# Computing Derivatives on the Infinity Computer

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In this lecture, algorithms for the computation of derivatives [1], Lie Derivatives [3], gradient vectors, Jacobian and Hessian matrices based on the Infinity Computer Arithmetic are presented. A preliminary Matlab class that uses a subset of the Infinity Computer Arithmetic has been implemented. The proper usage of this class enables the integration of the Infinity Computer into codes that require computation of derivatives. The potential of using this class is demonstrated by its application to the following areas:

- Computation of the Jacobian in codes for solving Boundary Value Problems. Examples of the solution of Optimal Control Problems with indirect methods will be presented [2];
- Computation of high-order dense output for super-convergent collocation Runge-Kutta methods (Gauss-Lobatto and Gauss-Legendre methods);
- Solution of Ordinary Differential equations using multi-derivative methods [3, 4];
- Computation of gradients.

The discussed set of successful case-studies shows the Infinity Computer Arithmetic to be a very promising tool for scientific numerical applications.

## References

[1] Sergeyev Ya. D. (2011) Higher order numerical differentiation on the Infinity Computer. *Optimization Letters*, 5(4):575–585. DOI: 10.1007/s11590-010-0221-y

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[3] Iavernaro F., Mazzia F., Mukhametzhanov M. S., Sergeyev Ya. D. (2021) Computation of higher order Lie derivatives on the Infinity Computer *Journal of Computational and Applied Mathematics* 383, art. no. 113135, DOI: 10.1016/j.cam.2020.113135

[4] Iavernaro F., Mazzia F., Mukhametzhanov M. S., Sergeyev Ya. D. (2020) Conjugate-symplecticity properties of Euler-Maclaurin methods and their implementation on the Infinity Computer *Applied Numerical Mathematics*, 155:58–72 DOI: 10.1016/j.apnum.2019.06.011