

Neural Metrics

YEGOR BUGAYENKO

Lecture #24 out of 24

80 minutes

All visual and text materials presented in this slidedeck are either originally made by the author or taken from public Internet sources, such as web sites. Copyright belongs to their respected authors.



MICHAEL PRADEL

“Neural software analysis offers a fresh approach, enhancing or even surpassing traditional program analysis in some areas.”

— Michael Pradel and Satish Chandra. Neural Software Analysis.
Communications of the ACM, 65(1):86–96, 2021. doi:[10.1145/3460348](https://doi.org/10.1145/3460348)



FRANCESCA ARCELLI FONTANA

“We conclude that the application of machine learning to the detection of [these] code smells can provide high accuracy (>96%), and only a hundred training examples are needed to reach at least 95% accuracy.”

— Francesca Arcelli Fontana, Mika V. Mäntylä, Marco Zanoni, and Alessandro Marino. Comparing and Experimenting Machine Learning Techniques for Code Smell Detection. *Empirical Software Engineering*, 21:1143–1191, 2016.
doi:[10.1007/s10664-015-9378-4](https://doi.org/10.1007/s10664-015-9378-4)



MARTIN WHITE

“Among the true positives, we found pairs mapping to all four clone types. We compared our approach to a traditional structure-oriented technique and found that our learning-based approach detected clones that were either undetected or suboptimally reported by the prominent tool Deckard.”

— Martin White, Michele Tufano, Christopher Vendome, and Denys Poshyvanyk. Deep Learning Code Fragments for Code Clone Detection. In *Proceedings of the 31st International Conference on Automated Software Engineering*, pages 87–98, 2016. doi:[10.1145/2970276.2970326](https://doi.org/10.1145/2970276.2970326)



PAVOL BIELIK

“In this paper we present a new, automated approach for creating static analyzers: instead of manually providing the various inference rules of the analyzer, the key idea is to learn these rules from a dataset of programs.”

— Pavol Bielik, Veselin Raychev, and Martin Vechev. Learning a Static Analyzer From Data. In *Proceedings of the 29th International Conference on Computer Aided Verification (CAV)*, pages 233–253. Springer, 2017.

[doi:10.1007/978-3-319-63387-9_12](https://doi.org/10.1007/978-3-319-63387-9_12)



TOMAS MIKOLOV

“The meanings of ‘Canada’ and ‘Air’ cannot be easily combined to obtain ‘Air Canada’. Motivated by this example, we present a simple method for finding phrases in text, and show that learning good vector representations for millions of phrases is possible.”

— Tomas Mikolov, Ilya Sutskever, Kai Chen, Greg S. Corrado, and Jeff Dean.
Distributed Representations of Words and Phrases and Their Compositionality.
Advances in Neural Information Processing Systems, 26, 2013



KOUSHIK SEN

“This paper presents DeepBugs, a learning approach to name-based bug detection, which reasons about names based on a semantic representation and which automatically learns bug detectors instead of manually writing them. We formulate bug detection as a binary classification problem and train a classifier that distinguishes correct from incorrect code.”

— Michael Pradel and Koushik Sen. DeepBugs: A Learning Approach to Name-Based Bug Detection. *Proceedings of the ACM on Programming Languages*, 2(OOPSLA):1–25, 2018. doi:[10.1145/3276517](https://doi.org/10.1145/3276517)



DARIO DI NUCCI

“While Arcelli Fontana et al. [2016] opened a new perspective for code smell detection, in the context of our research we found a number of possible limitations that might threaten the results of this study. Our findings show that the high performance achieved in their study was in fact due to the specific dataset employed rather than the actual capabilities of machine-learning techniques for code smell detection.”

— Dario Di Nucci, Fabio Palomba, Damian A Tamburri, Alexander Serebrenik, and Andrea De Lucia. Detecting Code Smells using Machine Learning Techniques: Are We There Yet? In *Proceedings of the 25th International Conference on Software Analysis, Evolution and Reengineering (SANER)*, pages 612–621. IEEE, 2018. doi:[10.1109/SANER.2018.8330266](https://doi.org/10.1109/SANER.2018.8330266)



URI ALON

“**code2vec**: The main idea is to represent a code snippet as a single fixed-length code vector, which can be used to predict semantic properties of the snippet.”

— Uri Alon, Meital Zilberstein, Omer Levy, and Eran Yahav. Code2vec: Learning Distributed Representations of Code. *Proceedings of the Principles of Programming Languages (POPL)*, 2019. doi:[10.1145/3290353](https://doi.org/10.1145/3290353)



Fig. 3. The top-4 attended paths of Figure 2a, as were learned by the model, shown on the AST of the same snippet. The width of each colored path is proportional to the attention it was given (**red** ①: **0.23**, **blue** ②: **0.14**, **green** ③: **0.09**, **orange** ④: **0.07**).

Source: Uri Alon, Meital Zilberstein, Omer Levy, and Eran Yahav. Code2vec: Learning Distributed Representations of Code. *Proceedings of the Principles of Programming Languages (POPL)*, 2019. doi:[10.1145/3290353](https://doi.org/10.1145/3290353)



Fig. 2. Examples of three methods that can be easily distinguished by our model despite having similar syntactic structure: our model successfully captures the subtle differences between them and predicts meaningful names. Each method portrays the top-4 paths that were given the most attention by the model. The widths of the colored paths are proportional to the attention that each path was given.

Source: Uri Alon, Meital Zilberstein, Omer Levy, and Eran Yahav. Code2vec: Learning Distributed Representations of Code. *Proceedings of the Principles of Programming Languages (POPL)*, 2019.
doi:[10.1145/3290353](https://doi.org/10.1145/3290353)



MOHAMMAD MAHDI
MOHAJER

“SkipAnalyzer consists of three components, 1) an LLM-based static bug detector that scans source code and reports specific types of bugs, 2) an LLM-based false positive filter, and 3) an LLM-based patch generator that can generate patches for the detected bugs above. As a proof-of-concept, SkipAnalyzer is built on ChatGPT.”

— Mohammad Mahdi Mohajer, Reem Aleithan, Nima Shiri Harzevili, Moshi Wei, Alvine Boaye Belle, Hung Viet Pham, and Song Wang. SkipAnalyzer: An Embodied Agent for Code Analysis With Large Language Models. *ArXiv*, 2023. doi:[10.48550/arXiv.2310.18532](https://doi.org/10.48550/arXiv.2310.18532)



HAONAN LI

“UBITect produces many false positives from the static analysis. With a pilot study of 20 false positives, we can successfully prune 8 out of 20 based on GPT-3.5, whereas GPT-4 had a near-perfect result of 16 out of 20.”

— Haonan Li, Yu Hao, Yizhuo Zhai, and Zhiyun Qian. Assisting Static Analysis With Large Language Models: A ChatGPT Experiment. In *Proceedings of the 31st Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering*, pages 2107–2111, 2023.
[doi:10.1145/3611643.3613078](https://doi.org/10.1145/3611643.3613078)



ELIF NUR HANER KIRÇIL

“In the study, the cohesion value, which is one of the most important criteria for evaluating software quality, was predicted by RF, KNN, REPTree, SVM, MLP, and LR machine learning techniques.”

— Elif Nur Haner Kırğıl and Tülin Erçelebi Ayyıldız. Predicting Software Cohesion Metrics With Machine Learning Techniques. *Applied Sciences*, 13(6): 3722, 2023. doi:[10.3390/app13063722](https://doi.org/10.3390/app13063722)

Table of Contents

No

No, they cannot.

LLaMa 65B (4-bit GPTQ) model: 1 false alarms in 15 good examples. Detects 0 of 13 bugs.
Baize 30B (8-bit) model: 0 false alarms in 15 good examples. Detects 1 of 13 bugs.
Galpaca 30B (8-bit) model: 0 false alarms in 15 good examples. Detects 1 of 13 bugs.
Koala 13B (8-bit) model: 0 false alarms in 15 good examples. Detects 0 of 13 bugs.
Vicuna 13B (8-bit) model: 2 false alarms in 15 good examples. Detects 1 of 13 bugs.
Vicuna 7B (FP16) model: 1 false alarms in 15 good examples. Detects 0 of 13 bugs.

GPT 3.5: 0 false alarms in 15 good examples. Detects 7 of 13 bugs.
GPT 4: 0 false alarms in 15 good examples. Detects 13 of 13 bugs.

Source: Chris Taylor. Can Open-Source LLMs Detect Bugs in C++ Code?
https://catid.io/posts/llm_bugs/, 2023. [Online; accessed 15-03-2024]

References

Uri Alon, Meital Zilberstein, Omer Levy, and Eran Yahav. Code2vec: Learning Distributed Representations of Code. *Proceedings of the Principles of Programming Languages (POPL)*, 2019. doi:[10.1145/3290353](https://doi.org/10.1145/3290353).

Francesca Arcelli Fontana, Mika V. Mäntylä, Marco Zanoni, and Alessandro Marino. Comparing and Experimenting Machine Learning Techniques for Code Smell Detection. *Empirical Software Engineering*, 21:1143–1191, 2016. doi:[10.1007/s10664-015-9378-4](https://doi.org/10.1007/s10664-015-9378-4).

Pavol Bielik, Veselin Raychev, and Martin Vechev. Learning a Static Analyzer From Data. In *Proceedings of the 29th International Conference on Computer Aided Verification (CAV)*, pages 233–253. Springer, 2017. doi:[10.1007/978-3-319-63387-9_12](https://doi.org/10.1007/978-3-319-63387-9_12).

Dario Di Nucci, Fabio Palomba, Damian A Tamburri, Alexander Serebrenik, and Andrea De Lucia. Detecting Code Smells using Machine Learning

Techniques: Are We There Yet? In *Proceedings of the 25th International Conference on Software Analysis, Evolution and Reengineering (SANER)*, pages 612–621. IEEE, 2018. doi:[10.1109/SANER.2018.8330266](https://doi.org/10.1109/SANER.2018.8330266).

Elif Nur Haner Kırğıl and Tülin Erçelebi Ayyıldız. Predicting Software Cohesion Metrics With Machine Learning Techniques. *Applied Sciences*, 13(6):3722, 2023. doi:[10.3390/app13063722](https://doi.org/10.3390/app13063722).

Haonan Li, Yu Hao, Yizhuo Zhai, and Zhiyun Qian. Assisting Static Analysis With Large Language Models: A ChatGPT Experiment. In *Proceedings of the 31st Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering*, pages 2107–2111, 2023. doi:[10.1145/3611643.3613078](https://doi.org/10.1145/3611643.3613078).

Tomas Mikolov, Ilya Sutskever, Kai Chen, Greg S. Corrado, and Jeff Dean. Distributed Representations of Words and Phrases and Their Compositionality. *Advances in Neural Information Processing Systems*, 26, 2013.

Mohammad Mahdi Mohajer, Reem Aleithan,

Nima Shiri Harzevili, Moshi Wei, Alvine Boaye Belle, Hung Viet Pham, and Song Wang. SkipAnalyzer: An Embodied Agent for Code Analysis With Large Language Models. *ArXiv*, 2023. doi:[10.48550/arXiv.2310.18532](https://doi.org/10.48550/arXiv.2310.18532).

Michael Pradel and Satish Chandra. Neural Software Analysis. *Communications of the ACM*, 65(1): 86–96, 2021. doi:[10.1145/3460348](https://doi.org/10.1145/3460348).

Michael Pradel and Koushik Sen. DeepBugs: A Learning Approach to Name-Based Bug Detection. *Proceedings of the ACM on Programming Languages*, 2(OOPSLA):1–25, 2018.

doi:[10.1145/3276517](https://doi.org/10.1145/3276517).

Chris Taylor. Can Open-Source LLMs Detect Bugs in C++ Code? https://catid.io/posts/llm_bugs/, 2023. [Online; accessed 15-03-2024].

Martin White, Michele Tufano, Christopher Vendome, and Denys Poshyvanyk. Deep Learning Code Fragments for Code Clone Detection. In *Proceedings of the 31st International Conference on Automated Software Engineering*, pages 87–98, 2016. doi:[10.1145/2970276.2970326](https://doi.org/10.1145/2970276.2970326).