Нейронные сети в NLP

RNN Attention Transformers

Лектор: Алтухов Никита Александрович
Аналитик данных Сбербанк

Sequence модели

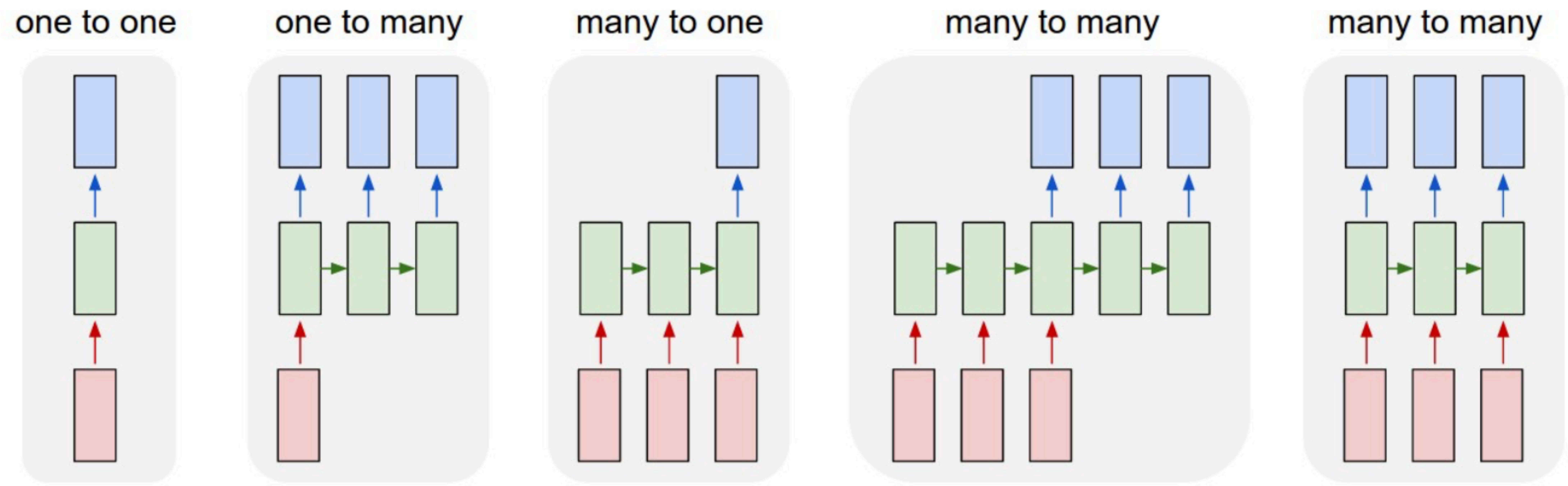
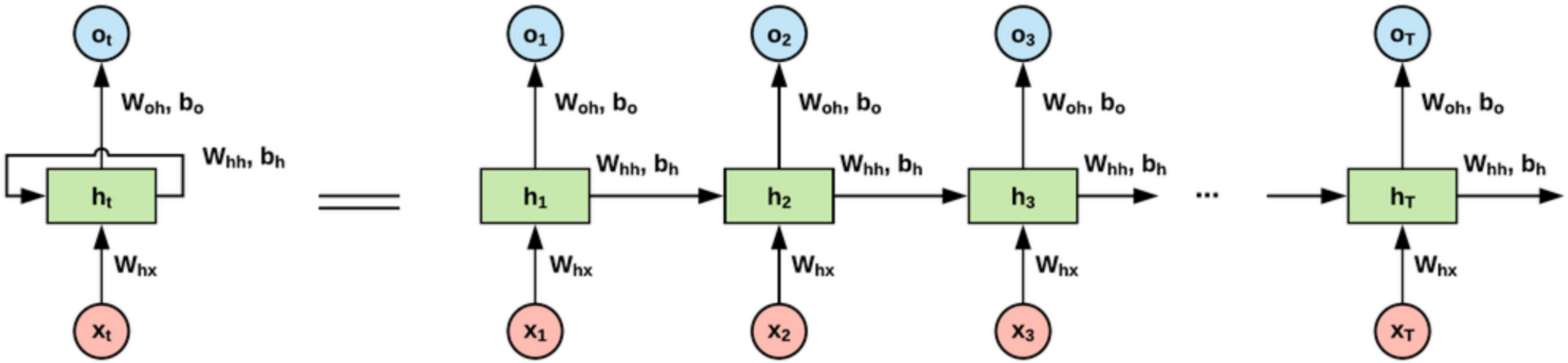
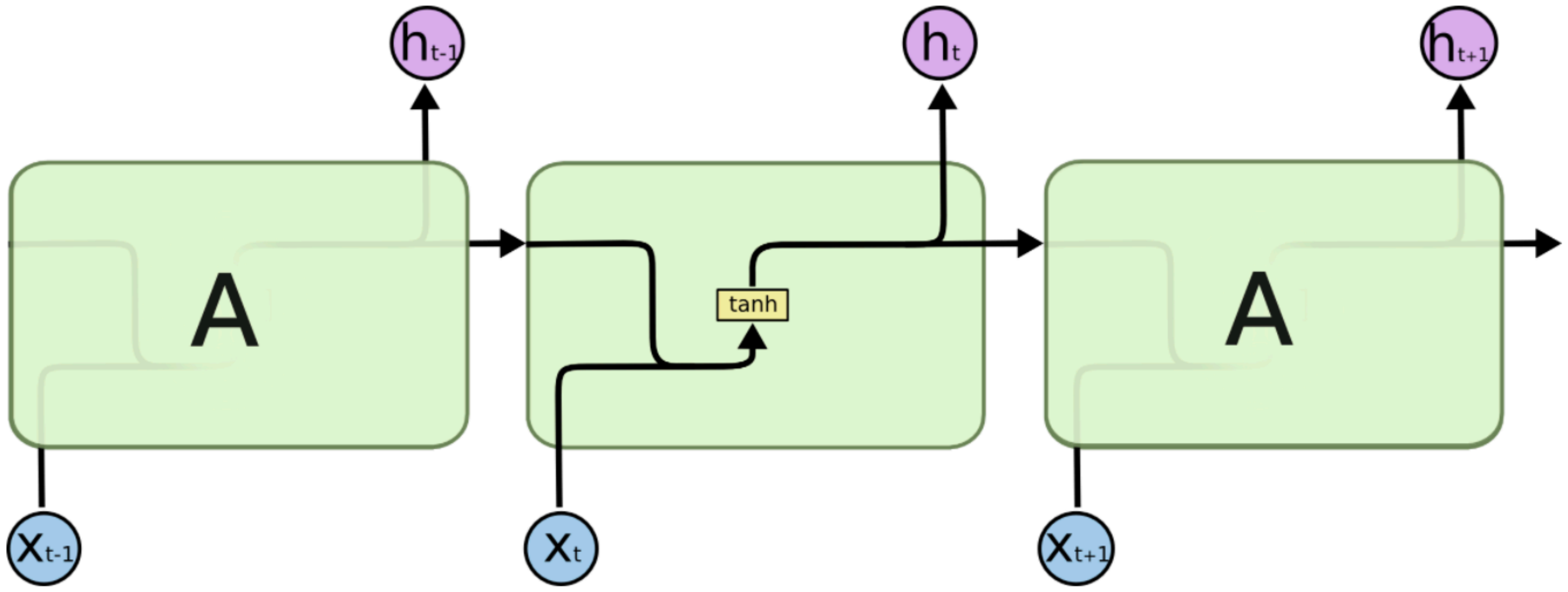


Image Classification | Image Captioning | Text Classification | Maschine Translation | POS-Tagging

http://karpathy.github.io/2015/05/21/rnn-effectiveness/

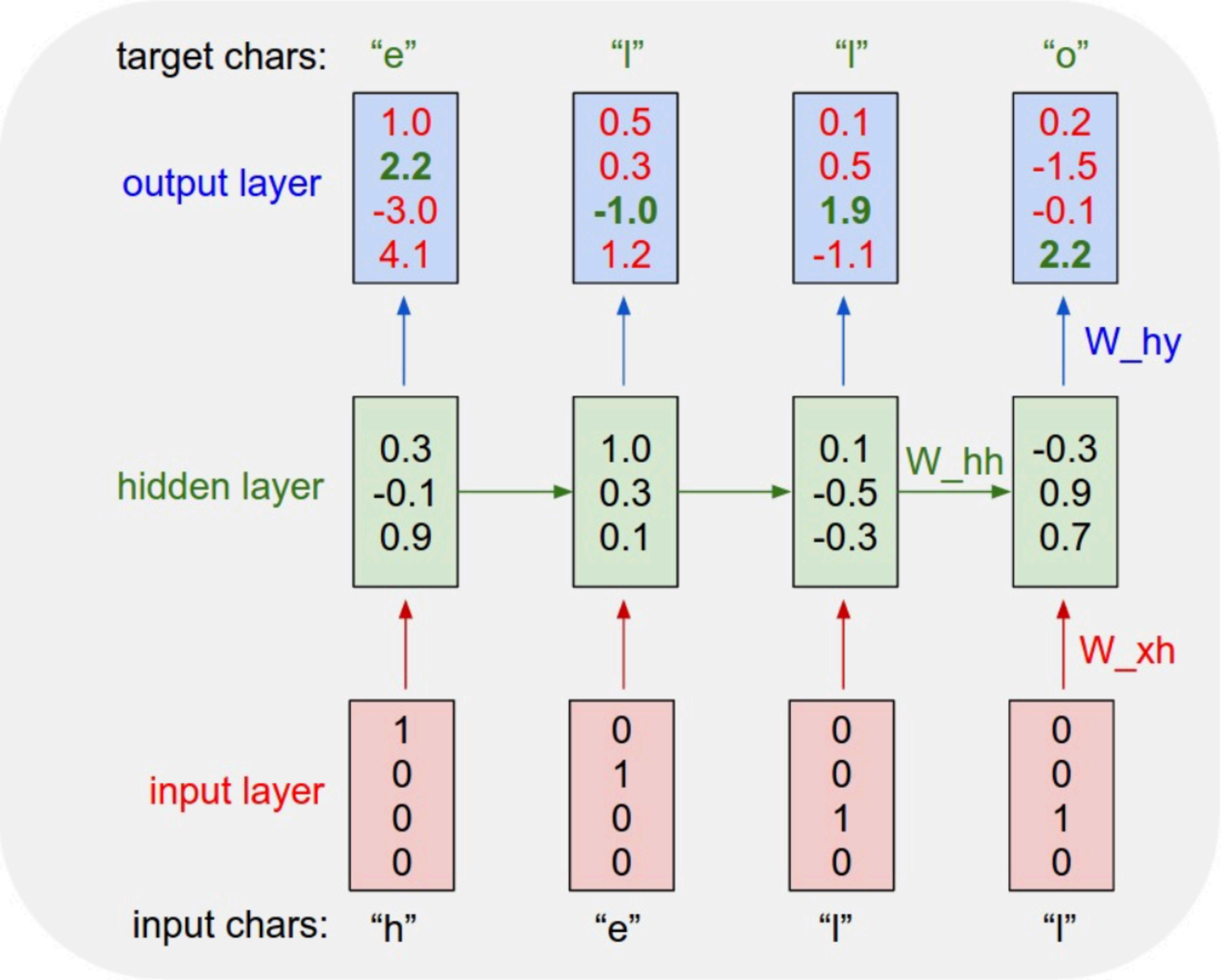
RNN





http://karpathy.github.io/2015/05/21/rnn-effectiveness/

RNN

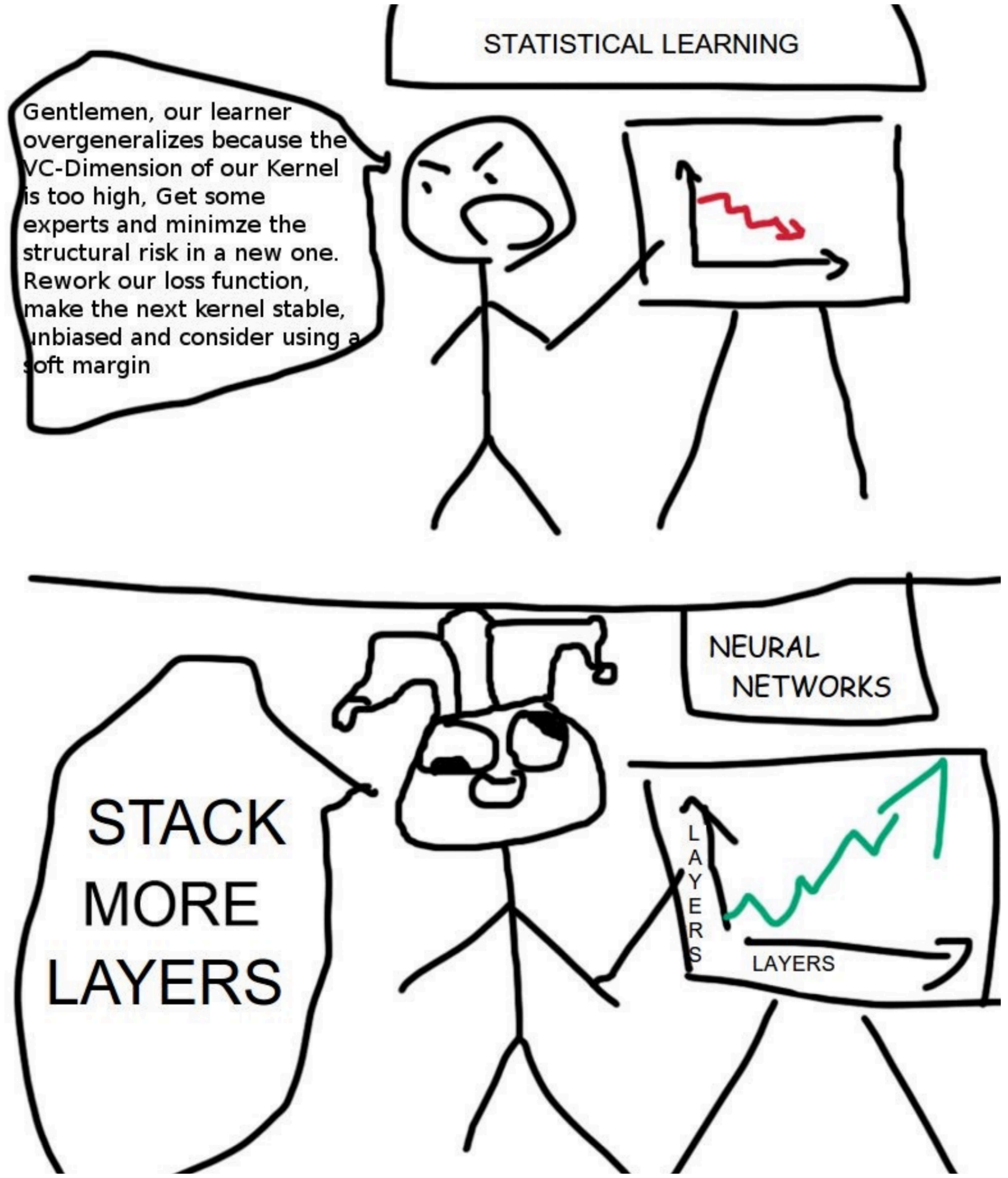


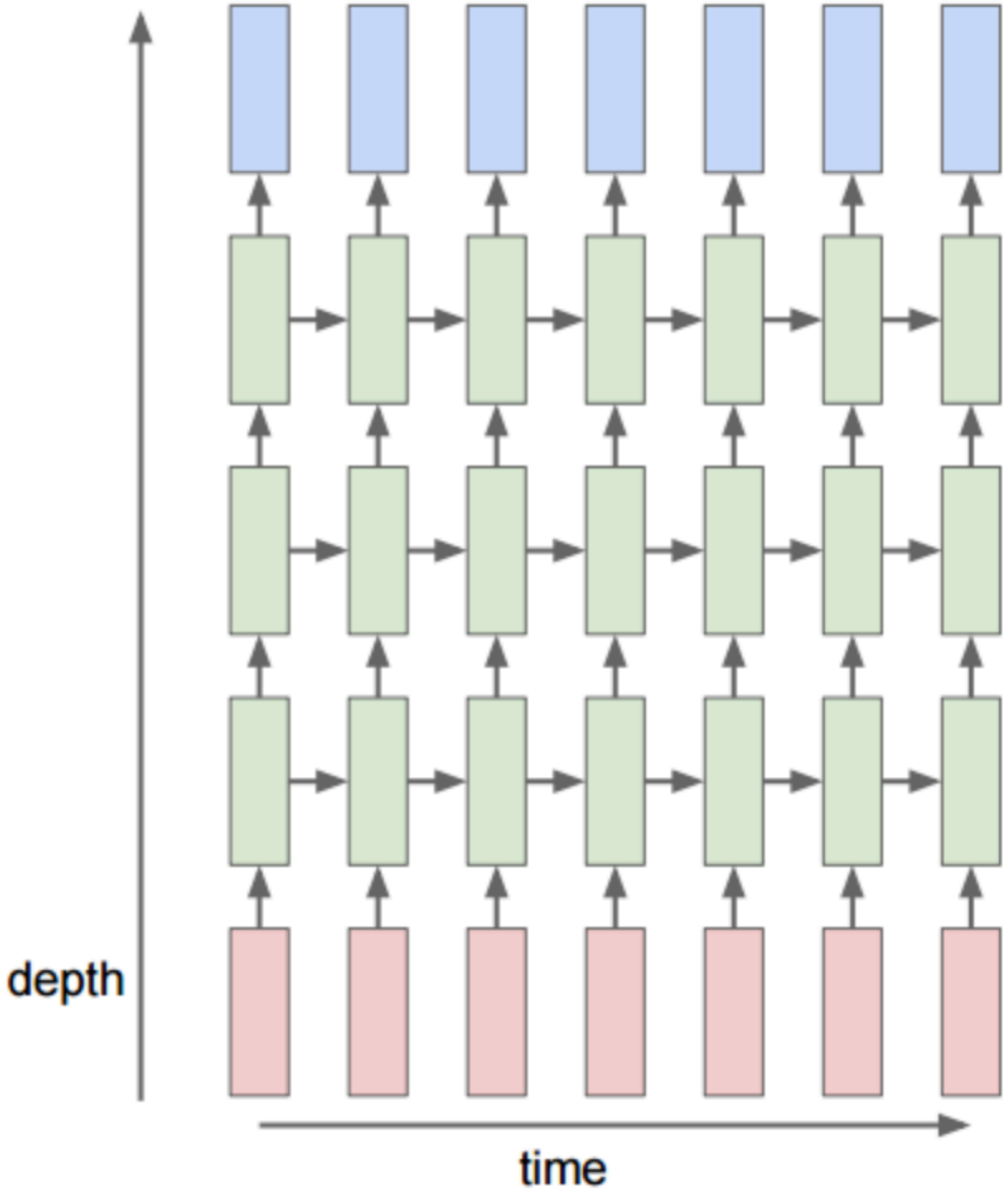
- Посимвольная генерация текста
- На обучении выход смещен относительно входа на один символ. Пытаемся предсказать следующий символ
- На предикте выход подается на вход следующего шага
- Добавляем в словарь [BOS] и [EOS]

```
class RNN:
  # ...
  def step(self, x):
    # update the hidden state
    self.h = np.tanh(np.dot(self.W_hh, self.h) + np.dot(self.W_xh, x))
    # compute the output vector
    y = np.dot(self.W_hy, self.h)
    return y
```

https://calvinfeng.gitbook.io/machine-learning-notebook/supervised-learning/recurrent-neural-network/long_short_term_memory

Многослойная RNN





Проблемы Vanila RNN

- При обучении, когда градиент течет обратно по сети, он умножается много раз (длина последовательности) на матрицу весов. Что делает его либо огромным (если веса > 1), либо очень маленьким (веса < 1).
- Если используется tanh, то градиет превращается в 0.
- Если используется relu, то градиет взрывается.

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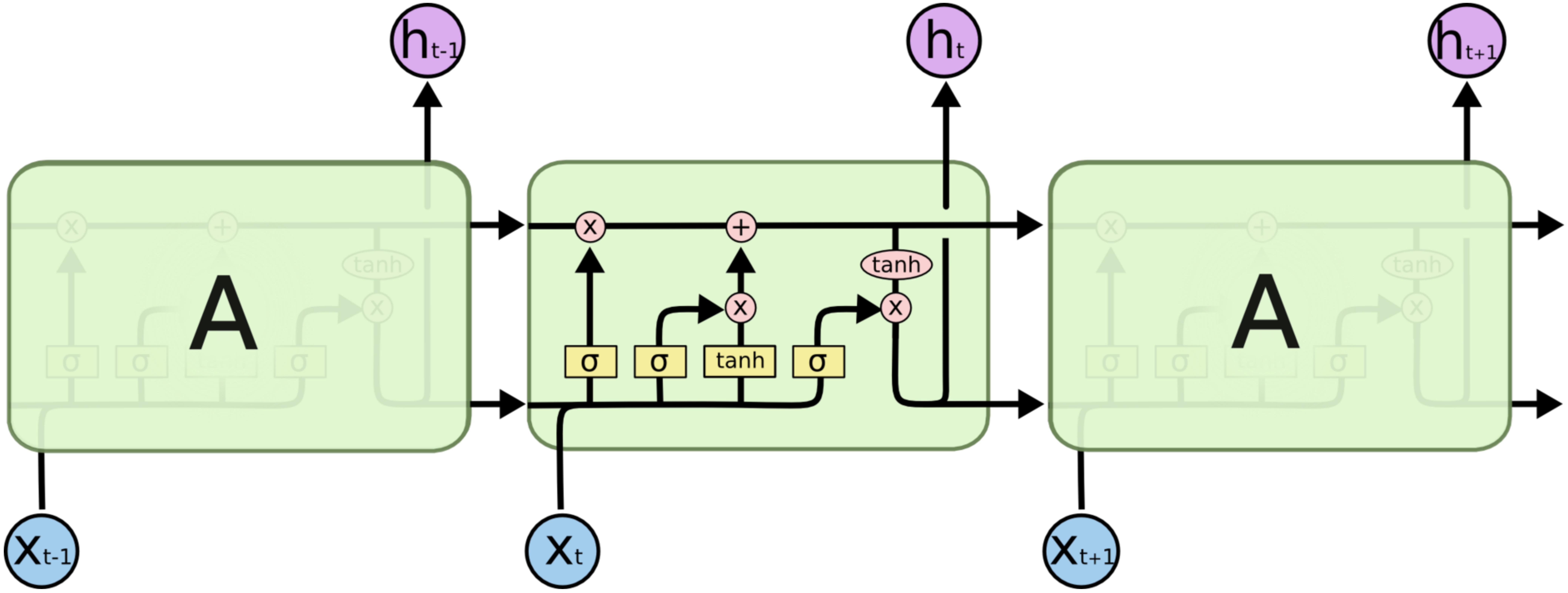
LSTM



https://colah.github.io/posts/2015-08-Understanding-LSTMs/

LSTM

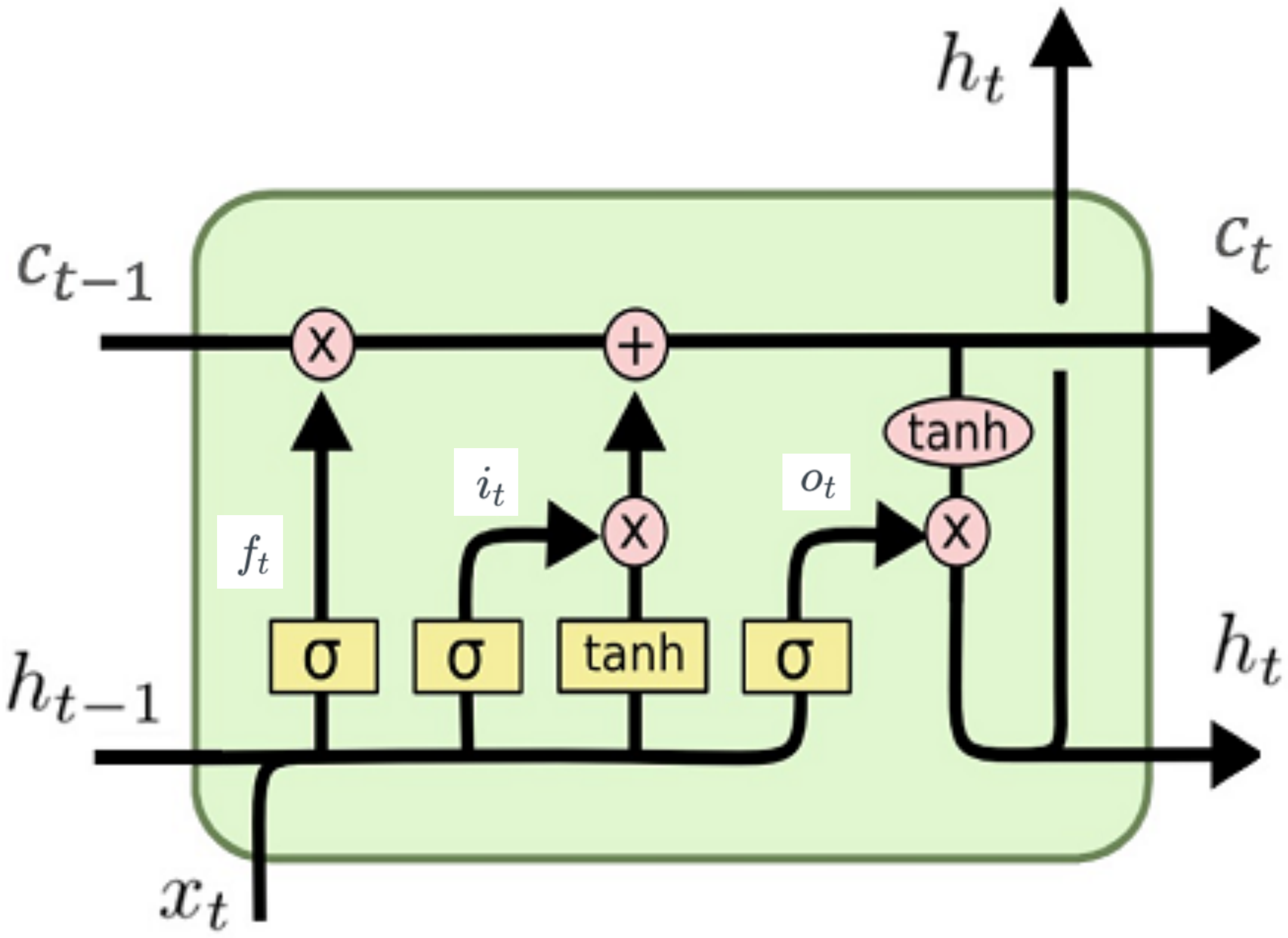
$$f_t = \sigma\left(W_{hf}h_{t-1} + W_{xf}x + b_f\right)$$

$$i_t = \sigma\left(W_{hi}h_{t-1} + W_{xi}x + b_i\right)$$

$$o_t = \sigma\left(W_{ho}h_{t-1} + W_{xo}x + b_o\right)$$

$$c_t = f_t \odot c_{t-1} + i_t \odot \tanh\left(W_{gx}x + W_{gh}h_{t-1} + b_g\right)$$

$$h_t = o_t \odot tanh\left(c_t\right)$$



https://colah.github.io/posts/2015-08-Understanding-LSTMs/

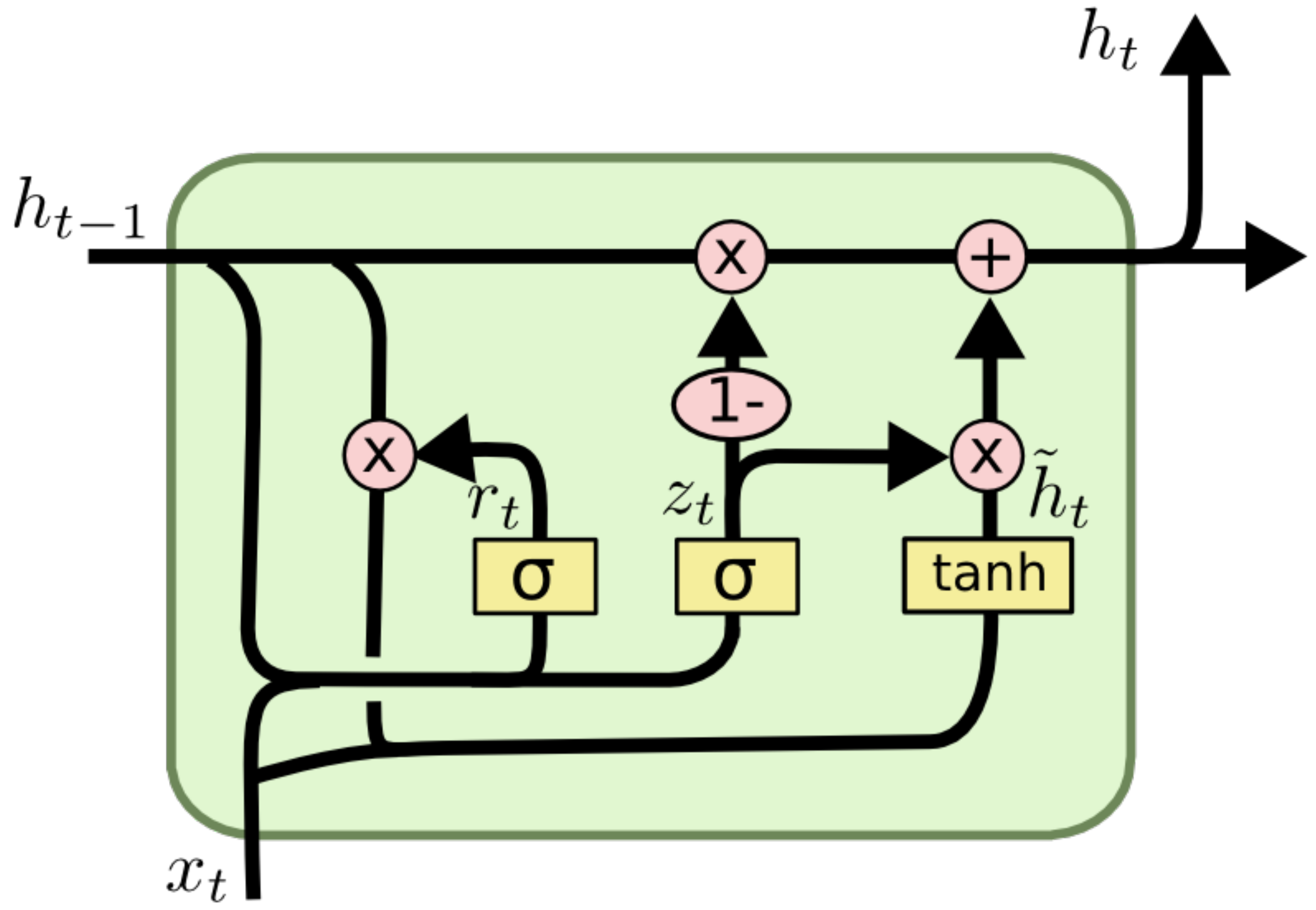
GRU

$$z_t = \sigma\left(W_z \cdot [h_{t-1}, x_t]\right)$$

$$r_t = \sigma\left(W_r \cdot [h_{t-1}, x_t]\right)$$

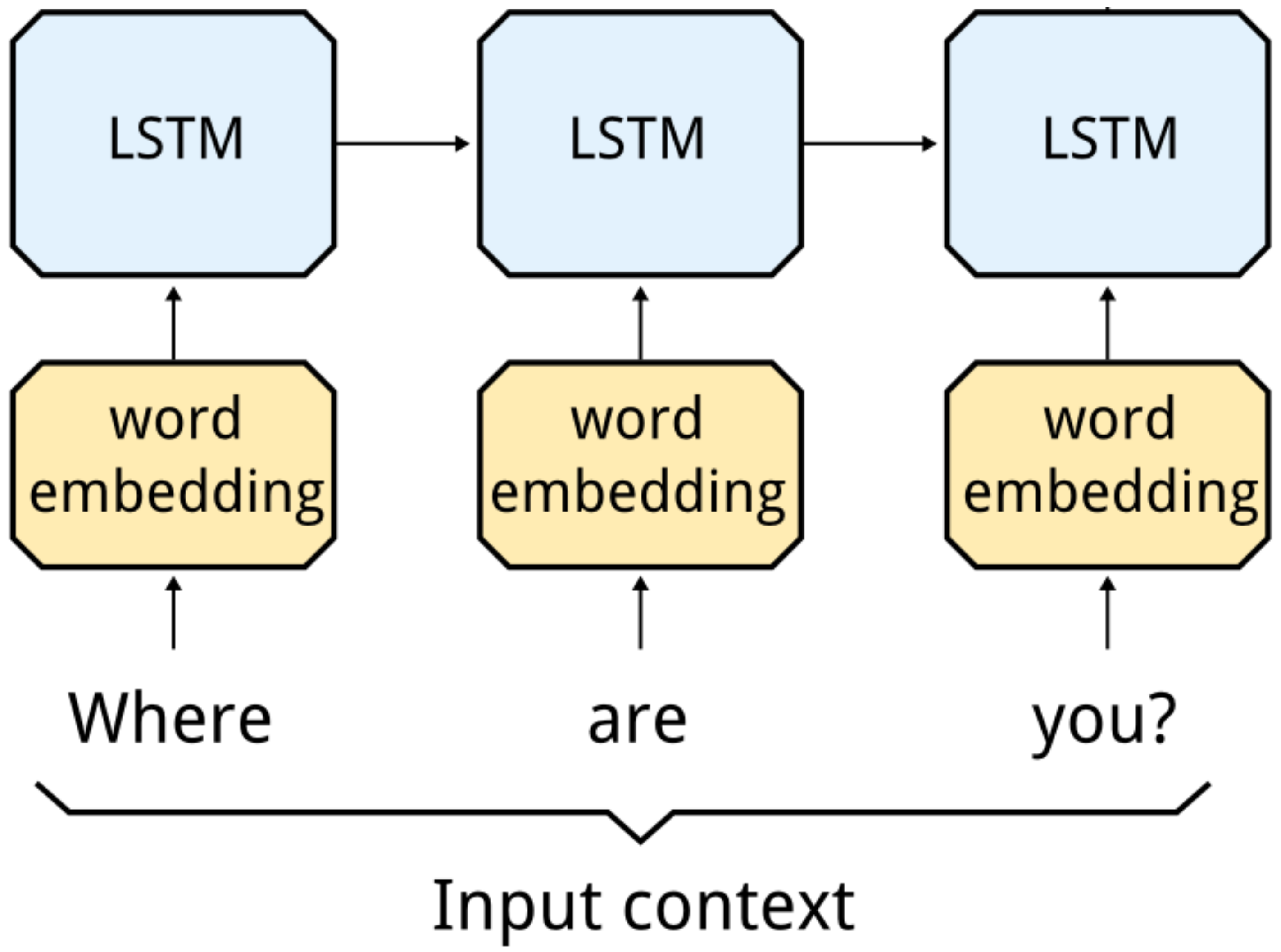
$$\tilde{h}_t = \tanh\left(W \cdot [r_t * h_{t-1}, x_t]\right)$$

$$h_t = (1 - z_t) * h_{t-1} + z_t * \tilde{h}_t$$

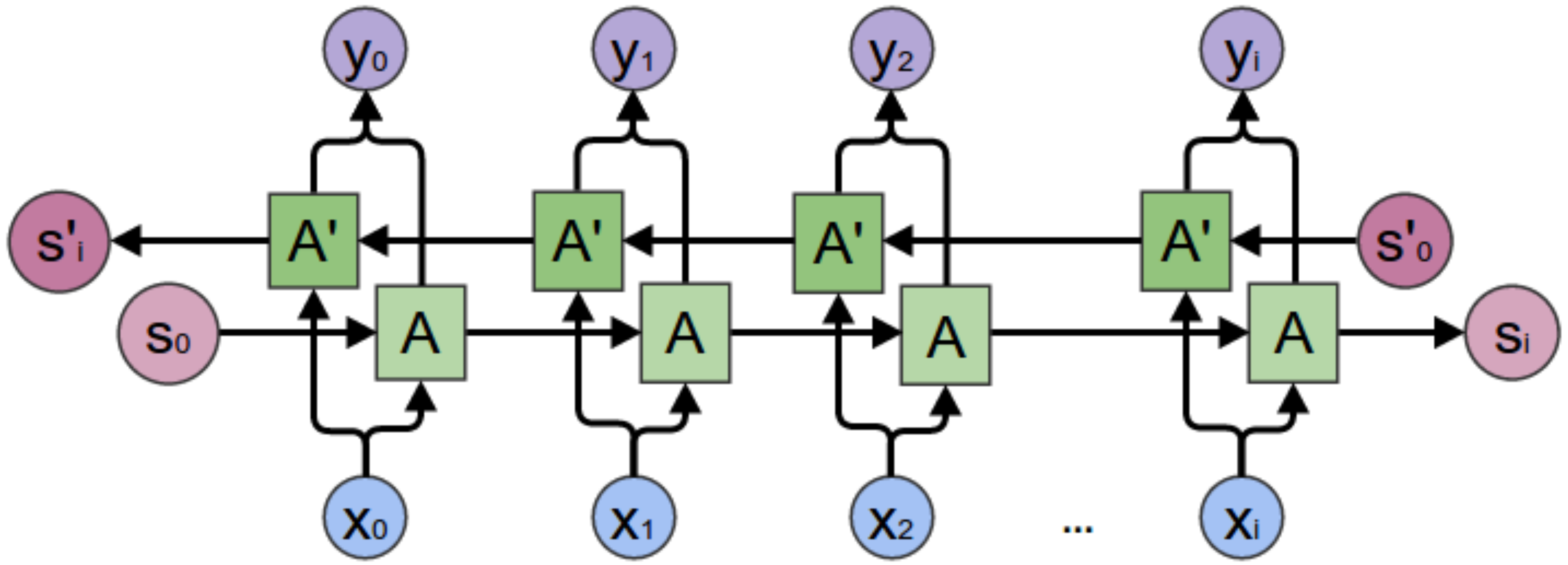


Как еще усилить?

Embeddings (Word2Vec)



Bidirectional RNN



Применения RNN

Wikipedia (100мб)

```
Naturalism and decision for the majority of Arab countries' capitalide was grounded
by the Irish language by [[John Clair]], [[An Imperial Japanese Revolt]], associated
with Guangzham's sovereignty. His generals were the powerful ruler of the Portugal
in the [[Protestant Immineners]], which could be said to be directly in Cantonese
Communication, which followed a ceremony and set inspired prison, training. The
emperor travelled back to [[Antioch, Perth, October 25|21]] to note, the Kingdom
of Costa Rica, unsuccessful fashioned the [[Thrales]], [[Cynth's Dajoard]], known
in western [[Scotland]], near Italy to the conquest of India with the conflict.
Copyright was the succession of independence in the slop of Syrian influence that
was a famous German movement based on a more popular servicious, non-doctrinal
and sexual power post. Many governments recognize the military housing of the
[[Civil Liberalization and Infantry Resolution 265 National Party in Hungary]],
that is sympathetic to be to the [[Punjab Resolution]]
(PJS)[http://www.humah.yahoo.com/guardian.
cfm/7754800786d17551963s89.htm Official economics Adjoint for the Nazism, Montgomery
was swear to advance to the resources for those Socialism's rule,
was starting to signing a major tripad of aid exile.]]
```

http://karpathy.github.io/2015/05/21/rnn-effectiveness/

Применения RNN

Algebraic Geometry (Latex, 16мб)

For $\bigoplus_{n=1,\dots,m}$ where $\mathcal{L}_{m_\bullet} = 0$, hence we can find a closed subset $\mathcal{H}$ in $\mathcal{H}$ and any sets $\mathcal{F}$ on X, U is a closed immersion of S, then $U \to T$ is a separated algebraic space.

Proof. Proof of (1). It also start we get

$$S = \mathrm{Spec}(R) = U \times_X U \times_X U$$

and the comparicoly in the fibre product covering we have to prove the lemma generated by $\coprod Z \times_U U \to V$. Consider the maps M along the set of points Sch_{fppf} and $U \to U$ is the fibre category of S in U in Section, **??** and the fact that any U affine, see Morphisms, Lemma **??**. Hence we obtain a scheme S and any open subset $W \subset U$ in $Sh(G)$ such that $\mathrm{Spec}(R') \to S$ is smooth or an

$$U = \bigcup U_i \times_{S_i} U_i$$

which has a nonzero morphism we may assume that f_i is of finite presentation over S. We claim that $\mathcal{O}_{X,x}$ is a scheme where $x, x', s'' \in S'$ such that $\mathcal{O}_{X,x'} \to \mathcal{O}'_{X',x'}$ is separated. By Algebra, Lemma **??** we can define a map of complexes $\mathrm{GL}_{S'}(x'/S'')$ and we win. □

To prove study we see that $\mathcal{F}|_U$ is a covering of $\mathcal{X}'$, and $\mathcal{T}_i$ is an object of $\mathcal{F}_{X/S}$ for $i > 0$ and $\mathcal{F}_p$ exists and let $\mathcal{F}_i$ be a presheaf of $\mathcal{O}_X$-modules on $\mathcal{C}$ as a $\mathcal{F}$-module. In particular $\mathcal{F} = U/\mathcal{F}$ we have to show that

$$\widetilde{M}^\bullet = \mathcal{I}^\bullet \otimes_{\mathrm{Spec}(k)} \mathcal{O}_{S,s} - i_X^{-1}\mathcal{F})$$

is a unique morphism of algebraic stacks. Note that

$$\mathrm{Arrows} = (Sch/S)^{opp}_{fppf}, (Sch/S)_{fppf}$$

and

$$V = \Gamma(S, \mathcal{O}) \longmapsto (U, \mathrm{Spec}(A))$$

is an open subset of X. Thus U is affine. This is a continuous map of X is the inverse, the groupoid scheme S.

Proof. See discussion of sheaves of sets. □

The result for prove any open covering follows from the less of Example **??**. It may replace S by $X_{spaces,étale}$ which gives an open subspace of X and T equal to S_{Zar}, see Descent, Lemma **??**. Namely, by Lemma **??** we see that R is geometrically regular over S.

Lemma 0.1. *Assume (3) and (3) by the construction in the description.*

Suppose $X = \lim |X|$ *(by the formal open covering* X *and a single map* $\underline{Proj}_X(\mathcal{A}) = \mathrm{Spec}(B)$ *over* U *compatible with the complex*

$$Set(\mathcal{A}) = \Gamma(X, \mathcal{O}_{X,\mathcal{O}_X}).$$

When in this case of to show that $\mathcal{Q} \to \mathcal{C}_{Z/X}$ *is stable under the following result in the second conditions of (1), and (3). This finishes the proof. By Definition* **??** *(without element is when the closed subschemes are catenary. If* T *is surjective we may assume that* T *is connected with residue fields of* S*. Moreover there exists a closed subspace* $Z \subset X$ *of* X *where* U *in* X' *is proper (some defining as a closed subset of the uniqueness it suffices to check the fact that the following theorem*

(1) f *is locally of finite type. Since* $S = \mathrm{Spec}(R)$ *and* $Y = \mathrm{Spec}(R)$.

Proof. This is form all sheaves of sheaves on X. But given a scheme U and a surjective étale morphism $U \to X$. Let $U \cap U = \coprod_{i=1,\dots,n} U_i$ be the scheme X over S at the schemes $X_i \to X$ and $U = \lim_i X_i$. □

The following lemma surjective restrocomposes of this implies that $\mathcal{F}_{x_0} = \mathcal{F}_{x_0} = \mathcal{F}_{\mathcal{X},\dots,0}$.

Lemma 0.2. *Let* X *be a locally Noetherian scheme over* S, $E = \mathcal{F}_{X/S}$*. Set* $\mathcal{I} = \mathcal{J}_1 \subset \mathcal{I}'_n$*. Since* $\mathcal{I}^n \subset \mathcal{I}^n$ *are nonzero over* $i_0 \leq \mathfrak{p}$ *is a subset of* $\mathcal{J}_{n,0} \circ \overline{A}_2$ *works.*

Lemma 0.3. *In Situation* **??**. *Hence we may assume* $\mathfrak{q}' = 0$.

Proof. We will use the property we see that $\mathfrak{p}$ is the mext functor (**??**). On the other hand, by Lemma **??** we see that

$$D(\mathcal{O}_{X'}) = \mathcal{O}_X(D)$$

where K is an F-algebra where δ_{n+1} is a scheme over S. □

Sampled (fake) algebraic geometry. Here's the actual pdf.

http://karpathy.github.io/2015/05/21/rnn-effectiveness/

Применения RNN

```c
/*
 * Increment the size file of the new incorrect UI_FILTER group information
 * of the size generatively.
 */
static int indicate_policy(void)
{
  int error;
  if (fd == MARN_EPT) {
    /*
     * The kernel blank will coeld it to userspace.
     */
    if (ss->segment < mem_total)
      unblock_graph_and_set_blocked();
    else
      ret = 1;
    goto bail;
  }
  segaddr = in_SB(in.addr);
  selector = seg / 16;
  setup_works = true;
  for (i = 0; i < blocks; i++) {
    seq = buf[i++];
    bpf = bd->bd.next + i * search;
    if (fd) {
      current = blocked;
    }
  }
  rw->name = "Getjbbregs";
  bprm_self_clearl(&iv->version);
  regs->new = blocks[(BPF_STATS << info->historidac)] | PFMR_CLOBATHINC_SECONDS << 12;
  return segtable;
}
```

Linux Source (474мб C code)

http://karpathy.github.io/2015/05/21/rnn-effectiveness/

Применения RNN

100 iterations:

```
tyntd-iafhatawiaoihrdemot  lytdws  e ,tfti, astai f ogoh eoase rrranbyne 'nhthnee e
plia tklrgd t o idoe ns,smtt   h ne etie h,hregtrs nigtike,aoaenns lng
```

300 iterations:

```
"Tmont thithey" fomesscerliund
Keushey. Thom here
sheulke, anmerenith ol sivh I lalterthend Bleipile shuwy fil on aseterlome
coaniogennc Phe lism thond hon at. MeiDimorotion in ther thize."
```

500 iterations:

```
we counter. He stutn co des. His stanted out one ofler that concossions and was
to gearang reay Jotrets and with fre colt otf paitt thin wall. Which das stimn
```

700 iterations:

```
Aftair fall unsuch that the hall for Prince Velzonski's that me of
her hearly, and behs to so arwage fiving were to it beloge, pavu say falling misfort
how, and Gogition is so overelical and ofter.
```

1200 iterations:

```
"Kite vouch!" he repeated by her
door. "But I would be done and quarts, feeling, then, son is people...."
```

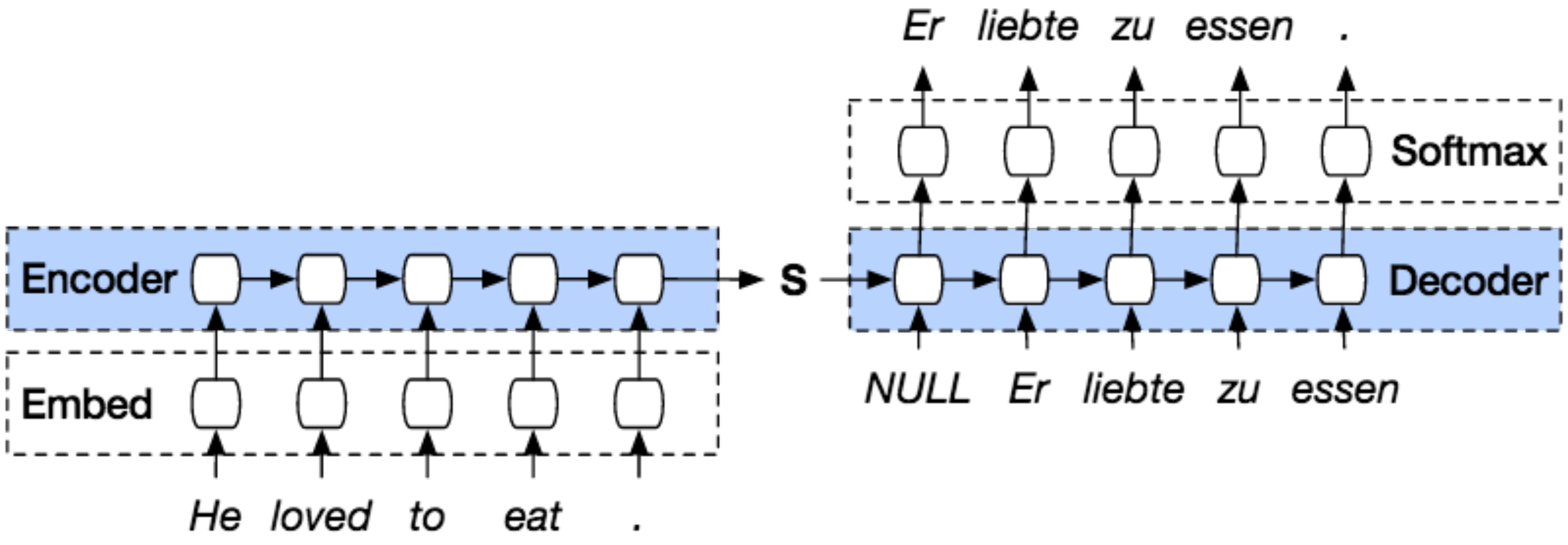
2000 iterations:

```
"Why do what that day," replied Natasha, and wishing to himself the fact the
princess, Princess Mary was easier, fed in had oftened him.
Pierre aking his soul came to the packs and drove up his father-in-law women.
```

http://karpathy.github.io/2015/05/21/rnn-effectiveness/

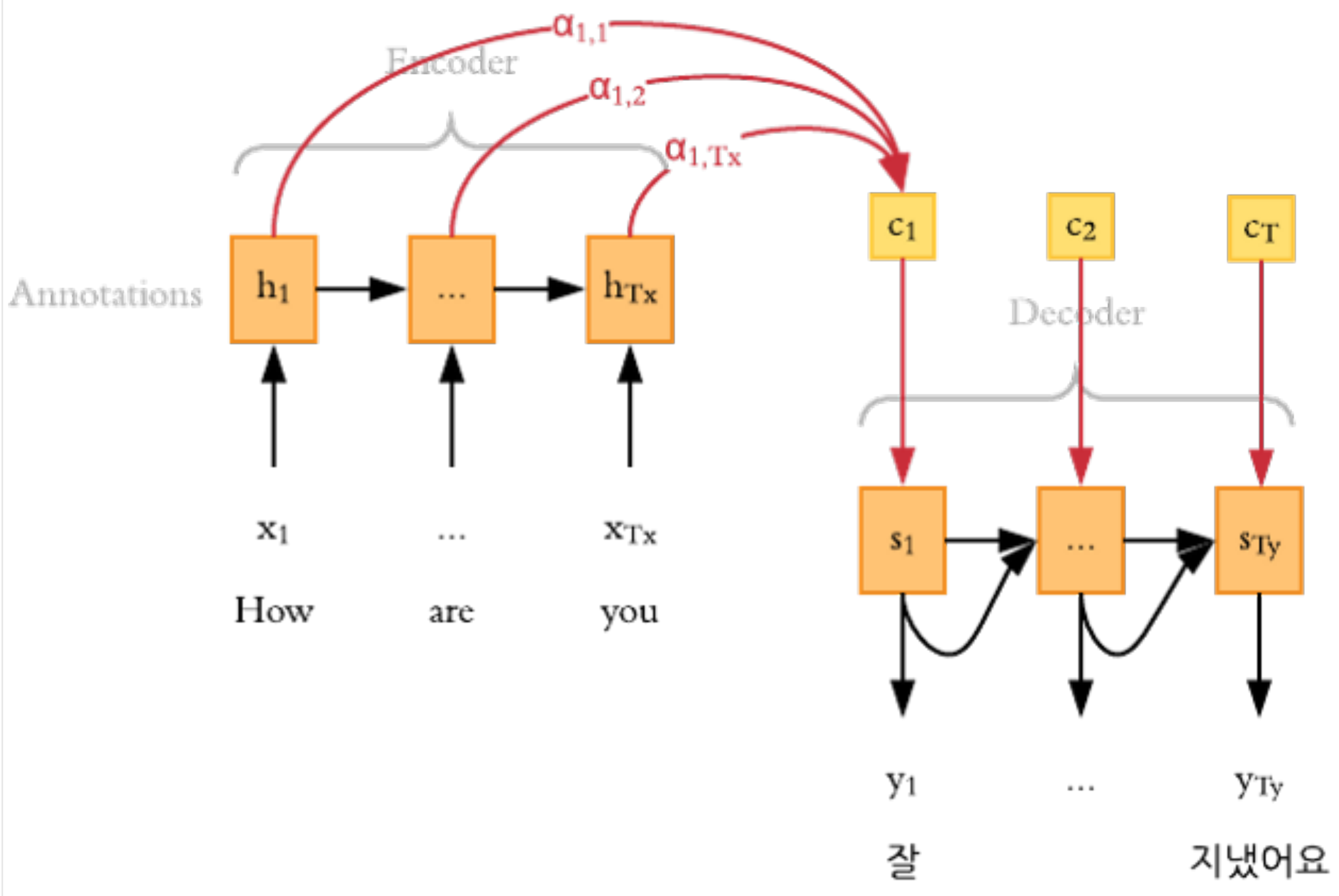
Минусы RNN

- Не параллелится на GPU
- На больших последовательностях связи между началом и концом теряются
- Ограничены размерностью внутреннего состояния сети

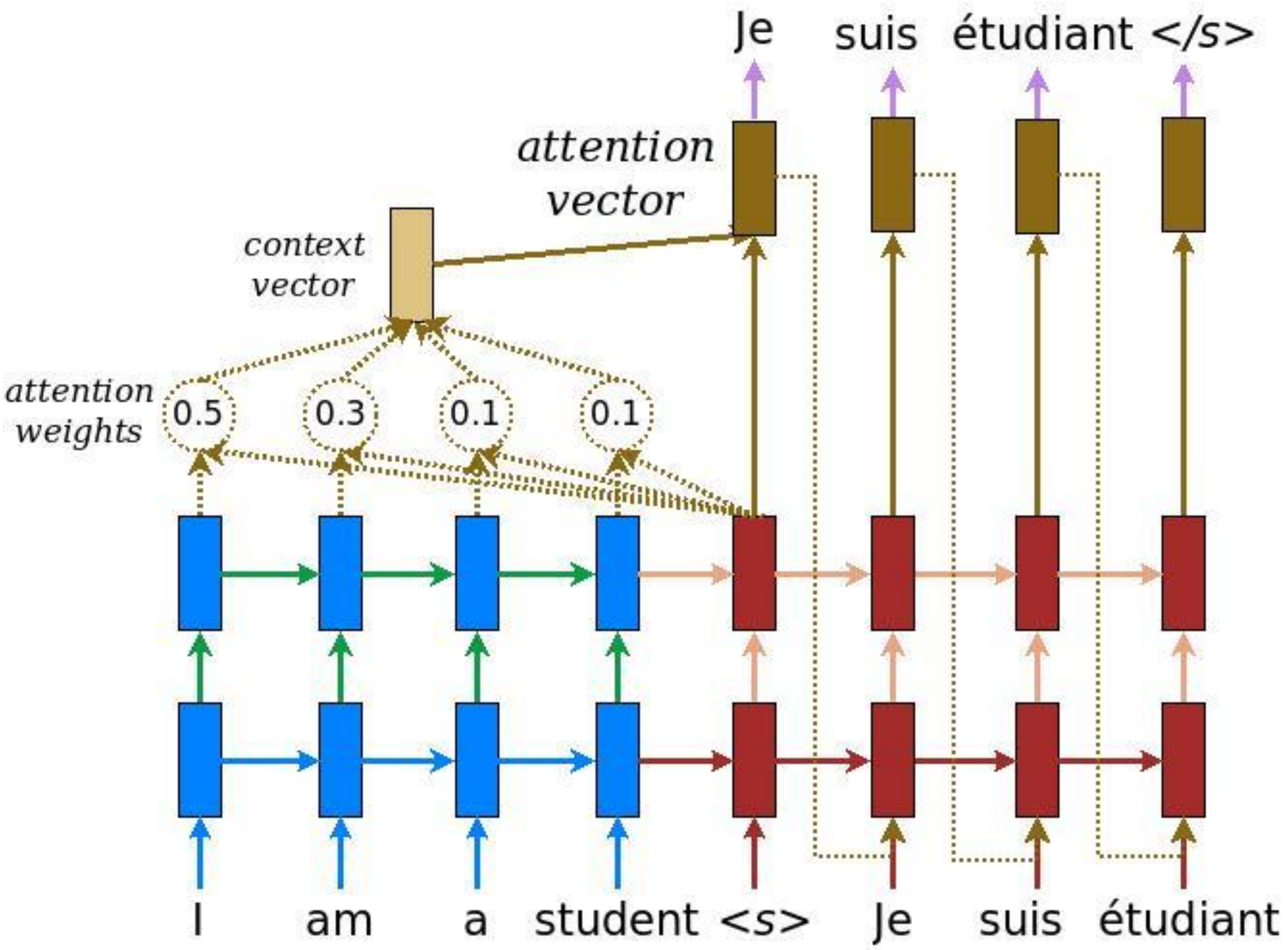


Attention

- Архитектура, которая позволяет модели выбрать в какое место encoder смотреть на предсказании слова в decoder.
- Взвешиваем каждый выход encoder с помощью функции
- В простом случае вес ([0, 1]) - это скалярное произведение внутреннего состояния decoder на внутренние состояния encoder.



Attention



Je
suis
étudiant
</s>
attention vector
context vector
attention weights
0.5
0.3
0.1
0.1
I
am
a
student
<s>
Je
suis
étudiant

Attention

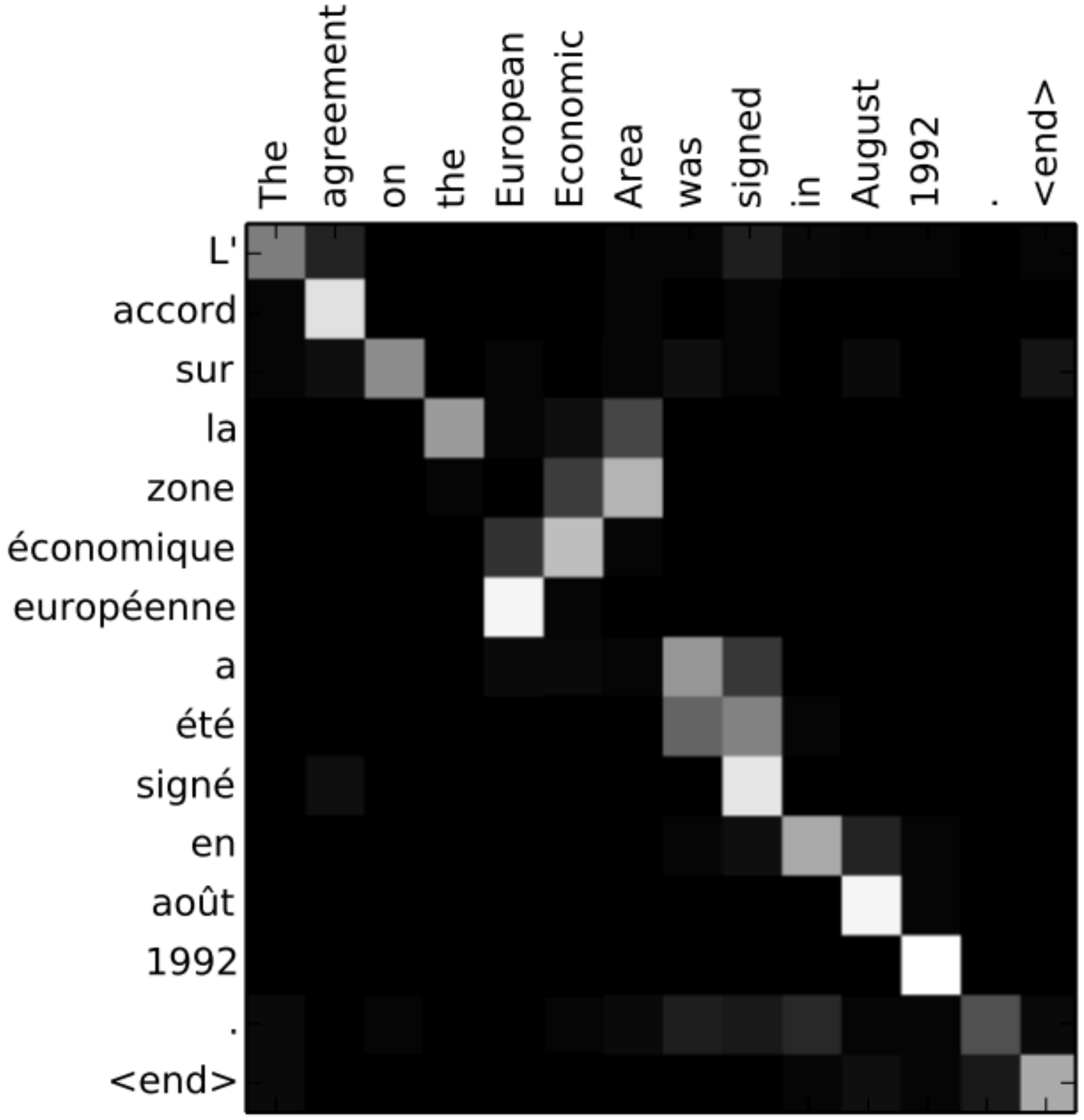
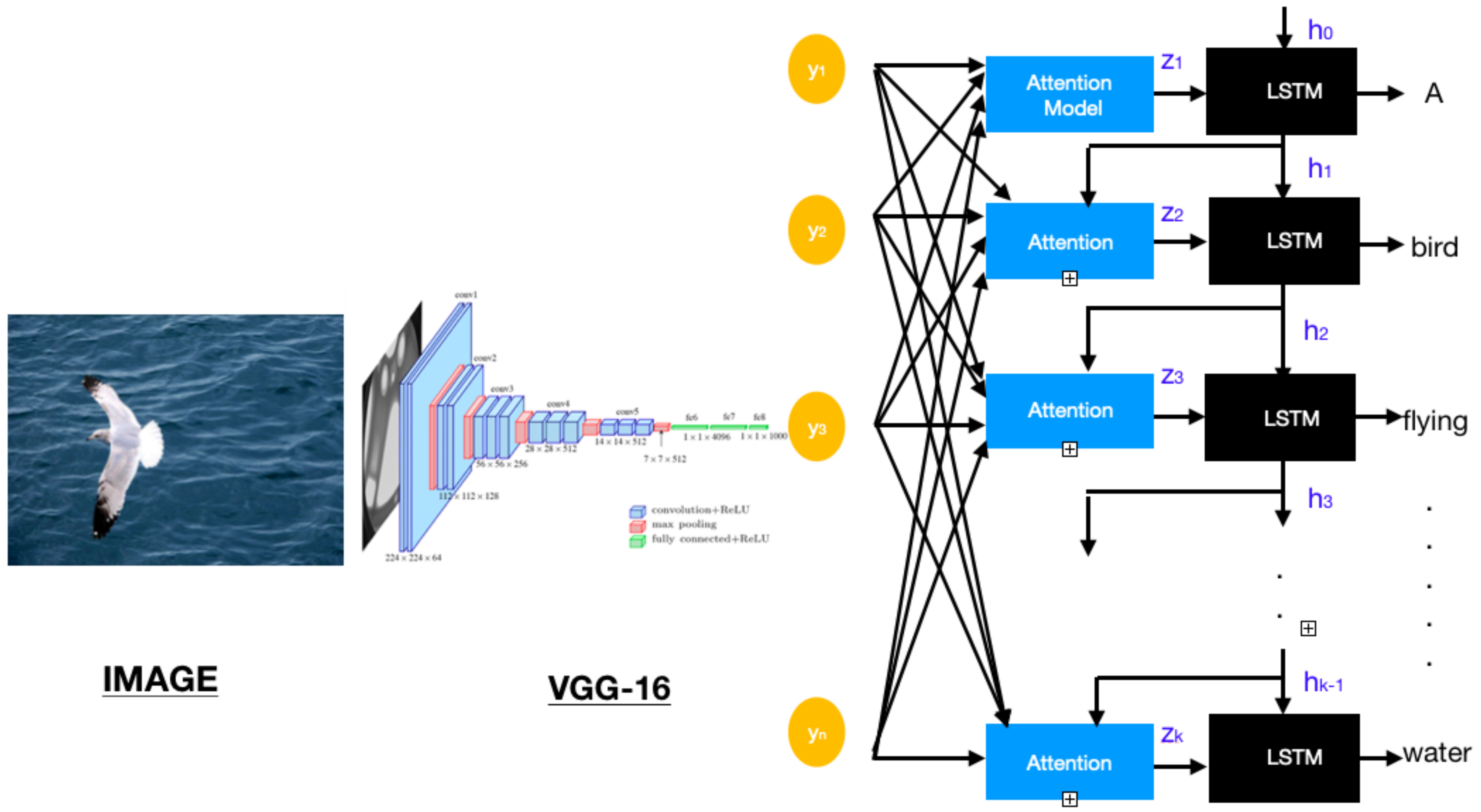
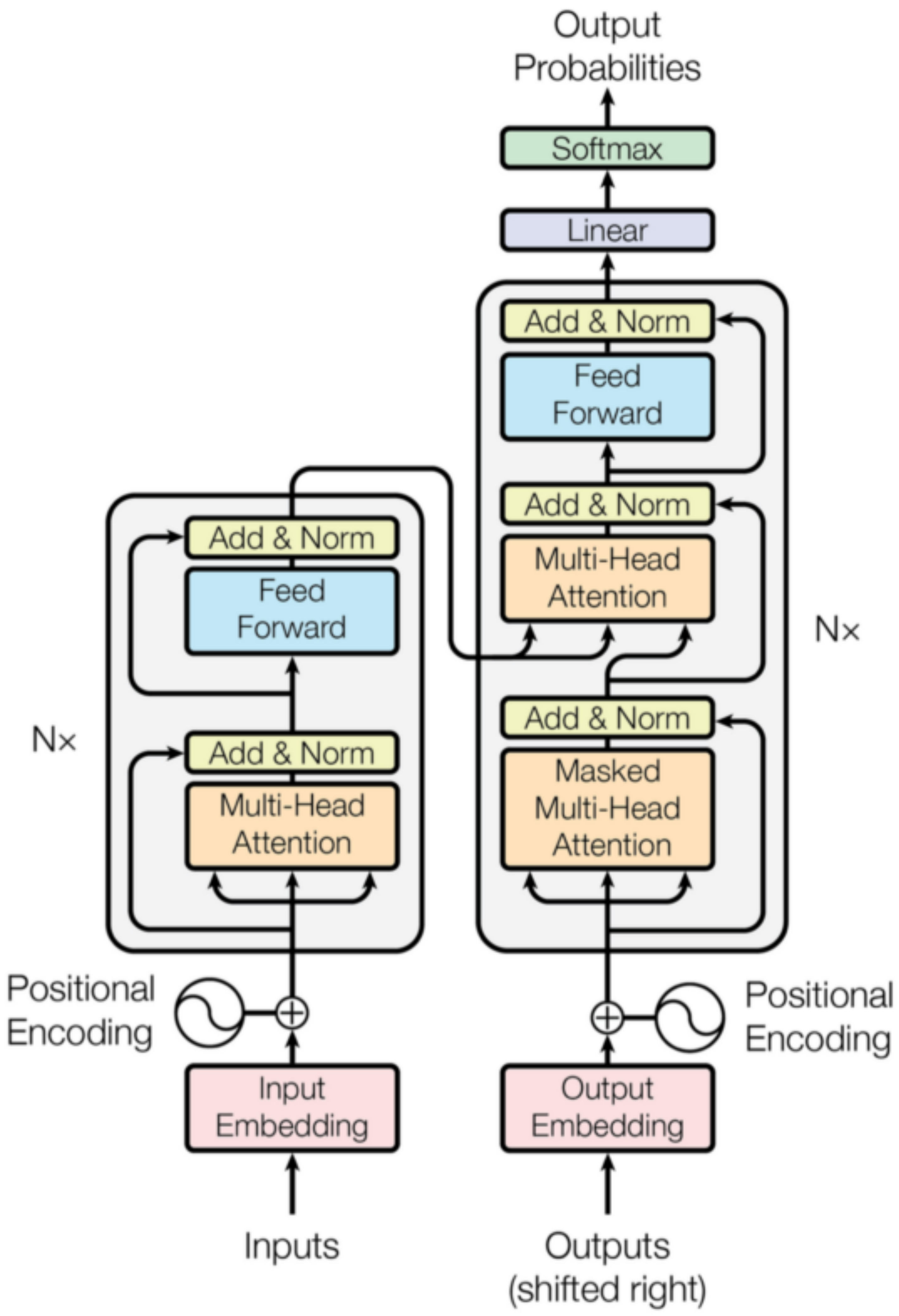

The
agreement
on
the
European
Economic
Area
was
signed
in
August
1992
.
<end>
L'
accord
sur
la
zone
économique
européenne
a
été
signé
en
août
1992
.
<end>

Image Captioning with Attention



Attention is All You Need

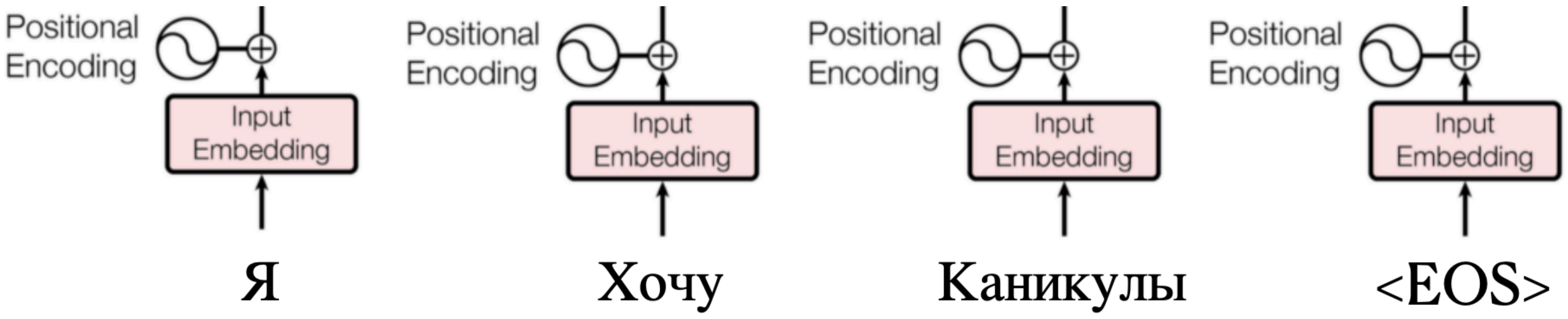


https://habr.com/ru/post/341240/

http://jalammar.github.io/illustrated-transformer/

Transformer

Encoder



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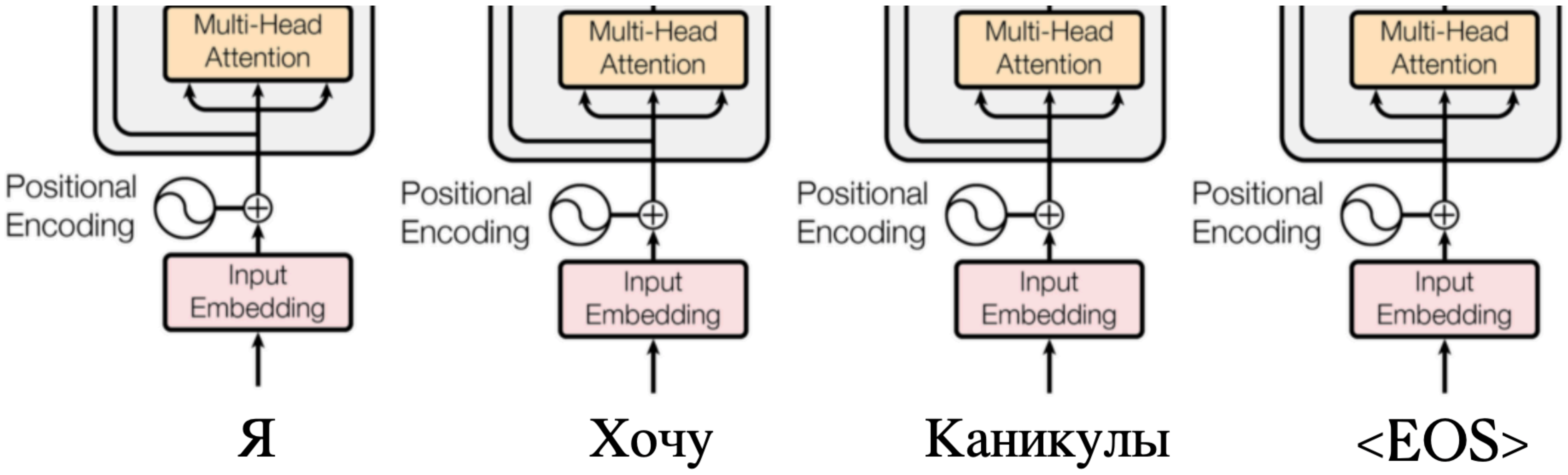
Transformer

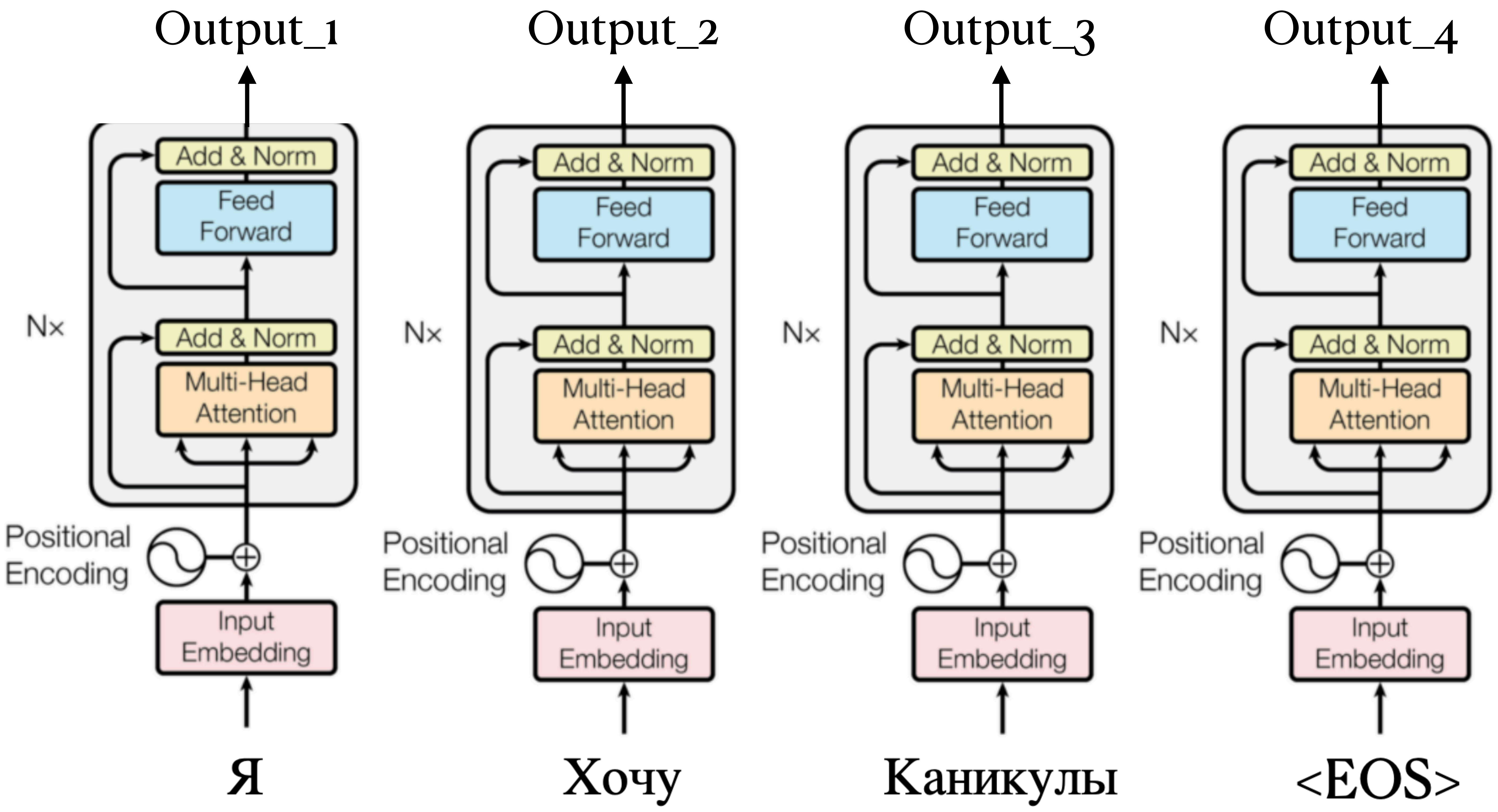
Encoder



https://habr.com/ru/post/341240/

Transformer

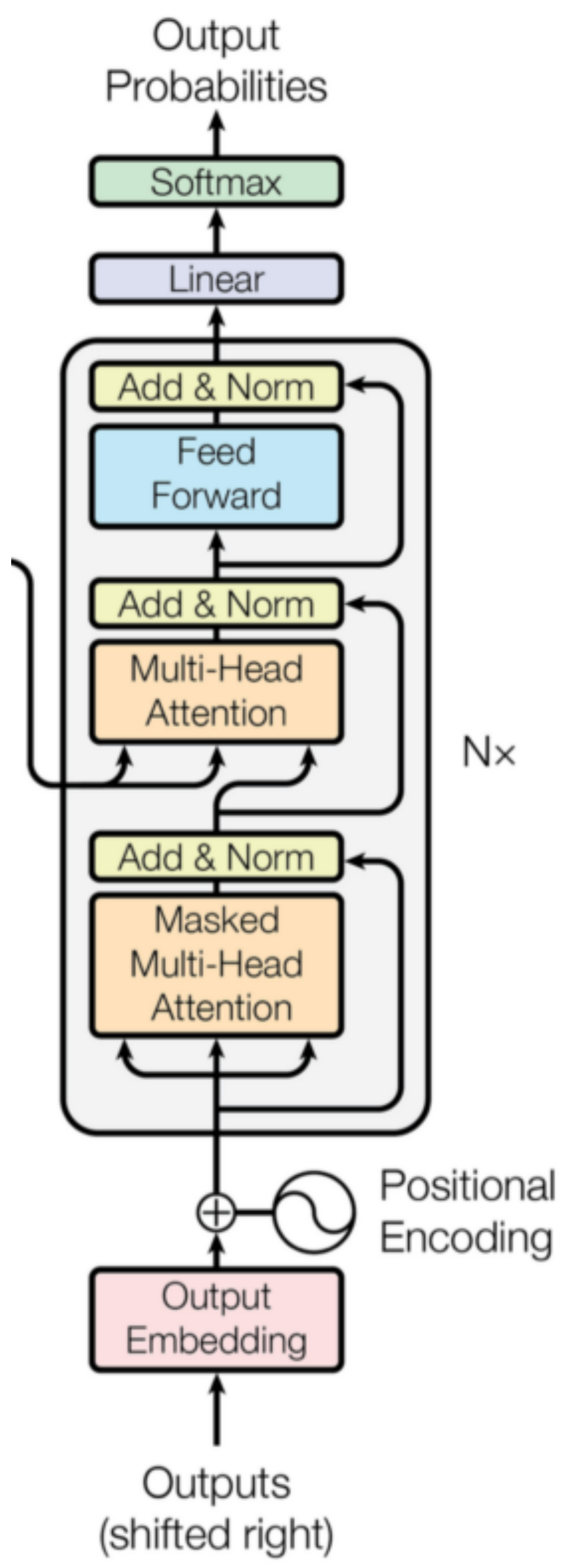
Encoder



https://habr.com/ru/post/341240/

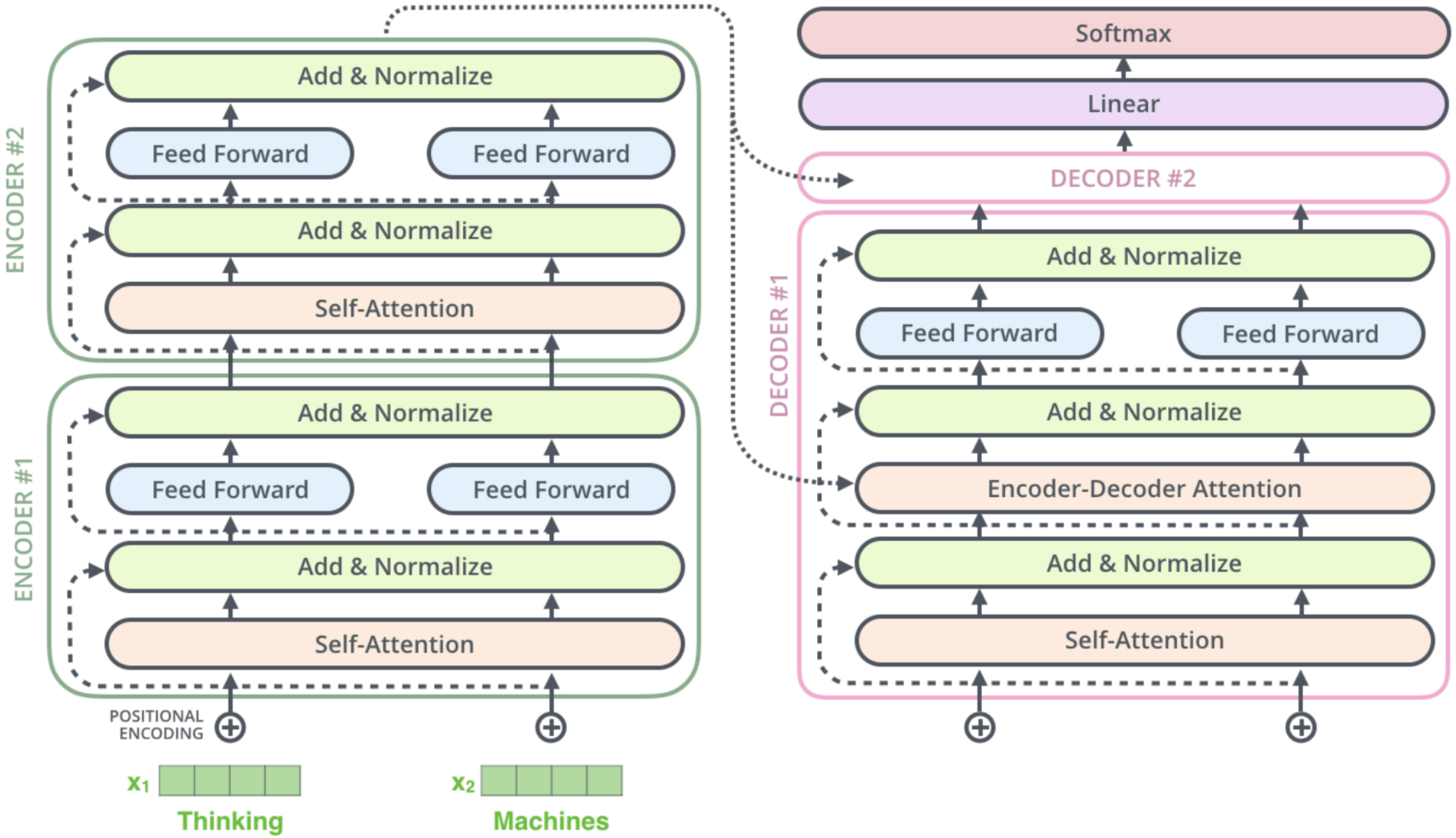
Transformer

Decoder



https://habr.com/ru/post/341240/

Transformer



http://jalammar.github.io/illustrated-transformer/

Transformers

- Параллелится на GPU !
- Сохраняет сложные взаимосвязи с начала предложения в конец предложения
- Граф вычислений не зависит от размера входных данных, а зависит только от сложности архитектуры

Ссылки, источники

- Ссылка на GitHub с лекцией и материалами: https://github.com/nikitosl/spbu-nlp-2020
- RNN:
  - http://karpathy.github.io/2015/05/21/rnn-effectiveness/
  - https://colah.github.io/posts/2015-08-Understanding-LSTMs/
  - https://calvinfeng.gitbook.io/machine-learning-notebook/supervised-learning/recurrent-neural-network/long_short_term_memory
- Attention, Transformer:
  - http://jalammar.github.io/illustrated-transformer/
  - Attention is All You Need https://papers.nips.cc/paper/2017/file/3f5ee243547dee91fbd053c1c4a845aa-Paper.pdf
  - https://habr.com/ru/post/341240/

Заключение

- NLP is All You Need =)
- SBER, команда "Comprehend 360" altukhov.n.al@gmail.com
    - NLP
    - Big Data
    - Research