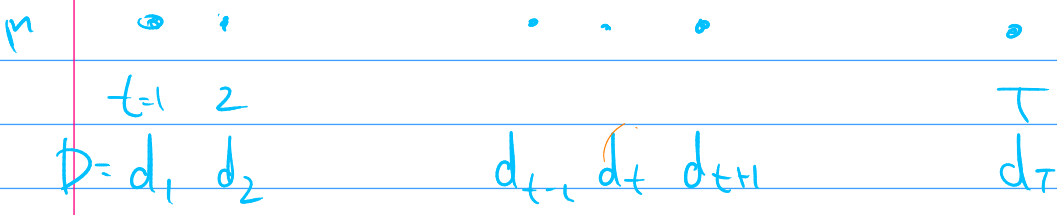
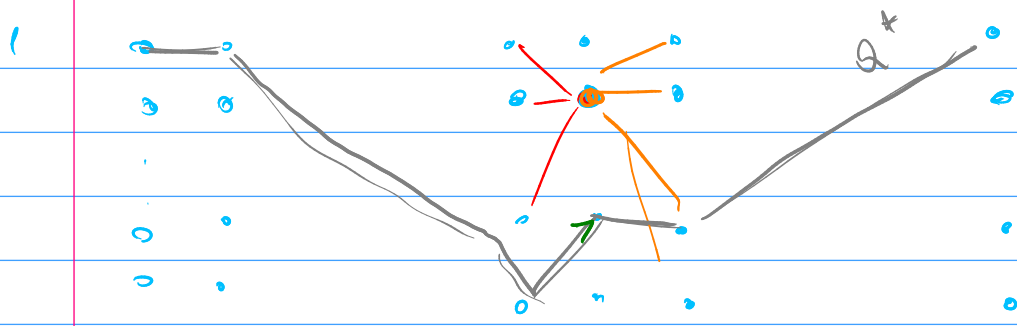
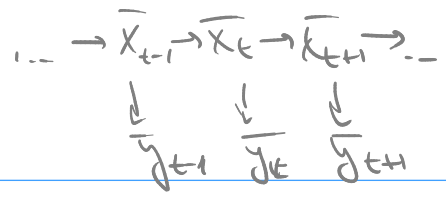


$$1) p(D|\lambda) = \sum_Q p(Q, D|\lambda)$$



$$\alpha_t(i) = p(d_1 \dots d_t, q_t = i | \lambda)$$

$$\beta_t(i) = p(d_{t+1} \dots d_T | q_t = i, \lambda)$$

2) Inference $\gamma_t(i) = p(q_t = i | D, \lambda) \propto \alpha_t(i) \cdot \beta_t(i)$

$$Q^* = \underset{q_1 \dots q_T}{\operatorname{argmax}} p(q_1 \dots q_T | D, \lambda)$$

Viterbi:

$$\delta_t(i) = \max_{q_{t-1}} p(q_1 \dots q_{t-1}, q_t = i, d_1 \dots d_t | \lambda)$$

$$\delta_t(i) = \max_{q_{t-1}} \left[\max_{q_{t-2}} p(q_1 \dots q_{t-2}, q_{t-1}, d_1 \dots d_{t-1} | \lambda) \cdot p(q_t = i | q_{t-1}, \lambda) \cdot p(d_t | q_t = i, \lambda) \right]$$

$\max p(Q, D | \lambda) = \max_i \delta_T(i)$

$$\delta_t(i) = \max_j \left[\delta_{t-1}(j) \cdot a_{ji} \cdot b_i(d_t) \right]$$

$$\psi_t(i) = \underset{j}{\operatorname{argmax}} \left[\dots \right]$$

$\underbrace{b_i(d_t)}_{p(d_t | \theta_i)}$

$$3) D = \{d_1, \dots, d_T\} \quad \lambda = (\pi, A, B) \quad p(D, Q | \lambda) \xrightarrow{\lambda} \max$$

$$p(D | \lambda) \xrightarrow{\lambda} \max$$

$$Q(\lambda, \lambda^{(m)}) = \mathbb{E}_{\lambda^{(m)}} [\log p(D, Q | \lambda)] =$$

$$= \mathbb{E}_{q_1, \dots, q_T | \lambda^{(m)}} [\log \pi_{q_1} + \log b_{q_1}(d_1) + \log a_{q_1, q_2} + \dots + \log b_{q_T}(d_T)]$$

$$= \left(\sum_Q p(Q | D, \lambda^{(m)}) \log \pi_{q_1} \right) + \left(\sum_Q p(Q | D, \lambda^{(m)}) \log a_{q_1, q_2} \right) + \dots$$

$\xrightarrow{\max} \pi, A, B$

E-var: $\alpha_t(i), \beta_t(i)$

$$\gamma_t(i) = p(q_t = i | D, \lambda^{(m)})$$

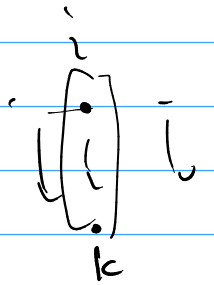
$$\zeta_t(i, j) = p(q_t = i, q_{t+1} = j | D, \lambda) \propto \alpha_t(i) a_{ij} b_j(d_{t+1}) \cdot \beta_{t+1}(j)$$

M-var:

$$\pi_i^* = \frac{\mathbb{E}[q_1 = i]}{N} = \gamma_1(i)$$

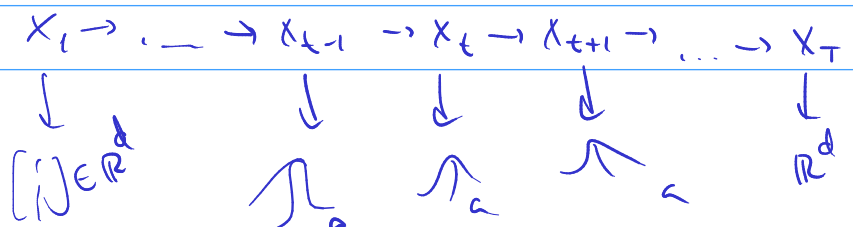
Baum-Welch

$$a_{ij}^* = \frac{\mathbb{E}[q_t = i, q_{t+1} = j]}{\mathbb{E}[q_t = i]} = \frac{\sum_{n,t} \zeta_t(i,j)}{\sum_{n,t} \gamma_t(i)}$$



$$b_i^*(k) = \frac{\mathbb{E}[q_t = i, d_t = k]}{\mathbb{E}[q_t = i]} = \frac{\sum_{n,t: d_t = k} \gamma_t(i)}{\sum_{n,t} \gamma_t(i)}$$

$$\lambda = (\pi, A, B)$$

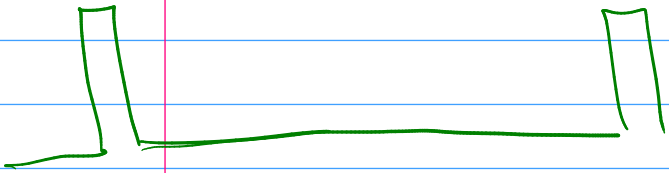


$$p(d_t = a | q_t = i, \bar{\theta})$$

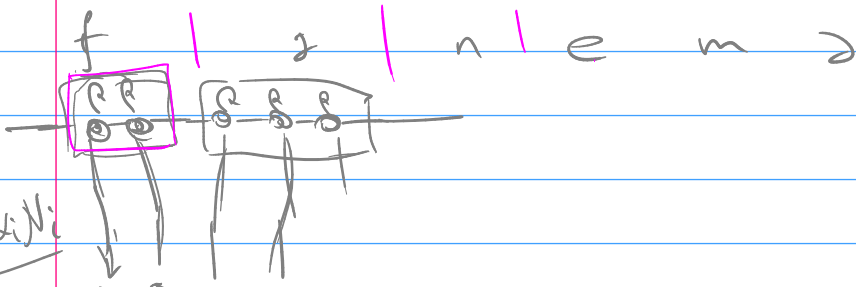
$\bar{\theta}_i$ - осыраем y D c бекан $\delta_t(i)$



$$\begin{aligned}
 1 - a_{ii} & \quad \tau = 1 \\
 a_{ii}(1 - a_{ii}) & \quad \tau = 2 \\
 a_{ii}^2(1 - a_{ii}) & \quad \tau = 3 \\
 \dots & \quad \dots \\
 a_{ii}^{k-1}(1 - a_{ii}) & \quad \tau = k
 \end{aligned}$$



Language model $\rightarrow p(w_t | w_1 \dots w_{t-1})$

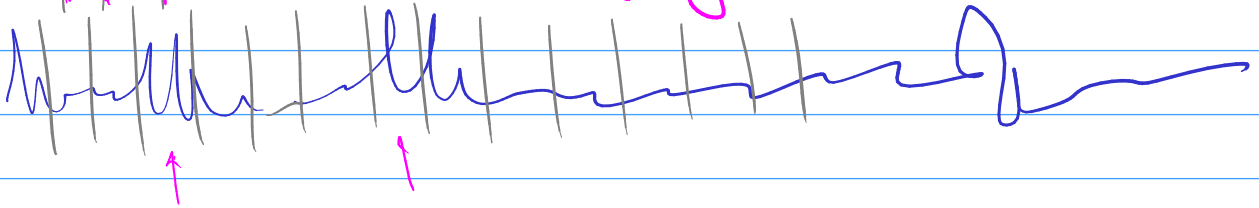


$\sum d_i w_i$

$\in \mathbb{R}^{40}$

MFCC mel-frequency cepstral coefficients

DL revolution 2009-10

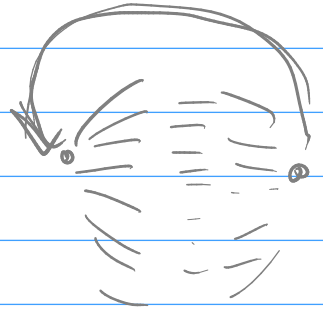
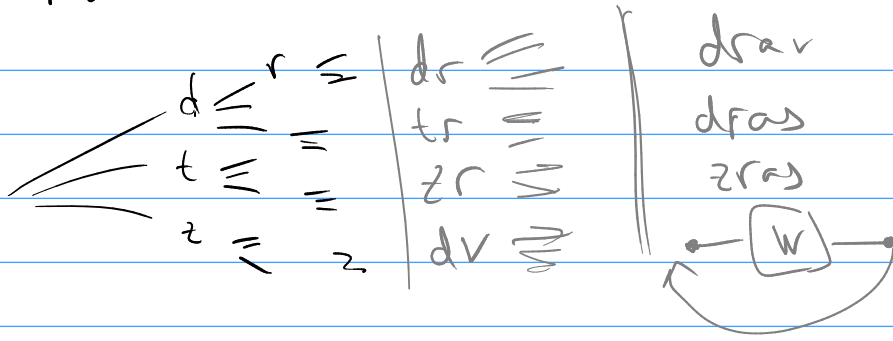


"фокера" \rightarrow f a h e m a
 \rightarrow f a n e m
 \rightarrow f n e m a

"3D пелестыжире"



Beam search



dras't'e i a r a j a t'io t'ia

z'pobuchyire , e bava re'as

