Natural Sciences and Engineering
Research Council of Canada

Conseil de recherches en sciences
naturelles et en génie du Canada

# FORM 200
## Application for an
## NSERC Scholarship or Fellowship
## COVER PAGE

| AID |
| --- |
| CTTEE |
| Date |
| 2008/09/19 |

| Type of Award | Reference No. |
| --- | --- |
| PGS M | 90444776 |

| Family name of applicant | Given name | Initial(s) of all given names | Personal identification no. (PIN) |
| --- | --- | --- | --- |
| Sayles | Maxwell | MTS | |

**ADDRESSES. Changes to any of the information below must be sent to schol@nserc.ca.**

| Current address | Permanent mailing address (if different than current address) |
| --- | --- |
| 155 Windermere Rd SW<br>Calgary, AB<br>CANADA          T3C  3K9 | |
| If current address is temporary, indicate leaving date | Telephone number at permanent mailing address |

| Telephone number | Facsimile number | E-mail address     NSERC will use this information as the initial point of contact. |
| --- | --- | --- |
| (403) 990-8238 | | mtsayles@ucalgary.ca |

**CITIZENSHIP**

[X] Canadian citizen          [ ] Permanent resident of Canada          [ ] Other

Indicate date of landing as stated on official immigration document

Indicate country of citizenship

**LANGUAGE OF CORRESPONDENCE**

I wish to receive my correspondence in:

[X] English          [ ] French

**SIGNATURE (Refer to the instructions under the heading  "What does my signature on the application mean?")**

I hereby agree that any award made to me as a result of this application will be subject to the general conditions governing scholarships and fellowships. These conditions are outlined in this Web site in the NSERC *Program Guide for Students and Fellows,* and *Visiting Fellowships in Canadian Government Laboratories* guide.

Applicant's signature

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**Not Completed**

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**FORM 200**
**Application for an**
**NSERC Scholarship or Fellowship**

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| Sayles | Maxwell | MTS | |

## ACADEMIC BACKGROUND (include only current and past degree programs)

| Degree | Name of discipline | Department, institution and country | Month and year started | Month and year awarded/expected |
| --- | --- | --- | --- | --- |
| Bachelor's | Bachelor of Arts | Philosophy / Calgary, CANADA | 09 / 1999 | 06 / 2005 |
| Master's | Masters of Science | Computer Science / Calgary, CANADA | 01 / 2008 | 09 / 2010 |

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**FORM 200**
**Application for an**
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Date
2008/09/19

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| --- | --- | --- | --- |
| Sayles | Maxwell | MTS | |

## ACADEMIC, RESEARCH AND OTHER RELEVANT WORK EXPERIENCE

| Position held and nature of work (begin with current) Full Time - Part Time | Organization and department | Supervisor | Period (mm/yyyy-mm/yyyy) |
| --- | --- | --- | --- |
| Research Assistant - Full Time<br><br>Research for swarm based interactive systems | University of Calgary<br>Computing Science | Dr. Jeffrey Boyd | 01/2007<br>- 09/2007 |
| Software Engineer - Full Time<br><br>Security Software (Early warning systems and malicious software entrapment) | Symantec<br>Security Software and Research | Farzad Bakhtiar | 02/2005<br>- 01/2007 |
| Research Assistant - Part Time<br><br>Computer vision research for network based systems (during my B.A. in Philosophy) | University of Calgary<br>Computing Science | Dr. Jeffrey Boyd | 01/2001<br>- 02/2005 |
| Senior Developer - Full Time<br><br>Development and research for two Nintendo 64 Games: Tetrisphere and The New Tetris | Nintendo of America<br>Nintendo 64 Game Development | Chris Bailey | 08/1995<br>- 06/1999 |

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| Personal identification no. (PIN) | Family name, given name and initial(s) of applicant |
|---|---|
| | Sayles, Maxwell MTS |

## AWARD APPLIED FOR

| Type of award | Proposed starting date of award |
|---|---|
| Postgraduate Scholarships - PGS M | 2008/09 |

| Proposed degree program (e.g. Bachelors, Masters, Doctorate) | Proposed field of study/research | Primary research subject code | Secondary research subject code |
|---|---|---|---|
| Master's | Software and development | 2705 | 3000 |

Title of proposed research (not required for VF applicants)
Simulating Adaptive Markets with Markov Games

List ten (10) key words that describe your proposed research. Use commas to separate them. (Not required for VF applicants.)

markov chains, game theory, economics, markets, algorithms, optimization, complexity, theory, statistics, probability

## PROPOSED LOCATION(S) OF TENURE (in order of preference)

| Institution/organization | Department | Proposed supervisor |
|---|---|---|
| Calgary | Computer Science | Dr. Peter Hoyer |

## SECTION TO BE COMPLETED BY PGS, IPS, VANIER CGS AND MITACS APPLICANTS ONLY

Indicate the total number of months of graduate studies (master's and doctoral) you have completed as of December 31 of the year of application in the natural sciences and engineering.

_____ months of full-time studies                _____ months of part-time studies

Indicate the number of months of studies you have completed, as of December 31 of the year of application, **in the program for which you are requesting funding.**

12 months of full-time studies                0 months of part-time studies

Indicate if you are attending university at the time of application.

[X] Attending full time          [ ] Attending part time          [ ] Not attending

## SECTION TO BE COMPLETED BY PGS APPLICANTS ONLY

If you are offered an award, do you plan to take it up at a foreign university?

[ ] Yes          [X] No

If you answered yes to the previous question, do you still want to be considered for an Alexander Graham Bell Canada Graduate Scholarship and an André Hamer Postgraduate Prize, both of which are **tenable only in Canada?**

[ ] Yes          [ ] No

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## FORM 200
## Scholarships and Other Awards Offered

| Type of Award | Personal Identification no. (PIN) | Family name, given name and initial(s) of applicant |
|---|---|---|
| PGS M | | Sayles, Maxwell MTS |

### SCHOLARSHIPS AND OTHER AWARDS OFFERED (start with most recent and include NSERC awards)

| Name of Award | Value (CDN$) | Level Institutional, Provincial, National, International | Type Academic, Research, Leadership, Communication | Location of tenure | Period held (yyyy/mm - yyyy/mm) |
|---|---|---|---|---|---|
| Silver Medallion Phil. Highest GPA. | 0 | Institutional | Academic | University of Calgary | 2005/01 - 2005/12 |
| Research Assistanceship | 8,000 | Institutional | Research | University of Calgary | 2004/05 - 2004/08 |
| Calgary Tech. Centre (1st place) | 3,000 | Provincial | Research | University of Calgary | 2004/01 - 2004/12 |
| Research Assistanceship | 8,000 | Institutional | Research | University of Calgary | 2003/05 - 2003/08 |
| Owen Family Scholarship | 500 | Institutional | Academic | University of Calgary | 2003/01 - 2003/12 |
| Rhoda F. Blythe Philosophy | 1,800 | Institutional | Academic | University of Calgary | 2003/01 - 2003/12 |
| Jason Lang Scholarship | 1,000 | Institutional | Academic | University of Calgary | 2000/01 - 2000/12 |
| Calgary Tech. Centre (1st place) | 3,000 | Provincial | Research | Mount Royal College | 1994/01 - 1994/12 |
| Calgary Tech. Centre (2nd place) | 2,000 | Provincial | Research | Mount Royal College | 1993/01 - 1993/12 |
| Calgary Tech. Centre (2nd place) | 2,000 | Provincial | Research | Mount Royal College | 1990/01 - 1990/12 |

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**URGENT**

Please return to:

By date: (yyyy/mm/dd)

Type of award

PGS M

Date

2008/09/19

**APPENDIX 1
Report on the Applicant
NSERC Scholarship or Fellowship
(FORM 200)**

**Read the instructions before you complete this report.** For PGS applicants, use this page only.
For all other applicants, use one additional page if necessary.

In accordance with the *Privacy Act,* this report will be accessible to the applicant. This report, including your name, may also be disclosed to organizations whose fellowships are administered by NSERC and to partner agencies that offer supplements to NSERC awards.

| Family name of applicant | Given name | Initial(s) of all given names | Personal identification no. (PIN) |
|---|---|---|---|
| Sayles | Maxwell | MTS | |

Comment on the applicant's research ability/potential and on the applicant's communication, interpersonal and leadership abilities.

I have known the applicant in my capacity as _____ for _____ years.

**Print respondent's**

**Name:** _____

**Title:** _____

**Affiliation:** _____

☐ I have read the applicant's completed Form 200.

_____
Signature of respondent

Form 200 (2008 W), Appendix 1

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**APPENDIX 1**
**Report on the Applicant**
**NSERC Scholarship or Fellowship**
**(FORM 200)**

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| Family name of applicant | Given name | Initial(s) of all given names | Personal identification no. (PIN) |
|---|---|---|---|
| Sayles | Maxwell | MTS | |

Comment on the applicant's research ability/potential and on the applicant's communication, interpersonal and leadership abilities.

I have known the applicant in my capacity as _____ for _____ years.

**Print respondent's**

**Name:** _____

☐ I have read the applicant's completed Form 200.

**Title:** _____

**Affiliation:** _____

_____
Signature of respondent

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**APPENDIX 2**
**University Evaluation**
**NSERC Scholarship or Fellowship**
**(FORM 200)**

| Type of Award |
|---|
| PGS M |
| Date |
| 2008/09/19 |

Read the instructions before you complete this report. In accordance with the *Privacy Act,* this report will be accessible to the applicant. This report, including your name, may also be disclosed to organizations whose fellowships are administered by NSERC and to partner agencies that offer supplements to NSERC awards.

**PART I: APPLICANT INFORMATION**

| Family name | Given name | Initial(s) of all given names | Personal identification no. (PIN) |
|---|---|---|---|
| Sayles | Maxwell | MTS | |

| University (indicate if current or former)   ( current ) | University department |
|---|---|
| Calgary | Computing Science |

**PART II [FOR PGS AND VANIER CGS ONLY]: TO BE COMPLETED BY THE SCHOLARSHIPS LIAISON OFFICER**

Academic averages

Second last period  _____ / _____ (maximum)

Last period  _____ / _____ (maximum)

University ranking of applicant

_____ of _____

Comments on the qualities or factors that led to the ranking of the applicant by the university.

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naturelles et en génie du Canada

**APPENDIX 3**
**Consent Form and Statistical Information**
**NSERC Scholarship or Fellowship**
**(FORM 200)**

| Type of Award |
| --- |
| PGS M |
| Date |
| 2008/09/19 |

| Family name of applicant | Given name | Initial(s) of all given names | Personal identification no. (PIN) |
| --- | --- | --- | --- |
| Sayles | Maxwell | MTS | |

## CONSENT FROM THE APPLICANT

If you wish to be considered for other types of NSERC scholarships or fellowships offered by the Canadian government, companies and/or associations or for the Canada-U.K Millenium Research Award as described in the *Program Guide for Students and Fellows,* you must complete and sign this form. By completing and signing this section, you agree to have your application (including Appendices 1 and 2) disclosed to the interested institutions (see the *Access to Information Act* and the *Privacy Act,* under Policies and Guidelines in the *Program Guide for Students and Fellows* ).

**PDF APPLICANTS**

[ ] I am eligible and wish to be considered for a Canada-U.K. Millennium Research Award.

If your application is not successful but is judged to be meritorious, would you like to be considered for the

[ ] Visiting Fellowships (VF) program? [ ] Industrial R&D Fellowships (IRDF) program?

Note: Applicants interested in the IRDF program agree to have their name and the title of their proposed research posted on the NSERC Web site.

**SIGNATURE**

_____
Applicant's signature

How did you hear about this NSERC scholarship/fellowship program?
Professors and other graduate students

Did you attend an NSERC Scholarships and Fellowships Programs information session at your university in the autumn of the year of application?

[X] Yes [ ] No

## OPTIONAL INFORMATION

Information on gender and language capability is used for statistical purposes, and may be used to identify prospective NSERC peer reviewers. Information on certain designated groups (disabled, visible minority) is used by NSERC only for statistical purposes. Information on Aboriginal status is not seen by NSERC award selection committees; however, it may be used by NSERC to identify and make awards to Aboriginal applicants whose applications were judged to be meritorious, but which could not be recommended initially because of budget limitations. None of the information collected will be released to persons outside NSERC. For more information, see *the Access to Information Act* and the *Privacy Act.*

**GENDER (completion optional)** | **DESIGNATED GROUPS (completion optional)**

[X] Male [ ] Female | [ ] Aboriginal [ ] Visible minority [ ] Disabled

**LANGUAGE CAPABILITY (completion optional)**

English [X] Read [X] Write [X] Speak

French [ ] Read [ ] Write [ ] Speak

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# Simulating Adaptive Markets with Markov Games
## Maxwell Sayles

Financial markets have an inherent level of uncertainty, and as they become more accessible a growing number of people are impacted. Laws regarding automated order placement make market analysis performed by computer programs relevant for investment purposes, economic forecasting, and market stability. The field of Economics provides theories to explain how institutions can influence financial markets, and market simulations illustrate such theories by showing institutions the short and long term effects of implementing various actions. As a result, institutions can improve market stability and stimulate market growth.

Many opponents to market analysis subscribe to the Efficient Market Hypothesis – the hypothesis that the price of a traded asset intrinsically reflects all information about that asset. If this were true, then market simulations would provide us with no additional information. Some empirical evidence against this hypothesis is the slow diffusion of relevant information and the relative success of certain market participants. An emerging model by Lo[1], known as the Adaptive Markets Hypothesis, attempts to reconcile these anomalies with the efficiency of markets by applying evolutionary principles such as competition, adaptation, and natural selection. Using this hypothesis and principles of game theory[2], I intend to simulate the expected future value of an asset and its standard deviation, and use this as a model for the strategic actions of selfish agents.

Central to this research will be the concept of Markov chains[3] – a stochastic process with the property that the conditional probability distribution of a future state depends only on the present state and not on the past states. Assuming that markets are efficient, all the available information about an asset is specified by the price of the traded asset. The future state of an asset is then determined probabilistically by its present state. One possible model is to define the state of an asset to be the logarithmic increase or decrease of its traded value, effectively normalizing the value of an asset. A $t$-step chain now represents the probability of a logarithmic increase on step $t$ and not the value of the asset; as such, all paths of length $t$ need to be evaluated in order to compute the expected value of the asset and its standard deviation. This in turn specifies the probability distribution for an agent's actions and is the basis for the simulation.

The accuracy of this simulation can be computed by training the simulation on a window of historical market data and then measuring the distance from the known values outside of this window to the probability of the expected value and deviation given by the simulation. This measurement is an indication of the degree to which the simulation models the information present in the market. The model is then adapted in order to minimize this distance measurement and increase the amount of information reflected by the simulation.

The purpose of this research is to simulate a financial market under the Adaptive Markets Hypothesis, whereby strategies of market participants will be modelled using Markov chains trained on historical market data. In addition, this research may improve the accuracy and efficiency of simulating social systems, and provide insight into the stochastic processes of financial markets and the strategies of market participants. The measure of deviation in future expected value may correspond to the volatility of an asset and to market stability as a whole. Finally, knowledge about potential strategies and the direction of market movement can help decide interventionist policies that may be used to increase market stability or growth.

1. A. Lo, "The Adaptive Markets Hypothesis: Market Efficiency from an Evolutionary Perspective ", 2004.
2. N. Noam, T. Roughgarden, E. Tardos, and V. Vazirani, "Algorithmic Game Theory", 2007.
2. C. Grinstead and J. Snell, "Introduction to Probability: Second Revised Edition", 1997.

<div align="center">

**Contributions and Statement**
**Maxwell Sayles**

</div>

**Refereed Contributations**:

Boyd, J., Hushlak, G., Jacob, C., **Sayles, M.**, and Nuttyen, P. (2007) *SwarmArt: Interactive Art from Swarm Intelligence.* Leonardo. June 2007, Volume 40, Number 3: 248-254 (while in industry).

Boyd, J., Hushlak, G., Jacob, C., **Sayles, M.**, and Nuttyen, P. (2004) *SwarmArt: Interactive Art from Swarm Intelligence.* Proceedings of the 12th ACM International Conference on Multimedia, October 12-14, 2004, New York, NY, USA. ACM Press: 628-635 (during a B.A. in Phil.).

Boyd, J., **Sayles, M.**, Olsen, L., and Tarjan, P. (2004) *Internet broadcasting of hockey: a scale prototype.* SPIE Internet Imaging V, January 2004, Santa Jose, CA: 193-201 (during a B.A.).

Boyd, J., **Sayles, M.**, Olsen, L., and Tarjan, P. (2004) *Content Description Servers for Networked Video Surveillance.* ITCC (1) 2004: 798-803 (during a B.A.).

Boyd, J., Kendrick, N., Olsen, L., **Sayles, M.**, and Tarjan, P. (2003) *Camera Interaction through CaML Video Information Sensors.* IS 2003 - 13th Annual Canadian Conference on Intelligent Systems: 28 (during a B.A.).

**Sayles, M.**, Wu, X., and Boyd, J. (2003) *CaML: Camera markup language for network interaction.* SPIE Internet Imaging IV, Volume 5018, January 2003, Santa Clara, CA: 248-256 (during a B.A.).

Boyd, J., and **Sayles, M.** (2001) *Real-Time Video Phase-Locked Loops.* ICCV 2001: 742 (during a B.A.).

**Research experience**: From 2001 through 2004, I worked as a research assistant for Dr. Jeffrey Boyd. This led to five full paper publications, two posters, three installations at computer vision conferences, and five art installations. The research covered three distinct projects: The first was a system for real-time gait recognition using video phase-locked loops. The second was a server I designed that implemented video processing in real-time (e.g. Lucas-Kanade optical flow) and distributed this information over a LAN using a markup known as CaML. The CaML server became the framework for several art installations known as SwarmArt – interactive art installations that combine elements of computer vision with swarm intelligence. During this time, I led other highly qualified personnel, improved my development skills, assisted with the installation of the CaML server in the Calgary Olympic oval and at two conferences, and assisted with the installation of the five swarm art exhibits.

**Relevant activities**: In 2000, I was hired by SAIT to teach an outside learning course on web development. By 2009, I will have acted in the role of teaching assistant for four university courses. During my B.A. in Philosophy, I was a teaching assistant for a 300-level course on machine language programming. Since then, I have acted as a teaching assistant for the 400-level algorithms course. As a teaching assistant, I have the opportunity to guide less experienced students and to give something back to the Canadian education system. I have improved my skills in oral presentation and my own understanding of computing science, and it is a way for me to help other students to do the same. I thoroughly enjoy working with students, and I very much look forward to furthering my teaching skills.

During my two years at Symantec, I gained additional leadership experience while I worked as project lead for a password auditing system. In addition to this, I have worked in teams on all of the CTC programming competitions, and in 1997 I organized an international conference on real-time computer graphics in Calgary, Alberta.

Lastly, I did a semester abroad in India where I took courses at the University of Pune on conversational Hindi, Indian Social Work, and Indian Ecology. This gave me the chance to experience a culture that is drastically different from my own, Canadian culture and to interact with many other students from abroad.

**Special circumstances**: My undergraduate degree was a B.A. with distinction with a major in Philosophy, a minor in Religious Studies, and a second minor in Anthropology. During this time I worked as a research assistant for Dr. Jeffrey Boyd in computing sciences, and I worked as a teaching assistant for Dr. Bidulock also in computing sciences. Upon completion of my undergraduate degree I was awarded the Silver Medallion, the award for highest academic achievement in the department of Philosophy. This award is only offered to the top student in the department of Philosophy. Despite this achievement, I have four withdrawals and one C+ on my transcript. The first two withdrawals were in introductory religious studies courses that I later retook and received an A in both of these courses. The reason for these withdrawals was a death in the family. The third withdrawal was during my term abroad to India when I contracted a parasite and became ill, and the fourth withdrawal was while I was working full time at Symantec and had a work related project that took precedence. As for the C+, there was a major component (50%) of this course that was contributed to group work. Although I did learn leadership skills when working in a group, I also learned that sometimes it is not possible to motivate people to do more than the minimum that is required. Under different circumstances, I would have selected different group members with which to work, but ultimately, I have to accept responsibility for the mark earned in this course. These blemishes aside, I did receive the award for the highest academic achievement in the field of Philosophy, and for this I am proud.

# Form 200 - Application for an NSERC Scholarship or Fellowship

**Reference Number:** 90444776

**Applicant:** Maxwell Sayles

**Program:** Postgraduate Scholarships - PGS M

**Application Title:** Simulating Adaptive Markets with Markov Games

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**Paper Attachment(s)**

**Transcripts**

Bachelor's from the University of Calgary

**Reference Letters**

Dr. Peter Hoyer - M.Sc. Supervisor

Dr. Jeffrey Boyd - Supervisor for R.A.