

Deckard: A Declarative Tool for Machine Learning Robustness Evaluations

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DOI: [10.xxxxxx/draft](https://doi.org/10.xxxxxx/draft)

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Submitted: 01 January 1970

Published: unpublished

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Summary

The software package presented, called deckard, is a modular software toolkit designed to streamline and standardize experimentation in machine learning (ML) with a particular focus on the adversarial scenario. It provides a flexible, extensible framework for defining, executing, and analyzing end-to-end ML pipelines in the context of a malicious actor. As it is built on top of the Hydra configuration system, deckard supports declarative YAML-based configuration of data preprocessing, model training, and adversarial attack pipelines, enabling reproducible, framework-agnostic experimentation across diverse ML settings.

In addition to configuration management, deckard includes a suite of utilities for distributed and parallel execution, automated hyperparameter optimisation, visualisation, and result aggregation. The tooling abstracts away much of the engineering overhead typically involved in adversarial ML research, allowing researchers to focus on algorithmic insights rather than implementation details. The presented software facilitates rigorous benchmarking by maintaining an auditable trace of configurations, random seeds, and intermediate outputs throughout the experimental lifecycle.

The system is compatible with a variety of ML frameworks and several classes of adversarial attacks, making it a suitable backend for both large-scale automated testing and fine-grained empirical analysis. By providing a unified interface for experimental control, deckard accelerates the development and evaluation of robust models, and helps close the gap between research prototypes and verifiable, reproducible results.

Statement of need

While tools such as mlflow ([Zaharia et al., 2018](#)), Weights & Biases ([Biewald, 2020](#)), optuna ([Akiba et al., 2019](#)), and Kubernetes ([Kubernetes, 2019](#)) provide essential infrastructure for model tracking and experiment management, deckard occupies a different position in the ML ecosystem—focusing specifically on configurable, adversarially robust experimentation.

Unlike MLflow and Weights & Biases, which emphasize logging, visualization, and reproducibility for various ML frameworks, deckard enforces reproducibility by construction through its declarative, YAML-driven configuration system built on Facebook's hydra ([Yadan, 2019](#)) configuration management tool. In contrast to cloud-management software like Kubernetes—which is a general-purpose container orchestration platform—deckard abstracts away orchestration details and offers native support for parallel and distributed experimentation, tailored to ML workflows involving attack/defense cycles, model retraining, or optimisation. While deckard integrates tightly with IBM's Adversarial Robustness Toolbox ([Nicolae et al., 2018](#)), the software is designed to be easily extensible to other attack frameworks. The human- and machine-readable parameter configuration system allows researchers to declaratively define end-to-end pipelines that span data sampling, preprocessing, model training, attack generation,

41 defense evaluation, multi-objective optimisation, and visualisation. Tools like ray (Moritz et
42 al., 2018), optuna (Akiba et al., 2019), or nevergrad (Bennet et al., 2021) offer components
43 of this pipeline (e.g., hyperparameter search or configuration management), but lack unified
44 support for adversarial ML, verification, or auditability at scale. While deckard complements
45 these existing tools, and in many cases can be integrated with them, its primary contribution
46 is in automating and verifying adversarial ML experiments in a way that is both extensible and
47 framework-agnostic.

48 Usage

49 Various versions of this software have been used in several recently published and not-yet-
50 published works by the author of this paper, all of which are available in the examples
51 folder in the source code repository [here](#). One published work, now reproducible via the
52 examples/attack_defence_survey folder, includes a large survey of attacks and defences
53 against canonical datasets and models (C. Meyers et al., 2023). Another work analysed the
54 run-time requirements of attacks against a particular model before and after retraining against
55 those attacks (C. Meyers, Löfstedt, et al., 2024) (reproducible via examples/retraining).
56 The next paper formalised a method for estimating the time-to-failure of a given model against
57 a suite of attacks and introduce a metric that quantifies the ratio of attack and training cost
58 (Meyers et al., 2023) (reproducible via examples/survival_heuristic). Furthermore, a not
59 yet published work uses this time-to-failure model as a mechanism for analysing the cost
60 efficacy of various hardware choices in the context of adversarial attacks (reproducible via
61 examples/power) (C. Meyers, Sedghpour, et al., 2024). Another work exploits the tooling to
62 train a custom model that is designed to run client-side by using compression algorithms to
63 measure the distance between text (reproducible via examples/compression).

64 Experiment Management

65 Typically ML projects are composed of long and complex pipelines that are highly dependent
66 on a number of parameters that must be configured by either the model builder or attacker.
67 Due to the large scale and cost associated with training ML models, it is often necessary
68 to tune a model using many individual model configurations (often called *hyper-parameters*).
69 To determine adversarial robustness, one of many benchmark datasets is first sampled, then
70 preprocessed, sent to a model, with optional pre- and post-processing defences, and then scored
71 according to some chosen metric which may include the performance against any number of
72 adversarial attacks. Each stage in this example pipeline might include tens or hundreds of
73 possible sets of hyper-parameters that must be exhaustively tested. Furthermore, this problem
74 scales drastically as we include more and more stages in a pipeline since each additional
75 stage introduces a new combinatorial layer of complexity, rapidly expanding the total number
76 of potential configurations that must be evaluated for robustness and be reproducible for
77 posterity. Not only does deckard provide a standard way to document and configure these
78 hyper-parameters, it gives each experiment an auditable identifier.

79 Reproducibility and Auditability

80 For ML, various regulatory and legal frameworks govern safety (*IEC 61508 Safety and Functional*
81 *Safety*, 2010; *IEC 62304 Medical Device Software - Software Life Cycle Processes*, 2006; *ISO*
82 *26262-1*, 2018; *The Parliament of the European Union*, 2024), privacy [The Parliament of the
83 European Union (2024); European Parliament & Council of the European Union (2016); Legisla-
84 ture of the United States (1996); Legislature of the United States (1998);] and/or transparency
85 (*The Legislature of California*, 2024; *The Parliament of the European Union*, 2024). The
86 software package presented here provides a machine- and human-readable format for creating
87 reproducible and auditable experiments as required by various regulations. In addition, several

88 examples connected to both published and not-yet-published work live in the examples folder
89 in the repository, allowing for easy reproducibility of several extensive sets of experiments across
90 several popular ML software frameworks. The power example provides a reproducible way to
91 run a suite of adversarial tests using popular cloud-based platforms and the retraining and
92 survival_heuristic examples provide examples of both CPU and GPU-based parallelisation,
93 respectively.

94 The basics subfolder provides a minimum working example for each of the supported ML
95 frameworks: tensorflow (Abadi et al., 2015), pytorch (Paszke et al., 1912), scikit-learn
96 (Pedregosa et al., 2011), and keras (Chollet, 2015). The basics folder also provides examples
97 of various classes of adversarial examples: *poisoning* attacks that change model behaviour by
98 injecting data during training (Biggio et al., 2012), *inference* attacks (Li & Zhang, 2021) that
99 attempt to reverse engineer properties of the training data, *extraction* attacks that attempt to
100 reverse engineer the model (Jagielski et al., 2020), and *evasion* attacks that induce errors of
101 classification during run-time (C. Meyers et al., 2023). The parameters file for each experiment
102 ensures that a given pipeline can be reproduced and the standardised format allows us to
103 derive a hash value that is hard to forge but easy to verify. Not only does this hash serve as an
104 identifier to track the state of an experiment, but also serves as a way to audit the parameters
105 file for tampering. Likewise, by using dvc (DVC Authors, 2023) to track any input or output
106 files specified in the parameters file, the software associates each score file with a identifier
107 that is easy to track and verify, but hard to forge—ensuring that forged or modified results are
108 easy to spot in version-controlled experiment repository.

109 Parallel and Distributed Design

110 Since ML projects can exploit specialized hardware such as multi-core processors or GPUs, and
111 often rely on clusters of machines for large-scale data processing, it was necessary to enable
112 parallel and distributed experiment execution and model optimization. By leveraging the hydra
113 configuration framework, deckard automatically supports optimization libraries like nevergrad
114 (Bennet et al., 2021), Adaptive Experimentation (A. Developers, 2025), and optuna (Akiba
115 et al., 2019), making the software modular and extensible. Additionally, experiments can
116 be managed using a variety of popular job schedulers, including Ray (Moritz et al., 2018),
117 Redis Queue (Stamps, 2025), and slurm (Yoo et al., 2003) for distributed jobs or joblib (J.
118 Developers, 2025) for jobs on a single machine.

119 By using a declarative design, a given set of experiments can be specified once and executed
120 seamlessly across different backends without modification to the underlying codebase. This
121 makes deckard both adaptable and scalable, suitable for use on personal laptops, multi-node
122 servers, or large-scale, high-performance clusters. When configured appropriately, experiment
123 batches can be parallelized, enabling massive parameter sweeps, ensemble evaluations, or
124 adversarial robustness tests to be executed in parallel—reducing turnaround time while main-
125 taining strong guarantees on reproducibility and auditability. The design of the presented
126 software prioritizes clarity and maintainability by capturing each experimental configuration as
127 a YAML artifact, making both successful and failed runs equally traceable and shareable. This
128 approach transforms experiment tracking from an afterthought into a first-class component of
129 the trustworthy ML workflow.

130 Funding

131 Financial support has been provided in part by the Knut and Alice Wallenberg Foundation
132 grant number 2019.0352 and by the eSSSENCE Programme under the Swedish Government's
133 Strategic Research Initiative.

Acknowledgements

The author would like to thank Aaron MacSween, Abel Souza, and Mohammad Saledghpour Reza for their guidance in software design principles. In particular, the author appreciates Mohammad's code and documentation regarding cloud-based and other Kubernetes deployments. The author would like to thanks his advisors, Erik Elmroth and Tommy Löfstedt for their research expertise, funding, and patience.

References

- Abadi, M., Agarwal, A., Barham, P., Brevdo, E., Chen, Z., Citro, C., Corrado, G. S., Davis, A., Dean, J., Devin, M., Ghemawat, S., Goodfellow, I., Harp, A., Irving, G., Isard, M., Jia, Y., Jozefowicz, R., Kaiser, L., Kudlur, M., ... Zheng, X. (2015). *TensorFlow: Large-scale machine learning on heterogeneous systems*. <https://www.tensorflow.org/>
- Akiba, T., Sano, S., Yanase, T., Ohta, T., & Koyama, M. (2019). Optuna: A next-generation hyperparameter optimization framework. *Proceedings of the 25th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*, 2623–2631.
- Bennet, P., Doerr, C., Moreau, A., Rapin, J., Teytaud, F., & Teytaud, O. (2021). Nevergrad: Black-box optimization platform. *ACM SIGEVOlution*, 14(1), 8–15.
- Biewald, L. (2020). *Experiment tracking with weights and biases*. <https://www.wandb.com/>
- Biggio, B., Nelson, B., & Laskov, P. (2012). Poisoning attacks against support vector machines. *International Conference on Machine Learning*.
- Chollet, F. (2015). Keras. In *GitHub repository*. <https://github.com/fchollet/keras>; GitHub.
- Developers, A. (2025). *AX: Adaptive experimentation platform*. <https://ax.readthedocs.io/en/stable/#>
- Developers, J. (2025). *Joblib: Running python functions as pipeline jobs*. <https://joblib.readthedocs.io/en/stable/>
- DVC Authors. (2023). *DVC–Data Version Control*. Github. <https://github.com/iterative/dvc.org>
- European Parliament, & Council of the European Union. (2016, May 4). *Regulation (EU) 2016/679 of the European Parliament and of the Council. Of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)*. <https://data.europa.eu/eli/reg/2016/679/oj>
- IEC 61508 safety and functional safety (2nd ed.). (2010). (2nd ed.) [Computer software]. International Electrotechnical Commission.
- IEC 62304 medical device software - software life cycle processes (2nd ed.). (2006). (2nd ed.) [Computer software]. International Electrotechnical Commission.
- ISO 26262-1:2011, road vehicles — functional safety. (2018). <https://www.iso.org/standard/43464.html> (visited 2022-04-20).
- Jagielski, M., Carlini, N., Berthelot, D., Kurakin, A., & Papernot, N. (2020). High accuracy and high fidelity extraction of neural networks. *29th USENIX Security Symposium (USENIX Security 20)*, 1345–1362.
- Kubernetes. (2019). *Kubernetes—an open source system for managing containerized applications*. Github. <https://github.com/kubernetes/kubernetes>
- Legislature of the United States. (1996). *Health insurance portability and accountability act*.

- Legislature of the United States. (1998). *Children's online privacy protection act*.
- Li, Z., & Zhang, Y. (2021). Membership leakage in label-only exposures. *Proceedings of the 2021 ACM SIGSAC Conference on Computer and Communications Security*, 880–895.
- Meyers, C., Löfstedt, T., & Elmroth, E. (2023). Safety-critical computer vision: An empirical survey of adversarial evasion attacks and defenses on computer vision systems. *Artificial Intelligence Review*, 1–35.
- Meyers, C., Löfstedt, T., & Elmroth, E. (2024). Massively parallel evasion attacks and the pitfalls of adversarial retraining. *EAI Endorsed Transactions on Internet of Things*, 10.
- Meyers, C., Sedghpour, M. R. S., Löfstedt, T., & Elmroth, E. (2024). *A training rate and survival heuristic for inference and robustness evaluation (TRASHFIRE)*. <https://arxiv.org/abs/2401.13751>
- Meyers, Reza, Löfstedt, & Elmroth. (2023). A systematic approach to robustness modelling. *Springer Artificial Intelligence Review*.
- Moritz, P., Nishihara, R., Wang, S., Tumanov, A., Liaw, R., Liang, E., Elibol, M., Yang, Z., Paul, W., Jordan, M. I., & others. (2018). Ray: A distributed framework for emerging {AI} applications. *13th USENIX Symposium on Operating Systems Design and Implementation (OSDI 18)*, 561–577.
- Nicolae, M.-I., Sinn, M., Tran, M. N., Buesser, B., Rawat, A., Wistuba, M., Zantedeschi, V., Baracaldo, N., Chen, B., Ludwig, H., & others. (2018). Adversarial robustness toolbox v1.0.0. *arXiv Preprint arXiv:1807.01069*.
- Paszke, A., Gross, S., Massa, F., Lerer, A., Bradbury, J., Chanan, G., Killeen, T., Lin, Z., Gimelshein, N., Antiga, L., & others. (2019). Pytorch: An imperative style, high-performance deep learning library. *arXiv Preprint arXiv:1912.01703*, 10.
- Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., Blondel, M., Prettenhofer, P., Weiss, R., Dubourg, V., Vanderplas, J., Passos, A., Cournapeau, D., Brucher, M., Perrot, M., & Duchesnay, E. (2011). Scikit-learn: Machine learning in Python. *Journal of Machine Learning Research*, 12, 2825–2830.
- Stamps. (2025). *RQ: Easy job queues for python*. Stamps, an Indonesian CRM company. <https://python-rq.org/>
- The Legislature of California. (2024). *AB-2013 generative artificial intelligence: Training data transparency*.
- The Parliament of the European Union. (2024). *High-level summary of the AI act*.
- Yadan, O. (2019). *Hydra – a framework for elegantly configuring complex applications*. Github. <https://github.com/facebookresearch/hydra>
- Yoo, A. B., Jette, M. A., & Grondona, M. (2003). Slurm: Simple linux utility for resource management. *Workshop on Job Scheduling Strategies for Parallel Processing*, 44–60.
- Zaharia, M., Chen, A., Davidson, A., Ghodsi, A., Hong, S. A., Konwinski, A., Murching, S., Nykodym, T., Ogilvie, P., Parkhe, M., & others. (2018). Accelerating the machine learning lifecycle with MLflow. *IEEE Data Eng. Bull.*, 41(4), 39–45.