Example-based Decoding for Statistical Machine Translation

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ATR Spoken Language Translation Research Laboratories

Overview

- Statistical Machine Translation (SMT)
- Decoding Problem in SMT
- Example-based Decoder
- Experiments
- Summary

Statistical Machine Translation

- Translation from J into E (Berger et al. 1993)

$$\begin{aligned}\hat{E} &= \operatorname*{argmax}_E P(E|J) \\ &= \operatorname*{argmax}_E P(E)P(J|E)\end{aligned}$$

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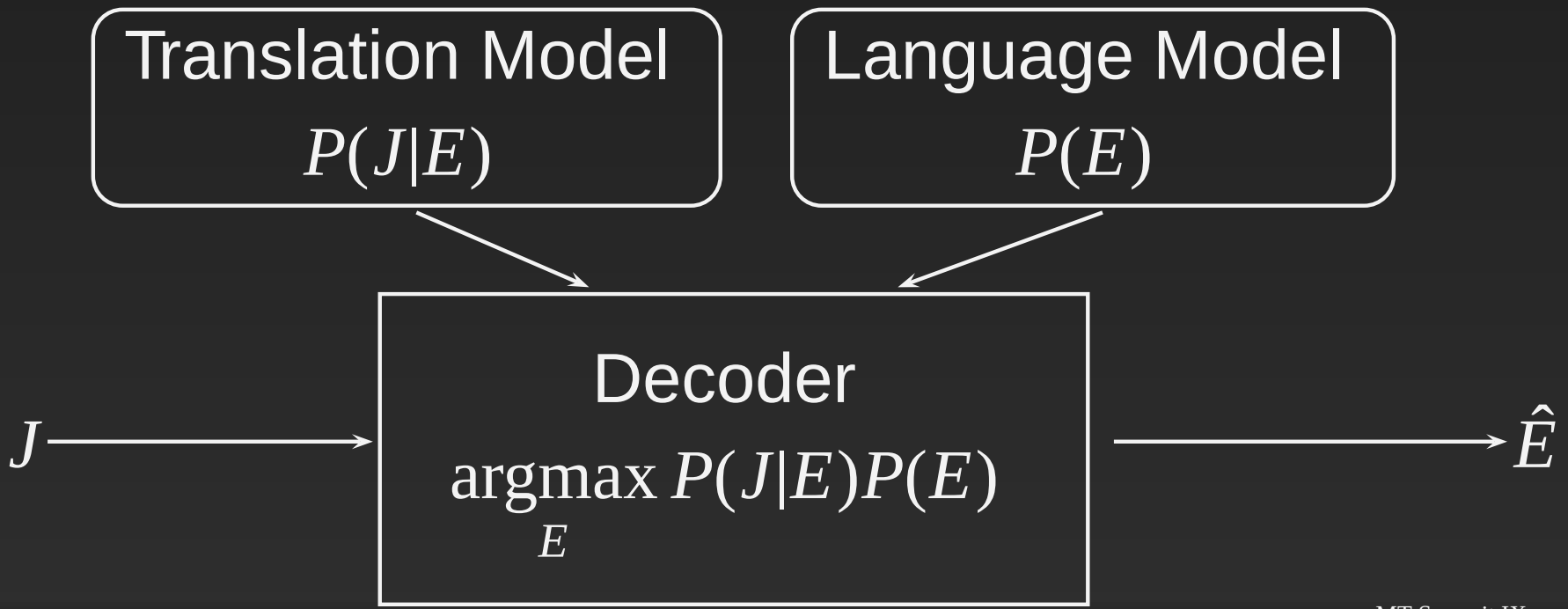
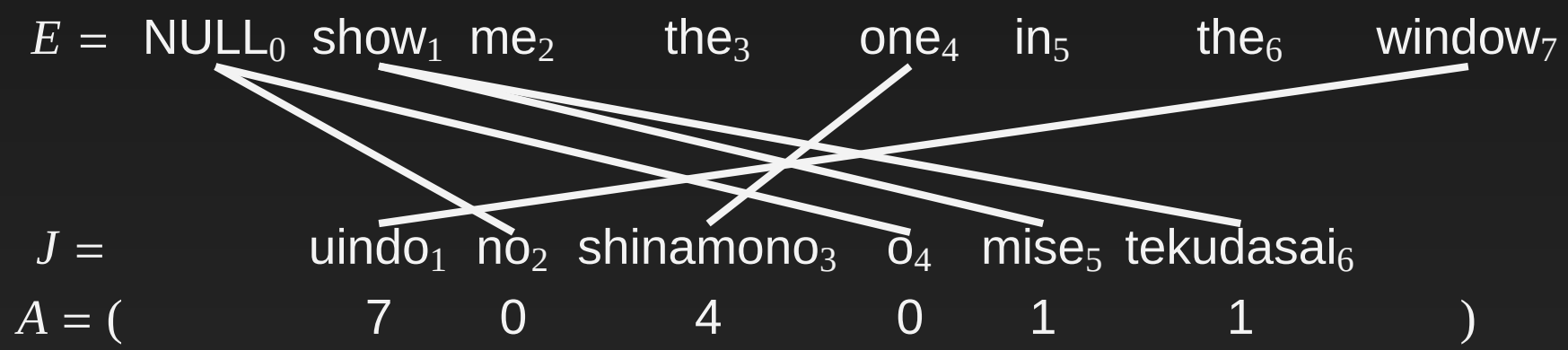


Word Alignment Based Statistical Translation

$$P(J|E) = \sum_{A} P(J, A|E)$$



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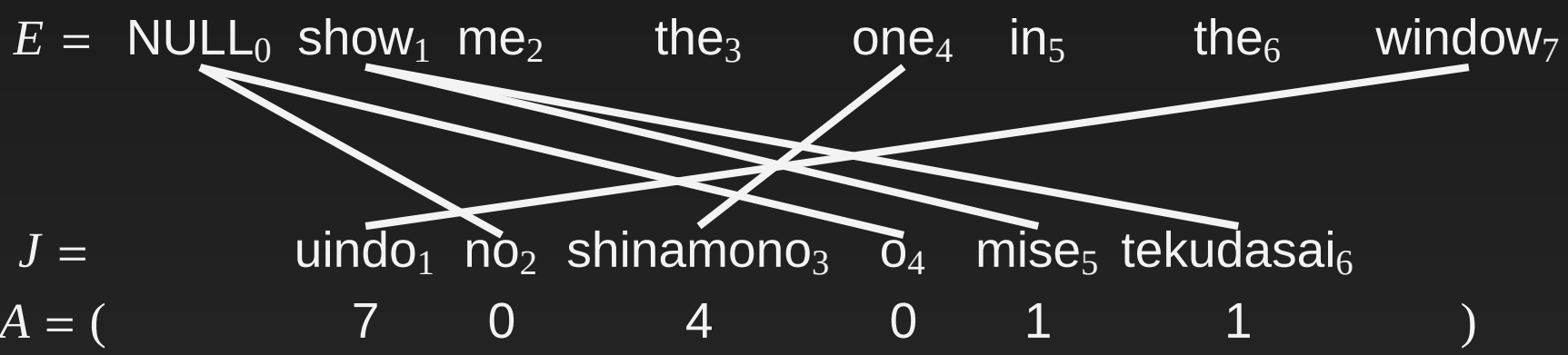

- Generative Process of $P(J, A|E)$
  IBM Model 1 — 5 (Berger, et al. 1993), HMM (Vogel, et al. 1996) etc.

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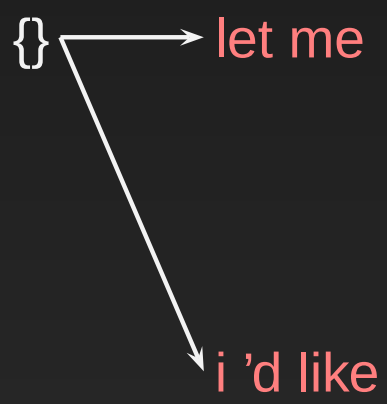

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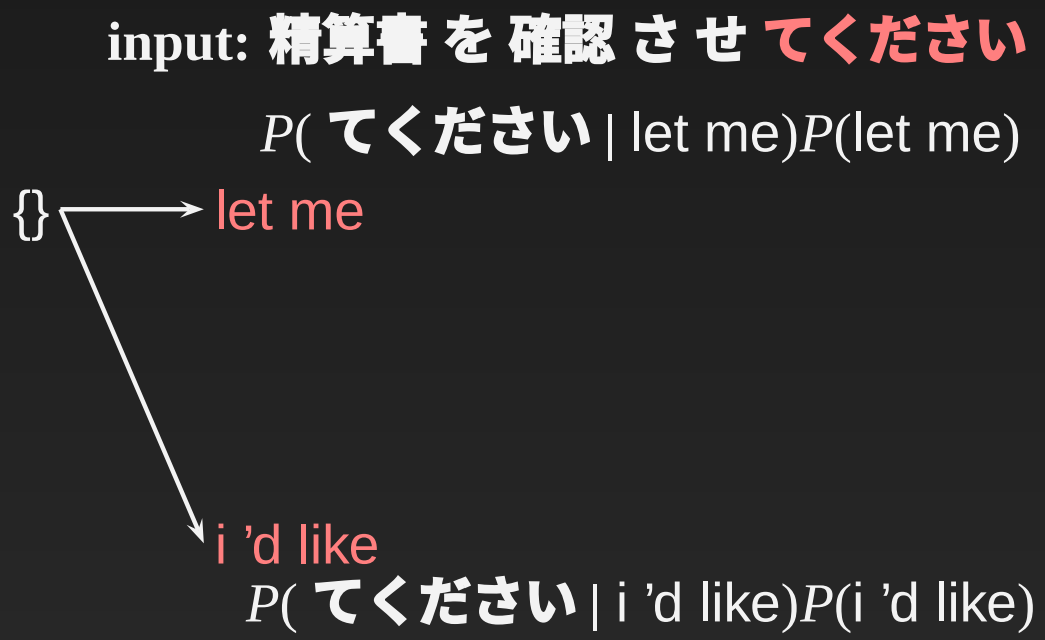

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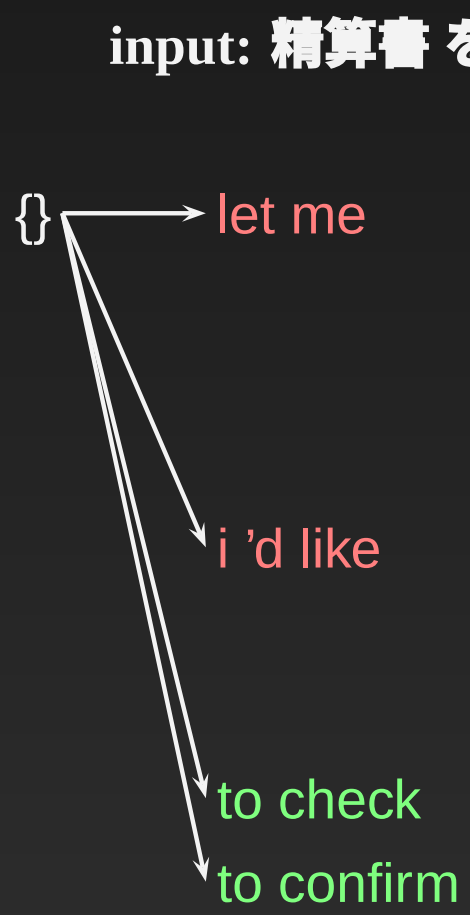

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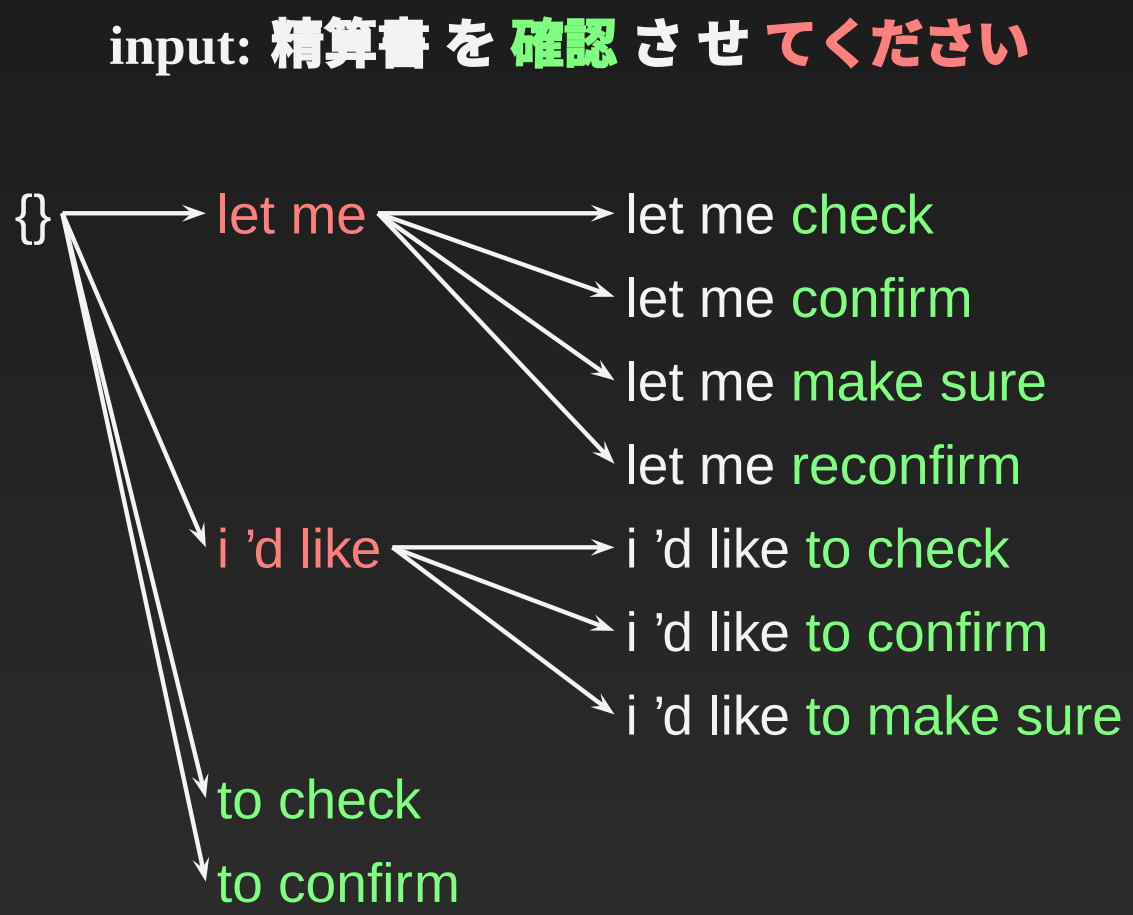

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- Application to similar language pairs
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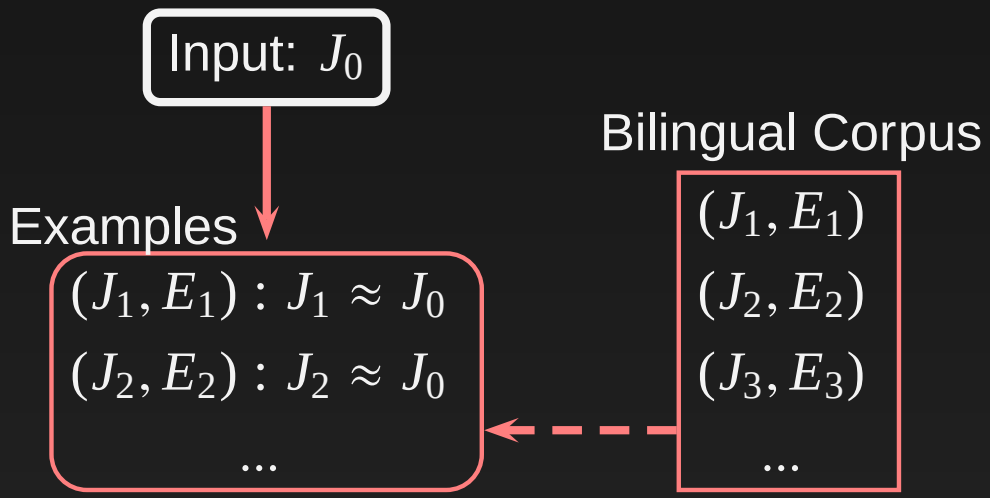
- Frequent insertion/deletion and intricated word alignments
- Word-by-word or phrase-by-phrase decoding
  - Frequent insertion/deletion — huge search space
  - Pruning is inevitable — search error

Example-based Decoder

Input: J_0

Example-based Decoder



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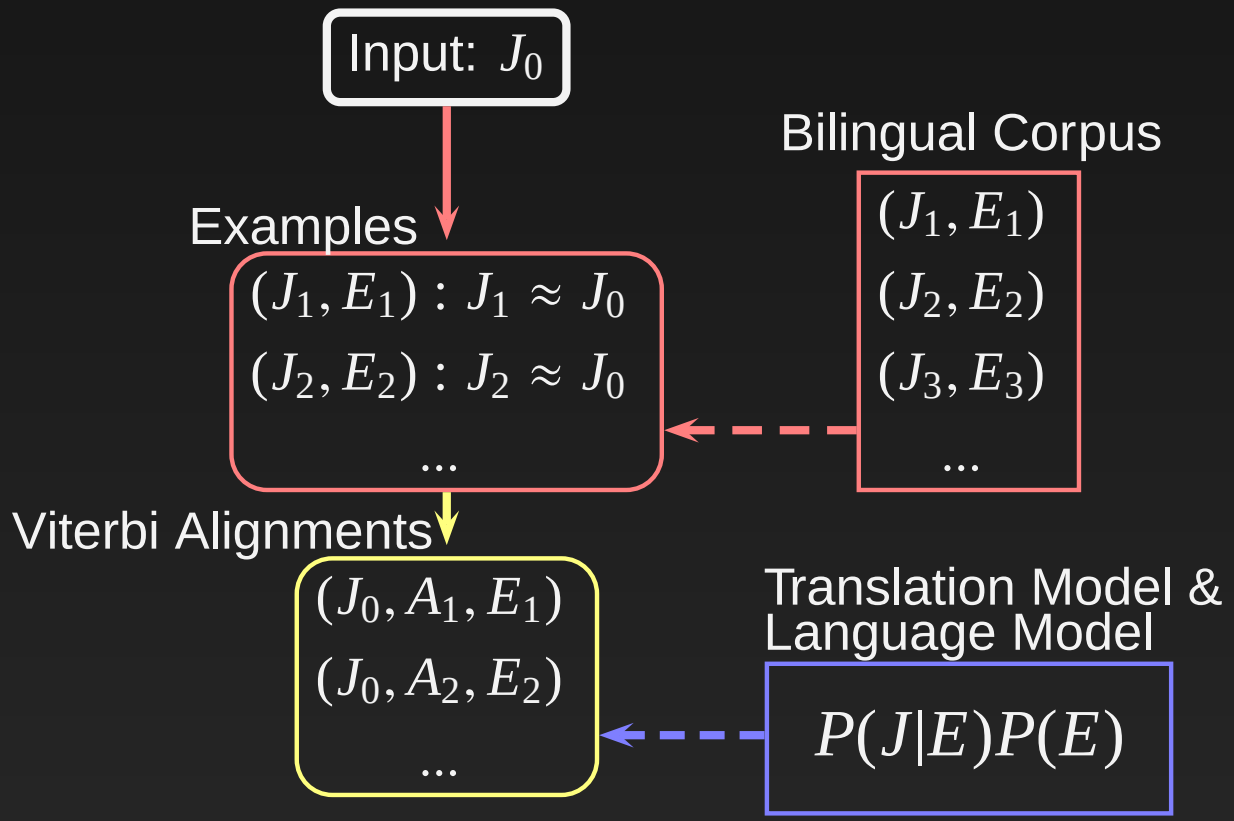

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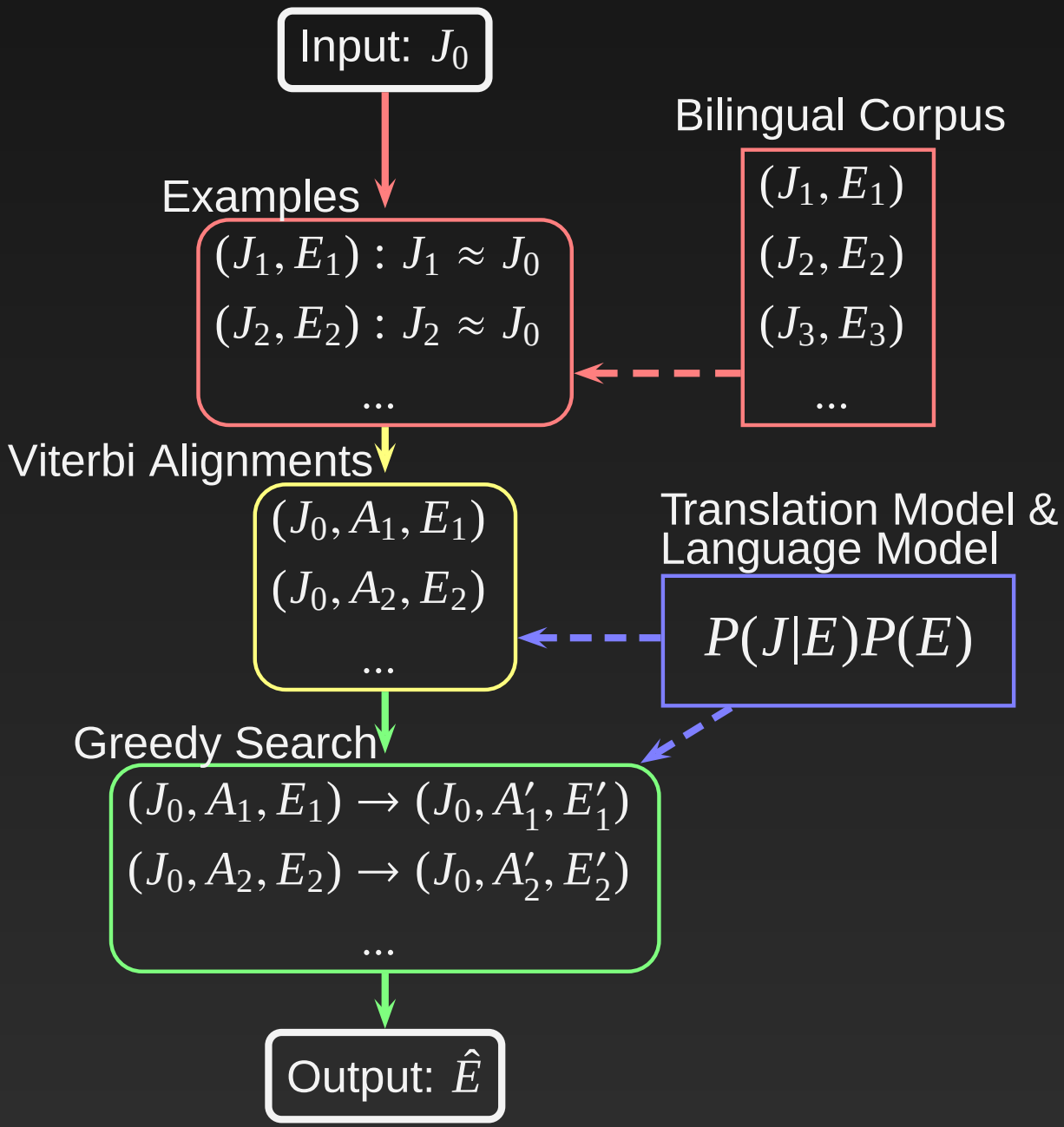

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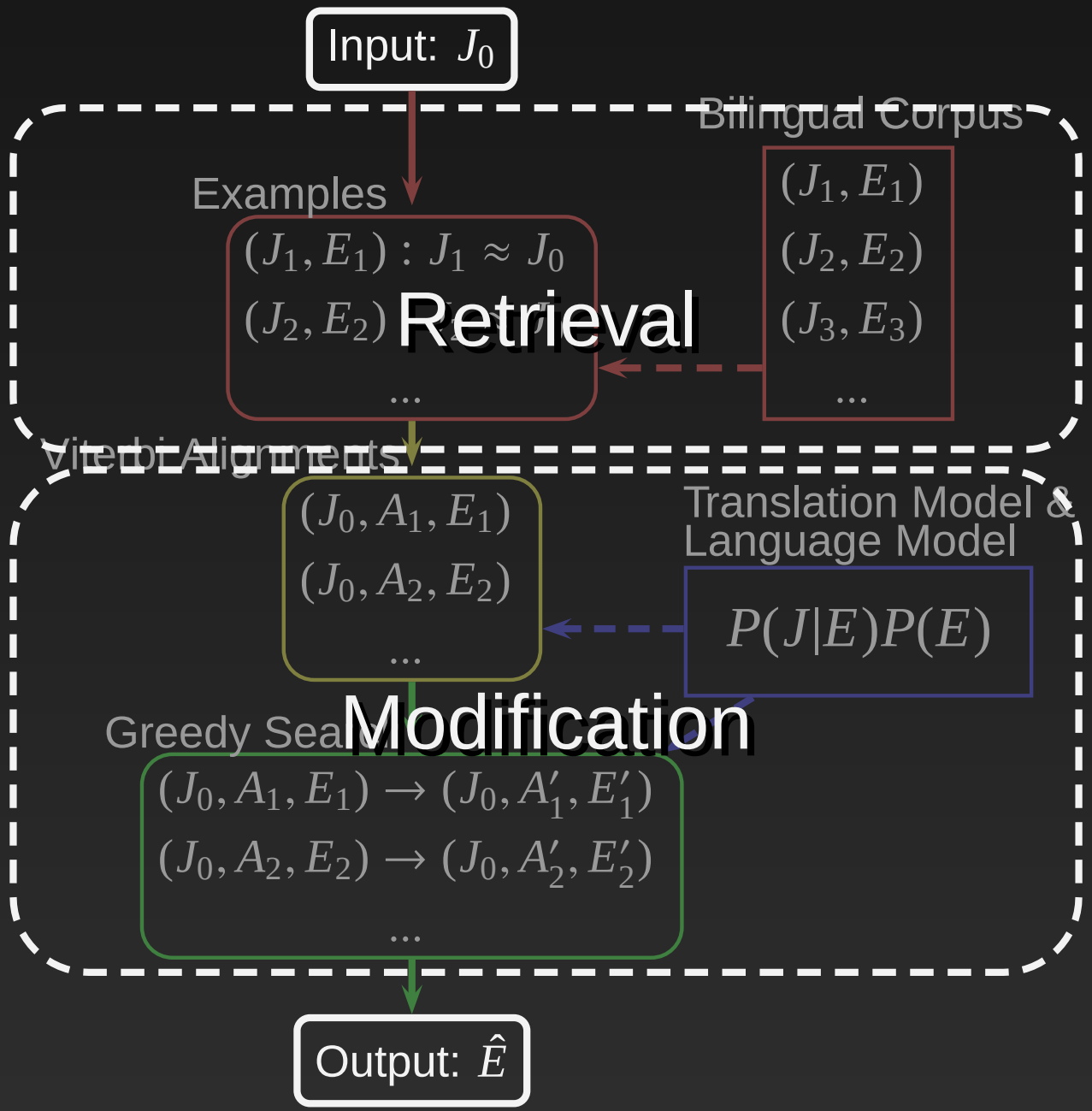

Retrieval of Examples

- Similarity measure
  - Edit distance criteria

$$dis(J_k, J_0) = I(J_k, J_0) + D(J_k, J_0) + S(J_k, J_0)$$

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$$score(J_k, J_0) = \begin{cases} (1.0 - \alpha)(1.0 - \frac{dis(J_k, J_0)}{|J_0|}) & dis(J_k, J_0) > 0 \\ \quad + \alpha P_{tf/idf}(J_k, J_0) & \\ 1.0 & \text{otherwise} \end{cases}$$

Modification of Examples

- For each translation example (J_k, E_k),
  1. Compute the viterbi alignment A_k for the pair (J_0, E_k)
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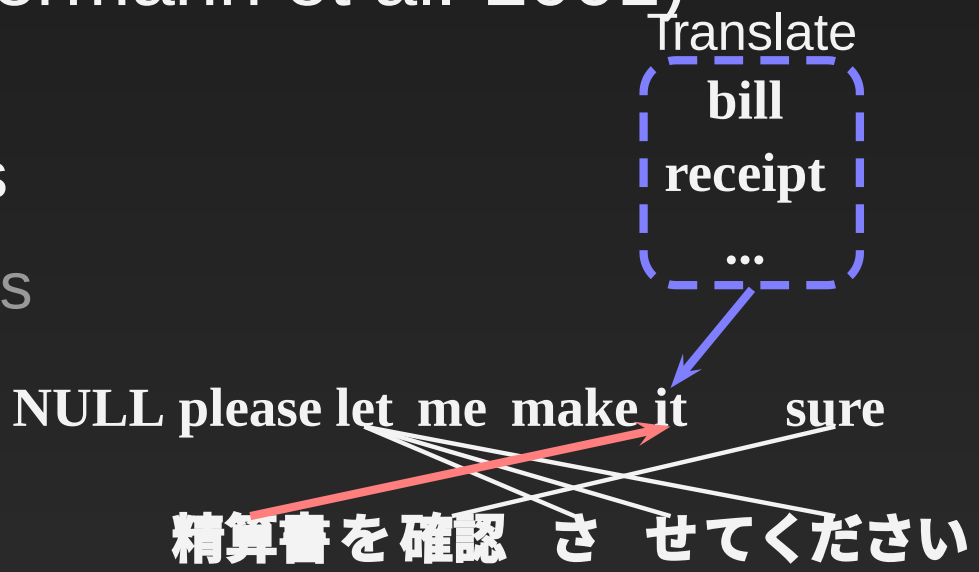

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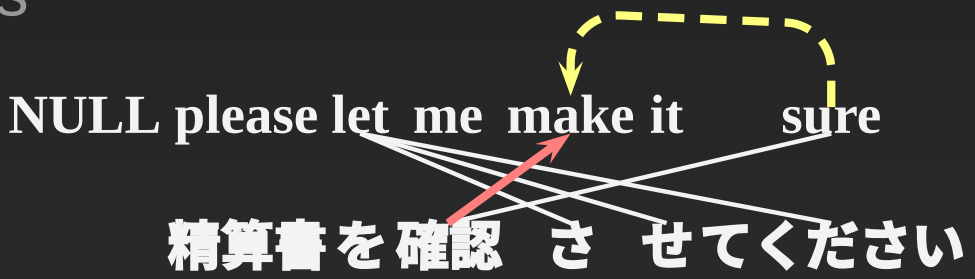

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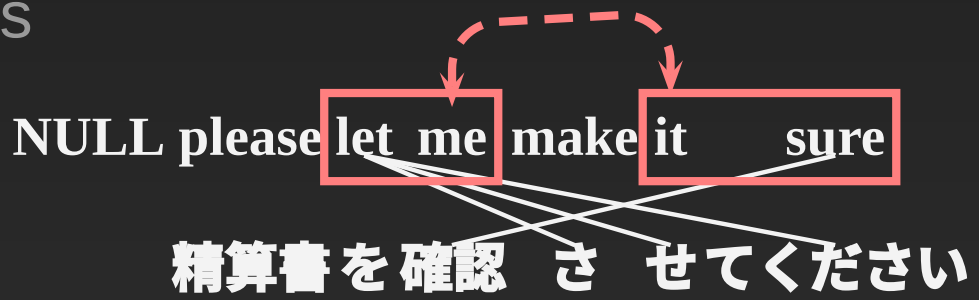

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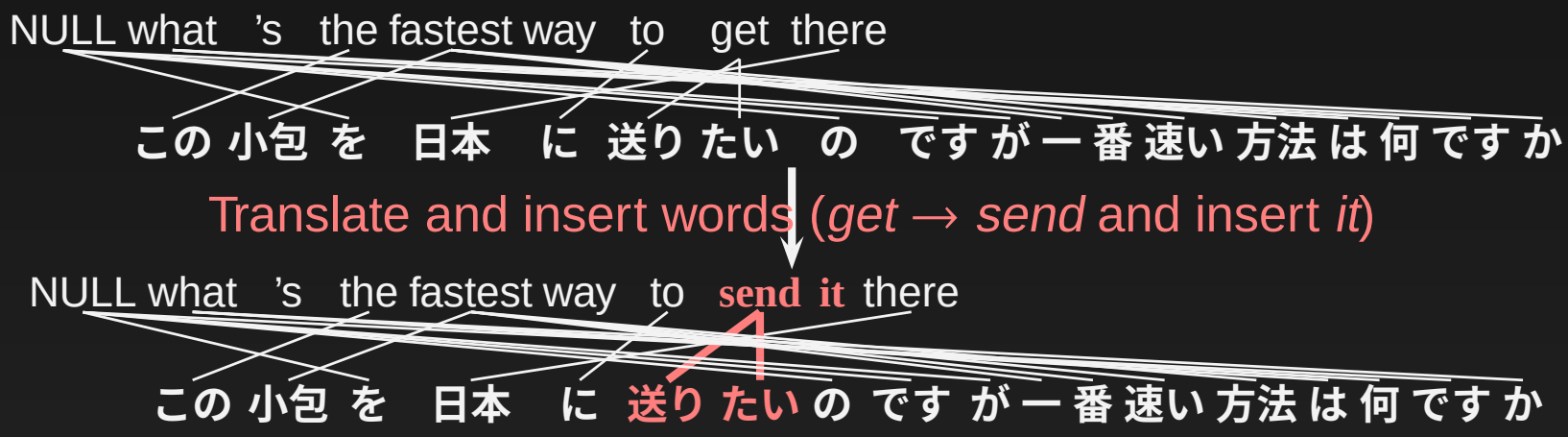

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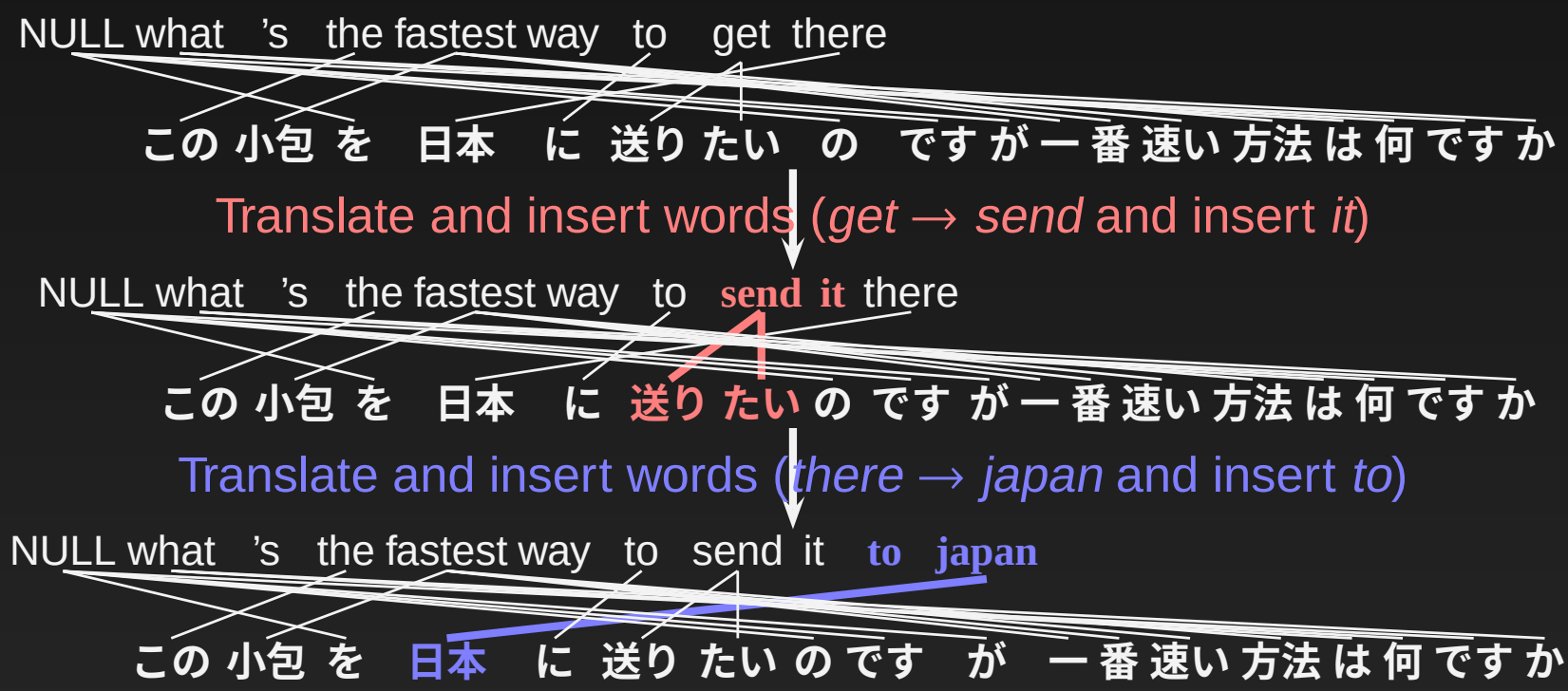

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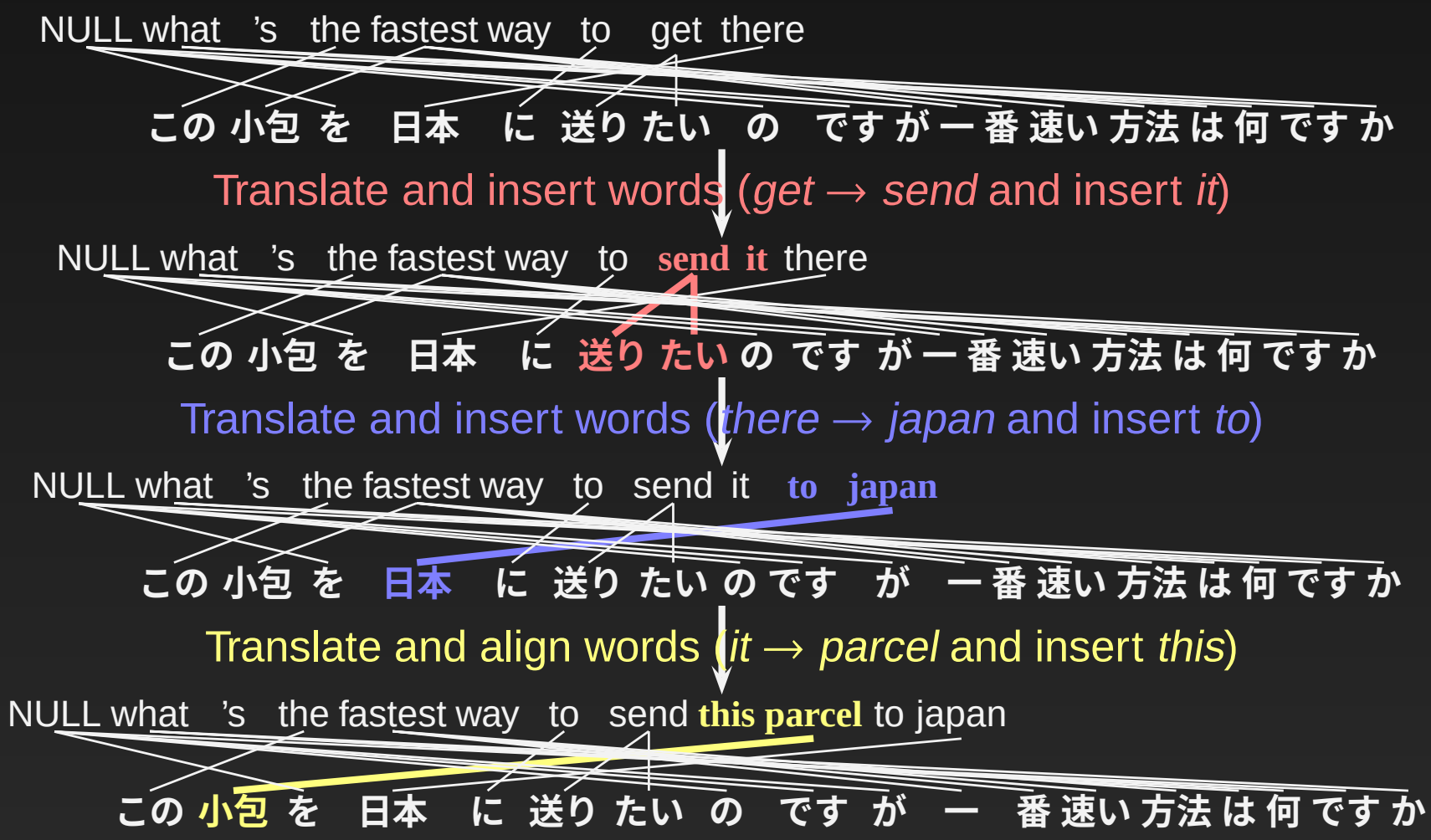

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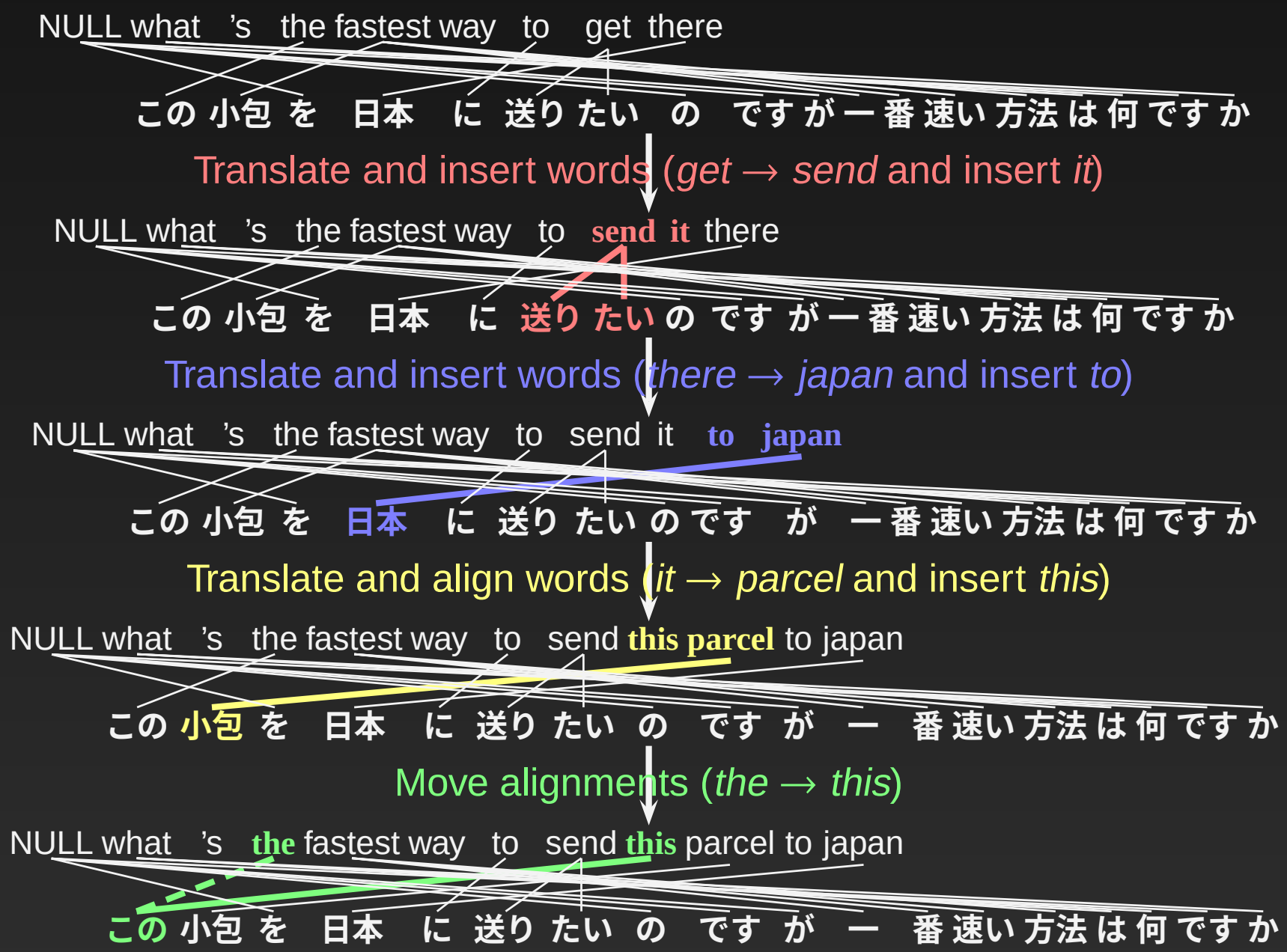

Experiments

Basic Travel Expression Corpus

	Chinese	English	Japanese	Korean
# of sentences		167,163		
# of words	956,732	980,790	1,148,428	1,269,888
vocabulary size	16,411	15,641	21,896	13,395
# of singletons	5,207	5,547	9,220	4,191
3-gram perplexity	45.53	35.35	24.06	20.34

Evaluation

- Two decoders on IBM Model 4 + 3-gram:
  - Left-to-right generation word-by-word beam search decoder
  - Example-based decoder
- Evaluation Metrics

WER: Word-error-rate — edit distance penalty

PER: Position independent WER — WER but ignore positional disfluencies

BLEU: Geometric mean of n-gram precision

SE: Subjective evaluation — ranks ranging from A : perfect, B : fair, C : acceptable and D : non-sense judged by a native speaker

SER: Search error rate — judged by TM+LM scores of outputs from two systems

Remarks: 16 referenses for WER, PER and BLEU

Results

	Exact [%]	WER [%]	PER [%]	BLEU [%]	SE [%] A	SE [%] A+B	SE [%] A+B+C
C-E		45.0/**34.3**	39.8/**30.3**	43.6/**56.7**	48.4/**65.3**	65.9/**76.9**	71.4/**81.0**
C-J	52.7	35.7/**25.5**	31.3/**22.6**	56.9/**67.8**	50.8/**69.0**	59.4/**74.3**	66.9/**80.2**
C-K		38.4/**29.1**	34.2/**26.2**	56.1/**65.0**	-	-	-
E-C		45.0/**38.0**	39.7/**33.4**	42.1/**51.9**	-	-	-
E-J	40.8	34.2/**29.0**	30.5/**26.1**	59.2/**65.7**	55.8/**65.1**	62.4/**71.6**	70.2/**77.8**
E-K		38.7/**35.6**	34.3/**31.6**	57.3/**61.5**	-	-	-
J-C		46.8/**33.0**	38.9/**27.8**	39.7/**57.1**	-	-	-
J-E	33.7	42.9/**35.0**	37.4/**30.3**	47.6/**57.4**	50.8/**63.7**	65.7/**74.5**	70.2/**77.6**
J-K		27.7/**20.8**	25.4/**19.2**	67.2/**73.5**	-	-	-
K-C		41.9/**32.9**	34.4/**27.6**	45.1/**55.5**	-	-	-
K-E	39.2	45.1/**36.4**	38.5/**32.1**	44.3/**56.8**	49.2/**61.6**	65.7/**72.9**	72.2/**78.4**
K-J		26.8/**20.8**	24.6/**19.3**	64.3/**70.8**	56.5/**69.2**	66.5/**77.5**	78.4/**84.7**

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beam search/example-based decoder

Detailed Results

	SE [%]					
	exactly matched			otherwise		
	A	A+B	A+B+C	A	A+B	A+B+C
C-E	65.4/**92.6**	78.4/**97.0**	82.5/**97.8**	29.5/**34.9**	51.9/**54.4**	58.9/**62.2**
J-E	72.1/**97.1**	80.8/**99.4**	83.7/**99.4**	39.9/**46.7**	58.0/**61.8**	63.3/**66.6**
K-E	69.0/**92.0**	81.0/**97.5**	85.0/**98.0**	36.5/**41.9**	55.8/**57.1**	63.9/**65.8**
C-J	65.4/**97.0**	73.6/**98.1**	78.4/**98.9**	34.4/**37.8**	43.6/**47.7**	53.9/**59.3**
E-J	79.3/**95.2**	81.7/**98.1**	84.6/**98.6**	39.4/**44.4**	49.0/**53.3**	60.3/**63.6**
K-J	74.5/**98.5**	80.0/**99.5**	87.5/**99.5**	44.8/**50.3**	57.7/**63.2**	72.6/**75.2**

beam search/example-based decoder

Search Error

	matched	non-matched	total
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C-K	14.9/**45.0**	25.7/**29.5**	20.0/**37.6**
E-C	19.2/**46.2**	39.1/**26.8**	31.0/**34.1**
E-J	19.7/**34.1**	33.4/**26.2**	27.8/**29.4**
E-K	14.4/**42.8**	31.8/**32.8**	24.7/**36.9**
J-C	10.5/**63.4**	37.6/**31.4**	28.4/**42.2**
J-E	16.3/**51.7**	35.8/**28.1**	29.2/**36.1**
J-K	14.5/**39.5**	50.3/**10.9**	38.2/**20.6**
K-C	14.0/**51.5**	31.9/**28.7**	24.9/**37.6**
K-E	19.5/**42.5**	31.3/**31.9**	26.7/**36.1**
K-J	15.0/**32.5**	27.7/**12.3**	22.7/**20.2**

beam search/example-based decoder

Some Examples of Translations

input:	銀行 の 前 で バッグ を ひったくら れ まし た
reference:	i was robbed of my bag in front of the bank
beam:	my bag was stolen in the front of the bank
example:	i was robbed of my bag in front of the bank
retrieved:	(i was robbed of my wallet bank on the subway)
input:	今 調べ ており ます ので しばらく お 待ち ください
reference:	would you wait for a moment while i check
beam:	i ’m out so please wait a moment
example:	would you wait a moment while we check
retrieved:	(would you wait for a moment while we check)
input:	お 金 を 入れ た のに 機械 が 動き ませ ん お 金 を 返し てもらい たい の です が
reference:	even though i put in some money the machine doesn’t work i ’d like a refund please
beam:	i ’d like a refund for this machine doesn’t money got heading
example:	although i put in some coins the machine didn’t work i ’d like a refund
retrieved:	(although i put in some coins the machine did’t work i ’d like a refund)

Some Examples of Translations 2

input:	十 時 に ここ で 待っ て い て くれる ん です ね
reference:	you will wait for me here at ten right
beam:	here is your pay wait ten o’clock
example:	are you waiting here at ten o’clock
retrieved:	(why are you waiting here)
input:	いいえ 赤い バッグ の 隣 に ある もの です
reference:	no the one next to the red bag
beam:	no red bag in the room next door is something
example:	no it ’s next to the red one
retrieved:	(it ’s next to that building)
input:	ええ それ と 似 た 手帳 が 届い て い ます
reference:	yes someone did turn in a notebook like that
beam:	yes it is similar there any messages for me
example:	i have a notebook come yes it is similar
retrieved:	(yes we have a japanese speaking guide)

Discussion

- Example-based decoder
  - A method to merge example-based framework and statistical machine translation
    - Retrieve-and-tweak strategy
    - Retrieval of examples — edit distance + *tf/idf*
    - Modification of examples — greedy method, but uses retrieved examples as the initial condition
  - Very strong bias to guide the search, especially suitable for long distance languaga pairs

Discussion, Contd.

- Related Work : Memory-based SMT (Marcu, 2001)
  - Extract phrase translation pattern
  - The greedy decoding process is initiated from the concatenation of phrases found in the translation memory
  - Difference in unit: Phrase vs. Sentence

Discussion, Contd.

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- Better model, better translation?
  - Some correlation between the probability assigned by the models and the translation quality (Akiba et al. 2002)

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- Better model, better translation?
  - Some correlation between the probability assigned by the models and the translation quality (Akiba et al. 2002)
- Future Works
  - *Post*-translation
  - Chunk-based (or Syntax-based) statistical translation model