# Task-Oriented Query Reformulation with Reinforcement Learning

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Group 25

Aadil Hayat
17111001

# Motivation

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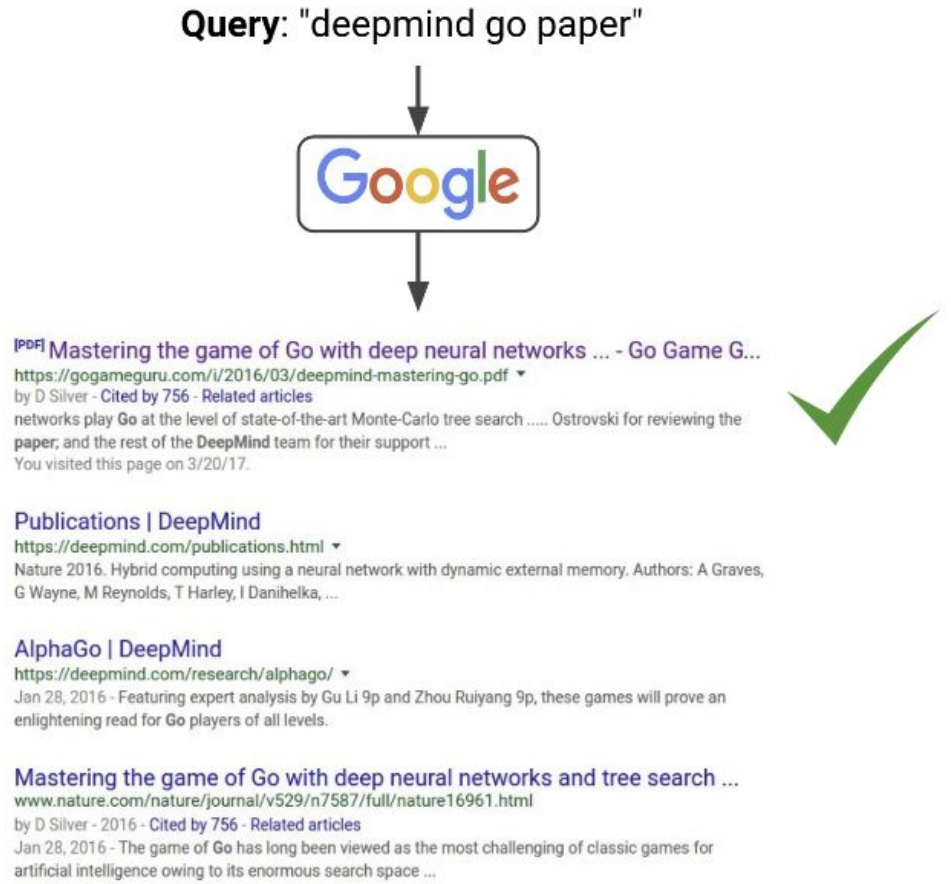
Query: "deepmind go paper"
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[PDF] Mastering the game of Go with deep neural networks ... - Go Game G...
https://gogameguru.com/i/2016/03/deepmind-mastering-go.pdf
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networks play Go at the level of 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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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
by D Silver - 2016 - Cited by 756 - Related articles
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
Jan 27, 2016 - In a milestone for **artificial intelligence**, a computer has beaten a ... human player at the 3,000-year-old **Chinese board game** known as Go, was ... of **Google** DeepMind, a British **artificial intelligence** (**AI**) company. ... added his colleague David Silver, who co-authored the **paper** in the science journal Nature.

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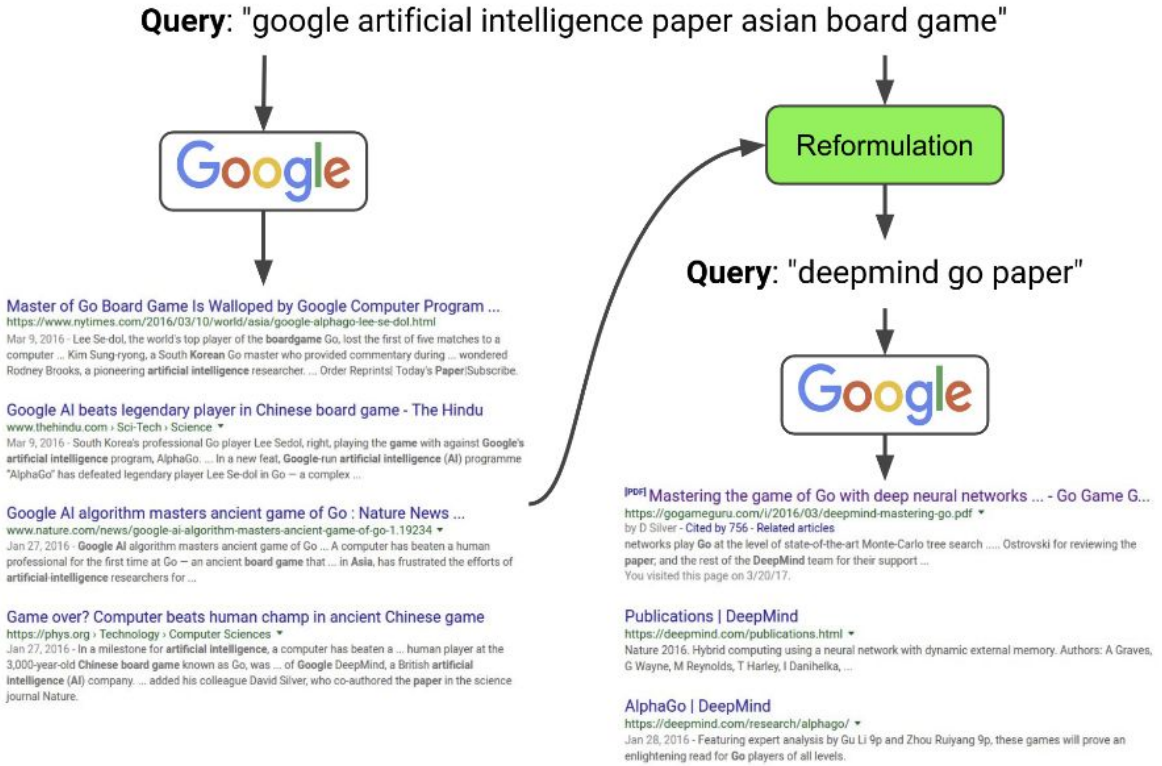
# Idea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Reformulation
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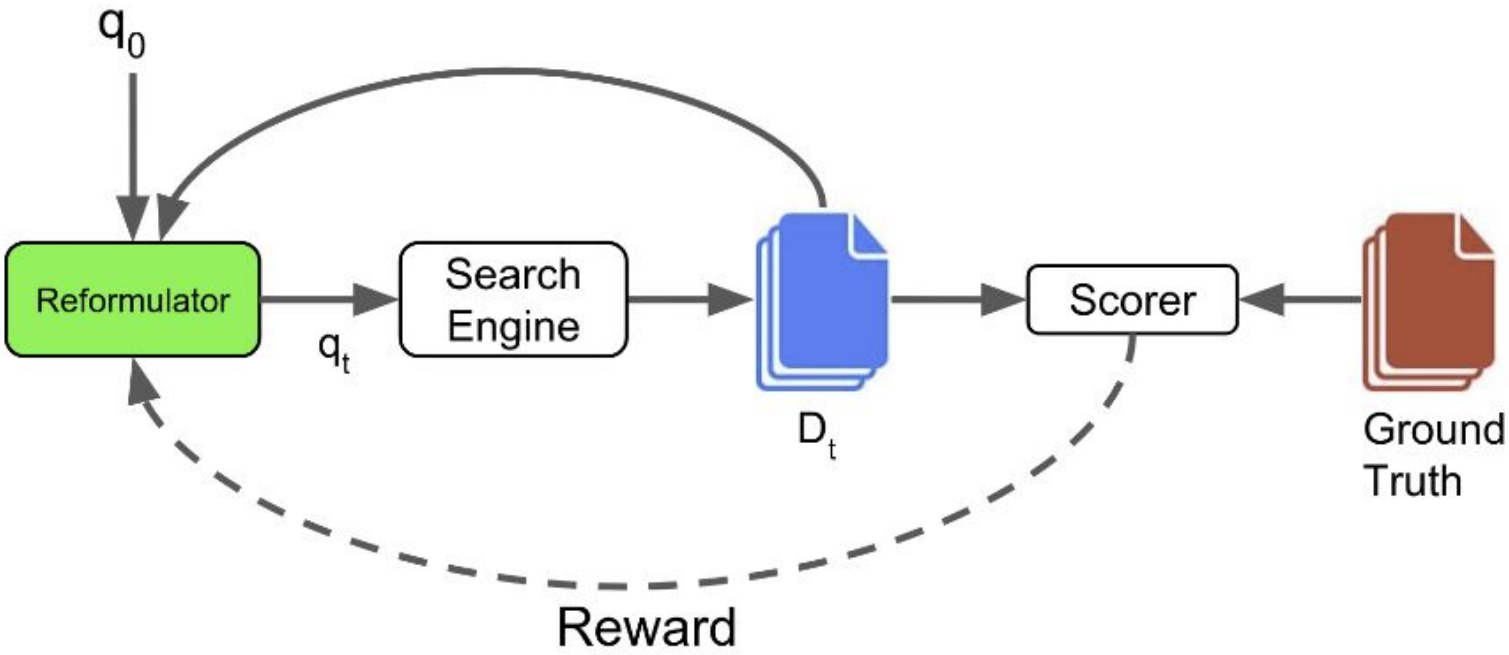
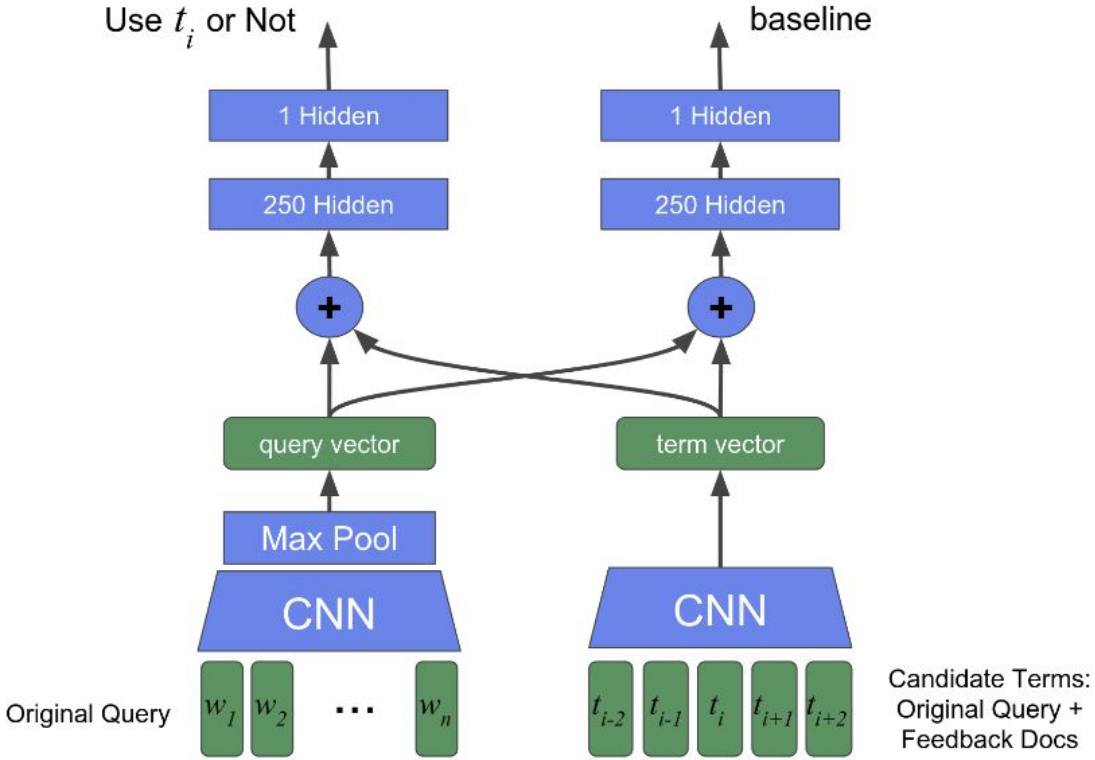
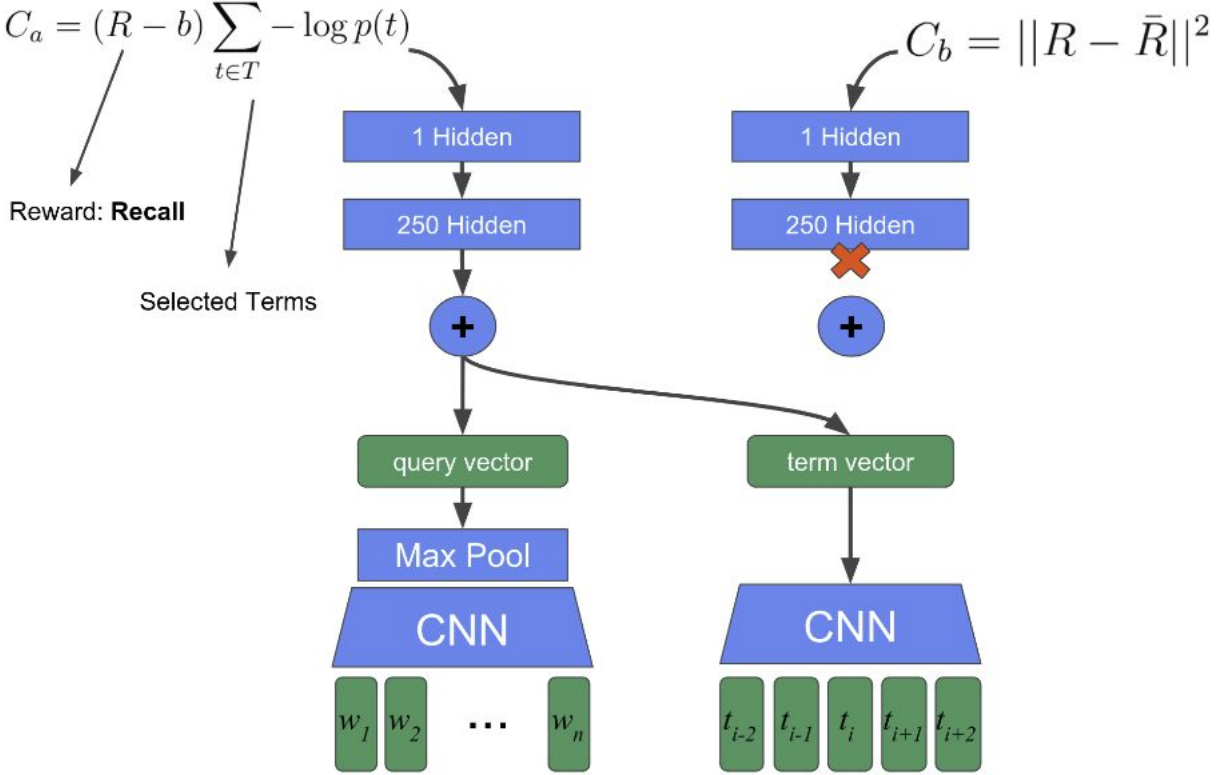

$q_0$
Reformulator
$q_t$
Search Engine
$D_t$
Scorer
Ground Truth
Reward

# Implementation

# Reformulator



# REINFORCE


$C_a = (R - b) \sum_{t \in T} - \log p(t)$
$C_b = ||R - \bar{R}||^2$
Reward: **Recall**
Selected Terms
1 Hidden
250 Hidden
1 Hidden
250 Hidden
+
+
query vector
term vector
Max Pool
CNN
CNN
$w_1$ $w_2$ ... $w_n$
$t_{i-2}$ $t_{i-1}$ $t_i$ $t_{i+1}$ $t_{i+2}$

# Oracle - RL

Conservative **Upper-Bound** performance of RL based model:

1. Split validation or test data into smaller subsets (~2000 samples)
2. Overfit RL model on each subset
3. Oracle performance = Average reward over all subsets

# Datasets

# 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]

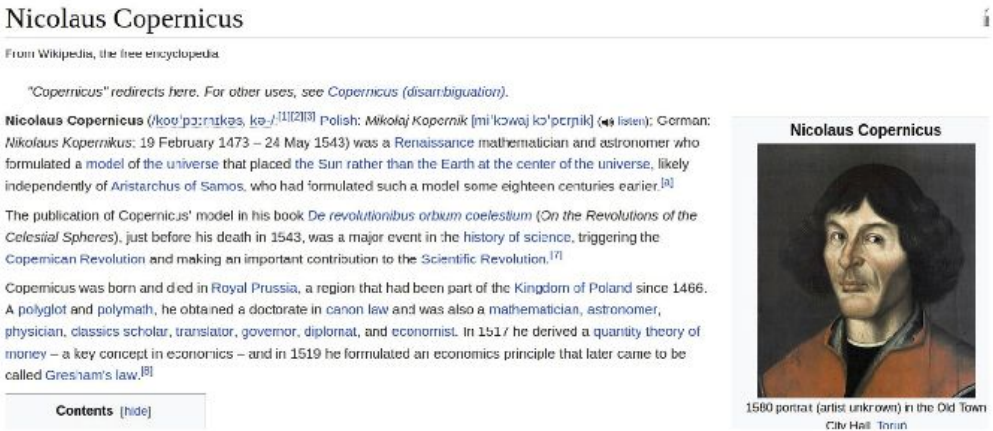
**CORPUS SIZE:** 5.9M

# 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]

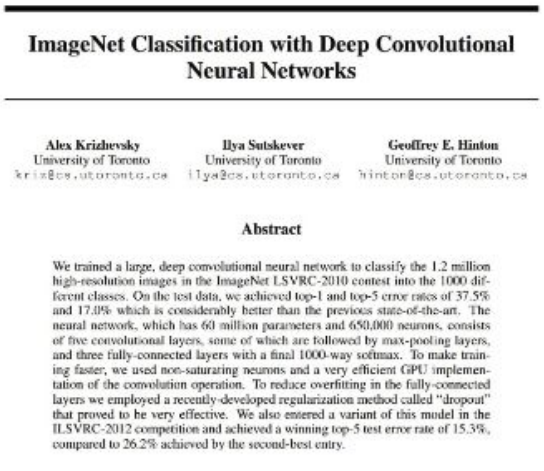
Nicolaus Copernicus

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

**CORPUS SIZE:** 3.5M

# Microsoft Academic Dataset

**Input**: Title/Abstract of a Paper



**ImageNet Classification with Deep Convolutional Neural Networks**

**Alex Krizhevsky**
University of Toronto
krix@cs.utoronto.ca

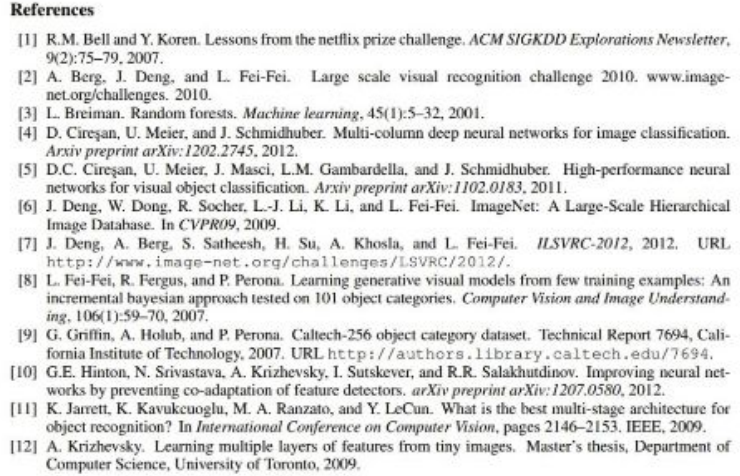
**Ilya Sutskever**
University of Toronto
ilya@cs.utoronto.ca

**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



**References**

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[3] L. Breiman. Random forests. *Machine learning*, 45(1):5–32, 2001.

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[8] L. Fei-Fei, R. Fergus, and P. Perona. Learning generative visual models from few training examples: An incremental bayesian approach tested on 101 object categories. *Computer Vision and Image Understanding*, 106(1):59–70, 2007.

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**CORPUS SIZE:** 500k

# Results

# Recall@40

| | 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 | - |
| REINFORCE | **47.3** | **33.4** | **14.9** |
| Oracle, RL | 55.9 | 42.4 | 24.6 |

# Samples

**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

# Discussion

# Discussion

- Oracle shows there is room for improvement
- Applicability: Click-through suggestion for commercial search engines
- Querying the search engine is 90% of training time

# References


- Rodrigo Nogueira and Kyunghyun Cho 2017. ***“Task-Oriented Query Reformulation with Reinforcement Learning”*** ***https://arxiv.org/pdf/1704.04572.pdf***

# Questions?