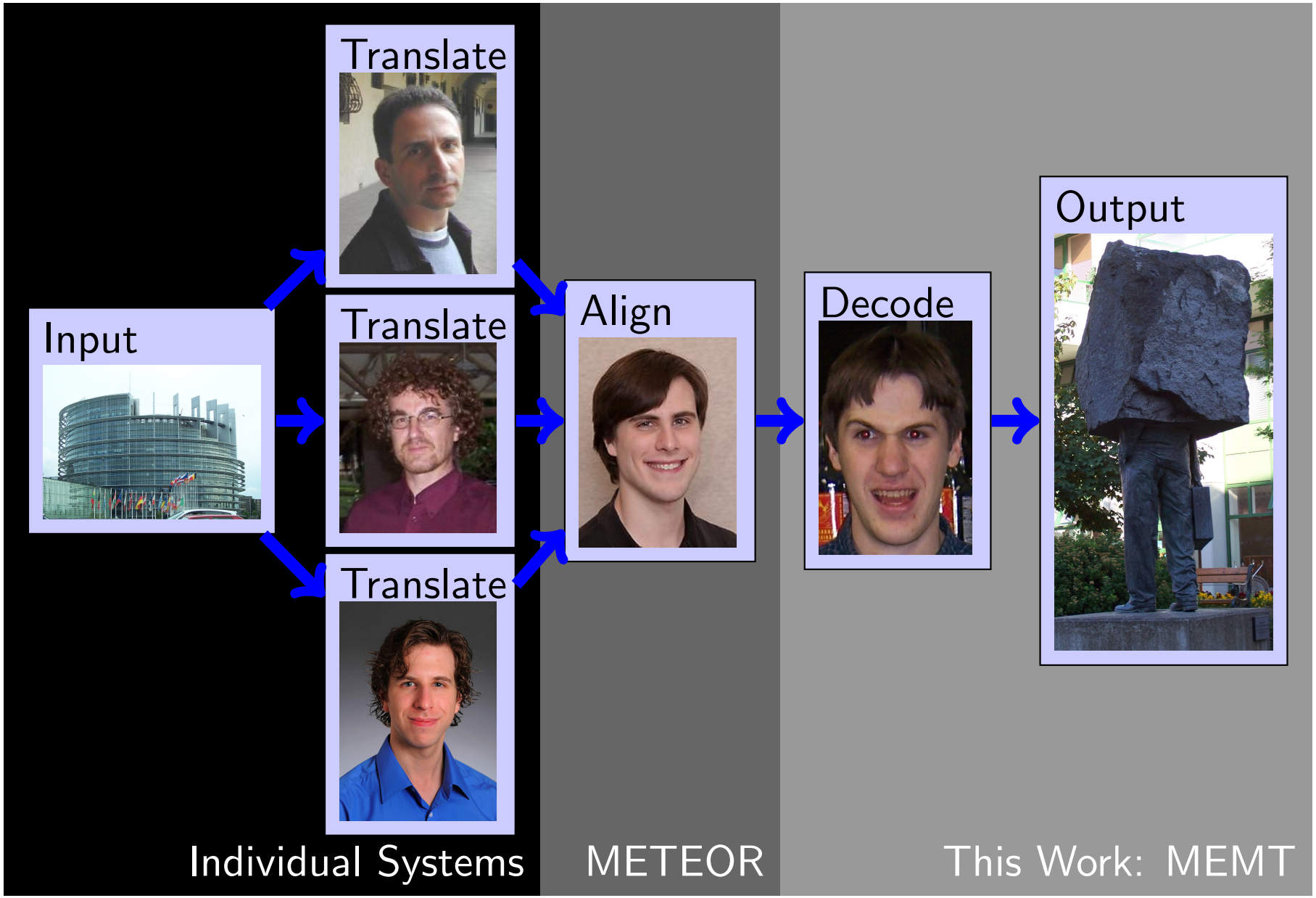
Outline


Input
Translate
Translate
Translate
Align
Decode
Output
Individual Systems
METEOR
This Work: MEMT

Arabic-English Example Combination

System 1: So even if that was meaningful , it is because you were late

System 2: Even if feasible , it is because you have been delayed

↓ Combine

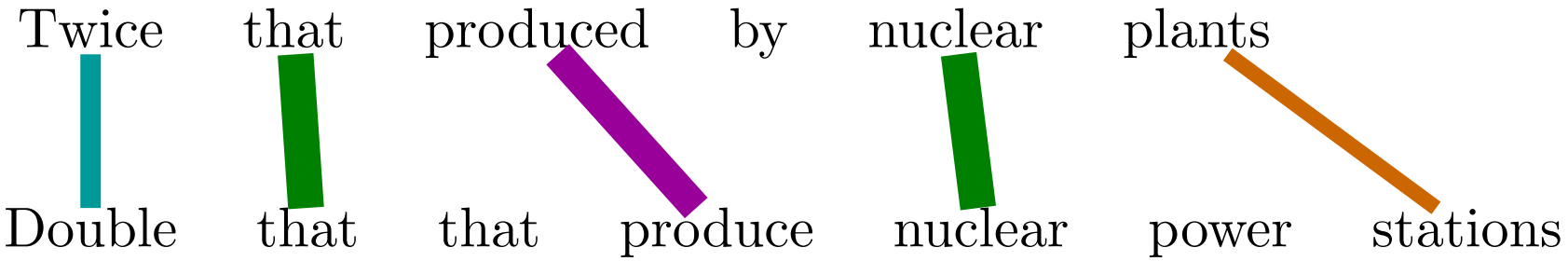
Combined: Even if feasible , it is because you were late

≠ Compare

Reference: And even if that was useful , it was because you were late

Sentence Pair Alignment

Match surface, stems, WordNet synsets, and automatic paraphrases
Minimize crossing alignments



Lavie and Agarwal, METEOR: An Automatic Metric for MT Evaluation with High Levels of Correlation with Human Judgments, WMT 2007.

Overall Alignment: Urdu-English Example

1 Russian President Putin Mir ولادی it for a big success .

2 The Russian president ولادی the result of a big victory for Putin .

Overall Alignment: Urdu-English Example

1 Russian President Putin Mir ولادی it for a big success .

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1 Russian President Putin Mir ولادی it for a big success .

3 For the result Russian President ولادی Mir Putin is a great success .

2 The Russian president ولادی the result of a big victory for Putin .

3 For the result Russian President ولادی Mir Putin is a great success .

Search Space

Algorithm

Start at the beginning of each sentence

Branch by appending the first unused word from a system

Example

System 1: Now can know why .

System 2: Now we can now know why .

Partial Hypothesis

Now
Now

Search Space

Algorithm

Start at the beginning of each sentence

Branch by appending the first unused word from a system

Use the appended word and those aligned with it

Example

System 1: Now can know why .

System 2: Now we can now know why .

Partial Hypothesis

Now { can / we }

Search Space

Algorithm

Start at the beginning of each sentence

Branch by appending the first unused word from a system

Use the appended word and those aligned with it

Loop until all hypotheses reach end of sentence

Example

System 1: Now can know why .

System 2: Now we can now know why .

Partial Hypothesis

Now we { can / can

Search Space

Algorithm

Start at the beginning of each sentence

Branch by appending the first unused word from a system

Use the appended word and those aligned with it

Loop until all hypotheses reach end of sentence

Example

System 1: Now can know why .

System 2: Now we can now know why .

Partial Hypothesis

Now we can { know / now }

Outline

Features

Length

Length of hypothesis

Language Model

Model: log probability from an ARPA language model
OOV: count of words not found in the model

Match

Count of *n*-grams matching each system

Feature Rationale

Length

Length of hypothesis

Compensate for length's impact on other features

Language Model

Model: log probability from an ARPA language model
OOV: count of words not found in the model

Fluent output with tuned OOV penalty

Match

Count of *n*-grams matching each system

Agreement with translation systems

Match Features

System 1: Supported Proposal of France

System 2: Support for the Proposal of France

↓ Hypothesis

Hypothesis: Support for Proposal of France

↓ Count

	Unigram	**Bigram**	**Trigram**	**Quadgram**
System 1	4	2	1	0
System 2	5	3	1	0

What's in a match?

Exact matches

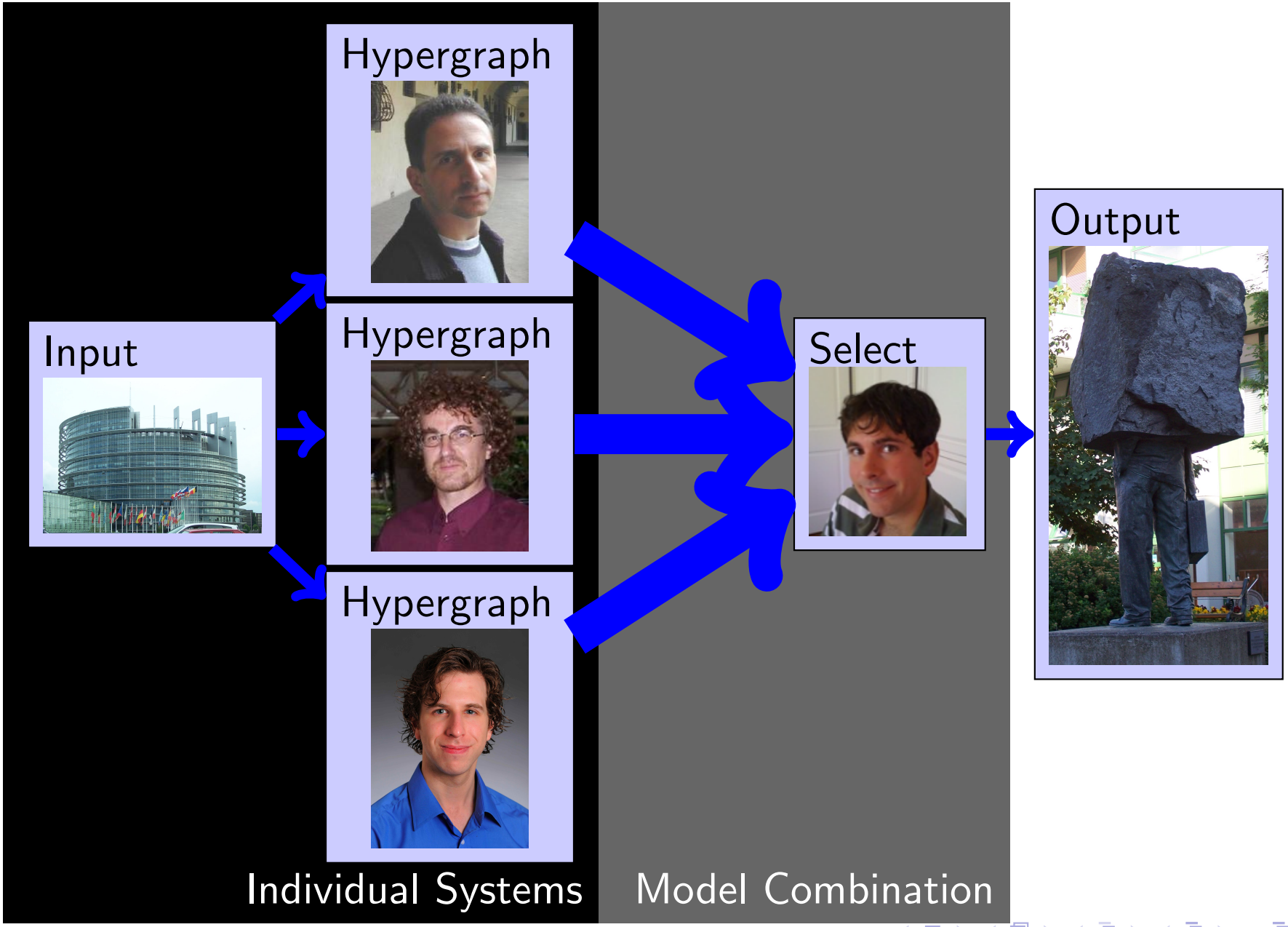
- Lexical choice
- Choosing between aligned alternatives

Approximate matches

- Vote to include/exclude text
- Word order

Answer

- Use both types of features
- Exact matches effectively get a tunable bonus


Input
Hypergraph
Hypergraph
Hypergraph
Select
Output
Individual Systems
Model Combination

Model Combination is Hypothesis Selection

The Search Space

- Union of search spaces from each system
- Combined sentence must be in one system's hypergraph

Formally

- Every system outputs a hypergraph
- Phrasal lattice is just a special-case hypergraph
- Add a root node and an edge to each system root

Model Combination is Hypothesis Selection

The Search Space

- Union of search spaces from each system
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Formally

- Every system outputs a hypergraph
- Phrasal lattice is just a special-case hypergraph
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Source Alignment

Hypergraphs retain alignment to source

Features

Length

Length of hypothesis

Model score

Score given by the underlying system

System indicator

Each system has a feature:

- 1 if derived from that system
- 0 otherwise

N-gram support

Support from each system for n-grams

N-gram support

Posterior of n-gram

What fraction of system i's translations include "crack rocks"?

Formally

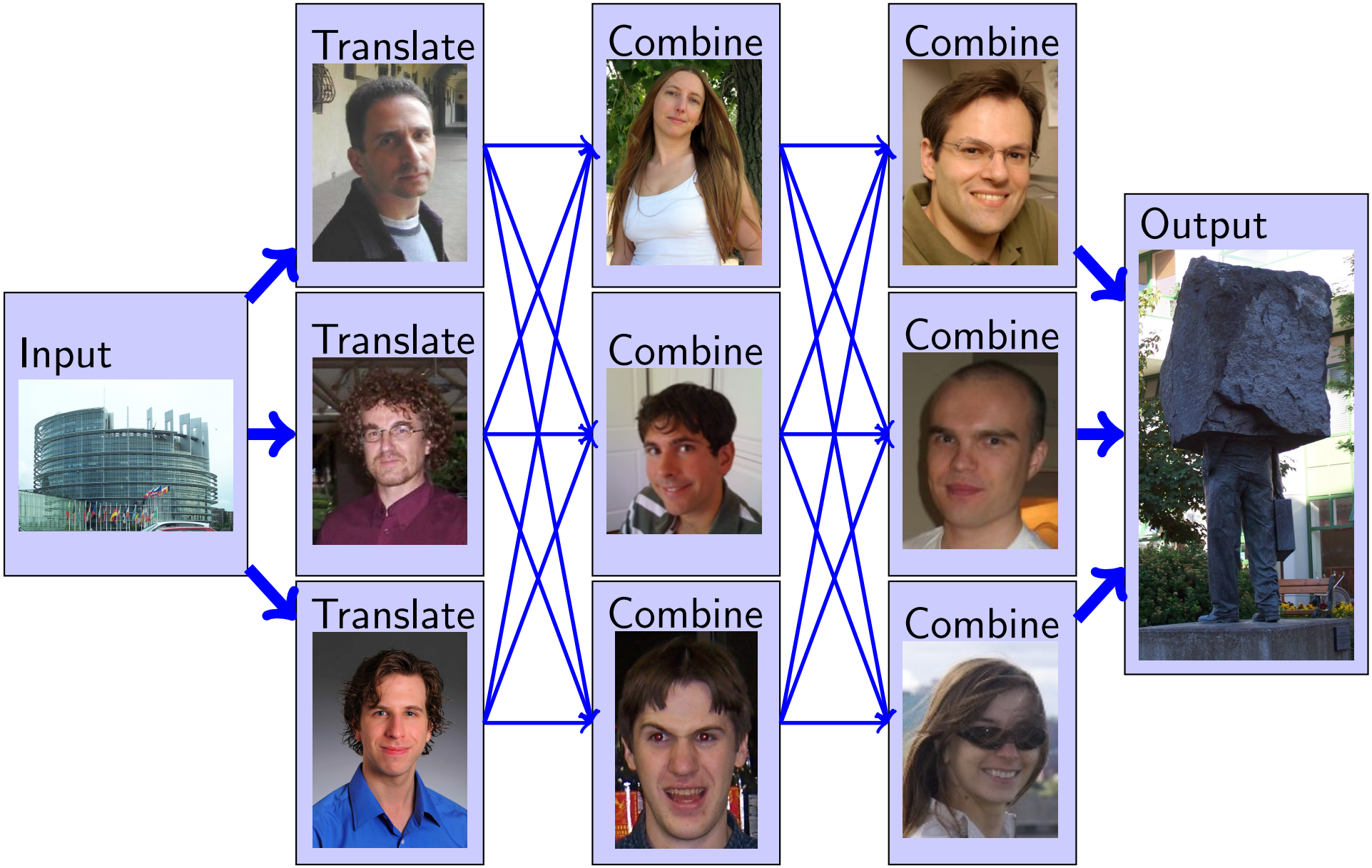
$$v_i^n(g) = \mathbb{E}_{P_i(d|f)} h(d, g)$$

$v_i^n(g)$	System i's vote for n-gram g
$P_i(d\|f)$	Probability of a derivation d in hypergraph f from system i
$h(d, g)$	1 if the derivation d contains n-gram g; 0 otherwise

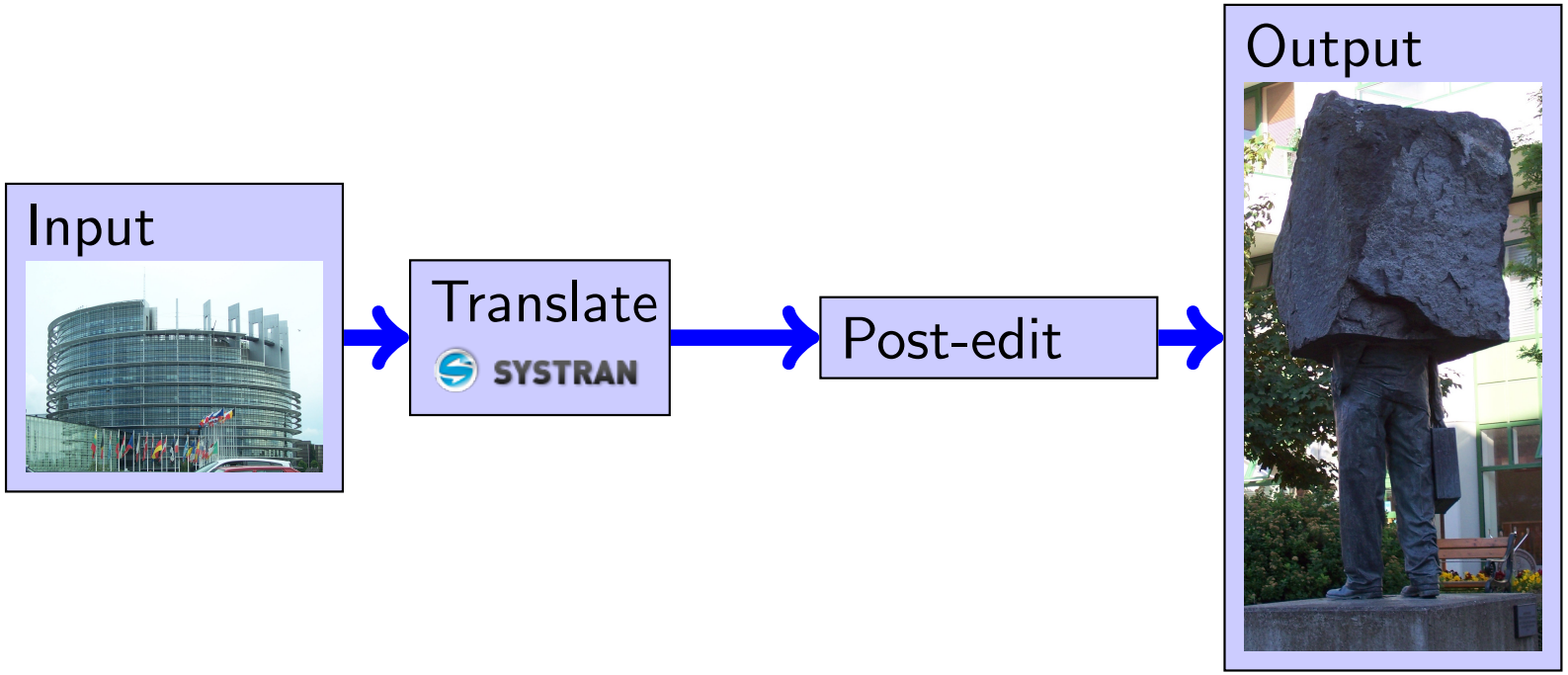
Performance

	ar-en	zh-en
Best individual	43.9	28.4
Combined	45.3	29.0

Table: Performance (BLEU) on NIST 2008 task using three systems


Input
Translate
Translate
Translate
Combine
Combine
Combine
Combine
Combine
Combine
Output

Serial System Combination

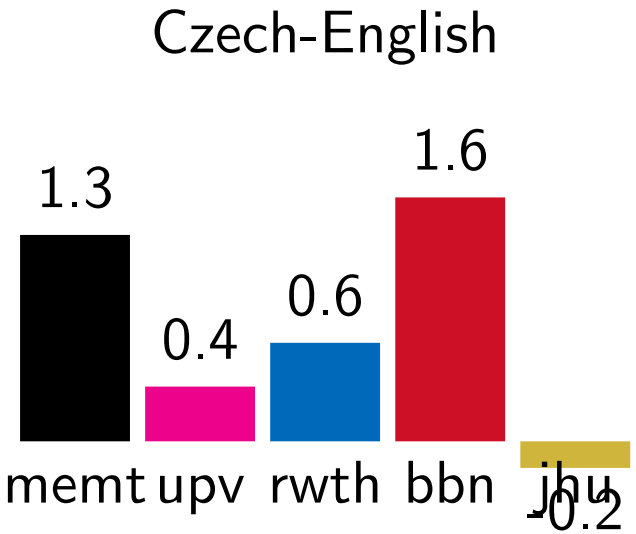


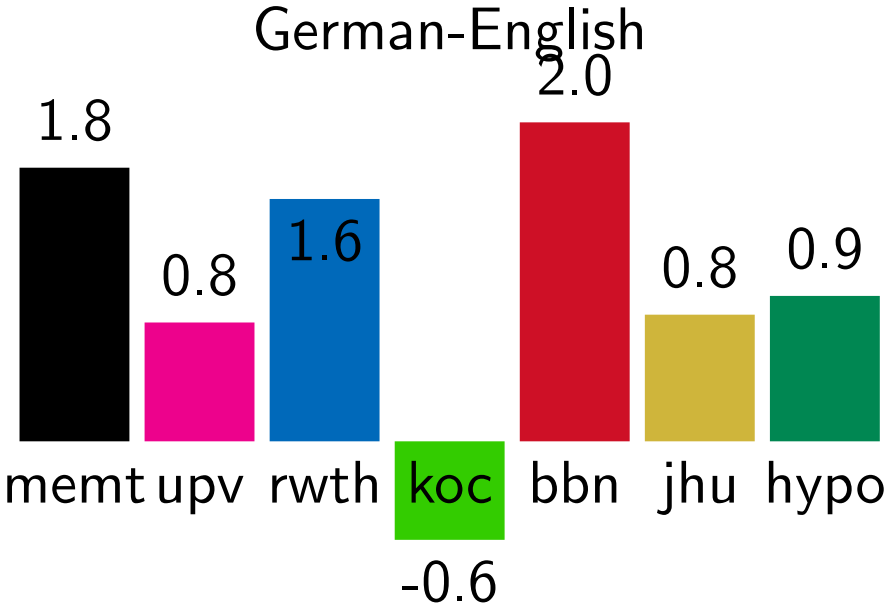
Input Comparison

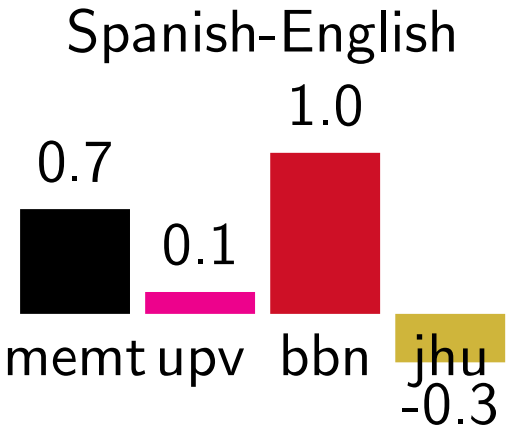
Input to System Combination

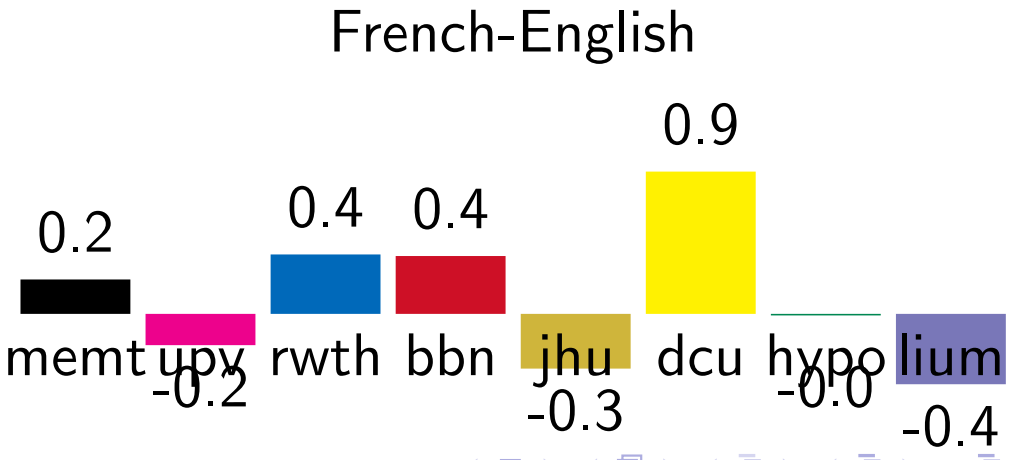
MBR	N-best list
Hyposel	N-best list
Confusion Networks	N-best list
MEMT	1-best
Model Combination	Hypergraph
Serial System Combination	Single output

Results Into English









Results From English