Dedicated to Prof. Qamrul Hasan Ansari on the occasion of his 60<sup>th</sup> anniversary

# Characterizing the Lagrange multiplier rule in nonconvex set-valued optimization

# S. Atarzadeh<sup>1</sup>, M. Fakhar<sup>1</sup> and J. Zafarani<sup>2</sup>

## ABSTRACT.

In this article, by using the notions of contingent derivative, contingent epiderivative and generalized contingent epiderivative, we obtain some characterizations of the Lagrange multiplier rule at points which are not necessarily local minima.

**Acknowledgement.** The authors would like to thank the reviewers for their constructive comments, which helped us to improve the paper.

### REFERENCES

- Aubin, J. P., Contingent derivatives of set valued maps and existence of solutions to nonlinear inclusions and differential inclusions, Mathematical analysis and applications, Part A, Adv. in Math. Suppl. Stud., 7a, Academic Press, New York-London, 1981 pp. 159–229
- [2] Aubin, J. P. and Frankowska, H., Set valued analysis. Systems, Control: Foundations, Applications, 2, Birkhäuser Boston, Inc., Boston, MA, 1990
- [3] Chen, G. Y. and Jahn, J., Optimality conditions for set-valued optimization problems, Math. Methods Oper. Res., 48, (1998) 187–200
- [4] Corley, H. W., Optimality conditions for maximizations of set-valued functions, J. Optim. Theory Appl., **58** (1988), 1–10
- [5] Flores-Bazán, F. and Mastroeni, G., Strong duality in cone constrained nonconvex optimization, SIAM J. Optim. 23 (2013), 153–169
- [6] Flores-Bazán, F. and Mastroeni, G., Characterizing FJ and KKT conditions in nonconvex mathematical programming with applications, SIAM J. Optim., 25 (2015), 647–676
- [7] Gerth, C. and Weidner, P., Nonconvex separation theorems and some applications in vector optimization, J. Optim. Theory Appl., 67 (1990), 297–320
- [8] Götz, A. and Jahn, J., The Lagrange multiplier rule in set valued optimization, SIAM J. Optim., 10 (2000), 331-344
- [9] Jahn, J., Vector Optimization. Theory, applications and extensions, Springer-Verlag, Berlin, 2004
- [10] Jahn, J., Mathematical vector Optimization in Partially Ordered Linear Spaces, Verlag Peter D. Lang, Frankfurt am Main, 1986
- [11] Jahn, J. and Khan, A., Generalized contingent epiderivatives in set-valued optimization: optimality conditions, Numer. Funct. Anal. Optim., 23 (2002), 807–831
- [12] Jahn, J. and Rauh, R., Contingent epiderivatives and set-valued optimization, Math. Methods Oper. Res., 46 (1997), 193–211
- [13] Khan, A. and Tammer, C., Zălinescu, C., Set-valued optimization. An introduction with applications, Springe, Heidelberg, 2015
- [14] Lagrange, J. L., Théorie des fonctions analytiques, Paris, 1797
- [15] Peng, Z. and Wan, Z., Second-order Karush-Kuhn-Tucker optimality conditions for set-valued optimization subject to mixed constraints, Results Math., 73 (2018) Art. 101, 20 pp.

Received: 22.05.2019; In revised form: 22.08.2019; Accepted: 30.08.2019

<sup>2010</sup> Mathematics Subject Classification. 90C46, 90C29, 49J53.

Key words and phrases. set-valued optimization, contingent derivative, generalized contingent epiderivative, Lagrange multipliers.

Corresponding author: M. Fakhar; fakhar@math.ui.ac.ir

#### Atarzadeh, Fakhar, Zafarani

- [16] Luc, D. T., Contingent derivatives of set-valued maps and applications to vector optimization, Math. Programming, 50 (1991), 99–111
- [17] Taa, A., Set-valued derivatives of multifunctions and optimality conditions, Numer. Funct. Anal. Optim., 19 (1998), 121–140

<sup>1</sup>DEPARTMENT OF MATHEMATICS UNIVERSITY OF ISFAHAN ISFAHAN, 81745-163, IRAN *E-mail address*: atarzadeh@shbu.ac.ir *E-mail address*: fakhar@sci.ui.ac.ir

<sup>2</sup>SHEIKHBAHAEE UNIVERSITY AND UNIVERSITY OF ISFAHAN DEPARTMENT OF MATHEMATICS ISFAHAN, IRAN *E-mail address*: jzaf@zafarani.ir

#### 408