipline Discipline	Institution Établissement	Supervisor Directeur de travaux	Year Année
Master's / Maîtrise	Computer Science	Waterloo	Wei-Pai Tang	1999
Doctorate / Doctorat	Scientific Computing & Computational Math	Stanford University	Ronald Fedkiw	2003

EVALUATION GROUP ASSIGNMENT / ASSIGNATION DU GROUPE D'ÉVALUATION

Suggest the number of the evaluation group you feel should review your application. / Entrez le numéro du groupe d'évaluation qui selon vous devrait évaluer votre demande.

1507 Computer Science

APPLICATION INFORMATION / RENSEIGNEMENTS SUR LA DEMANDE

Title of proposal / Titre de la proposition
Numerical and Geometric Algorithms for Virtual Practical Effects

TYPE OF APPLICATION / TYPE DE DEMANDE

- Individual / Individuelle: X
- Team / Équipe:
- Subatomic Physics / Physique subatomique:

The application will be submitted in / La demande sera présentée en [X] English / anglais [ ] français / French

Research topic(s) that describe the proposed research / Sujet(s) de recherche décrivant la recherche proposée

CS19 - Computer Graphics and Visualization
CS03 - Mathematical Computing
MS12 - Numerical Analysis
MS22 - Computational Methods

KEY WORDS that best describe the proposed research / MOTS CLÉS qui décrivent le mieux la recherche proposée

numerical methods, animation, visual effects, computational geometry

Personal Information Bank Number: SER/P-PU-095.
For information on the *Privacy Act*, consult the current NSERC *Program Guide for Professors.*

N° du fichier de renseignements personnels : RSG/P-PU-095.
Pour obtenir de l'information sur la Loi sur la protection des renseignements personnels, consultez le plus récent *Guide des programmes destiné aux professeurs* du CRSNG.

Canada

Valid/Valide 214193	Bridson, RE (Robert)

SUMMARY OF PROPOSAL / RÉSUMÉ DE LA PROPOSITION

In the space provided below, state the objectives of the proposed research project and summarize the scientific approach, highlighting the novelty and expected significance of the work to a field or fields in the natural sciences and engineering. Note that NSERC supports research in the natural sciences and engineering (other than the health sciences).

Dans l'espace prévu ci-dessous, énoncez les objectifs du projet de recherche proposé et résumez la démarche scientifique, en soulignant l'originalité et l'importance prévue des travaux dans un ou plusieurs domaines des sciences naturelles ou du génie. Veuillez noter que le CRSNG appuie la recherche dans le domaine des sciences naturelles et du génie, à l'exception des sciences de la santé.

In my 2010 Science article, I coined the term 'virtual practical effects' to describe a steadily emerging way for technical artists to create digital effects for film: supported by physics-based simulations of adequate fidelity, they can use their natural intuition to virtually build 'physical' mechanisms to create the desired effects. This is much more productive than than laboriously modelling everything at a low level. For example, synchronized crashing ocean waves in Avatar were produced by virtual wave generators modelled after the real thing, running in a physical simulation of the water I helped write.

The scope in which artists can work this way is now still quite limited. This research program will push the frontiers of how capable and usable physics-based simulators can be, extending both what can be modelled (e.g. more detailed fluid-solid interaction, surface-tension-dominated scenarios) and the scale of what is tractable (e.g. tackling violent ocean storms with detailed interaction between water and characters). Primarily this will involve advances in core numerical and geometric algorithms together with development of the right mathematical models of the phenomena in question, but effective high-performance parallel implementation will also play an important role.

Some of the projects I will work on have a computational geometry flavour, such as provably robust collision resolution and more effective surface tracking using dynamic meshes. Others will be more in line with numerical linear algebra and optimization: flexible linear and nonlinear (but Jacobian-free) conjugate-gradient-like solvers appropriate for parallel black-box multiphysics coupling, algebraic domain decomposition preconditioners for fluid-solid interaction and other multi-domain problems. Others will involve more work on the modeling level, but also involve interesting numerical methods for solving partial differential equations: vortex sheet methods for fluid flow and their coupling with solid mechanics, boundary element methods for fracture mechanics. Throughout there will be a focus on the nontraditional needs of the application to computer animation, with system-related requirements (such as the nature of the user interaction) informed by my strong connections to the visual effects industry.

Valid/Valide 214193	Bridson, RE (Robert)

REFEREE SUGGESTIONS / EXAMINATEURS SUGGÉRÉS

Before completing the following section, refer to the instructions.

Referees **should be** capable of reviewing your application in the language in which it is written.

Avant de remplir la section suivante, consultez les instructions.

Les examinateurs **devraient pouvoir** étudier votre demande dans la langue de présentation.

BY THE APPLICANT PAR LE CANDIDAT	Area(s) of expertise Domaine(s) d'expertise	BY THE EVALUATION GROUP PAR LE GROUPE D'ÉVALUATION
A Turk, G (Greg) College of Computing Georgia Institute of Technology 85 5th Street NW Atlanta, GA, UNITED STATES 303320760 1 (770) 492-1219 turk@cc.gatech.edu	computer graphics, physics-based animation, fluid simulation	**1** PIN / NIP: Lang.
B James, DL (Doug) Computer Science Cornell University 5146 Upson Hall Ithaca, NY, UNITED STATES 148537501 1 (607) 2559215 djames@cs.cornell.edu	computer graphics, physics-based animation, scientific computing	**2** PIN / NIP: Lang.
C Otaduy, MA (Miguel) Computer Science Universidad Rey Juan Carlos Madrid ETS Ingeniería Informática, URJC Edf. Ampliación Rectorado, D-0052 Móstoles, SPAIN 34 (914) 8881150 miguel.otaduy@urjc.es	computer graphics, physics-based animation, geometric algorithms, collisions	**3** PIN / NIP: Lang.
D Desbrun, M (Mathieu) Computing and Mathematical Sciences California Institute of Technology MS 305-16, California Inst. Technology 1200 E. California Boulevard Pasadena, CA, UNITED STATES 91125 1 (626) 3956230 mathieu@caltech.edu	computer graphics, geometric algorithms, physics-based animation, discrete differential geometry	**4** PIN / NIP: Lang.
E Gross, M (Markus) Computer Science ETH Zürich CNB G 109, Universitätstrasse 6 ETH Zentrum Zürich, SWITZERLAND 41 (446) 3271140 grossm@inf.ethz.ch	computer graphics, physics-based animation, fluid simulation	**5** PIN / NIP: Lang.

Robert Bridson: Contributions

Refereed Journal Articles

[J1] **Schecter, H.** and Bridson, R., *Ghost SPH for animating water*, accepted to ACM Trans. Graph.: Proc. SIGGRAPH 2012, 8 pages.

[J2] **Brochu, T.**, **Edwards, E.**, and Bridson, R., *Efficient geometrically exact continuous collision detection*, to appear in ACM Trans. Graph.: Proc. SIGGRAPH 2012, 7 pages.

[J3] **Boyd, L.** and Bridson, R., *MultiFLIP for energetic two-phase fluid simulation*, ACM Trans. Graph. 31 (2), 2012, 12 pages.

[J4] **Edwards, E.** and Bridson, R., *A high-order accurate particle-in-cell method*, Intl. J. Numerical Methods in Engineering, 2012, 20 pages.

[J5] **Nielsen, M.** and Bridson, R., *Guide shapes for high resolution naturalistic liquid simulation*, ACM Trans. Graph. 30 (3): Proc. SIGGRAPH, 2011, 7 pages.

[J6] **Brochu, T.**, **Batty, C.**, and Bridson, R., *Matching fluid simulation elements to surface geometry and topology*, ACM Trans. Graph. 29 (3): Proc. SIGGRAPH, 2010, 9 pages.

[J7] **Brochu, T.** and Bridson, R., *Robust topological operations for dynamic explicit surfaces*, SIAM J. Sci. Comput. 31 (4), 2009, pp. 2472–2493.

[J8] **English, E.** and Bridson, R., *Animating developable surfaces using nonconforming elements*, ACM Trans. Graph. 27 (3): Proc. SIGGRAPH, 2008, 5 pages.

[J9] Bridson, R., Hourihan, J., and Nordenstam, M., *Curl-noise for procedural fluid flow*, ACM Trans. Graph. 26 (3): Proc. SIGGRAPH, 2007, 3 pages.

[J10] **Batty, C.**, **Bertails, F.**, and Bridson, R., *A fast variational framework for accurate solid-fluid coupling*, ACM Trans. Graph. 26 (3): Proc. SIGGRAPH, 2007, 7 pages.

Refereed Conference Papers

[C1] **Brochu, T.**, **Keeler, T.**, and Bridson, R., *Linear-time smoke animation with vortex sheet meshes*, Proc. ACM/Eurographics Symp. Comp. Anim., 2012, 6 pages.

[C2] Misztal, M. K. Erleben, K., Bargteil, A., Fursund, J., Christensen B. B., Baerentzen, A., Bridson, R., *Multiphase flow of immiscible fluids on unstructured moving meshes*, Proc. ACM/Eurographics Symp. Comp. Anim., 2012.

[C3] Bhatacharya, H., Nielsen, M., and Bridson, R., *Steady state Stokes flow interpolation for fluid control*, to appear in Eurographics 2012, 4 pages.

[C4] **Misztal, M. K.**, Bridson, R., Erleben, K., Baerentzen, A., and Anton, F., *Optimization-based fluid simulation on unstructured meshes*, Proc. Virtual Reality Interaction and Physical Simulation (VRIPHYS), 2010, 10 pages.

[C5] **Batty, C.** and Bridson, R., *Accurate viscous free surfaces for buckling, coiling and rotating liquids*, Proc. ACM/Eurographics Symp. Comp. Anim., 2008, pp. 219–228.

[C6] **Schechter, H.** and Bridson, R., *Evolving sub-grid turbulence for smoke animation*, Proc. ACM/Eurographics Symp. Comp. Anim., 2008, 7 pages.

[C7] Bridson, R., *Fast Poisson disk sampling in arbitrary dimensions*, Proc. ACM SIGGRAPH Sketches (abstracts), 2007.

Refereed Conference Posters

[P1] Bridson, R., *SpikeNav: using stylus tilt in three-dimensional navigation*, ACM UIST Posters, 2009.

[P2] **Brochu, T.** and Bridson, R., *Animating smoke as a surface*, ACM/Eurographics Symp. Comp. Anim. Posters, 2009.

[P3] **Tsiknis, D.** and Bridson, R., *Cloth animation through unbiased strain limiting and physics-aware subdivision*, ACM/Eurographics Symp. Comp. Anim. Posters, 2006.

[P4] **Brochu, T.** and Bridson, R., *Fluid animation with explicit surface meshes*, ACM/Eurographics Symp. Comp. Anim. Posters, 2006.

Refereed Conference Course Notes

[N1] Bridson, R. and Mueller-Fischer, M., *Fluid simulation*, ACM SIGGRAPH Course Notes, 2007, 93 pages.

[N2] Bridson, R., Mueller-Fischer, M., and Guendelman, E., *Fluid simulation*, ACM SIGGRAPH Course Notes, 2006, 113 pages.

Invited Journal Articles

[I1] Bridson, R. and **Batty, C.**, *Computational physics in film*, Science, 2010 September 24: 330 no. 6012, pp. 1756–1757.

Books

[B1] Bridson, R., *Fluid simulation for computer graphics*, 2008, A. K. Peters Ltd., 246 pages.