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Análisis de feature sets con redes neuronales NNUE para engines de ajedrez

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1 Introduction

1.1 Chess Engines

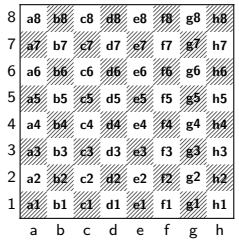
2 Feature sets (board encodings)

To evaluate a chess positions, we will use a neural network with an architecture explained in detail in the next chapter. In this chapter, we will build the input vector to such network, which can be described entirely by a feature set.

A feature set is a set built by a cartesian product of smaller sets of features, where each set extracts a different aspect of a position. hablar de el subset "activado" Let's consider some basic sets of features.

The following sets encode positional information about the board:

$$\begin{aligned}\textsc{File} &= \{a, b, ..., h\}\\ \textsc{Rank} &= \{1, 2, ..., 8\}\\ \textsc{Square} &= \{a1, a2, ..., h8\}\end{aligned}$$

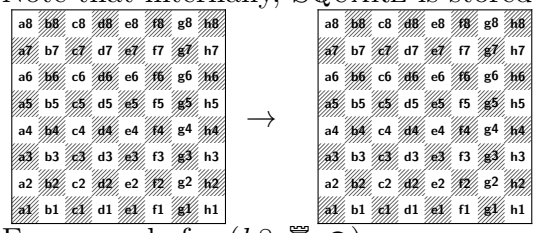


Each set is associated with some information extracted from the position. For example, a feature set could be $\textsc{Square}_P$ where P is *any* piece of the board, meaning that the squares that will be active will be the ones where there is *any* kind of piece. Another possible feature set could be $\textsc{Square}_K$, where r is

That may or may not be related to a piece on the board. move from/to two Square-s

$$\begin{aligned}\textsc{Role} &= \{\ \text{♙ Pawn}, \text{♘ Knight}, \text{♗ Bishop}, \text{♖ Rook}, \text{♕ Queen}, \text{♔ King}\}\\ \textsc{Color} &= \{\text{○ White}, \text{● Black}\}\end{aligned}$$

The input to the network is a one-dimensional vector with multi-hot encoding.
Since
Note that internally, Square is stored as numbers 0 ... 63:



For example for $(h8, ♖, ●)$
file, color vs file, role

2.1 Piece

This feature set is the most natural encoding for a chess position. There is a one-to-one mapping between pieces in the board and features:

$$\text{Piece} = \text{Square}_p \times \text{Role}_p \times \text{Color}_p$$
for every p piece in the board

$\langle piece\_square, piece\_type, piece\_color \rangle$
$64 * 6 * 2 = 768$ features

2.2 Compact

This is one of the simplest feature sets.
$\langle piece\_rank, piece\_type, piece\_color \rangle \oplus \langle piece\_file, piece\_type, piece\_color \rangle$
$(8 * 6 * 2) * 2 = 192$ features

2.3 Piece+Moves

HalfP $\oplus \langle move\_from, move\_to \rangle$
$768 + 64 * 64 = 4864$ features
Not friendly to efficiently update the network. It is almost always better to do a full refresh on eval.

2.4 Half-King-Piece

King-Piece = $\text{Square}_K \times \text{Piece}_P$ where K is the king to move and P is any *non-king* piece
$\langle side\_king\_square, piece\_square, piece\_type, piece\_color \rangle$ excl. king
$64 * 64 * 5 * 2 = 40960$ features
There are variations to this feature set, such as HalfKAv2 or notably HalfKAv2_hm that is currently the latest feature set used by Stockfish 16.1. I will not consider them in this work.
known as "KP" in the literature
if we skip the king, you may be thinking where does it get the information about the other king's side, ... blabla arquitectura Half

2.5 Half-Relative(H|V|HV)King-Piece

$\langle side\_king\_file - piece\_file + 7, side\_king\_rank - piece\_rank + 7, piece\_type, piece\_color \rangle$ excl. king
$15 * 15 * 5 * 2 = 2250$ features (for HV)
only H or only V have $8 * 15 * 5 * 2 = 1200$ features

2.6 Half-Top(PP)

Statistical feature set, blabla, wasted features blabla

2.7 Recap

Feature set	Tuple	# features
Piece	$\text{Square}_P \times \text{Role}_P \times \text{Color}_P$	768
Compact	asd	192
Piece+Moves	asd	4864
King-Piece	asd	40,960
RelativeHV-King-Piece	asd	2250
TopPP	asd	64

Table 1: Comparison of feature sets

3 Efficiently updatable neural networks

NNUE (ƎUИИ Efficiently updatable neural network) is a neural network architecture that allows for very fast inferences. It was invented for Shogi by Yu Nasu in 2018.

In essence, NNUEs "Neural Network Update Efficient" are just regular neural networks that allow for really fast inferences.

... Most of the information described here can be found in Stockfish's documentation about NNUEs [1].

It is important to combine this with aggresive quantization techniques.

3.1 Architecture

arquitectura half, dos capas

3.2 Efficient updates

pesada al principio y liviana al final, acumular filas de la primera capa en domove, undomove

3.3 Stockfish quantization scheme

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. $\sin^2(\alpha) + \cos^2(\beta) = 1$. If you read this text, you will get no information $E = mc^2$. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. $\sqrt[n]{a} \cdot \sqrt[n]{b} = \sqrt[n]{ab}$. This text should contain all letters of the alphabet and it should be written in of the original language. $\frac{\sqrt[n]{a}}{\sqrt[n]{b}} = \sqrt[n]{\frac{a}{b}}$. There is no need for special content, but the length of words should match the language. $a\sqrt[n]{b} = \sqrt[n]{a^n b}$. Hello, here is some text without a meaning. $\mathrm{d}\Omega = \sin\vartheta \mathrm{d}\vartheta \mathrm{d}\varphi$. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. $\sin^2(\alpha) + \cos^2(\beta) = 1$. This text should contain all letters of the alphabet and it should be written in of the original language $E = mc^2$. There is no need for special content, but the length of words should match the language. $\sqrt[n]{a} \cdot \sqrt[n]{b} = \sqrt[n]{ab}$. Hello, here is some text without a meaning. $\frac{\sqrt[n]{a}}{\sqrt[n]{b}} = \sqrt[n]{\frac{a}{b}}$. This text should show what a printed text will look like at this place. $a\sqrt[n]{b} = \sqrt[n]{a^n b}$. If you read this text, you will get no information. $\mathrm{d}\Omega = \sin\vartheta \mathrm{d}\vartheta \mathrm{d}\varphi$. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression

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This is text bla bla. [2]

More testing on section 3.3.

Rango de activación: en el modelo original usamos ClippedReLU, asi que queremos que el rango vaya de 0..1 a 0..127.

Siendo $\boldsymbol{x}$, $\boldsymbol{w}$ y $\boldsymbol{b}$ los parámetros de una capa lineal sin cuantizar e $\boldsymbol{y}$ la salida de la misma, se tiene que:

$$\begin{aligned} \boldsymbol{y} &= \boldsymbol{x}\boldsymbol{w} + \boldsymbol{b} \\ s_a s_w \boldsymbol{y} &= (s_a \boldsymbol{x})(s_w \boldsymbol{w}) + s_a s_w \boldsymbol{b} \end{aligned} \tag{1}$$

$s_o((s_a \boldsymbol{x})(s_w \boldsymbol{w}) + s_a s_w \boldsymbol{b}) = s_a s_w s_o \boldsymbol{y}$

3.4 Network sparsity

o combinar con 3.2? poner graficos con la sparsity de cada feature set, decir que es muy esparso todo y que se podría mejorar aún más

[2] This is a example footnote

4 Training

4.1 Dataset

Lichess is a free online site to play chess, and it provides a database[1] with all the games played on the site. It consists of serveral compressed PGN files[2] splitted by month since 2013, that add up to 1.7 terabytes compressed. It contains over 5 billion games, that equates to around 200 billion positions. In reality, that many positions are too much to handle so I'll use only a fraction of them, but I restrict derived datasets to only take one sample per game, to maximize the diversity of positions.

decir que la data de entrenamiento no es la misma. SF original usaba datos de hand-crafted, hoy en dia usa de LC0. Nosotros usamos de Lichess, computada por el SF moderno

4.2 Methods

4.2.1 Stockfish evaluations

4.2.2 PQR triplets

This is an additional technique I wanted to try, described in [METER REF BLOG]. Remember that we are trying to obtain a function f (the model) to give an evaluation of a position. The method is based in the assumption that players make optimal or near-optimal moves most of the time, even if they are amateurs.

1. For two position in succession $p \to q$ observed in the game, we will have $f(p) \neq f(q)$.
2. Going from p, not to q, but to a *random* position $p \to r$, we must have $f(r) > f(q)$ because the random move is better for the next player and worse for the player that made the move.

... With infinite compute, f would be the result of running minimax to the end of the game, since minimax always finds optimal moves.

4.3 Metrics

asd [1]

[1] Lichess database: `https://database.lichess.org`

[2] Portable Game Notation: a textual format to store chess games (moves and metadata)

5 Engine implementation

5.1 Alpha-Beta

5.2 Prunes

6 Results

6.1 Active neurons

medir si hay feature sets que no usen neuronas, que esto disparo el uso de HalfTopK

7 Final words

7.1 Conclusions

7.2 Future work

References

[1] Yu Nasu. “NNUE: Efficiently Updatable Neural-Network-based Evaluation Functions for Computer Shogi”. In: *Ziosoft Computer Shogi Club* (2018). URL: https://www.apply.computer-shogi.org/wcsc28/appeal/the_end_of_genesis_T.N.K.evolution_turbo_type_D/nnue.pdf.