# Easy-to-implement *hp*-adaptivity for non-elliptic goal-oriented problems

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# Main Achievements

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## Peer-Reviewed Publications

F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, and D. Pardo. "A Multi-Adaptive-Goal-Oriented Strategy to Generate Massive Databases of Parametric PDEs," To be submitted to *Computer Methods in Applied Mechanics and Engineering*, December 2023.

F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, E. Alberdi, and D. Pardo. "A Painless Multi-Level Automatic Goal-Oriented *hp*-Adaptive Coarsening Strategy for Elliptic and Non-Elliptic Problems," *Computer Methods in Applied Mechanics and Engineering*, vol. 401, 115641, 2022. https://doi.org/10.1016/j.cma.2022.115641

F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, E. A. Celaya, and D. Pardo. "1D Painless Multi-Level Automatic Goal-Oriented *h* and *p* Adaptive Strategies Using a Pseudo-Dual Operator," In *Computational Science – ICCS 2022*, pp. 347–357, 2022. https://doi.org/10.1007/978-3-031-08754-7_43

# Main Achievements

## Conference Talks

[1] F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, and D. Pardo.
*Databases for Deep Learning Inversion Using A Goal-Oriented hp-Adaptive Strategy.*
XI International Conference on Adaptive Modeling and Simulation,
Gothenburg, Sweden, June 19-21, 2023.

[2] F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, E. Alberdi, and D. Pardo.
*A Painless Automatic hp-Adaptive Coarsening Strategy For Non-SPD problems: A Goal-Oriented Approach.* 15th World Congress on Computational Mechanics & 8th Asian Pacific Congress on Computational Mechanics,
Yokohama, Japan, July 31 - August 5, 2022.

[3] F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, E. Alberdi, and D. Pardo.
*1D Painless Multi-Level Automatic Goal-Oriented h and p Adaptive Strategies using a Pseudo-Dual Operator.* 22nd International Conference on Computational Science,
London, United Kingdom, June 21-23, 2022.

# Main Achievements

## Conference Talks

[4] F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, E. Alberdi, and D. Pardo. *Goal-Oriented hp-Adaptive Finite Element Methods: A Painless Multilevel Automatic Coarsening Strategy For Non-SPD Problems.* 8th European Congress on Computational Methods in Applied Sciences and Engineering, Oslo, Norway, June 5-9, 2022.

[5] F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, E. Alberdi, and D. Pardo. *A Painless Goal-Oriented hp-Adaptive Strategy for Indefinite Problems.* 16th U.S. National Congress on Computational Mechanics, Chicago, U.S.A, July 25-29, 2021.

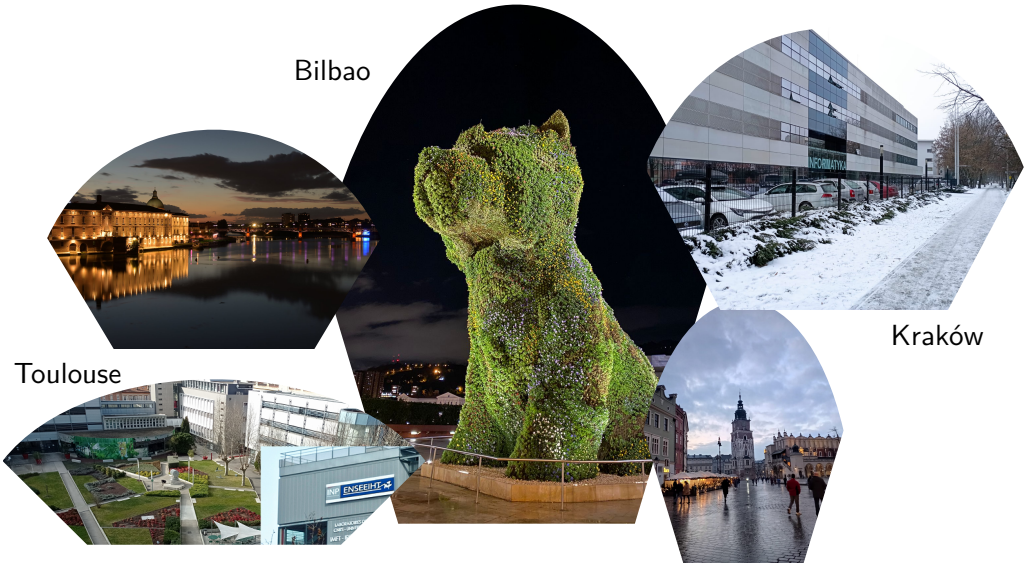
[6] F. V. Caro, V. Darrigrand, J. Alvarez-Aramberri, E. Alberdi, and D. Pardo. *Goal-Oriented hp-Adaptive Finite Element Methods: A Painless Multi-level Automatic Coarsening Strategy.* 10th International Conference on Adaptive Modeling and Simulation, Gothenburg, Sweden, June 21-23, 2021.

# Main Achievements

## Research Stays

| | |
|---|---|
| Feb. 2023 – Mar. 2023 (2 months) | University of Science and Technology (AGH), Krakow (Poland). **Supervisor:** Maciej Paszynski. |
| Sep. 2021 – Nov. 2021 (2 months) | CNRS-IRIT-ENSEEIHT (N7), Toulouse (France). **Supervisor:** Vincent Darrigrand. |
| Nov. 2020 – Dec. 2020 (1 month) | CNRS-IRIT-ENSEEIHT (N7), Toulouse (France). **Supervisor:** Vincent Darrigrand. |

# Main Achievements



# Conclusions and Future Work

# Conclusions

- We employ hierarchical basis functions that effectively address the challenge of *hanging nodes*.
- We have developed **simple-to-implement** *h*- and *p*-GOA strategies that use an unconventional symmetric and positive definite bilinear form for possibly non-elliptic goal-oriented problems.
- We have expanded upon a painless automatic *hp* strategy, initially developed for energy-norm adaptivity, to both non-elliptic and goal-oriented problems.
- We have extended the applicability of a coarsening strategy to encompass parametric PDEs.

# Future Work

- Extend algorithms to address multi-physics problems, notably $H(\text{curl})$ and $H(\text{div})$.
- Validate the efficacy of our algorithms in real-world scenarios such as Magnetotellurics, Controlled Sources, and Logging While Drilling.
- Analyze the impact of the nature and distribution of various random samples on DL inversion for optimization.
- Enhance parallelization and factorization techniques to reduce computational resource requirements in future applications.