Detecting Off-topic Responses to Visual Prompts

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Image Relevance Detection

- Given an image, **evaluate the relevance** of a text to that image.

An astronaut is celebrating on Mars.
Two signs are sticking out of the sand.
The sun is setting behind mountains.
The whales are breaching the surface.

- Important for automated **essay scoring** and high-stakes testing.

Relevance Model

- Text is represented with **word embeddings** $[w_1, w_2, ..., w_N]$ and composed to a single vector $u = h_N$ using an LSTM:

$$h_n = LSTM(w_n, h_{n-1})$$

- The image is represented with vector x, which we extract from a pre-trained GoogLeNet **image recognition** network.
- The model first reads the text, then decides which parts of the image are relevant to the task, using **gating**:

$$z = \sigma(uW_z + b_z) \qquad x' = z * x$$

- The image vector is then **mapped to a new space** which is specialised for relevance scoring:

$$v = tanh(x'W_x)$$

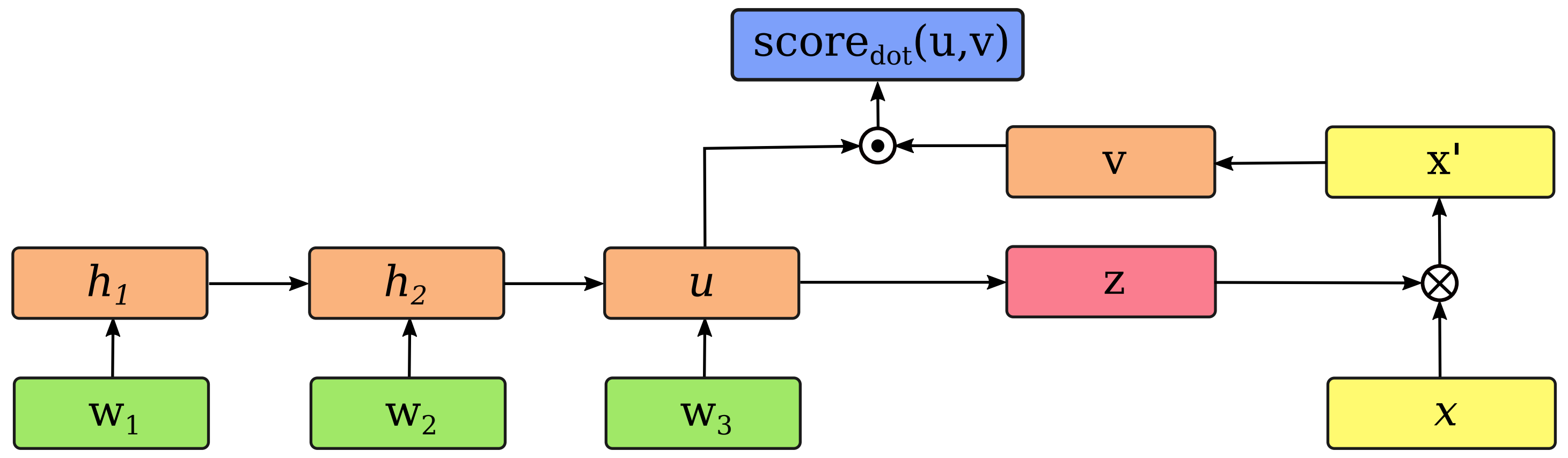
- The final **relevance score** is given as a dot product of the text vector u and the image vector v:

$$score_{dot}(u, v) = uv$$

Optimisation

- The model is optimised using **cross-entropy** over all examples in the minibatch:

$$Loss_{ce} = -\sum_{i \in I} log(\frac{\exp(score_{dot}(u_i, v_i))}{Z})$$



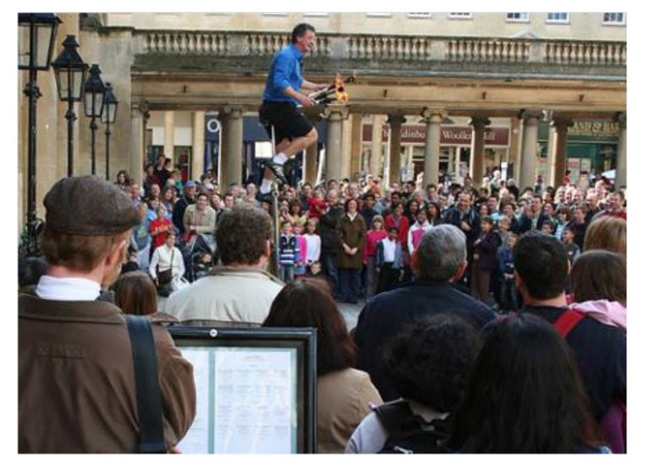
Evaluation

- Training on 31,014 images from the **Flickr30k** captioning dataset.
- Evaluating on a dataset of **543 answers** written by language learners.

	Learner texts			Flickr30k		
	ACC	AP	P@50	POS	NEG	ACC
LSTM-COS	68.2	71.6	81.0	0.7	0.0	72.6
+ gating	69.6	74.6	84.4	0.5	-0.6	76.5
+ cross-ent	71.1	79.0	**92.2**	5.8	-5.2	83.8
+ dropout	**75.4**	**81.9**	89.8	5.6	-3.7	**87.4**

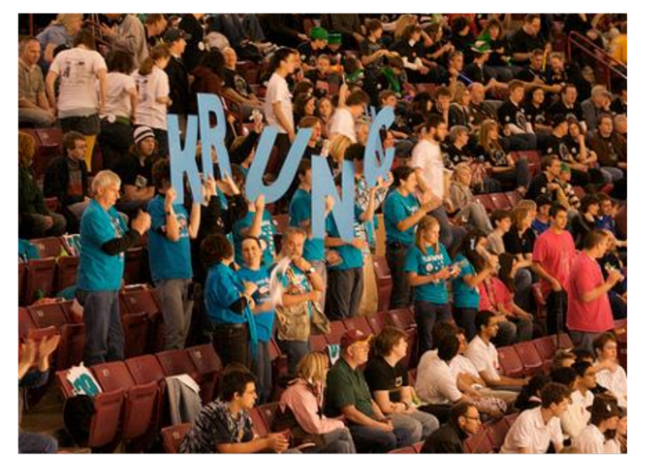
Analysis

- Looking at examples that the system **incorrectly** classifies as unrelated.



A man rides a unicycle while holding fire lit batons.

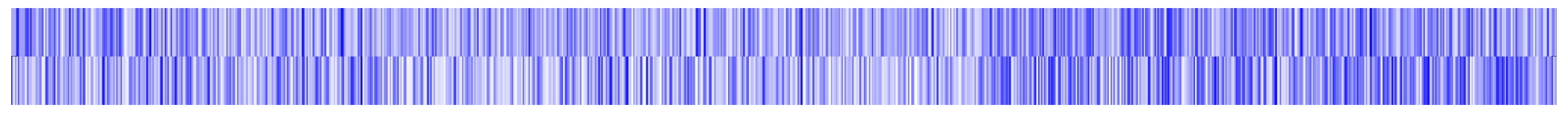
score: -3.27



A crowd in stands holding up the letters "k", "r", "u", "n" , and "c"

score: -2.19

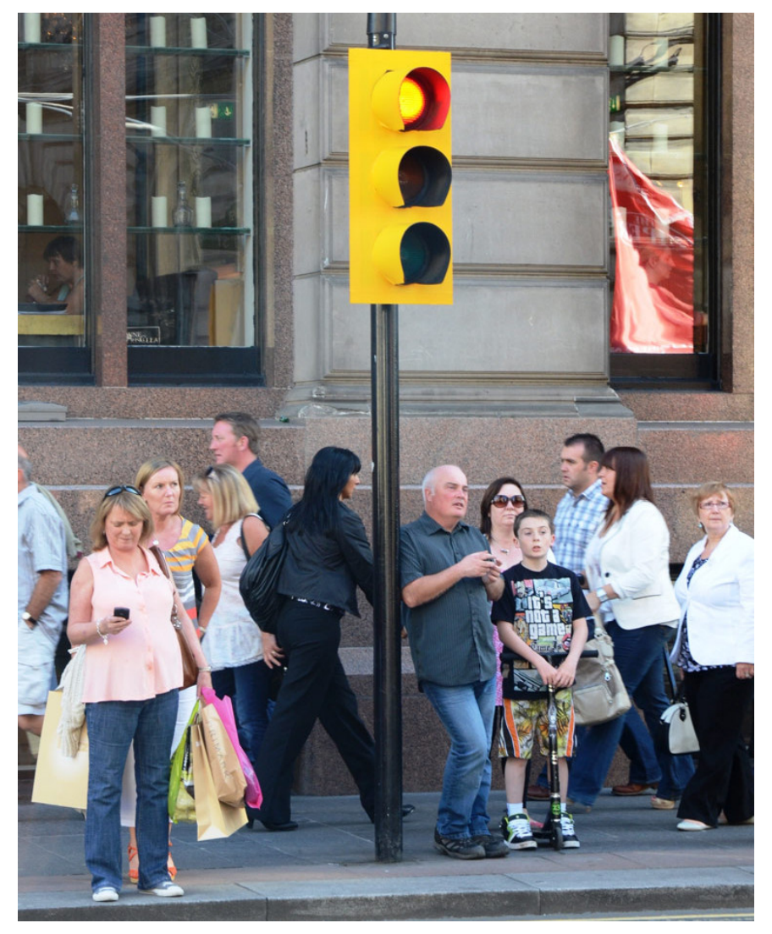
- The uses of **rare terms** and unusual images are potential sources of confusion for the model.
- Visualising the **gating vector** for two different sentences, values close to 0 are represented with white:



Conclusion

- An automated system can reliably **evaluate the relevance** of a written text to a given image.
- Texts and images can be mapped into a shared **semantic space** for comparison.
- Each of the modifications gives a **consistent improvement**: gating the image based on the text, applying dropout, and jointly optimising all examples in the minibatch.

Examples



In this picture there are lot of people and each one has a different attitude.	0.65
In the foreground, people are waiting for the green light in order to cross the street.	0.81
Generally speaking, the picture is full of bright colours and it conveys the idea of crowded city.	0.63
Looking at this pictures reminds me of the time I went scuba diving in the sea.	-2.38
You swim to the surface and you see the sunlight coming nearer and nearer until you get out.	-1.70