Journal of Visualization and Interaction

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Issue #16 (open): [REVIEW] 2024-Cashman-PAC-learning-game

@janeadams on Apr 21, 2025 21:24: [opened]

@janeadams on Apr 21, 2025 21:24:

Conflicts of interest

- ☒ I declare that I have no known conflicts of interest with the authors.

Reviewed version

c2a1a745bd921f67dc32d862cc4bba598ed3e270

Review

This explorable explanation is a simulation of an interactive game to demonstrate PAC (Probably Approximately Correct) learning for minimization of empirical risk (ERM) and potential pitfalls in applied ML. The explanation covers domain mismatch, data dependencies, and model class errors, and provides a compelling case for the value of visualization for identifying these vulnerabilities.

The explanation offers a comprehensive introduction to the fundamentals of PAC learning and challenges to the paradigm from real-world, applied machine learning. The dialogue between the text and the simulation is tightly interwoven, which makes this a great candidate for the experimental explorations track of JoVI. I have included some writing and technical notes below: the most important remaining issues are some conceptual polishing (though the majority of the work is solid) and some technical problems with the simulation. Overall, I enjoyed reading and interacting with this exploration and think it would be a lovely contribution to the visualization research community via JoVI, with interdisciplinary significance also for statistics, applied machine learning, and A.I. ethics.

Writing notes:

- The tone of the explanation is collegial and clear
- The explanation positions itself in the context of prior work by providing direct links to related papers and introducing concepts directly from those papers; similarly, the author provides direct links to modern real-world uses of ML models for which these vulnerabilities are relevant
- The use of questions as a rhetorical device make for an interesting read and helps to break up paragraphs
- The "why this is important" section relates closely to the "domain mismatch" vulnerability mentioned in the introduction, but doesn't explicitly call this problem "domain mismatch". It would be nice to use this term again as a callback to the introduction.
- I'm not sure that the provided simulation is an example of "No Free Lunch" as-is -- my understanding of NFL is that there is a tradeoff, e.g. improved performance in one class comes at the cost of reduced performance on another class. In the example, the lesson is just that no data means no idea of correctness. I think it would be a better illustration of NFL if there was an explanation like "to maximize True Positives, we could draw a box covering the whole area, at the cost of having a high number of False Positives". Something about the tradeoff between Type I and Type II errors based on strategy.

- In "PAC-learning", the parallels drawn between classical statistical methods and computational learning theory are a helpful introduction to a field that I was less familiar with
- The PAC learning mathematical definition strikes a good balance between being complex enough to explain the concept fully, without being too dense for a college-level reader to understand
- "These two parameters in the definition explain the redundancy in the term" thank you, I was wondering!
- The argument for "why we should care about PAC learnability" is very compelling
- In "tightest fit errors", I would expect to see the "four strips" described illustrated in the example. If I try to draw the tightest fit rectangle myself, the points are so close together that in some cases my "tightest rectangle" is still outside of the actual (green) concept rectangle, so it would be nice to see the tightest fit model illustrated for me instead
- In "error from top strip", I'm not seeing anything in the simulation to illustrate T'. Not sure if this is a bug or a misunderstanding on my part
- Be consistent about using mathematical notation for variables, e.g. "M" and "T"
- There is a big conceptual leap from "Error from top strip" to "Error from all strips" if the intended audience includes people without a background in mathematics. The simulation was not working for me at this point (see technical notes below), so maybe if there had been a visual explanation alongside this proof, it would be easier to understand. If readers were to get "lost" at any point, this would be it, so adding some more 'conceptual padding' would help. However, my expertise in interpreting these concepts is somewhat hamstringed by a lack of college-level math, so maybe I am not the intended audience
- The doctor visits analogy in the "not IID" section is a good one
- Fig. 11 here (https://arxiv.org/pdf/1602.04938) is also a good example for Training-Testing Mismatch
- The choice of an ellipse for the "incorrect model class" is a great one -- it's a simple concept that illustrates a vulnerability of models in practice that can be much more complex to understand
- Fantastic summary of why visualization is important for applied machine learning. This explorable would be a useful pedagogical tool in a classroom, because it leaves many questions unanswered (because they are open research questions!) and directs curious readers to further resources with deeper technical complexity

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Openness/Transparency

Overall, the article is very open and reproducible/extensible because of its shared format on Github. Some technical notes:

- When installing, I had to run `sudo npm install -g idyll` in order for the idyll command to work. Otherwise I had no issues cloning and running the code.
- The page does not render properly on mobile (the simulation takes up the whole canvas, so it is not possible to see the text). I think this is okay for an explorable (it's really a desktop experience) but maybe having some kind of pop-up for mobile users ("visit me on desktop!") would be a nice way to "fail elegantly"
- The "?" next to the first "play" button is a helpful detail
- While the cultural association of "red = no" and "green = yes" fits well here, it may be more difficult for colorblind users to differentiate between samples in the simulation when relying only on symbols, but the dual encoding does somewhat alleviate this problem

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Submission categories

- ☐ Registered Report
- ☐ Replication Study
- ☐ Empirical Research - Quantitative
- ☐ Empirical Research - Qualitative
- ☐ Systems or design research

- ☒ Commentary
- ☒ Systematic Literature Review

Suggested outcome

Minor revisions: this paper requires some smaller changes, after which I am confident I would be able to endorse it.

Requested changes

- The "why this is important" section should explicitly call back to the term "domain mismatch" used in the introduction
- Consider revising the "No Free Lunch" example or including an explanation that clarifies the tradeoff more clearly (e.g., between Type I and Type II errors)
- Add an illustration of the "tightest fit" rectangle and the "four strips" in the "tightest fit errors" section
- Clarify the representation or explanation of T' in the "error from top strip" section
- Be consistent with mathematical notation for variables (e.g., "M", "T")
- Add more conceptual explanation between "Error from top strip" and "Error from all strips" for accessibility to non-mathematical readers
- Consider a mobile failover message (e.g., "visit on desktop") for better UX on small screens

Address the simulation bugs:

- "No Free Lunch" test case: clicking "test" yields 0.00% error and no testing samples appear, despite a non-aligned concept box
- Clicking "A little lunch, as a treat" and "Tightest Fit" results in "datum is not defined" error
- "What if the data is not independent and identically distributed?" appears too early, possibly due to the error in the previous section

Fix minor typos and grammar:

- "taskis" â†’ "task is"
- Remove "of" in "the task of a machine learning algorithm does"
- "here error defined" â†’ "here error is defined"
- Consistent casing for "Machine Learning"
- "humans,including" â†’ "humans, including"
- Avoid using "break down" twice in the same sentence
- Add a period after "Tabacof and Valle (2016)"

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@janeadams on Apr 21, 2025 21:25:

Note: I wasn't sure really which submission category this should be. Should there maybe be a category that's just "Explorable Explanations" if this is a track we expect more submissions to? cc @leibatt

@janeadams on Sep 02, 2025 15:36:

Conflicts of interest

- ☒ I declare that I have no known conflicts of interest with the authors.

Reviewed version

https://github.com/journalovi/2024-Cashman-PAC-learning-game/commit/895a9ef0180ee638bc147ec76b9bce92749463ed

Re-Review This revision appears to have integrated all of the feedback from the prior review. In particular, the T' explanation is much clearer, the conceptual padding around the error analysis is much more understandable for a non-technical audience, and all bugs appear to be resolved. I think this explorable would be a valuable resource in the classroom and for self-directed learners alike.

Checklist

- ☒ Explicitly call the problem "domain mismatch"
- ☒ Clearer explanation of "no free lunch"
- ☒ "No Free Lunch" test case: clicking "test" yields 0.00% error and no testing samples appear, despite a non-aligned concept box
- ☒ Clicking "A little lunch, as a treat" and "Tightest Fit" results in "datum is not defined" error
- ☒ "What if the data is not independent and identically distributed?" appears too early
- ☒ The "four strips" tightest fit model illustrated in the example
- ☒ In the simulation illustrate T'
- ☒ Be consistent about using mathematical notation for variables, e.g. "M" and "T"
- ☒ Adding some more 'conceptual padding' from "Error from top strip" to "Error from all strips"
- ☒ Render on mobile or have some kind of pop-up for mobile users ("visit me on desktop!")
- ☒ "taskis" â†’ "task is"
- ☒ Remove "of" in "the task of a machine learning algorithm does"
- ☒ "here error defined" â†’ "here error is defined"
- ☒ Consistent casing for "Machine Learning"
- ☒ "humans,including" â†’ "humans, including"
- ☒ Avoid using "break down" twice in the same sentence
- ☒ Add a period after "Tabacof and Valle (2016)"

Suggested outcome I believe this explorable explnation is ready for publication.

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@janeadams on Sep 02, 2025 15:36:	[closed]
@leibatt on Oct 06, 2025 20:15:	Reopening so the reviews are visible to anyone who visits the repo.