Segment-Phrase Table for Semantic Segmentation, Visual Entailment and Paraphrasing

Hamid Izadinia, Fereshteh Sadeghi,
Santosh K. Divvala, Hannaneh Hajishirzi,
Yejin Choi, Ali Farhadi

Presentated by Edward Banner

Outline

- What is a SPT?
- Motivation: What does a SPT enable us to do?
- How to build a SPT?
- How to make use of a SPT?
- Evaluation
- Discussion

What is a segment-phrase table?

One to many mapping from phrases
to segmentation models

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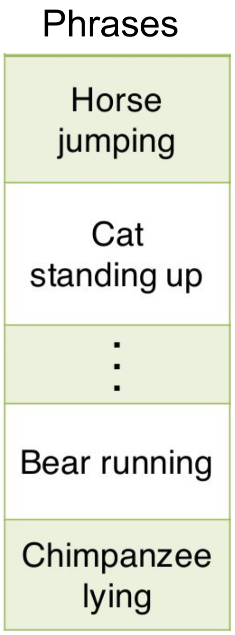

Phrases
Horse jumping
Cat standing up
⋮
Bear running
Chimpanzee lying

Image credit: Izadinia et al.

What is a segment-phrase table?

One to many mapping from phrases to segmentation models

Phrases	Segments
Horse jumping	
Cat standing up	
⋮	⋮
Bear running	
Chimpanzee lying	

Image credit: Izadinia et al.

Why build a segment-phrase table?

Many reasons!

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Entailment

If a horse is **grazing**, is it also **standing**?

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Entailment

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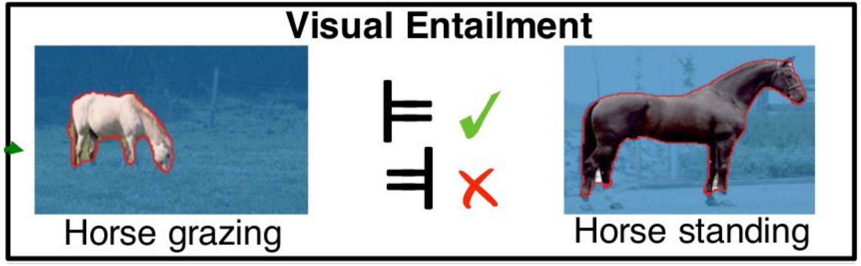

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Paraphrasing

Are “horse **jumping**” and “horse **leaping**” paraphrases of each other?

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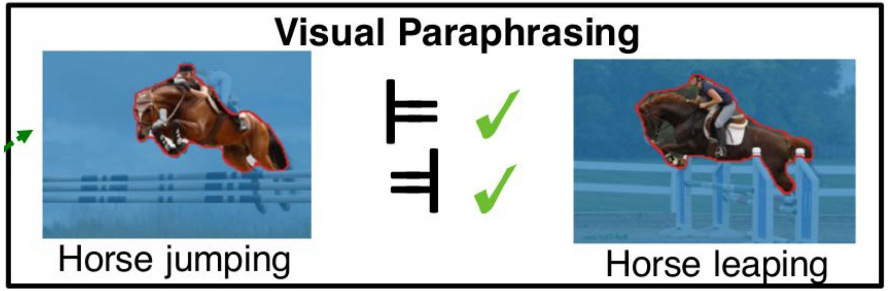

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Relative similarity

Is “**cat standing up**” closer to “**bear standing up**” or “**deer standing up**”?

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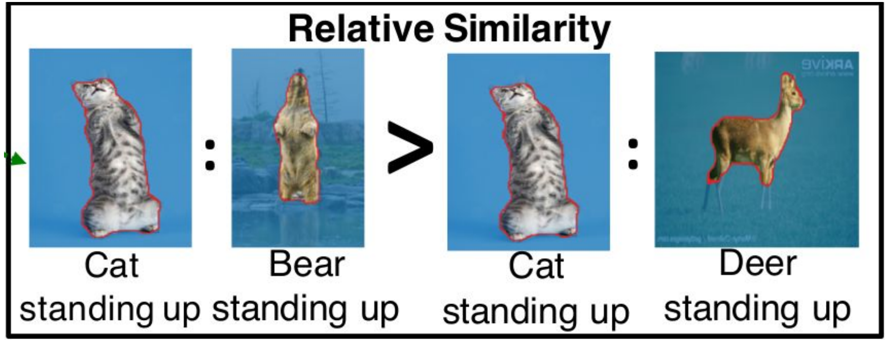

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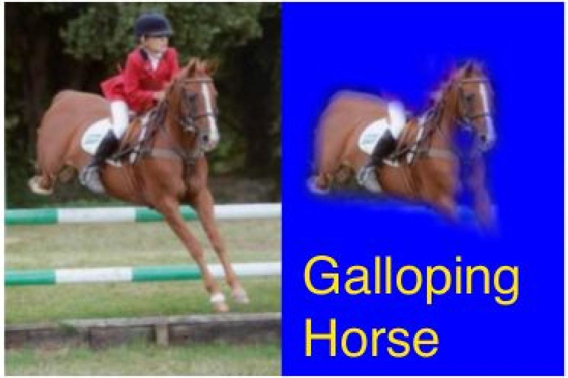
Why build a segment-phrase table?

Semantic segmentation



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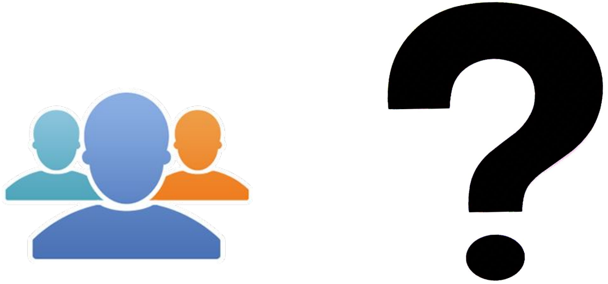
Considerations in building segment-phrase table

Human annotators?



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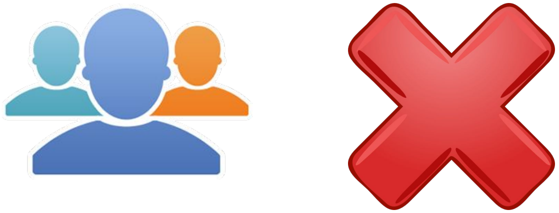


Too **expensive** to obtain human-labeled pixel labels

Opt instead for **weakly-supervised** approach instead

How do they build it?

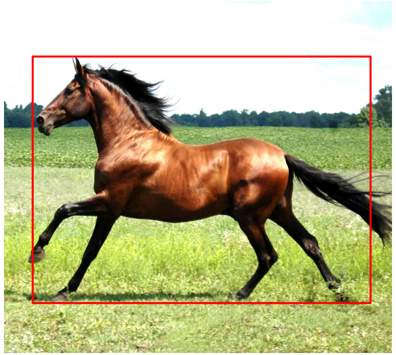
Three components:

1. Train a webly-supervised **detection model** *for each phrase*
2. Model each phrase as a **deformable parts model**
3. Learn **segmentation model** for each part

How do they build it?

1. Train a webly-supervised **detection model** *for each phrase*

e.g. **running horse**



How do they build it?

2. Model each phrase as a **deformable parts model**

Concerned about intra-class variation?

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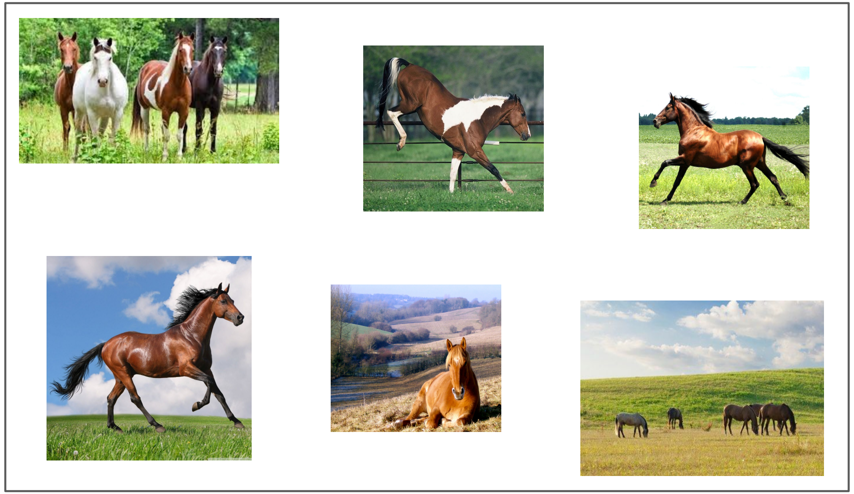
Concerned about intra-class variation?

Key insight: parts of phrases have low intra-class variation

horse



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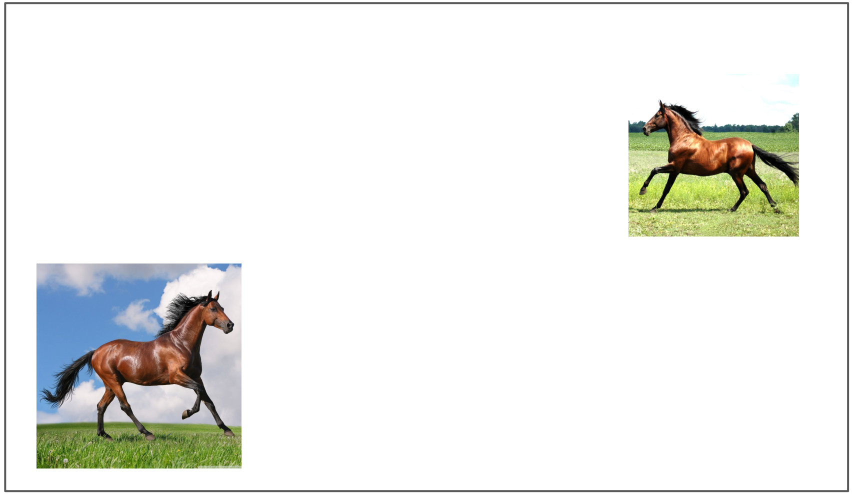

How do they build it?

$$E(\mathbf{x}) = \sum_{i \in V} u_i(x_i) + \sum_{(i,j) \in E} v_{ij}(x_i, x_j)$$

3. Learn **segmentation model** $\theta_c^{fg}, \theta_c^{bg}$ for each part

Model superpixels with GMM and solve with EM and Graphcut

Rough initialization with Grabcut and HOG root filter

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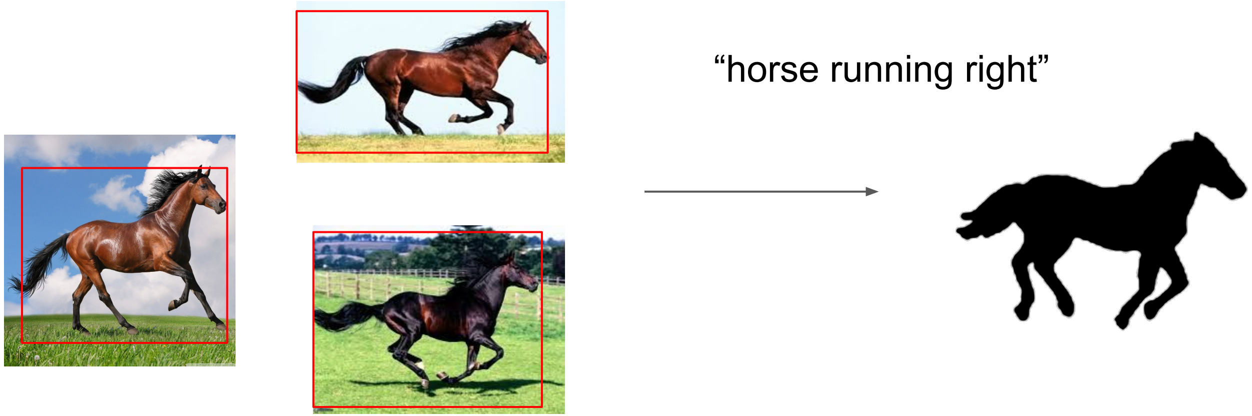


“horse running right”

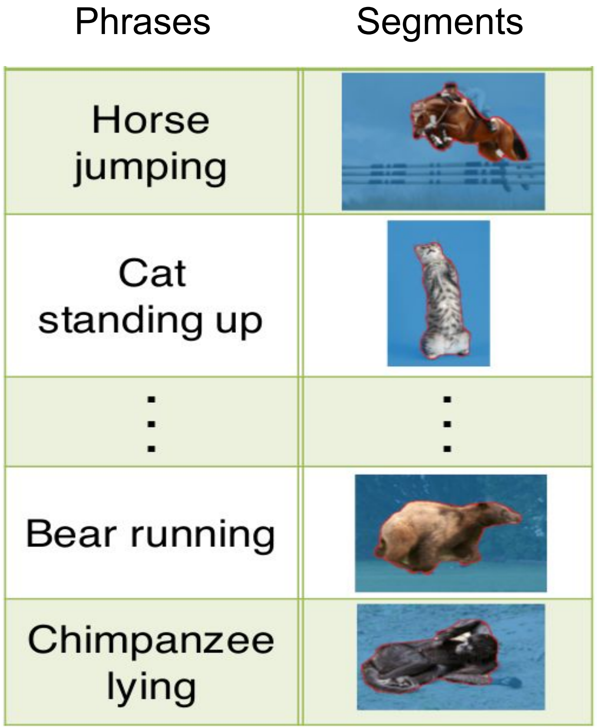
Segment-phrase table built

Results:

For each phrase, we have learned:

- Bounding box detector
- Segmentation model for each part

What can we do now?



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Semantic segmentation

Example: “horse”

Test image

Image credit: Izadinia et al.

Semantic segmentation

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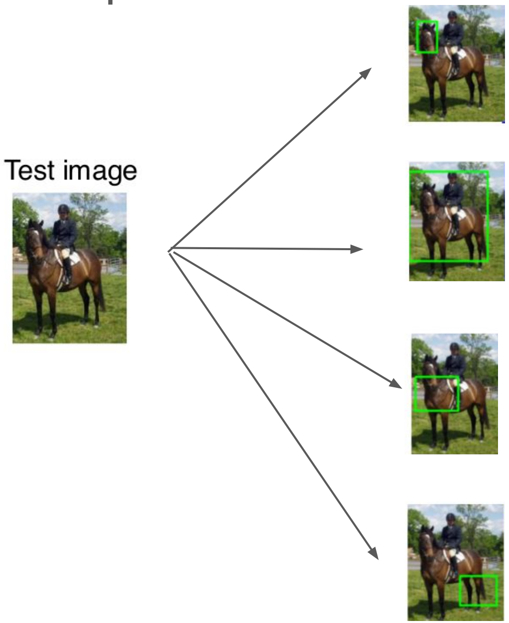

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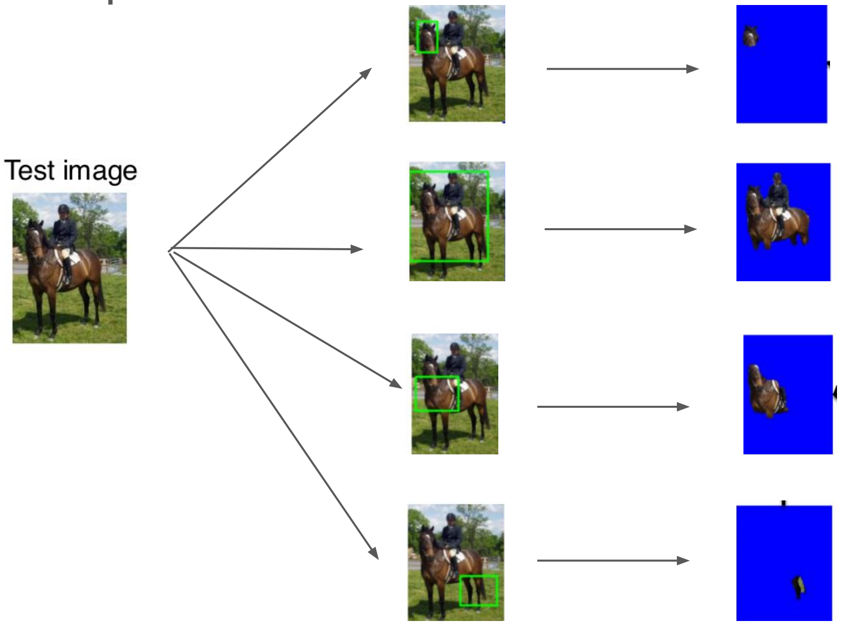

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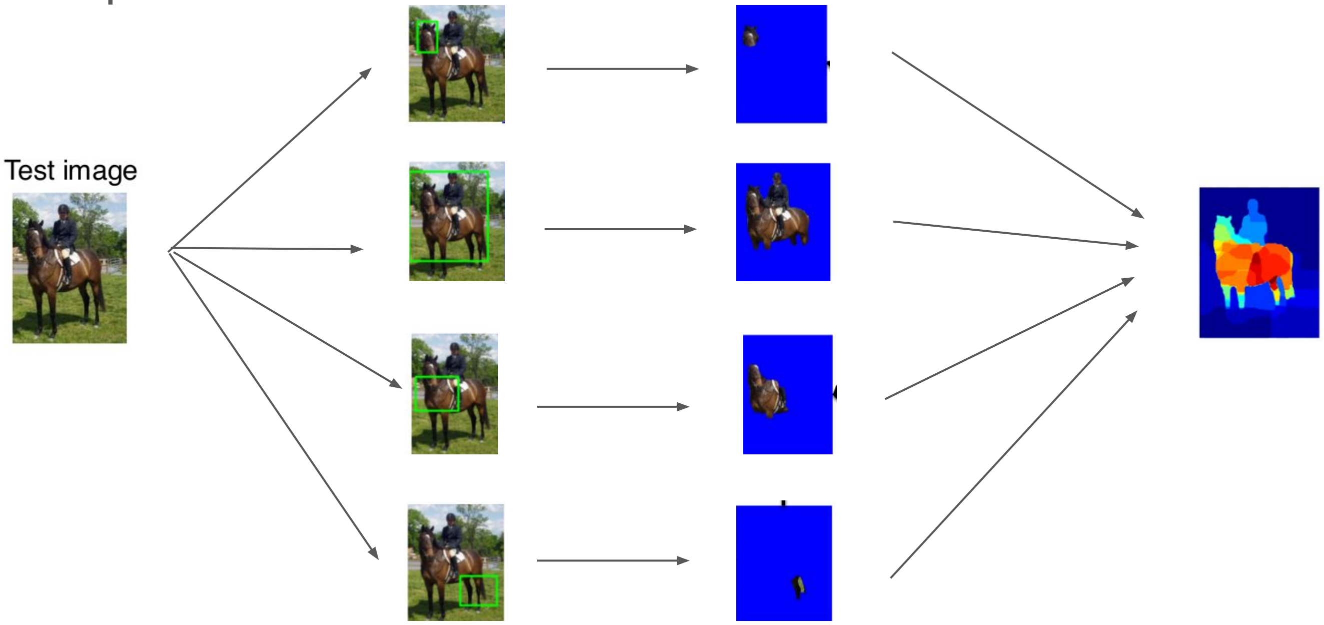

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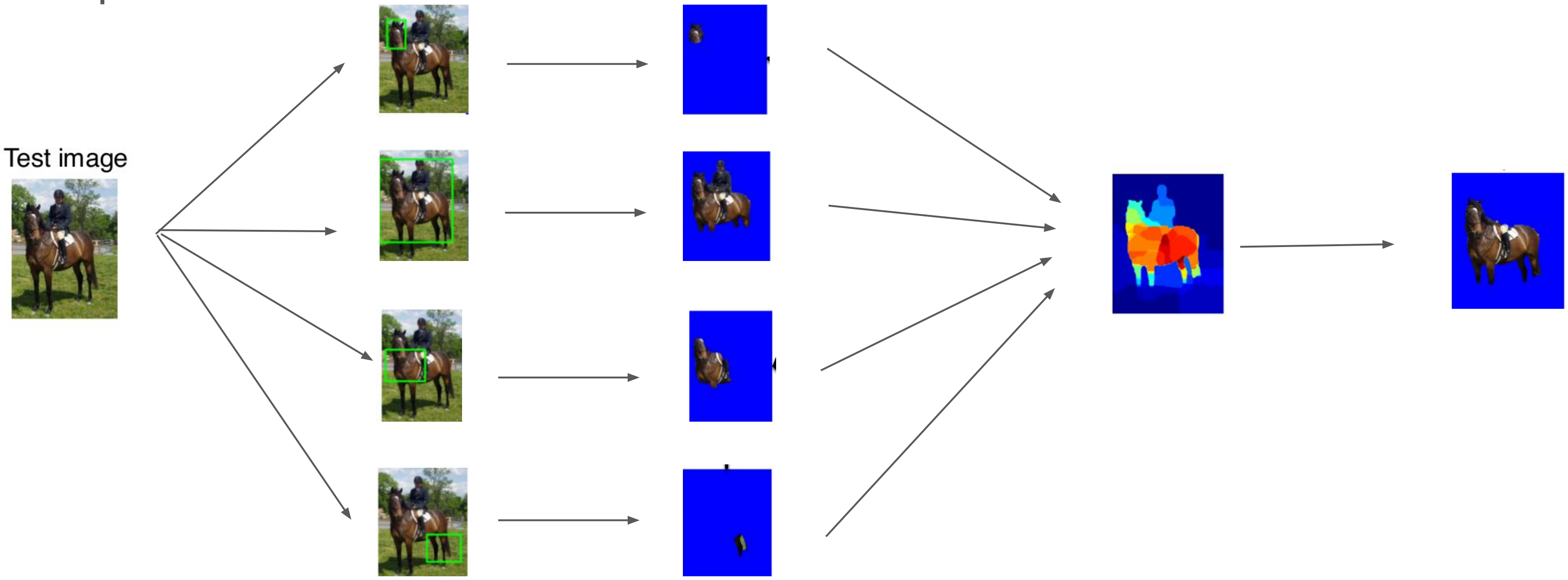

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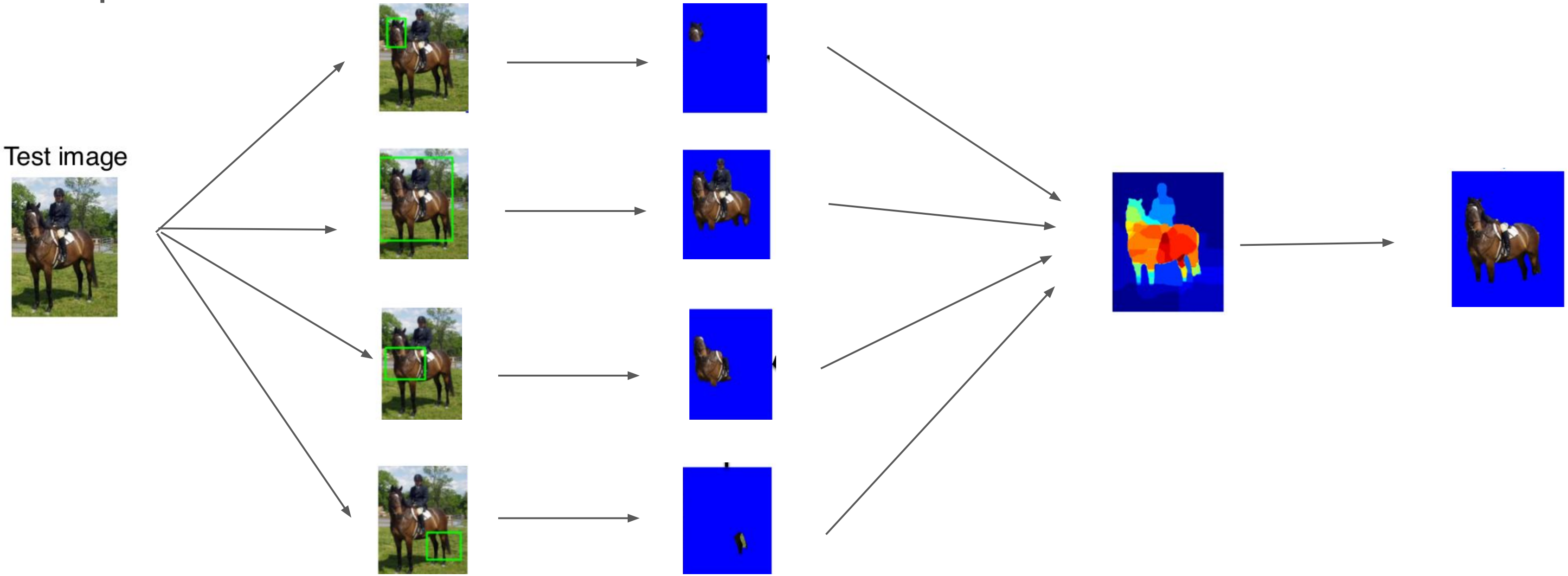
Semantic segmentation *using linguistic constraints*

Example: “horse”



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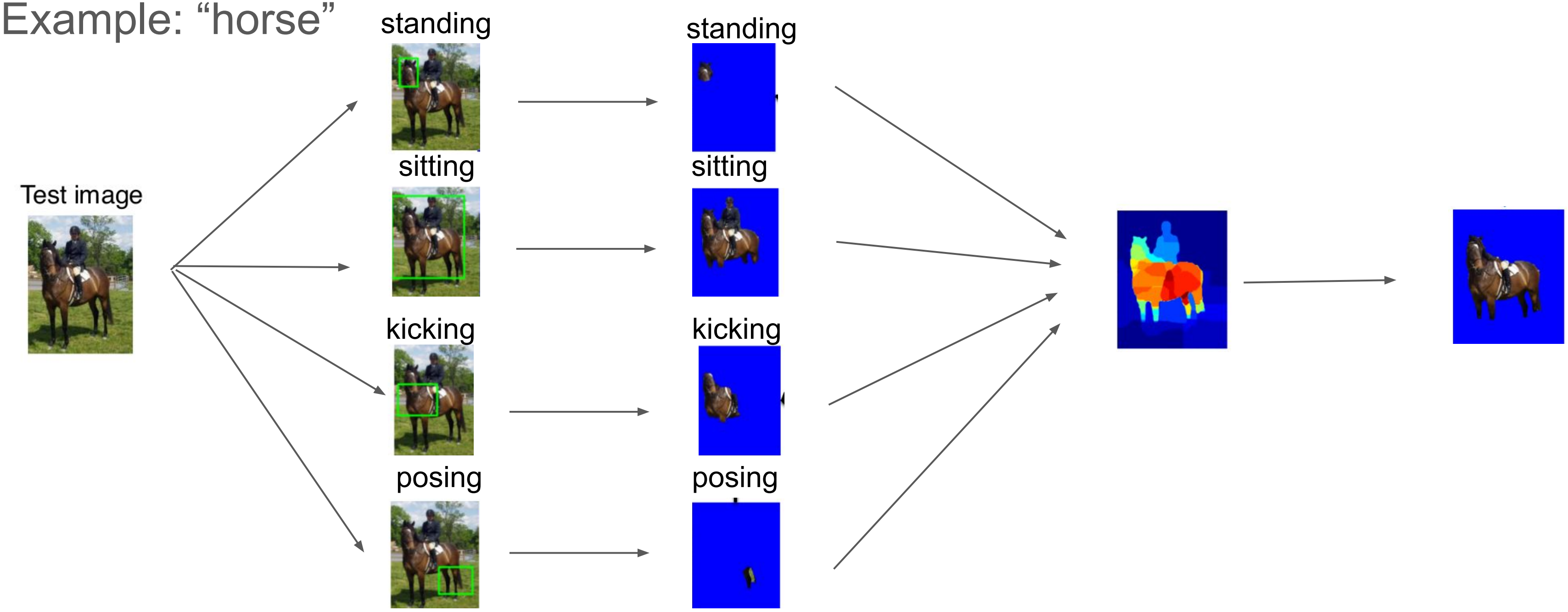

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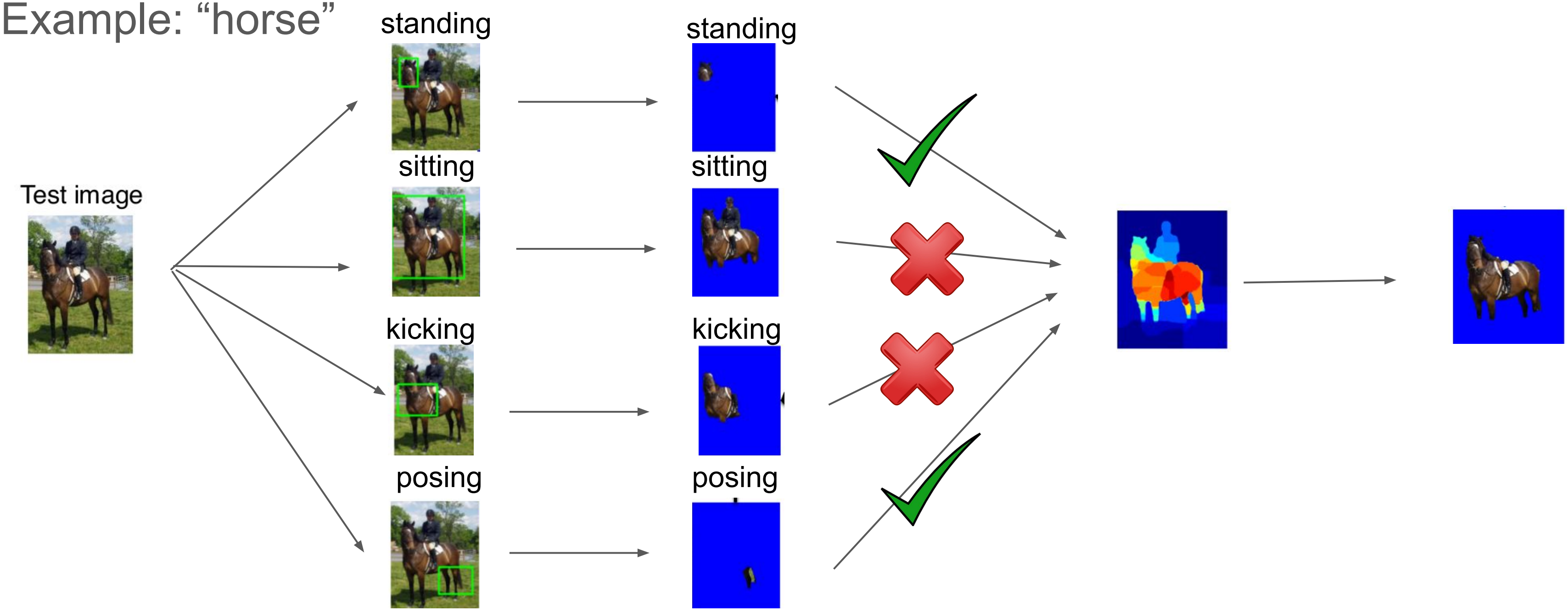

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Entailment

$$\text{entail}(X \vDash Y) := Sim_{\overrightarrow{R2I}}(X, Y) - Sim_{\overrightarrow{R2I}}(Y, X),$$

Does phrase X entail phrase Y?

Intuition: All segments for which phrase X
is a valid description, then phrase Y is also a valid description

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horse grazing

horse standing

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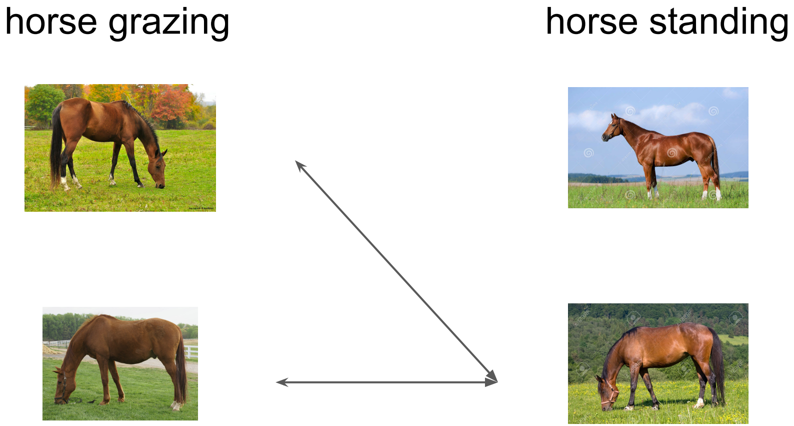
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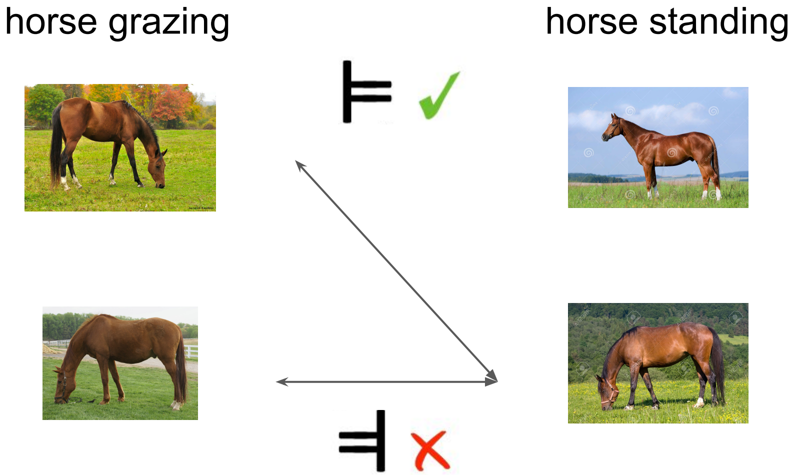

horse grazing

horse standing

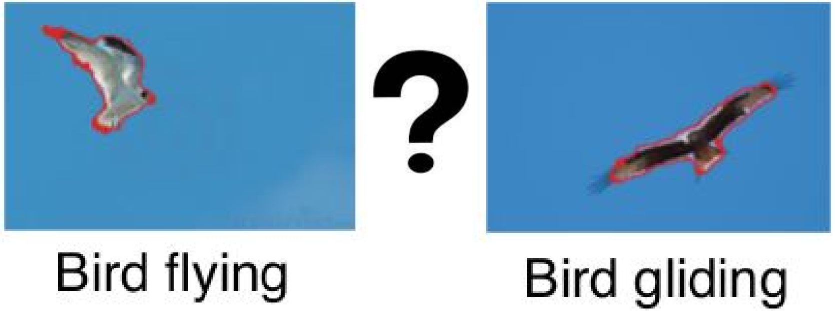
⊨ ✓

⫤ ✗

Paraphrasing

Are phrase X and phrase Y paraphrases of each other?

Strategy: compute X ⊨ Y and Y ⊨ X and say they're paraphrases if they're close



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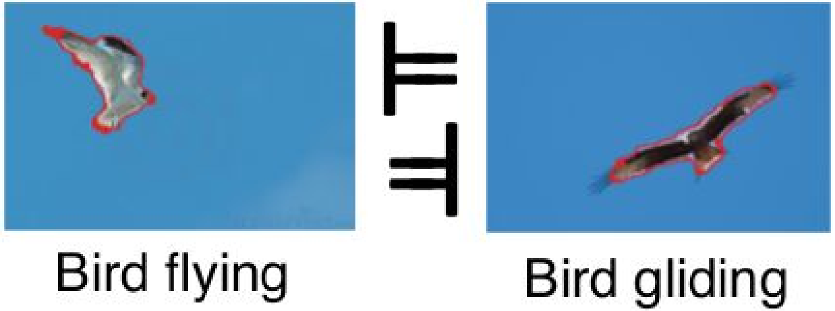

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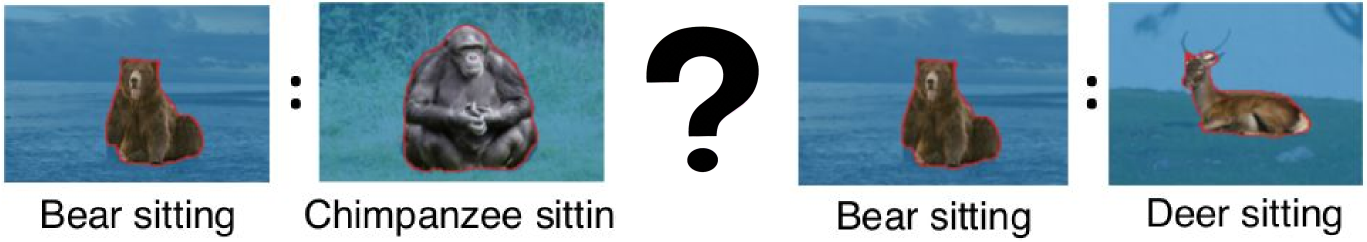
Relative Semantic Similarity

Is phrase X closer to phrase Y or phrase Z?

Strategy: compute $X \models Y$ and $X \models Z$ and pick highest number of the two



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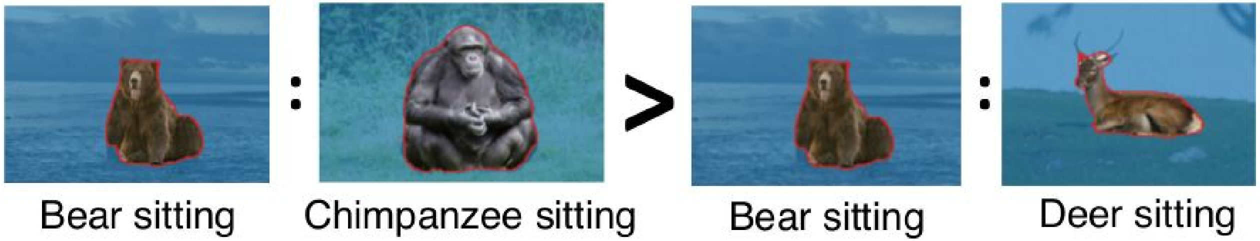

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Evaluation - Takeaways

Semantic segmentation state of the art or near it

Highlights tradeoffs between unsupervised approach on large data and supervised approaches on small dataset

Linguistic constraints help semantic segmentation

SPT approach beats language-only and vision-only baselines on entailment, paraphrasing, and relative similarity

Discussion

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Leverage supervision

Variable number of part models per phrase

Larger evaluation dataset

Comparison against state-of-the-art entailment and paraphrase systems