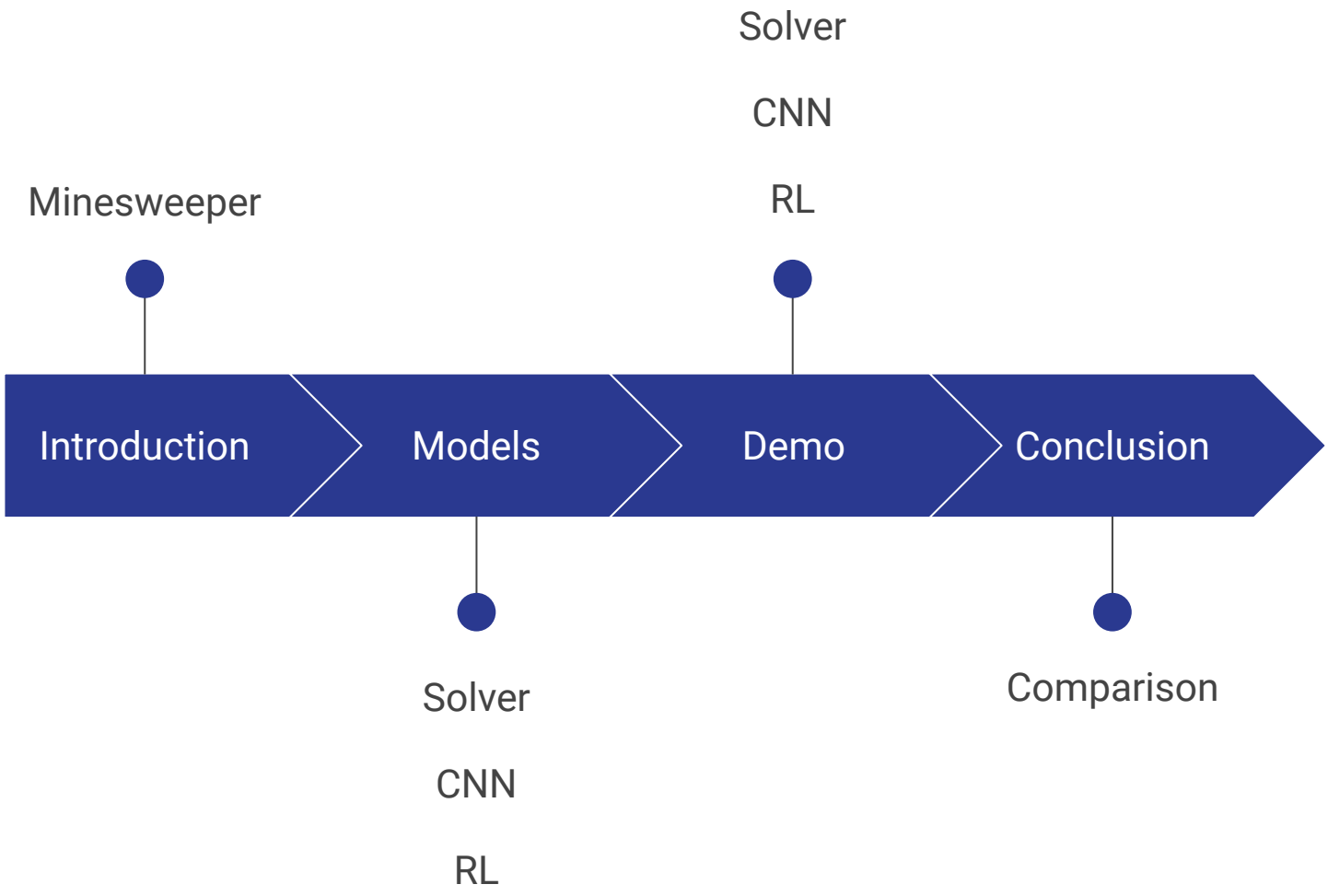
Minesweeper

Techniques of artificial intelligence

Anthony Zhou, Hamza EL Miri & Julien Baudru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RL
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Introduction

Introduction

Single-player game.

Goal : The player must discover as many tiles in the game as possible while trying to never click on a mine.

Clues : The number on a discovered tile indicating how many mines are in its neighborhood

Introduction

Minesweeper is a **NP-Complete*** puzzle so there is **no deterministic** algorithm that can solve it efficiently **in polynomial time**.

*Moti Ben-Ari, "Minesweeper is NP-Complete", Weizmann Institute of Science 2018

Models

Solver

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Solver

Algorithm

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Solver

Testing

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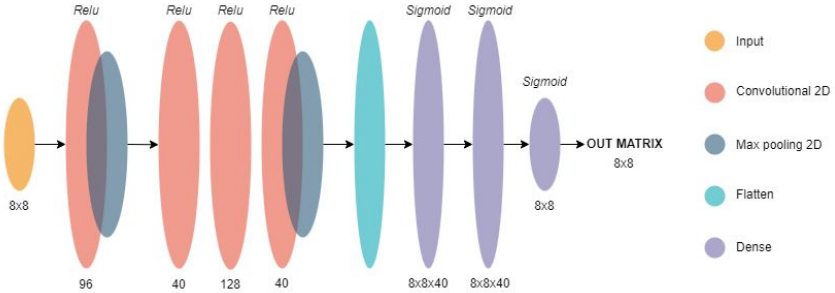
Convolutional neural network

Architecture



We chose **CNN** because they are usually used in image processing.

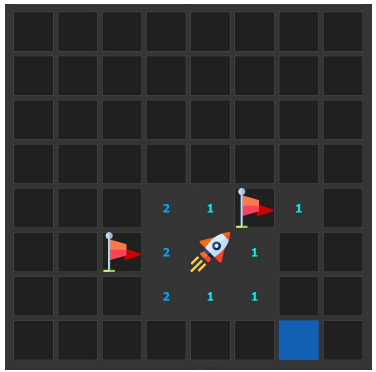
Effective for detecting **features inside matrices**.

Close to the famous **AlexNet** architecture.

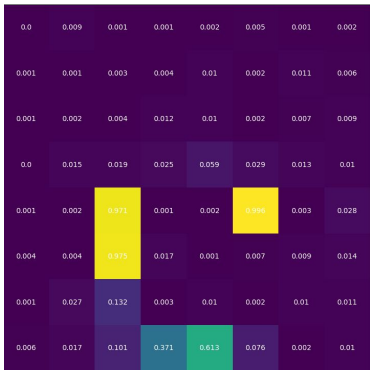
Convolutional neural network

Data

Input



Output



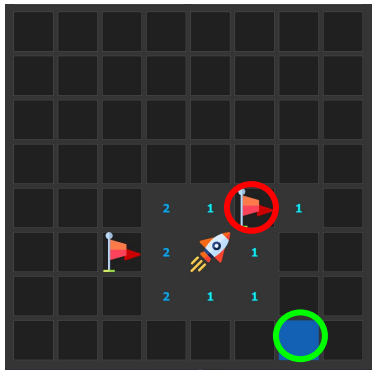
Input : Board game of size 8X8 with the value of the revealed tiles (0 to 8) and -1 for the unknown tiles.

Output : Matrix giving probability of finding a mine at each position (close to 1 if mine, close to 0 otherwise)

Convolutional neural network

Algorithm

Input



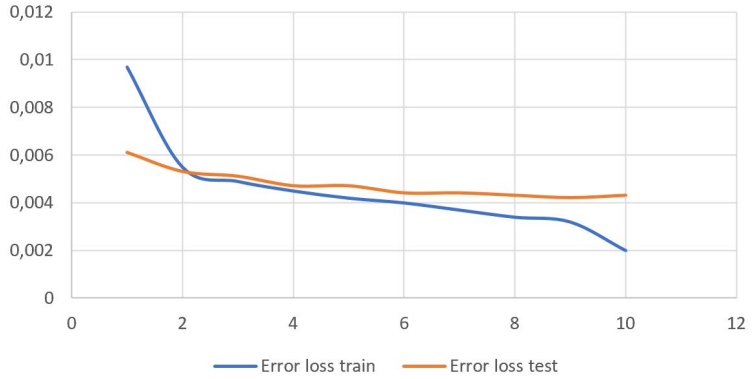
Output

Algorithm :

- **Click** on the tile with the **lowest probability** in the perimeter of the revealed tiles
- Place a **flag** on the tile with the **highest probability** in the perimeter of the revealed tiles

Convolutional neural network

Training



We trained our model on **5,000,000 boards** for **10 epochs**

On the test set the model has reached an **error loss of 0.0424%.**

Convolutional neural network

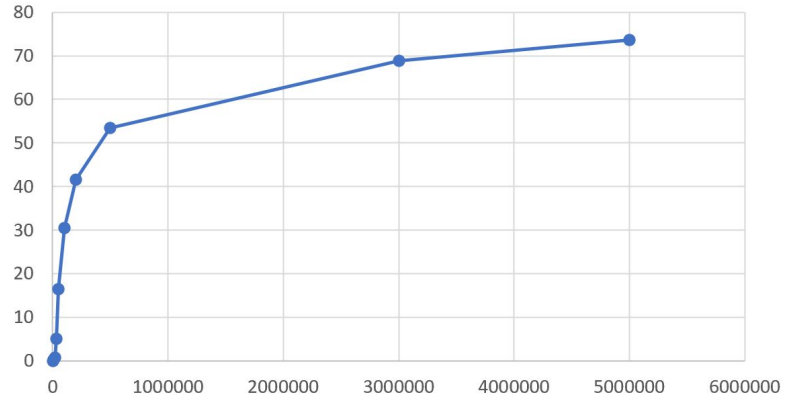
Training

We trained our model on **5,000,000 boards** for **10 epochs**

On the test set the model has reached an **accuracy of 62.35%**.

Convolutional neural network

Testing



Validation set of 1,000 games that the model has never been confronted with.

With the training of 5,000,000 boards, the model has reached a **win rate of 73.6%**.

Reinforcement learning

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Reinforcement learning

Training

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Reinforcement learning

Testing

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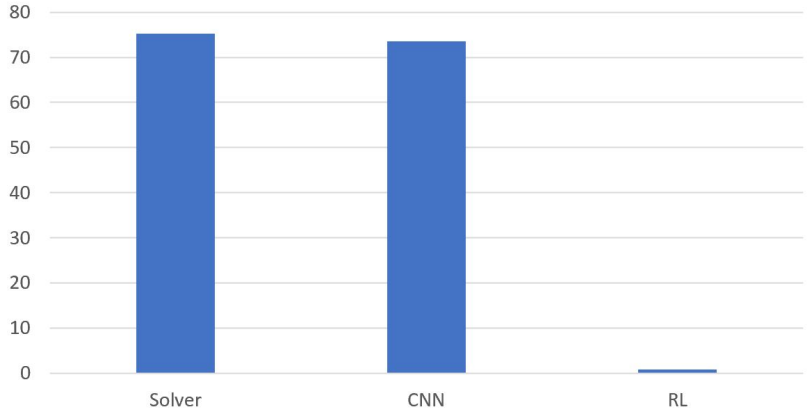
Demo

Conclusion

Conclusion

Win rate

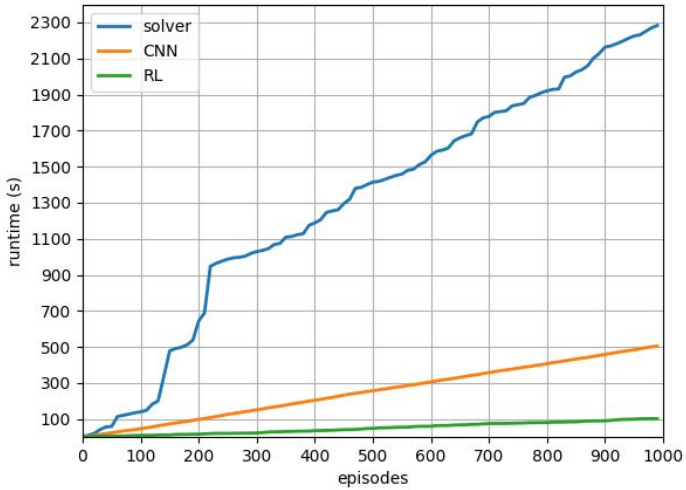


Each of the models played **1000 validation games** :

1. Solver **75.2% of win**
2. CNN **73.6% of win**
3. RL **0.8% of win**

Conclusion

Speed



Each of the models played **1000 validation games** :

1. RL took **1 min 40 sec**
2. CNN took **8 min 20 sec**
3. Solver took **38 min 20 sec**