Wyprawa w głąb LSTMa

CORE, 13 maja 2020
Julia Bazińska

Na podstawie Greff et al., LSTM: A Search Space Odyssey

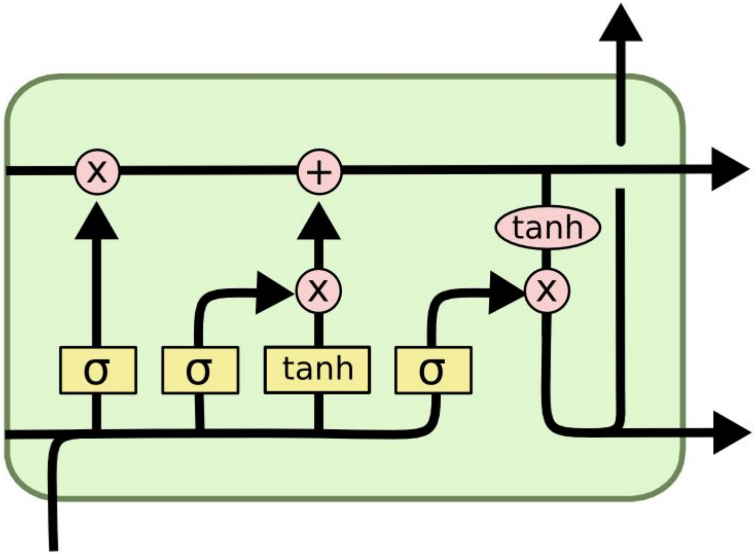
Long Short-Term Memory

“Recurrent networks can in principle use their feedback connections to store representations of recent input events in the form of activations ("short-term memory", as opposed to "long-term memory embodied by slowly changing weights).”

Hochreiter et al, “Long Short-Term Memory”, 1997

Agenda

1. LSTM vs prosta jednostka
2. Co tam się właściwie dzieje? Szczegóły działania.
3. Możliwe warianty
4. Trzy benchmarki
5. Wyniki



http://colah.github.io/posts/2015-08-Understanding-LSTMs/index.html

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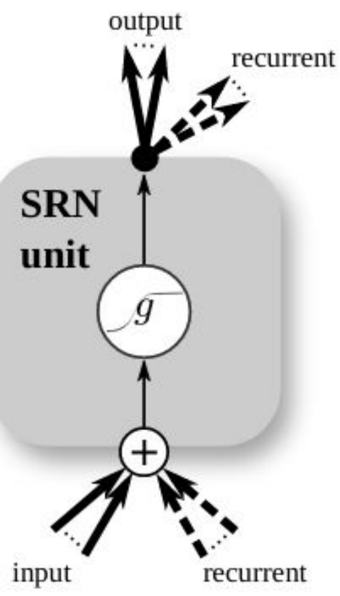
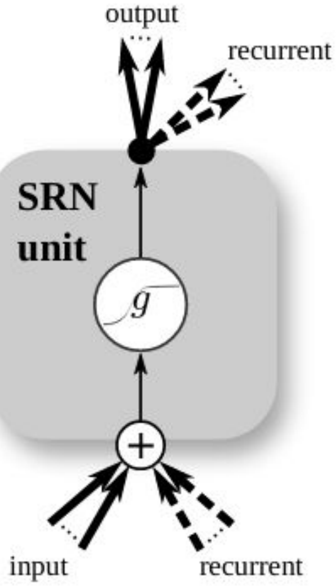
LSTM vs prosta jednostka rekurencyjna

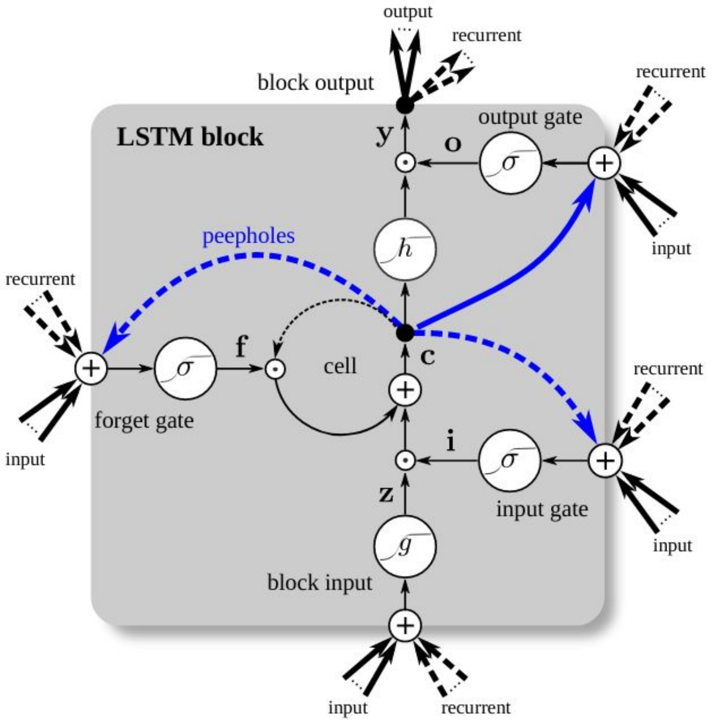
Najprostsza jednostka rekurencyjna



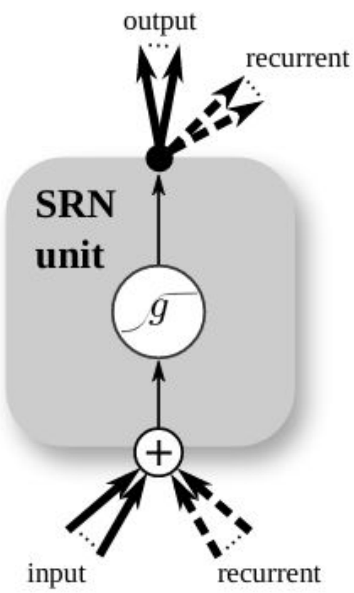
$$y_t = g(W\,x_t + R\,y_{t-1} + b)$$

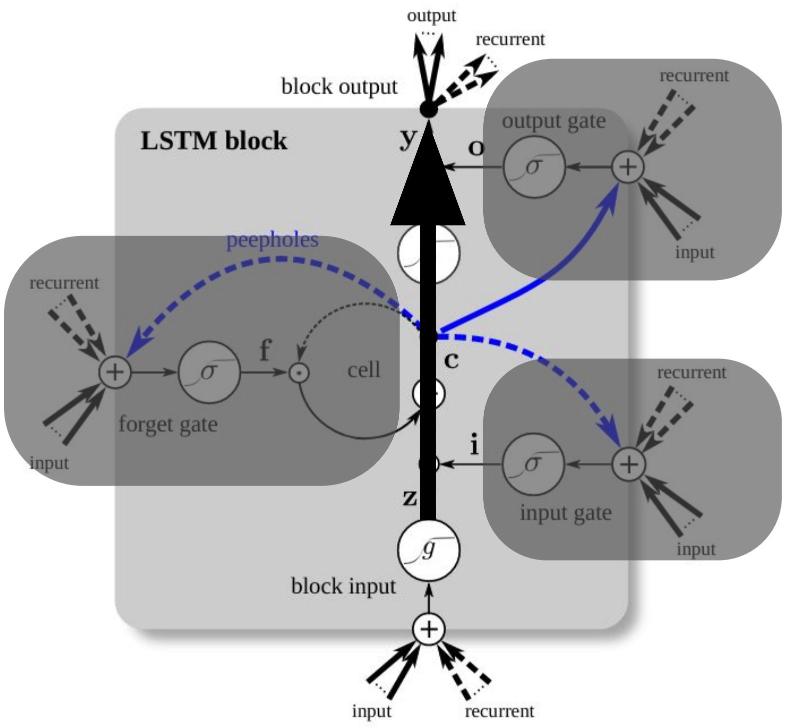
...kontra LSTM


output
recurrent
SRN
unit
input
recurrent


output
recurrent
block output
recurrent
LSTM block
y
o
output gate
peepholes
input
recurrent
f
cell
c
forget gate
recurrent
i
input
z
input gate
input
block input
input
recurrent

Czy to na pewno jest potrzebne?





Co tam się właściwie dzieje?

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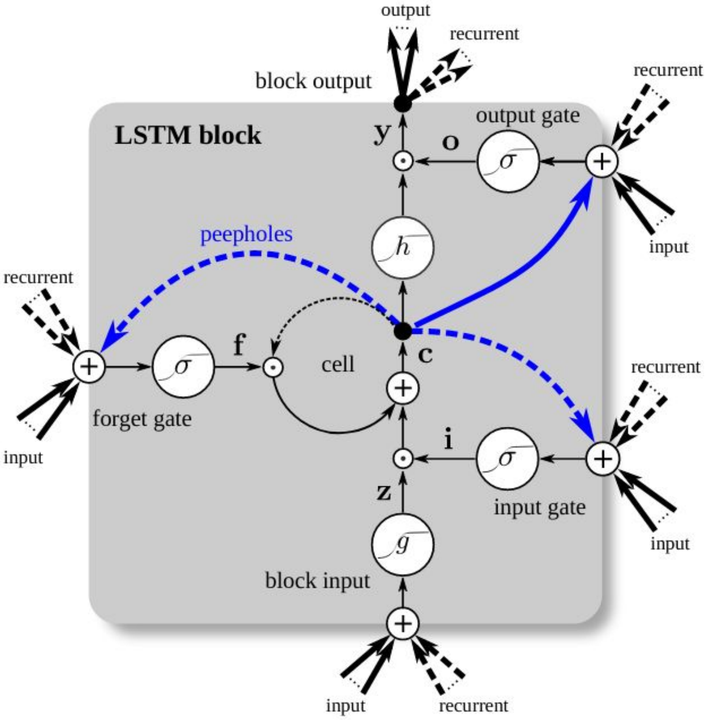

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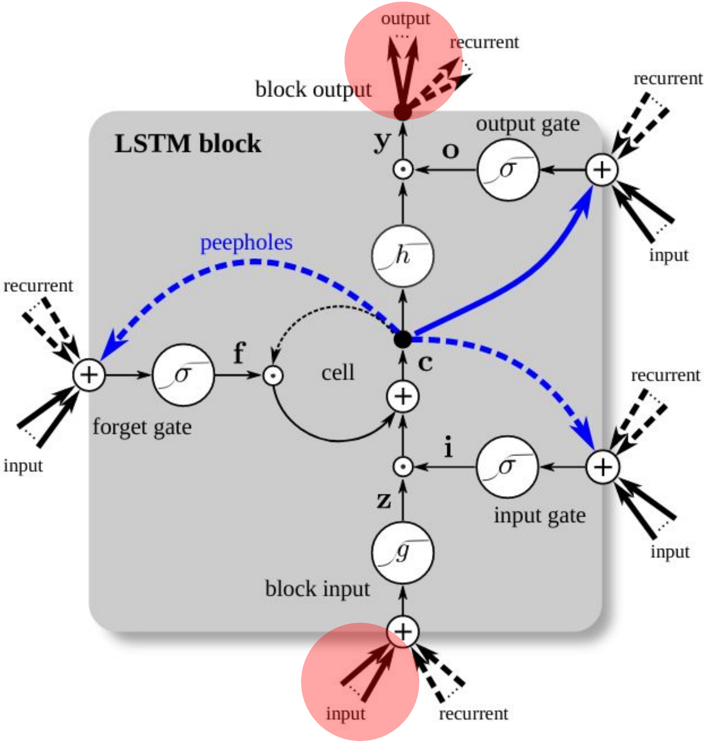

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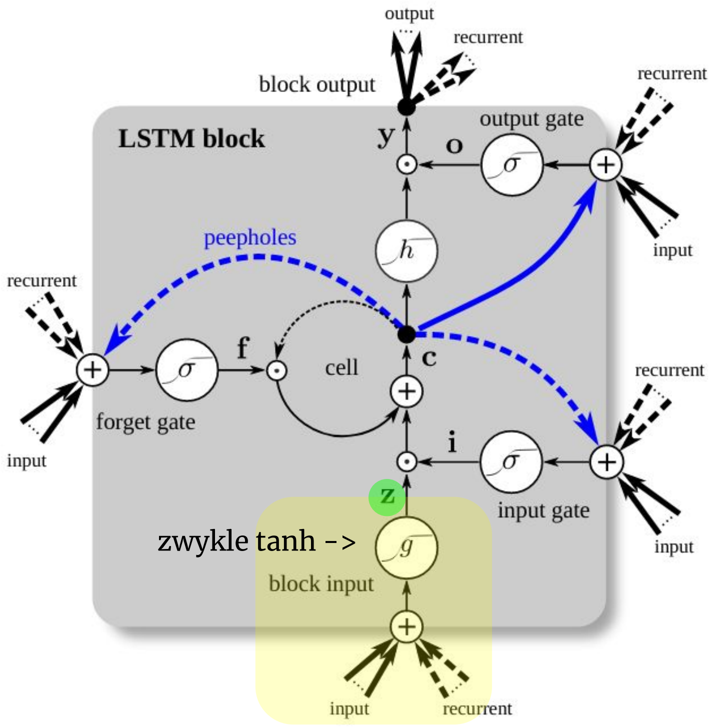

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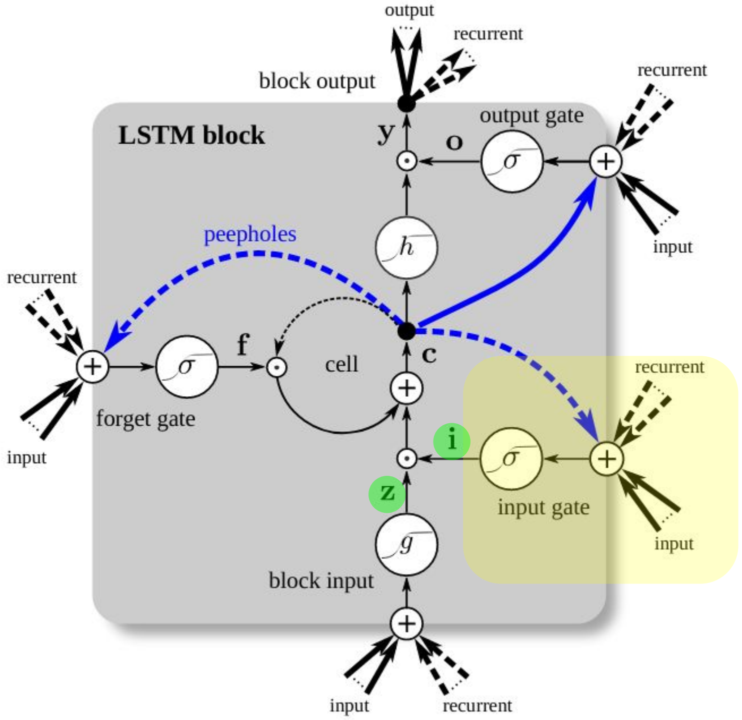

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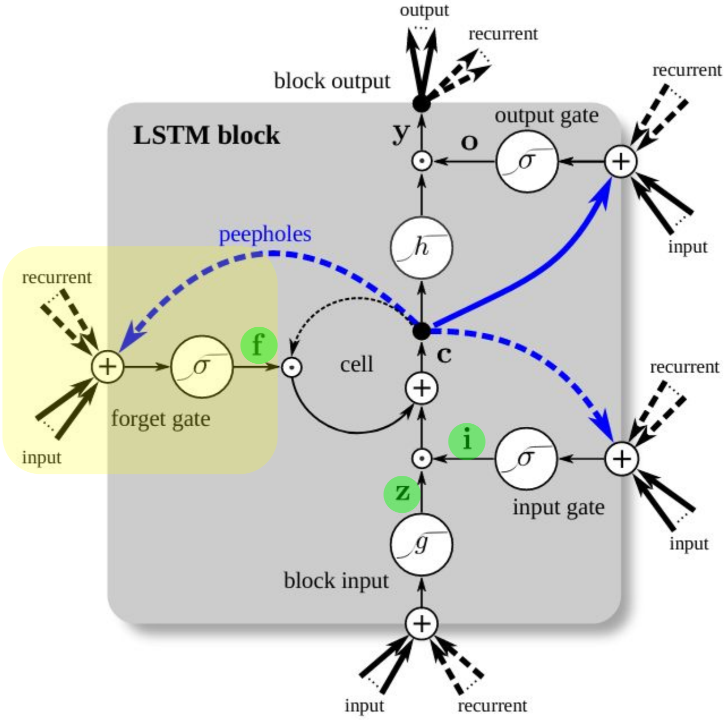

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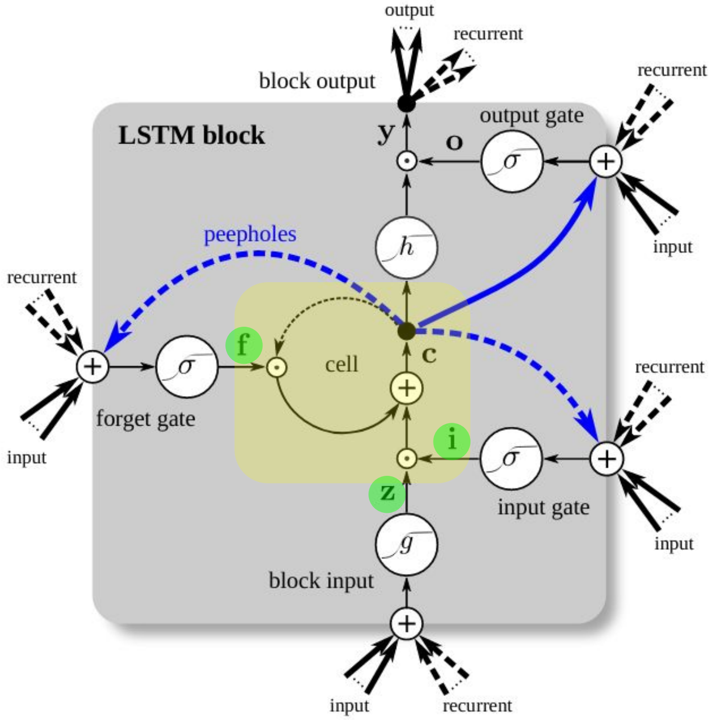

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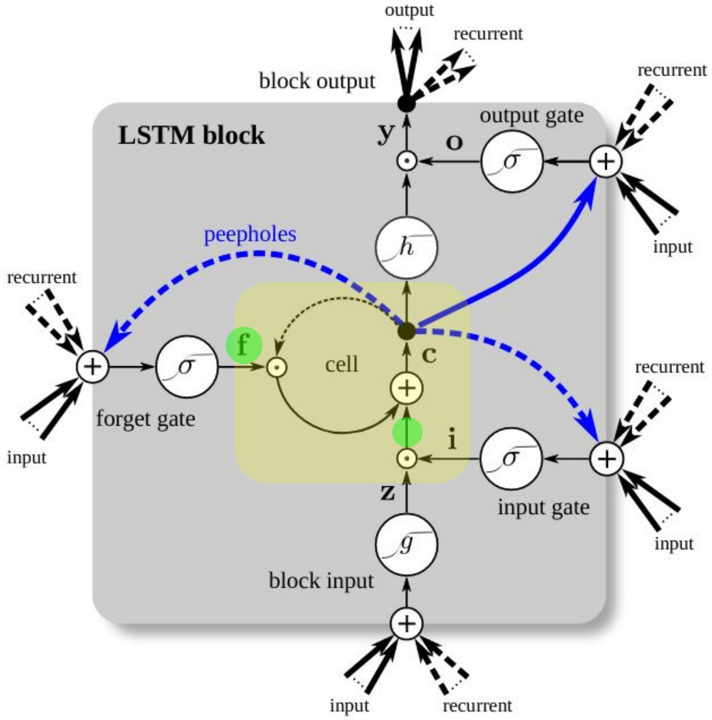

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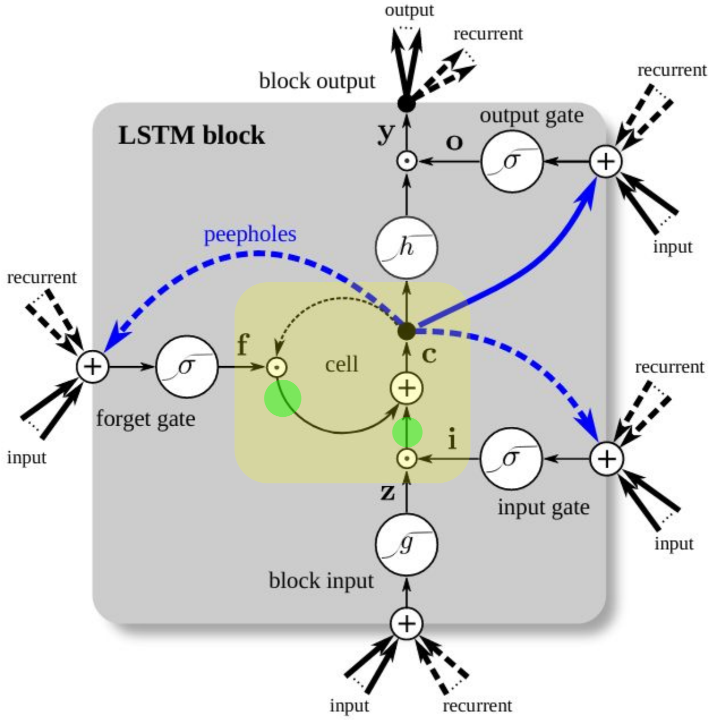

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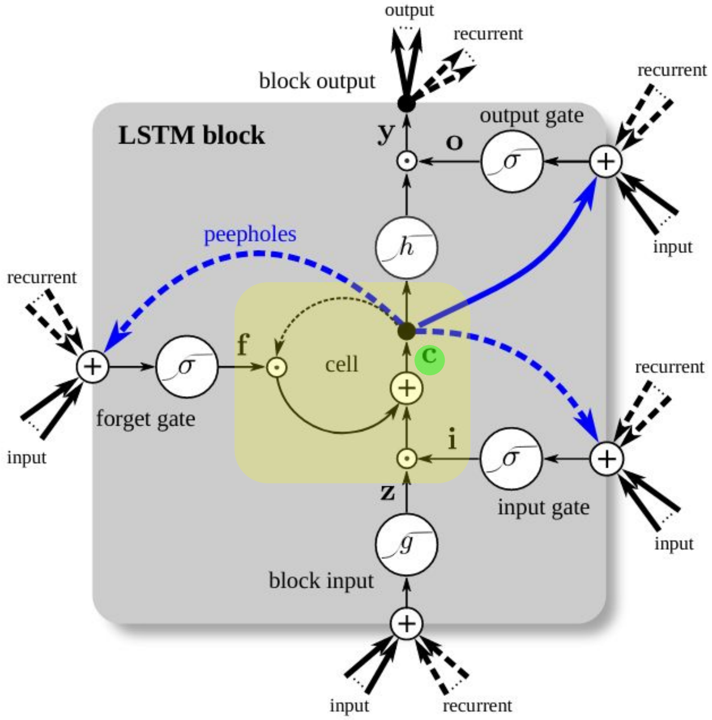

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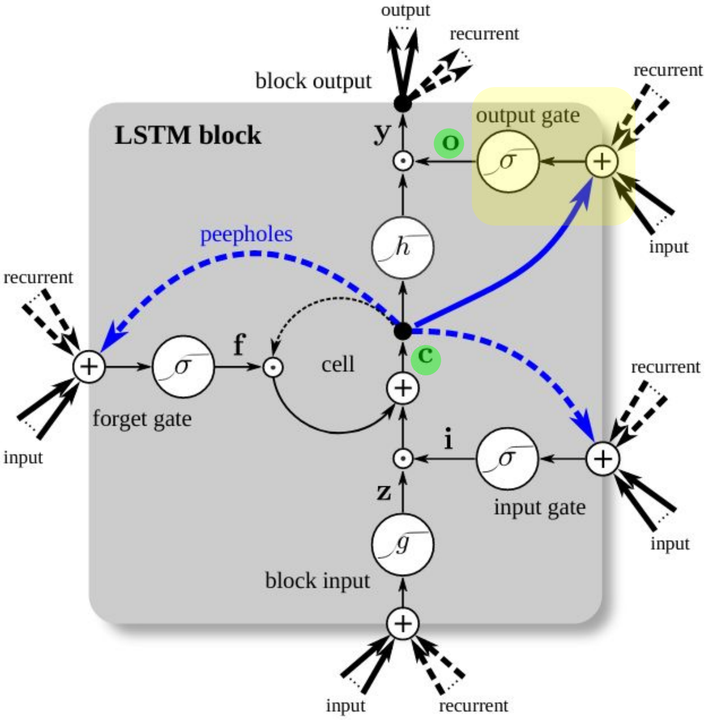

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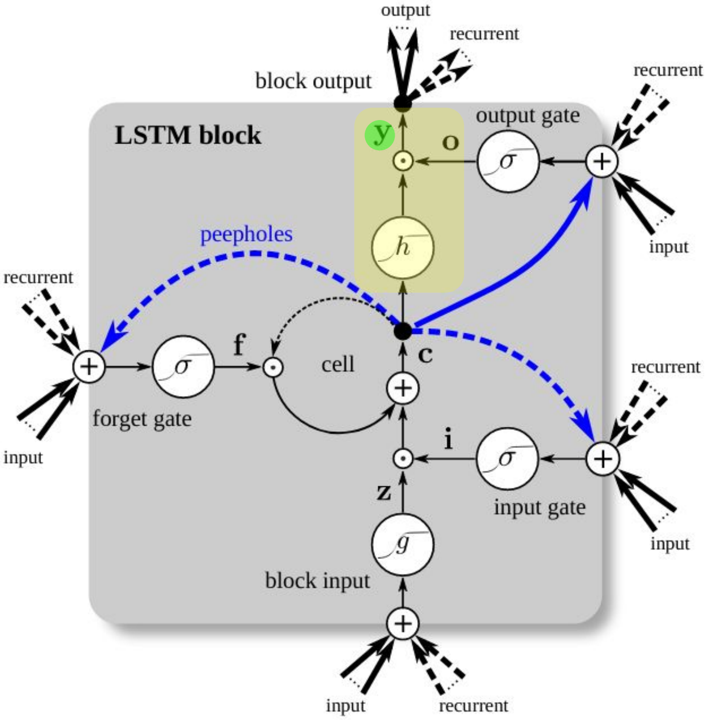

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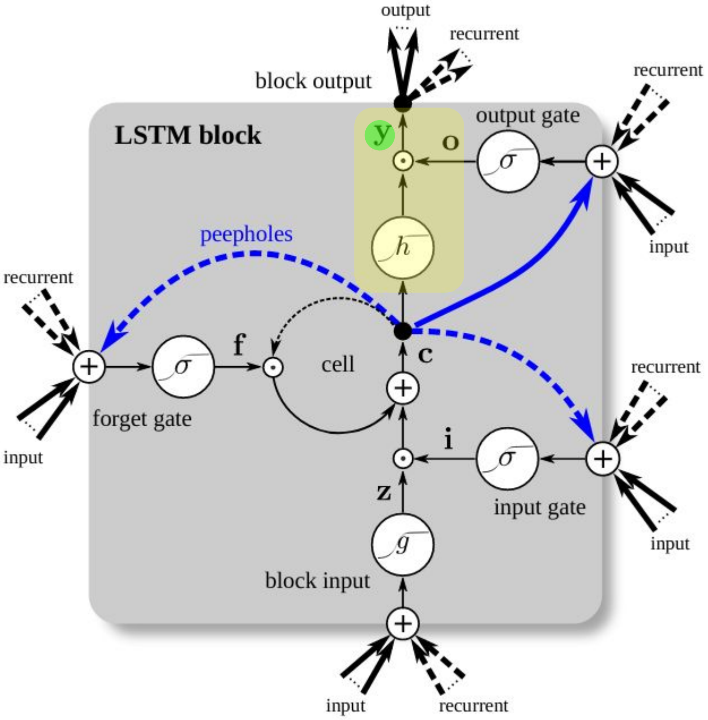

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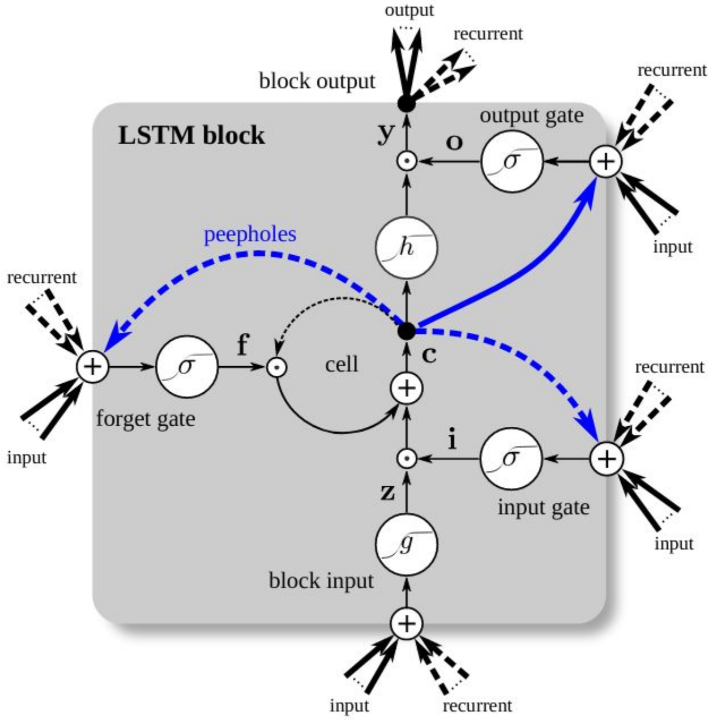
Peephole connections



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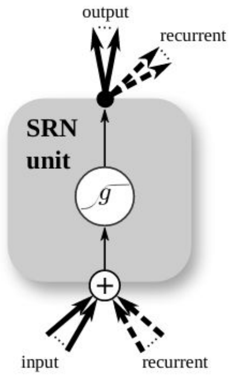
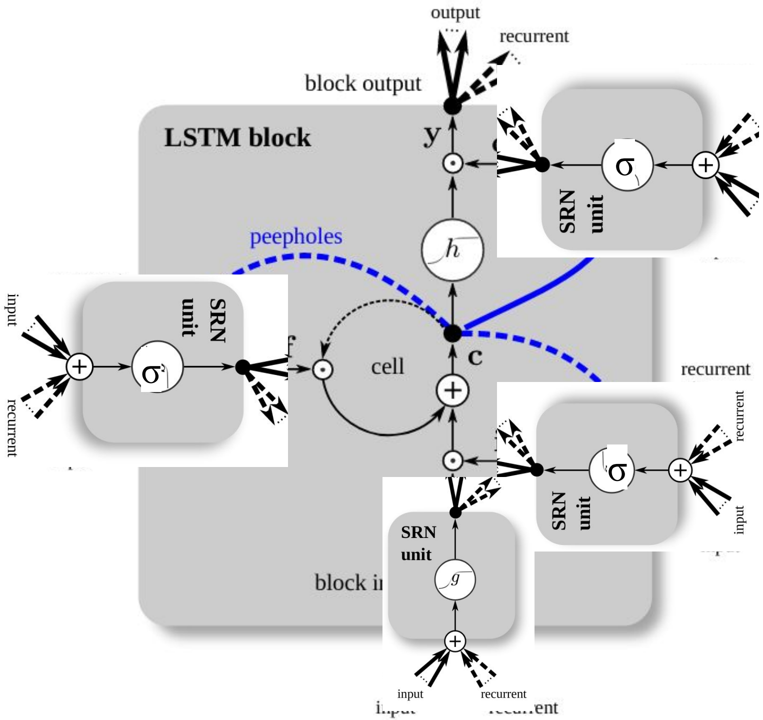
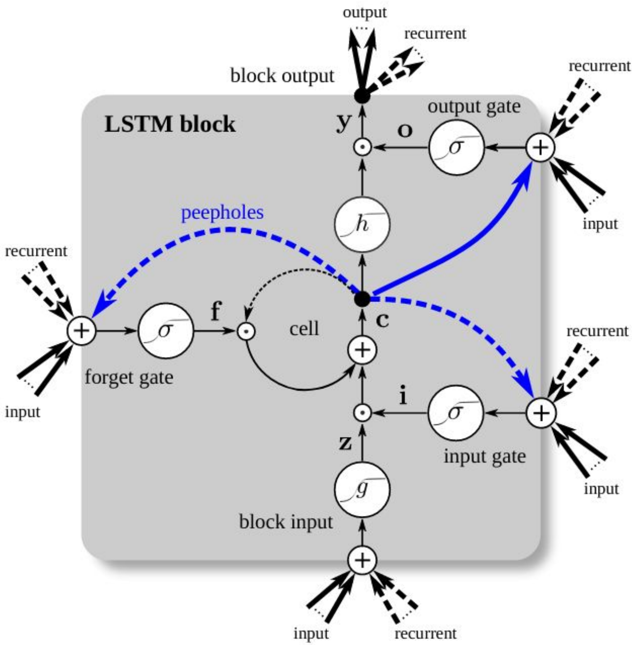
LSTM vs prosta jednostka reukrencyjna



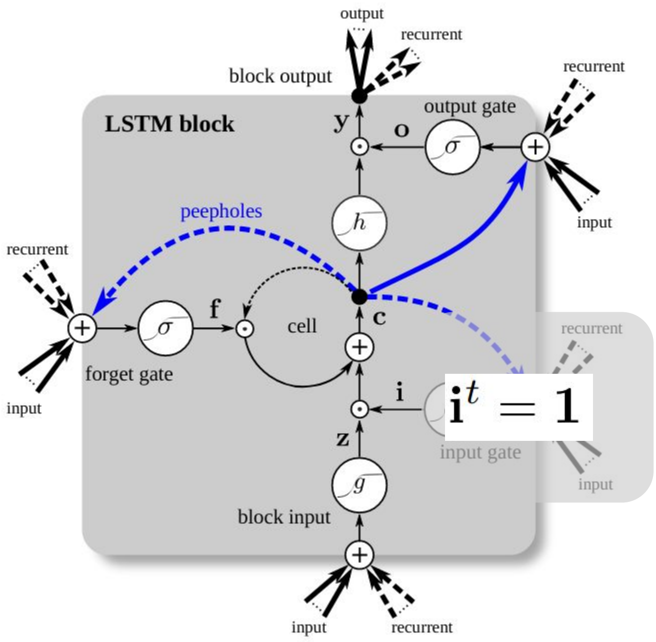




Warianty LSTM

Warianty

1. Usunięcie gate'a:
   a. **No Input Gate**
   b. No Forget Gate
   c. No Output Gate
2. Usunięcie aktywacji:
   a. No Input Activation Function
   b. No Output Activation Function
3. Couple Input and Forget Gate
4. No Peepholes
5. Full Gate Recurrence



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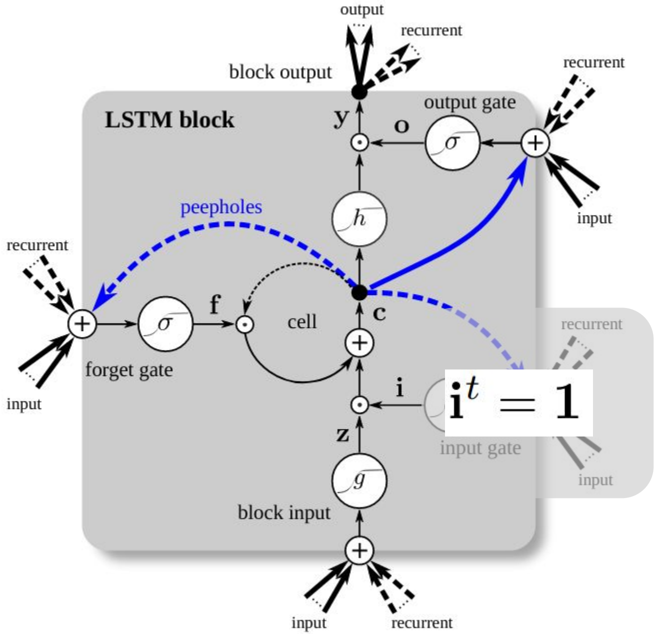

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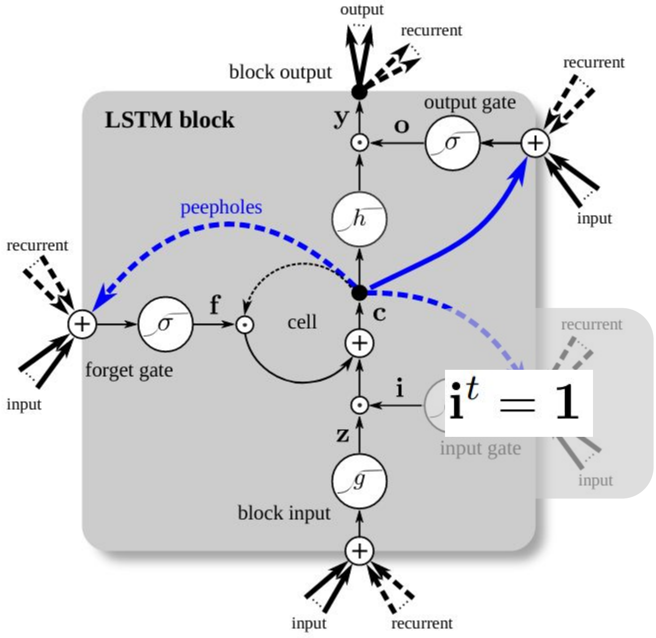

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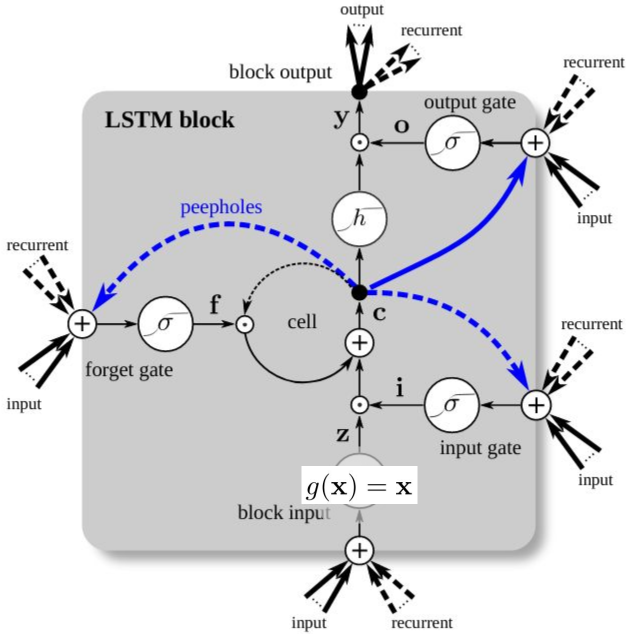

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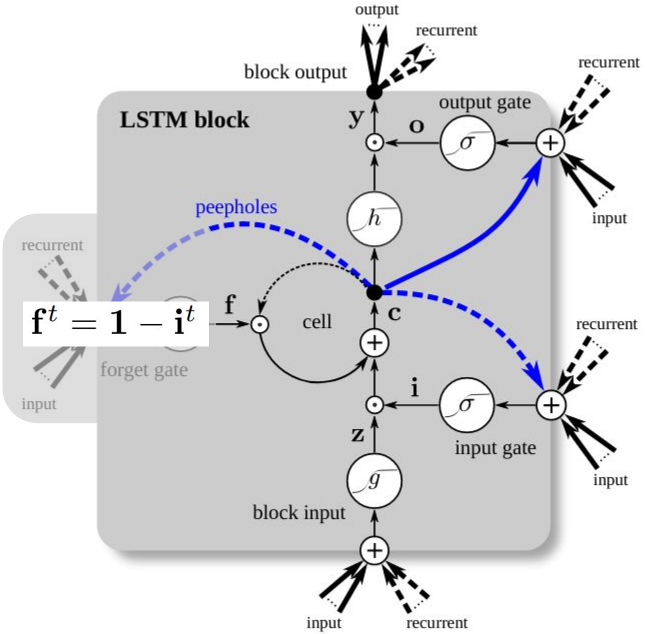
3. **Coupled Input and Forget Gate**
4. No Peepholes
5. Full Gate Recurrence



Warianty

1. Usunięcie gate'a:
    a. No Input Gate
    b. No Forget Gate
    c. No Output Gate
2. Usunięcie aktywacji:
    a. No Input Activation Function
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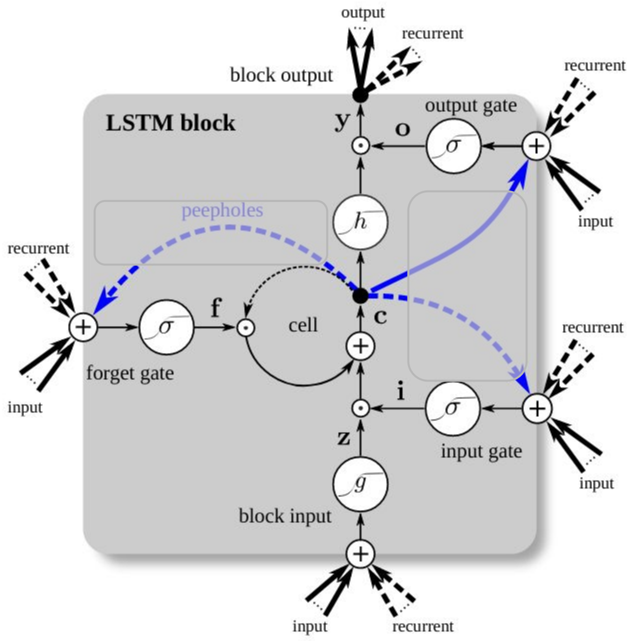
3. Coupled Input and Forget Gate
4. **No Peepholes**
5. Full Gate Recurrence



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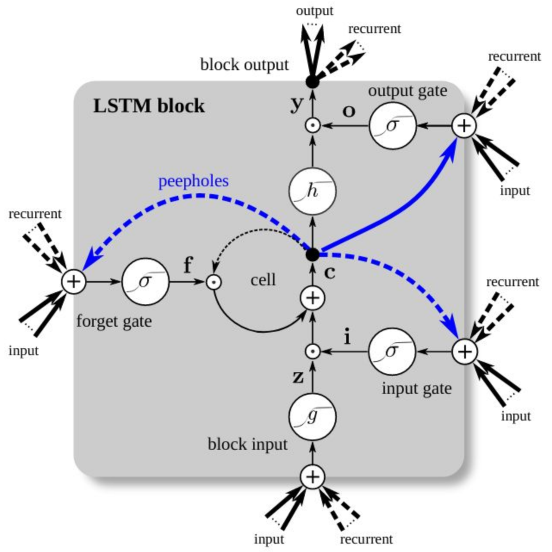
każdy gate + wyniki z poprzedniego kroku ze wszystkich gate'ów

$$+\mathbf{R}_{ii}\mathbf{i}^{t-1} + \mathbf{R}_{fi}\mathbf{f}^{t-1} + \mathbf{R}_{oi}\mathbf{o}^{t-1}$$

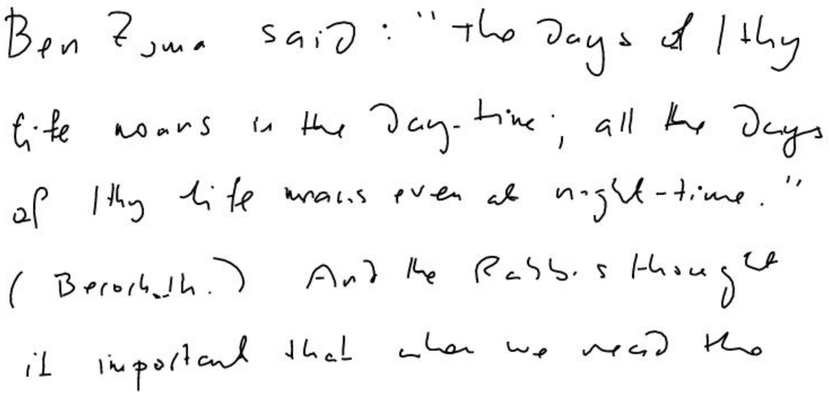


$$\begin{aligned}
\bar{\mathbf{i}}^t &= \mathbf{W}_i\mathbf{x}^t + \mathbf{R}_i\mathbf{y}^{t-1} + \mathbf{p}_i \odot \mathbf{c}^{t-1} + \mathbf{b}_i \\
&\quad + \mathbf{R}_{ii}\mathbf{i}^{t-1} + \mathbf{R}_{fi}\mathbf{f}^{t-1} + \mathbf{R}_{oi}\mathbf{o}^{t-1} \\
\bar{\mathbf{f}}^t &= \mathbf{W}_f\mathbf{x}^t + \mathbf{R}_f\mathbf{y}^{t-1} + \mathbf{p}_f \odot \mathbf{c}^{t-1} + \mathbf{b}_f \\
&\quad + \mathbf{R}_{if}\mathbf{i}^{t-1} + \mathbf{R}_{ff}\mathbf{f}^{t-1} + \mathbf{R}_{of}\mathbf{o}^{t-1} \\
\bar{\mathbf{o}}^t &= \mathbf{W}_o\mathbf{x}^t + \mathbf{R}_o\mathbf{y}^{t-1} + \mathbf{p}_o \odot \mathbf{c}^{t-1} + \mathbf{b}_o \\
&\quad + \mathbf{R}_{io}\mathbf{i}^{t-1} + \mathbf{R}_{fo}\mathbf{f}^{t-1} + \mathbf{R}_{oo}\mathbf{o}^{t-1}
\end{aligned}$$

Trzy benchmarki

Benchmarki / architektury

- TIMIT - rozpoznawanie mowy (fonetyczne)
    - 1 warstwa, dwukierunkowy LSTM
- IAM Online - rozpoznawanie pisma
    - 1 warstwa, dwukierunkowy LSTM
- JSB Chorales - predykcja muzyki
    - 1 warstwa, jednokierunkowy LSTM



Eksperymenty i wyniki

Eksperymenty

- każdy wariant x każdy benchmark
- random search hiperparametrów:
    - rozmiar warstwy
    - szum na wejściu
    - momentum
    - learning rate

Kula Zorba tocząca się w dół zbocza, obrazująca dążenie do minimum funkcji straty, *iStock*.

Wyniki

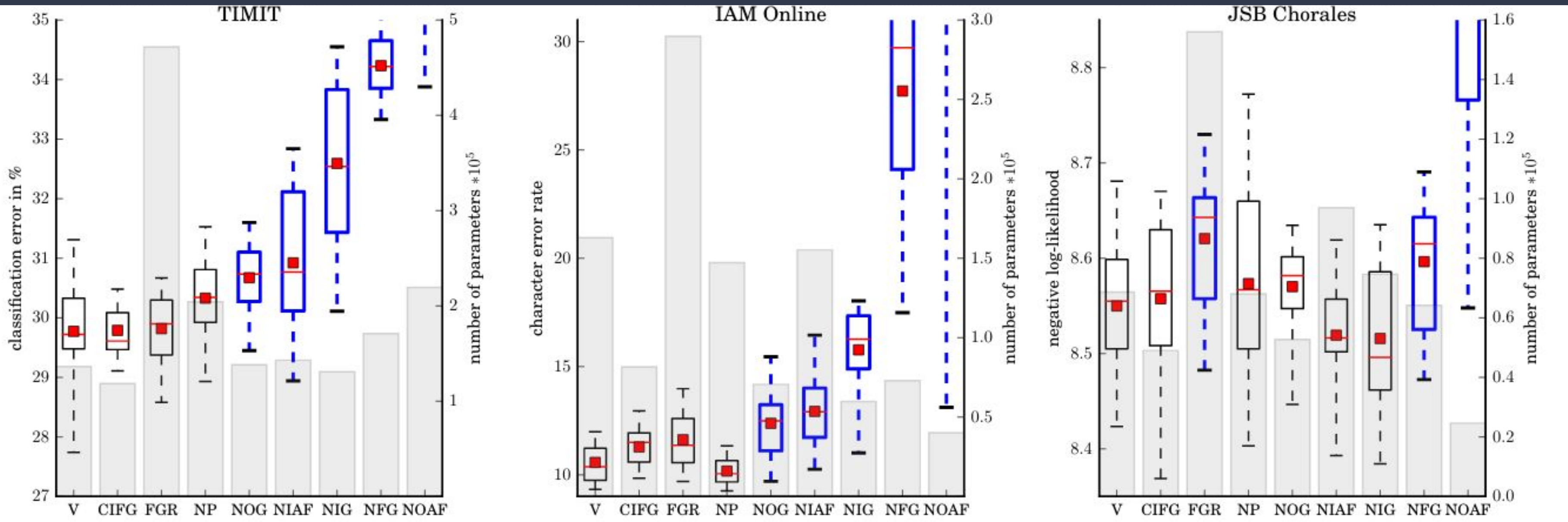
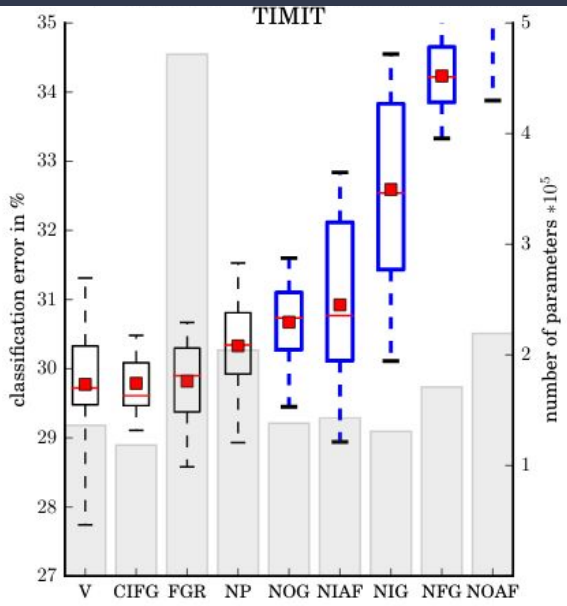


Figure 3. *Test set* performance for all 200 trials (top) and for the best 10% (bottom) trials (according to the *validation set*) for each dataset and variant. Boxes show the range between the 25^{th} and the 75^{th} percentile of the data, while the whiskers indicate the whole range. The red dot represents the mean and the red line the median of the data. The boxes of variants that differ significantly from the vanilla LSTM are shown in blue with thick lines. The grey histogram in the background presents the average number of parameters for the top 10% performers of every variant.

Wyniki



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CIFG - Coupled Input Forget Gates,
FGR - Full Gate Recurrence,
NP - No Peepholes,
NOG - No Output Gate,
NIAF - No Input Activation Function,
NIG - No Input Gate,
NFG - No Forget Gate,
NOAF - No Output Activation Function

- Output Activation, Forget Gate - bardzo ważne!
- ...ale już CIFG nadal radzi sobie dobrze
- NP - nieznaczne zmiany w wynikach...
- FGR nie pomaga, ale dodaje parametrów
- NIG, NOG, NIAF - gorzej w rozpoznawaniu pisma i mowy, ale dla muzyki ok.

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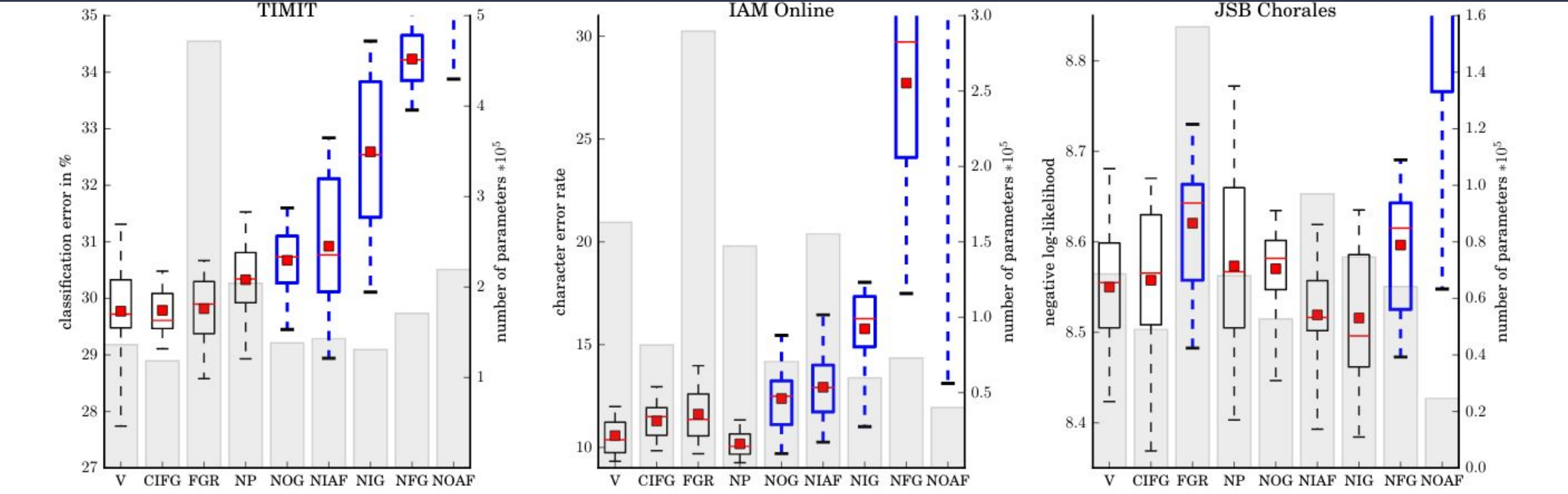
Wyniki



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