M5 : Optimality, Stabilization, and Feedback in Nonlinear Control

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This course presents some modern tools for treating truly nonlinear control problems, including nonsmooth calculus and discontinuous feedback. The need for such tools will be motivated, and applications will be made to central issues in optimal and stabilizing control. The context throughout is that of systems of ordinary differential equations, and the level will be that of a graduate course intended for a general control audience.

Topics include:

1. Dynamic optimization: from the calculus of variations to the Pontryagin Maximum Principle
2. Some constructs of nonsmooth analysis, and why we need them
3. Lyapunov functions, classical to modern
4. Discontinuous feedback for stabilization
5. Sliding modes and hybrid systems

Some references are listed below. Most of them are available on Francis Clarke's website :
http://igd.univ-lyon1.fr/~clarke/Clarke-english.html

• F. Clarke, Yu. Ledyaev, R. Stern and P. Wolenski, Nonsmooth Analysis and Control Theory, Graduate Texts in Mathematics Vol. 178, Springer-Verlag, New York, 1998.

• F. Clarke, Necessary Conditions in Dynamic Optimization, Memoirs of the American Mathematical Society, No. 816 (2005).

• F. Clarke, “Nonsmooth analysis in systems and control theory,” in Encyclopedia of Complexity and System Science, Springer, Berlin (to appear).

• F. Clarke, Lyapunov functions and feedback in nonlinear control, in "Optimal Control, Stabilization and Nonsmooth Analysis", M.S. de Queiroz, M. Malisoff, P. Wolenski (Eds.), Lecture Notes in Control and Information Sciences Vol. 301, pp. 267-282, Springer-Verlag, 2004.

• F. Clarke, Yu. Ledyaev, L. Rifford and R. Stern, Feedback stabilization and Lyapunov functions, SIAM J. Control and Optim. 39 (2000) 25-48.

• F. Clarke, Yu. Ledyaev, and R. Stern, Asymptotic stability and smooth Lyapunov functions, Journal of Differential Equations 149 (1998) 69-114.

• F. Clarke, P. Caines, X. Liu and R. Vinter, A maximum principle for hybrid optimal control problems with pathwise constraints, Proc. 45th Conf. on Dec. and Control, pp. 4821-4825, IEEE, 2006.

Francis Clarke was born in 1948 in Montréal. His PhD is from the University of Washington (1973); he became full professor at the University of British Columbia in 1978. In 1984 he was named director of the Centre de Recherches Mathématiques (CRM) at l’Université de Montréal.
During his nine-year tenure, CRM evolved into Canada’s first national research center for mathematics and its applications. Clarke was also founding director of ISM, a mathematics institute spanning Montréal’s four universities. He is now a faculty member at l’Université de Lyon, in l’Institut Camille Jordan, and also holds a chair in mathematical control theory at l’Institut universitaire de France. Francis Clarke’s research interests lie in nonsmooth analysis (a term he coined), differential equations, control theory, optimization, and the calculus of variations.
His contributions have involved the development of nonsmooth calculus, its applications to dynamic optimization, regularity and existence theory in the calculus of variations, Hamiltonian mechanics, generalized solutions of the Hamilton- Jacobi equation, and feedback control synthesis. Francis Clarke is the author of the book Optimization and Nonsmooth Analysis (Wiley 1983, now in SIAM’s Classics in Applied Mathematics Series), which has been translated into Russian. A Fellow of the Royal Society of Canada, he has received the Coxeter-James and the Archambault research prizes, and a Killam Fellowship. He has been a featured speaker at the International Congress of Mathematicians (Helsinki 1978), plenary speaker at the CDC (Brighton 1991) and the ECC (Porto 2001), and keynote speaker at the Congress of Nonlinear Analysts (Athens 1996). In 2004 he was president of the scientific committee for the first joint meeting of the six mathematical societies of Canada and France.