Context-aware Captions from Context-agnostic Supervision

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Objective

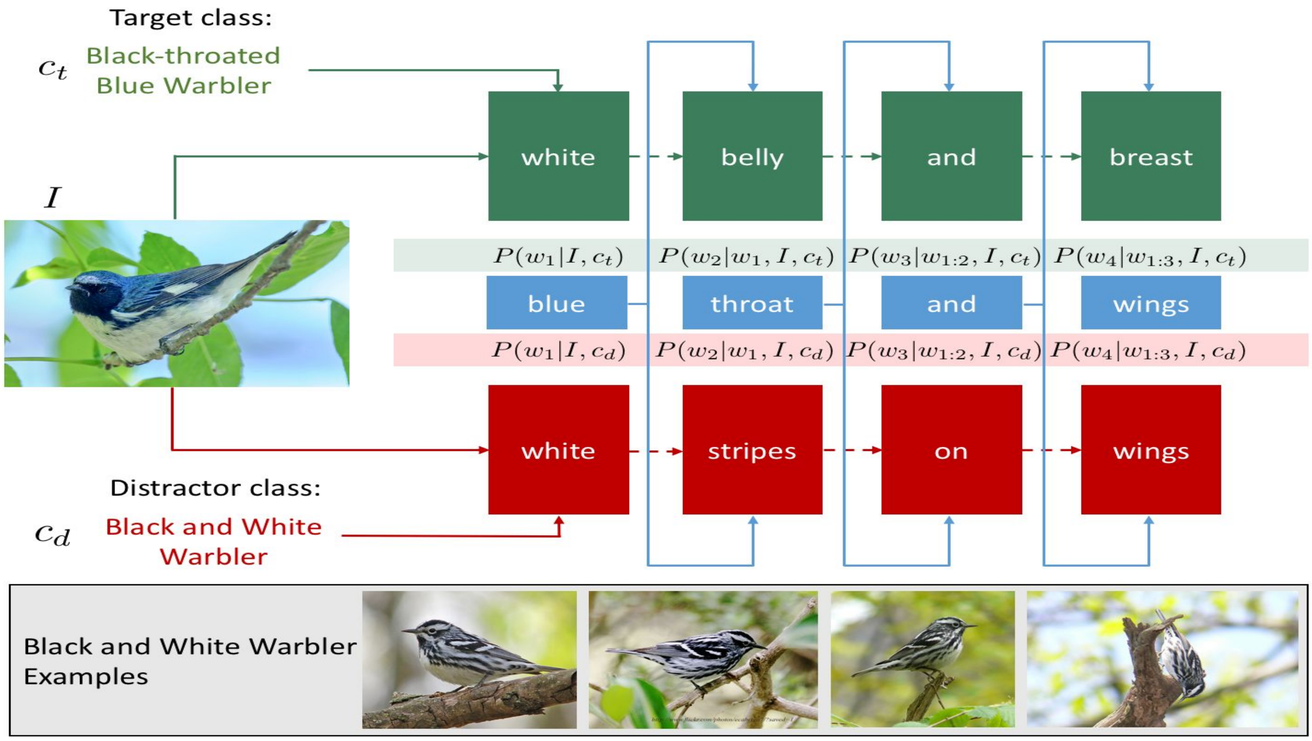
Produce pragmatic, context aware descriptions of images (captions that describe differences between images or visual concepts) using context agnostic data (captions that describe a concept or an image in isolation). We attempt the following two problems.

- *Justification*:
  - Given an image, a target (ground-truth) class, and a distractor class, describe the target image to explain why it belongs to the target class, and not the distractor class.
- *Discriminative image captioning*
  - Given two similar images, produce a sentence to identify a target image from the distractor image.

Approach

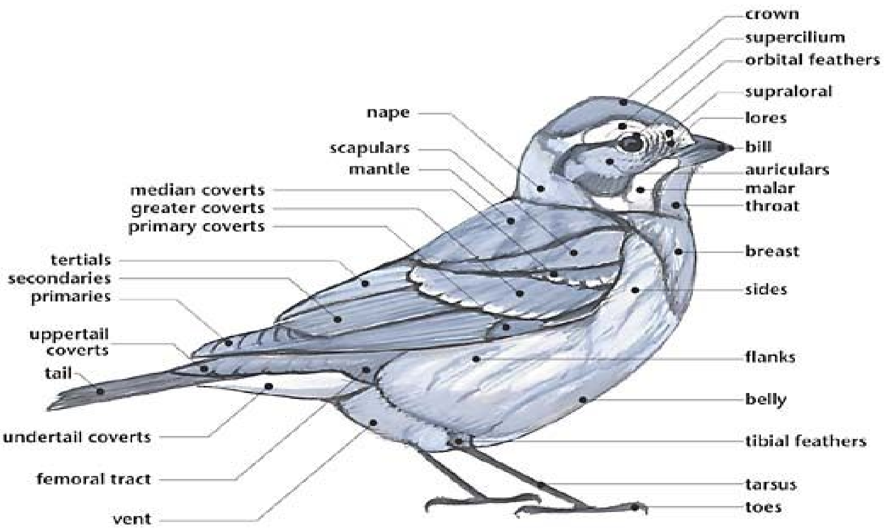
We trained our model using generic context-agnostic data (captions that describe a concept or an image in isolation), in an encoder-decoder paradigm along with attention, and used an inference technique called Emitter-Suppressor Beam Search to produce context aware image captions. Our model develops upon the architecture of Show attend and tell. For justification, apart from the image, the decoder is also conditioned on target-class.

Emitter-Suppressor Beam Search Algorithm



Dataset

We have used the CUB-200-2011 dataset which contains images of birds and their descriptions. The dataset has 200 bird classes (species), each class has 30 images and each image has 10 descriptions. The descriptions are mostly about the morphology of the birds i.e., details about various parts of their body.

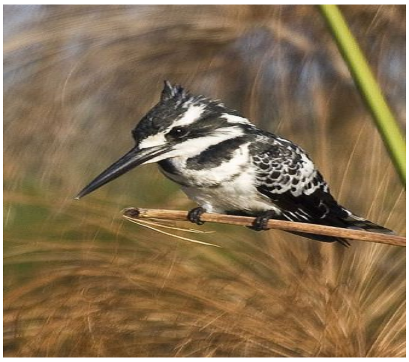


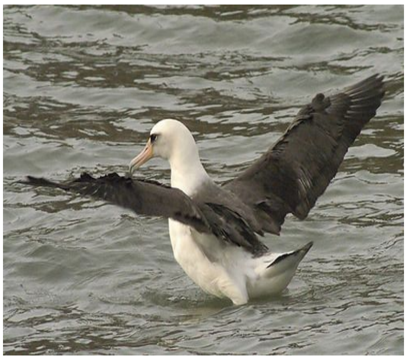
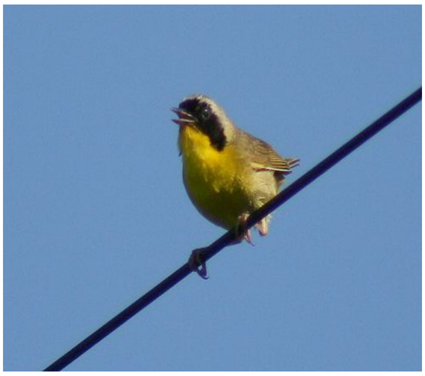
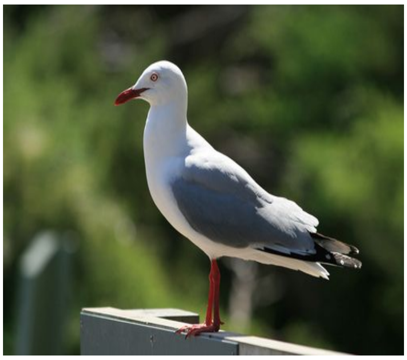
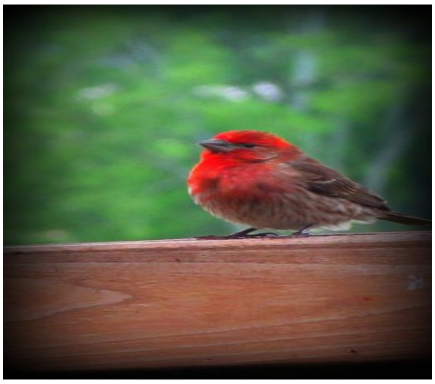
Implementation details

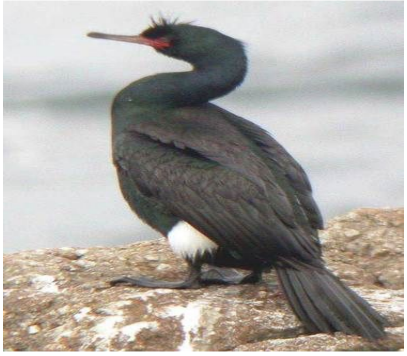
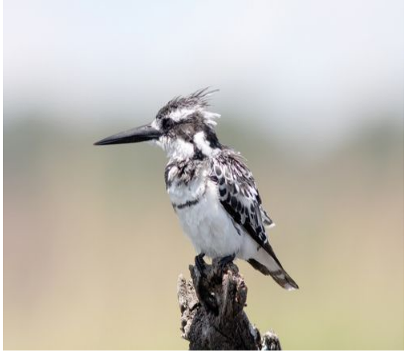
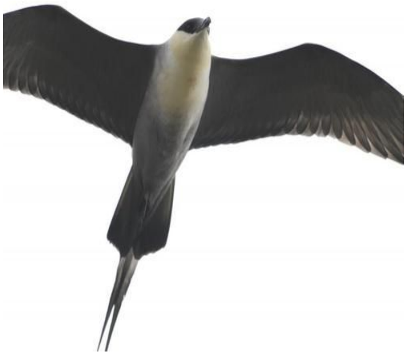
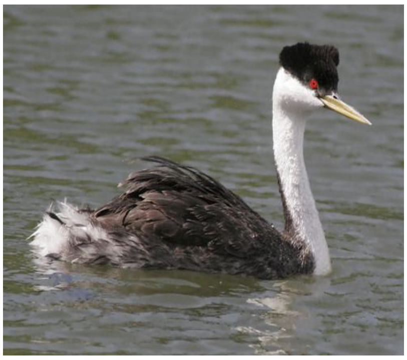
- *Encoder*
    - We used a pretrained `ResNet-34` already available in the PyTorch's `torchvision` module and discarded the last two layers (pooling and linear layers), since we only need to encode the image, and not classify it.
- *Decoder*
    - We used LSTMs with `input embedding of size 512` and `hidden states of size 1800`. For justification the class is embedded into a `512 size vector`.
- *Attention*
    - We used adaptive pooling over encoder to get a `14*14*512` vector from the encoder and then applied a linear layer with ReLu activation to get the attention weights. Note that we used the soft version of the attention.
- We used Adam's optimizer with `learning rate of 0.002` which is annealed every 5 epochs. We used dropout with `p = 0.5`. The `batch size used was 64` and the `number of epochs were 100`. The model was trained on GTX 1060 for 15 hours.

Results

Context Agnostic Captioning

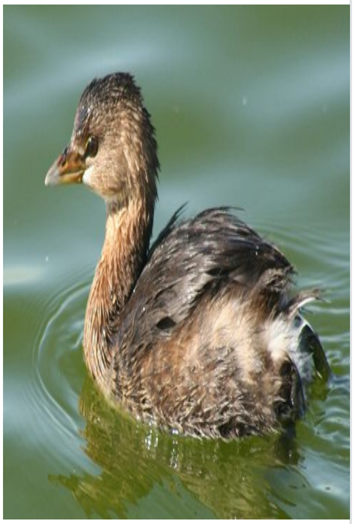
Image	Context Agnostic Caption
	this bird has a white belly and breast with black superciliary and crown

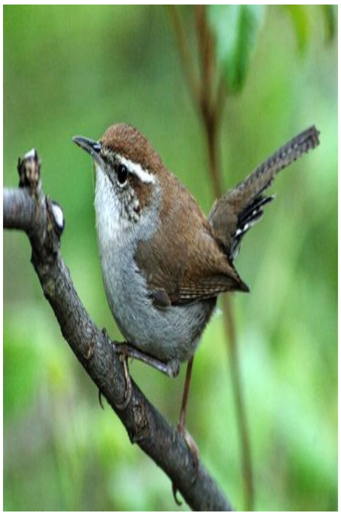
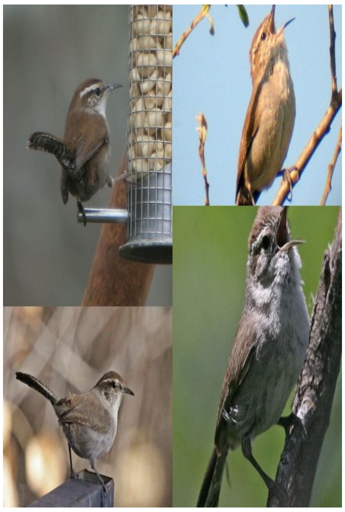
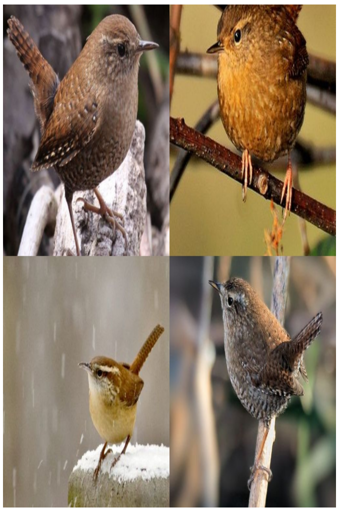
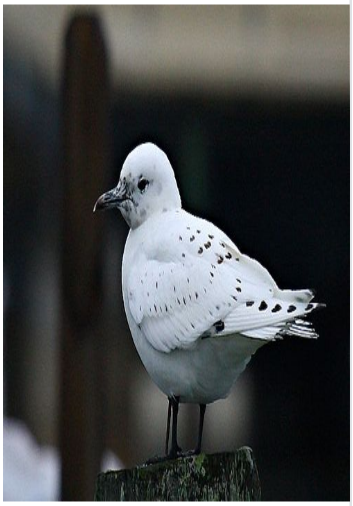
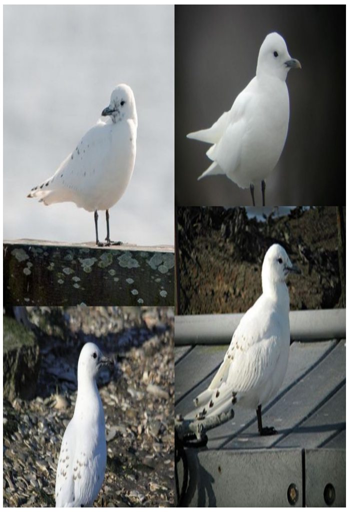
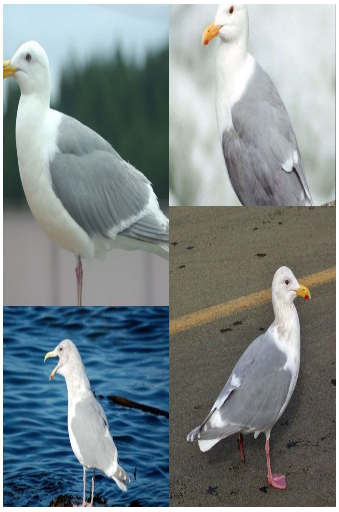
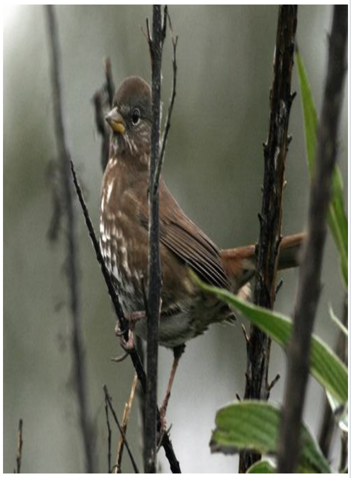
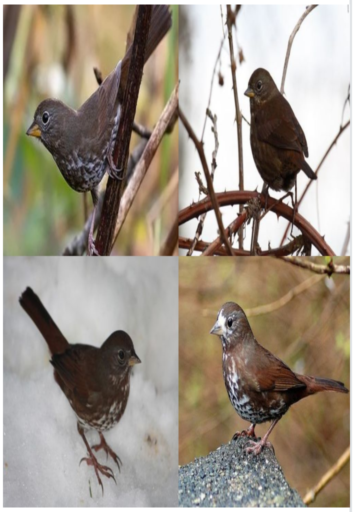
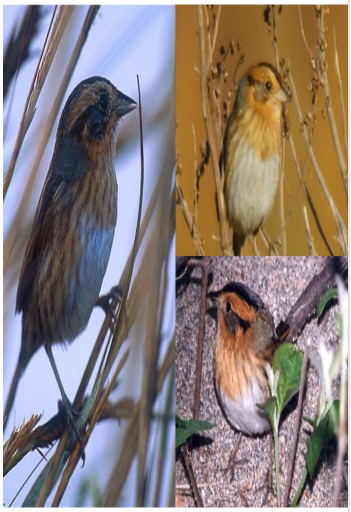
	this bird has a white head and breast with grey wings and a yellow beak
	this bird has a yellow belly and breast with a black superciliary and gray crown
	this bird has a white crown a white breast and grey wings with black edges
	this bird has a red crown a short bill and a red breast

	this bird has a long neck and a long bill
	this bird has a long black bill and a black and white spotted body
	this bird has a black crown a white breast and a large wingspan
	this bird has a long yellow bill a black crown and red eyes

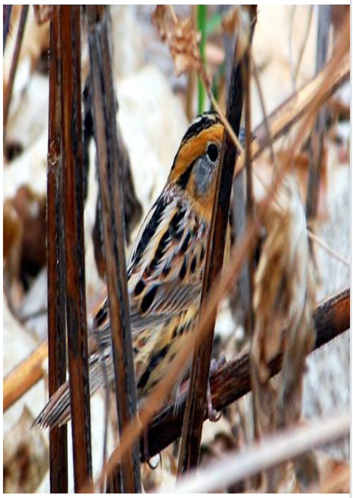
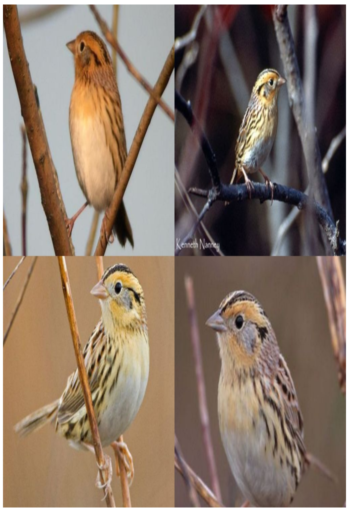
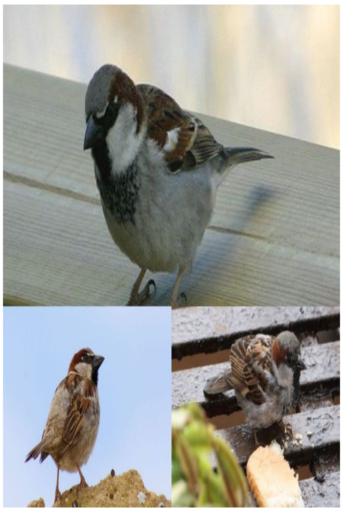
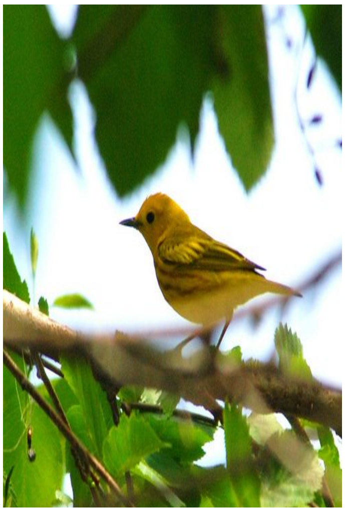
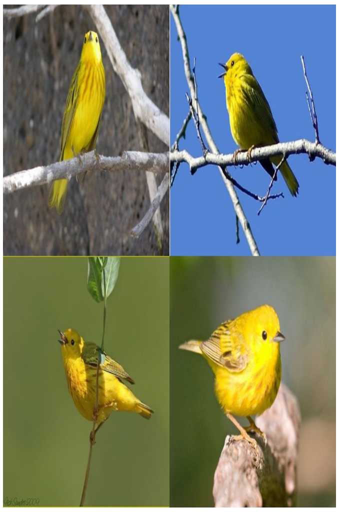
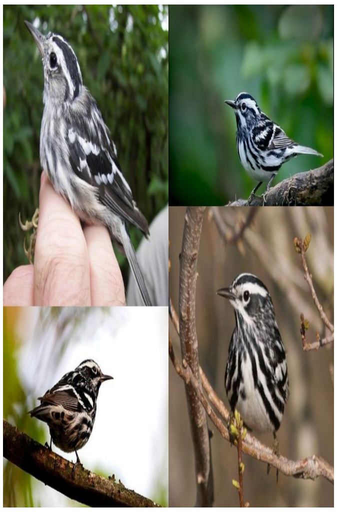
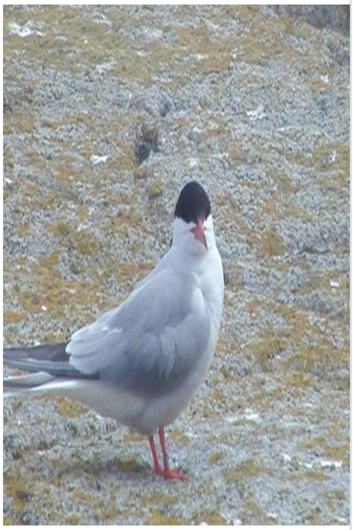
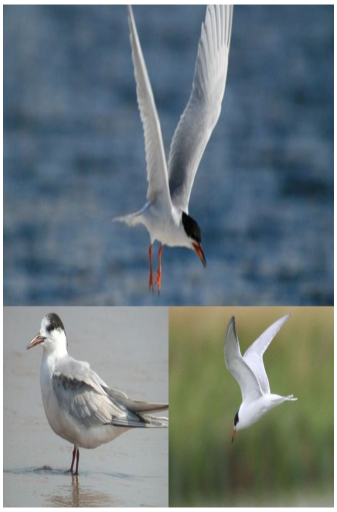
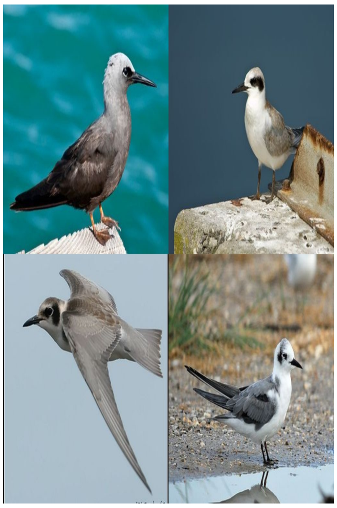
	this bird has a white belly and breast with a brown crown and white wing bars.

Justification Captioning

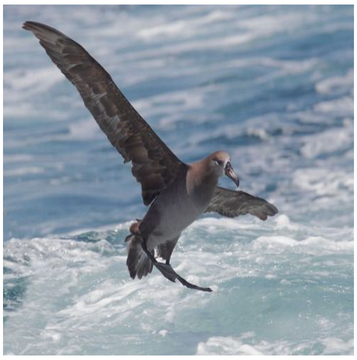
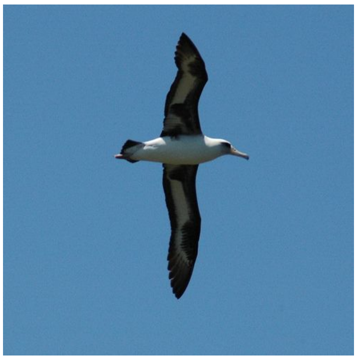
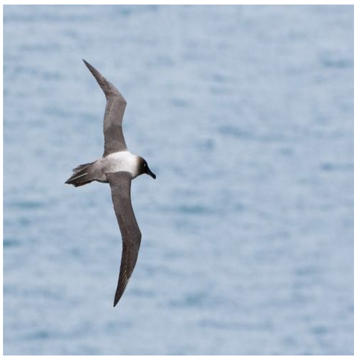
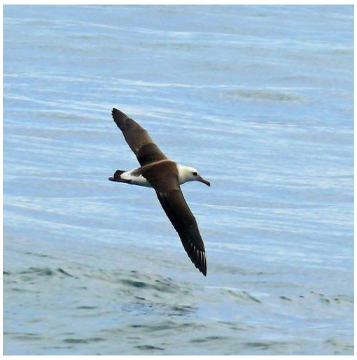
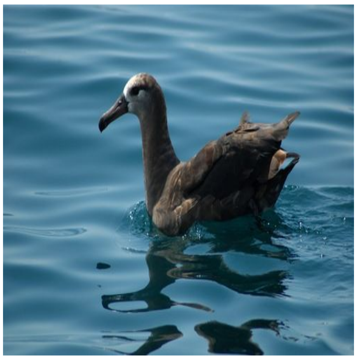
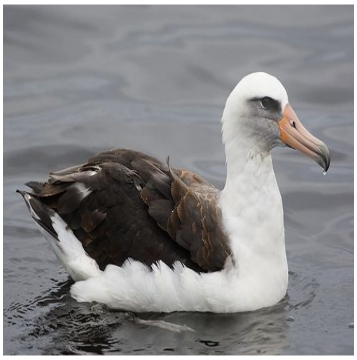
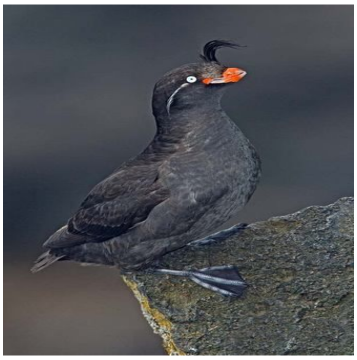
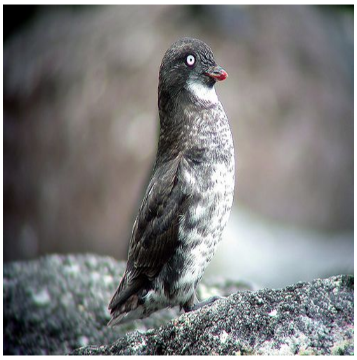
Image	Target class	Distractor class	Caption
			this bird has a brown crown brown primaries and a brown throat

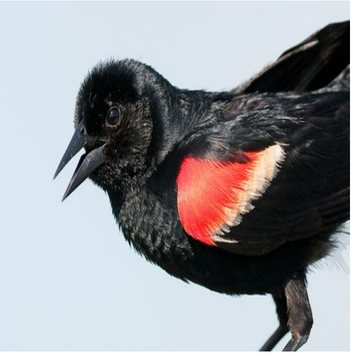
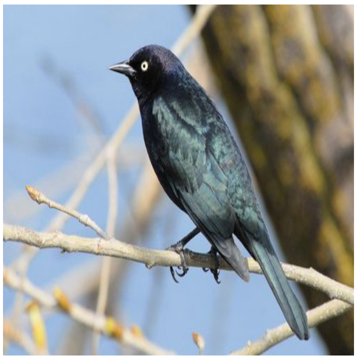
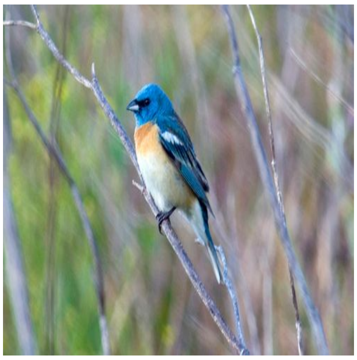
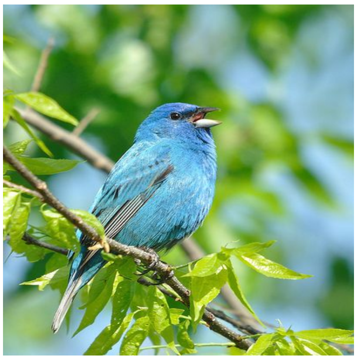
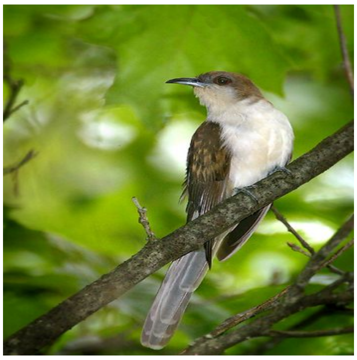
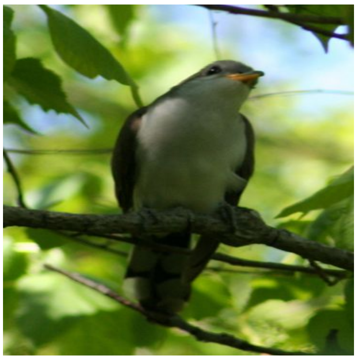
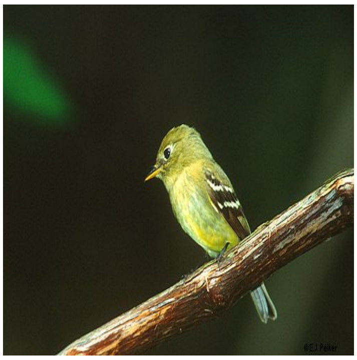
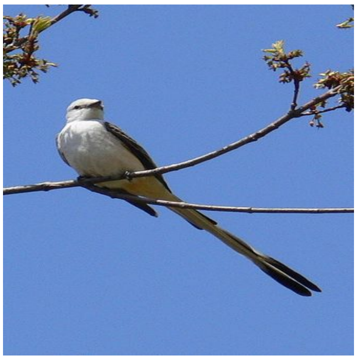
			this bird has a white belly and breast with a brown crown and wing
			this bird has a white crown as well as a black bill
			this bird has a brown crown brown primaries and a brown belly

			this bird has a blue crown green primaries and a yellow belly
			this bird has a yellow belly and breast with a black neck and crown
			this bird has a red crown red primaries and a red belly

			this bird has a pointed yellow bill with a yellow breast
			this bird has a yellow crown a short bill and a yellow breast
			this bird has a black crown white primaries and a white belly

Discriminative Captioning

Target Image	Distractor Image	Caption
		this bird is brown in color over all of its body except for its wings and tail that have white around them
		this bird has wings that are gray and has a black tail and a black bill
		this bird has a brown crown brown primaries and a brown throat
		this bird has webbed feet with a bright orange wide beak and jet black over the rest of its body

		this bird has blackhead and body but there is fins of feathers off of the wing that are black white and red
		this bird has a white belly brown breast blue head and white wing bars
		a small brown bird with a white throat and red eyerings
		a small green bird with a yellow breast and yellow bill

		this bird has a white belly and breast with blue wings a light gray eyebrow on the head of a front of black and white striped on the wings and bright pale blue rectrices

Requirements

Kindly use the requirements.txt to set up your machine for replicating this project, some dependencies are :

```
h5py==2.9.0
matplotlib==3.0.3
nltk==3.4.1
numpy==1.16.2
pandas==0.24.2
pillow==5.3.0
python==3.7.3
pytorch==1.0.0
torchfile==0.1.0
torchvision==0.2.1
tqdm==4.31.1
```

You can install these dependencies using `pip install -r requirements.txt`

Setup

Training

```
python datapreprocess.py \path\to\data\set
\path\to\vocab\
python train.py
python train_justify.py
```

Testing

Download the pretrained models checkpoint_d and checkpoint_j

1. Context agnostic captioning: `python beamsearch.py c image_path`
2. Justification: `python beamsearch.py cj target_image_path target_class_path distractor_class_path`
3. Discrimination: `python beamsearch.py cd target_image_path distractor_image_path`

License

This project is licensed under the MIT License - see the LICENSE file for details.

References

1. Paper: Context-aware Captions from Context-agnostic Supervision
2. Dataset:
   - Images : CUB-200-2011
   - Captions : Reed et al.
3. A beautiful tutorial on Show, Attend and Tell Implementation