Department of Statistical and Actuarial Sciences

Decision Making and Object Oriented Programming

Actuarial Sciences 9903B

Course Outline, Winter 2013

Course Goals and Expectations:

High performance algorithms and next generation computing technologies for supporting general and honors undergraduate and graduate programs, as well as postgraduate research projects in statistical & actuarial sciences, applied mathematics and related fields.

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Lecture Hours: Tue, Thu 03:30 PM-05:00 PM in NS 101

Office Hours: TBA

Prerequisite(s): Basic calculus, linear algebra, and statistics are helpful. Curiosity, determination, and desire to learn new things are necessary.

Textbook Notes will be handed out during lectures, or posted on the course website. Optional textbooks will be suggested for those who wish to learn some topics deeper.

Course website https://owl.uwo.ca

Course description

We shall master fundamental concepts of object-oriented programming with a particular emphasis on the object-oriented programming language C# and its various applications, including analytical and numerical methods useful in probability, statistics, applied mathematics, actuarial risk theory, financial modeling, business, and engineering.

Preface

Decision theory permeates – consciously or unconsciously – every aspect of our lives. Sometimes we call it 'gut feeling,' but quite often we need to resort to data analysis and mathematical language to arrive at well-informed decisions, and perhaps even to correct our 'gut feeling.' Two classical examples would be hypothesis testing and constructing confidence intervals, with which most of the students are familiar with, but perhaps not necessarily within the context of decision making. Throughout the course we shall dissect examples of decision making in areas such as statistical and actuarial sciences, physics, economics, finance, real-estate research and decisions, biological and medical sciences, signal processing, image reconstruction, classification, and optimal control.

The course will consists of several parts, with underlying computing and mathematical theories intertwined with numerous illustrative examples provided in C# object oriented programming language.

C# is one of the most powerful languages in many kinds of projects such as WWW-based services, database, GUI, from single user products to enterprise solutions in network-wide distributed environments. C# combines the power of C++, and incorporates best features of other popular programming languages such as C, Java, and Visual Basic.

C# is becoming the dominant language for building applications on Windows platforms. It was approved as a standard by ECMA (ECMA-334) and ISO (ISO/IEC 23270:2006), and has cross-language capabilities and the ability to interoperate with other languages on the .NET platform.

Many powerful features of C# will be introduced, including data types, arrays and matrices, classes and objects that make the language an ideal platform for deploying high-performance scientific code to solve complex engineering and scientific problems typically found in real-word applications.

No prior C# experience is required, but some knowledge with various programming languages such as C, C++, Java, SQL, Matlab, Maple, R, and Mathematica would be an asset.

Course outline by topical areas

Part 1: Fundamental considerations of decision making

- Data, judgments, probability, and statistics
- Decisions under risk and under uncertainty
- Operations research and optimization
- Computational tools, performance, and precision

Part 2: Object-oriented programming fundamentals

- C# and the .NET Framework
- Basic expressions and operators
- Matrices and arrays
- Classes, objects, methods, and properties
- Constructors and operators
- Encapsulations, overloading, inheritance, and polymorphism
- File input and output
- Installation, configuration, design
- Modeling, testing and debugging

Part 3: Numerical methods and algorithms

- Vectors and matrix classes, numerical computation, eigensystems, matrix exponentials
- Matrix computing, systems of linear and nonlinear equations
- Complex analysis
- Ordinary and partial differential equations
- Scientific libraries, The .NET Framework and Math Class Library

Part 4: Hands-on programming in probability and statistics

- Random numbers, simulation techniques, and generating probability distributions
- Numerical integration, inverse cumulative distribution functions
- Matrix approach to multiple regression

- Curve fitting methods, polynomial and spline interpolations

Part 5: Decision making programming and applications

- Iterative algorithms, linear and nonlinear optimization
- Statistical data analysis, modeling data and visualization
- Statistical functions, analysis of variance (ANOVA), and testing
- Statistical process control and control charts
- Exponentially weighted moving average (EWMA), CUSUM and Shewhart reports and control charts development

Part 6: Advance technology and decision making

- Problems with large databases, database management
- Multiple database engines and support for SQL Server, MY SQL, SQLite, MS Access and others
- Internet programming, ASP.NET Web services

Potential projects and other optional topics

Advanced matrix library in C#. NET
Matrix class library and multiple regression models
Pricing American and European options
Simulating of European option prices with Black-Scholes formula
Quadratic programming
Portfolio optimization models
Least-squares fitting applied to biostatistics
Implementation and application of extended precision in C++/C# and Matlab
Gaver-Stehfest algorithm to calculate inverse Laplace transforms and extended precision
Complex analysis, Lambert W function and extended precision
Partial differential equations
Reliability engineering and risk analysis
Signal processing, image reconstruction,
Classification, cluster analysis
Transportation and assignment problems
Networks and queues, iterative algorithms for performance evaluations
Periodic Poisson processes and almost-lack-of-memory (ALM) distribution
Spatial statistics, stochastic models for generating disturbances in landscapes
Environmental and computational statistics
Interfaces with Geographic Information Systems (GIS)
Environmental management, continuous emission monitoring (CEMS)
European and American statistical control standards for monitoring process-characteristics in industry
Parallel computing and applications
Integrating C++ and C# with Matlab, R and Mathematica.

Application areas

Statistics, actuarial sciences, applied mathematics and related disciplines
Computational physics, engineering, economics, financial mathematics
Biological and medical sciences
Real-estate research and decisions
Use of technology in the teaching of mathematics, statistics and actuarial sciences

Method of evaluation

The final course grade will based upon two assignments, two projects, a presentation, and an in-class portion.

5%	Assignment 1
5%	Assignment 2
30%	Midterm programming project
40%	Final programming project
10%	Presentation
10%	In-class portion

The in class portion of your grade will be determined by your instructor, and may include points for participation, in class quizzes, etc.

References and other suggested reading

Introductory reading:

1. Making Better Decisions: Decision Theory in Practice, by I. Gilboa, Wiley-Blackwell, 2011.
2. Seeing Through Statistics, by J.M. Utts, Thomson Brooks/Cole, 2005.
3. Against the Gods: The Remarkable Story of Risk, by P.L. Bernstein, Wiley, 1998.

Optional C# textbooks:

4. Computing with C# and the .NET Framework, by A. Gittleman, 2nd. Ed., Jones & Bartlett Learning, 2012
5. Microsoft Visual C# 2010: An Introduction to Object-Oriented Programming, by J. Farrell, Cengage Learning, 2010.
6. Numerical Methods, Algorithms and Tools in C#, by W. Dos Passos, CRC Press, 2010.
7. MATLAB - C# for Engineers, by Jack Phan, CreateSpace, 2010.
8. Practical Numerical Methods with C#, by J. Xu, Unicad, 2008.
9. Visual C# 2010 Recipes: A Problem-Solution Approach, by Allen Jones, Adam Freeman**,** Berkeley, CA : Apress, 2010.

Advanced reading:

10. Quantitative Risk Management: Concepts, Techniques, and Tools, by A.J. McNeil, R. Frey and P. Embrechts, Princeton University Press, 2005.
11. Statistical Analysis of Extreme Values: with Applications to Insurance, Finance, Hydrology and Other Fields, by R.-D. Reiss and M. Thomas (third edition), Birkhauser, 2007.
12. Finance for Engineers: Evaluation and Funding of Capital Projects, by F.K. Crundwell, Springer, 2008.
13. Nonlinear Optimization, by A. Ruszczynski, Princeton University Press, 2006.

Addendum to all courses outlines (follows)