

## MINIMIZATION OF NONDIFFERENTIABLE FUNCTIONS IN THE PRESENCE OF NOISE

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The development of methods of minimization of nondifferentiable functions is of great interest for the solution of many problems such as minimax problems, two-stage mathematical-programming problems, etc. From the point of view of practical application it is of considerable interest to ascertain the performance of these methods in the presence of noise. The principal result of this paper consists in the fact that the specific character of nondifferentiable functions makes it possible in certain cases to get rid of the conventional conditions of stochastic approximation used for the suppression of random noise.

We shall consider nonconvex nondifferentiable functions whose properties are defined as follows [1, 2].

**Definition.** A continuous function  $f(x)$  is said to be weakly convex if for any  $x$  there exists a set  $M(x)$  of vectors  $g$  such that for any  $y$ ,

$$f(y) - f(x) \geq g(y - x) + r(x, y) \quad (1)$$

where for  $y \rightarrow x$  we have  $r(x, y)/|x - y| \rightarrow 0$  uniformly in  $x$  in any closed bounded subset of  $E_n$ .

In [1], the vector  $g$  is called the quasigradient of a weakly convex function.

For solving the problem

$$\min_{x \in E_n} f(x) \quad (2)$$

we have proposed in [2] the quasigradient method

$$x^{n+1} = x^n - \rho_n g(x^n), \quad n = 0, 1, \dots$$

and we proved its convergence under appropriate assumptions. In the present paper we shall ascertain the conditions of convergence of the algorithm

$$x^{n+1}(\omega) = x^n(\omega) - \rho_n \tilde{g}^n(x^n, \omega),$$

where

$$\tilde{g}^n(x^n, \omega) = g(x^n(\omega)) + \eta^n(\omega),$$

$\eta^n(\omega)$  being independent uniformly distributed random disturbances,  $E|\eta^n|^2 < \infty$ . In the following we shall sharpen the requirements towards  $\eta^n(\omega)$ . We shall assume that problem (2) has the following property: If we denote by  $X^*$  the set  $\{x^* : 0 \in M(x^*)\}$ , then there exists a positive  $\delta$  such that for any  $x \in X^*$  we have  $g \geq \delta$ , where  $g \in M(x)$ .

This property is not very rigorous, and it holds for practically all linear minimax problems, i.e., for problems of form (2) in which  $f(x) = \max_{i \in I} (x_i, x)$ .

We have the following theorem.

**THEOREM.** Let  $E|\eta^n| < \gamma$ , where  $\gamma$  is sufficiently small,

$$\rho_n = \infty, \rho_n/\rho_{n+1} \rightarrow 1, \rho_n \rightarrow 0,$$

$f(x)$  assumes on  $X^*$  not more than a countable number of values, and the set  $\{f(x) \leq f(x^*) + C\}$  is bounded for a positive  $C$ . Then the algorithm

$$x^{n+1}(\omega) = \begin{cases} x^n(\omega) - \rho_n \tilde{g}^n(x^n, \omega), & f(x^n) \leq f(x^*) + C, \\ x^n, & \text{otherwise.} \end{cases}$$

Translated from *Kibernetika*, No. 4, pp. 59-61, July-August, 1974. Original article submitted January 29, 1974.

# Minimization Methods For Nondifferentiable Functions

**M Woodhall**

## **Minimization Methods For Nondifferentiable Functions:**

**Minimization Methods for Non-Differentiable Functions** N.Z. Shor, 2012-12-06 In recent years much attention has been given to the development of automatic systems of planning design and control in various branches of the national economy Quality of decisions is an issue which has come to the forefront increasing the significance of optimization algorithms in mathematical software packages for automatic systems of various levels and purposes Methods for minimizing functions with discontinuous gradients are gaining in importance and the experts in the computational methods of mathematical programming tend to agree that progress in the development of algorithms for minimizing nonsmooth functions is the key to the construction of efficient techniques for solving large scale problems This monograph summarizes to a certain extent fifteen years of the author's work on developing generalized gradient methods for nonsmooth minimization This work started in the department of economic cybernetics of the Institute of Cybernetics of the Ukrainian Academy of Sciences under the supervision of V S Mikhalevich a member of the Ukrainian Academy of Sciences in connection with the need for solutions to important practical problems of optimal planning and design In Chap 1 we describe basic classes of nonsmooth functions that are differentiable almost everywhere and analyze various ways of defining generalized gradient sets In Chap 2 we study in detail various versions of the subgradient method show their relation to the methods of Fejer type approximations and briefly present the fundamentals of e subgradient methods

Minimization Methods for Non-Differentiable Functions N. Z. Shor, K. C. Kiwiel, A. Ruszczynski, 1984-12-01

## **Nondifferentiable**

**Optimization and Polynomial Problems** N.Z. Shor, 2013-04-17 Polynomial extremal problems PEP constitute one of the most important subclasses of nonlinear programming models Their distinctive feature is that an objective function and constraints can be expressed by polynomial functions in one or several variables Let  $e \in \mathbb{R}^n$  be the vector in  $n$  dimensional real linear space  $\mathbb{R}^n$   $P_0, P_1, \dots, P_m$  are polynomial functions in  $\mathbb{R}$  with real coefficients In general a PEP can be formulated in the following form 0 1 find  $r \in \mathbb{R}$  subject to constraints 0 2  $P_i(e) \leq 0$   $i = 1, \dots, m$  a constraint in the form of inequality can be written in the form of equality by introducing a new variable for example  $P(e) = 0$  is equivalent to  $P(e) = 0$  Boolean and mixed polynomial problems can be written in usual form by adding for each boolean variable  $z$  the equality  $Z_2 = Z_0$  Let  $a$  be an integer vector with nonnegative entries  $a \in \mathbb{N}^n$  Denote by  $R_a$  a monomial in  $n$  variables of the form  $n! R_a e^{aT} e^a$   $|a| = 1$   $d = \sum a_i$  is the total degree of monomial  $R_a$  Each polynomial in  $n$  variables can be written as sum of monomials with nonzero coefficients  $P(e) = \sum a_i R_a e^{aT} e^a$  Nondifferentiable optimization and polynomial problems where  $A \subseteq P$  is the set of monomials contained in polynomial  $P$

*Algorithms for Solving Nonlinear Programming Problems with Noisy Data* Michael Hintermüller, 1998

*Sensitivity Analysis and Optimization of Discrete Event Systems*, 1992

*Computational Methods in Science and Engineering* George Maroulis, Theodore E. Simos, 2009-09-02 The aim of ICCMSE 2008 is to bring together computational scientists and engineers from several disciplines in order to share methods methodologies and ideas The

potential readers are all the scientists with interest in Computational Mathematics Theoretical Physics Computational Physics Theoretical Chemistry Computational Chemistry Mathematical Chemistry Computational Engineering Computational Mechanics Computational Biology and Medicine Scientific Computation High Performance Computing Parallel and Distributed Computing Visualization Problem Solving Environments Software Tools Advanced Numerical Algorithms Modelling and Simulation of Complex Systems Web based Simulation and Computing Grid based Simulation and Computing Computational Grids and Computer Science *Numerical Methods of Nonlinear Programming and Their Implementations*

Claus Richter, Horst Hollatz, Diethard Pallaschke, 1991 **Stable Methods for III-Posed Variational Problems** Alexander Kaplan, Rainer Tichatschke, 1994-09-13 Iterative prox regularization methods for solving ill posed convex variational problems in Hilbert spaces are subject of this book. A general framework is developed to analyse simultaneously procedures of regularization and successively refined discretization in connection with specific optimization methods for solving the discrete problems. This allows an efficient control of the solution process as a whole. In the first part of the book various methods for treating ill posed problems are presented including a study of the regularizing properties of a number of specific optimization algorithms. In the second part a new class of multi step methods is introduced which is based on a generalization of the iterative prox regularization concept. Compared with former methods these new methods permit a more effective use of rough approximations of the infinite dimensional problems and consequently an acceleration of the numerical process. Special versions of these methods are given for ill posed convex semi infinite optimization problems and elliptic variational inequalities with weakly coercive operators including some problems in elasticity theory **Introduction to Optimization**

Boris Teodorovich Poliak, 1987 Computational Techniques and Applications, CTAC, 1995 **Vestnik** Leningrad (R.S.F.S.R.). Universitet, 1983 **A M. Kir. Ferencz Jozsef-Tudomanyegyetem tudomanyos ko zlemenyei.**

**Mathematikai tudomanyok** József Attila Tudományegyetem, 1986 **Iterative Methods for Solving Linear Complementarity and Linear Programming Problems** Yun-Chian Cheng, 1981 Mathematical Reviews, 2003

**Mathematical Programming** Masao Iri, Kunio Tanabe, 1989-11-30 System Modelling and Optimization Hans-Jürgen Sebastian, K. Tammer, 1990 The aim of the present proceedings volume is to discuss recent advances in the mathematical representation of engineering socio technical and socio economical systems as well as in the optimization of their performance. The papers presented are extended versions of about 100 lectures plenary lectures as well as lectures of the parallel sessions of the conference. All papers include original researching results of the authors. Some have the character of a survey **Automation and Remote Control**, 1981 **Bulletin de l'Académie polonaise des sciences** Polska Akademia Nauk, 1987 **Technical Report**, **Bollettino Della Unione Matematica Italiana** Unione matematica italiana, 1994

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