Information structure prediction for visual-world referring expressions

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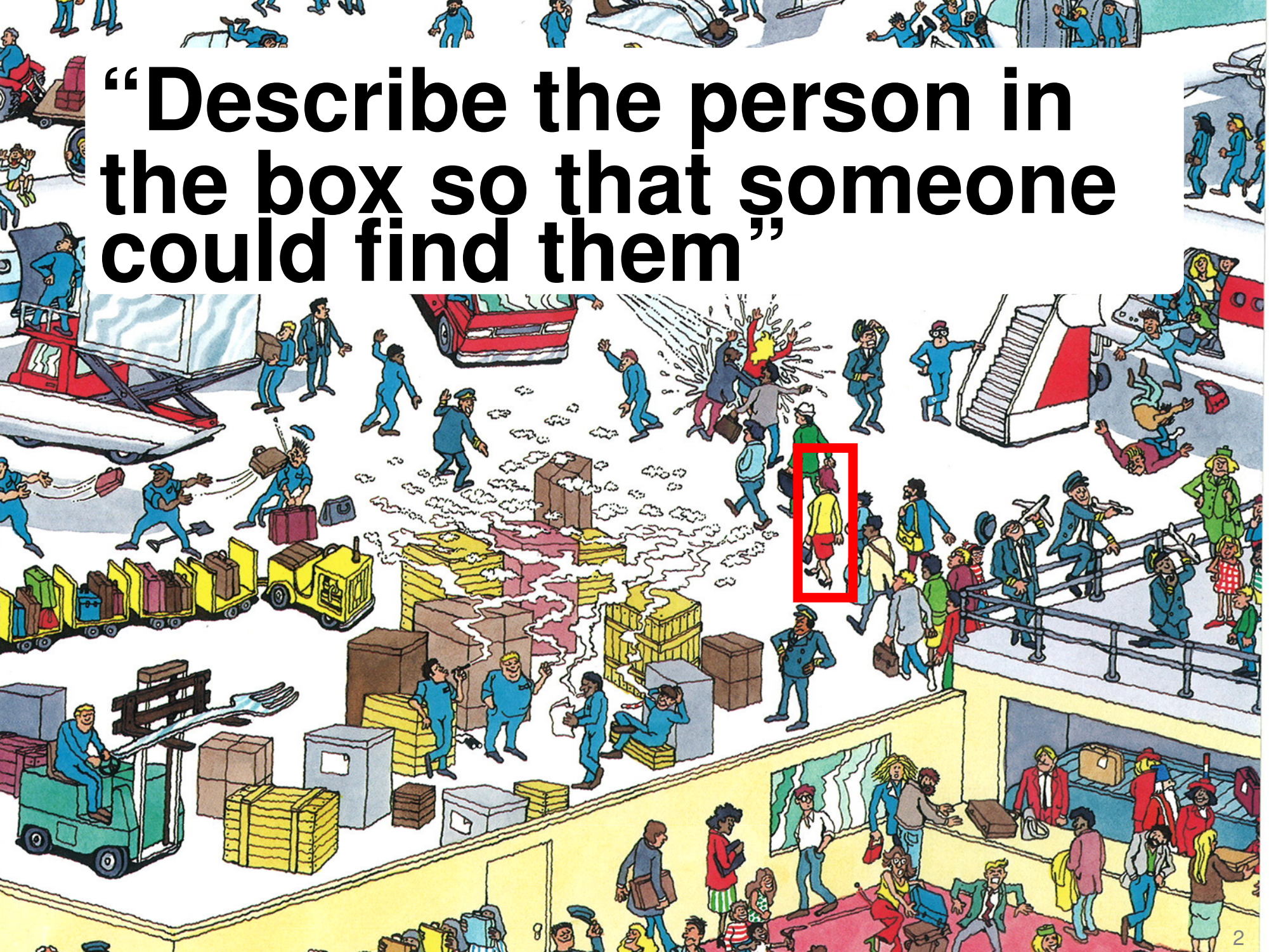
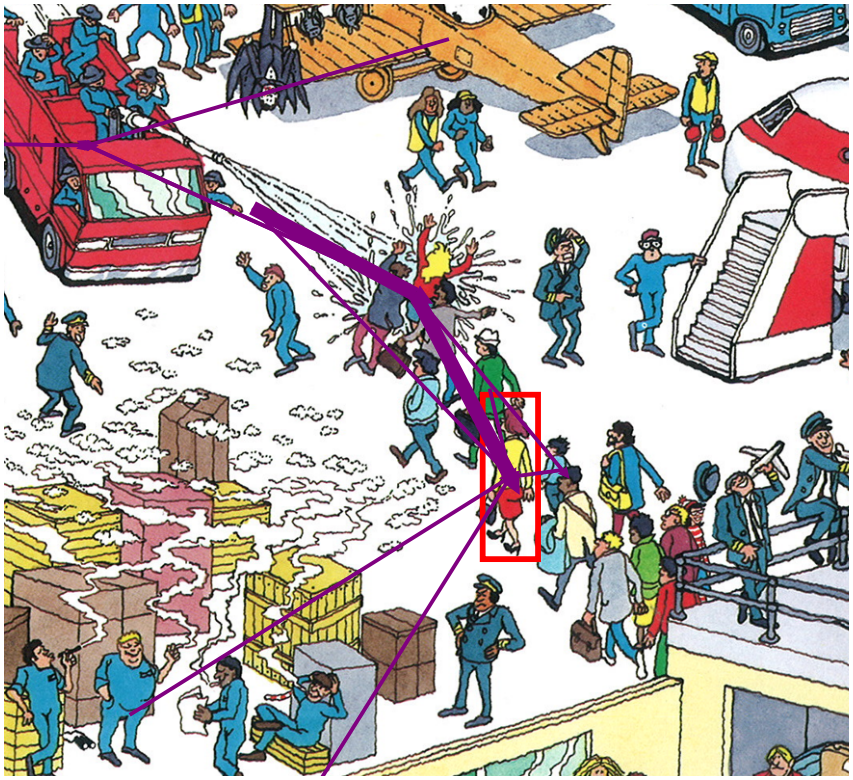
“Describe the person in the box so that someone could find them”



- To the right of the men smoking a woman wearing a yellow top and red skirt.
- woman in yellow shirt, red skirt in the queue leaving the building
- the woman in a yellow short just behind the spray of the hose

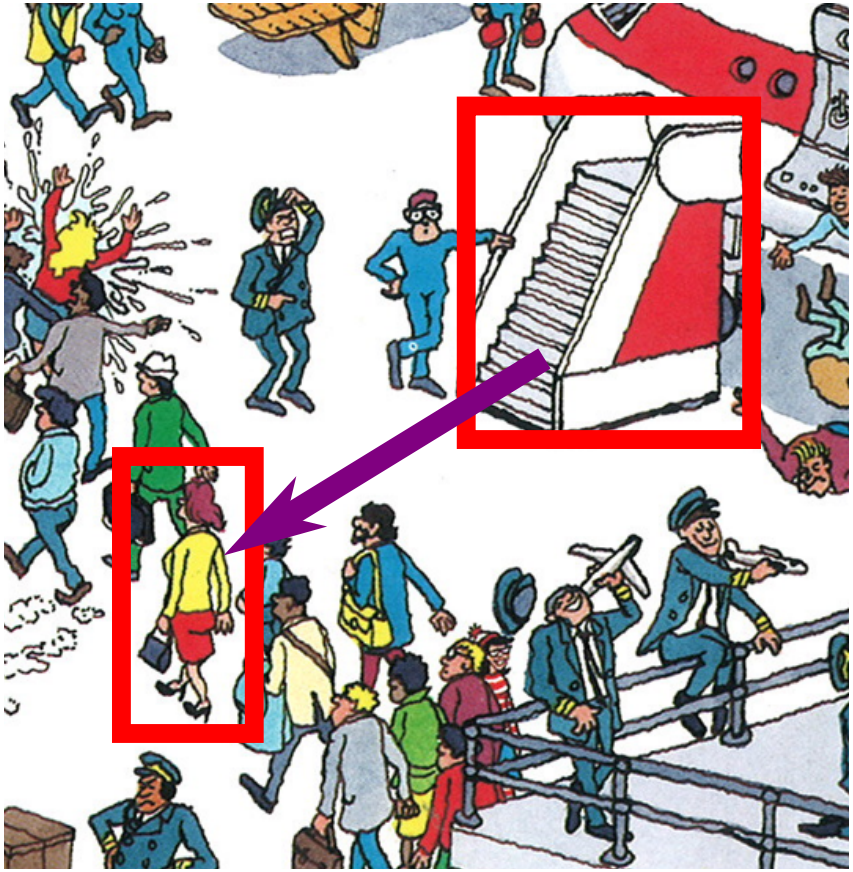


- Between the yellow and white airplanes there is a red vehicle spraying people with a hose. The people getting sprayed have a small line behind them. In the line there is a woman with brownish red hair, a yellow shirt and a red skirt holding a purse. She is standing behind a man dressed in green.

Relational descriptions

"The *woman* standing near the *jetway*"

- Overall *target*:
  - "the woman"
- *Landmark*:
  - "the jetway"
  - *relative to* "woman"



The intersection of:

- Visual perception
  - What do you see?
- Discourse pragmatics
  - What information is useful?
  - Extensive prior work, see (Krahmer+van Deemter '12)
- Language production and syntax
  - In what order?

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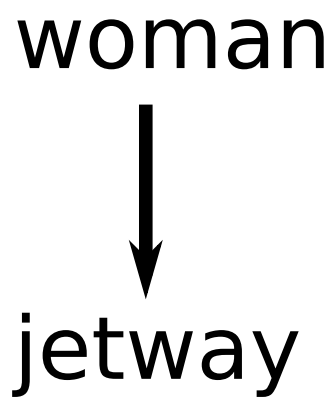
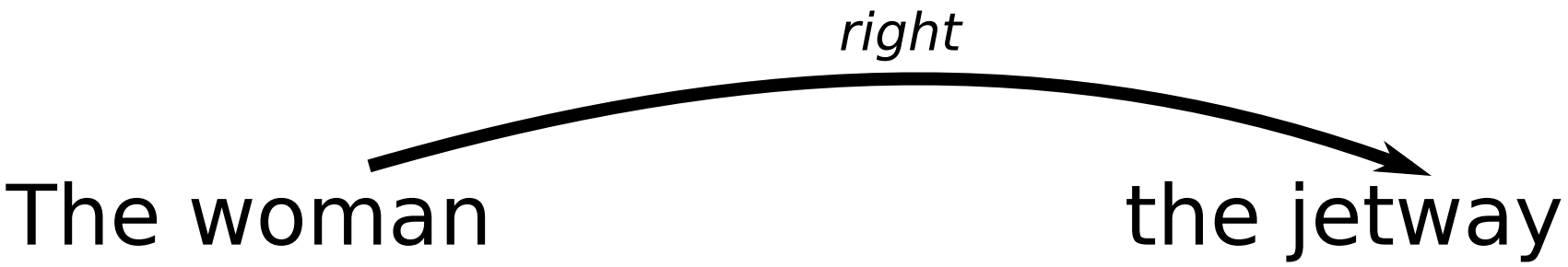
Setting:

Given abstract structure:

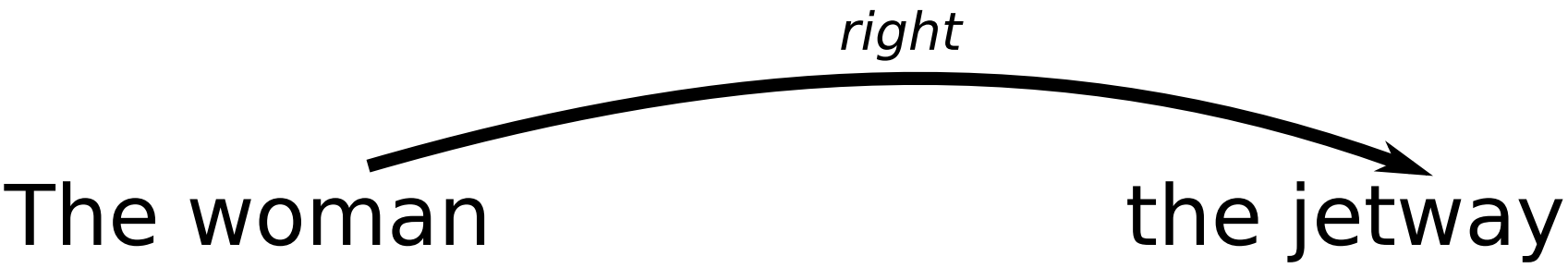


Predict information structure:



An intermediate stage

Information structure:



Surface realization:

Motivation:

- What factors predict information structure?
- What is the effect of visual features?

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Theory:

- Structure usually for *discourse* salience
- We show: *visual* salience plays similar role

Practice:

- Eventually, text generation...
- With visually aware surface realization

Overview

“Where’s Wally”: the dataset

Ordering strategies in the corpus

Learning to use visual features

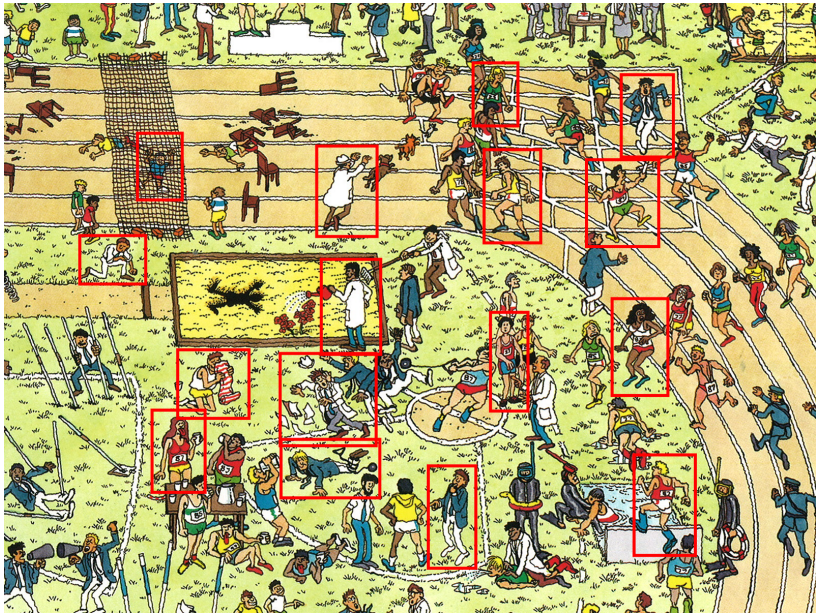
Experiments: predicting the order

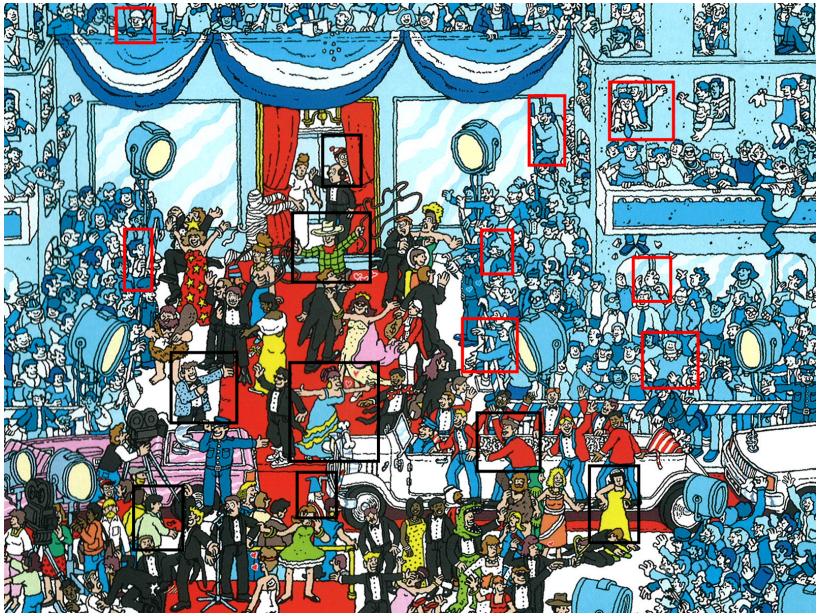
Where's Wally

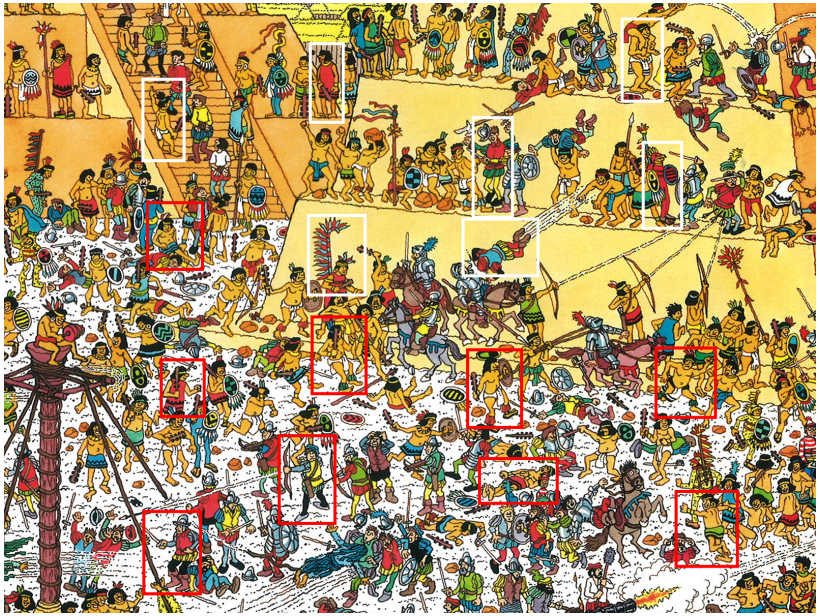
By Martin Handford: Walker Books, London

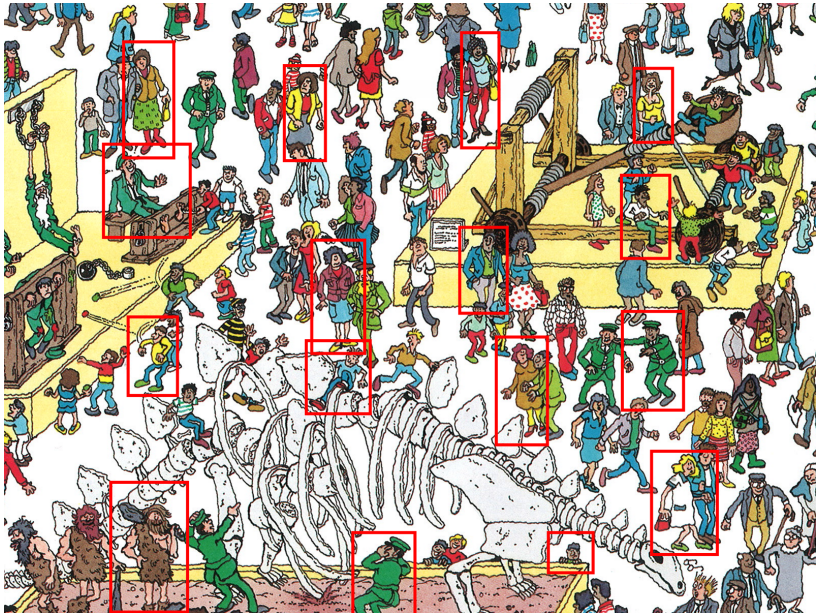
- Published in US as "Where's Waldo"
- Series of childrens' books: a game based on visual search
- Gathered referring expressions through Mechanical Turk
- Each subject saw a single target in each image

28 images x 16 targets x 10 subjects per image







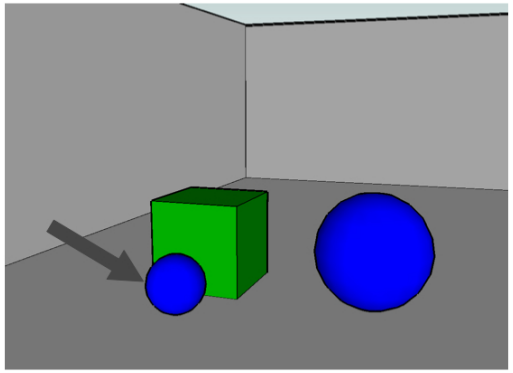


Why Wally?

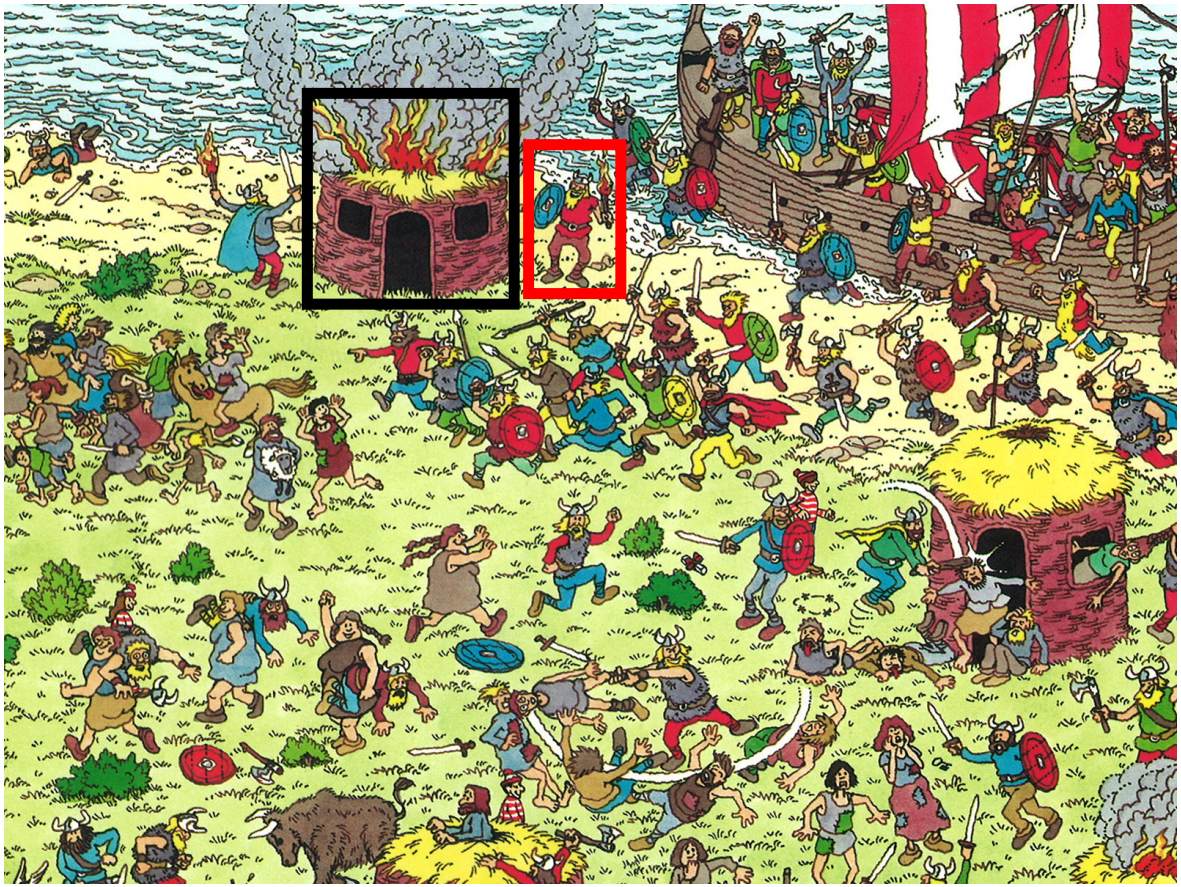
- Wide range of objects with varied visual salience
- Deliberately difficult visual search
- Relational descriptions a must
  - Not: “Wally is wearing a red striped shirt and a bobble hat”

- Previous studies used fewer objects
- Got fewer relational descriptions

(Viethen+Dale ‘08)



Annotation: 11 images complete so far



The <targ>man</targ> just to the left of the <lmark rel="targ" obj="(id)">burning hut</lmark> <targ>holding a torch and a sword</targ>

Ordering strategies: direction

right

The woman standing near **the jetway**

left

Near **the hut that is burning**, there is **a man**...

inter

Man... next to **railroad tracks** **wearing a white coat**

- Orders defined WRT first mention
- Information structure, not syntax

Basic ordering

- RIGHT default for landmarks (40%)
- LEFT default for image regions (57%)
  - “On the left is a woman”...
- Other orders are marked:
  - LEFT landmarks (33%)
  - INTER landmarks (27%)

Non-relational mentions

Look at **the plane**. **This man is holding a box that he is putting** on **the plane**.

- First mention isn't relational
  - "There is", "look at", "find the"...
- Annotated as ESTABLISH construction
- Usually occurs with LEFT ordering

Individual variation

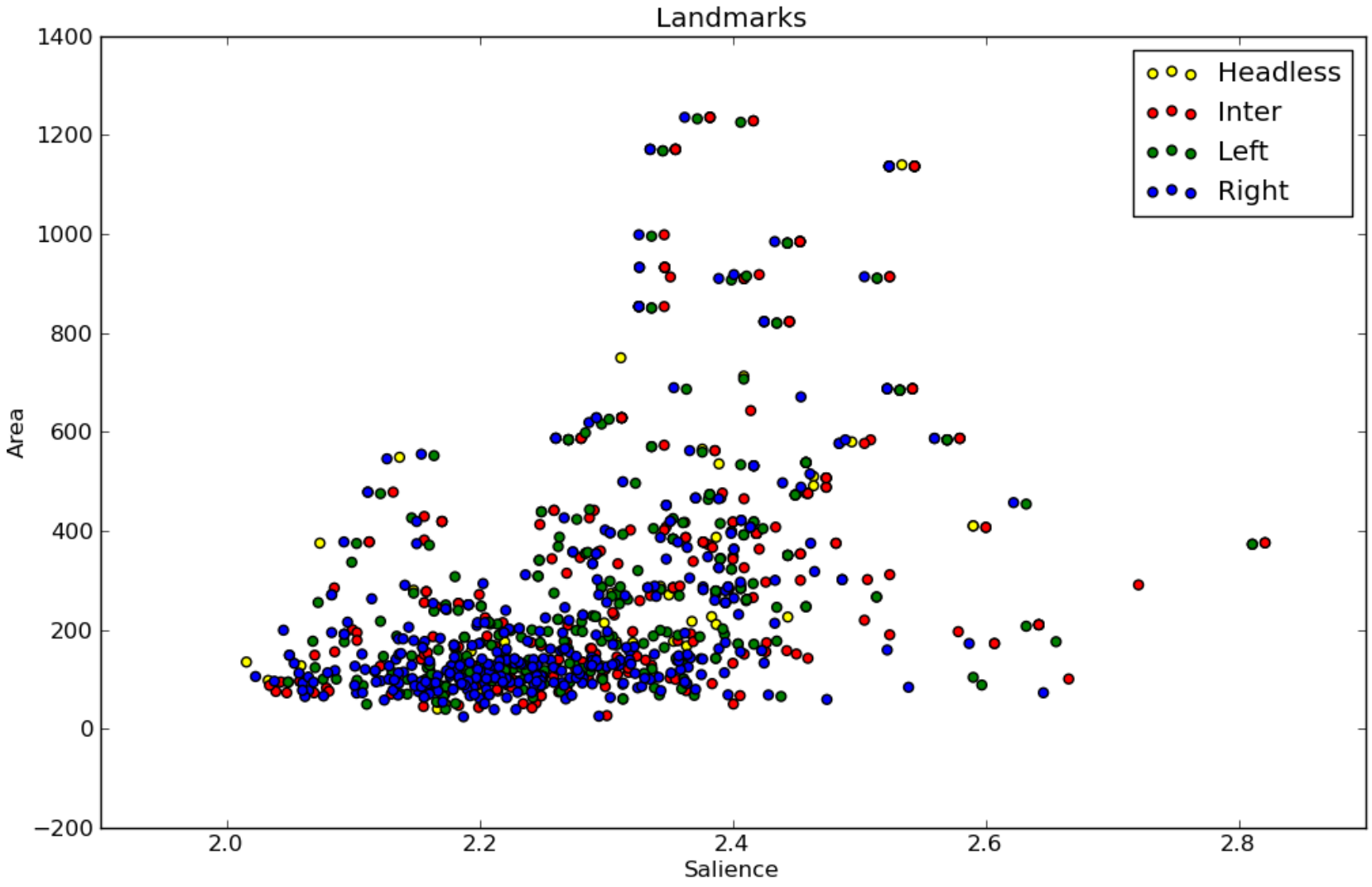
For head/landmark pairs mentioned by multiple subjects:

- 65% agreement about mention direction
- 40% ESTABLISH constructions agreed on

Strategies are predictable but vary

- Based on other landmarks selected?
- Different cognitive strategies?

Effects of visual perception



Visual information:

- Root area of object...
- (Low-level) visual salience of object
- Distance between objects

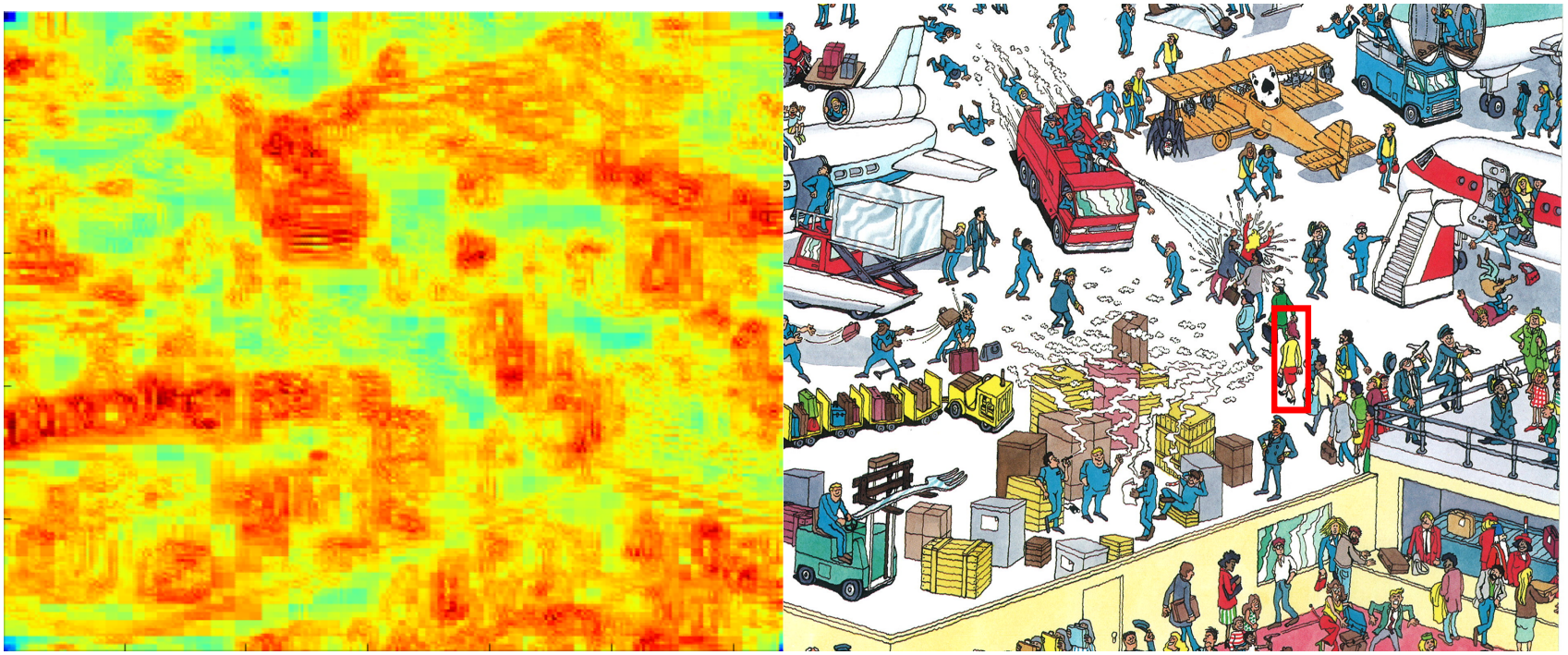
Visual salience:

- Psychological models of low-level vision

  (Toet ‘11, Itti+Koch ‘00, others)
- Where will people look in an image?
- Which objects are easy to find?

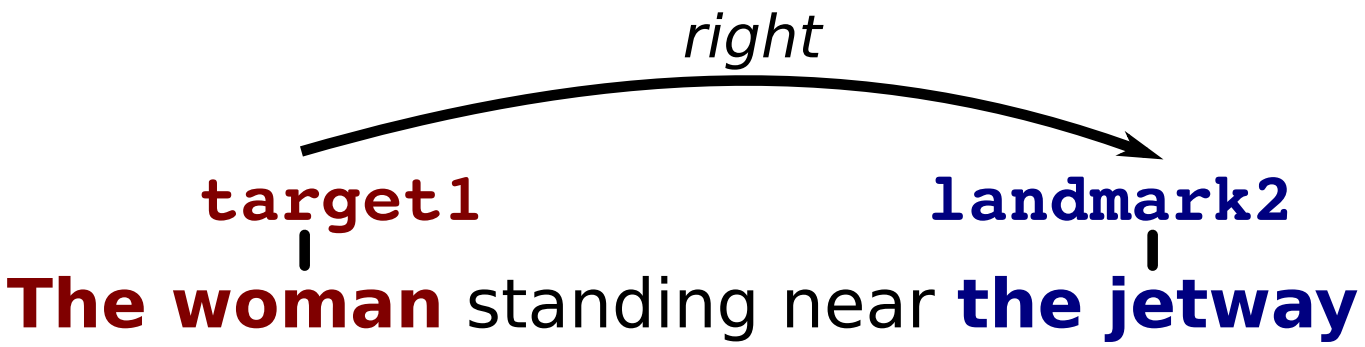
Salience map

- Based on responses from filter bank
- Bottom-up part of (Torralba+al '06)



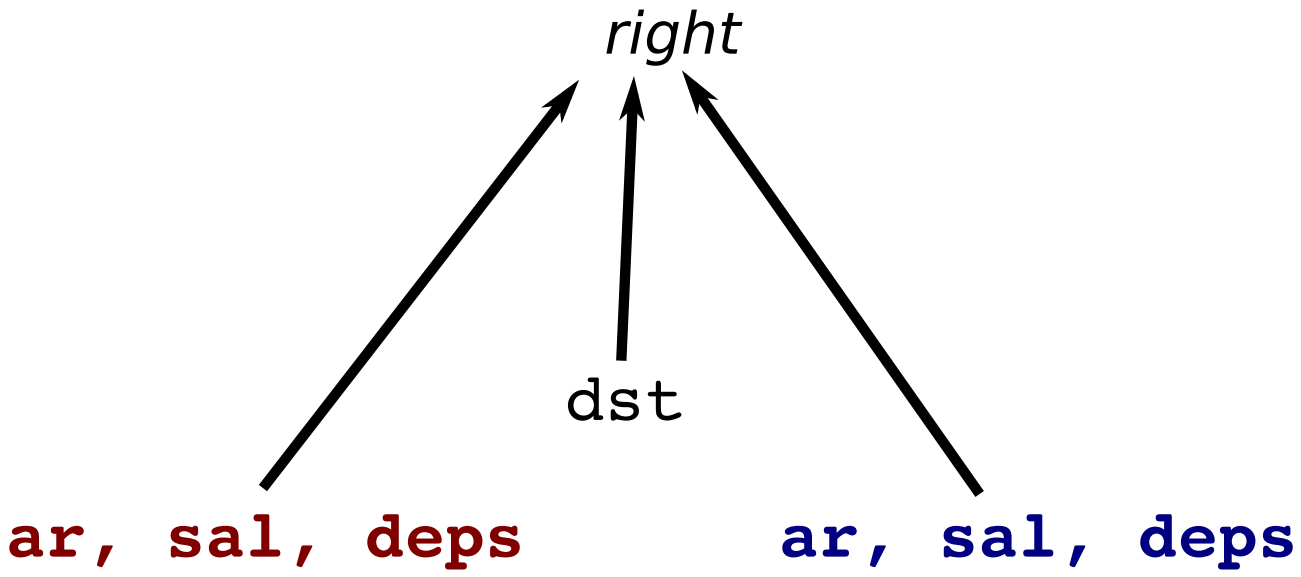
Modeling: tag induction

- Information structure as tagging problem
- Each object has (hidden) *type*
  - Analogous to part of speech
- Order controlled by types



Begin with simple discriminative system

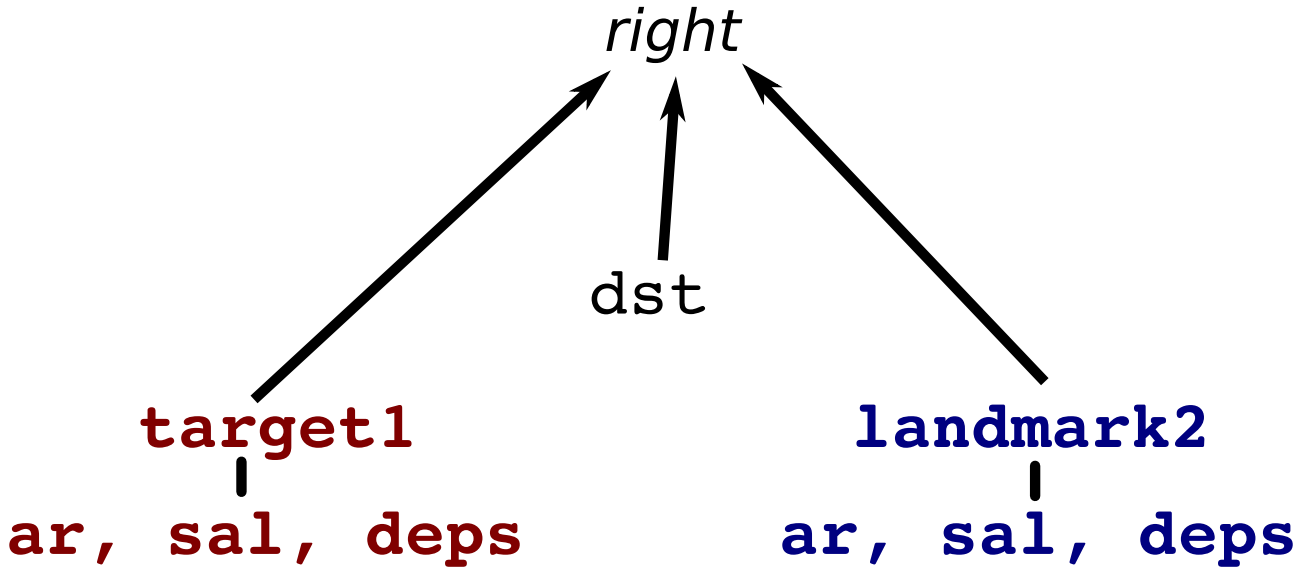
- Features: discretized area, salience, distance
  - Thresholds set at training set quartiles
- Number of landmarks used for each object



The woman standing near **the jetway**

Multilayer system

- No longer reliant on hand-tuned discretization
- CRF/Neural Net with latent *type* variables
- Area, salience, deps predict type
- ...which predict direction

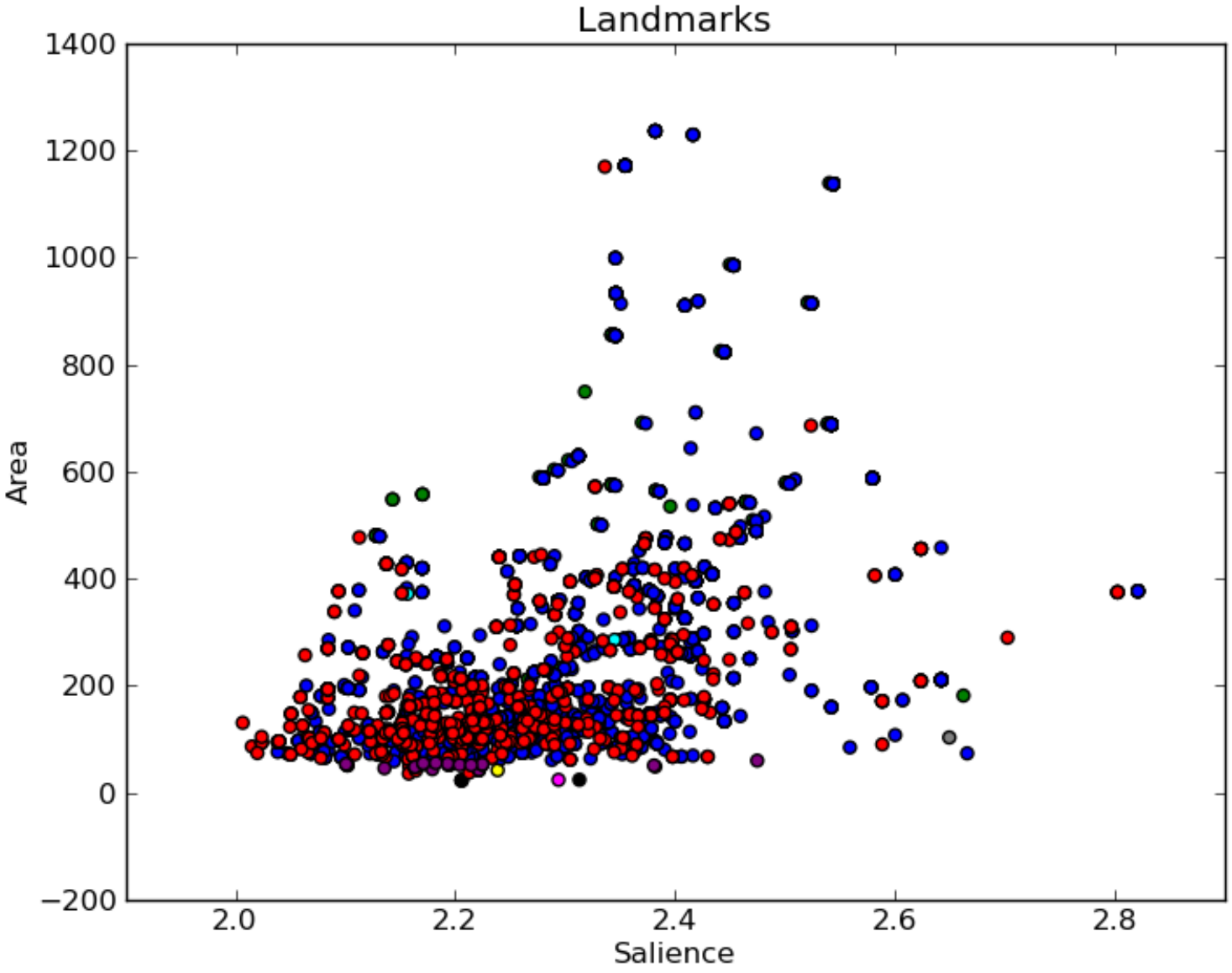


The woman standing near **the jetway**

System design

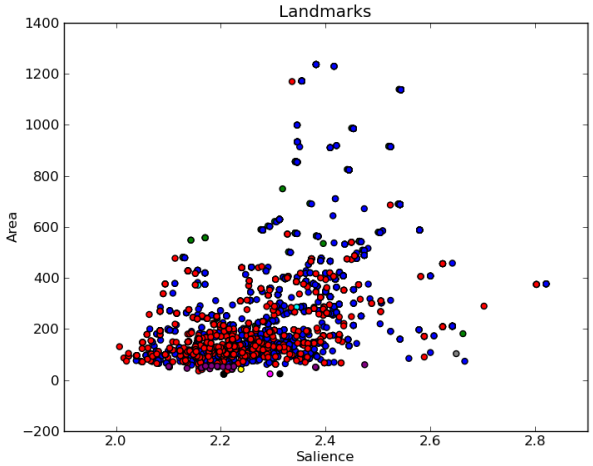
- Tag induction: *almost* grammar induction
  - Not hierarchical yet though
- Based on Berkeley-style latent variable grammar
  - (Matsuzaki+al '05, Petrov+al '06,'08)
- Implemented with Theano package
  - Automatic computation of gradients

Visualization of types for objects



Linguistic analysis

- Red class: small and hard to see
  - Usually RIGHT of head
  - More dependents (other landmarks) of their own
- Blue class: larger and more visible
  - Often LEFT or INTER
  - Rarer in ESTABLISH construction
  - Few dependents



Information ordered by givenness/familiarity:

(Prince '81, Birner and Ward '98 etc)

- Subject position: more familiar entities
- New information (outside common ground) later in sentence

Visual salience plays similar role:

- Highly visible landmarks appear on left
  - Assumed in common ground
  - Rarely need their own landmarks
- Harder-to-see landmarks on right
  - Assumed discourse-new
- ESTABLISH construction introduces unfamiliar entity (Ward and Birner '95)

How well can we predict the order?

- Input: unordered abstract structure

	Acc (direction)	F (ESTABLISH)
All RIGHT	36	0
Regs LEFT	43	0

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Multilevel	52	50
Majority oracle	75	65

Results II

	Left (F1)	Inter (F1)	Right (F1)
All RIGHT	0	0	53
Regs LEFT	40	0	55
Basic discr	57	34	53
Multilevel	60	29	56
Majority oracle	65	60	70

Conclusions:

- Complex information structure of relational descriptions
- Predictable from visual information...
- More visible objects act like familiar entities

Future work:

- Does fully hierarchical model work better?
- Surface realization of these structures
- More sophisticated visual models