The Implementation of Model Pruning to Optimize zk-SNARKs in Machine Learning

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Introduction

- Cloud Computing
- How is it Secure?

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- How is it Secure?

- (zero-knowledge) Succinct Non-Interactive Argument of Knowledge **(zk-SNARK)**

Our Goal

- Proof must be less computationally expensive than outsourced program

- Proposed Optimization:
  - Model Pruning

1.

zk-SNARKs

(zero-knowledge) Succinct Non-Interactive Argument of Knowledge

3 Properties

- Completeness: prover can convince the verifier through a proof given a statement and a witness
- Soundness: in the case the prover is a malicious party, the verifier cannot be convinced of a false statement
- Zero-Knowledge: the prover will not reveal its witness.

Constructing a zk-SNARK

- R1CS: rank 1 constraint system

Example: $x^3 + x + 5 == 35$

```
sym_1 = x * x
y = sym_1 * x
sym_2 = y + x
~out = sym_2 + 5
```

Constructing a zk-SNARK

- R1CS: rank 1 constraint system
- zk-SNARK

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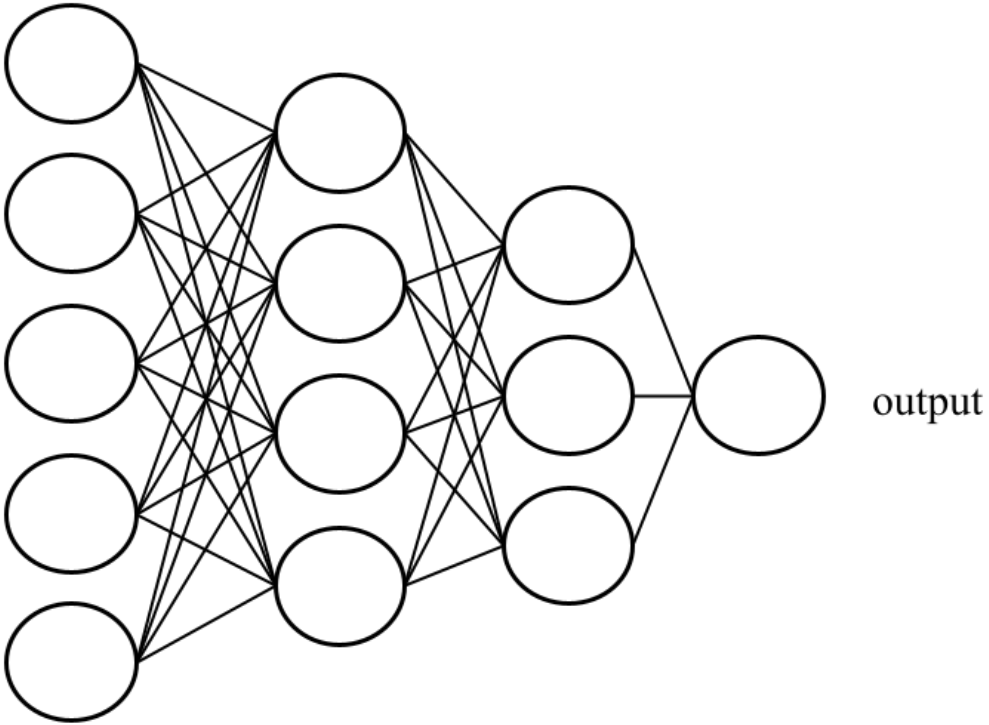
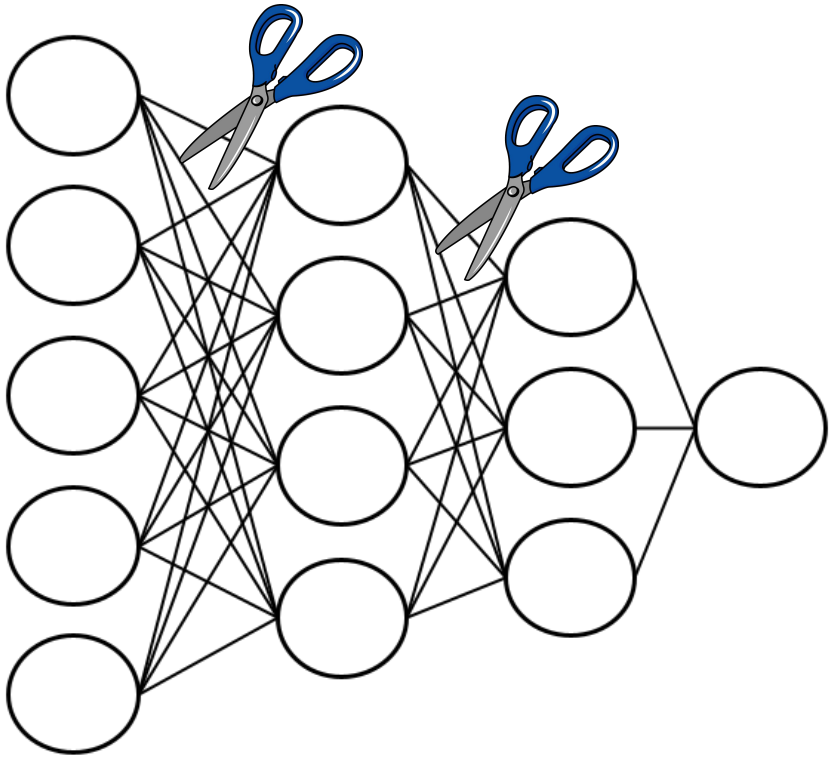
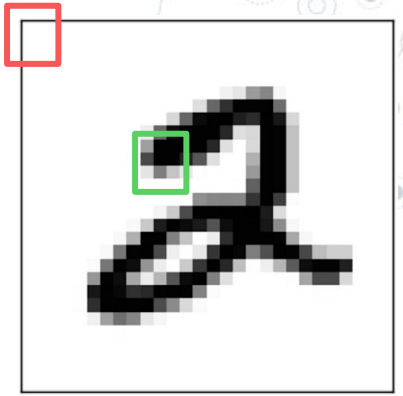
2.
Model Pruning

Network Pruning



Network Pruning





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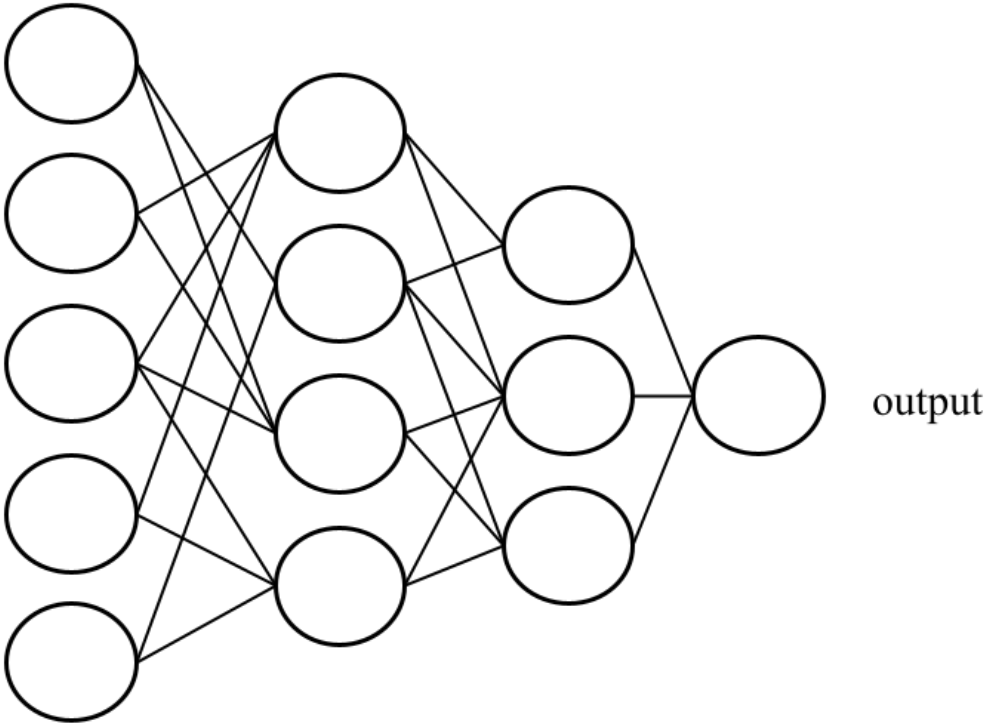

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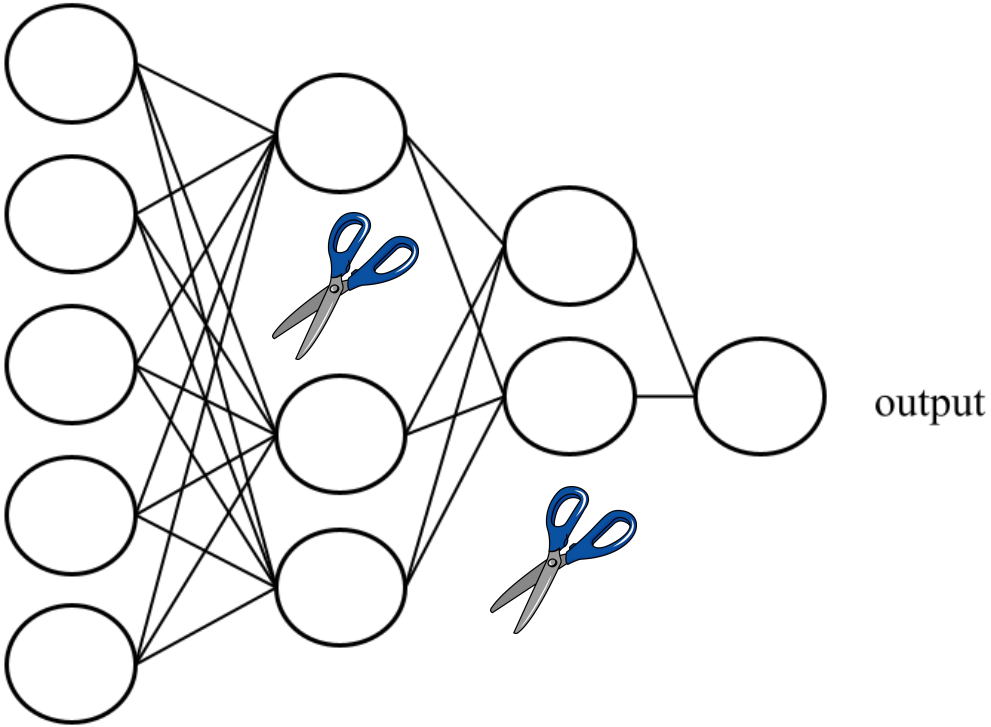
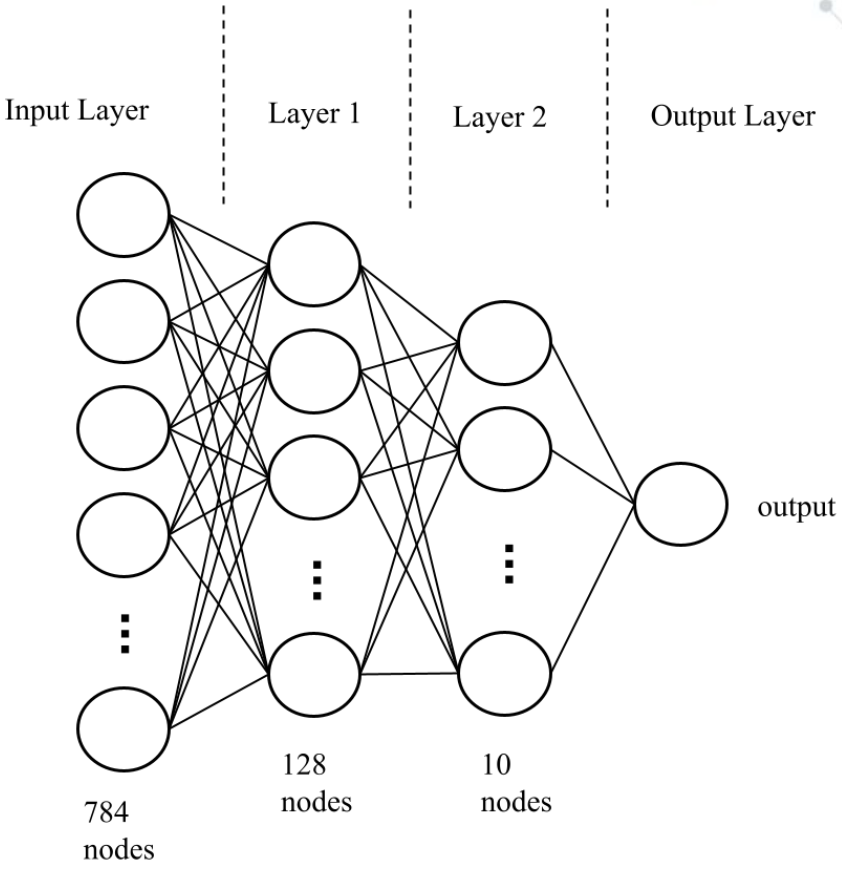


3.
Methods

Neural Network

- MNIST-dataset
- Shallow-Net Architecture



ZEN (Zero-Knowledge Proof for Neural Networks)

- ZEN reduces R1CS constraints → less complex proof
- Other Characteristics:
  - ZEN_{infer} and ZEN_{acc}
  - zk-SNARKs only support integers

Experiment

- Calculate constraints for neural network without pruning (0, 0.50, 1.0)
- Find accuracy of model

4.
Results

Amount Pruned	Accuracy	# of Constraints
0%	**0.9516**	**363736**
50%	**0.9505**	**363719**
100%	**0.0980**	**363644**

5.
Conclusion

Applications of this Research

- Contributions to Cloud Computing
  - outsource more powerful computations
- Decrease complexity of authentication proofs

Further Research

- Further decrease number of constraints
- Experiment with:
  - pruning methods (movement pruning)
  - neural network structures
  - datasets

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