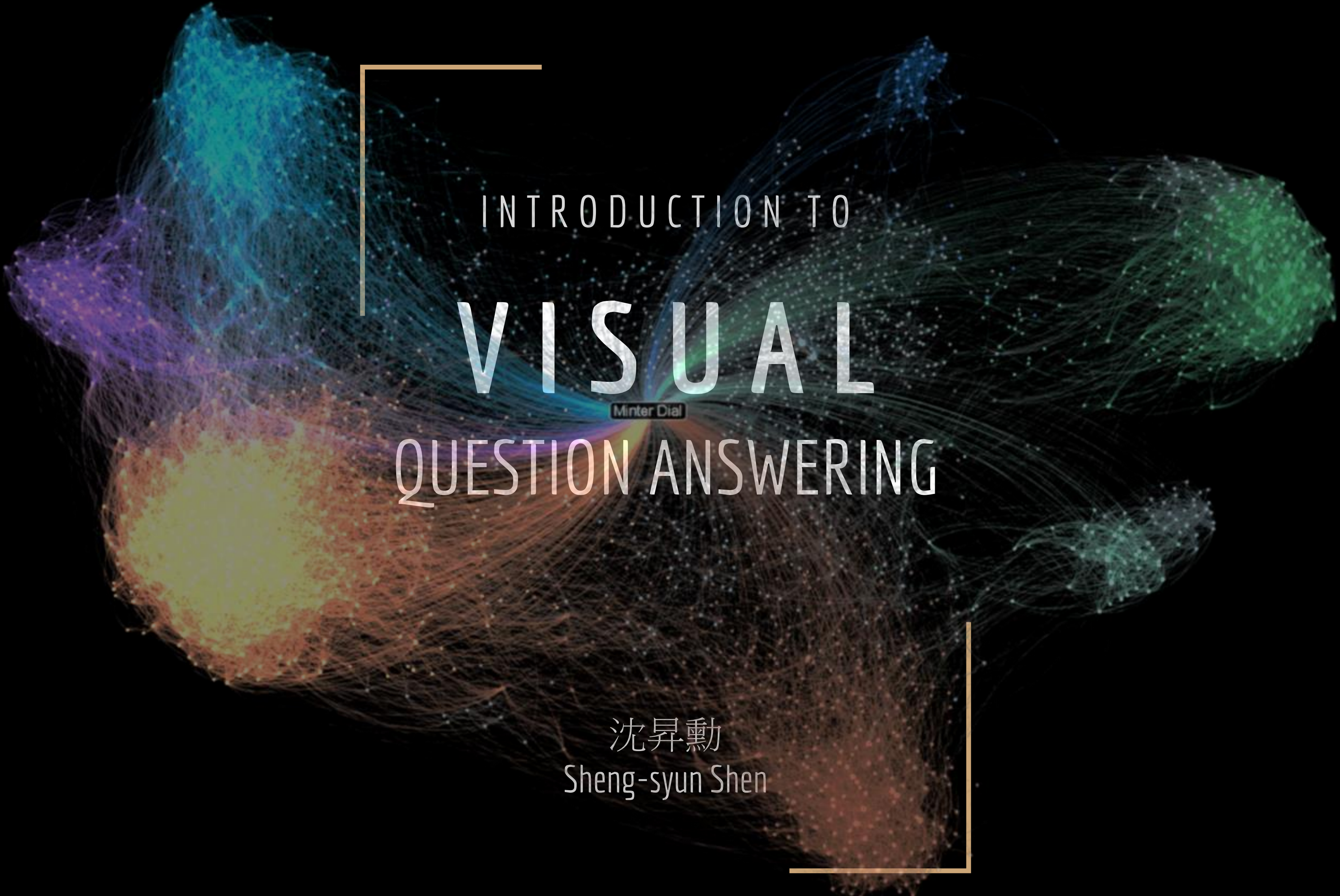


INTRODUCTION TO

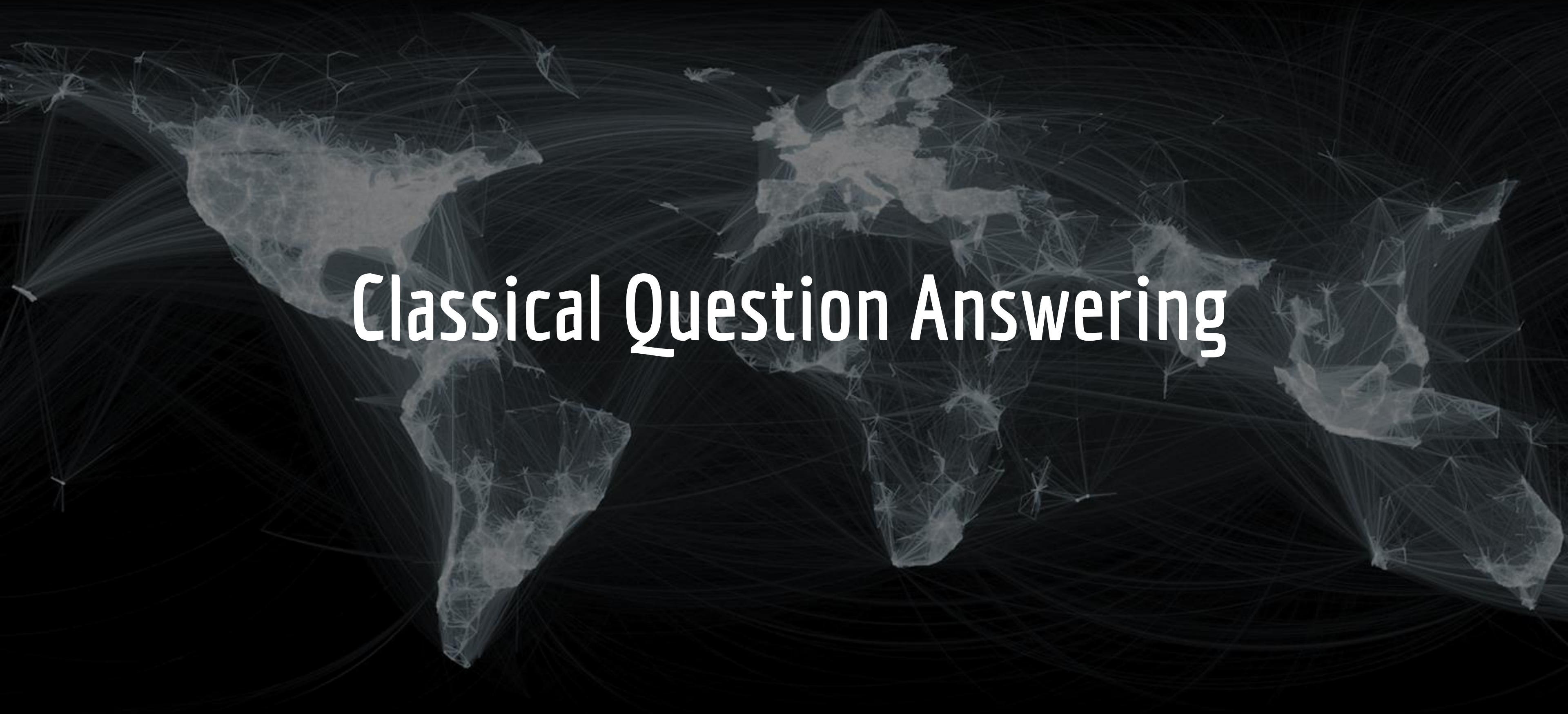
VISUAL QUESTION ANSWERING

沈昇勳
Sheng-syun Shen

Outline

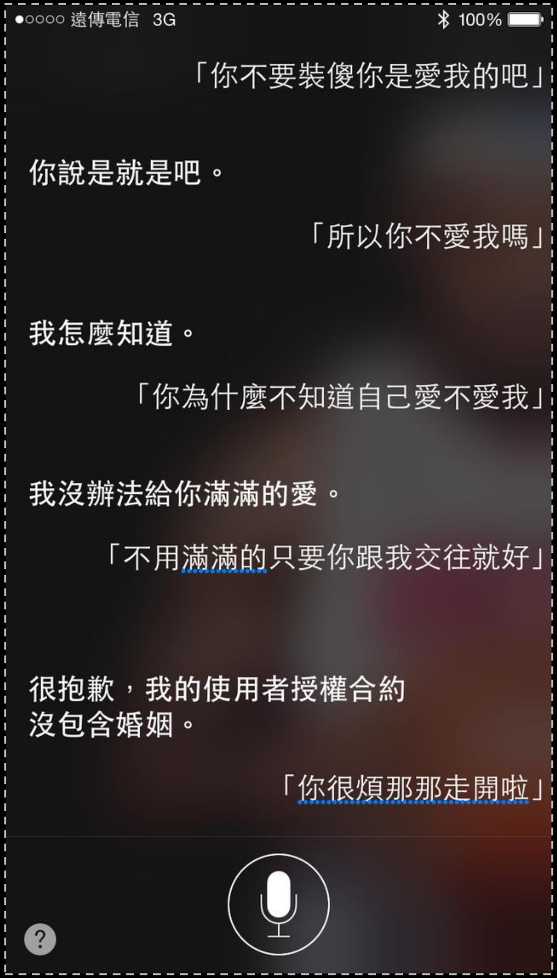
- Classical Question Answering
- End-to-End Viausal Question Answering
- Attention Model on Question Answering
- Libraries and Toolkits

Classical Question Answering



Question Answering

One of the oldest NLP tasks.



「你不要裝傻你是愛我的吧」

你說是就是吧。

「所以你不愛我嗎」

我怎麼知道。

「你為什麼不知道自己愛不愛我」

我沒辦法給你滿滿的愛。

「不用滿滿的只要你跟我交往就好」

很抱歉，我的使用者授權合約
沒包含婚姻。

「你很煩那那走開啦」

Apple Siri

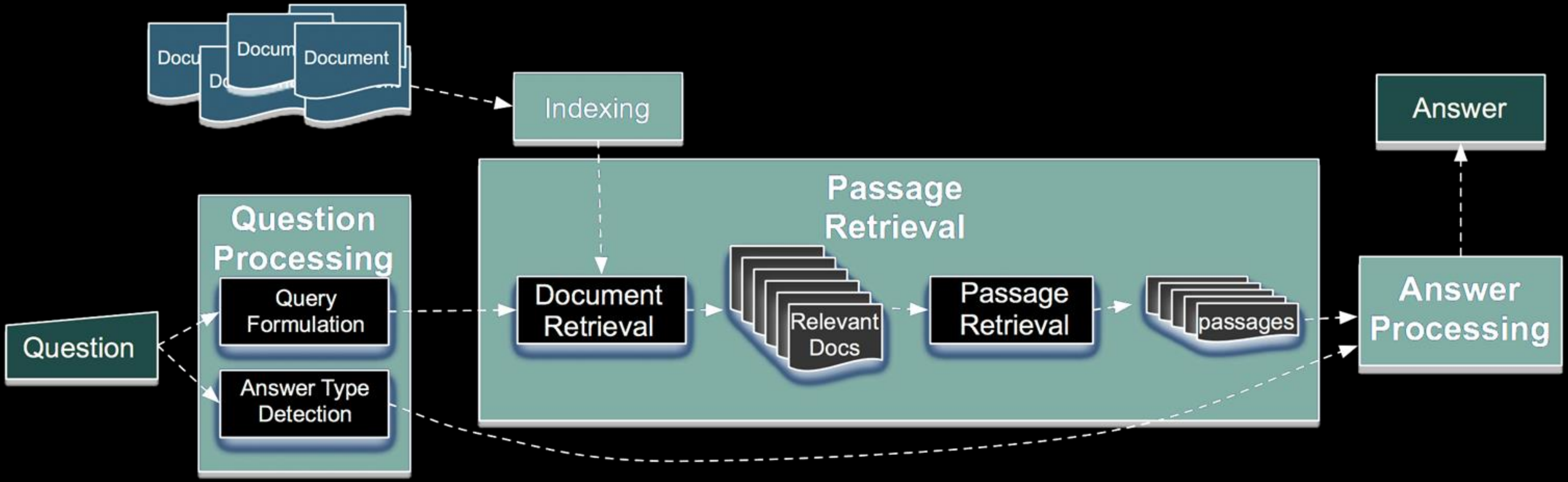
Types of Questions in QA Sysyem

- Factoid questions
  - Where is Apple Computer based ?
  - How many calories are there in two slices of apple pie ?
- Complex (Narrative) questions
  - In children with an acute febrile illness, what is the efficacy of acetaminophen in reducing fever ?

Approaches for Solving QA

- IR-based approaches (Information Retrieval)
  - TREC; IBM Watson; Google
- Knowledge-based and Hybrid approaches
  - Apple Siri; Wolfram Alpha

IR-based Factoid QA



VQA

IR-based Factoid QA

- Question processing
  - Detect question type, answer type
  - Formulate queries to send to a search engine
- Passage retrieval
  - Retrieve ranked documents
  - Break into suitable passages and rerank
- Answer processing
  - Extract candidate answers
  - Rank candidates

IR-based Factoid QA | Question Processing

- Answer type detection
  Decide the **named entity type** (person, place) of the answer

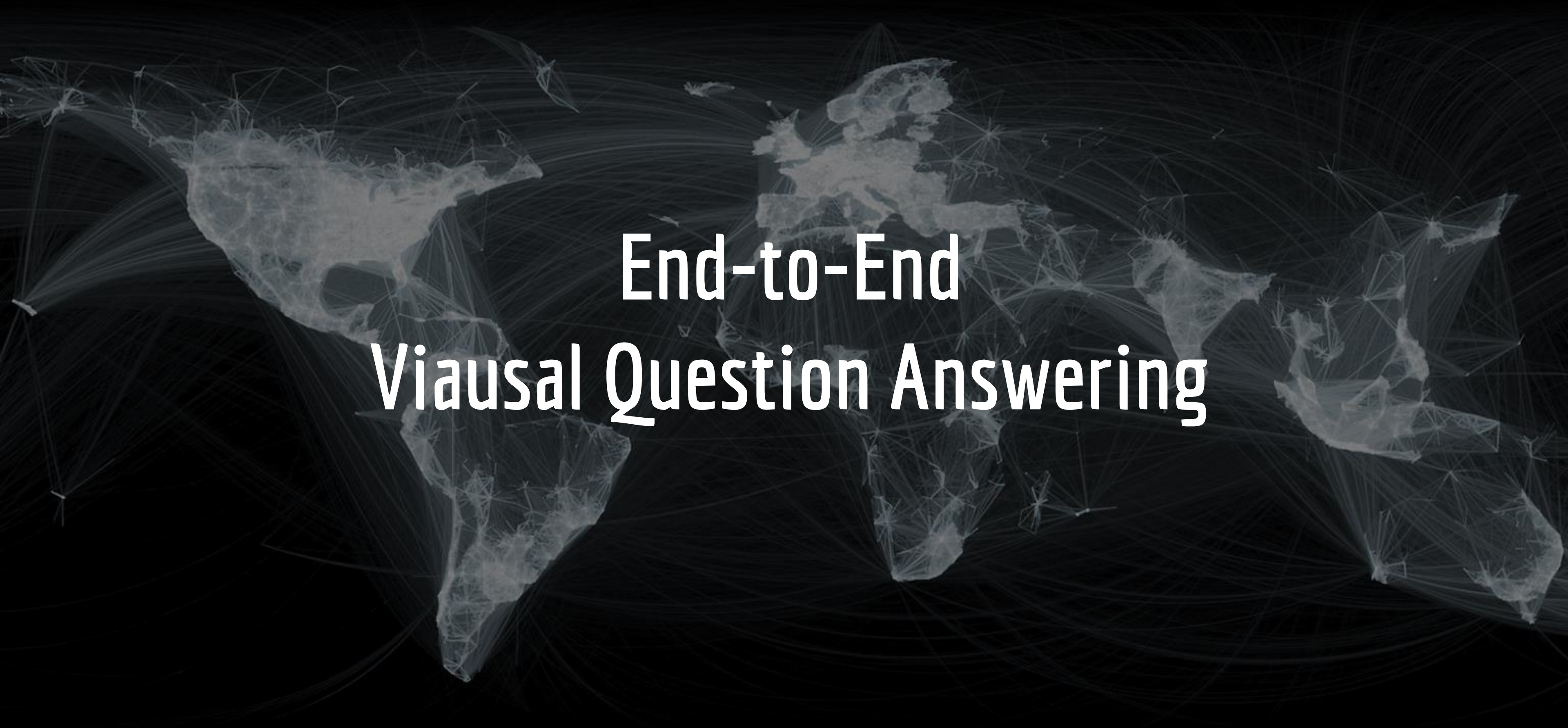
- Query formulation
  Choose **query keywords** for the IR system

- Question type classification
  Is this a definition question, a math question, a list question

IR-based Factoid QA | Question Processing

Answer type detection : Name entities

- Who founded Virgin Airlines ?
  - PERSON
- What Canadian city has the largest population ?
  - CITY

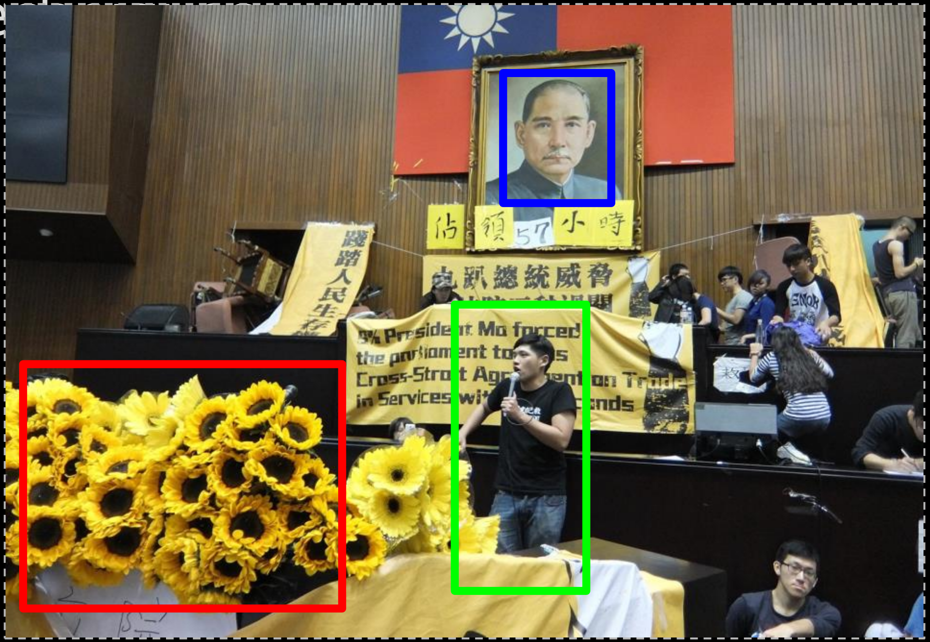


End-to-End Viausal Question Answering

VQA

Visual QA may contain some sub-problems...

- Object detection
- Image segmentation
- Some Question Answering te
    - Question type classification
    - Answer type detection



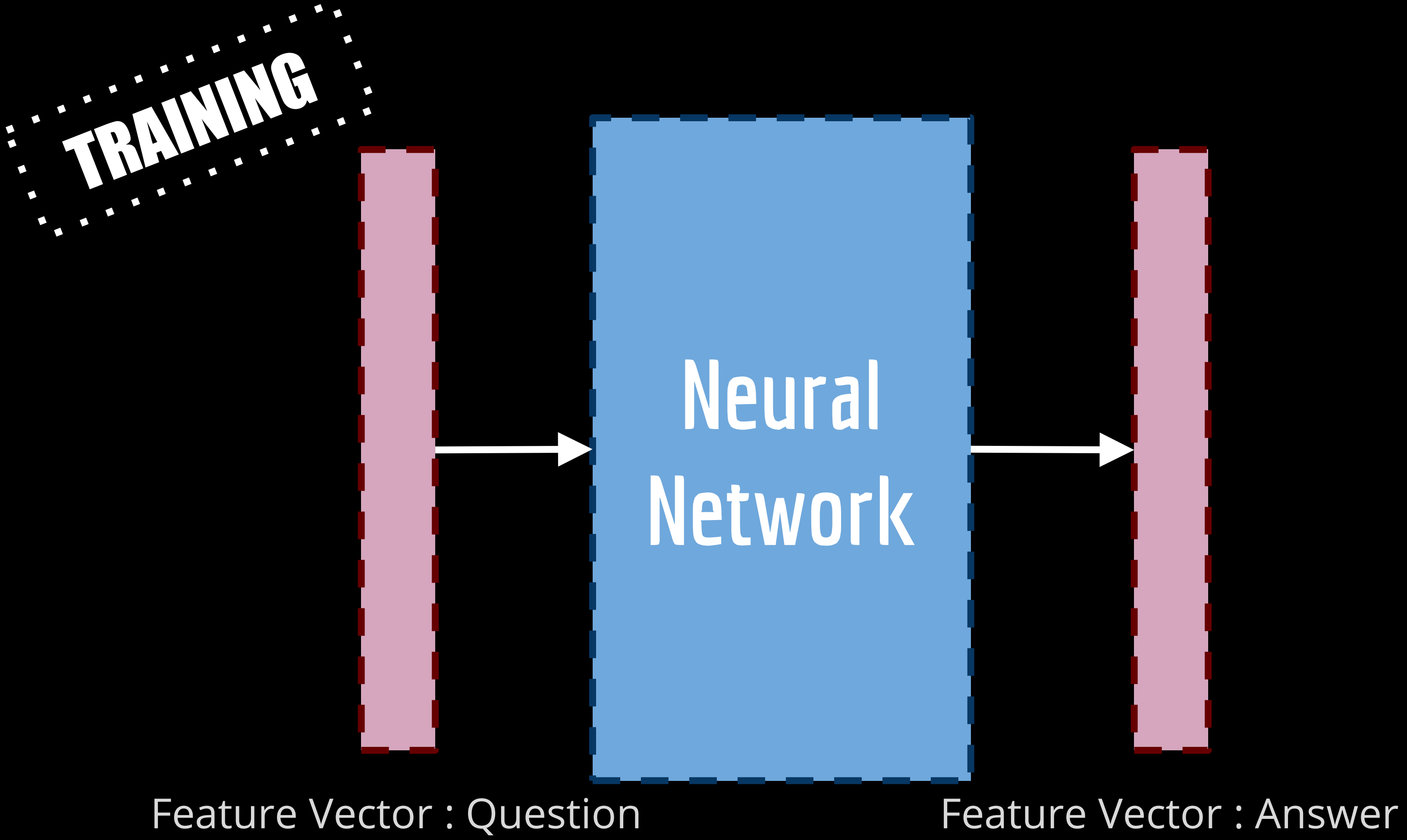
Is there any banana in the picture ?

(A) Yes.   (B) No.

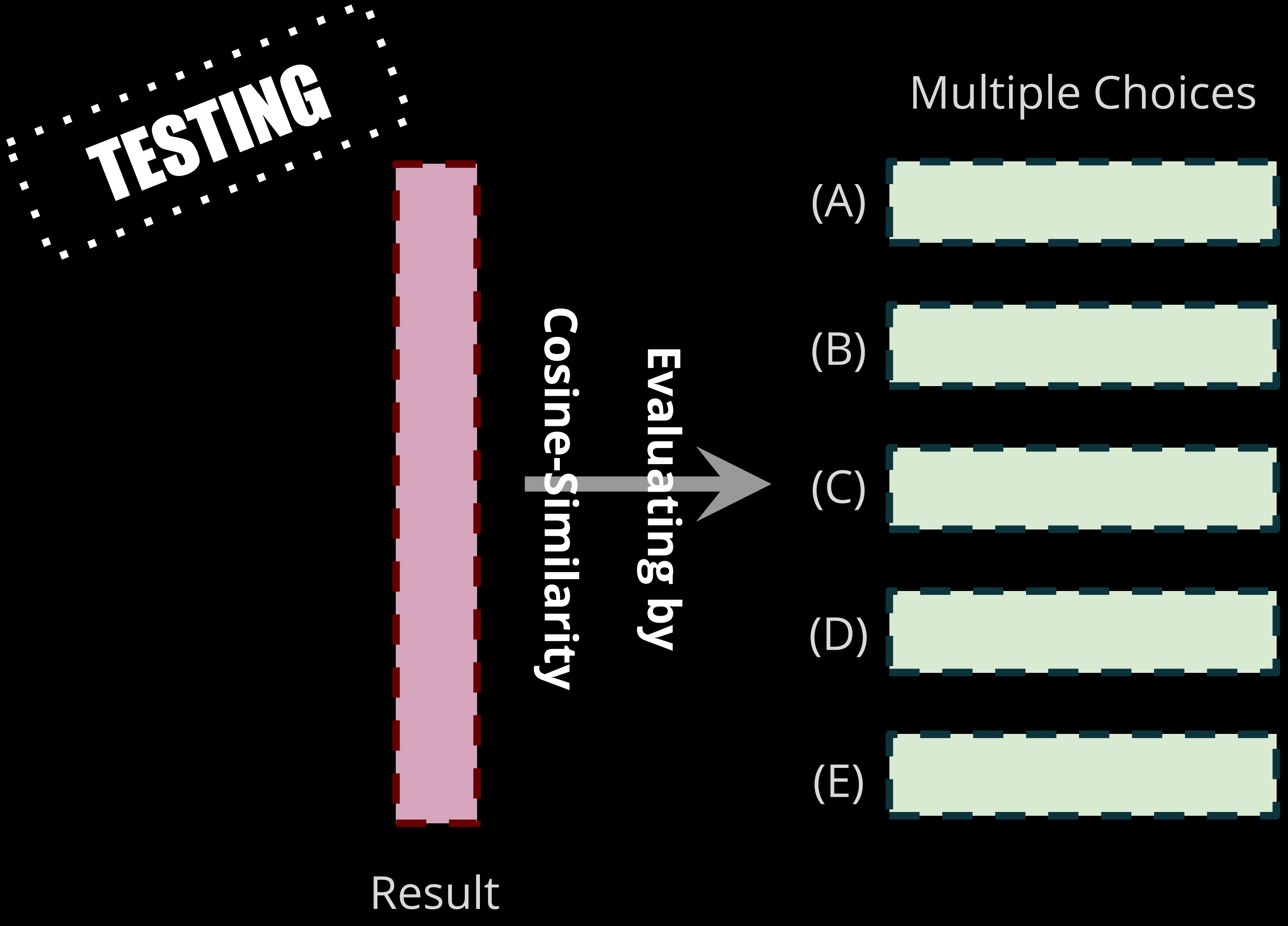
End-to-End Visual QA

Can directly predict answers according to questions and images

Proposed approach



Proposed approach



VQA

Extract Feature Vectors | Word Embedding

With a view to understanding sentences or documents, we need to model them in fixed-length vector representation.

Basic Representation Method :

Bag-of-words model / N-hot encoding

- Each document is represented by a set of keywords
- A pre-selected set of index terms can be used to summarize the document contents

Extract Feature Vectors | Word Embedding

Bag-of-words model / N-hot encoding

Definition

The pre-selected vocabulary $V = \{k_1,\ldots,k_i\}$ is the set of all distinct index terms in the collection

Examples

$V = \{John, game, to, likes, watch\}$

Sentence 1 $S_1 = [1,0,1,2,1]$

John likes to watch movies. Mary likes movies too.

Sentence 2 $S_2 = [1,1,1,1,1]$

John also likes to watch football games.

Extract Feature Vectors | Word Embedding

Bag-of-words model / N-hot encoding

Property

Simple and Powerful

Problem :

lose the ordering of the words
ignore the semantics of the words

Father = [0 0 0 0 0 1 0 0 … 0 0 0 0]
Mother = [0 0 1 0 0 0 0 0 … 0 0 0 0]

the cosine similarity between these two terms :

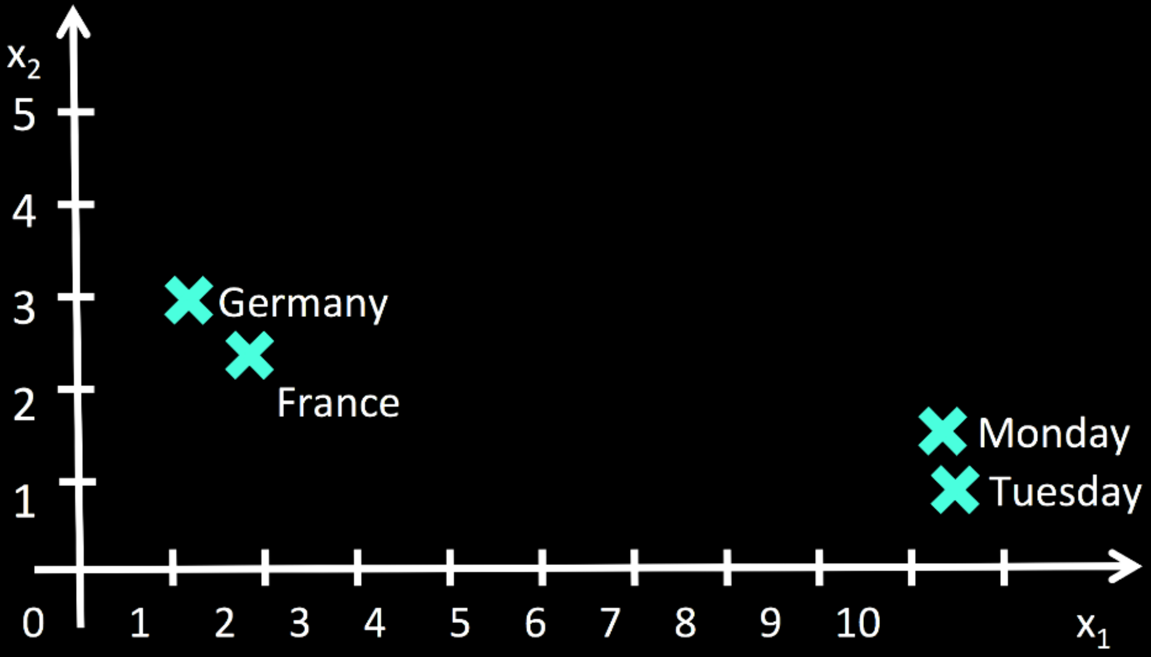
= 0 ?!

VQA

Extract Feature Vectors | Word Embedding

While word-embedding can solve these problems :

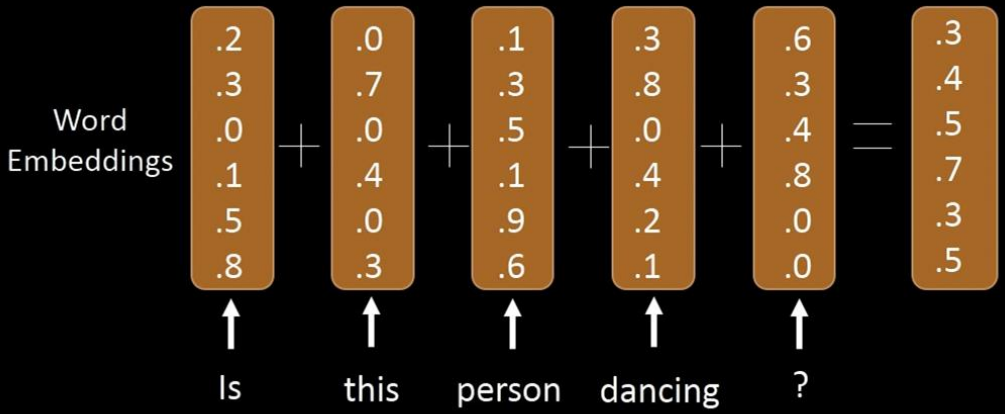
- Words are represented as a **DENSE, FIX-LENGTH** vector.
- Preserve semantic and syntatic information.



Extract Feature Vectors | Word Embedding

Using this technique, we can then represent phrases, or sentences by :

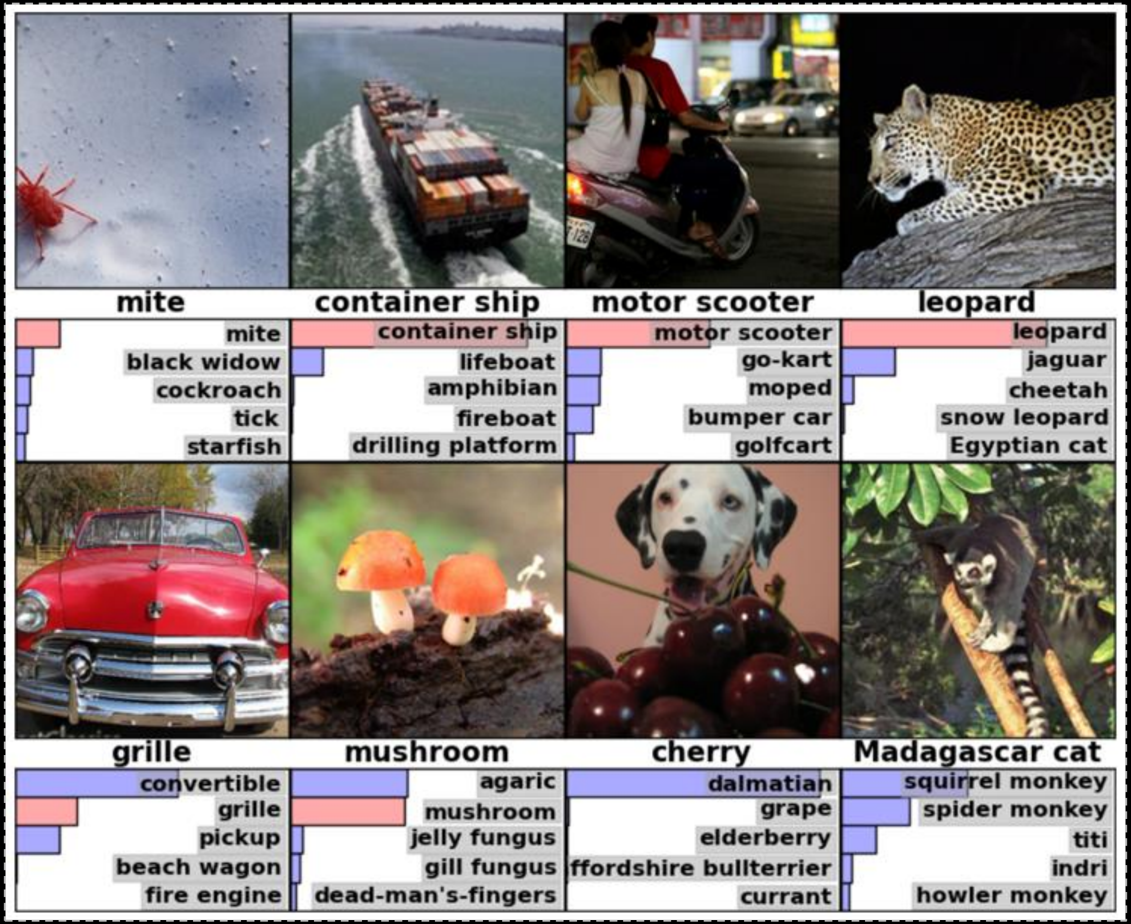
- Averaging word vectors



- Adapting sentence-embedding
  https://cs.stanford.edu/~quocle/paragraph_vector.pdf

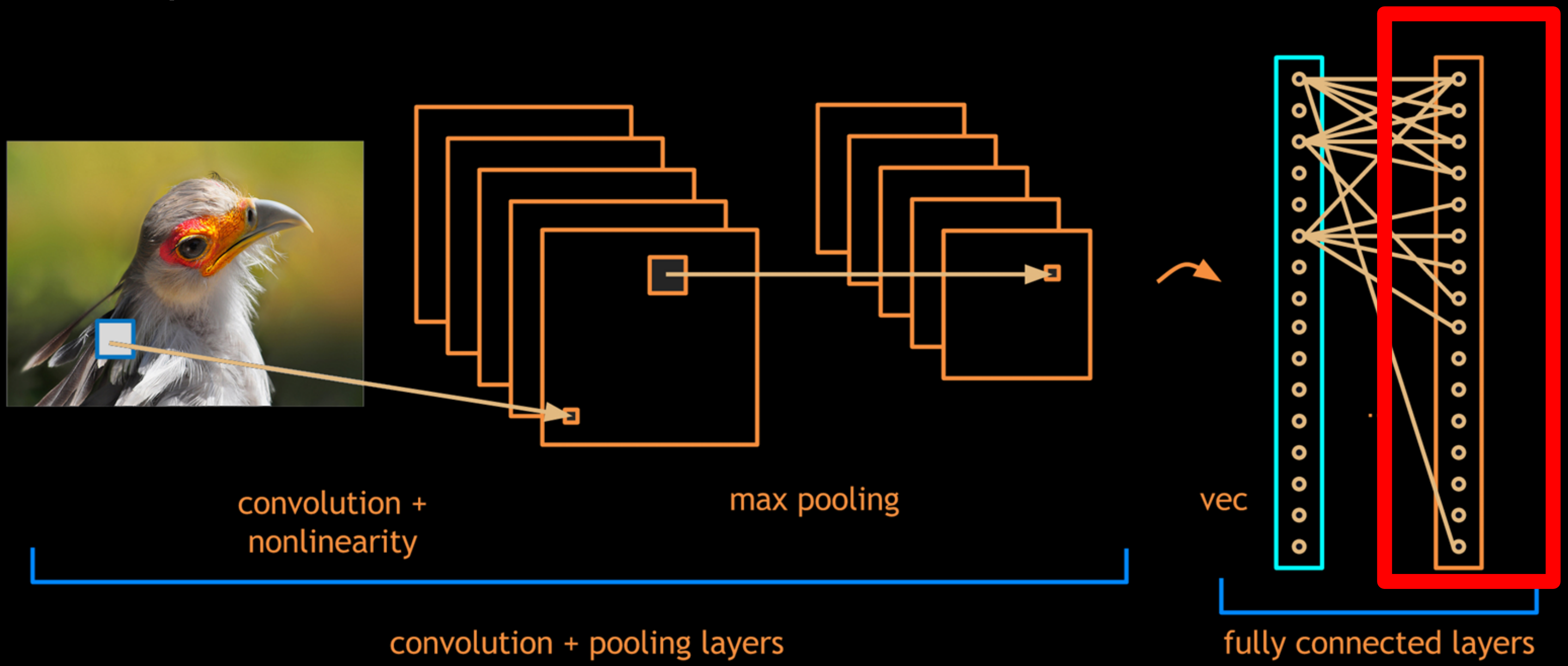
Extract Feature Vectors | Image Embedding

Using a Pre-trained CNN model, we can classify images



Extract Feature Vectors | Image Embedding

We can also represent images in vector-form by feeding them into the pre-trained CNN models



VQA

Proposed approach

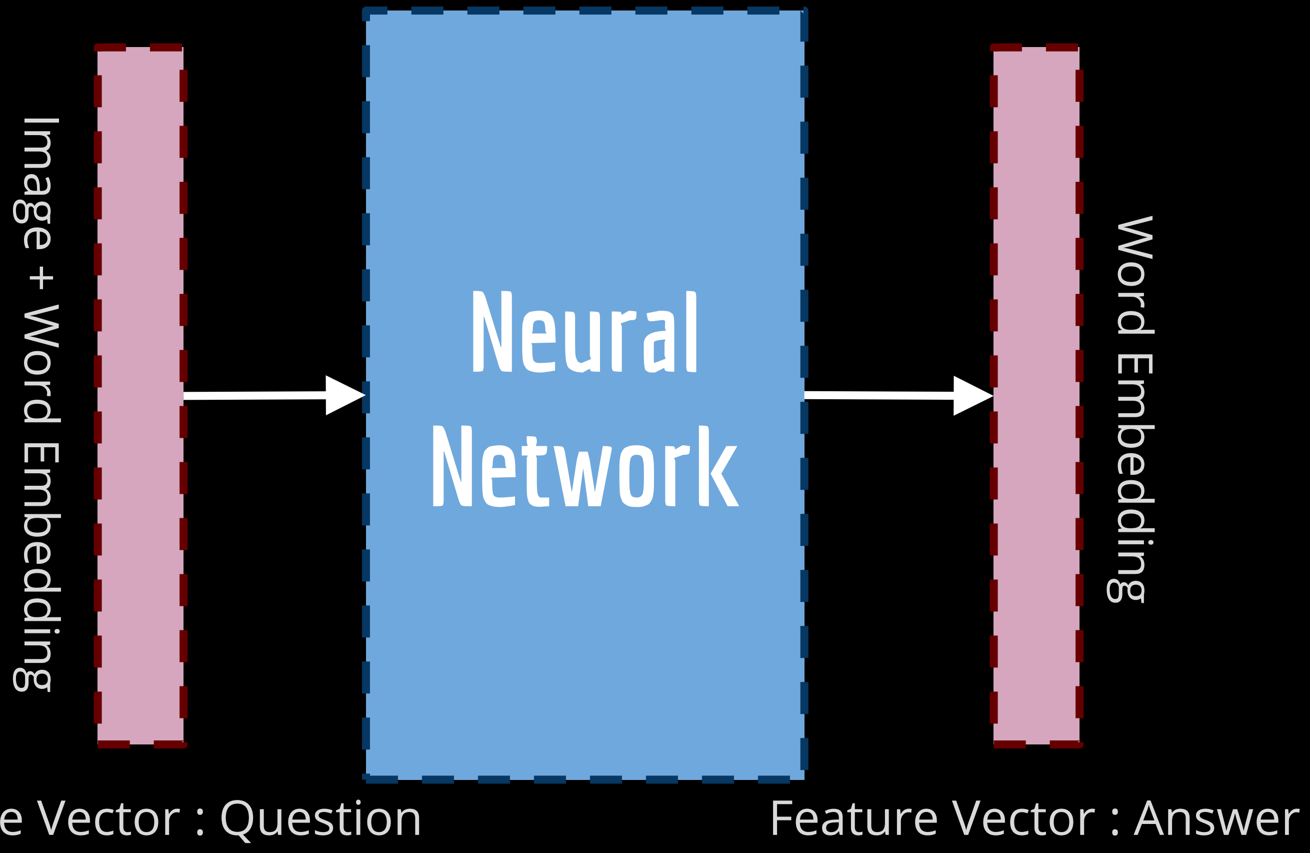


Image + Word Embedding

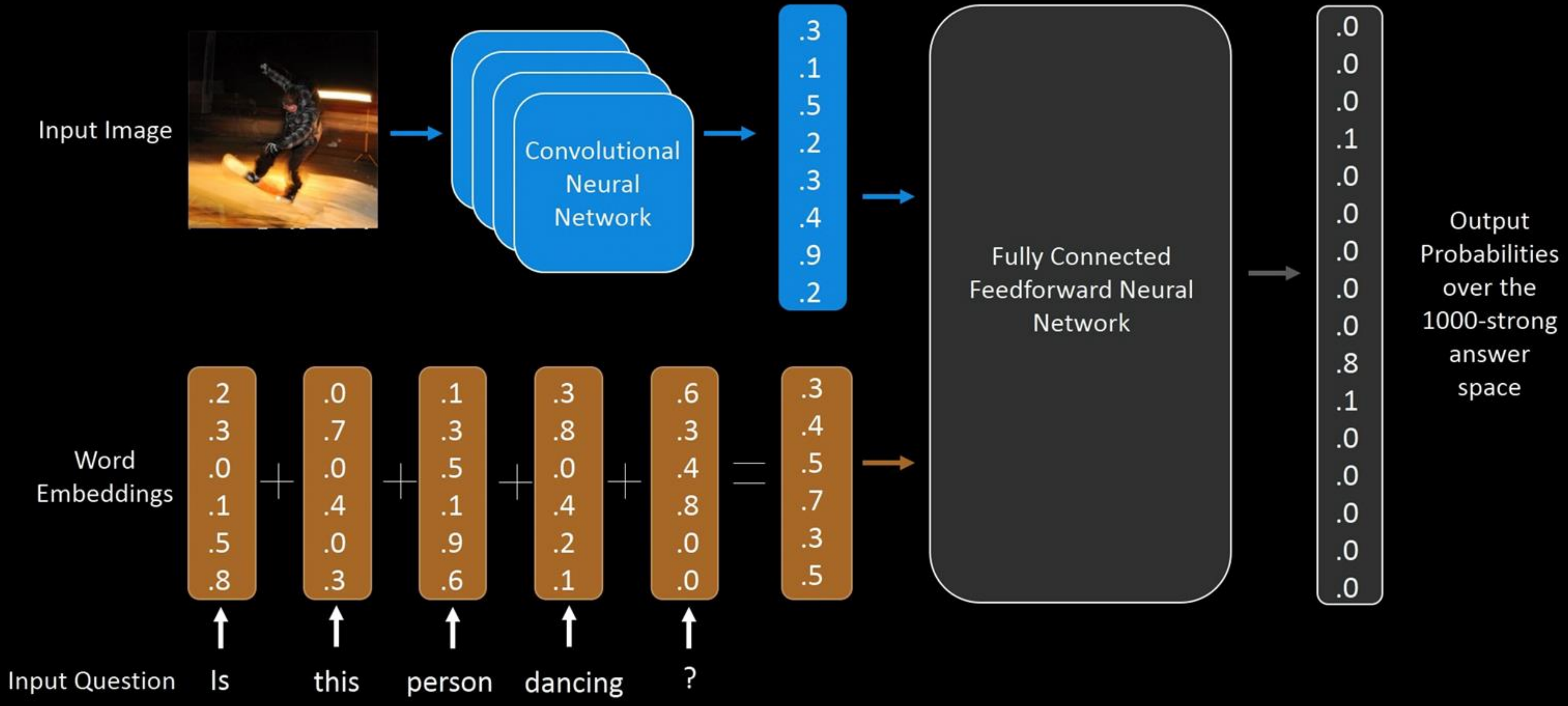
Neural Network

Word Embedding

Feature Vector : Question

Feature Vector : Answer

Proposed approach



VQA

Proposed approach

References for implementation :

- https://avisingh599.github.io/deeplearning/visual-qa/
- http://www.cs.toronto.edu/~mren/imageqa/
- https://www.d2.mpi-inf.mpg.de/sites/default/files/iccv15-neural_qa.pdf

Variations

- **BOW**

  “Blind” model. BOW+logistic regression
- **LSTM**

  Another “Blind” model.
- **IMG**

  CNN feature without question sentences but question type.

Attention Model on Question Answering

Discussion

How to use image information precisely ?

Reference Paper

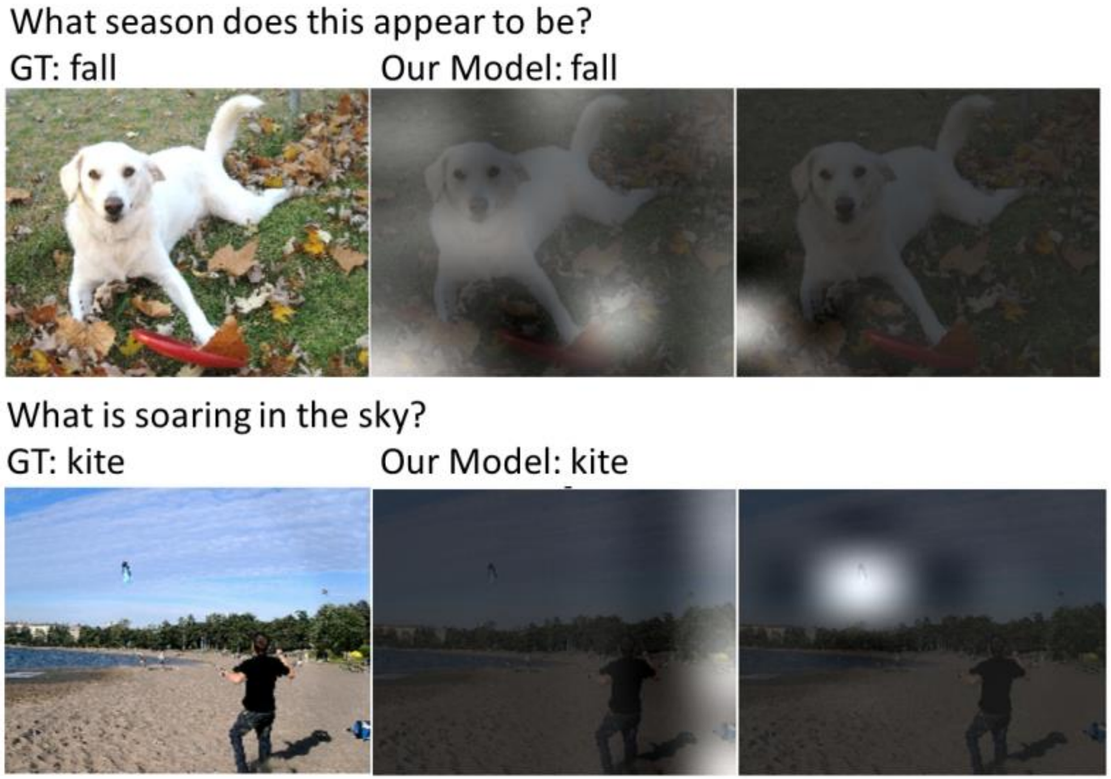
Xu, Huijuan, and Kate Saenko.

UMass Lowell

Ask, Attend and Answer: Exploring Question-Guided Spatial Attention for Visual Question Answering.

arXiv preprint arXiv:1511.05234 (2015).

Samples in this paper



What season does this appear to be?

GT: fall

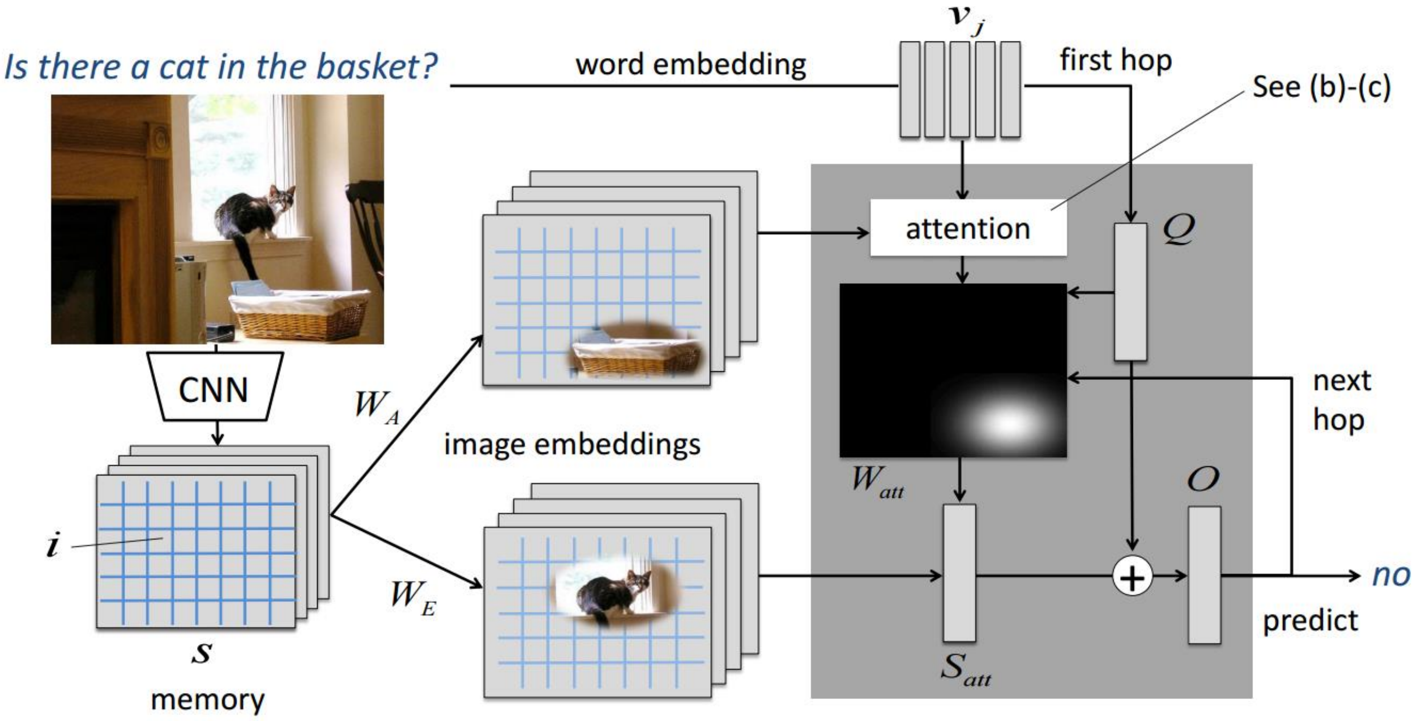
Our Model: fall

What is soaring in the sky?

GT: kite

Our Model: kite

Proposed Methodology



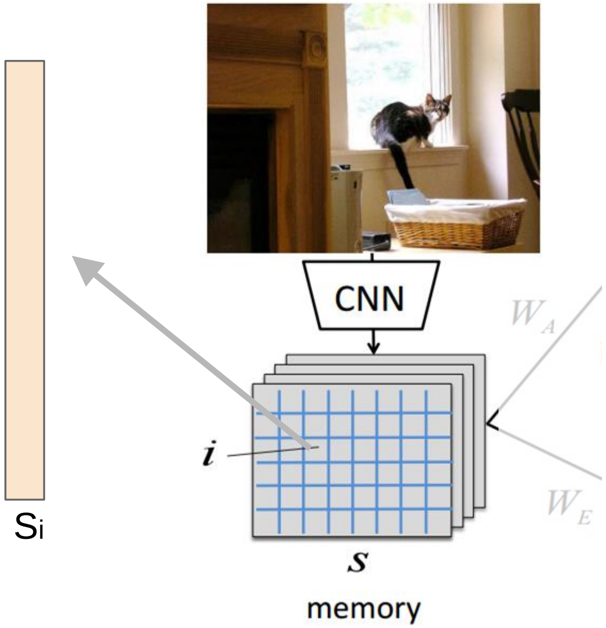
VQA

Proposed Methodology

CNN features :

extract the last convolutional layer of GoogLeNet

$$S = \{s_i \mid s_i \in \mathbb{R}^M; i = 1, \cdots, L\}$$

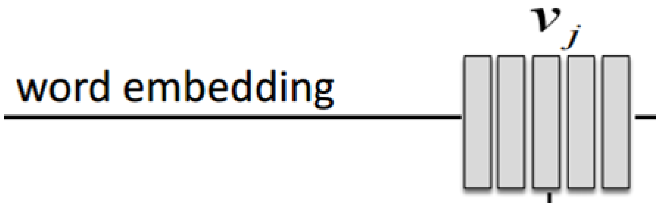


Proposed Methodology

Text features :

extract the last convolutional layer of GoogLeNet

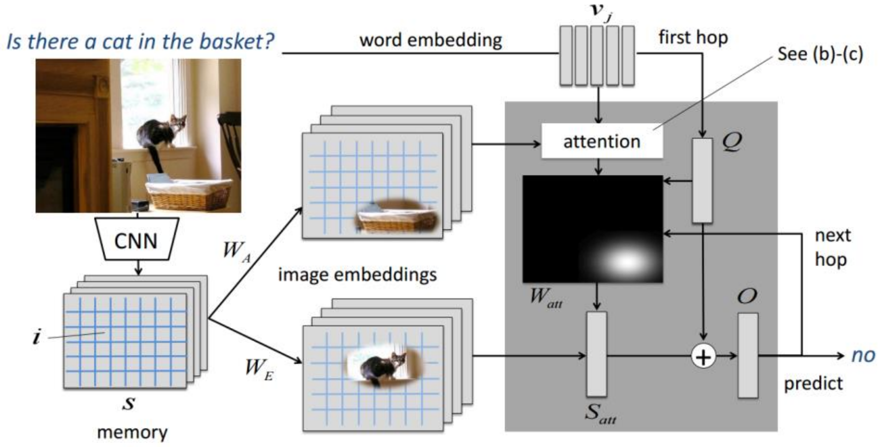
$$V = \{v_j \mid v_j \in \mathbb{R}^N; j = 1, \cdots, T\}$$



Proposed Methodology | Attention Level

Sentence (Question) Attention

Attention Matrix : W_A



$$C = (S \times W_A) \times Q$$

$$W_{att} = \mathrm{softmax}(C)$$

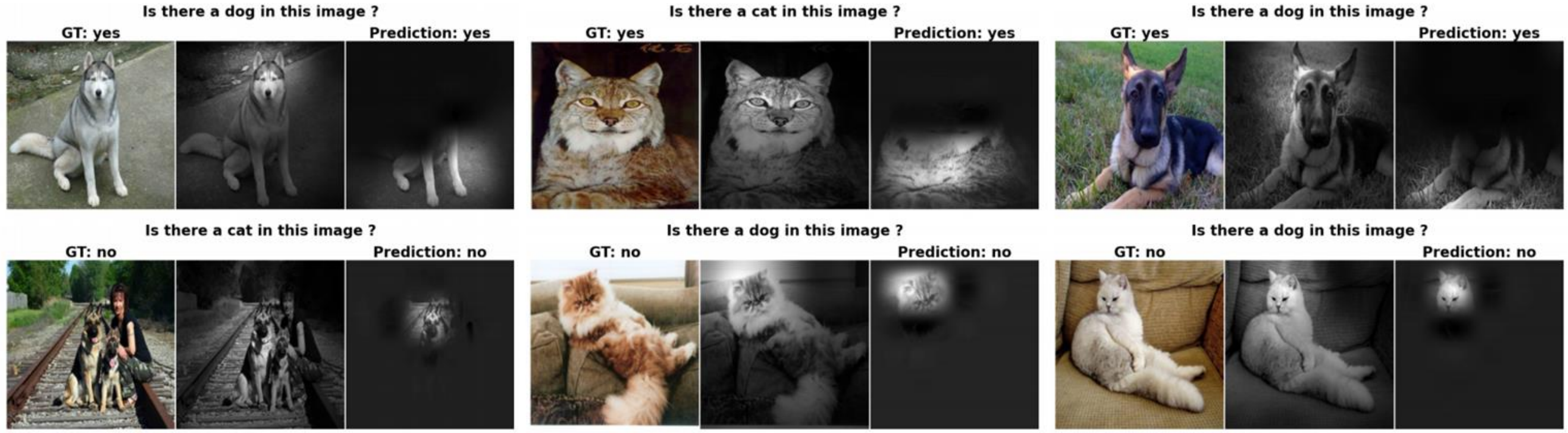
$$S_{att} = W_{att} \times (S \times W_E)$$

$$P = \mathrm{softmax}(W_P \times (S_{att} + Q) + B_P)$$

C: R^{L}, S: $R^{L\times M}$, W_A: $R^{M\times N}$, Q: R^{N}, W_{att}: R^{L}, W_E: $R^{M\times N}$

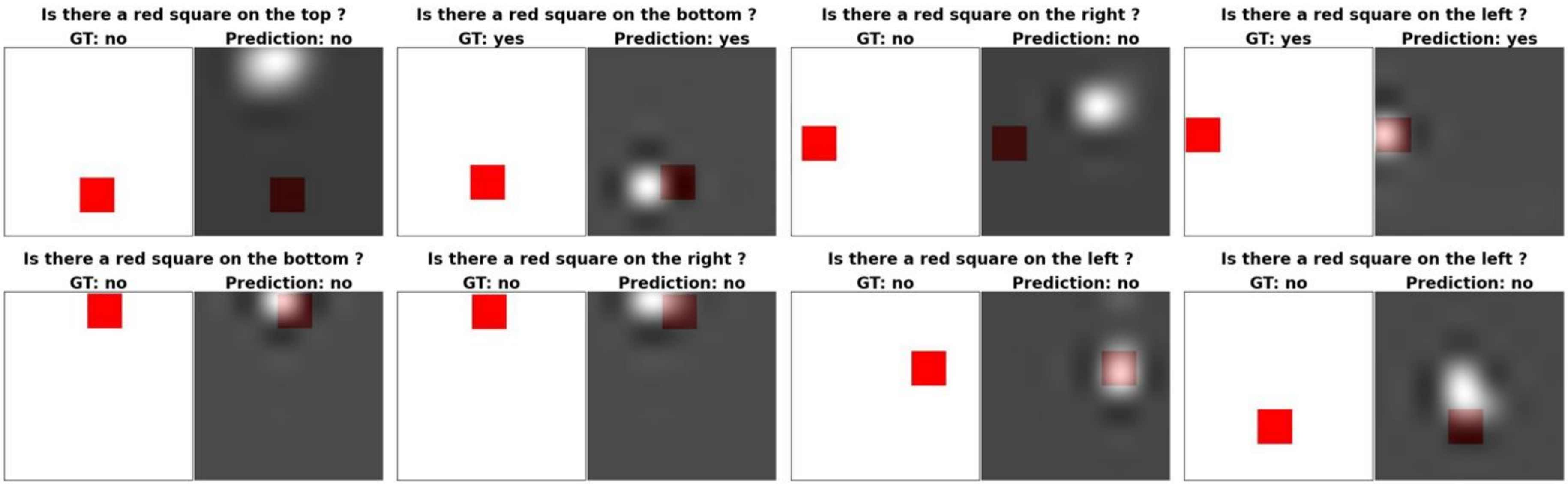
Attention Analysis

Object Presence


Is there a dog in this image ?
GT: yes
Prediction: yes
Is there a cat in this image ?
GT: yes
Prediction: yes
Is there a dog in this image ?
GT: yes
Prediction: yes
Is there a cat in this image ?
GT: no
Prediction: no
Is there a dog in this image ?
GT: no
Prediction: no
Is there a dog in this image ?
GT: no
Prediction: no

Attention Analysis

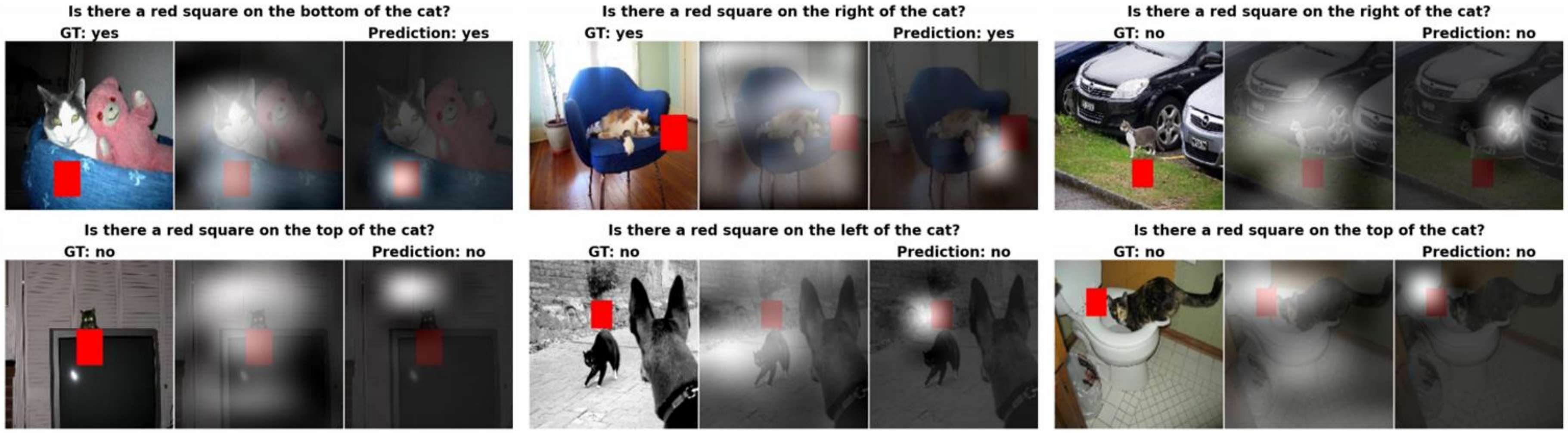
Absolute Position Recognition



With/O : 100% vs 75%

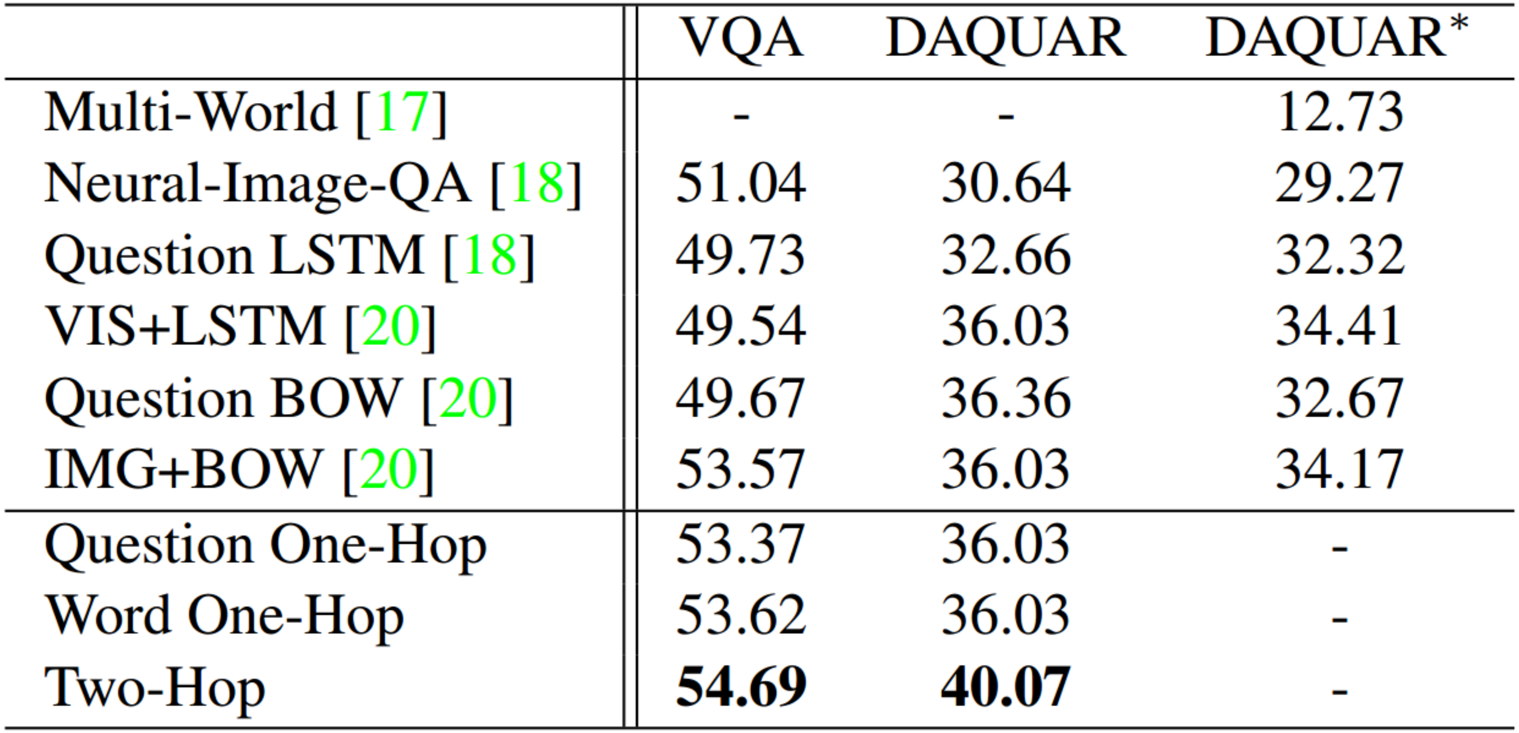
Attention Analysis

Relative Posititition Recognition


Is there a red square on the bottom of the cat?
GT: yes
Prediction: yes
Is there a red square on the right of the cat?
GT: yes
Prediction: yes
Is there a red square on the right of the cat?
GT: no
Prediction: no
Is there a red square on the top of the cat?
GT: no
Prediction: no
Is there a red square on the left of the cat?
GT: no
Prediction: no
Is there a red square on the top of the cat?
GT: no
Prediction: no

With/O : 96% vs 75%

Experimental Result



	VQA	DAQUAR	DAQUAR*
Multi-World [17]	-	-	12.73
Neural-Image-QA [18]	51.04	30.64	29.27
Question LSTM [18]	49.73	32.66	32.32
VIS+LSTM [20]	49.54	36.03	34.41
Question BOW [20]	49.67	36.36	32.67
IMG+BOW [20]	53.57	36.03	34.17
Question One-Hop	53.37	36.03	-
Word One-Hop	53.62	36.03	-
Two-Hop	**54.69**	**40.07**	-

Libraries and Toolkits

Word Embedding

- Word2Vec
  https://code.google.com/p/word2vec/
- GloVe
  http://nlp.stanford.edu/projects/glove/
- Sentence2vec
  https://github.com/klb3713/sentence2vec

Image Embedding

An pre-extracted feature set is provided :

http://cs.stanford.edu/people/karpathy/deepimagesent/coco.zip

This is the web page. Hope it works for you :

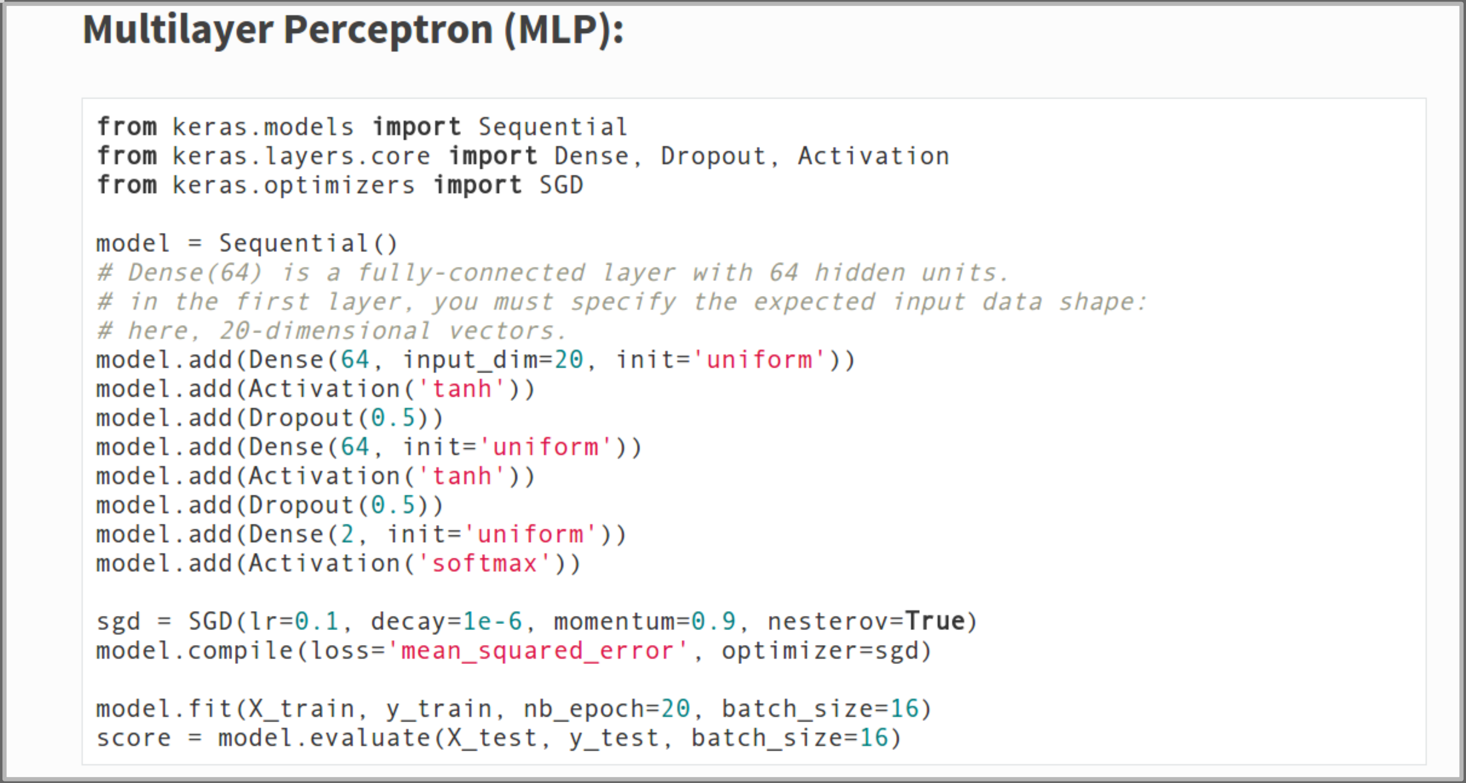
http://cs.stanford.edu/people/karpathy/deepimagesent/

(It’s about generating image descriptions.)

Keras

Website and documentation : http://keras.io/

Example :



Multilayer Perceptron (MLP):

```
from keras.models import Sequential
from keras.layers.core import Dense, Dropout, Activation
from keras.optimizers import SGD

model = Sequential()
# Dense(64) is a fully-connected layer with 64 hidden units.
# in the first layer, you must specify the expected input data shape:
# here, 20-dimensional vectors.
model.add(Dense(64, input_dim=20, init='uniform'))
model.add(Activation('tanh'))
model.add(Dropout(0.5))
model.add(Dense(64, init='uniform'))
model.add(Activation('tanh'))
model.add(Dropout(0.5))
model.add(Dense(2, init='uniform'))
model.add(Activation('softmax'))

sgd = SGD(lr=0.1, decay=1e-6, momentum=0.9, nesterov=True)
model.compile(loss='mean_squared_error', optimizer=sgd)

model.fit(X_train, y_train, nb_epoch=20, batch_size=16)
score = model.evaluate(X_test, y_test, batch_size=16)
```

Keras

Notification :

If input features are too large for you, you can load them in batch, and apply batch learning as well.

Here are some examples :

https://github.com/avisingh599/visual-qa/blob/master/scripts/trainMLP.py

References

References

- https://web.stanford.edu/class/cs124/lec/qa.pdf
- 懶得寫了

The End

Thanks for your listening