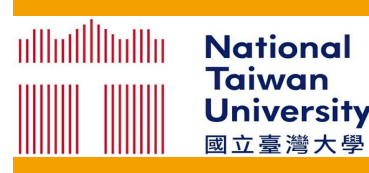


NQuAD: 70,000+ Questions for Machine Comprehension of the Numerals in Text



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An Example Question in NQuAD

News Article:

Major banks take the lead in self-discipline. The five major banks' newly-imposed mortgage interest rates climbed to **1.986%** in May. ... Also approaching **2%** integer alert ... Up to **2.5%** ... Also increased by **0.04** percentage points from the previous month ... Prevent the housing market bubble from fully starting.

Question Stem: Driven by self-discipline, the five major banks' new mortgage interest rates are approaching nearly _____%.

Answer Options: (A) 0.04 (B) 1.986 (C) 2 (D) 2.5

Answer: (C)

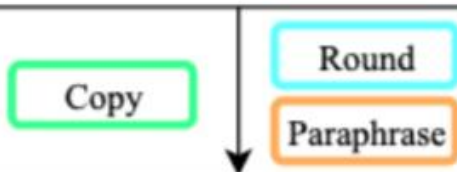


Motivation

(Article1) FED raises the rates, showing the confidence for economic recovery. This also stimulates the European stock market, especially the export stocks, in which the Germany ones boosts by 2.6%.

(Article2) The numbers of manufacturing are in bad situation, dragging the US stocks to pullback for 24 days. The NASDAQ composite index of technology stocks drops down by 1.67%.

(Article3) Ride-hailing giant Uber released its first safety report on Thursday, disclosing that it received a total of 5,981 reports of sexual assault incidents during its ride-hailing trips in the U.S. in 2017 and 2018.



(Headline1) European Stock Takes a Rides of US Rates Raise. The Germany Stock Rises by 2.6%.

(Headline2) US Manufacturing Stocks Struggle. NASDAQ Composite Collapses by 1.7%.

(Headline3) Uber Discloses Nearly 6K Reports of Sexual Assaults

	Chinese	NQuAD	CMRC-2017	DRCD	CMRC-2018
# Questions		71,998	5,000	33,953	14,363
# Num-related		71,998	0	6,575	3,506
% of Num-related		100.00%	0.00%	19.37%	24.41%

	English	MCTest	RACE	MCScript	ARC
# Questions		2,640	97,687	13,939	7,787
# Num-related		46	3,343	249	233
% of Num-related		1.74%	3.42%	1.79%	2.99%



Numeral-related Question Answering Dataset (NQuAD)

News Article:

Major banks take the lead in self-discipline. The five major banks' newly-imposed mortgage interest rates climbed to **1.986%** in May. ... Also approaching **2%** integer alert ... Up to **2.5%** ... Also increased by **0.04** percentage points from the previous month ... Prevent the housing market bubble from fully starting.

Question Stem: Driven by self-discipline, the five major banks' new mortgage interest rates are approaching nearly _____%.

Answer Options: (A) 0.04 (B) 1.986 (C) 2 (D) 2.5

Answer: (C)

- (1) We filter out those news articles that match at least one of following two conditions: (1) no numeral in the headline, and (2) less than 4 numerals in the content.
- (2) We use a numeral in the headline as the target numeral, mask the target numeral from the headline, and regard the masked headline as the stem of a question. Note that we only mask one target numeral for each question. For a headline containing k numerals, we will form k questions, each of them corresponding to each individual numeral.
- (3) From the news content, we select 4 distinct numerals whose values are closest to the value of the target numeral as the plausible options of the question.

Numeracy Test

Coarse-grained Numeracy Numeracy-600K

Magnitude	Range	Ratio
Decimal	$0 \leq m < 1$	23.24
1	$1 \leq m < 10$	37.53
2	$10 \leq m < 10^2$	25.36
3	$10^2 \leq m < 10^3$	12.21
4	$10^3 \leq m < 10^4$	1.12
5	$10^4 \leq m < 10^5$	0.29
6	$10^5 \leq m < 10^6$	0.23
> 6	$10^6 \leq m$	0.01

Fine-grained Numeracy NQuAD

Avg Diff (d)	# Questions	%	Cum. %
$0 \leq d < 1$	25,870	35.93	35.93
$1 \leq d < 2$	19,546	27.15	63.08
$2 \leq d < 4$	10,639	14.78	77.86
$4 \leq d < 6$	3,670	5.10	82.95
$6 \leq d < 8$	1,860	2.58	85.54
$8 \leq d < 10$	1,462	2.03	87.10
$d \geq 10$	9,287	12.90	100.00

The Degree of Difficulty – Similarity

Algorithm	NQuAD	CMRC-2018	DRCD
MLIPNS	19.65%	33.41%	74.22%
Cosine similarity	40.26%	56.32%	30.41%
Overleap coefficient	45.09%	59.17%	33.02%
Monge-Elkan	48.28%	58.84%	35.46%



Numeracy-Enhanced Model (NEMo)

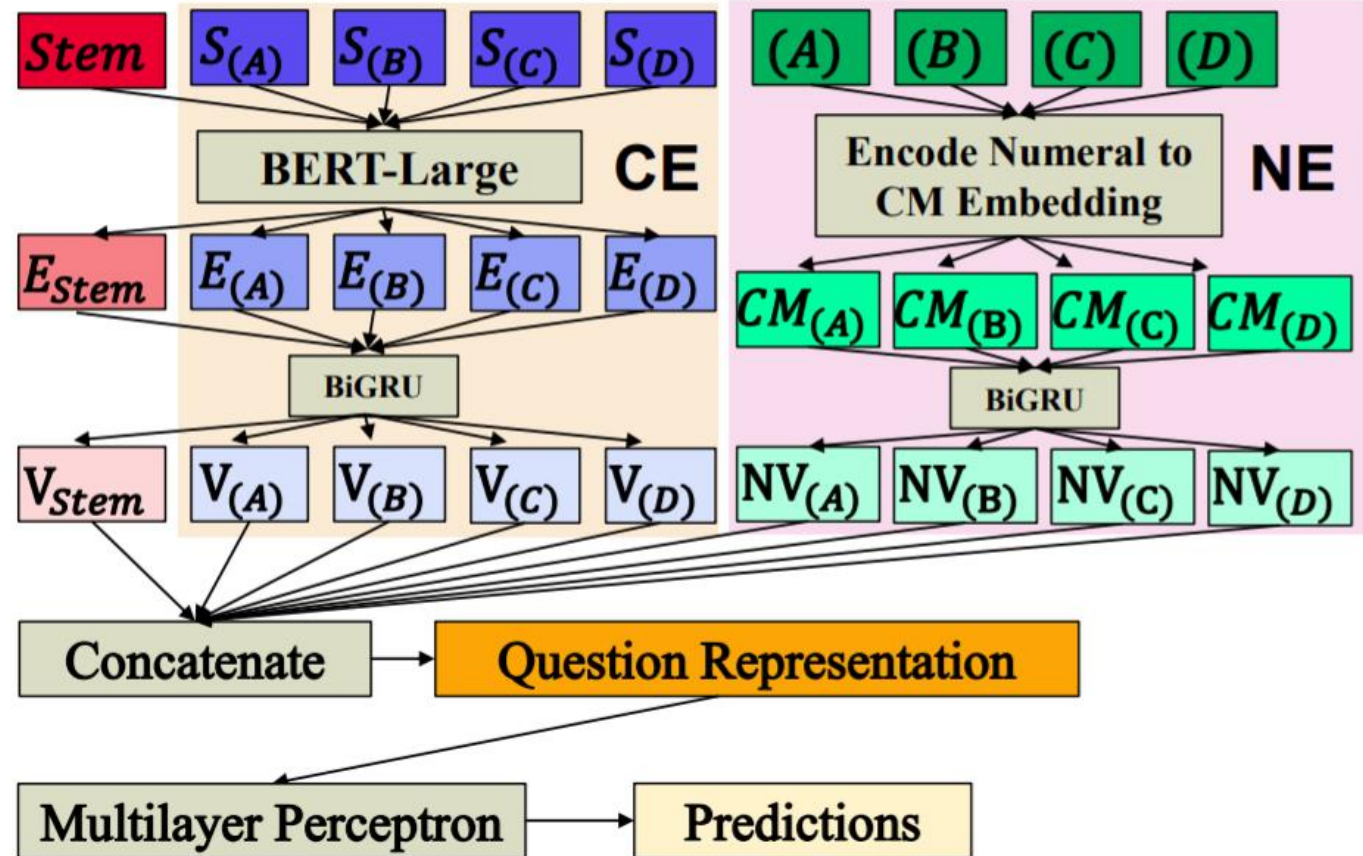
News Article:

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Question Stem: Driven by self-discipline, the five major banks' new mortgage interest rates are approaching nearly _____%.

Answer Options: (A) 0.04 (B) 1.986 (C) 2 (D) 2.5

Answer: (C)



Results

Model	Accuracy
BERT Embedding Similarity	57.30%
Vanilla BERT	66.41%
BERT-BiGRU	67.15%
BERT-CNN	63.92%
NEMo	69.95%*

Model	Accuracy
NEMo	69.95%
-Numeral Encoder	67.15%
-Context Encoder	55.56%



Conclusion

- We present a new numeral-related machine reading comprehension dataset, NQuAD
- We provide a pilot exploration in the proposed dataset, and propose a tailor-made model, NEMo, which enhances the numeracy of the model, for solving the numeral-related questions

Future Directions (NQuAD 2.0)

- Human Evaluation
- Numerical Reasoning



Related Works and Events

• Related Works

- **From Opinion Mining to Financial Argument Mining.** (Springer Nature – Open Access)
 - <http://springer.nlpfin.com/>
- Distilling Numeral Information for Volatility Forecasting (CIKM'21)
- Constructing Noise Free Economic Policy Uncertainty Index (CIKM'21)

• Related Events

- **Call for Paper:** Financial Technology on the Web @ ACM TWEB
 - <https://acmfinweb.nlpfin.com/>
- **FinNum-3 Shared Task @ NTCIR-2022 – Investor's and Manager's Fine-grained Claim Detection**
- **EMNLP-2021 Tutorial:** Financial Opinion Mining
- The **Workshop of Financial Technology** and Natural Language Processing (FinNLP @ **IJCAI**)
- The Workshop on Financial Technology on the Web (FinWeb @ **WWW**)

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Thank you for your attention!

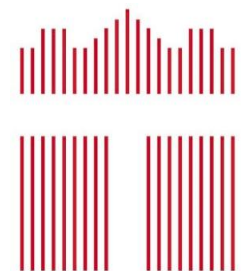
Feel free to contact us if you have any questions.

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