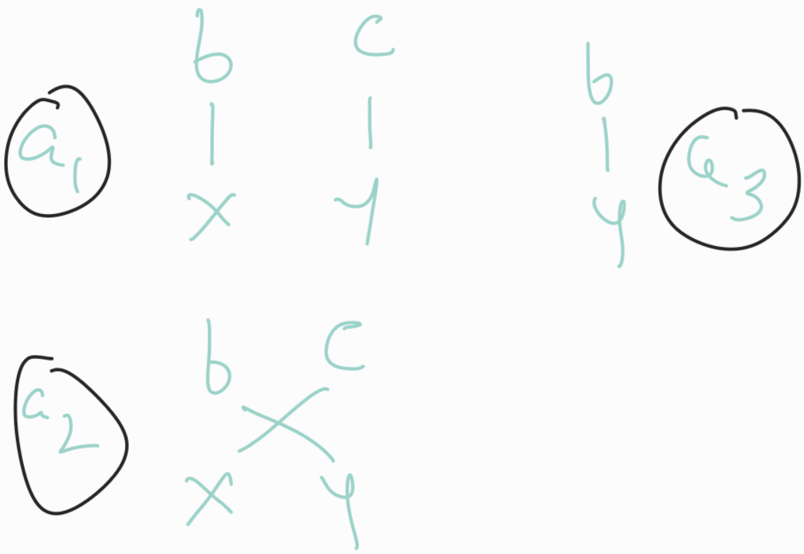
EM for MT (Machine translation)

$bc \rightarrow xy$

$b \rightarrow y$



Step-1 M_0 step

(max entropy assumption)

$p(x|b) = \frac{1}{2}$ $p(y|b) = \frac{1}{2}$

$p(x|c) = \frac{1}{2}$ $p(y|c) = \frac{1}{2}$

(E step) generative process to identify the likelihood term

$p(a_1, f|e) = p(b|x) \times p(c|y)$

$= \frac{1}{4}$

$p(a_2, f|e) = p(b|y) \times p(c|x)$

$= \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

Collecting step

$p(a_3, f|e) = \frac{1}{2}$

$p(a_1|f, e)$

$= \frac{p(a_1, f|e)}{p(a_1, f|e) + p(a_2, f|e)}$

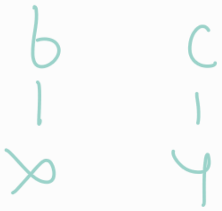
$= \frac{\frac{1}{4}}{\frac{1}{2}} = \frac{1}{2}$

$p(a_2|f, e)$

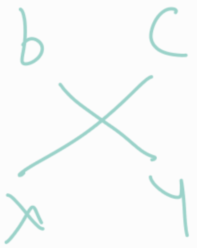
$= \frac{1}{2}$

$p(a_3|f, e)$

$= 1$

a_1  $-\ \frac{1}{2}$

$t(x|b) = \dfrac{\frac{1}{2}}{\frac{1}{2}+\frac{1}{2}+1} = \frac{1}{4}$

a_2  $-\ \frac{1}{2}$

$t(x|c) = \frac{1}{2}$

$t(y|b) = \dfrac{\frac{1}{2}+1}{2} = \dfrac{\frac{3}{2}}{2} = \frac{3}{4}$

a_3  $-\ 1$

$t(y|c) = \frac{1}{2}$

$p(a_1, f|e) = \frac{1}{8}$

$p(a_2, f|e) = \frac{3}{8}$

$p(a_3, f|e) = \frac{3}{4}$

$p(a_1|f, e) = \frac{1}{4}$

$p(a_2|f, e) = \frac{3}{4}$

$p(a_3, f|e) = 1$

$a_1 - \frac{1}{4}$ $t(x|b) = \frac{1}{8}$

$c_2 = \frac{3}{4}$ $t(x|c) = \frac{3}{4}$

$c_3 = 1$ $t(y|b) = \frac{7}{8}$

$t(y|c) = \frac{1}{4}$

$a_1 - \frac{1}{32}$

this way continued

till convergence

for a confidence

interval

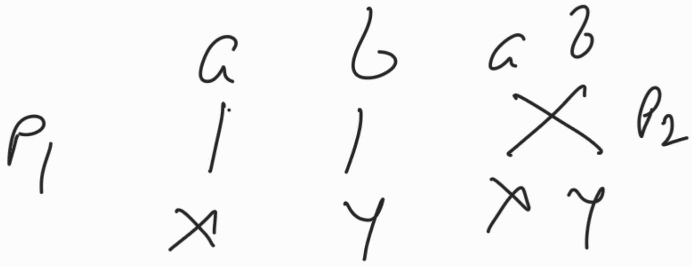
practice → (EM for MT

for two tokens matching (sentence)

problem come → Question paper)

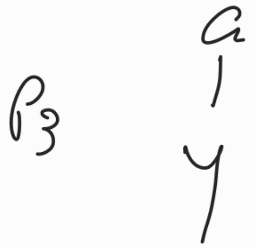
Eat something

Kuch khao



Eat

khaao



translation parameters →

No → step

$$\begin{cases} t(x|a) = \frac{1}{2} & t(y|a) = \frac{1}{2} \\ t(x|b) = \frac{1}{2} & t(y|b) = \frac{1}{2} \end{cases}$$

(max entropy assumption →)

E_1 $\boxed{\text{(prob step)}}$

$$p(P_1, h/e) = \frac{1}{4} \qquad p(P_2, h/e) = \frac{1}{4}$$

$$p(P_3, h/e) = \frac{1}{2}$$

$\boxed{\text{(Colorings step)}}$

$$p(P_1/h, e) = \frac{p(P_1, h/e)}{p(P_1, h/e) + p(P_2, h/e)}$$

$$= \frac{1}{2}$$

$$p(P_2/h, e) = \frac{1}{2} \qquad p(P_3/h, e) = 0$$

M step

a — x, b — y	a — y, b — x	a — y
$\frac{1}{2}$	$\frac{1}{2}$	1

estimating the translation parameters

$$t(x|a) = \frac{\frac{1}{2}}{\frac{1}{2}+\frac{1}{2}+1} = \frac{1}{4} \qquad t(x|b) = \frac{1}{2}$$

$$t(y|a) = \frac{\frac{1}{2}+1}{\frac{1}{2}+\frac{1}{2}+1} = \frac{3}{4} \qquad t(y|b) = \frac{1}{2}$$

E2 prob step

$$p(a_1, h|e) = \frac{1}{8}$$

$$p(a_2, h|e) = \frac{3}{8}$$

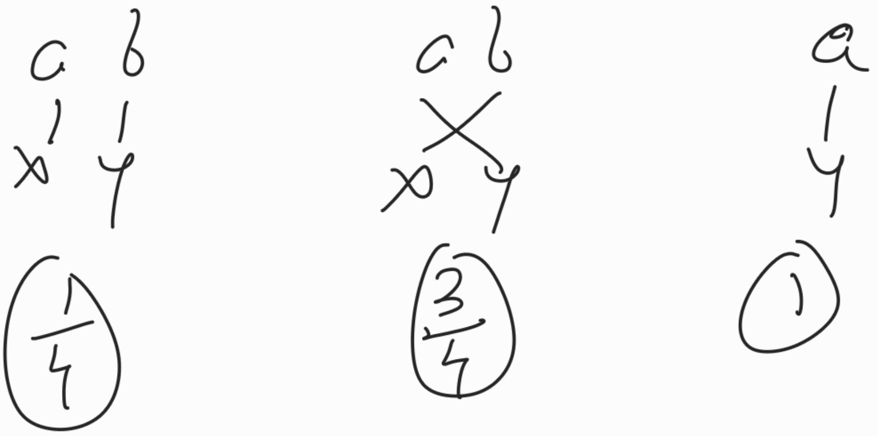
$$p(a_3, h|e) = \frac{3}{4}$$

Coloring step

$p(a_1|f,e) = \frac{1}{4}$

$p(a_2|f,e) = \frac{3}{4}$

$p(a_3|f,e) = 1$



M_2 step

Sum = 1

translation parameters

$\boxed{t(x|a) = \frac{1}{8} \qquad t(y|a) = \frac{7}{8}}$

$t(x|b) = \frac{3}{4} \qquad t(y|b) = \frac{1}{4}$

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then M_0 E_1 M_1 E_2 M_2

(steps done)

for estimating the translation

parameters

thus we scale at
the translation
probabilities | likelihoods)
we turning output correct
al

Eat → Khaa0 → 7/8 ≫ Something → Khaa 1/8

useful and correct inferences we being made

Something → Kuch → 3/4 > Eat → Kuch 2/4

another example for EM for MT

go there fast — Jaldi udhar jao

go there — udhar jao

go — jao

a b c

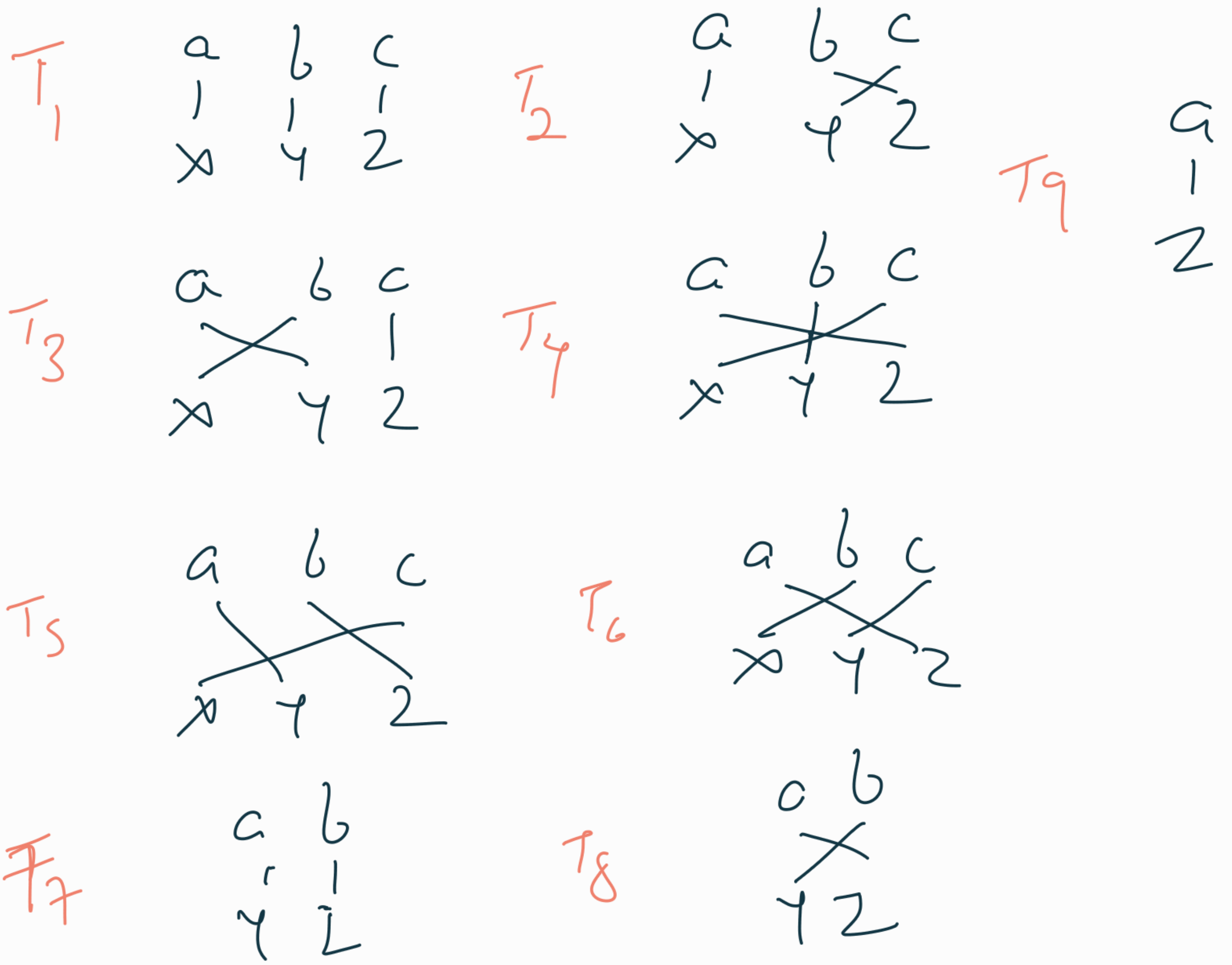
x y z

a b

y z

a

z



M_0 step

$t(x|a)$ $t(y|c)$ $t(z|c)$

$t(x|b)$ $t(y|b)$ $t(z|b)$

$t(x|c)$ $t(y|c)$ $t(z|c)$

$\frac{1}{3}$ $\frac{1}{3}$ $\frac{1}{3}$

E_1 step

propagation

$P(T_1, h|e) = \frac{1}{27}$ $P(T_3, h|e) = \frac{1}{27}$

$P(T_2, h|e) = \frac{1}{27}$ $P(T_4, h|e) = \frac{1}{27}$

$P(T_5, h|e) = \frac{1}{27}$ $P(T_6, h|e) = \frac{1}{27}$

$P(T_7, h|e) = \frac{1}{9}$ $P(T_8, h|e) = \frac{1}{9}$

$P(T_9, h|e) = \frac{1}{3}$

(calcing step)

$P(T_1|h,e) = \frac{1}{6}$ $P(T_3|h,e) = \frac{1}{6}$

$P(T_2|h,e) = \frac{1}{6}$ $P(T_4|h,e) = \frac{1}{6}$

$P(T_5|h,e) = \frac{1}{6}$ $P(T_6|h,e) = \frac{1}{6}$

$P(T_7|h,e) = \frac{1}{2}$ $P(T_8|h,e) = \frac{1}{2}$

$P(T_9|h,e) = 1$

(M, step)

$T_1 - \frac{1}{6}$ $T_4 - \frac{1}{6}$ $T_7 - \frac{1}{2}$

$T_2 - \frac{1}{6}$ $T_5 - \frac{1}{6}$ $T_8 - \frac{1}{2}$

$T_3 - \frac{1}{6}$ $T_6 - \frac{1}{6}$ $T_9 - 1$

$t(x|a) = \frac{2}{18}$ $t(y|c) = \frac{5}{18}$ $t(z|a) = \frac{11}{18}$

$t(x|b) = \frac{1}{6} = \frac{2}{12}$ $t(y|b) = \frac{5}{12}$ $t(z|b) = \frac{5}{12}$

$t(x|c) = \frac{1}{3}$ $t(y|c) = \frac{1}{3}$ $t(z|b) = \frac{1}{3}$

(E step)

preparation step - 1

$p(T_1, h|e) = 0.015$

$p(T_2, h|e) = 0.012$

$p(T_3, h|e) = 0.015$

$p(T_4, h|e) = 0.08$

$p(T_5, h|e) = 0.0385$

$p(T_6, h|e) = 0.0339$

$p(T_7, h|e) = 0.1157$

$p(T_8, h|c) = 0.254$

$P(T_9, h|e) = 0'611$

Calcling step -1 $P(T_1|h,e) = 0'077$

$P(T_2|h,e) = 0'0617$

$P(T_3|h,e) = 0'077$

$P(T_4|h,e) = 0'411$ $P(T_5|h,e) = 0'1980$

$P(T_6|h,e) = 0'174$

$P(T_7|h,e) = 0'312$ $P(T_8|h,e) = 0'687$

$$P(T_9|h,e) = \frac{0'611}{0'611} = 1$$

(M, step) :-> (translation parameter estimation)

highest →

$t(x|a) = 0'046$ $t(y|a) = 0'1956$ $t(z|a) = 0'7577$

highest

$t(x|b) = 0'1255$ $t(y|b) = 0'5875$ $t(z|b) = 0'2858$

$t(x|c) = 0'609$ $t(y|c) = 0'2357$ $t(z|c) = 0'154$

all sum close to 1

highest value