Learning from Multilingual Multimodal Data

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KØBENHAVNS UNIVERSITET

ERCIM
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amazon research awards

Machine translation works in practice ...

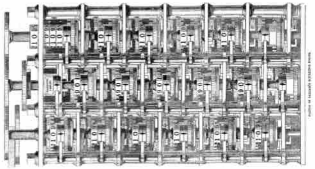
A baseball player in a black shirt just tagged a player in a white shirt.

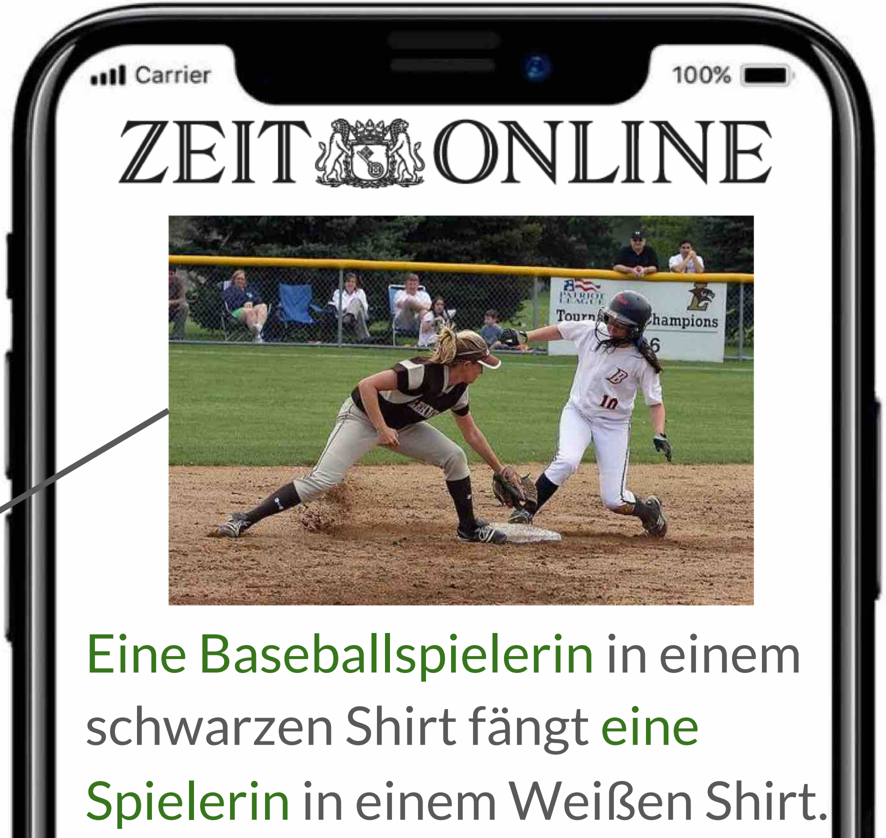
Ein Baseballspieler in einem schwarzen Shirt fängt einen Spieler in einem weißen Shirt.

Google
Translate

… but multimodality can help to resolve ambiguities

A baseball player in a black shirt just tagged a player in a white shirt.





Eine Baseballspielerin in einem schwarzen Shirt fängt eine Spielerin in einem Weißen Shirt.

Applications for Multilingual Multimodal Models

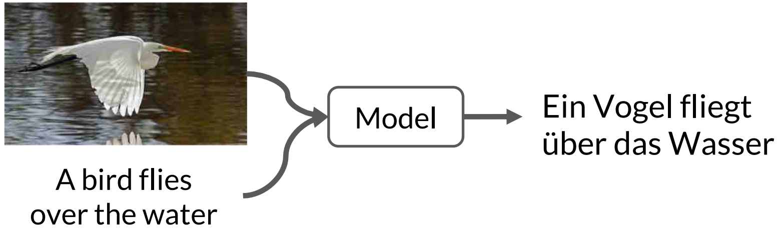
- Localised alt-text generation across the Web
- Image search and retrieval
- Audio described movies for more languages

The Danish flag flying against a cloudy sky

Det danske flag vajende mod en blå himmel

This talk

1. Multimodal machine translation

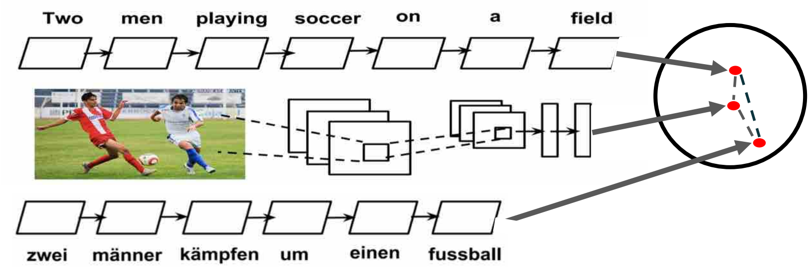


A bird flies
over the water

Model

Ein Vogel fliegt
über das Wasser

2. Multilingual image-sentence retrieval



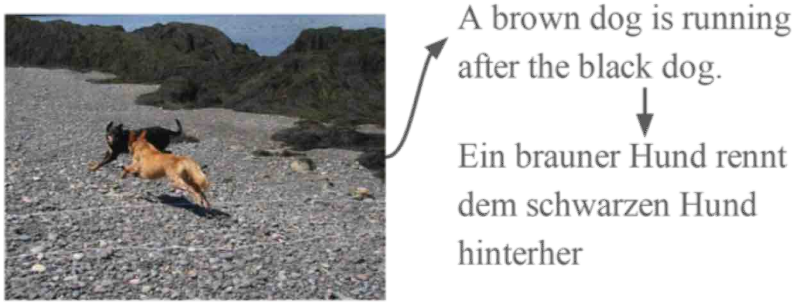
Multimodal machine translation

Elliott and Kádár.
Imagination Improves Multimodal Translation.
IJCNLP 2017

Elliott, Frank, Hasler (2015)

Problem Formulation

- Data ∈ (*x*, *y*, *v*):
  - ○ *x* is a description of image *v*
  - ○ *y* is a translation of *x*



A brown dog is running after the black dog.

↓

Ein brauner Hund rennt dem schwarzen Hund hinterher

- Task: Generate best $\hat{y}$, given *x* and *v*.
- Evaluation: Meteor (Denkowski and Lavie, 2014)

Decomposing Multimodal Translation

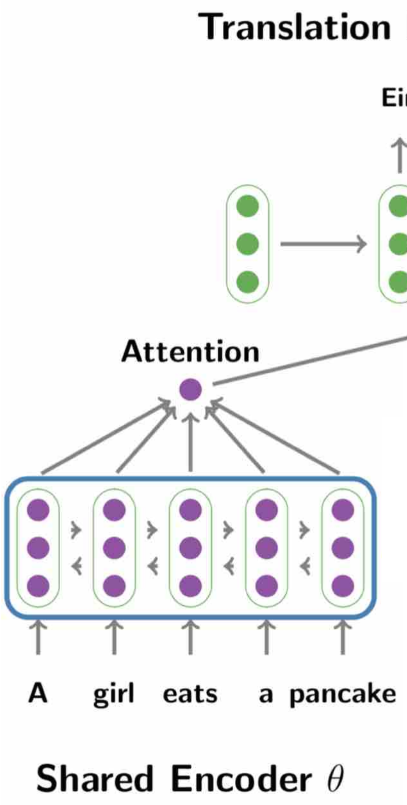
- Decompose the problem into two steps:

  1. Learning to translate: $J_T(\theta, \phi^t)$
  2. Learning to ground: $J_G(\theta, \phi^g)$

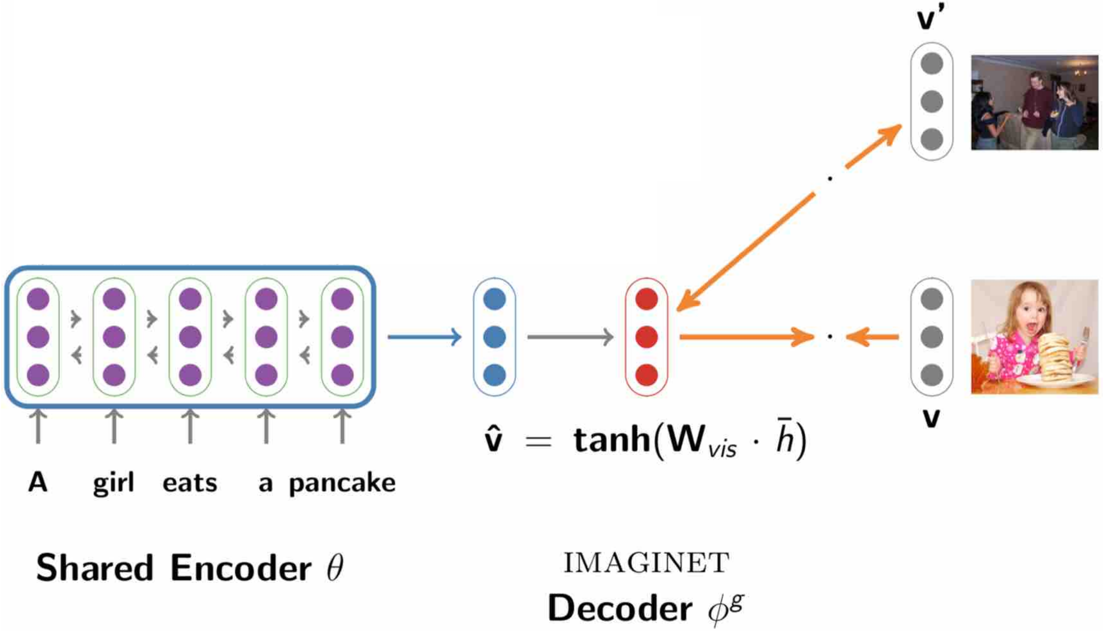
     → Use external resources for each problem

- Multitask learning shared parameters θ (Caruana, 1997)

Model: Learning to Translate: $J_T(\theta, \phi^t)$



Model: Learning to ground: $J_G(\theta, \phi^g)$



v’

v

$\hat{\mathbf{v}} = \mathbf{tanh}(\mathbf{W}_{vis} \cdot \bar{h})$

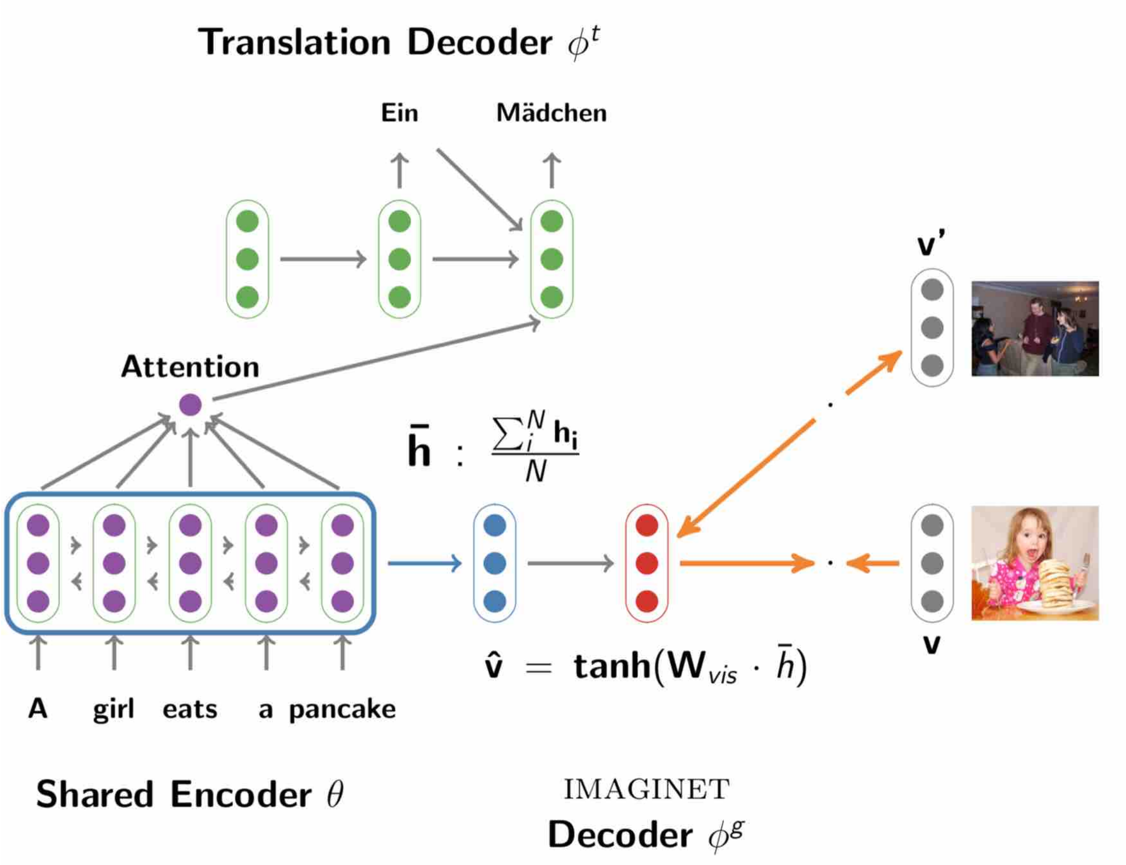
A girl eats a pancake

Shared Encoder θ

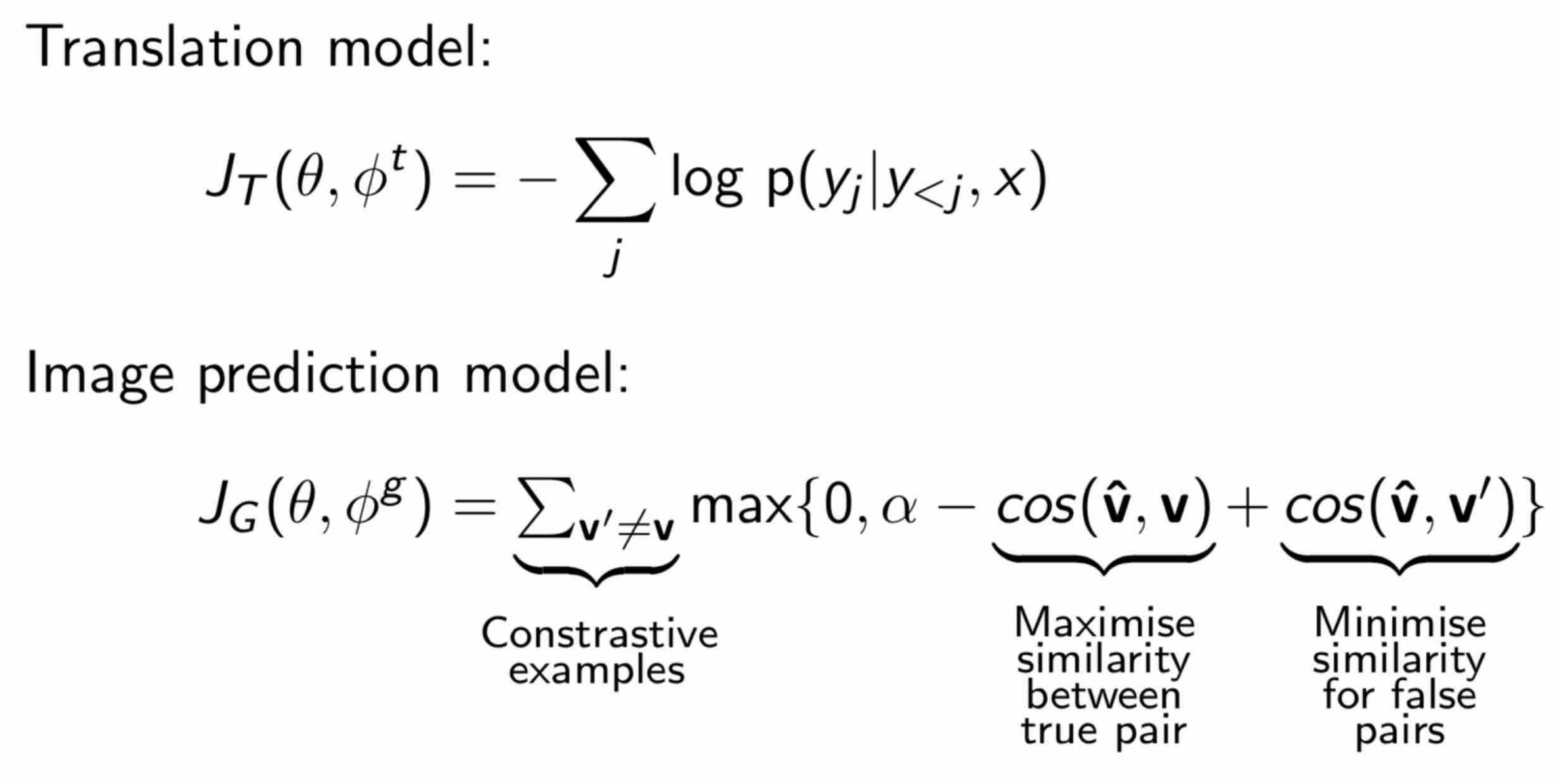
IMAGINET

Decoder ϕ^g

Multitask Learning Model


Translation Decoder ϕ^t
Ein
Mädchen
v'
Attention
$\bar{\mathbf{h}} : \frac{\sum_i^N \mathbf{h_i}}{N}$
v
$\hat{\mathbf{v}} = \mathbf{tanh}(\mathbf{W}_{vis} \cdot \bar{h})$
A
girl
eats
a
pancake
Shared Encoder θ
IMAGINET
Decoder ϕ^g

Objectives



Translation model:

$$J_T(\theta, \phi^t) = -\sum_j \log \mathrm{p}(y_j | y_{<j}, x)$$

Image prediction model:

$$J_G(\theta, \phi^g) = \underbrace{\textstyle\sum_{\mathbf{v}' \neq \mathbf{v}}}_{\text{Constrastive examples}} \max\{0, \alpha - \underbrace{cos(\hat{\mathbf{v}}, \mathbf{v})}_{\text{Maximise similarity between true pair}} + \underbrace{cos(\hat{\mathbf{v}}, \mathbf{v}')}_{\text{Minimise similarity for false pairs}}\}$$

Data: Multi30K

Elliott et al. (V&L 2016, WMT 2017)
Barrault et al. WMT 2018

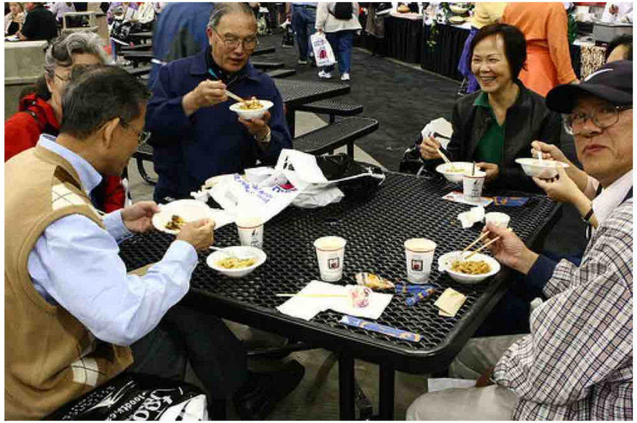
- 32K English-captioned images with German, French, and Czech translations

A group of people are eating noodles.

Eine Gruppe von Leuten isst Nudeln.

Un groupe de gens mangent des nouilles.

Skupina lidí jedí nudle.



Related Work

Models

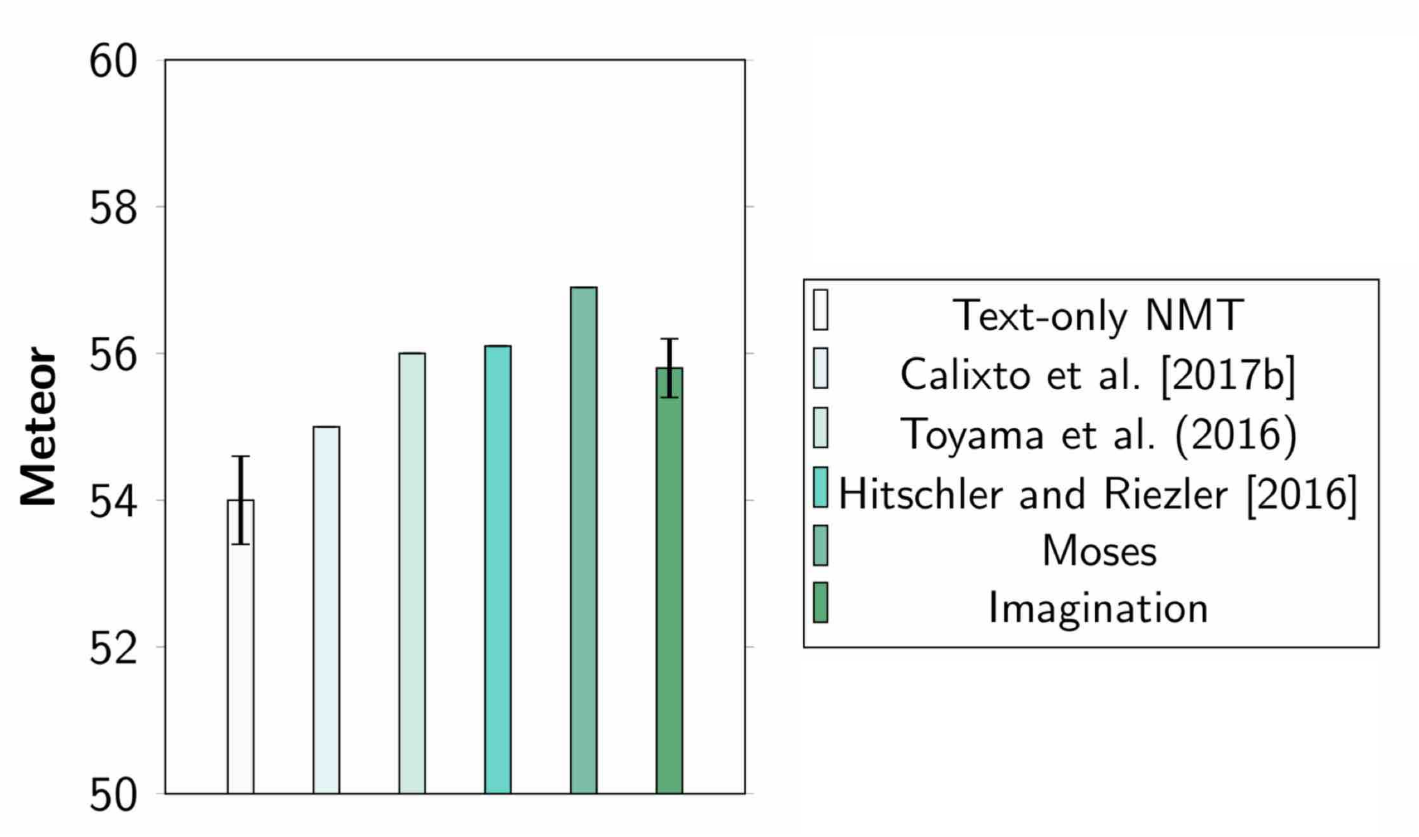
- Sentence-to-image prediction for word similarity and image retrieval (Chrupala et al. ACL 2015)
- Word-to-image prediction for word similarity and zero-shot image retrieval (Collell et al. AAAI 2017)
- Video description with video prediction and lexical entailment (Pasunuru and Bansal, EMNLP 2017)
- Related caption prediction and image prediction (Kiela et al. NAACL 2018)

Data

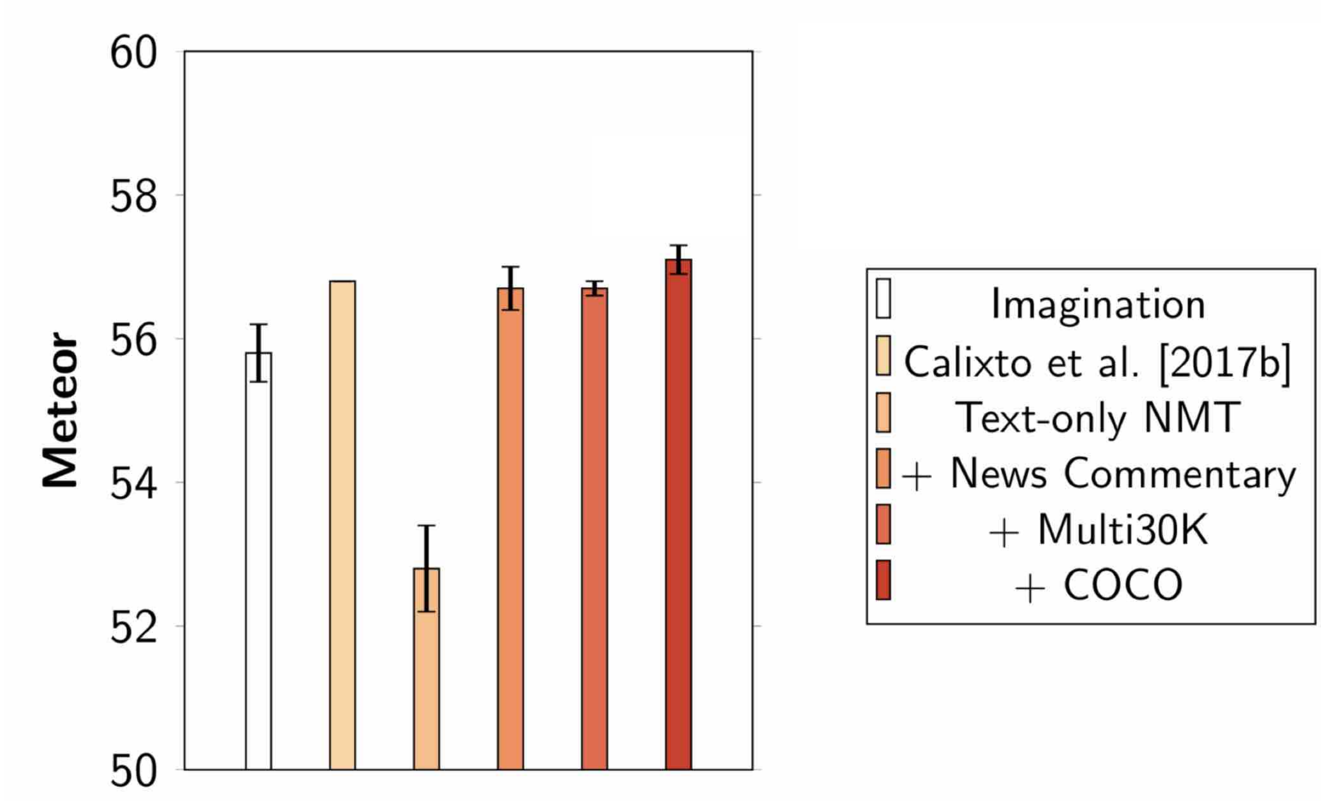
- Turkish Flickr8K (Unal et al. SIU 2016)
- Chinese Flickr8K (Li et al. MM 2016)
- Japanese extension of COCO (Yoshikawa et al. ACL 2017)
- How2: 300 hours of instructional videos with Portuguese translations (Sanabria et al. NeurIPS ViGIL 2018)

See Frank et al. (NLE 2018) for a more comprehensive overview of related datasets.

Image Prediction Improves Translation



Further Improvements with External Resources



Conclusions

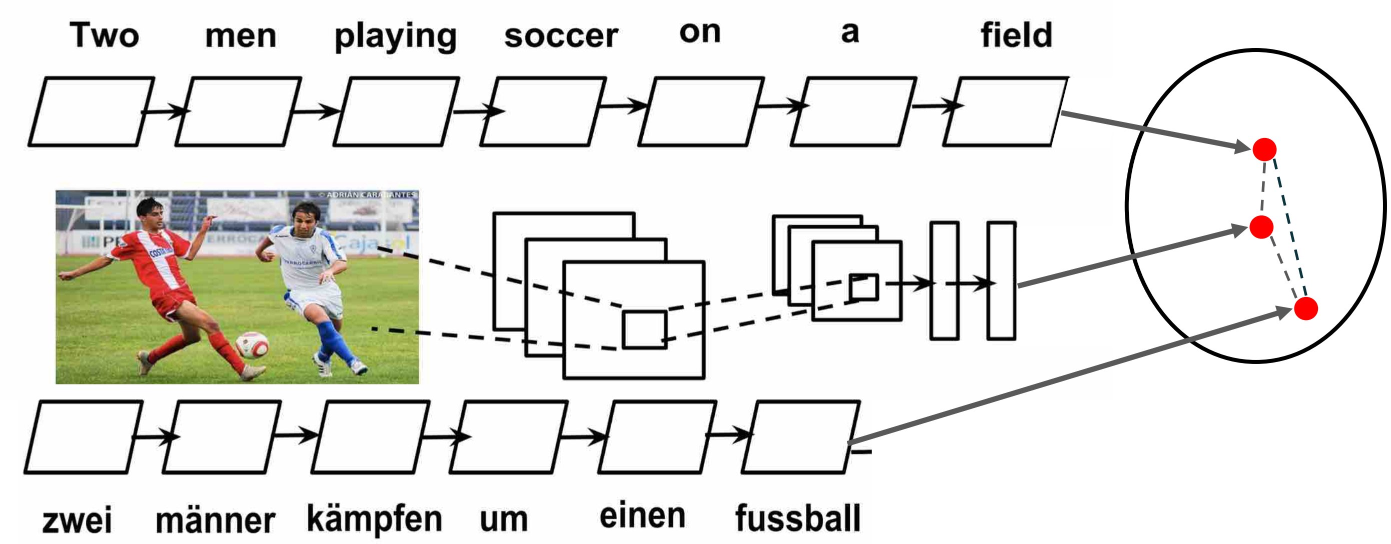
- Image representation prediction helps multimodal translation
- Easy to train with external data
  - Improvements with out-of-domain
    - Newswire parallel text
    - Crowdsourced described images

Multilingual image - sentence retrieval

Kádár, Elliott, Côté, Chrupała, Alishahi.
Lessons learned in multilingual grounded language learning.
CoNLL 2018

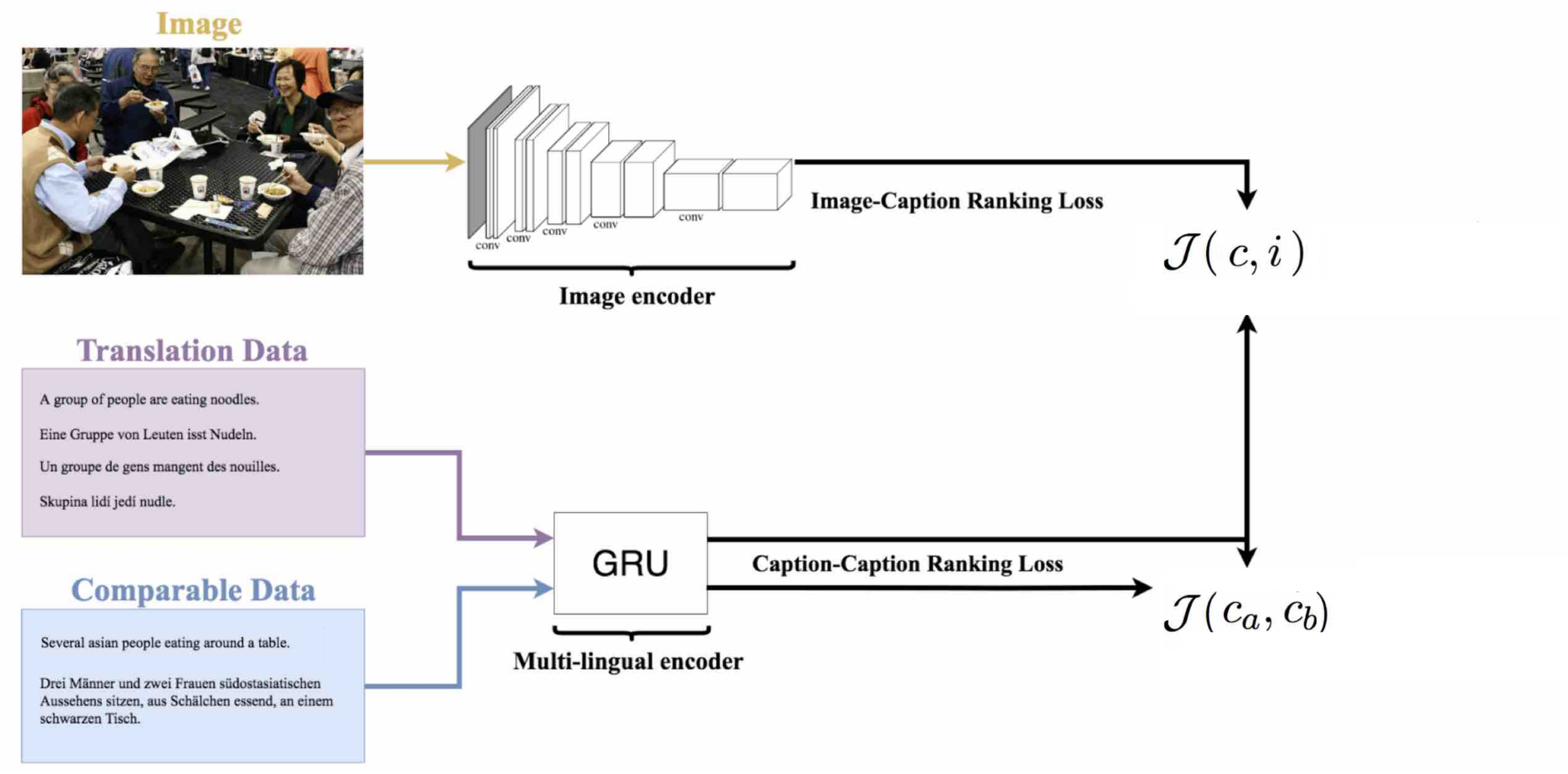
Problem Formulation

- Given an image, retrieve its sentence from a shared space (and vice-versa)
- Evaluation: Recall@K, Median Rank



Credit: Spandana Gella

Model (following Gella et al. 2017)



Image

conv conv conv conv conv

Image encoder

Image-Caption Ranking Loss

$\mathcal{J}(c, i)$

Translation Data

A group of people are eating noodles.

Eine Gruppe von Leuten isst Nudeln.

Un groupe de gens mangent des nouilles.

Skupina lidí jedí nudle.

Comparable Data

Several asian people eating around a table.

Drei Männer und zwei Frauen südostasiatischen Aussehens sitzen, aus Schälchen essend, an einem schwarzen Tisch.

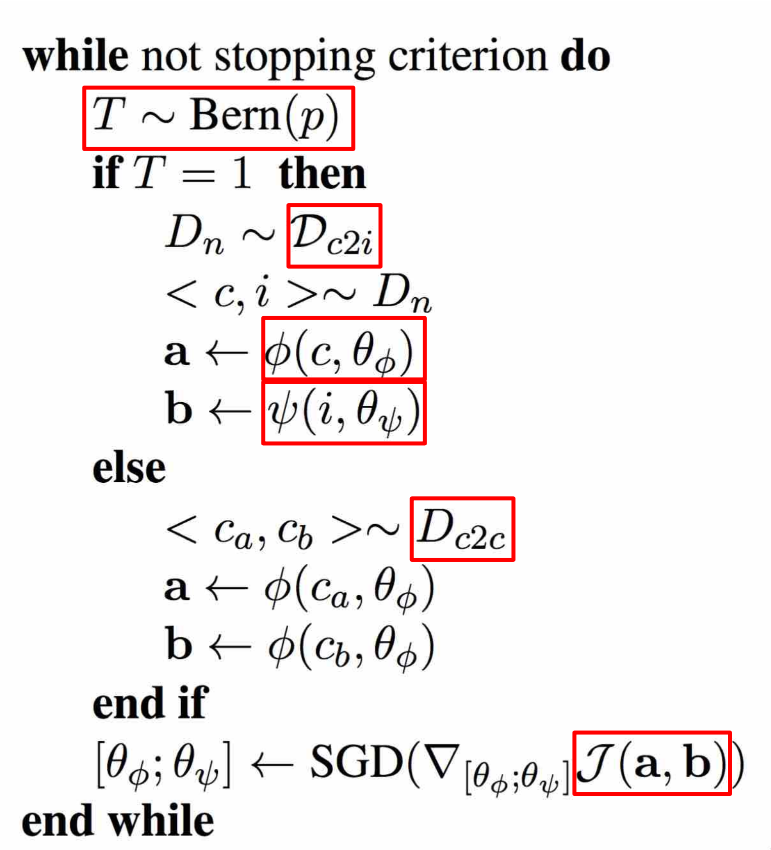
GRU

Multi-lingual encoder

Caption-Caption Ranking Loss

$\mathcal{J}(c_a, c_b)$

Training



```
while not stopping criterion do
    $\boxed{T \sim \text{Bern}(p)}$
    if $T = 1$ then
        $D_n \sim \boxed{\mathcal{D}_{c2i}}$
        $< c, i >\sim D_n$
        $\mathbf{a} \leftarrow \boxed{\phi(c, \theta_\phi)}$
        $\mathbf{b} \leftarrow \boxed{\psi(i, \theta_\psi)}$
    else
        $< c_a, c_b >\sim \boxed{D_{c2c}}$
        $\mathbf{a} \leftarrow \phi(c_a, \theta_\phi)$
        $\mathbf{b} \leftarrow \phi(c_b, \theta_\phi)$
    end if
    $[\theta_\phi; \theta_\psi] \leftarrow \text{SGD}(\nabla_{[\theta_\phi;\theta_\psi]} \boxed{\mathcal{J}(\mathbf{a}, \mathbf{b})})$
end while
```

- Choose a task *T*
- $\mathcal{D}_{c2i}$: image--caption datasets
- $\phi(c, \theta_\phi)$: sentence encoder
- $\psi(i, \theta_\phi)$: image encoder
- D_{c2c}: caption--caption datasets

Gella et al. (EMNLP 2017)

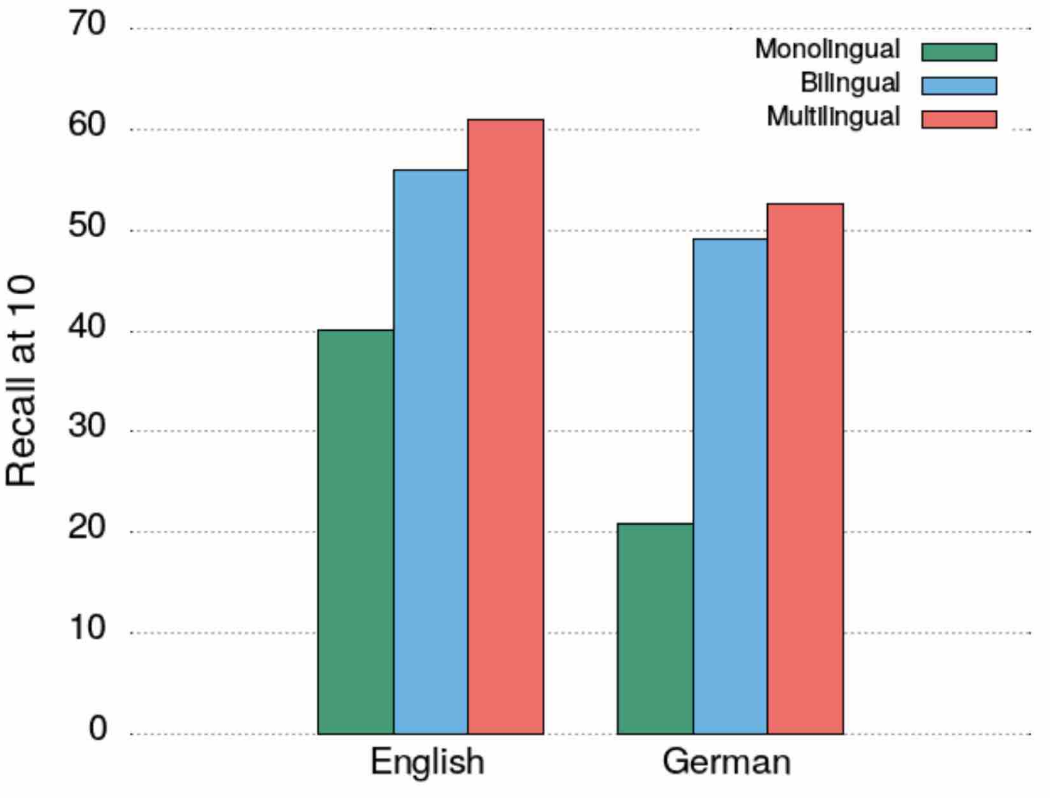
- $\mathcal{J}(\mathbf{a}, \mathbf{b})$: $\max_{c'} \left[\alpha + s(i, c') - s(i, c)\right]_+ + \max_{i'} \left[\alpha + s(i', c) - s(i, c)\right]_+$

Faghri et al. (BMVC 2018)

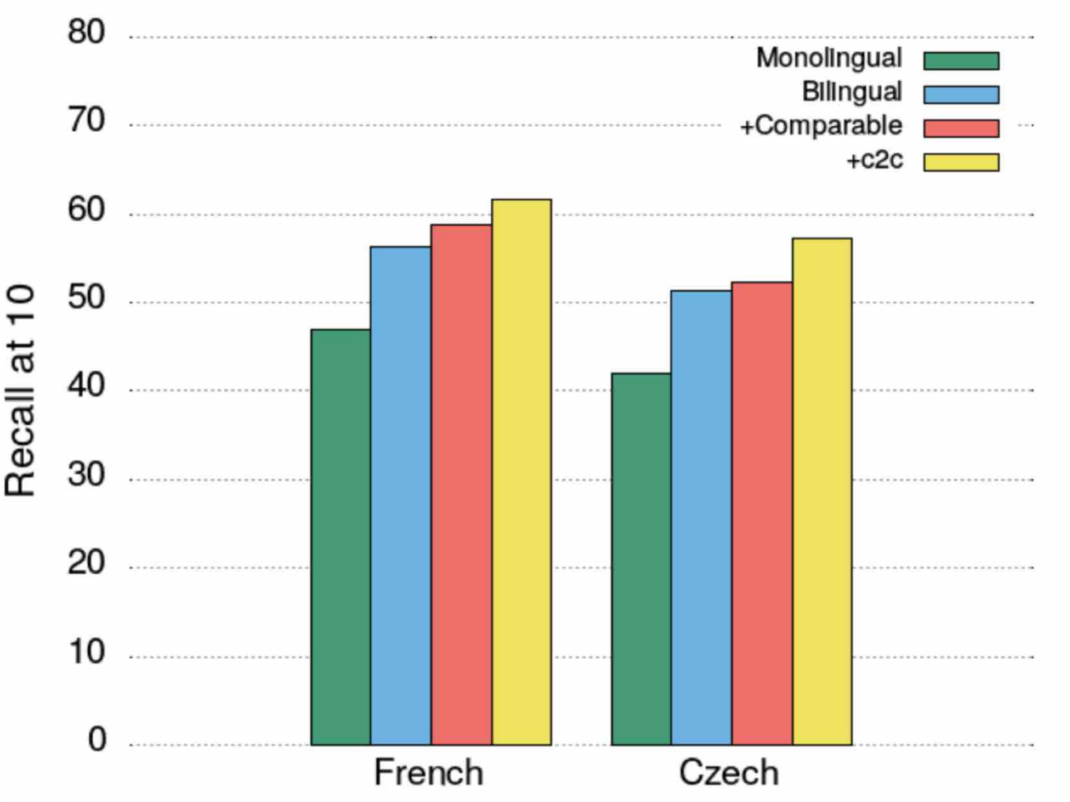
Related Work

- Image—sentence ranking with KCCA (Hodosh et al. JAIR 2013)
- Ranking with dependency tree recursive neural nets (Socher et al. TACL 2014)
- Order-embeddings for ranking (Kiros et al. ICLR 2015)
- Bilingual ranking with caption—caption objective (Gella et al. EMNLP 2017)
- Max-of-hinges training for ranking models (Faghri et al. BMVC 2018)

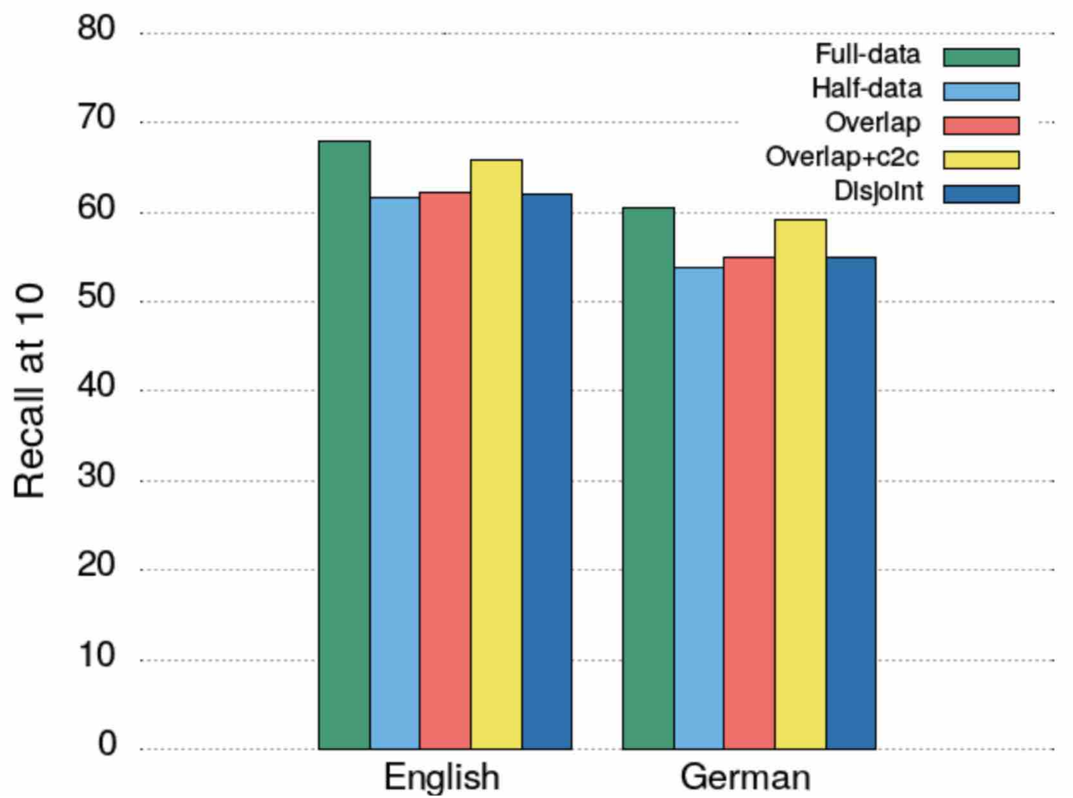
Multilingual data improves image retrieval



High-to-low resource transfer with multilingual data



Controlling for data exposure



Conclusions

- Multilingual data improves the ranking model
- Improvements also hold for “low-resource” settings
- Mixed results when controlling for data exposure

Summary

- Two ways of looking at multilingual and multimodal data
  - Retrieval task: *multilinguality* is useful
  - Translation task: *multimodality* is useful
- Both models benefited from learning to solve multiple tasks

Open Problems

- Data: need larger (more naturally occurring) multimodal datasets
- Ranking: how can our models exploit disjoint datasets?
- Translation: how can we show the value of the visual data?

Why does MTL help for translation?

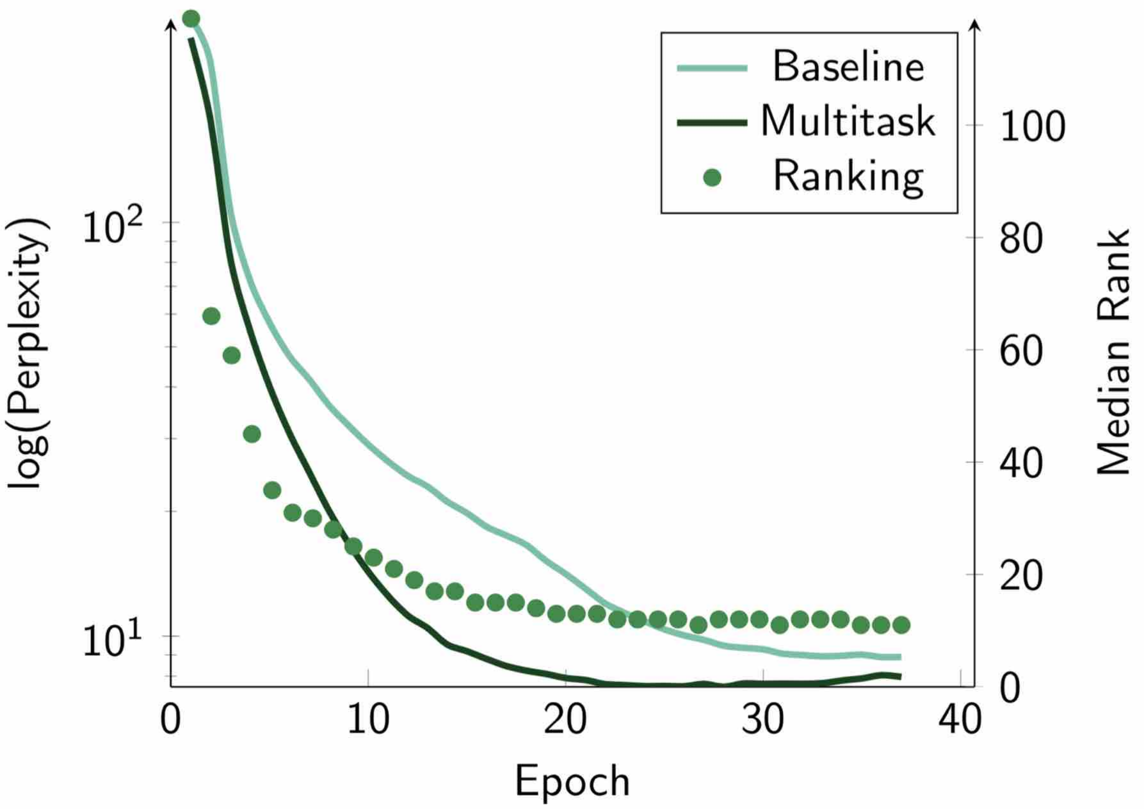
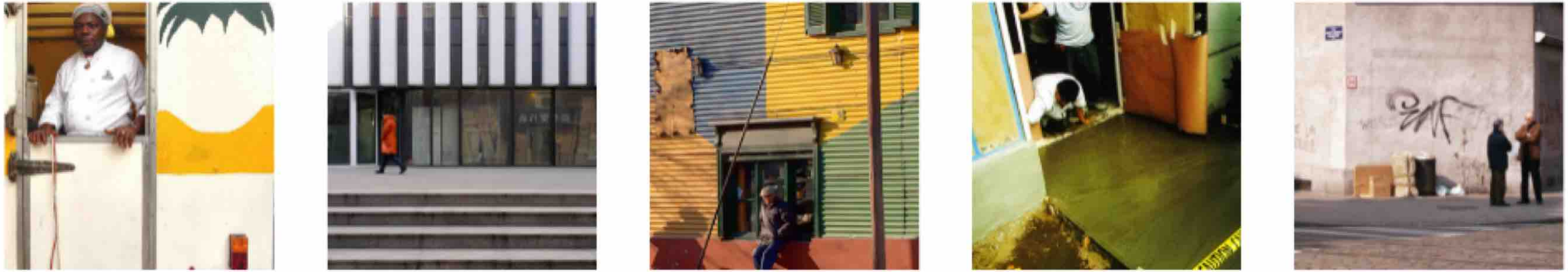
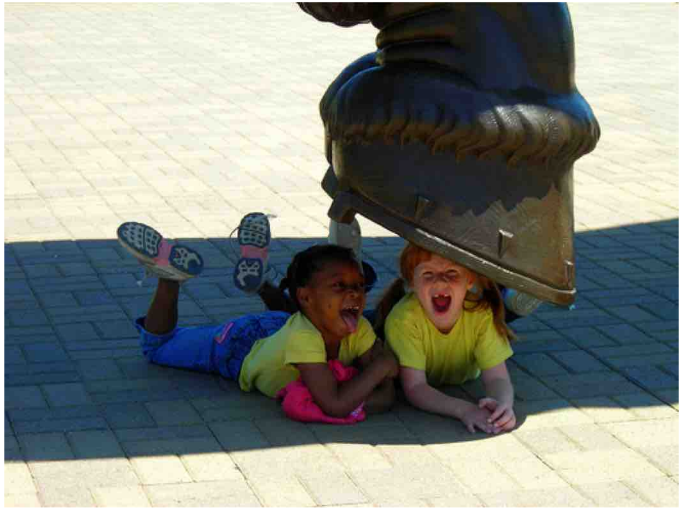


Image Prediction Visualisation

“there is a cafe on the street corner with an oval painting on the side of the building .”



Improved prepositional phrase translation



Two children on their stomachs lay on the ground under a pipe

Zwei Kinder auf ihren Gesichtern liegen unter dem Boden auf dem Boden

Zwei Kinder liegen Bäuchlings auf dem Boden unter einer Schaukel

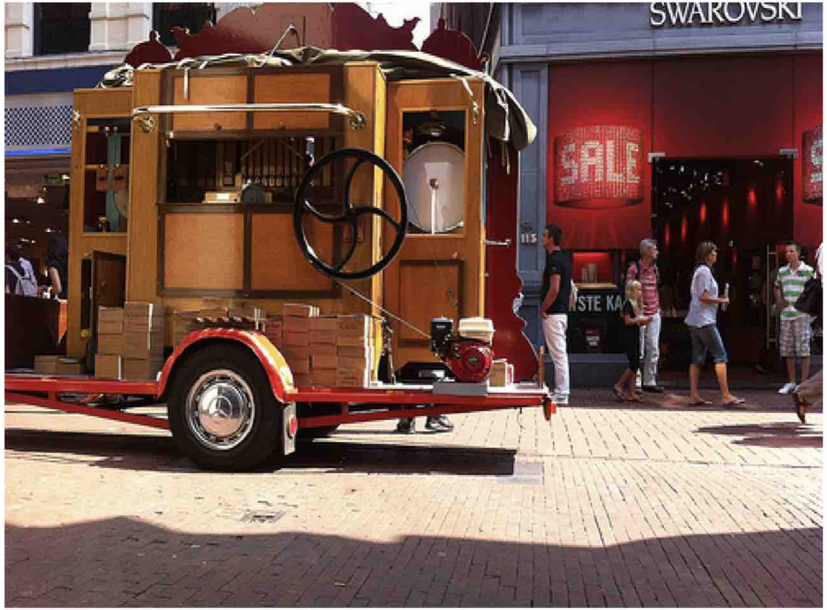
Worse preposition selection

A bird flies across the water

Ein Vogel fliegt über das Wasser

Ein Vogel fliegt durch das Wasser

Data: translation won’t always work



“draaiorgel”

- A **yellow truck** is standing on a busy street in front of the Swarovski store.
- A **strange looking wood trailer** is parked in a street in front of stores.
- An **unusual looking vehicle** parked in front of some stores.

van Miltenburg et al. INLG 2017