
1-
Explain what does the marginal probability $P(F|E) = \Sigma_A P(F, A|E)$ calculate?

Answer:
$P(F, A|E)$calculates the probability of translating F as a foriegn language with an alignment A (matrix A) given E as a target language.
The whole equation $P(F|E)$ then calculates all possible alignments A of a foriegn language F sentence, given a target language E sentence.
In other words, it calculates the summation of probabilities of a sentence in foriegn language and it's all alignments (E-F alignment matrices) given a sentence in target language E.

2-

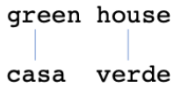
$$P(F, A|E) = \prod_{j=1}^{J} P(f_j|e_j). \quad (2)$$

Figure 1: Two pairs of E and F. Each pair has two alignments indicated by the links between the words.

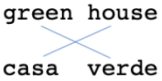
$P(\text{casa} \mid \text{green}) = 0.5$	$P(\text{verde} \mid \text{green}) = 0.5$	$P(\text{la} \mid \text{green}) = 0$
$P(\text{casa} \mid \text{house}) = 0.5$	$P(\text{verde} \mid \text{house}) = 0.25$	$P(\text{la} \mid \text{house}) = 0.25$
$P(\text{casa} \mid \text{the}) = 0.5$	$P(\text{verde} \mid \text{the}) = 0$	$P(\text{la} \mid \text{the}) = 0.5$

Table 1: Translation probabilities $P(f|e)$

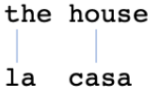
E-step a

1)


$$P(F, A|E) = P(Casa|green) * P(verde|house) = 0.5 * 0.25 = 0.125$$

2)


$$P(F, A|E) = P(Casa|house) * P(verde|green) = 0.5 * 0.5 = 0.25$$

3)


$$P(F, A|E) = P(la|the) * P(casa|house) = 0.5 * 0.5 = 0.25$$

Amin Hosseiny Marani

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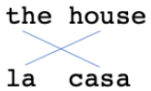
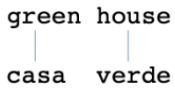
4) 

$P(F, A|E) = P(la|house) * P(casa|the) = 0.25 * 0.5 = 0.125$

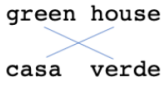
E-step b

$P(A|E,F) = P(A|E) = \frac{P(F, A|E)}{\sum_A P(F, A|E)}$

$\Sigma_A P(F, A|E)\ for\ F = case\ verde\ and\ E = green\ house: 0.125 + 25 = 0.375$

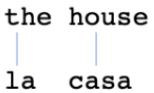
1) 

$P(A|E, F) = 0.125 / 0.375 = 1/3$

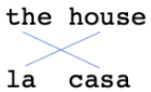
2) 

$P(A|E, F) = 0.25 / 0.375 = 2/3$

$\Sigma_A P(F, A|E)\ for\ F = la\ casa\ and\ E = the\ house: 0.125 + 25 = 0.375$

3) 

$P(A|E, F) = 0.25 / 0.375 = 2/3$

4) 

$P(A|E, F) = 0.125 / 0.375 = 1/3$

E-step c

$Expected\ count\ (W_f|W_e) = \Sigma\ P(when\ W_f\ is\ aligned\ with\ W_e),\ as\ ws\ are\ terms\ in\ foriegn\ and\ target\ languag$

Count(casa|green) = ⅓	Count(verde|green) = ⅔	count(la|green) = 0	Total (green) = 1
count(casa|house) = ⅔+⅔	count(verde|house) = ⅓	count(la|house) = ⅓	total(house) = 2
count(casa|the) = ⅓	count(verde|the) = 0	count(la|the) = ⅔	total(the) = 1

Amin Hosseiny Marani

3-
M-step: re-estimate the translation probabilities by row normaliziation of the obtained table in the previous question's answer.

Count(casa|green) = ⅓	Count(verde|green) = ⅔	count(la|green) = 0
count(casa|house) = ⅔	count(verde|house) = ⅙	count(la|house) = ⅙
count(casa|the) = ⅓	count(verde|the) = 0	count(la|the) = ⅔

4-

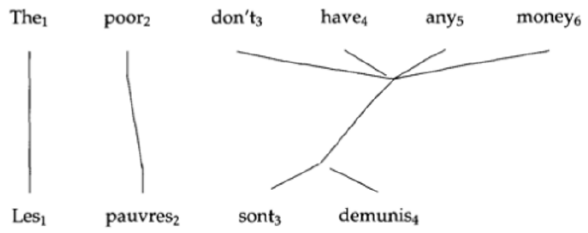


Figure 2: A translation of a French sentence into an English sentence

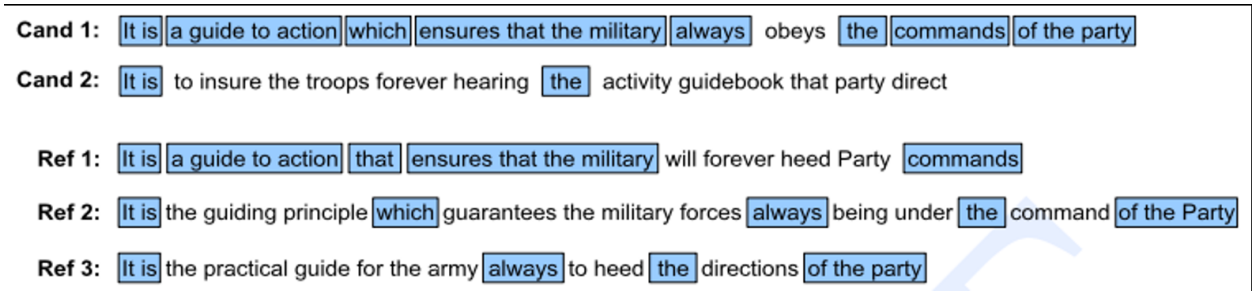
Answer: A translation of a french sentence into an English sentence means the French is the Source (E) and the english language is the target (F). So, we will have 4 rows and 6 columns.

E\F	1	2	3	4	5	6
1	1					
2		1				
3			1	1	1	1
4			1	1	1	1

*For easier readability I only put 1s for the matches. Empty cells have 0 values.

Amin Hosseiny Marani

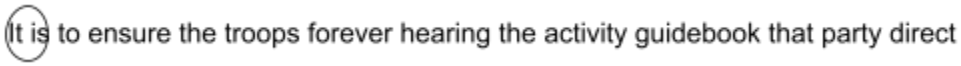
5-



Candidate translation

$$\text{prec}_n = \frac{\sum_{C \in \{Candidates\}} \sum_{n\text{-}gram \in C} \text{Count}_{\text{match}}(n\text{-}gram)}{\sum_{C' \in \{Candidates\}} \sum_{n\text{-}gram' \in C'} \text{Count}(n\text{-}gram')}$$

To compute $Prec_2$For precision for bigrams we have to check every possible bi-grams in cand1 and cand 2 with all three references.
Black circles show there is a match with the bigram and Ref 1, and blue circles show a match to the ref 2. Since, I check matches with references in order of 1 to 3, a black circle does not mean there is only a match with the ref 1, but the first match was seen in the ref1.



$$Prec_{2,candid1} = matches\ /\ all - biragram = 10/17$$
$$Prec_{2,candid2} = matches\ /\ all - biragram = 1/13$$

Clearly the first candidate is a better candidate, based on Precision of bigrams.