Learning to Google

Rodrigo Nogueira, Kyunghyun Cho, Urjitkumar Patel and Vincent Chabot

Motivation

Query: "deepmind go paper"

[PDF] Mastering the game of Go with deep neural networks ... - Go Game G...
https://gogameguru.com/i/2016/03/deepmind-mastering-go.pdf
by D Silver - Cited by 756 - Related articles
networks play **Go** at the level of state-of-the-art Monte-Carlo tree search ..... Ostrovski for reviewing the **paper**; and the rest of the **DeepMind** team for their support ...
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Publications | DeepMind
https://deepmind.com/publications.html
Nature 2016. Hybrid computing using a neural network with dynamic external memory. Authors: A Graves, G Wayne, M Reynolds, T Harley, I Danihelka, ...

AlphaGo | DeepMind
https://deepmind.com/research/alphago/
Jan 28, 2016 - Featuring expert analysis by Gu Li 9p and Zhou Ruiyang 9p, these games will prove an enlightening read for **Go** players of all levels.

Mastering the game of Go with deep neural networks and tree search ...
www.nature.com/nature/journal/v529/n7587/full/nature16961.html
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Jan 28, 2016 - The game of **Go** has long been viewed as the most challenging of classic games for artificial intelligence owing to its enormous search space ...

Motivation

Query: "google artificial intelligence paper asian board game"

Master of Go Board Game Is Walloped by Google Computer Program ...
https://www.nytimes.com/2016/03/10/world/asia/google-alphago-lee-se-dol.html
Mar 9, 2016 - Lee Se-dol, the world's top player of the **boardgame** Go, lost the first of five matches to a computer ... Kim Sung-ryong, a South **Korean** Go master who provided commentary during ... wondered Rodney Brooks, a pioneering **artificial intelligence** researcher. ... Order Reprints| Today's **Paper**|Subscribe.

Google AI beats legendary player in Chinese board game - The Hindu
www.thehindu.com › Sci-Tech › Science
Mar 9, 2016 - South Korea's professional Go player Lee Sedol, right, playing the **game** with against **Google's artificial intelligence** program, AlphaGo. ... In a new feat, **Google**-run **artificial intelligence** (**AI**) programme "AlphaGo" has defeated legendary player Lee Se-dol in Go — a complex ...

Google AI algorithm masters ancient game of Go : Nature News ...
www.nature.com/news/google-ai-algorithm-masters-ancient-game-of-go-1.19234
Jan 27, 2016 - **Google AI** algorithm masters ancient game of Go ... A computer has beaten a human professional for the first time at Go — an ancient **board game** that ... in **Asia**, has frustrated the efforts of **artificial-intelligence** researchers for ...

Game over? Computer beats human champ in ancient Chinese game
https://phys.org › Technology › Computer Sciences
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Motivation

The Vocabulary Mismatch Problem

The Idea

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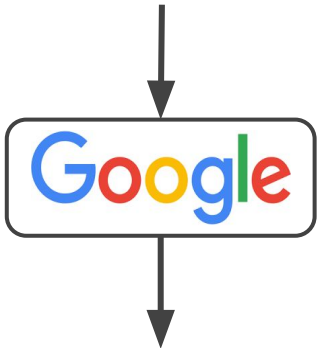

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Reformulation

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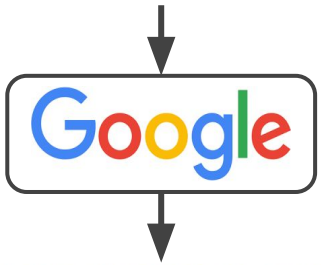

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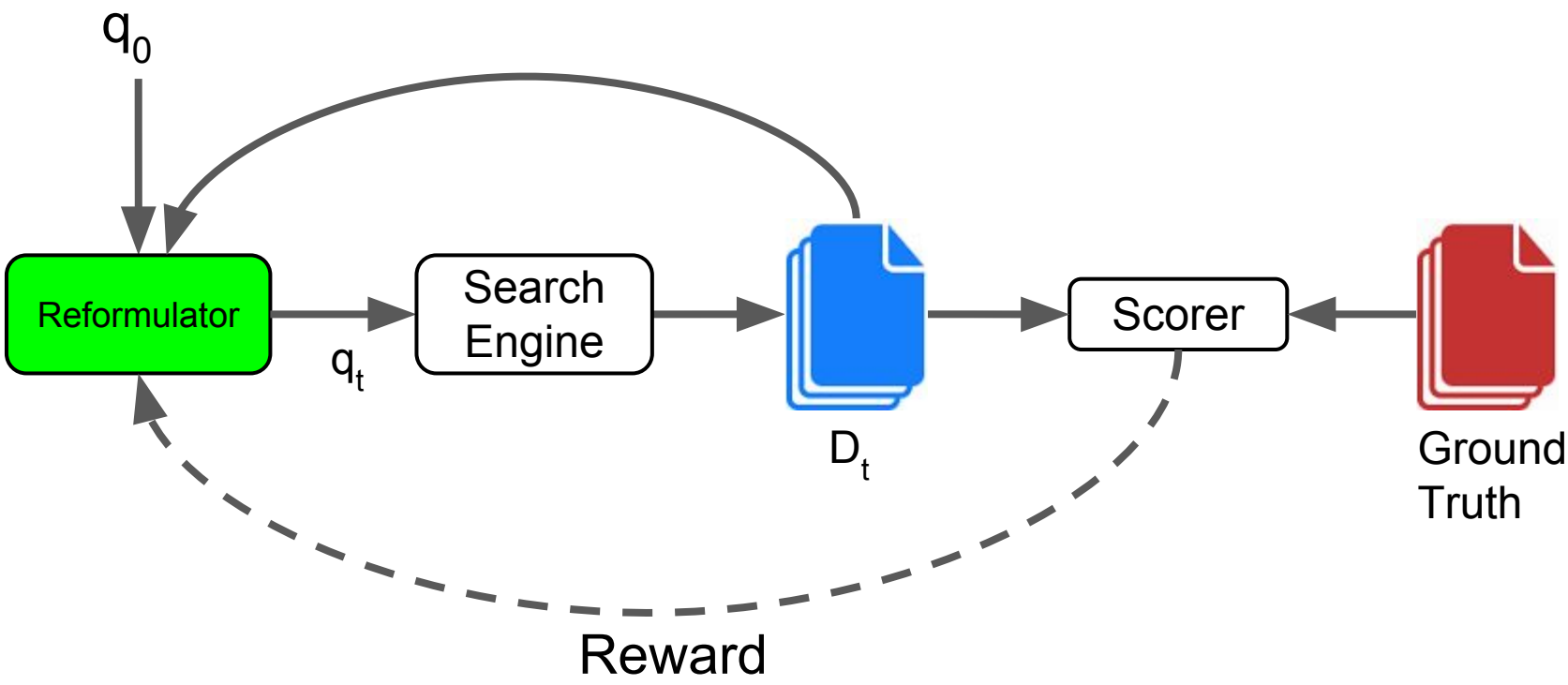
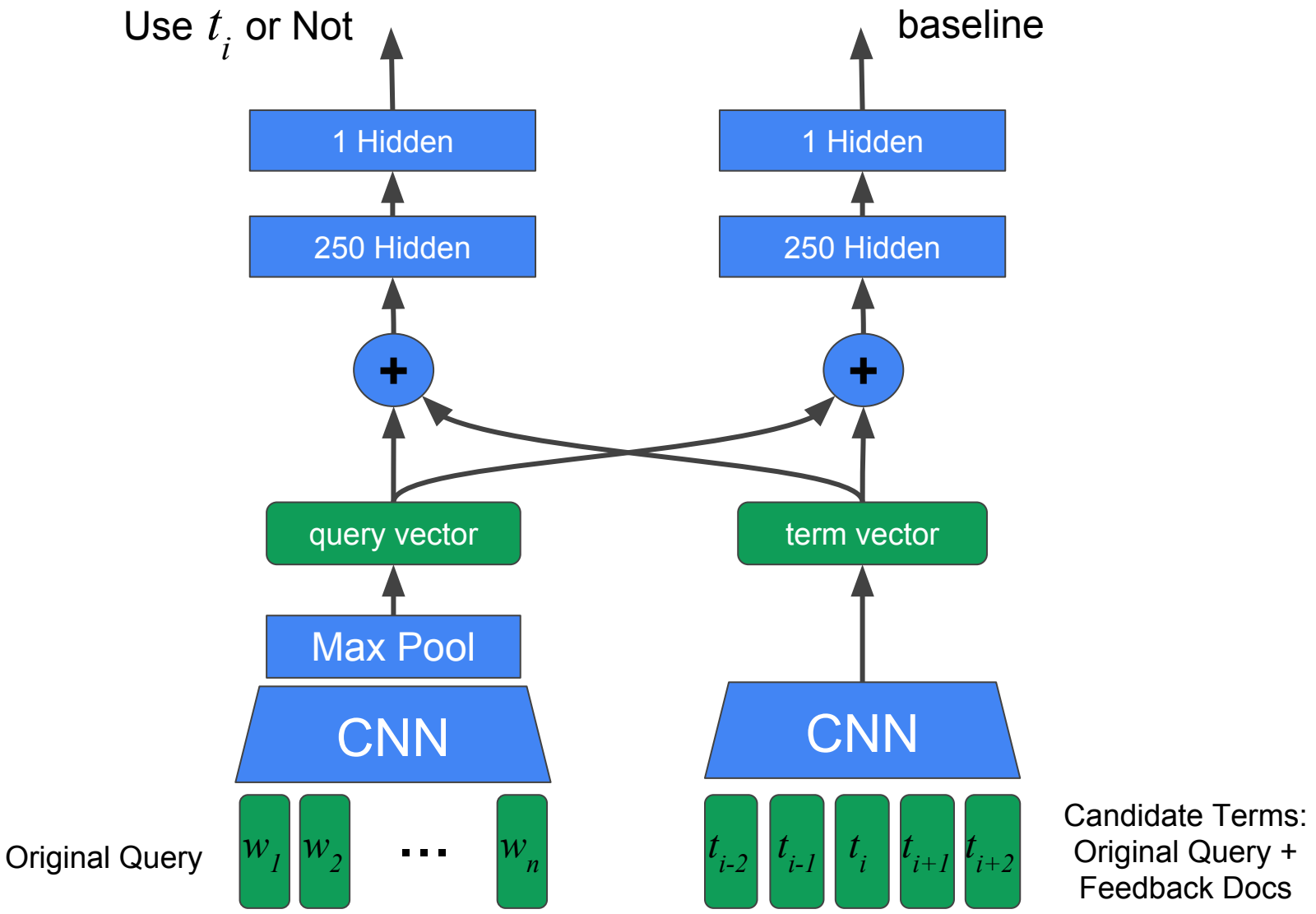
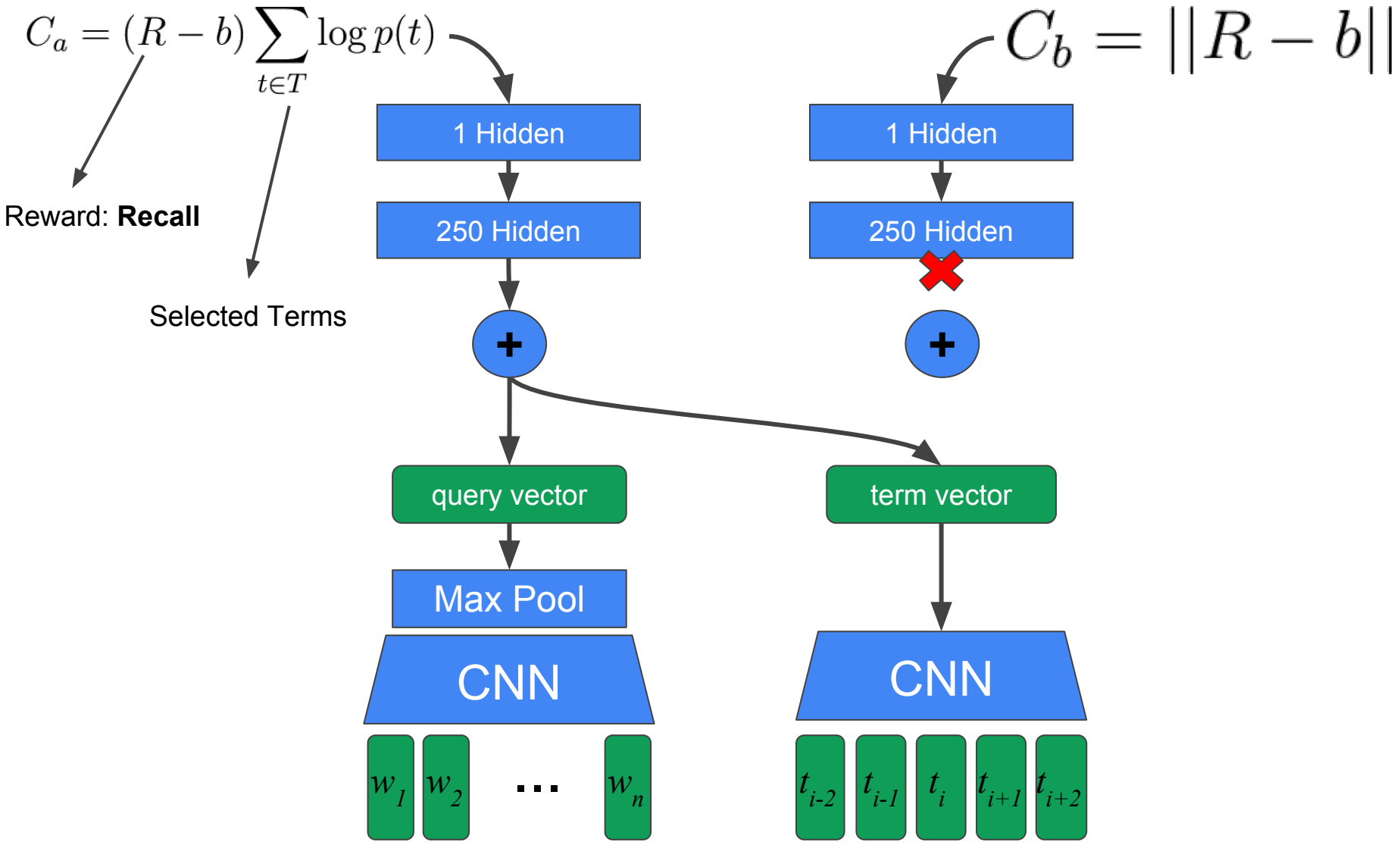

q_0
Reformulator
q_t
Search Engine
D_t
Scorer
Ground Truth
Reward

Reformulator



Vanilla REINFORCE



Supervised Method

Step 1: Label each term as positive or negative based on its incremental reward.

Ex:

Query	Recall	Diff	Label
Google asian board game paper	0.40	-	-
Google asian board game paper **Deepmind**	0.45	0.05	**Pos**
Google asian board game paper **go**	0.43	0.03	**Pos**
Google asian board game paper **beats**	0.32	-0.08	**Neg**
Google asian board game paper **legendary**	0.35	-0.05	**Neg**

Step 2: Train a supervised classifier to predict if a term is positive or not.

Oracle: A classifier that perfectly selects relevant terms.

(Cao et al. 2008)

Oracle - RL

A conservative upper-bound performance of a RL model in a particular environment:

1- Split the **validation or test** data into smaller subsets (~2000 samples)

2- Overfit the RL model on each subset

3- Oracle performance = Average reward over all subsets

Datasets

- TREC-Complex Answer Retrieval
- Jeopardy
- Microsoft Academic

TREC-Complex Answer Retrieval Dataset

Input: Wikipedia Title + Section

"Sea Turtle Diet"

Output: Wikipedia Paragraphs under the Section

Sea turtle

Diet [edit]

The loggerhead, Kemp's ridley, olive ridley, hawksbill, flatback, and leatherback sea turtles are omnivorous for their entire life. Omnivorous turtles may eat a wide variety of plant and animal life including, decapods, seagrasses, seaweed, sponges, mollusks, cnidarians, echinoderms, worms and fish.[36][37][38][39] However some species specialize on certain prey.

The diet of green turtles changes with age.[40] Juveniles are omnivorous, but as they mature they become exclusively herbivorous.[37][40] This diet shift has an effect on the green turtle's morphology.[41][42] Green sea turtles have a serrated jaw that is used to eat sea grass and algae.[43]

Leatherback turtles feed almost exclusively on jellyfish and help control jellyfish populations.[44][45]

Hawksbills principally eat sponges, which constitute 70–95% of their diets in the Caribbean.[46]

Corpus: Paragraphs of all Wikipedia Articles

http://trec-car.cs.unh.edu/

Jeopardy Dataset

Input: Jeopardy question

> *"For the last 8 years of his life, Galileo was under house arrest for espousing this man's theory."*

Output: Wikipedia article whose title is the Answer.

Nicolaus Copernicus

From Wikipedia, the free encyclopedia

"Copernicus" redirects here. For other uses, see Copernicus (disambiguation).

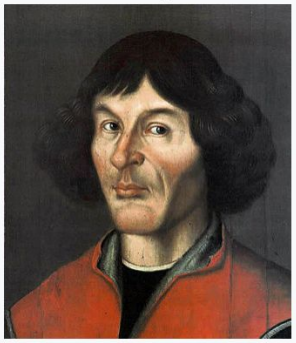
Nicolaus Copernicus (/koʊˈpɜːrnɪkəs, kə-/;[1][2][3] Polish: *Mikołaj Kopernik* [miˈkɔwaj kɔˈpɛrɲik] (listen); German: *Nikolaus Kopernikus*; 19 February 1473 – 24 May 1543) was a Renaissance mathematician and astronomer who formulated a model of the universe that placed the Sun rather than the Earth at the center of the universe, likely independently of Aristarchus of Samos, who had formulated such a model some eighteen centuries earlier.[a]

The publication of Copernicus' model in his book *De revolutionibus orbium coelestium* (*On the Revolutions of the Celestial Spheres*), just before his death in 1543, was a major event in the history of science, triggering the Copernican Revolution and making an important contribution to the Scientific Revolution.[7]

Copernicus was born and died in Royal Prussia, a region that had been part of the Kingdom of Poland since 1466. A polyglot and polymath, he obtained a doctorate in canon law and was also a mathematician, astronomer, physician, classics scholar, translator, governor, diplomat, and economist. In 1517 he derived a quantity theory of money – a key concept in economics – and in 1519 he formulated an economics principle that later came to be called Gresham's law.[8]

Contents [hide]

Nicolaus Copernicus

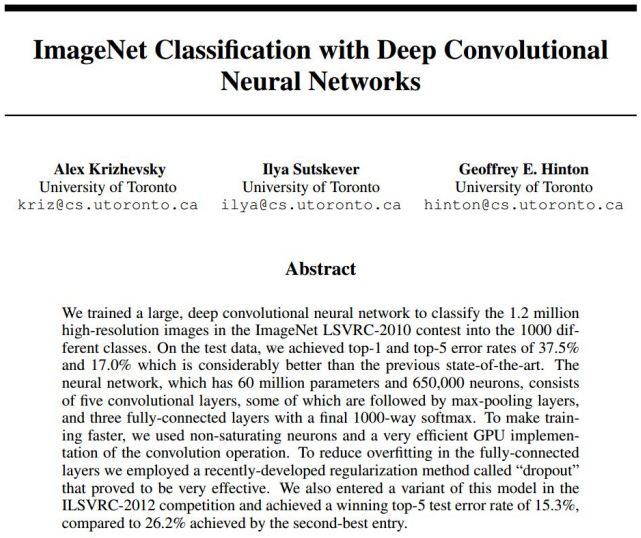


1580 portrait (artist unknown) in the Old Town City Hall, Toruń

(Nogueira and Cho, NIPS 2016)

Microsoft Academic Dataset

Input: Title/Abstract of a Paper



ImageNet Classification with Deep Convolutional Neural Networks

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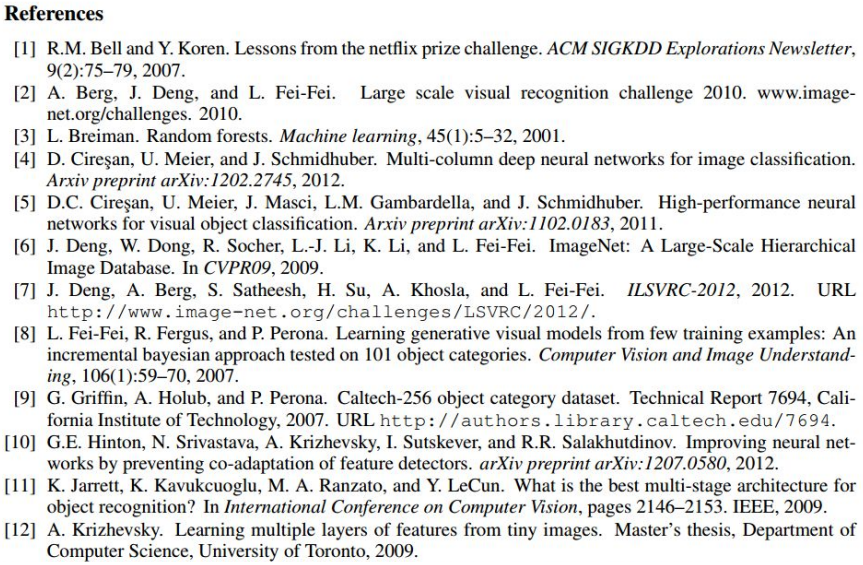
Ilya Sutskever University of Toronto ilya@cs.utoronto.ca
Geoffrey E. Hinton University of Toronto hinton@cs.utoronto.ca

Abstract

We trained a large, deep convolutional neural network to classify the 1.2 million high-resolution images in the ImageNet LSVRC-2010 contest into the 1000 different classes. On the test data, we achieved top-1 and top-5 error rates of 37.5% and 17.0% which is considerably better than the previous state-of-the-art. The neural network, which has 60 million parameters and 650,000 neurons, consists of five convolutional layers, some of which are followed by max-pooling layers, and three fully-connected layers with a final 1000-way softmax. To make training faster, we used non-saturating neurons and a very efficient GPU implementation of the convolution operation. To reduce overfitting in the fully-connected layers we employed a recently-developed regularization method called "dropout" that proved to be very effective. We also entered a variant of this model in the ILSVRC-2012 competition and achieved a winning top-5 test error rate of 15.3%, compared to 26.2% achieved by the second-best entry.

Output: References in that paper



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[9] G. Griffin, A. Holub, and P. Perona. Caltech-256 object category dataset. Technical Report 7694, California Institute of Technology, 2007. URL http://authors.library.caltech.edu/7694.
[10] G.E. Hinton, N. Srivastava, A. Krizhevsky, I. Sutskever, and R.R. Salakhutdinov. Improving neural networks by preventing co-adaptation of feature detectors. *arXiv preprint arXiv:1207.0580*, 2012.
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(An in-house crawl of 200k papers)

Datasets - Summary

	TREC-CAR	**Jeopardy**	**MS Academic**
Corpus	Wikipedia Paragraphs	Wikipedia Articles	Academic Papers
Corpus Size	5.9M	3.5M	200k
Train / Valid / Test	600k / 200k / 200k	120k / 10k / 10k	120k / 10k / 10k

Results

Recall@40 on Test Set

	TREC-CAR	Jeopardy	MS Academic
Original Query	43.6	23.4	12.8
Pseudo Relevance Feedback - TFIDF	44.3	29.9	13.1
Pseudo Relevance Feedback - Word2Vec	44.5	27.5	11.9
Google	-	30.1	-
Supervised	44.1	31.1	14.0
REINFORCE	**46.7**	**33.4**	**15.3**
Oracle, Supervised	50.8	37.4	17.9
Oracle, RL	55.8	39.0	19.1

Examples

Original: *It can be a herdsman's little house in the Swiss Alps, or a ski lodge built in that style*

Reformulated: *house Swiss Alps ski lodge that style castle board chalet*

Original: Homelessness in Canada, Public Policy

Reformulated: *homelessness in canada public policy* human service programs social policy california treatment of the homeless numerous

Experiment Details

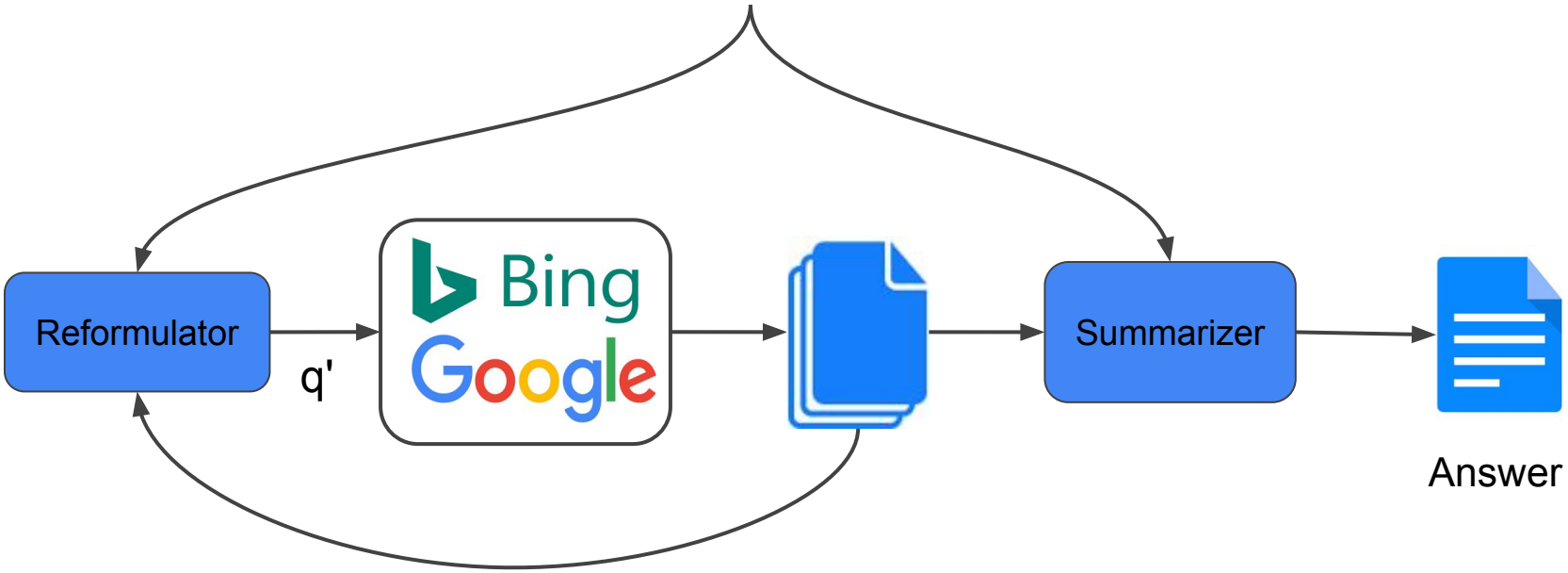
Choice	Why?
Search Engine: Lucene	Free and Fast!
Feedback docs: Top-5 Wikipedia Articles Feedback terms: 300 first words of a Wikipedia doc	Maximum fit on a GPU
CNN for Docs: 1st layer: 9-word window, 250 filters 2nd layer: 3-word window, 500 filters CNN for Query: 2 layers, 3-word window, 250 filters	Painful Manual Trial-and-Error
Reward: Recall@40	Query Reformulation: Recall Ranking Functions: Precision

Discussion

- Oracle shows lots of room for improvements.
- Applicability: Commercial search engines have click-through datasets.
- Querying the search engine is 90% of training time.

Future Work: Automated Researcher

Query: "*What are the most promising directions to cure cancer and why?*"



Thank you!