Extending Layerwise Relevance Propagation using Semiring Annotations

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- Problem statement
- Layerwise Relevance Propagation
- Semiring-based provenance annotations

Extending LRP

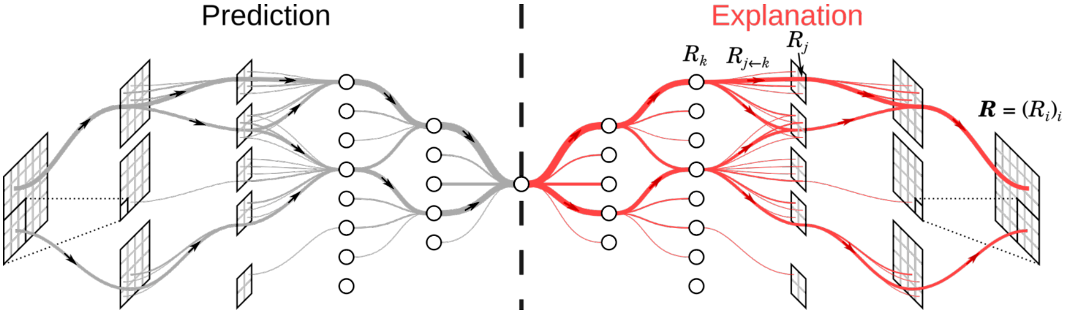
Applications

- Image mask computation
- Network pruning using LRP ranking
- Comparison to image perturbation

Conclusion

Problem statement

Layerwise Relevance Propagation



Layerwise Relevance Propagation

Propagation rules

Initialization:

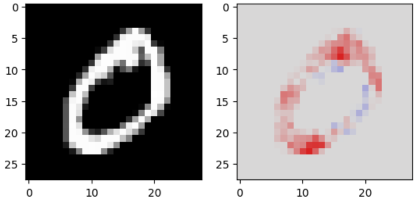
$$R_i^{(L)} = \begin{cases} a_i^{(L)} & \text{if } i = y \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

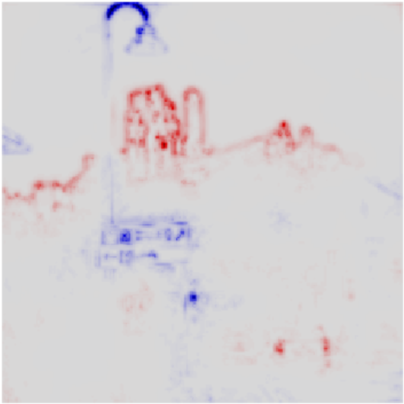
LRP-0 rule:

$$R_j^{(l)} = \sum_k \frac{a_j^{(l)} w_{j,k}}{\sum_{j'} a_{j'}^{(l)} w_{j',k}} R_k^{(l+1)} \tag{2}$$

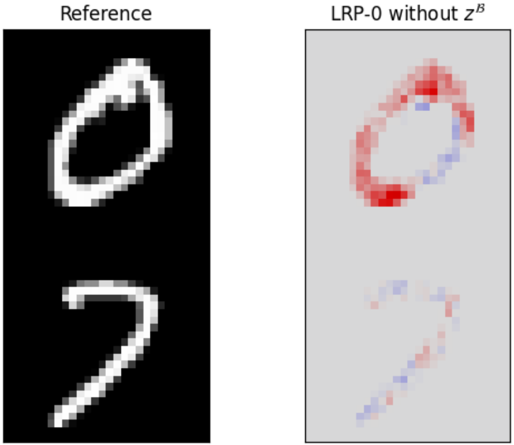
Layerwise Relevance Propagation

Results visualization





Pertinence of LRP results



Semiring-based provenance annotations

Definition (Semiring)

A semiring $(\mathbb{K}, \oplus, \otimes, \mathbf{0}, \mathbf{1})$ is composed of a set $\mathbb{K}$, binary operators $\oplus$ and $\otimes$ such that $\otimes$ distributes over $\oplus$, verifying the following properties:

- $(\mathbb{K}, \oplus, \mathbf{0})$ is a commutative monoid
- $(\mathbb{K}, \otimes, \mathbf{1})$ is a monoid such that $\mathbf{0}$ is absorbing

Example

The following structures are semirings:

- Real semiring: $(\mathbb{R}, +, \times, 0, 1)$
- Boolean semiring: $(\{\bot, \top\}, \vee, \wedge, \bot, \top)$
- Counting semiring: $(\mathbb{N}, +, \times, 0, 1)$
- Viterbi semiring: $([0, 1], \max, \times, 0, 1)$

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Comparison to image perturbation

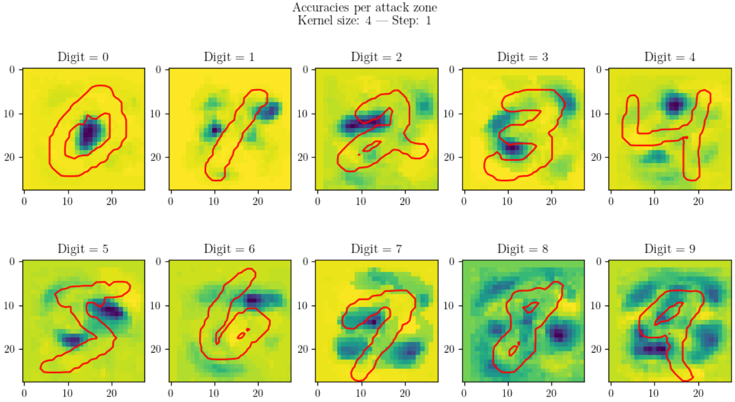

Figure: Accuracies per attack zone

Plan

[1] Sebastian Bach et al. "On Pixel-Wise Explanations for Non-Linear Classifier Decisions by Layer-Wise Relevance Propagation". In: *PLOS ONE* (2015), pp. 1–46. DOI: 10.1371/journal.pone.0130140. URL: https://doi.org/10.1371/journal.pone.0130140.

[2] Ruth C Fong and Andrea Vedaldi. "Interpretable explanations of black boxes by meaningful perturbation". In: *Proceedings of the IEEE international conference on computer vision*. 2017, pp. 3429–3437. URL: https://arxiv.org/abs/1704.03296.

[3] Robert Geirhos et al. "Shortcut learning in deep neural networks". In: *Nature Machine Intelligence* 2 (2020), pp. 665–673.

[4] Todd J Green, Grigoris Karvounarakis, and Val Tannen. "Provenance semirings". In: *Proceedings of the twenty-sixth ACM SIGMOD-SIGACT-SIGART symposium on Principles of database systems*. 2007, pp. 31–40.

[5] Grégoire Montavon et al. "Layer-Wise Relevance Propagation: An Overview". In: *Explainable AI: Interpreting, Explaining and Visualizing Deep Learning*. Springer International Publishing, 2019, pp. 193–209. URL: https://doi.org/10.1007/978-3-030-28954-6_10.

[6] Yann Ramusat, Silviu Maniu, and Pierre Senellart. "Provenance-Based Algorithms for Rich Queries over Graph Databases". In: *EDBT 2021 - 24th International Conference on Extending Database Technology*. 2021. URL: https://inria.hal.science/hal-03140067.