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Online Benchmarking for Active Learning

A competitive lossless data compression challenge in Algorithmic Information Theory

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Resumo / Abstract

This work presents an active learning experience build around a competitive online benchmark for lossless data compression, implemented in the Algorithmic Information Theory (AIT) course unit attended by first-year master's students (2026). Students designed, implemented and evaluated compressor and decompressor pairs for challenge datasets, using public training data and hidden test data to promote reproducibility, generalization and fair comparison between solutions. They were also encouraged to use large language models (LLMs) as assistive tools, provided they explained their design and implementation choices. Submissions were assessed through objective metrics, including compression ratio, compression and decompression time, lossless verification and comparison with reference compressors. The online platform provided a continuously updated leaderboard, interactive filters, colour-coded visual cues and dynamic exploration tools, allowing students to monitor performance, compare alternatives and identify opportunities for improvement. The website was also refined during the activity according to student feedback, creating a collaborative development environment in which requests made in class could be incorporated by the following session. This short feedback loop increased engagement, strengthened the perception of joint work between teacher and students, and supported iterative experimentation. The benchmark generated more than one hundred valid compressors, an average of more than ten submissions per group, and scientific material consolidated into a research article.

Pedagogical objectives

The activity aimed to connect information theory, algorithmic reasoning and experimental programming, while bringing assessment closer to real practices in computational research and development. It also sought to promote autonomy in hypothesis formulation, testing and interpretation of results, as well as teamwork, technical documentation, evidence-based decision-making and scientific communication. In this way, the benchmark was used not only as an assessment instrument but also as a structured environment for inquiry, iteration and reflective improvement.

Activity design

The activity combined public training data, hidden test data and iterative submissions of compressor and decompressor pairs, with minimal but verifiable rules. The online leaderboard provided updated results, filtering tools, plots and rankings by performance, while classroom discussion supported the interpretation of trade-offs between compression, speed, memory use and generalization. The website also evolved in response to student feedback. Suggestions such as filtering by multiple string patterns, improving comparisons between approaches and adding colors to distinguish results were incorporated between classes, reinforcing the idea that students and teachers were improving the challenge together.

Benchmark website

The AIT Data Compression Challenge website was developed as a highly interactive JavaScript/CSS platform, allowing students to choose, filter and compare submissions, rankings, plots, metrics and Weissman scores (Fig.1). Its dynamic behavior, color coding and usability features helped students inspect results in greater detail and obtain additional information without leaving the leaderboard. Because the platform was progressively improved during the activity, students could see their feedback reflected in the tool used for assessment. This "mirror effect" increased engagement, effort and ownership of the learning process.

https://aitdcc.github.io/

Article

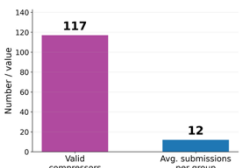

Fig.2 Quantitative benchmark outcomes: valid compressors & average submissions per group.

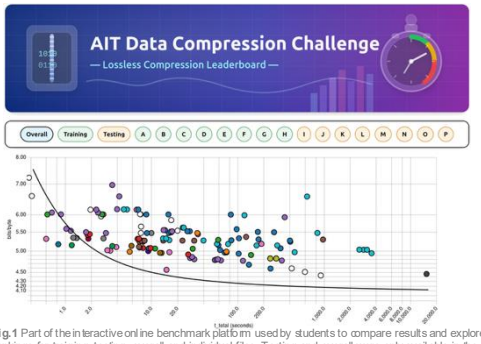

Fig.1 Part of the interactive online benchmark platform used by students to compare results and explore rankings for training, testing, overall and individual files. Testing and overall were only available in the end.

Observed results

A total of 117 valid compressors were evaluated, with an average of approximately 12 submissions per group (Fig.2). Compared with the previous academic year, in which no online benchmark was used, the average number of submissions increased by roughly one order of magnitude. This numerical evidence indicates that the benchmark, together with its public leaderboard, hidden tests, interactivity and iterative feedback, contributed to stronger participation and involvement. Several solutions achieved competitive performance and some outperformed reference compressors. The quality and diversity of the submissions also generated scientific material that supported the writing of a research article.

Learning evidence

Evidence of learning was not restricted to the final product. It included the submission history, the progressive improvement of performance, the correct operation of compressor and decompressor pairs, quantitative comparison with reference methods, documentation of methodological and technical choices, presentation of results and design decisions, and students' contributions to improving the website. The rapid incorporation of feedback created a perception of shared work and transformed assessment into a visible co-construction process. This was particularly relevant because students could observe that more effort on their side was mirrored by improvements in the learning environment.

Developed competences

The activity developed technical competences in lossless compression, programming, reproducible evaluation, metrics, algorithmic efficiency and experimental analysis. At the same time, it promoted transversal competences such as autonomy, collaboration, data-driven decision-making, technical documentation, oral communication and scientific argumentation. The competitive but transparent format encouraged students to justify their choices, compare alternatives and learn from the behavior of other groups without reducing the process to a single final score.

Conclusions

Online benchmarking worked as a challenge-based active learning strategy. Competition increased motivation, engagement and participation, as shown by the increase of approximately one order of magnitude in average submissions compared with the previous year. The training/test structure, public ranking, iterative submissions, interactive website and continuous platform improvement connected theory and practice and created a strong feedback loop. The process produced pedagogical and scientific value, including evidence of transversal competence development, stronger student involvement and material for a research article.

References

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