An interview with R. Terry Rockafellar —— Jie Sun

(We also include in this issue the interview paper published in Bulletin of the Portuguese International Center for Mathematics and prepared by Luís Nunes Vicente (University of Coimbra))

1. Your full name, address and e-mail address

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2. Your highest degree, awarding institution and year

Ph.D., Harvard University, 1963 (Mathematics). Also, though, I have received the degree of Doctor Honoris Causa from universities in the Netherlands, France, Chile and Spain.

3. How many research papers have you published (including papers accepted for publication)? How many of them in the field of optimization?

Almost 190 articles, along with 3 major books and 4 lesser monographs. All of these works are, in a broad sense, related to optimization, if studies of convexity and nonsmoothness are included. My research in such directions of basic theory has always been inspired by questions arising from optimization problems of one kind or another. On the other hand, a lot of effort has gone into convex and nonconvex programming, network optimization, stochastic programming, optimal control, variational inequalities, numerical methodology, and many applications, especially to finance in recent years.

4. Your research interests

Optimization problems of virtually all kinds (except combinatorial), and the foundations in convex and variational analysis for understanding their solutions and stability.

5. Some of your most representative papers, books and/or software packages

The books I would like to emphasize are:

Variational Analysis, *Grundlehren der Mathematischen Wissenschaften 317*, Springer-Verlag, 1997 (733 pp.) (with R. J-B Wets).
Network Flows and Monotropic Optimization, Wiley-Interscience, 1984 (610 pp.).
Conjugate Duality and Optimization, No. 16 in Conference Board of Math. Sciences Series, SIAM Publications, 1974 (79 pp.).
Convex Analysis, Vol. 28 of Princeton Math. Series, Princeton Univ. Press, 1970 (470 pp.).

Out of the multitude of articles, the following are some that I am particularly proud of in optimization methodology:

"Augmented Lagrange multiplier functions and duality in nonconvex programming," SIAM J. Control 12 (1974), 268-285,
"Monotone operators and the proximal point algorithm," SIAM J. Control Opt. 14 (1976), 877–898,
"Scenarios and policy aggregation in optimization under uncertainty," Math. of Oper. Res. 16 (1991), 119–147 (with R. J-B Wets),
"Convergence rates in forward-backward splitting," SIAM J. Optim. 7 (1997), 421–444 (with G. H.-G. Chen).

In optimal control and its generalizations, on which I have worked so hard from the beginning, two key papers are:

"Equivalent subgradient versions of Hamiltonian and Euler-Lagrange equations in variational analysis," SIAM J. Control Opt. 34 (1996), 1300–1315,
"Convexity in Hamilton-Jacobi theory 1: dynamics and duality," SIAM J. Control Opt. 40 (2001), 1323–1350 (with P. R. Wolenski).

Some of the toughest, yet far-ranging applications of variational analysis can be found in:

"Stability of locally optimal solutions," SIAM J. Optim. 10 (2000), 580–604 (with A. B. Levy and R. A. Poliquin),
"The radius of metric regularity," Trans. Amer. Math. Soc. 355 (2002), 493–517 (with A. L. Dontchev and A. S. Lewis).

Finally, in the line of applications, two papers in finance can be listed. The first of these probably counts as the paper that has had the most immediate and wide-spread practical impact of anything I have ever done. The second, which required endless efforts at translating the language of laws and regulations into consistent mathematics was surely, if not the hardest of accomplishments, the most frustrating!

"Conditional value-at-risk for general loss distributions," J. Banking and Finance 26 (2002), 1443–1471,
"Mathematics of debt instrument taxation," Financial Markets, Institutions and Instruments 3 (1994), 1–87 (with J. C. Dermody).

6. Please describe your major contributions in optimization
Convex and variational analysis, duality theory (including stochastic programming and control), subgradient theory, extended nonlinear programming models, the neoclassical framework for optimal control, augmented Lagrangians, and such numerical approaches as the proximal point algorithm and the progressive hedging algorithm, along with the recent reduction to linear programming of portfolio optimization problems involving conditional value-at-risk.

7. Your PhD students: how many them, please present names of some of them
I supervised 21 doctoral students. L. McLinden was the first, followed by F. Clarke, J. Spingarn, J. Murray, J. Treiman, A. King, B. Bell, Jie Sun, R. Poliquin, P. Wolenski, Chi Do, Roxin Zhang, S.E. Wright, Ciyou Zhu, Sien Deng, Honggang Chen, A. Levy, D. Salinger, G. Galbraith, T. Pennanen, and R. Goebel.

8. What are the most important recent developments in the optimization branch you are working on? Please specify the name of the branch
Since I am working in several areas simultaneously, I need to give several answers. In practical applications of optimization, where much of my energy these days goes into topics in finance, the biggest thing recently has been the development of "risk measures" such as conditional-value-at-risk, which make great sense, utilize convexity and dramatically improve capability in computations. On the variational analysis front, a new understanding of "metric regularity" is now unifying what we know about solution stability and conditioning in optimization, constraint systems and equilibrium modeling. For optimal control, I am especially excited about new approaches to feedback rules which are emerging from duality theory.

9. What are the most interesting unsolved problems in the opti-

mization branch you are working on

This is hard to say, because I don't generally think in such terms. We always wish to solve optimization problems that are bigger and harder than in the past, and which involve ever more complicated structures. Tools like duality, subgradients, stability analysis, optimality conditions suggestive of decomposition algorithms, and the like, are extremely important in that. I like to focus on contributing to the broad and steady advance of optimization theory. as needed for such purposes, instead of on targets of a more specific sort.