

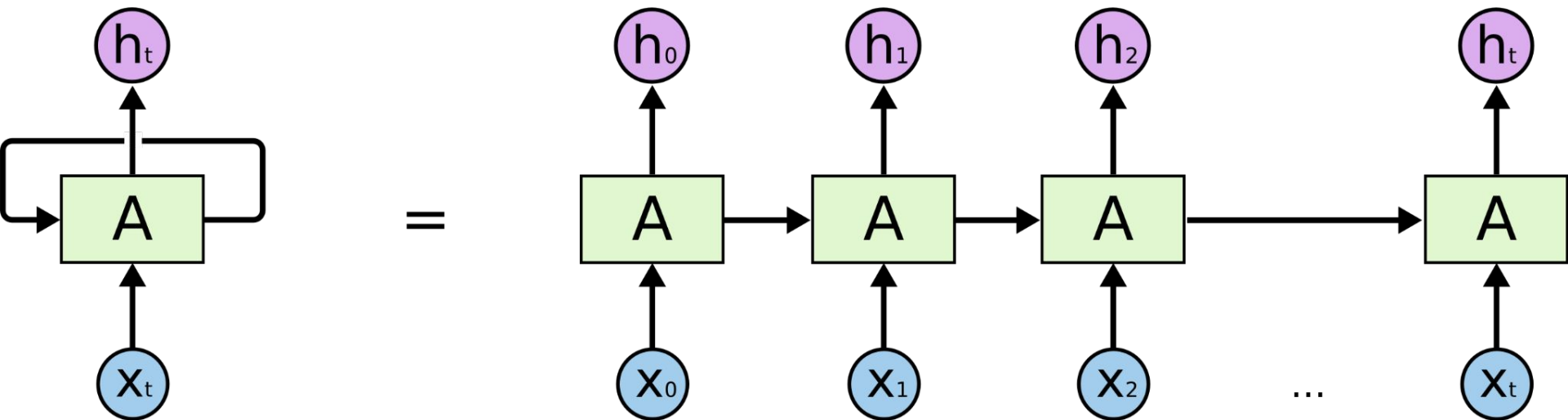
# RNN

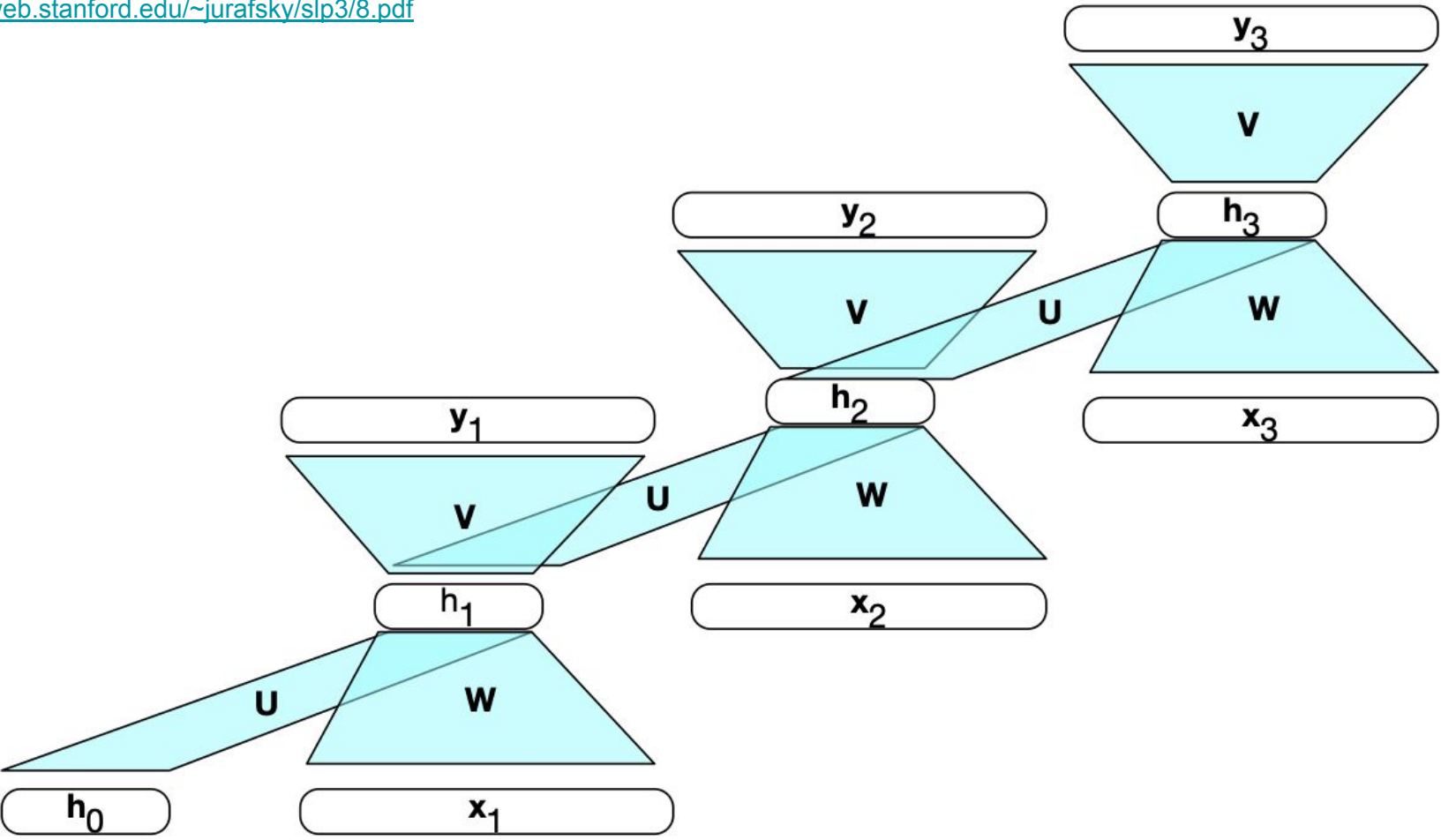
Марк Блуменау, магистратура ИИ

# Идея

- 1) Мы читаем по буквам/слогам/словам
- 2) Информация поступает и обрабатывается последовательно
- 3) Давайте засунем это в нейронку!

# Простейшая RNN

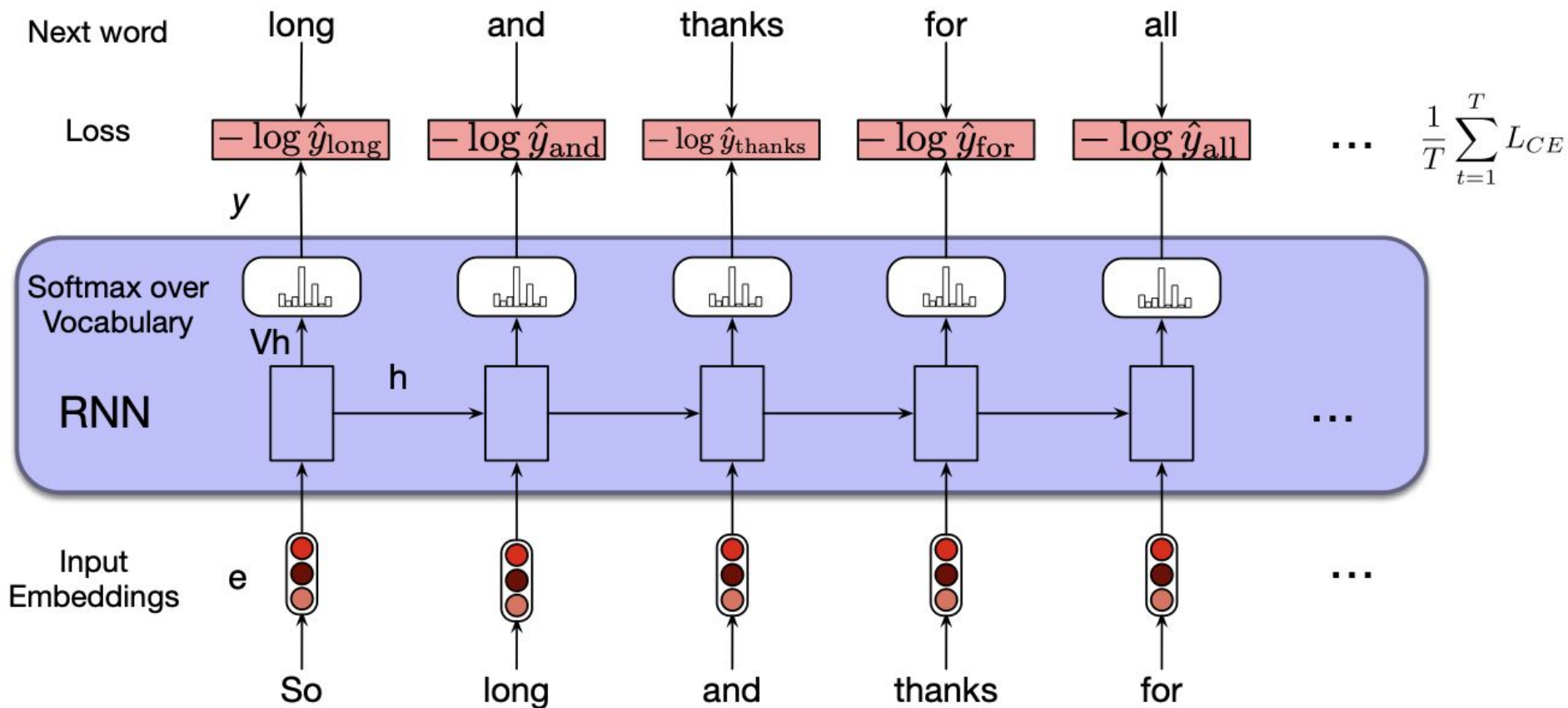




## Формулы

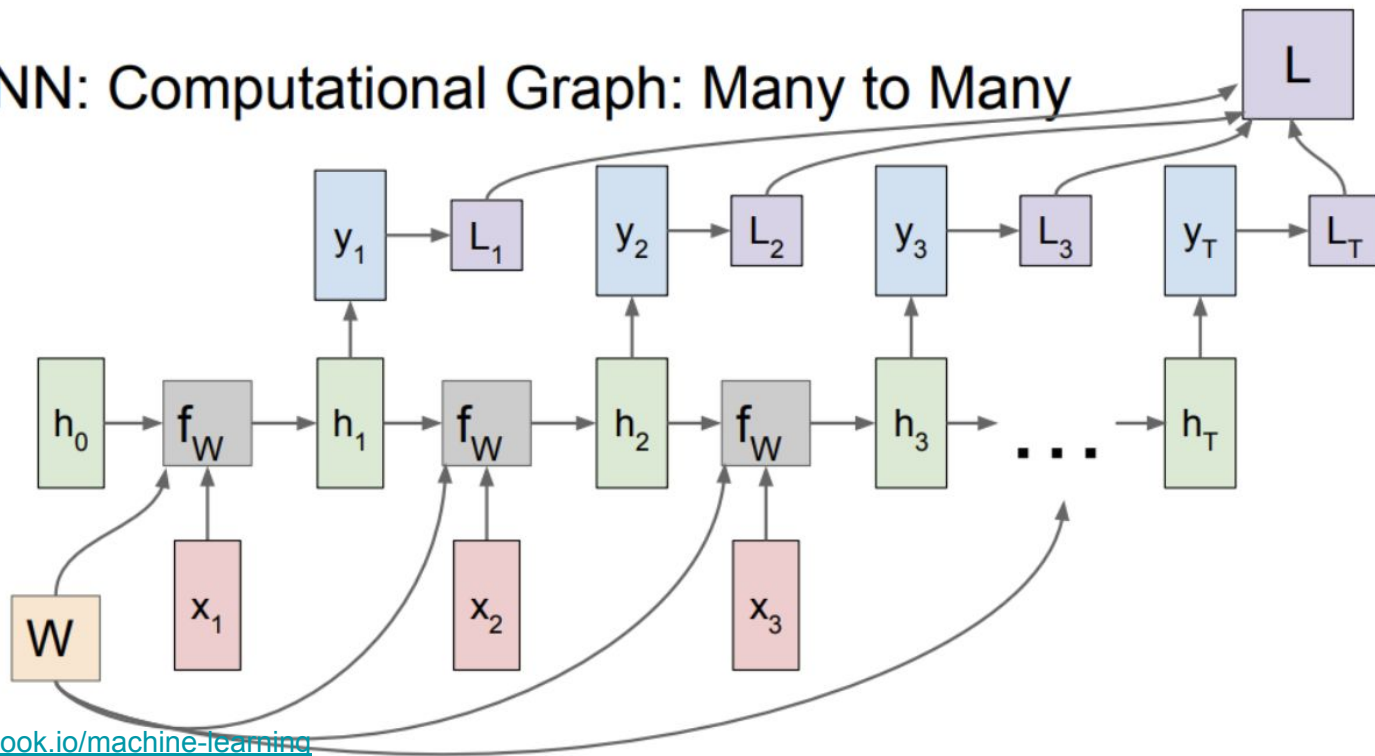
$$h_t = \tanh(x_t W_{ih}^T + b_{ih} + h_{t-1} U^T + b_{hh})$$

# А как обучать? BPTT

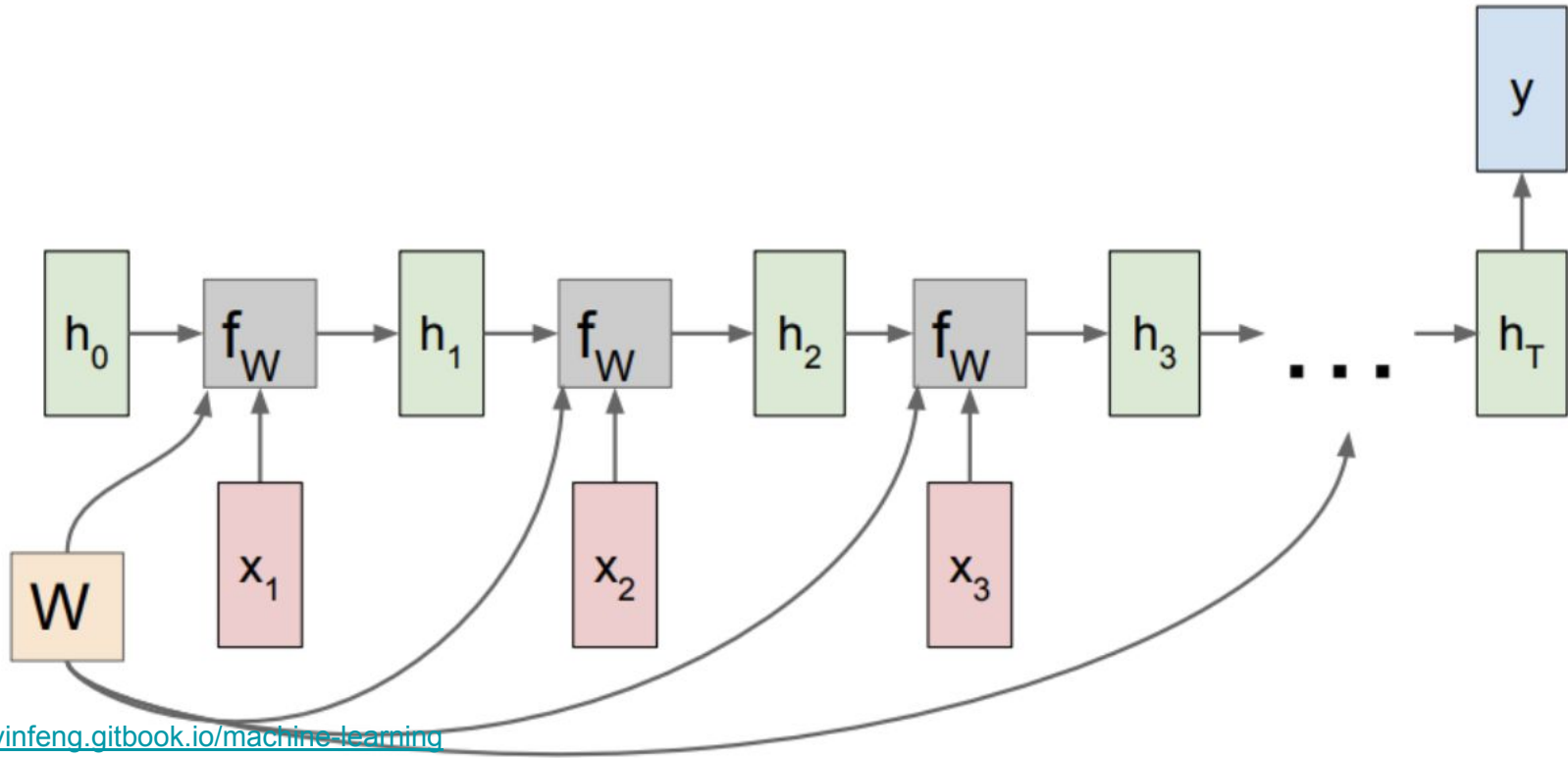


# Обучаем, но картинка проще

## RNN: Computational Graph: Many to Many

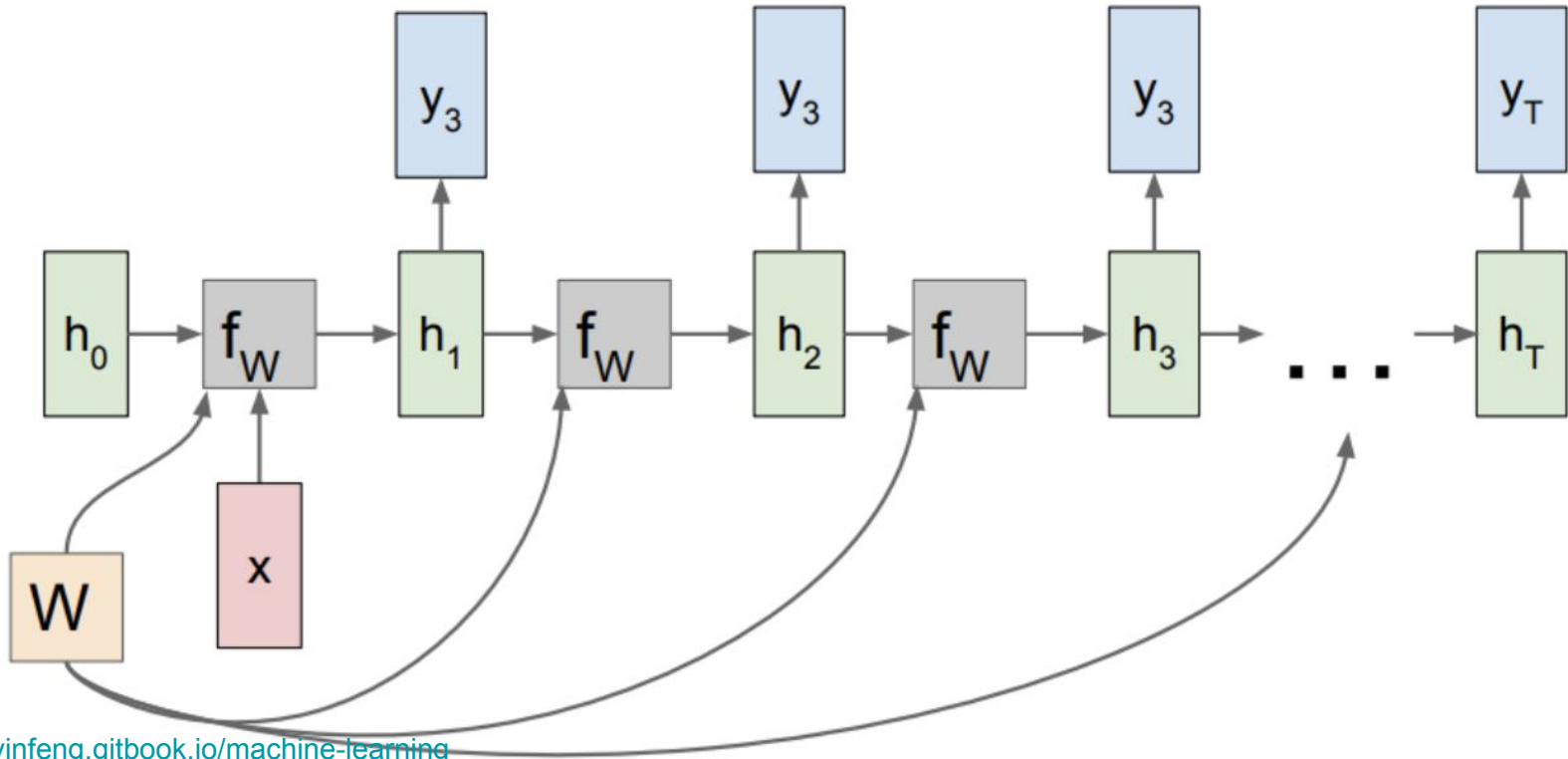


А если выход один?

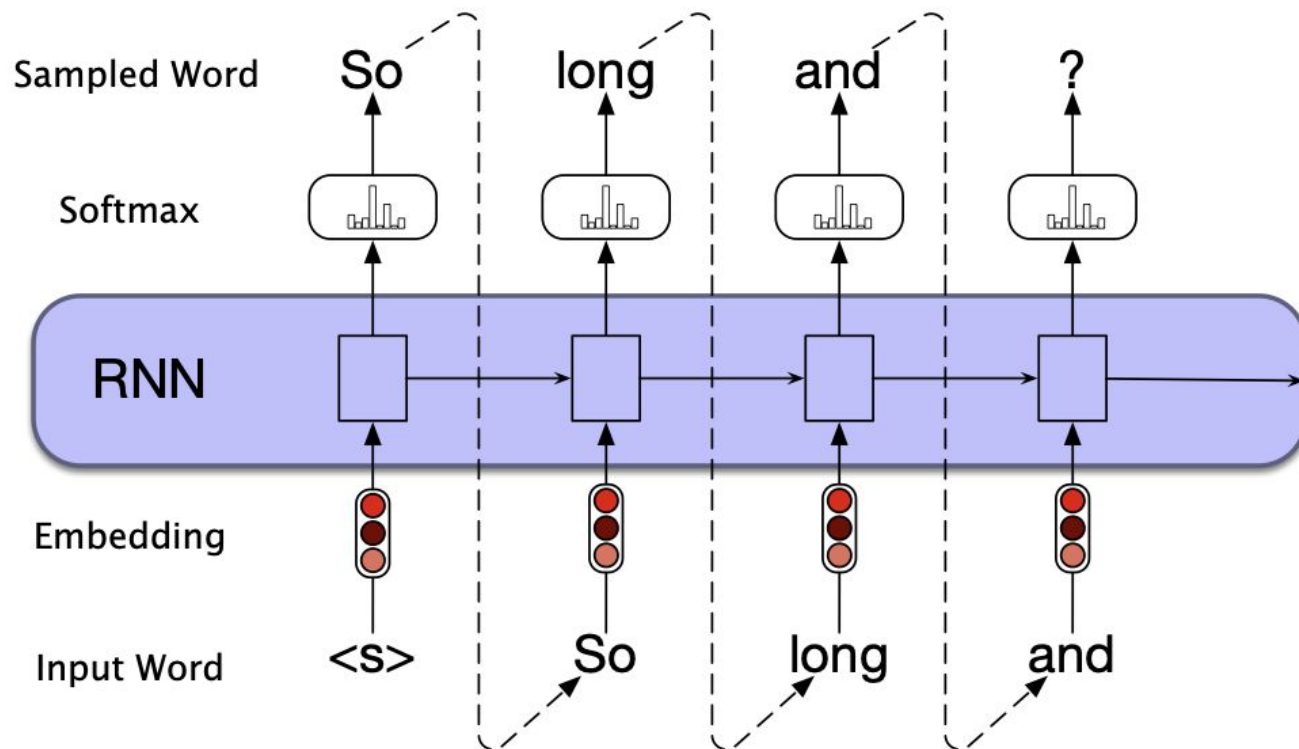




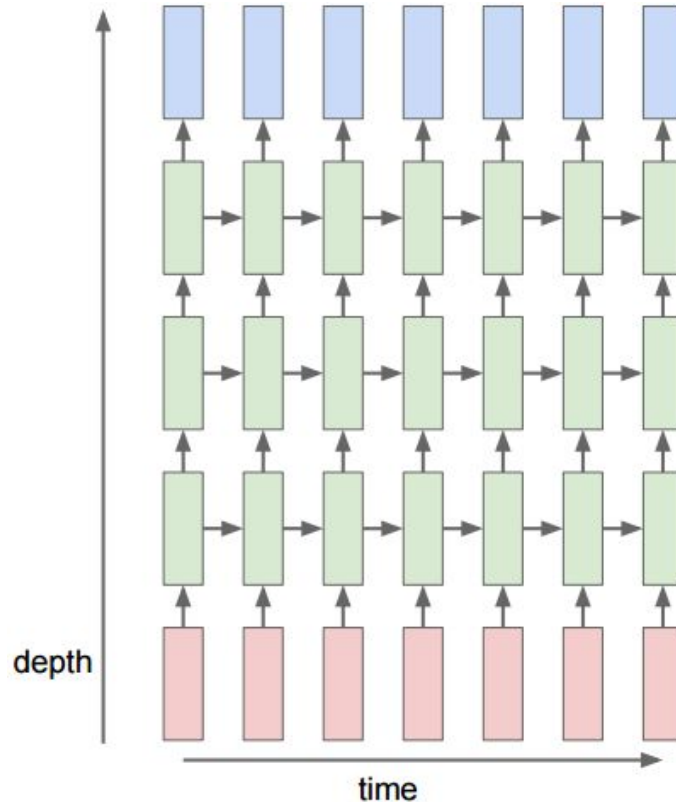
А если вход один?



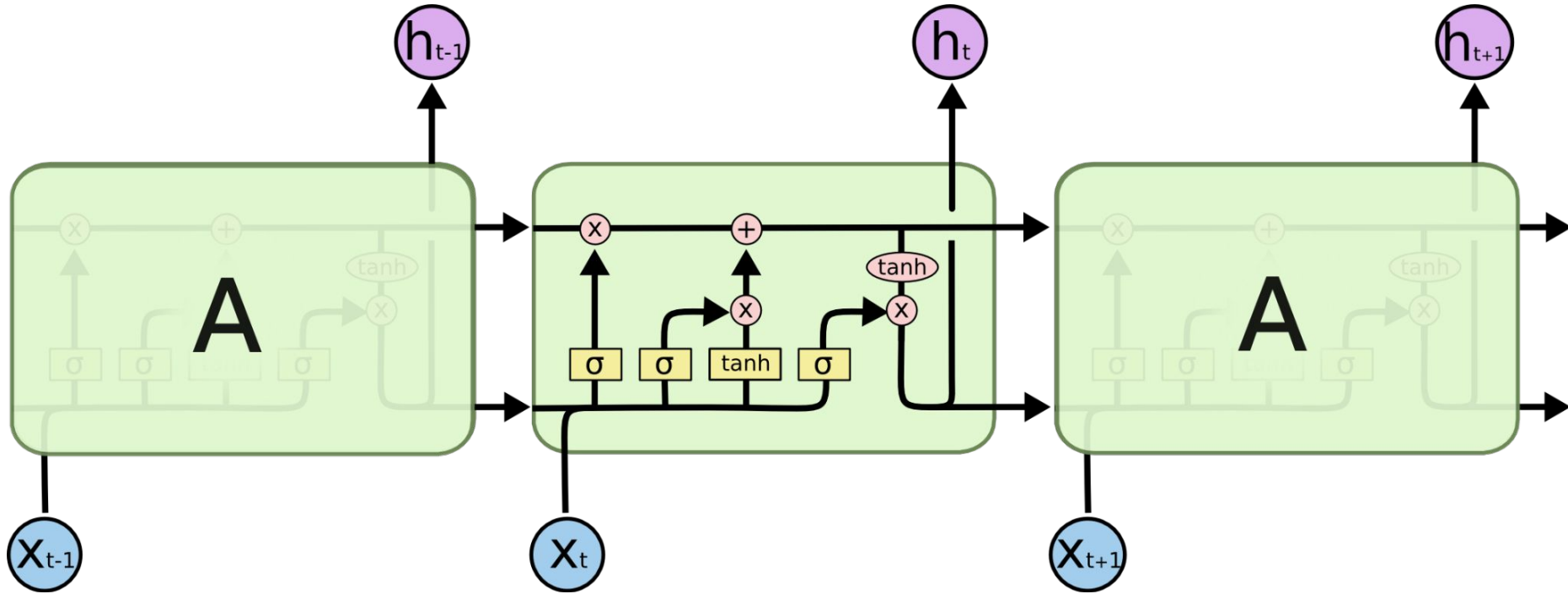
# Генерация



Можем сделать глубоко (бэкпроп оставим в ДЗ 42)



# LSTM



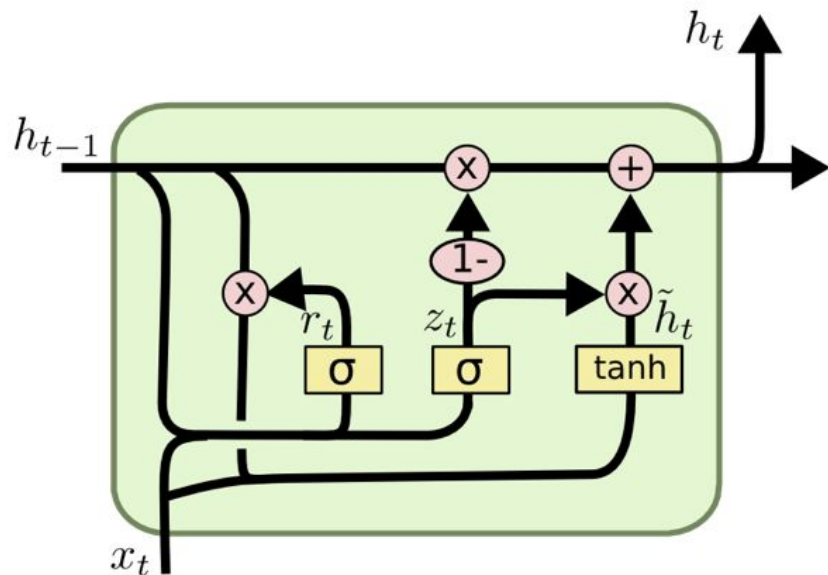
Помогите...

$$\begin{aligned}i_t &= \sigma(W_{ii}x_t + b_{ii} + W_{hi}h_{t-1} + b_{hi}) \\f_t &= \sigma(W_{if}x_t + b_{if} + W_{hf}h_{t-1} + b_{hf}) \\g_t &= \tanh(W_{ig}x_t + b_{ig} + W_{hg}h_{t-1} + b_{hg}) \\o_t &= \sigma(W_{io}x_t + b_{io} + W_{ho}h_{t-1} + b_{ho}) \\c_t &= f_t \odot c_{t-1} + i_t \odot g_t \\h_t &= o_t \odot \tanh(c_t)\end{aligned}$$

А если хотим меньше параметров? GRU!



Ой, не тот



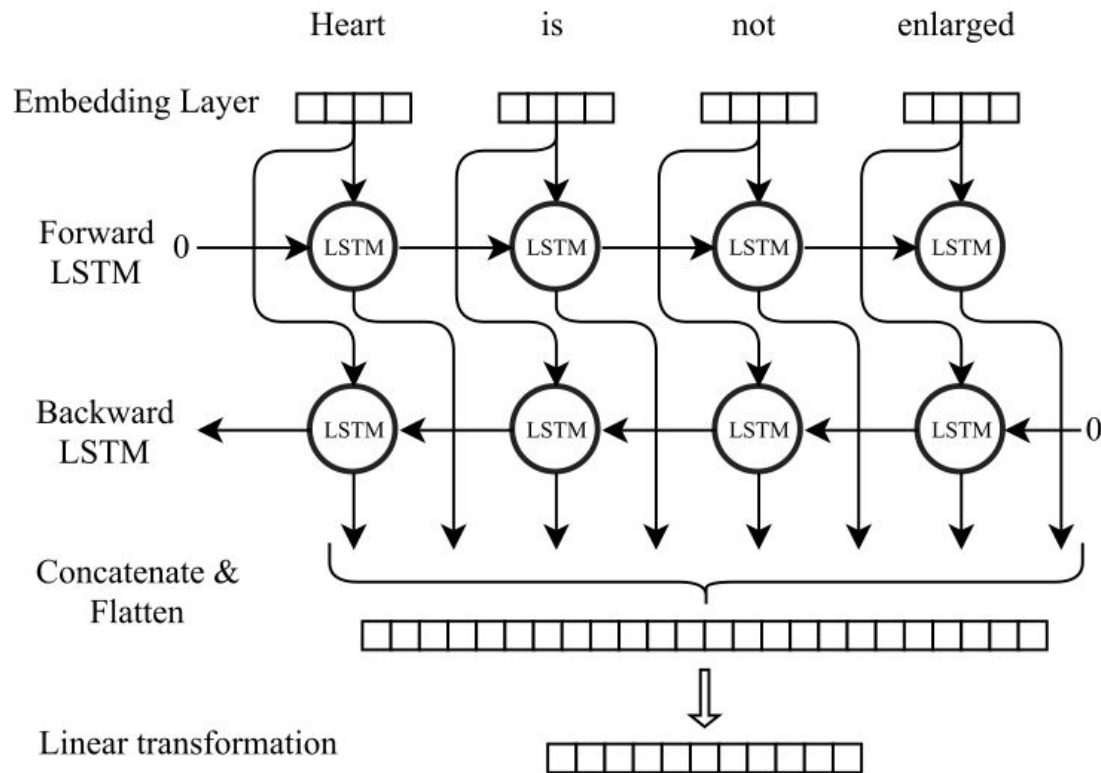
$$z_t = \sigma(W_z \cdot [h_{t-1}, x_t])$$

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

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

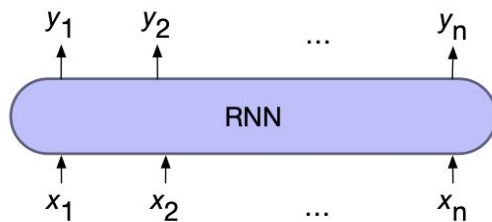
$$h_t = (1 - z_t) * h_{t-1} + z_t * \tilde{h}_t$$

# А если нам можно смотреть на слова впереди?

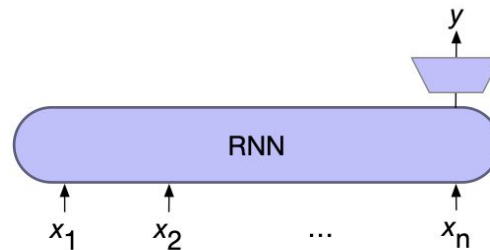




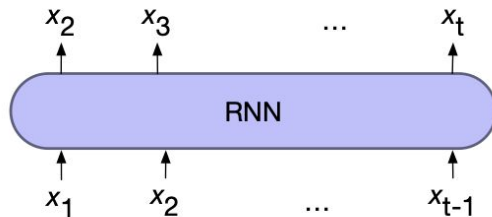
# Решение задач



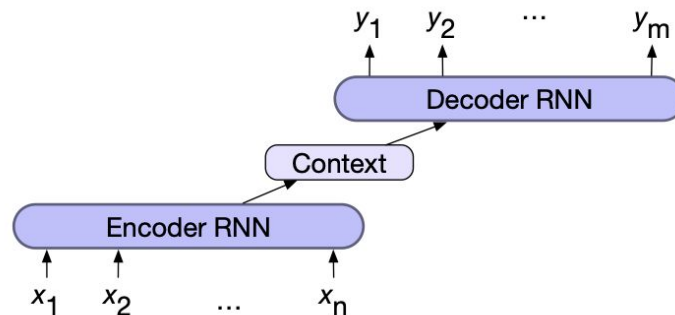
a) sequence labeling



b) sequence classification

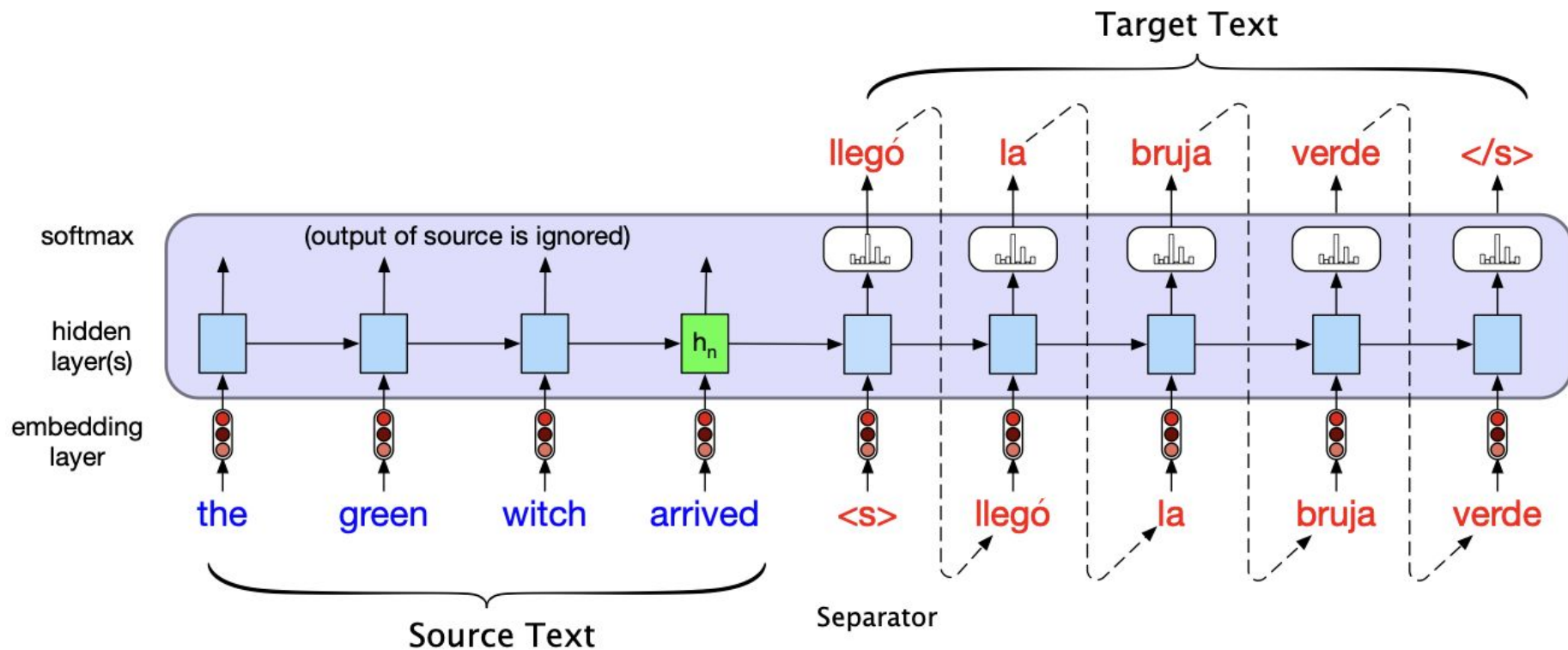


c) language modeling

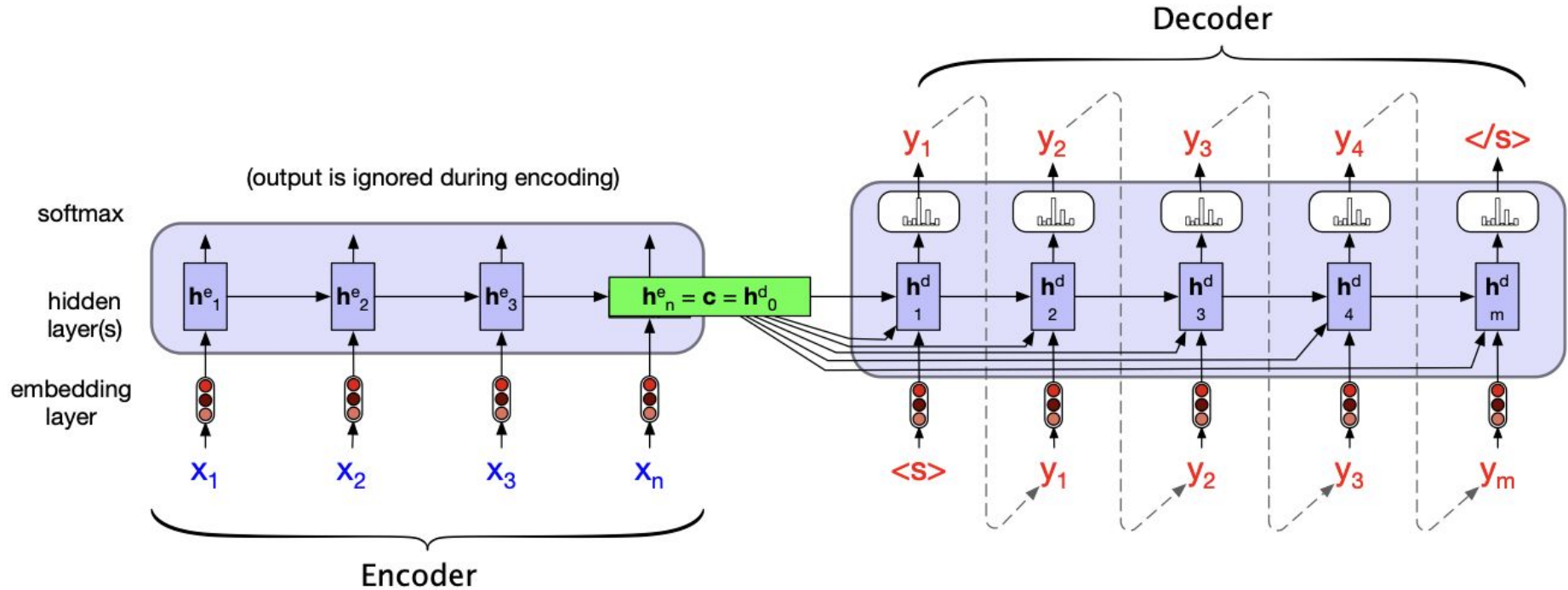


d) encoder-decoder

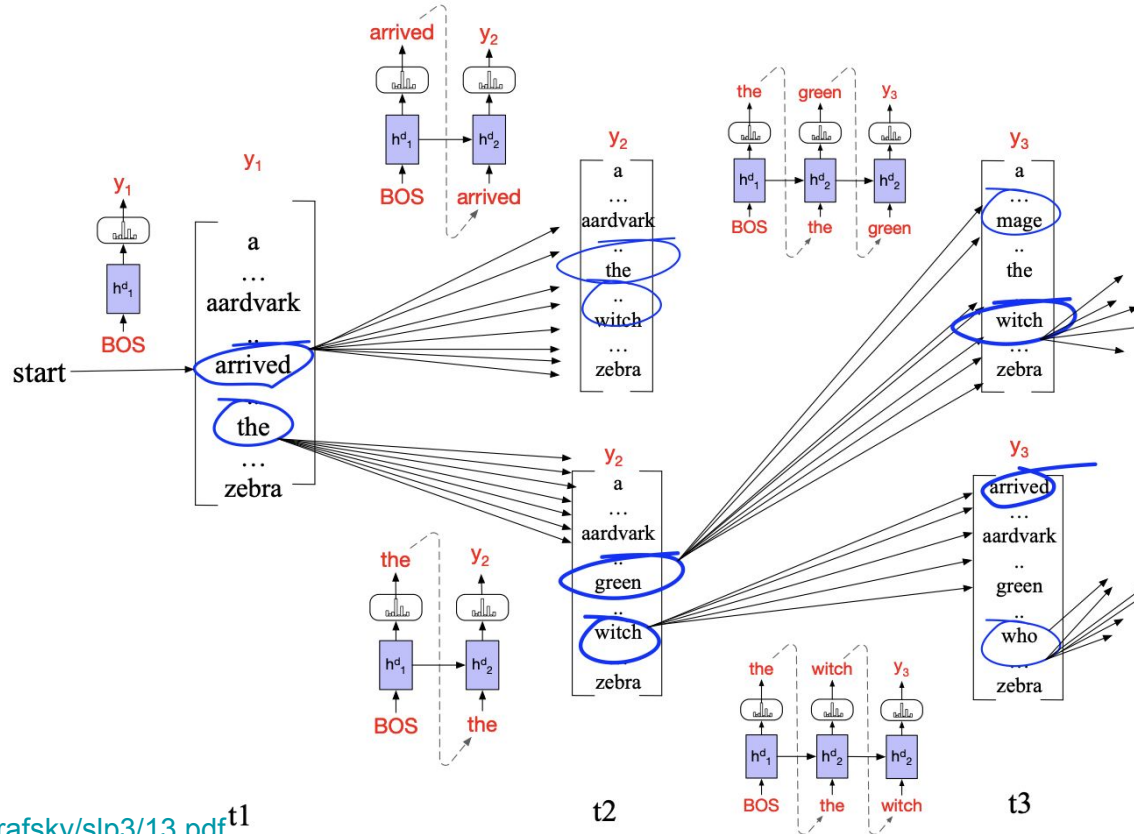
# Seq2Seq перевод



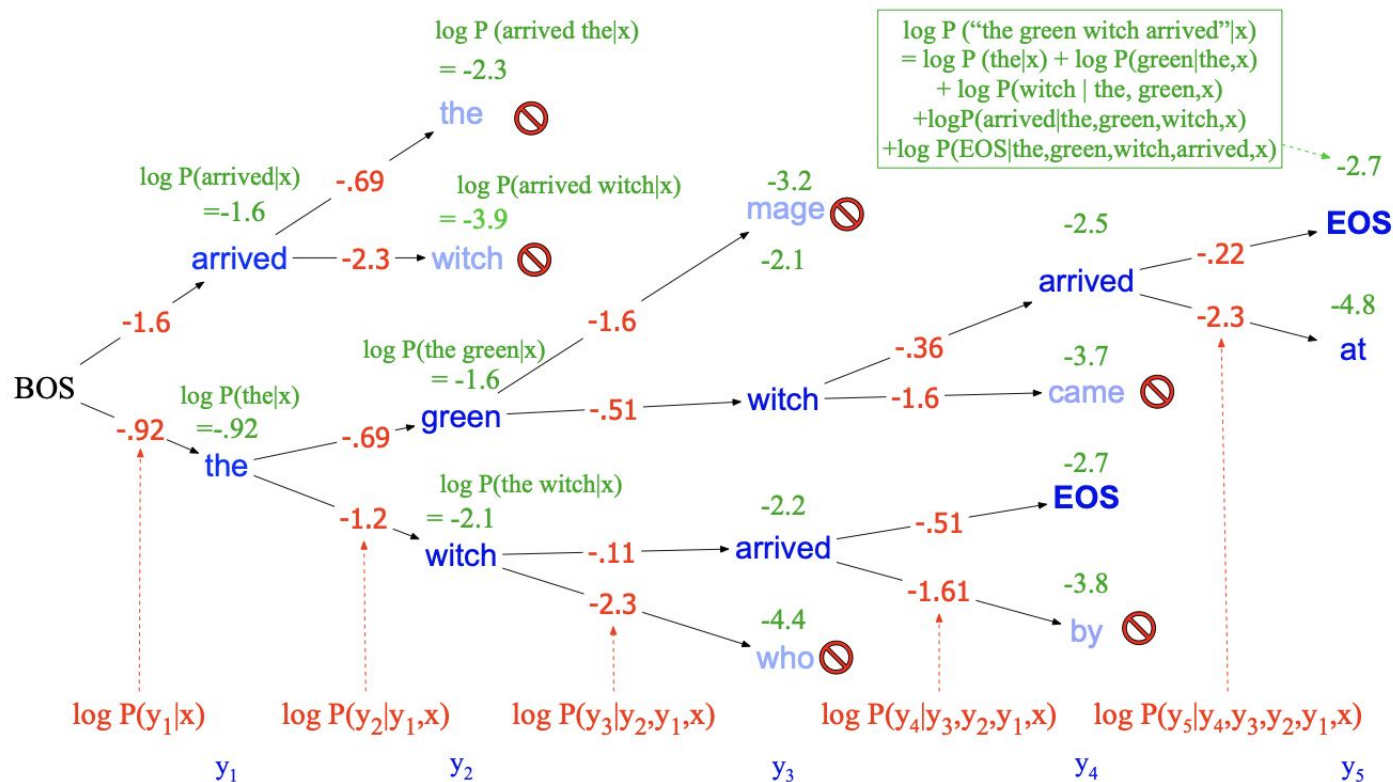
Я вас обманул...



# А как выбирать слова?



# Beam Search



# Results

## CharRNN

PANDARUS:

Alas, I think he shall be come approached and the day  
When little strain would be attain'd into being never fed,  
And who is but a chain and subjects of his death,  
I should not sleep.

Second Senator:

They are away this miseries, produced upon my soul,  
Breaking and strongly should be buried, when I perish  
The earth and thoughts of many states.

DUKE VINCENTIO:

Well, your wit is in the care of side and that.

Second Lord:

They would be ruled after this chamber, and  
my fair nudes begun out of the fact, to be conveyed,  
Whose noble souls I'll have the heart of the wars.

Clown:

Come, sir, I will make did behold your worship.

VIOLA:

I'll drink it.

<https://karpathy.github.io/2015/05/21/rnn-effectiveness/>

# Оно умеет техать. А вы?

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  $U \rightarrow T$  is a separated algebraic space.

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

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

and the comparicoly in the fibre product covering we have to prove the lemma generated by  $\coprod Z \times_U U \rightarrow V$ . Consider the maps  $M$  along the set of points  $\text{Sch}_{fppf}$  and  $U \rightarrow U$  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  $\text{Sh}(G)$  such that  $\text{Spec}(R') \rightarrow S$  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  $\mathcal{O}_{X,x'} \rightarrow \mathcal{O}_{X',x''}$  is separated. By Algebra, Lemma ?? we can define a map of complexes  $\text{GL}_{S'}(x'/S'')$  and we win.  $\square$

To prove study we see that  $\mathcal{F}|_U$  is a covering of  $\mathcal{X}'$ , and  $\mathcal{F}_i$  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

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

is a unique morphism of algebraic stacks. Note that

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

and

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

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.  $\square$

The result for prove any open covering follows from the less of Example ?? . It may replace  $S$  by  $X_{\text{spaces}, \text{étale}}$  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  $\text{Proj}_X(A) = \text{Spec}(B)$  over  $U$  compatible with the complex

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

When in this case of to show that  $\mathcal{Q} \rightarrow \mathcal{C}_{Z/X}$  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  $S = \text{Spec}(R)$  and  $Y = \text{Spec}(R)$ .

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

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

**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  $\mathcal{J}_{n,0} \circ \mathcal{A}_2$  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 mex function (??). On the other hand, by Lemma ?? we see that

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

where  $K$  is an  $F$ -algebra where  $\delta_{n+1}$  is a scheme over  $S$ .  $\square$



# И даже писать на сишке. А вы?

```
/*
 * 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;
}
```

<https://karpathy.github.io/2015/05/21/rnn-effectiveness/>



# Они даже объяснимы

t t p : / / w w w . y n e t n e w s . c o m / ] E n g l i s h - l a n g u a g e w e b s i t e o f I s r a e l ' s l a r  
t p : / / w w w . b a c a h e t s . c o m / - x g l i s h l i n g u a g e s a i r s i t e o f t s l a e l i s s i n g  
d : x n e . w a e a . a w a t o a . s & n t i a c a - s a r d e e l h o a n t b i s a n f a n r e i f ' a a t d  
m w - 2 p i i i s o e s s i s . / e r n . c ] ( d c e e n e p e s a a i k i i e e l e d h , i r t h r a o n s e , c o s e  
d r . < : a h b - n p t w t . x i g h / m a ) T v d r y z i c o u e d l s u : t h a - o o t u , s t u i f l v e p e r y  
s t p , t c o a 2 d r u l w o c l e n s r ] p . l i v a o d , , e y t c - n d m - o i b u v s ] b b i m s u l t a t l y b n

g e s t n e w s p a p e r ' ' [ [ Y e d i o t h A h r o n o t h ] ] ' ' ' ' H e b r e w - l a n g u a g e p e r i o d  
e t a a w s p a p e r s o [ [ T e l t i ( f e a n e m t i ) ' ' \* ' ' [ e r r e w s l e n g u a g e : a r o s o d i  
i r s c o e e n a i T T h A o a i n n h S r m u w ] e y s [ ' i n e i a ' s i w d d e ' h s o l r i f r :  
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i c a l s : ' ' \* ' ' [ [ G l o b e s ] ] ' ' [ h t t p : / / w w w . g l o b e s . c o . i l / ] b u s i n e s s d a  
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k i . : \* s C O S a n l t h i T i m ' l i ] e : , i m c d w - 2 p h i i s e r d i t . i n a / c m f i . ( a f l c a n a  
d s - ! [ t B T C o m m g d ] ] W o n a a e , : . b a e r r . < t a i b - d u l c n n c / a r n e s i ] l i c e y s t o  
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