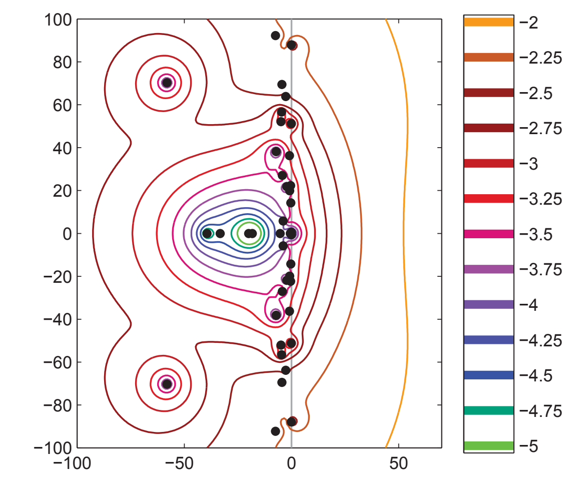
Pacific Institute *for the* Mathematical Sciences

Workshop on Numerical Linear Algebra & Optimization



Conference program

August 8-10, 2013

Pacific Institute for the Mathematical Sciences
Rm 2012 Earth Sciences Building (ESB)
2207 Main Mall, Vancouver

Welcome Message from the Organizing Committee

We are thrilled to welcome everybody to Vancouver for this festive conference. We have a rich and action-packed program, and a 60 years young Michael Overton who is celebrating a milestone birthday. Michael is well known for his work in the two themes of this conference, numerical linear algebra and optimization, especially eigenvalue optimization. We are grateful to PIMS (and its director Alejandro Adem and deputy director Bud Homsy) and NSF (specifically the Computational Mathematics program) for their generous support. We look forward to a productive and enjoyable conference, and thank all attendees for taking the time and effort to participate in this event.

Sincerely,

Ioana Dumitriu, University of Washington

Chen Greif, University of British Columbia

Emre Mengi, Koc University

Thursday August 8th

8:30am – 8:50am	Registration & Refreshments
8:50am – 9:00am	Welcome Message
	Session Th1 (Chair: Chen Greif)
9:00am – 9:25am	**Lloyd N. Trefethen**: Eigenvalue Avoidance
9:30am – 9:55am	**Anne Greenbaum**: K-Spectral Sets and Applications
10:00am – 10:25am	**Nicola Guglielmi**: Differential Equations for the Approximation of the Closest Defective Matrix
10:30am – 11:00am	Coffee Break
	Session Th2 (Chair: Emre Mengi)
11:00am – 11:25am	**Adrian S. Lewis**: Active Sets and Nonsmooth Geometry
11:30am – 11:55am	**James Burke**: Piecewise Linear Quadratic and Quadratic Support Functions in Regularized Regression, Machine Learning, System Identification, and Kalman Smoothing
12:00pm – 12:25pm	**Frank Curtis**: A Quasi-Newton Gradient Sampling Algorithm for Nonsmooth Optimization
12:30pm – 2:00pm	Lunch
	Session Th3 (Chair: Philip D. Loewen)
2:00pm – 2:25pm	**Henry Wolkowicz**: Taking Advantage of Degeneracy in Cone Optimization with Applications to Sensor Network Localization and Molecular Confirmation
2:30pm – 2:55pm	**Michael Friedlander**: A Dual Approach to Sparse Optimization
3:00pm – 3:25pm	**Jane Ye**: Minimizing the Condition Number to Construct Optimal Experimental Designs
3:30pm – 4:00pm	Coffee Break
	Session Th4 (Chair: Andrew Knyazev)
4:00pm – 4:25pm	**Daniel Kressner**: Nonlinear Eigenvalue Problems with Specified Eigenvalues
4:30pm – 4:55pm	**Stephen Vavasis**: Convex Relaxation for Finding Planted Influential Nodes in a Social Network
5:00pm – 7:00pm	Wine & Cheese Reception and Poster Session (ESB Atrium)

Friday August 9th

8:30am – 8:55am	Refreshments
	Session Fr1 (Chair: David S. Watkins)
9:00am – 9:25am	**Volker Mehrmann**: Stability of Descriptor Systems
9:30am – 9:55am	**Didier Henrion**: Solving Structured Eigenvalue Assignment Problems
10:00am – 10:25am	**Sara Grundel**: Interpolation and Classical Model Order Reduction to Create Parametric Model Order Reduction
10:30am – 11:00am	Coffee Break
	Session Fr2 (Chair: Andy Wathen)
11:00am – 11:25am	**Michael Saunders**: Solving linear systems by orthogonal tridiagonalization (GMINRES and/or GLSQR)

11:30am – 11:55am	**Daniel Szyld**: Inexact and truncated Parareal-in-time Krylov subspace methods for parabolic optimal control problems
12:00pm – 12:25pm	**Josef Sifuentes:** Approximate Murphy-Golub-Wathen Preconditioning for Saddle Point Problems
12:30pm – 2:00pm	Lunch
	Session Fr3 (Chair: Uri Ascher)
2:00pm – 2:25pm	**Donald Goldfarb**: Low-rank Tensor Recovery: Theory and Algorithms
2:30pm – 2:55pm	**Maryam Fazel**: Recovery of Simultaneously Structured Models from Limited Observations
3:00pm – 3:25pm	**Zhaosong Lu**: Randomized Block Coordinate Gradient Methods for a Class of Nonlinear Programming Problems
3:30pm – 4:00pm	Coffee Break
	Session Fr4 (Chair: Jiawang Nie)
4:00pm – 4:25pm	**Julio Moro**: Directional Perturbation in Structured Eigenproblems
4:30pm – 4:55pm	**Shreemayee Bora**: Structured Eigenvalue Backward Errors for Structured Matrix Polynomials
7:00pm	Banquet at Enigma

Saturday August 10th

8:30am – 8:55am	Refreshments
	Session Sa1 (Chair: Randall J. LeVeque)
9:00am – 9:25am	**Margaret Wright**: Numerical Linear Algebra and Derivative-Free Optimization on Facebook: "in a relationship" or "it's complicated"?
9:30am – 9:55am	**Franz Rendl**: A Hierarchy of Relaxations for Max-Cut and Related Problems Based on Small Exact Subproblems
10:00am – 10:25am	Coffee Break
	Session Sa2 (Chair: Ioana Dumitriu)
10:30am – 10:55am	**James Demmel**: Communication-Avoiding Algorithms for Linear Algebra and Beyond
11:00am – 11:25am	**Paul Van Dooren**: On Solving Indefinite Least Squares-type Problems via Anti-triangular Factorization
11:30am – 11:55am	**Charles Van Loan**: The Higher Order Generalized Singular Value Decomposition
12:00pm – 12:15pm	Closing Remarks
12:15pm	Lunch

- **Get Connected to the Internet:** Select the "ubcvisitor" wireless network on your wireless device. Open up a web browser, and you will be directed to the login page.
- **Event Evaluation Survey**: Please help PIMS to improve the quality of its events and plan for the future by filling out the survey at the end of the conference. It is located at: http://www.pims.math.ca/scientific-event/130808-wnlao
- **All Speaker Abstracts can be found on Pages 5-15.**
- **Directions, on-campus eateries, and a UBC map can be found on Pages 16-21.**

Speaker Abstracts

** In alphabetical order

Shreemayee Bora: IIT Guwahati

Structured Eigenvalue Backward Errors for Structured Matrix Polynomials

We consider the problem of obtaining the backward error of $\lambda \in \mathbb{C}$ considered as an approximate eigenvalue of a structured matrix polynomial with respect to structure preserving perturbations and present formulas for these backward errors for certain structures. Numerical examples suggest that in many instances there is a considerable difference in the values of the backward errors with respect to structure preserving and arbitrary perturbations. *Joint work with Christian Mehl and Michael Karow (TU Berlin) and Punit Sharma (IIT Guwahati)*

James Burke: University of Washington

Piecewise Linear Quadratic and Quadratic Support Functions in Regularized Regression, Machine Learning, System Identification, and Kalman Smoothing.

We discuss the class of piecewise linear quadratic (PLQ) penalties. Well known examples include the L2, L1, Huber, Vapnik, hinge loss, elastic net, and many others. These functions play a crucial role in a variety of applications, including machine learning, robust statistical inference, sparsity promotion, and inverse problems such as Kalman smoothing.

We build on a dual representation of this class of penalties, and use it to characterize conditions necessary to interpret these functions as negative logs of true probability densities. We then present a generalized function class called quadratic support (QS) functions that shares this statistical interpretation.

In the second part of the talk, we discuss a general solver for the PLQ class. The dual representation of these penalties allows a simple calculus, which we exploit to build an overall objective from simple parts. The resulting algorithm can handle a number of fairly general problems, while still efficiently exploiting structure. Moreover, simple constraints are easily incorporated. We present several numerical examples from different areas, and end with a discussion of an application of these ideas to Kalman smoothing.
Joint work with Sasha Aravkin, Brad Bell, and Gianluigi Pillonetto.

Frank Curtis: Lehigh University

A Quasi-Newton Gradient Sampling Algorithm for Nonsmooth Optimization

The gradient sampling algorithm proposed by Burke, Lewis, and Overton provides a theoretically strong framework for solving non-convex, non-smooth optimization problems. In this talk, we discuss practical enhancements to the algorithm (adaptive sampling, quasi-Newton Hessian approximations, etc.) that make it more computationally appealing, and discuss extensions for solving constrained problems. Numerical experiments with an algorithm that automatically transitions from a BFGS method to our adaptive gradient sampling scheme show that the method is quite promising as a general-purpose solver for non-convex, non-smooth optimization.

James Demmel: University of California, Berkeley

Communication-Avoiding Algorithms for Linear Algebra and Beyond

Algorithms have two costs: arithmetic and communication, i.e. moving data between levels of a memory hierarchy or processors over a network. Communication costs (measured in time or energy per operation) already greatly exceed arithmetic costs, and the gap is growing over time following technological trends. Thus our goal is to design algorithms that minimize communication. We present algorithms that attain provable lower bounds on communication, and show large speedups compared to their conventional counterparts. These algorithms are for direct and iterative linear algebra, for dense and sparse matrices, as well as direct n-body simulations. Several of these algorithms exhibit *perfect strong scaling*, in both time and energy: run time (resp. energy) for a fixed problem size drops proportionally to p (resp. is independent of p). Finally, we describe extensions to algorithms involving arbitrary loop nests and array accesses, assuming only that array subscripts are linear functions of the loop indices.

Maryam Fazel: University of Washington

Recovery of Simultaneously Structured Models from Limited Observations

Recovering a signal with a low-dimensional structure given a limited number of observations is a central problem in signal processing (compressed sensing), machine learning (recommender systems), and system identification. Structured models are often represented by sparse vectors, low-rank matrices, the sum of sparse and low-rank matrices, etc. Existing results characterize the number of observations for successful recovery for these structures.

In many applications, however, the desired model has *multiple* structures simultaneously. Applications include sparse phase retrieval, and learning models with several structural priors in machine learning tasks. Often, penalties that promote individual structures are known (e.g., ℓ_1 norm for sparsity, nuclear norm for matrix rank), and require a minimal number of generic measurements, so it is reasonable to minimize a combination of such norms. We show that, surprisingly, if we use multi-objective optimization with the individual norms, we can do no better (order-wise) than an algorithm that exploits only one of the structures. This result holds in a general setting and suggests that to fully exploit the multiple structures, we need a new convex relaxation.

Michael Friedlander: University of British Columbia

A Dual Approach to Sparse Optimization

A feature common to many sparse optimization problems is that the number of variables may be significantly larger than the number of constraints---e.g., the standard matrix-lifting approach for binary optimization results in a problem where the number of variables is quadratic in the number of constraints. We consider a duality framework applicable to a wide range of nonsmooth sparse optimization problems that allows us to leverage the relatively small number of constraints. Preliminary numerical results illustrate our approach and its flexibility.

Joint work with Nathan Krislock and Ives Macedo.

Donald Goldfarb: Columbia University

Low-rank Tensor Recovery: Theory and Algorithms

Recovering a low-rank tensor from incomplete or corrupted observations is a recurring problem in signal processing and machine learning. To exploit the structure of data that is intrinsically more than three-dimensional, convex models such low-rank completion and robust principal component analysis (RPCA) have been extended to tensors. In this work, we rigorously establish the recovery guarantees for both tensor completion and tensor RPCA. We also demonstrate that using the most popular convex relaxation for the tensor Tucker rank can be substantially suboptimal in terms of the number of observations needed for exact recovery. We introduce a very simple, new convex relaxation, which is shown, both theoretically and empirically, to be greatly superior to the previous model. Moreover, we propose algorithms to solve these low-rank tensor recovery models based on the Accelerated Linearized Bregman (ALB) method and the Alternating Direction Augmented Lagrangian (ADAL) method. Finally, we empirically investigate the recoverability properties of the convex models, and compare the computational performance of the algorithms on both simulated and real data.

Anne Greenbaum: University of Washington

K-Spectral Sets and Applications

Let A be an $n \times n$ matrix or a bounded linear operator on a Hilbert space. If $f : \mathbb{C} \longrightarrow \mathbb{C}$ is analytic in a region Ω containing the spectrum of A, then the matrix or operator $f(A)$ can be defined through the Cauchy integral formula:

$$f(A) = \frac{1}{2\pi i} \int_{\Omega} (zI - A)^{-1} f(z)\ dz.$$

For many years, there has been interest in relating the 2-norm of the operator $f(A)$ (that is, $\| f(A) \| \equiv \sup_{\| v \|_2 = 1} \| f(A)v \|_2$) to the $\mathcal{L}^{\infty}$-norm of f on such a set Ω (that is, $\| f \|_{\infty} \equiv \sup_{z \in \Omega} |f(z)|$). If all rational functions f with poles outside Ω satisfy $\| f(A) \| \leq K \| f \|_{\Omega}$, then Ω is said to be a $K - spectral\ set$ for A.

The first identification of a 1-spectral set (or, just a *spectral set*) was by Von Neumann in 1951: If A is a contraction (that is, $\| A \| \leq 1$) then $\| f(A) \| \leq \| f \|_{\mathcal{D}}$ where $\mathcal{D}$ denotes the unit disk. More recently (2004), M. Crouzeix has shown that the *field of values* or *numerical range* ($W(A) \equiv \{ < Aq, q > : \| q \|_2 = 1 \}$) is a K-spectral set for A with $K = 11.08$, and he conjectures that K can be taken to be 2. Another K-spectral set is the ϵ-pseudospectrum of A: $\Lambda_{\epsilon}(A) \equiv \{ z \in \mathbb{C} : \| (zI - A)^{-1} \| > \epsilon^{-1} \}$. If L denotes the length of the boundary of $\Lambda_{\epsilon}(A)$, then $\| f(A) \| \leq \left(\frac{L}{2\pi\epsilon} \right) \| f \|_{\Lambda_{\epsilon}(A)}$. Many other K-spectral sets can be derived for a given operator A by noting that if Ω is a K-spectral set for B and if $A = f(B)$, then $f(\Omega)$ is a K-spectral set for A.

In this talk, I will discuss these ideas and some others. I will show that Crouzeix's conjecture holds for matrices of the form

$$\begin{pmatrix} \lambda & \alpha_1 & & \\ & \ddots & \ddots & \\ & & \ddots & \ddots \\ & & \lambda & \alpha_{n-1} \\ \alpha_n & & & \lambda \end{pmatrix}$$

I will also establish the identity $\lim_{k\to\infty}[\ W(A^{1/k})\ ]^k = \exp[\ \mathrm{W}(\ln(\mathrm{A}))\ ]$ for nonsingular matrices A and show how it can be used to give information about the convergence of GMRES, even when $W(A)$ contains the origin.

Sara Grundel: Max Planck Institute, Magdeburg

Interpolation and Classical Model Order Reduction to Create Parametric Model Order Reduction

Model Order Reduction Methods for linear systems are well studied and many successful methods exist. We will review some and explain more recent advances in Parametric Model Order Reduction. The focus will be on methods where we interpolate certain significant measures, that are computed for specific values of the parameters by Radial Basis Function Interpolation. These measures have a disadvantage as they behave like eigenvalues of matrices depending on parameters and we will explain how that can be dealt with in practice. We will furthermore need to introduce a technique to create a medium size model by an extension of barycentric interpolation to make our algorithm efficient.

Nicola Guglielmi: University of L'Aquila

Differential Equations for the Approximation of the Closest Defective Matrix

Let A be a matrix with distinct eigenvalues. We address the problem of determining the closest defective matrix to A.

We propose a new method for the approximation of the complex and real distance to the set of defective matrices, which is based on a differential equation in the manifold of rank-2 (for the complex case) and rank-4 (in the real case) matrices. An approximation of the closest defective matrix of the form $A+E$ is constructed explicitly with E of low rank.

Due to the local behavior of the method we are able to compute upper bounds of the distances; nevertheless the algorithms typically find good approximations in cases where we can test this.

Extensions to different structures will also be discussed.

Joint work with P. Butta' and S. Noschese (Università di Roma La Sapienza) and M. Manetta (Università dell'Aquila).

Didier Henrion: University of Toulouse

Solving Structured Eigenvalue Assignment Problems

We address the problem of finding a structured control law assigning given closed-loop poles for a linear feedback system. Mathematically, the problem can be formulated as follows: given a set of distinct negative numbers $S = \{\ s_1, \dots, s_n\ \}$ and given n-by-n real matrices $A_0, A_1, \dots, A_n$, find real numbers $k_1, \dots, k_n$ such that the matrix $A_0 + k_1 A_1 + \cdots + k_n A_n$ has spectrum S. We propose two approaches to this problem: (1) a numerical method based on polynomial optimization and semi-definite programming relaxations; (2) a symbolic method based on techniques of computer algebra (Gröbner bases, rational univariate representation). We discuss the relative merits and shortcomings of these two approaches applied to a challenging benchmark problem of electrical network design.

Joint work with Sergio Galeani(Roma), Alain Jacquemard (Dijon and Vienna) and Luca Zaccarian(Toulouse and Trento), see http://arxiv.org/abs/1301.7741

Daniel Kressner: EPF Lausanne

Nonlinear Eigenvalue Problems with Specified Eigenvalues

This talk considers eigenvalue problems that are nonlinear in the eigenvalue parameter: $T(\lambda)x = 0$ for some matrix-valued function T. We are concerned with the task of assessing the quality of eigenvalue approximations obtained from a numerical algorithm, for example a quasi-Newton method. While the usual resolvent norm addresses this question for a single eigenvalue of multiplicity one, the general setting involving the simultaneous approximation of several eigenvalues is significantly more difficult. We show how the recently introduced concept of invariant pairs can be put to good use and derive a singular value optimization characterization.

Joint work with Michael Karow (TU Berlin) and Emre Mengi (Koc University).

Adrian S. Lewis: Cornell University

Active Sets and Nonsmooth Geometry

The active constraints of a nonlinear program typically define a surface central to understanding both theory and algorithms. The standard optimality conditions rely on this surface; they hold generically, and then the surface consists locally of all solutions to nearby problems. Furthermore, standard algorithms "identify" the surface: iterates eventually remain there. A blend of variational and semi-algebraic analysis gives a more intrinsic and geometric view of these phenomena, attractive for less classical optimization models. A recent proximal algorithm for composite optimization gives an illustration.

Joint work with J. Bolte, A. Daniilidis, D. Drusvyatskiy, M.L. Overton and S. Wright.

Zhaosong Lu: Simon Fraser University

Randomized Block Coordinate Gradient Methods for a Class of Nonlinear Programming Problems

In this talk we discuss randomized block coordinate gradient (RBCG) methods for minimizing the sum of two functions in which one of them is block separable. In particular, we present new iteration complexity results for these methods when applied to convex optimization problems. We also propose non-monotone RBCG methods for solving a class of non-convex problems with the above structure, and establish their global convergence. Finally, we present new complexity results for the accelerated RBCG method proposed by Nesterov for solving unconstrained convex optimization problems.

Volker Mehrmann: TU Berlin

Stability of Descriptor Systems

In this talk we discuss stability concepts for dynamical systems described by (linear or nonlinear) differential-algebraic equations (DAEs), we survey classical stability concepts (Lyapunov, Sacker Sell spectra), their generalizaions to DAEs, and also appropriate distance concepts to the nearest unstable system. We also discuss computational methods to compute the spectra and we present first results on the computation of the appropriate distance to the nearest unstable system.

Julio Moro: Universidad Carlos III de Madrid

Directional Perturbation in Structured Eigenproblems

The design and analysis of structure-preserving algorithms for structured eigenproblems has led in the last decades to a steady interest in structured eigenvalue perturbation theory, i.e., in analyzing the behavior of eigenvalues and other spectral objects (e.g., invariant subspaces, sign characteristics, ...) when a matrix or operator is subject to perturbations which belong to the same class of operators as the unperturbed one. It is well known that this behavior can be quite different from the behavior under arbitrary, non-structured perturbations.

In this talk we make use of the Newton polygon, an elementary geometric construction first devised by Sir Isaac Newton, to give an overview of first order perturbation theory, i.e., of results involving the local variation of eigenvalues as expressed by their directional derivatives as a function of the perturbation. We will do this both when the perturbation is unstructured (i.e., arbitrary), and when it is structured, i.e., when it belongs to the same class of interest as the unperturbed matrix. This latter case shows up in many relevant practical situations when eigenvalues need to be pushed in certain specific directions, or must be moved as fast as possible away from a critical (or dangerous) region by a small, usually structured, perturbation. Special emphasis will be made on classes of matrices and matrix pencils with symmetries with respect to some indefinite scalar product, since these often arise in applications to Control and Systems Theory.

Franz Rendl: University of Klagenfurt

A Hierarchy of Relaxations for Max-Cut and Related Problems Based on Small Exact Subproblems

The basic semidefinite relaxation for Max-Cut, underlying the Goemans-Williamson hyperplane rounding procedure, allows various tightenings. The simplest one includes constraints from the metric polytope. More refined approaches are iterative, and provide a sequence of relaxations, which come arbitrarily close to the convex hull of cut matrices, but at an increasingly high computational effort. A natural systematic hierarchy was introduced by Lasserre. The first step in this hierarchy corresponds to the basic semidefinite relaxation, where the optimization is done over the set of correlation matrices. The second one is a relaxation in the space of matrices of order $O(n^2)$.

We propose an iterative refinement of the basic semidefinite relaxation intersected with the metric polytope. The refinement is obtained by asking that submatrices to certain carefully selected small node-induced subgraphs of the problem are actually contained in the cut-polytope of the subgraph. The matrix order in the refinement process is always n, and only the number of constraints may grow exponentially.

A similar approach has been used in the context of linear relaxations under the heading of 'target cuts'. We will discuss the connections and differences of the present approach to previous methods, and also consider applications to stable-set relaxations. We provide some theoretical insights as well as first computational experience.

Joint work with E. Adams, M. Anjos (Montreal) and A. Wiegele (Klagenfurt).

Michael Saunders: Stanford University

Solving Linear Systems by Orthogonal Tridiagonalization (GMINRES and/or GLSQR)

A general matrix A can be reduced to tridiagonal form by orthogonal transformations on the left and right: $U^T A\, V = T$. We can arrange that the first columns of U and V are proportional to given vectors b and c. An iterative form of this process was given by Saunders, Simon, and Yip (SINUM 1988) and used to solve square systems $Ax = b$ and $A^T y = c$ simultaneously. (One of the resulting solvers becomes MINRES when A is symmetric and $b = c$.)

The approach was rediscovered by Reichel and Ye (NLAA 2008) with emphasis on rectangular A and least-squares problems $Ax \approx b$. The resulting solver was regarded as a generalization of LSQR (although it doesn't become LSQR in any special case). Careful choice of c was shown to improve convergence.

In his last year of life, Gene Golub became interested in ``GLSQR'' for estimating $c^T x$ and $b^T y$ without computing x or y. Golub, Stoll, and Wathen (ETNA 2008) revealed that the orthogonal tridiagonalization is equivalent to a certain block Lanczos process. This reminds us of Golub, Luk, and Overton (TOMS 1981): a block Lanczos approach to computing singular vectors.

Josef Sifuentes: Texas A&M University

Approximate Murphy-Golub-Wathen Preconditioning for Saddle Point Problems

Murphy, Golub, and Wathen proposed a preconditioner for saddle-point systems that yields a diagonalizable coefficient matrix having three distinct eigenvalues, giving exact convergence of GMRES in three iterations. However, this preconditioner involves the inverse of a large submatrix. Practical computations only approximate this inverse, so GMRES will generally require more iterations. How many more? Recent results on the stability of GMRES lead to rigorous bounds on the number of required iterations as a function of the accuracy to which the preconditioner is applied, along with spectral properties of the constituent matrices. Numerical computations verify these results for problems from optimization and fluid dynamics.

Daniel B. Szyld: Temple University

Inexact and Truncated Parareal-in-time Krylov Subspace Methods for Parabolic Optimal Control Problems

We study the use of inexact and truncated Krylov subspace methods for the solution of the linear systems arising in the discretized solution of the optimal control of a parabolic partial differential equation. An all-at-once temporal discretization and a reduction approach are used to obtain a symmetric positive definite system for the control variables only, where a Conjugate Gradient (CG) method can be used at the cost of the solution of two very large linear systems in each iteration. We propose to use inexact Krylov subspace methods, in which the solution of the two large linear systems are not solved exactly, and their approximate solutions can be progressively less exact. The option we propose is the use of the parareal-in-time algorithm for approximating the solution of these two linear systems. The use of less parareal iterations makes it possible to reduce the time integration costs and to improve the time parallel scalability, and therefore, making it possible to really consider optimization in real time. We also show that truncated methods could be used without much delay in convergence, but with important savings in storage. Spectral bounds are provided and numerical experiments with the full orthogonalization method (FOM), and with inexact and truncated version of FOM are presented, illustrating the potential of the proposed methods.

Lloyd N. Trefethen: University of Oxford

Eigenvalue Avoidance

It is well known that eigenvalues like to avoid each other, even when Michael Overton tries to push them together. We'll have some fun exploring this effect.

Paul Van Dooren: Catholic University of Louvain

On Solving Indefinite Least Squares-type Problems via Anti-triangular Factorization

The indefinite least squares problem and the equality constrained indefinite least squares problem are modifications of the least squares problem and the equality constrained least squares problem, respectively, involving the minimization of a certain type of indefinite quadratic form. Such problems arise in the solution of Total Least Squares problems, in parameter estimation and in H-infinity smoothing. Algorithms for computing the numerical solution of indefinite least squares and indefinite least squares with equality constraint are described by Bojanczyk et al. and Chandrasekharan et al. The indefinite least squares problem and the equality constrained indefinite least squares problem can be expressed in an equivalent fashion as augmented square linear systems. Exploiting the particular structures of the coefficient matrices of such systems, new algorithms for computing the solution of such problems are proposed relying on the anti-triangular factorization of the coefficient matrix (by Mastronardi et al.). Some results on their stability are shown together with some numerical examples. *Joint work with Nicola Mastronardi*

Charles Van Loan: Cornell University

The Higher Order Generalized Singular Value Decomposition

Suppose you have a collection of data matrices each of which has the same number of columns. The HO-GSVD can be used to identify common features that are implicit across the collection. It works by identifying a certain (approximate) invariant subspace of a matrix that is a challenging combination of the collection matrices. In describing the computational process I will talk about the Higher Order CS decomposition and a really weird optimization problem that I bet you have never seen before!

Joint work with Orly Alter, Priya Ponnapalli, and Mike Saunders.

Stephen Vavasis: University of Waterloo

Convex Relaxation for Finding Planted Influential Nodes in a Social Network

We consider the problem of maximizing influence in a social network. We focus on the case that the social network is a directed bipartite

graph whose arcs join senders to receivers. We consider both the case of deterministic networks and probabilistic graphical models, that is, the so-called ``cascade'' model. The problem is to find the set of the k most influential senders for a given integer k. Although this problem is NP-hard, there is a polynomial-time approximation algorithm due to Kempe, Kleinberg and Tardos. In this work we consider convex relaxation for the problem. We prove that convex optimization can recover the exact optimizer in the case that the network is constructed according to a generative model in which influential nodes are planted but then obscured with noise. We also demonstrate computationally that the convex relaxation can succeed on a more realistic generative model called the "forest fire" model.
Joint work with Lisa Elkin and Ting Kei Pong of Waterloo.

Henry Wolkowicz: University of Waterloo
Taking Advantage of Degeneracy in Cone Optimization with Applications to Sensor Network Localization and Molecular Conformation.

The elegant theoretical results for strong duality and strict complementarity for linear programming, LP, lie behind the success of current algorithms. However, the theory and preprocessing techniques that are successful for LP can fail for cone programming over nonpolyhedral cones.
Surprisingly, many instances of semidefinite programming, SDP, problems that arise from relaxations of hard combinatorial problems are degenerate. (Slater's constraint qualification fails.) Rather than being a disadvantage, we show that this degeneracy can be exploited. In particular, several huge instances of SDP completion problems can be solved quickly and to extremely high accuracy. In particular, we illustrate this on the sensor network localization and Molecular conformation problems.

Margaret Wright: New York University
Numerical Linear Algebra and Derivative-free Optimization on Facebook: "in a relationship" or "it's complicated"?

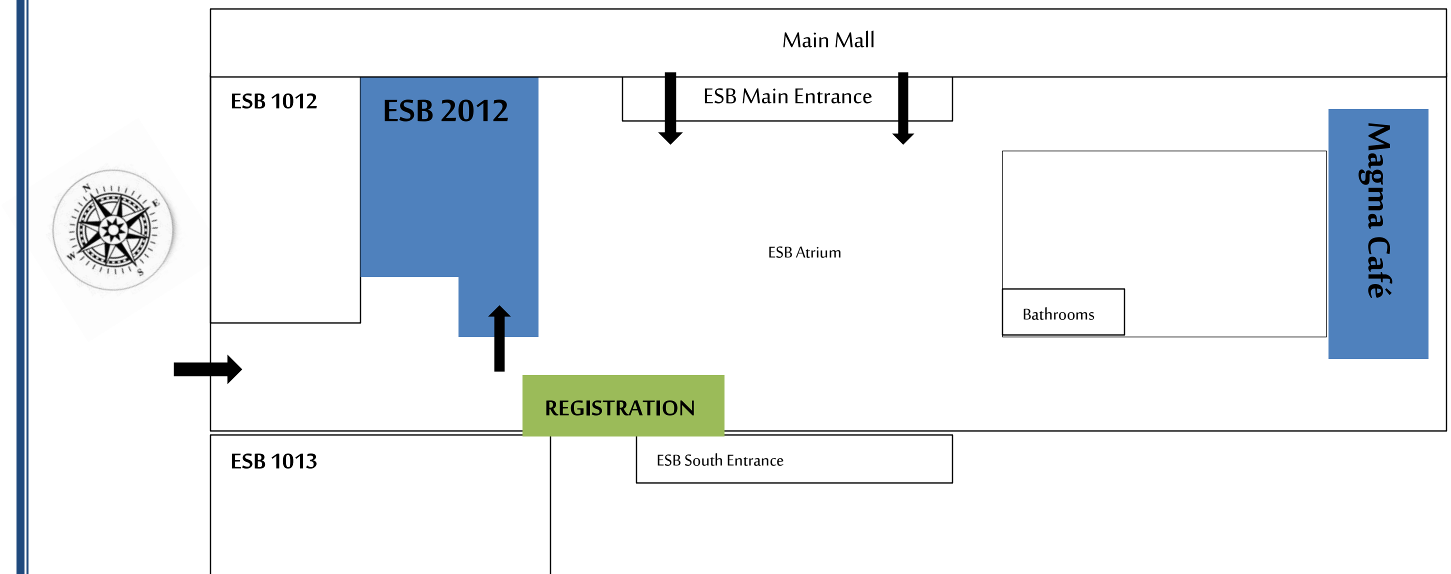
The longstanding connection between numerical linear algebra and optimization has often, but not always, been close---think about linear programming, the product form of the inverse, and numerically stable rank-one updates of the basis. If we pretend that derivative-free optimization and numerical linear algebra are on Facebook (after all, SIAM is), how would they describe their connection? This talk will discuss a selection of the varied roles played by numerical linear algebra in recent work on derivative-free optimization.

Jane Ye: University of Victoria
Minimizing the Condition Number to Construct Optimal Experimental Designs

Many practical and theoretical problems in science and engineering consider the relationship between an explanatory variable and a response variable as a p-th order polynomial regression model. In a controlled experiment, one can select the levels of the explanatory variable and the way to select the level of the explanatory variables is called a design of experiment. In the literature, several design criteria have been introduced for constructing optimal experimental designs so that the least squares estimator is more efficient. We introduced a new optimality criterion, the K-optimality criterion, for constructing optimal experimental designs for polynomial regression models based on minimizing the condition number of the information matrix. A condition number of a symmetric positive definite matrix is the ratio of the largest and the smallest eigenvalues. It is an important measure of sensitivity for many practical problems. It is well known that the condition number for a positive definite matrix as the ratio of the maximum eigenvalue to the minimum eigenvalue is usually nonsmooth. For the case where the design space is the interval [-1,1], we show that the condition number of the information matrix is continuously differentiable. Moreover we show that there is always a symmetric *K*-optimal design with exactly $p+1$ support points including the boundary points -1 and 1. These results allow us to use standard optimization solvers to find the *K*-optimal designs. For the general case where the design space is an interval [a,b], we propose a two-stage strategy. In the first stage we find an optimal moment matrix by using semi-definite program (SDP). In the second stage we use the entropy optimization to find an approximate optimal design.

Directions

ESB Building Ground Floor Plan:



General Travel Directions:

UBC Map link: http://www.maps.ubc.ca/PROD/images/pdf/ubcmap.pdf

Airport to UBC: Easiest by taxi (25min, around $30). If your accommodation is at Walter H Gage Towers, please give them the address: *5959 Student Union Boulevard, UBC.* By public transport, take the Canada Line (rail) to Broadway-City Hall station. From Broadway-City Hall station, cross Broadway and Cambie streets to get to the #99 UBC bus stop in front of London Drugs. Tickets (valid for the whole journey to UBC) can be purchased from the machine in the airport station. Cost: approximately $6. Journey time: Circa more than 1 hour

UBC Bus Loop/ Gage to Earth Science Building (ESB) 2207 Main Mall: A quick 10min walk. See UBC map. Head west past the student union building, cross East Mall and get onto Main Mall. Turn left (South) on Main Mall and Earth Science Building will be on your right after a few minutes. It is a large new building, and is on Main Mall directly across from the Beatty Biodiversity Centre and prominent blue whale skeleton.

Public Transit: Feel free to search and plan your public transport rides by visiting http://www.translink.ca/, where directions, ticket costs and bus schedules are indicated.

Parking at UBC: http://www.parking.ubc.ca/visitor.html

Campus Dining

at the University of British Columbia

From world-class catering to casual dining, coffee shops and internationally-inspired food outlets, UBC offers a delicious assortment of food services solutions. Here is an overview of food service providers certain to deliver a satisfying campus dining experience.

UBC Food Services

www.food.ubc.ca

Serving only locally-roasted fair trade organic shade-grown coffee at all UBC Food Services non-franchise locations

Wescadia Catering

Conference and special event catering

www.catering.ubc.ca

Sage Bistro at University Centre

Casual fine dining available for breakfast, lunch and special events

www.sage.ubc.ca

The Point Grill at Marine Drive Residence

New upscale casual dining restaurant open for brunch, lunch, and dinner. Open M-F

Triple O's at David Lam Research Centre

Casual dining in a family-friendly environment. Open daily

Residence Dining

Totem Park and Place Vanier Cafeterias

For information about group meal plans, please call 604-822-6204 or email rene.atkinson@ubc.ca

Pacific Spirit Place Cafeteria at the SUB

Student Union Building, 6138 Student Union Blvd

Pacific Spirit Place is open weekdays for breakfast and lunch. For information about group meal plans, please call 604-822-9310 or email fred.cheng@ubc.ca

Bakeshop	A&W
Pasta Bar	Koya Japan
Salad Bar	Manchu Wok
Pizza Pizza	Subway

Proudly Brewing Starbucks Coffee

Starbucks Coffee at Student Union Building
The Barn at Main Mall
Starbucks Coffee at Fred Kaiser
Steamies Café at the Bookstore
Pond Café at Ponderosa Centre

More Great Locations…

Niche Café at Beaty Biodiversity Museum
Caffé Perugia at Life Sciences Centre
Café MOA at Museum of Anthropology
Ike's Café at Irving K. Barber Learning Centre
Tim Horton's at Forest Sciences Centre

For guests, visitors, or groups visiting the UBC Campus, the UBC Food Services gift card is the easiest way for you and your group to dine at any of our locations.

Food Outlets

at the Student Union Building (SUB)

The SUB features a variety of food outlets all under one roof and conveniently located at the heart of campus. Get a delicious bagel or muffin to go, grab a slice of pizza at Pie R Squared, pick up some freshly made sushi or sit and enjoy a juicy beef burger at Pit Pub. The SUB has something for everyone!

Concourse and Sub-Level

Blue Chip Cookies

Proudly serving organic, fair trade coffees, cappuccinos and lattés. All our cookies and fabulous baked goods are made in-house and baked fresh daily.

Bernoulli's Bagels

Montreal-style bagels, sandwiches, and bagel melts using high-quality ingredients and freshly squeezed vegetable or citrus juice!

The Delly

Fresh sandwiches made to order. A wide selection of salads, wraps, curries, soups and pasta made daily.

The Honour Roll

Maki rolls, nigiri, sushi, donburi rice bowls and bento boxes are made fresh throughout the day. Ask about party platters and catering.

The Pit Burger Bar

Charbroiled hamburger specials, veggie burgers, hot wings, beer-battered fish & chips and more!

The Pit Pub

Satellite big-screen sports, six high-definition TV's, great drink prices, and a great atmosphere!

The Moon Noodle House

Great wonton soup, daily specials, fresh steamed veggies, combos and hot & sour soup.

The Patio BBQ

On the south side of the SUB, Monday to Friday (weather permitting) offering grilled 1/4 pound burgers, veggie burgers, smokies and drinks.

The Pendulum Restaurant

Delicious grilled sandwiches and panninis, and lots of vegetarian and vegan dishes!

Pie R Squared

Great house-made pizza slices, great prices, cold drinks. Now offering soft-serve ice cream and doughnuts.

www.catering.ubc.ca

NEED CATERING? *For catered events or meals on the go, Wescadia Catering offers a multitude of menu ideas to meet a range of dietary needs. We pride ourselves on our knowledgeable, friendly staff, professional service and quality ingredients.*

University Boulevard

Restaurants and Food Outlets

University Boulevard boasts a vibrant neighbourhood feel, and features dozens of places to enjoy a sit-down meal, people-watch over coffee, or grab a quick bite on the run. Visitors will feel right at home choosing from internationally-recognized franchises and unique offerings from local entrepreneurs.

The Boulevard Coffee Roasting Co.

at David Strang, 5870 University Blvd.
theboulevard.ca

Mahony & Sons Public House

at David Strang, 5990 University Blvd.
www.mahonyandsons.com

The Well Café

at Regent College, 5800 University Blvd.

University Village

5700 Block, University Blvd.

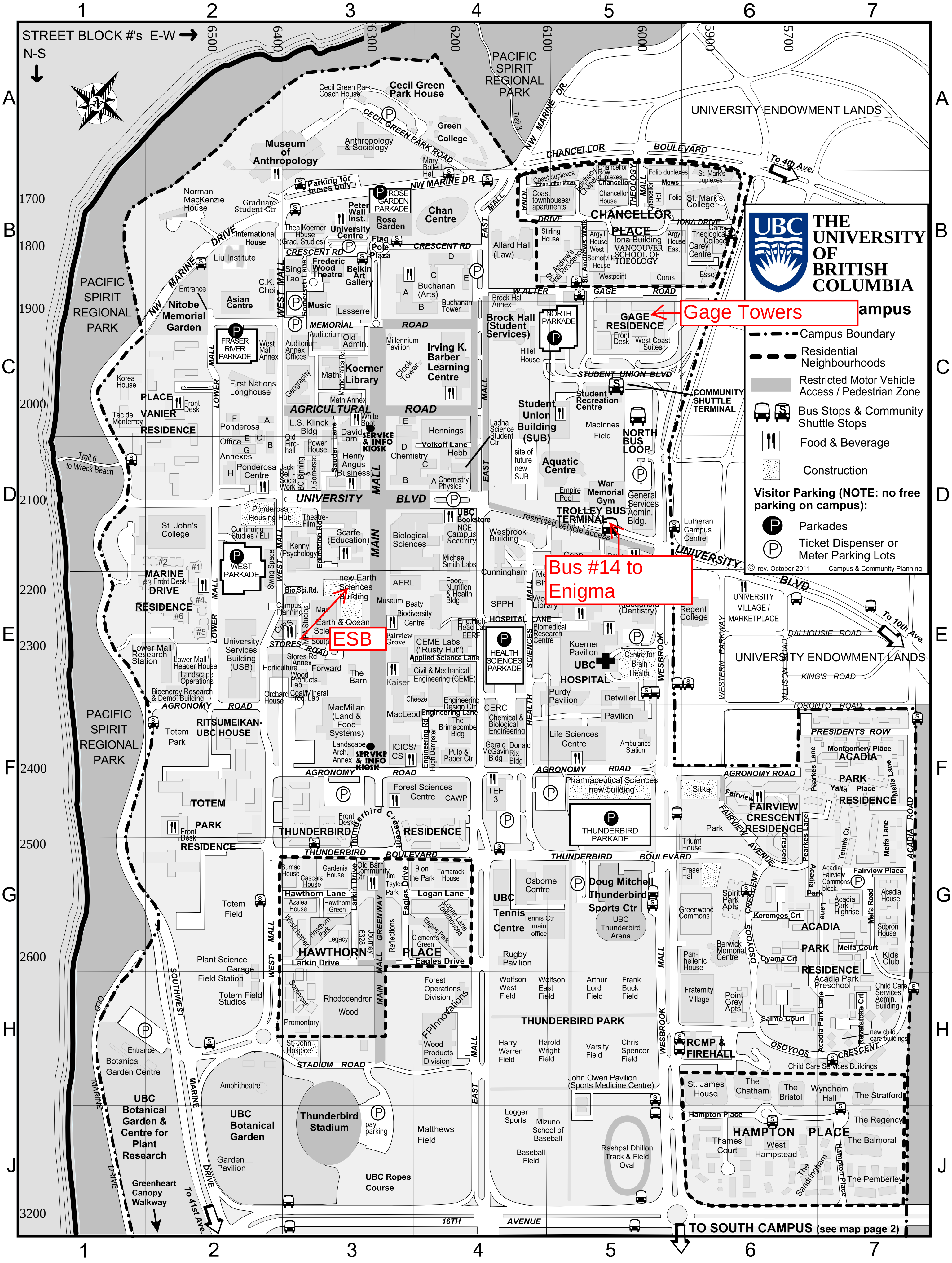
- Blenz Coffee Shop
- Booster Juice Juice & Snack Bar
- Mio Japan Japanese Fast Food
- McDonald's Breakfast – Late-Night Fast Food
- Pearl Fever Tea House & Snack Bar
- Pita Pit Lunch – Late-Night Take-Out & Delivery
- One More Sushi Japanese Dining
- Only U Café Deli & Diner
- Starbuck's Coffee Shop
- University Pizza Take-Out & Delivery
- Vera's Burger Shack Diner
- Village Restaurant Chinese Dining

International Food Fair

University Marketplace, Lower Level

- A-1 Vietnamese Food Pho & Noodle House
- Curry Point East Indian
- Donair Town Persian, Mediterranean, Catering
- Leona Mediterranean Food Lebanese
- Malaysian Cuisine Malaysian, Thai
- Osaka Sushi Japanese
- Timpo Mongolian BBQ Stir-Fry
- Yi Kou Xiang Chinese

Also Recommended… ***Westward Ho! PublicHouse & Grill Room*** *at the University Golf Club*
www.universitygolf.com/dine



STREET BLOCK #'s E-W
N-S
THE UNIVERSITY OF BRITISH COLUMBIA
UBC
Campus
Gage Towers
Bus #14 to Enigma
ESB
Campus Boundary
Residential Neighbourhoods
Restricted Motor Vehicle Access / Pedestrian Zone
Bus Stops & Community Shuttle Stops
Food & Beverage
Construction
Visitor Parking (NOTE: no free parking on campus):
Parkades
Ticket Dispenser or Meter Parking Lots
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Campus & Community Planning
PACIFIC SPIRIT REGIONAL PARK
UNIVERSITY ENDOWMENT LANDS
Museum of Anthropology
Cecil Green Park House
Green College
NW MARINE DR
CHANCELLOR BOULEVARD
To 4th Ave.
CHANCELLOR PLACE
Chan Centre
Rose Garden
Nitobe Memorial Garden
Asian Centre
Irving K. Barber Learning Centre
Koerner Library
Brock Hall (Student Services)
NORTH PARKADE
GAGE RESIDENCE
STUDENT UNION BLVD
COMMUNITY SHUTTLE TERMINAL
Student Union Building (SUB)
Student Recreation Centre
NORTH BUS LOOP
Aquatic Centre
War Memorial Gym
TROLLEY BUS TERMINAL
restricted vehicle access
UNIVERSITY BLVD
PLACE VANIER RESIDENCE
AGRICULTURAL ROAD
MEMORIAL ROAD
MAIN MALL
EAST MALL
WEST MALL
LOWER MALL
St. John's College
WEST PARKADE
MARINE DRIVE RESIDENCE
FRASER RIVER PARKADE
Scarfe (Education)
Biological Sciences
UBC Bookstore
Wesbrook Building
new Earth Sciences Building
Earth & Ocean Sciences
CEME Labs ("Rusty Hut")
HEALTH SCIENCES PARKADE
UBC HOSPITAL
Koerner Pavilion
Purdy Pavilion
Detwiller Pavilion
UNIVERSITY VILLAGE / MARKETPLACE
Regent College
To 10th Ave.
DALHOUSIE ROAD
KING'S ROAD
TORONTO ROAD
WESBROOK MALL
AGRONOMY ROAD
RITSUMEIKAN-UBC HOUSE
TOTEM PARK RESIDENCE
MacMillan (Land & Food Systems)
CERC
Life Sciences Centre
Forest Sciences Centre
Pharmaceutical Sciences new building
THUNDERBIRD PARKADE
THUNDERBIRD RESIDENCE
THUNDERBIRD BOULEVARD
PRESIDENTS ROW
ACADIA PARK RESIDENCE
FAIRVIEW CRESCENT RESIDENCE
HAWTHORN PLACE
Doug Mitchell Thunderbird Sports Ctr
UBC Tennis Centre
THUNDERBIRD PARK
Plant Science Field Station
Totem Field
SOUTHWEST MARINE DRIVE
RCMP & FIREHALL
OSOYOOS CRESCENT
HAMPTON PLACE
STADIUM ROAD
UBC Botanical Garden & Centre for Plant Research
UBC Botanical Garden
Thunderbird Stadium
Matthews Field
UBC Ropes Course
John Owen Pavilion (Sports Medicine Centre)
Rashpal Dhillon Track & Field Oval
16TH AVENUE
To 41st Ave.
TO SOUTH CAMPUS (see map page 2)

Map Directory

Site or Building Name & Address	Grid
Abdul Ladha Science Student Ctr, 2055 East Mall	D4
Acadia/Fairview Commonsblock, 2707 Tennis Cres	G7
Acadia House, 2700-2720 Acadia Rd	G7
Acadia Park Residence	F/H-6/7
Acadia Park Highrise, 2725 Melfa Rd	G7
Acadia Park Preschool, 2750 Acadia Park Lane	H7
Allard Hall [Faculty of Law], 1822 East Mall	B4
Anthropology & Sociology Bldg, 6303 NW Marine Dr	A3
Aquatic Centre, 6121 University Blvd	D5
Aquatic Ecosystems Research Lab (AERL), 2202 Main Mall	E3
Asian Centre, 1871 West Mall	B2
Auditorium (a.k.a. "Old Auditorium"), 6344 Memorial Rd	C3
Auditorium Annex Offices, 1924 West Mall	C3
Barn (daycare), 2323 Main Mall	E3
B.C. Binning Studios (formerly Hut M-17), 6373 University Blvd	D3
Beaty Biodiversity Centre & Museum, 2212 Main Mall	E3/4
Belkin (Morris & Helen) Art Gallery, 1825 Main Mall	B3
Berwick Memorial Centre, 2765 Osoyoos Cres	G6
Bioenergy Research & Demonstration Bldg., 2337 Lower Mall	E2
Biological Sciences Bldg [Science Faculty office], 6270 University Blvd	D3
Biomedical Research Ctr, 2222 Health Sciences Mall	E4
Biotechnology Laboratory, 2125 East Mall	D4
Bollert (Mary) Hall, 6253 NW Marine Dr	A4
Bookstore, 6200 University Blvd	D4
Botanical Garden Centre/Gatehouse, 6804 SW Marine Dr	H1
Botanical Garden Pavilion (enter at Gatehouse, 6804 SW Marine Dr)	J2
Botan. Gard. Greenhses/ Workshops, 6088 S. Campus Rd	South Campus
Brimacombe Building, 2355 East Mall	F4
BROCK HALL: Student Services & Welcome Centre, 1874 East Mall	**C4**
Brock Hall Annex, 1874 East Mall	C4
Buchanan Building (Blocks A, B, C, D, & E) [Arts], 1866 Main Mall	B3/4
Buchanan Tower, 1873 East Mall	C4
C.K. Choi Building for the Institute of Asian Research, 1855 West Mall	B2
Campus & Community Planning, 2210 West Mall	E3
Campus Security, 2133 East Mall	D4
Carey Centre, 5920 Iona Drive	B6
Carey Theological College, 1815 Wesbrook Mall	B6
CAWP (Centre for Advanced Wood Processing), 2424 Main Mall	F4
Cecil Green Park Coach House, 6323 Cecil Green Park Rd	A3
Cecil Green Park House, 6251 Cecil Green Park Rd	A3
CEME — *see Civil & Mechanical Engineering Building*	
Centre for Comparative Medicine, 4145 Wesbrook Mall	South Campus
Centre for Interactive Research on Sustainability (CIRS), 2260 West Mall	E3
CERC (Clean Energy Research Ctr), 2360 East Mall	F4
Chan Centre for the Performing Arts, 6265 Crescent Rd	B4
Chancellor Place neighbourhood	B5
Chemical & Biological Engineering Bldg, 2360 East Mall	F4
Chemistry A Block - Chemistry Physics Building, 6221 University Blvd	D4
Chemistry B,C,D & E Blocks, 2036 Main Mall	D3
Child Care Services Administration Bldg, 2881 Acadia Rd	H7
Child Care Services Bldgs, Osoyoos Cresc and Revelstoke Crt	H7
CIRS — *see Centre for Interactive Research on Sustainability...*	
Civil & Mechanical Engineering Bldg (CEME), 6250 Applied Science Lane	E4
Civil & Mechanical Eng. Labs ("Rusty Hut"), 2275 East Mall	E4
Coal & Mineral Processing Lab, 2332 West Mall	E3
Continuing Studies Bldg [English Language Institute], 2121 West Mall	D2
Copp (D.H.) Building, 2146 Health Sciences Mall	D5
Cunningham (George) Building [Pharmaceutical Sc.], 2146 East Mall	E4
David Lam Learning Centre, 6326 Agricultural Rd	C3
David Lam Management Research Ctr, 2033 Main Mall	C3
Donald Rix Building, 2389 Health Sciences Mall	F4
Doug Mitchell Thunderbird Sports Centre, 6066 Thunderbird Blvd	G5
Dorothy Somerset Studios (formerly Hut M-18), 6361 University Blvd	D3
Earth Sciences Building (ESB) under construction, 2207 Main Mall	E3
Earth & Ocean Sciences (EOS) - Main and South, 6339 Stores Rd	E3
Earthquake Engineering Research Facility (EERF), 2235 East Mall	E4
Engineering High Head Room Lab, 2225 East Mall	E4
English Language Institute (E.L.I.) — *see Continuing Studies Building*	
Environmental Services Facility, 6025 Nurseries Rd	South Campus
Fairview Crescent Residence, 2600-2804 Fairview Cres	F6
Fire Department, 2992 Wesbrook Mall	H6
First Nations Longhouse, 1985 West Mall	C2
Flag Pole Plaza (Main Mall & Crescent Rd)	B3
Food, Nutrition and Health Bldg, 2205 East Mall	E4
Forest Sciences Centre [Faculty of Forestry], 2424 Main Mall	F4
Forward (Frank) Building, 6350 Stores Rd	E3
FPInnovations (Forest Operations & Wood Products), 2601/2665 E. Mall	H4
FPInnovations (Pulp & Paper Division), 3800 Wesbrook Mall	South Campus
Fraser Hall (public rental housing), 2550 Wesbrook Mall	G6
Fraternity Village, 2880 Wesbrook Mall	H6
Frederic Wood Theatre, 6354 Crescent Rd	B3
Friedman Bldg, 2177 Wesbrook Mall	E5
Gage Residence, 5959 Student Union Blvd	C5
General Services Administration Bldg (GSAB), 2075 Wesbrook Mall	D5
Geography Building, 1984 West Mall	C3
Gerald McGavin Building, 2386 East Mall	F4
Graduate Student Centre — *see Thea Koerner House*	
Green College, 6201 Cecil Green Park Rd	A4
Greenheart Canopy Walkway, Botanical Garden, 6804 SW Marine Dr	H1
Greenwood Commons (public rental housing), 2660 Wesbrook Mall	G6
Hampton Place neighbourhood	H/J-6/7
Hawthorn Place neighbourhood	G/H3
Hebb Building, 2045 East Mall	D4
Hennings Building, 6224 Agricultural Rd	C4
Henry Angus Building [Sauder School of Business], 2053 Main Mall	D3
Hillel House - The Diamond Foundation Centre for Jewish Campus Life, 6145 Student Union Blvd	C4
Horticulture Building/Greenhouse, 6394 Stores Rd	E2/3
Hugh Dempster Pavilion, 6245 Agronomy Rd	F4
ICICS/CS (Institute for Computing, Information & Cognitive Systems/Computer Science), 2366 Main Mall	F4
Instructional Resources Centre (IRC), 2194 Health Sciences Mall	E5
International House, 1783 West Mall	B2
In-Vessel Composting Facility, 6035 Nurseries Road	South Campus
Irving K. Barber Learning Centre, 1961 East Mall	C4
Jack Bell Building for the School of Social Work, 2080 West Mall	D3
John Owen Pavilion & Allan McGavin Sports Medicine Centre, 3055 Wesbrook Mall	H5
Kaiser (Fred) Building [Faculty of Applied Science], 2332 Main Mall	E3
Kenny (Douglas T) Building, 2136 West Mall	D3
Kids Club, 2855 Acadia Rd	G7
Klinck (Leonard S.) Bldg, 6356 Agricultural Rd	C3
Koerner (Walter C.) Library, 1958 Main Mall	C3
Landscape Architecture Annex, 2371 Main Mall	F3
Lasserre (Frederic) Building, 6333 Memorial Rd	C3
Law, Faculty of — *see Allard Hall*	
Leon and Thea Koerner University Centre, 6331 Crescent Rd	B3
Life Sciences Centre, 2350 Health Sciences Mall	F5
Liu Institute for Global Issues, 6476 NW Marine Dr	B2
Lower Mall Header House, 2269 Lower Mall	E2
Lower Mall Research Station, 2259 Lower Mall	E2
Macdonald (J.B.) Building [Dentistry], 2199 Wesbrook Mall	E5
MacLeod (Hector) Building, 2356 Main Mall	F3
MacMillan (H.R.) Bldg [Faculty of Land & Food Systems], 2357 Main Mall	F3
Marine Drive Residence (Front Desk in Bldg #3), 2205 Lower Mall	E2
Material Recovery Facility, 6055 Nurseries Rd	South Campus
Mathematics Annex, 1986 Mathematics Rd	C3
Mathematics Building, 1984 Mathematics Rd	C3
Medical Sciences Block C, 2176 Health Sc. Mall	E4
M.F.A. Studios (formerly B.C. Binning MFA Studios), 6363 Stores Rd	E3
Michael Smith Laboratories, 2185 East Mall	D4
Museum of Anthropology (MOA), 6393 NW Marine Dr	A2/3
Music Building, 6361 Memorial Rd	B/C3
Networks of Ctrs of Excellence (NCE), 2125 East Mall	D4
Nitobe Memorial Garden, 1895 Lower Mall	B/C2
Nobel Biocare Oral Heath Centre (David Strangway Bldg), 2151 Wesbrook Mall	E5
Norman MacKenzie House, 6565 NW Marine Dr	B2
NRC Institute for Fuel Cell Innovation, 4250 Wesbrook Mall	South Campus
Old Administration Building, 6328 Memorial Rd	C3
Old Auditorium — *see Auditorium*	
Old Barn Community Centre, 6308 Thunderbird Blvd	G3
Old Firehall, 2038 West Mall	D3
Orchard House, 2336 West Mall	E2
Osborne (Robert F.) Centre/Gym, 6108 Thunderbird Blvd	G4
Panhellenic House, 2770 Wesbrook Mall	G6
Peter Wall Institute for Advanced Studies, 6331 Crescent Rd	B3
Place Vanier Residence, 1935 Lower Mall	C/D2
Plant Ops Nursery/Greenhouses, 6029 Nurseries Rd	South Campus
Plant Science Field Station & Garage, 2613 West Mall	H2
Point Grey Apartments, 2875 Osoyoos Cresc	H6
Police (RCMP) & Fire Department, 2990/2992 Wesbrook Mall	H6
Ponderosa Centre, 2071 West Mall	D2
Ponderosa Office Annexes: A, B, & C, 2011-2029 West Mall	C/D2
Ponderosa Office Annexes: E to H, 2008-2074 Lower Mall	C/D2
Power House, 2040 West Mall	D3
Pulp and Paper Centre, 2385 East Mall	F4
Ritsumeikan-UBC House, 6460 Agronomy Rd	F2
Rose Garden	B3
Roy Barnett Recital Hall - in Music Building	
Rugby Pavilion, 2584 East Mall	G4
Scarfe (Neville) Building [Education], 2125 Main Mall	D3
School of Population & Public Health (SPPH), 2206 East Mall	E4
Simon K.Y. Lee HKU-UBC House — Bldg #1, Marine Drive Residence	E2
Sing Tao Building, 6388 Crescent Rd	B3
Sopron House, 2730 Acadia Rd	G7
South Campus Warehouse, 6116 Nurseries Rd	South Campus
Spirit Park Apartments, 2705-2725 Osoyoos Cresc	G8
St. Andrew's Hall/Residence, 6040 Iona Dr	B5
St. John's College, 2111 Lower Mall	D2
St. Mark's College, 5935 Iona Dr.	B6
Staging Research Centre, 6045 Nurseries Rd	South Campus
Stores Road Annex, 6368 Stores Rd	E3
Student Recreation Ctr, 6000 Student Union Blvd	C5
Student Union Bldg (SUB), 6138 Student Union Blvd	C4
TEF3 (Technology Enterprise Facility 3), 6190 Agronomy Rd	F4
Thea Koerner House [Faculty of Graduate Studies], 6371 Crescent Rd	B3
Theatre-Film Production Bldg, 6358 University Blvd	D3
Thunderbird Residence, 6335 Thunderbird Cresc	F3/4
Thunderbird Stadium, 6288 Stadium Rd	J3
Thunderbird Winter Sports Ctr — *see Doug Mitchell Thunderbird Sports...*	
Totem Field Studios, 2613 West Mall	H2
Totem Park Residence, 2525 West Mall	F/G2
TRIUMF, 4004 Wesbrook Mall	South Campus
Triumf House (TRIUMF Visitor's Residence), 5835 Thunderbird Blvd	G6
UBC Bookstore, 6200 University Blvd	D4
UBC Farm, 6182 Wesbrook Mall	South Campus
UBC Hospital, 2211 Wesbrook Mall	E5
UBC Tennis Centre, 6160 Thunderbird Blvd	G4
UBC Thunderbird Arena (in Doug Mitchell Centre), 2555 Wesbrook Mall	G5
University Centre (Leon & Thea Koerner), 6331 Crescent Rd	B3
University Neighbourhoods Association, 5923 Berton Ave	South Campus
University Services Building (USB), 2329 West Mall	E2
Vancouver School of Theology, 6000 Iona Drive	B5
Walter H. Gage Residence, 5959 Student Union Blvd	C5
War Memorial Gymnasium, 6081 University Blvd	D5
Wayne & William White Engineering Design Ctr, 2345 East Mall	E4
Wesbrook Bldg, 6174 University Blvd	D4
Wesbrook Place neighbourhood	South Campus
Wesbrook Village shopping centre	South Campus
West Mall Annex, 1933 West Mall	C2
West Mall Swing Space Bldg, 2175 West Mall	D2
Wood Products Laboratory, 2324 West Mall	E3
Woodward IRC, 2194 Health Sciences Mall	E4/5
Woodward Library, 2198 Health Sciences Mall	E4/5

SOUTH CAMPUS MAP

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Campus & Community Planning
www.planning.ubc.ca

Note:
Local traffic only along Wesbrook Mall on South Campus

Map Information

Need help finding your way on campus? Call the Campus & Community Planning MapInfo Line at 604-827-5040, M-F, 8:30-4:30

Or use the online searchable colour map at www.maps.ubc.ca