PaperRobot: Knowledge Extraction, Prediction and Paper Writing to Assist Scientific Discovery
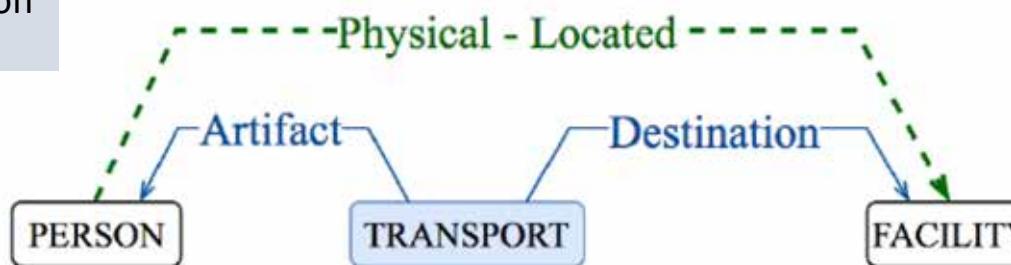
Qingyun Wang, Diya Li and Heng Ji (UIUC)

Kevin Knight (DiDi Labs)

Information Extraction for Knowledge Graph Construction

Relation Extraction

Event Extraction (Trigger Labeling + Argument Role Labeling)

Knowledge Base Population

Source Collection

13岁以前的杨丽萍，是云南一个山村小镇里光着脚丫到处拾麦穗的乡下小姑娘，在洱海之源过着艰苦而又不无乐趣的童年生活。

Now, Ms. Yang, one of China's best-known dancers, is the director, choreographer and star of ...

Aunque nacida en Dali, a la edad de nueve años Yang se mudó con su familia a Xishuangbanna. Debido a su extraordinario talento, la eligieron para integrar la Agrupación Artística de Canto ...

...

Entity Discovery and Linking

KB

Yang Liping

Traditional Chinese	楊麗萍
Simplified Chinese	杨丽萍
Transcriptions	[show]

Spouse: Liu Chunqing
State/Province-of-Residence: Yunnan

Liping Yang

Slot Filling

Employer: University of Maine
Title: Professor

Liping Yang

Employer: Ningbo
Title: Mayor

Recent Progress

		2015	2019
Portability	# Languages for EDL	1-3	300
	# Entity types	5	16,000
	# Slot types (English)	41	2,000
	# Event types (English)	33	1,000
Quality (Low-resource Languages without gold standard annotations)	Name Tagging	0%	Up to 76% F-score
	Cross-lingual Entity Linking	Up to 16% absolute improvement in accuracy	
Development Time		Half a year	1-10 hours
Cost		Supervised models based on 500 fully annotated documents	No manual annotation required for new language/domain

Applications: Disaster Relief

- Re-trainable Systems: http://blender02.cs.rpi.edu:3300/elisa_ie/api
- Data and Resources: http://nlp.cs.rpi.edu/wikiann/
- Demos: http://blender02.cs.rpi.edu:3300/elisa_ie http://blender02.cs.rpi.edu:3300/elisa_ie/heatmap **5**

Applications: Event Tracking

https://blender04.cs.rpi.edu/~lim22/gaia/GAIA_arg.html

Applications: Event Recommendation

https://blender04.cs.rpi.edu/~lud2/video_recommendation_demo2019/navigation_dark.html

Applications: Entity Relation Tracking
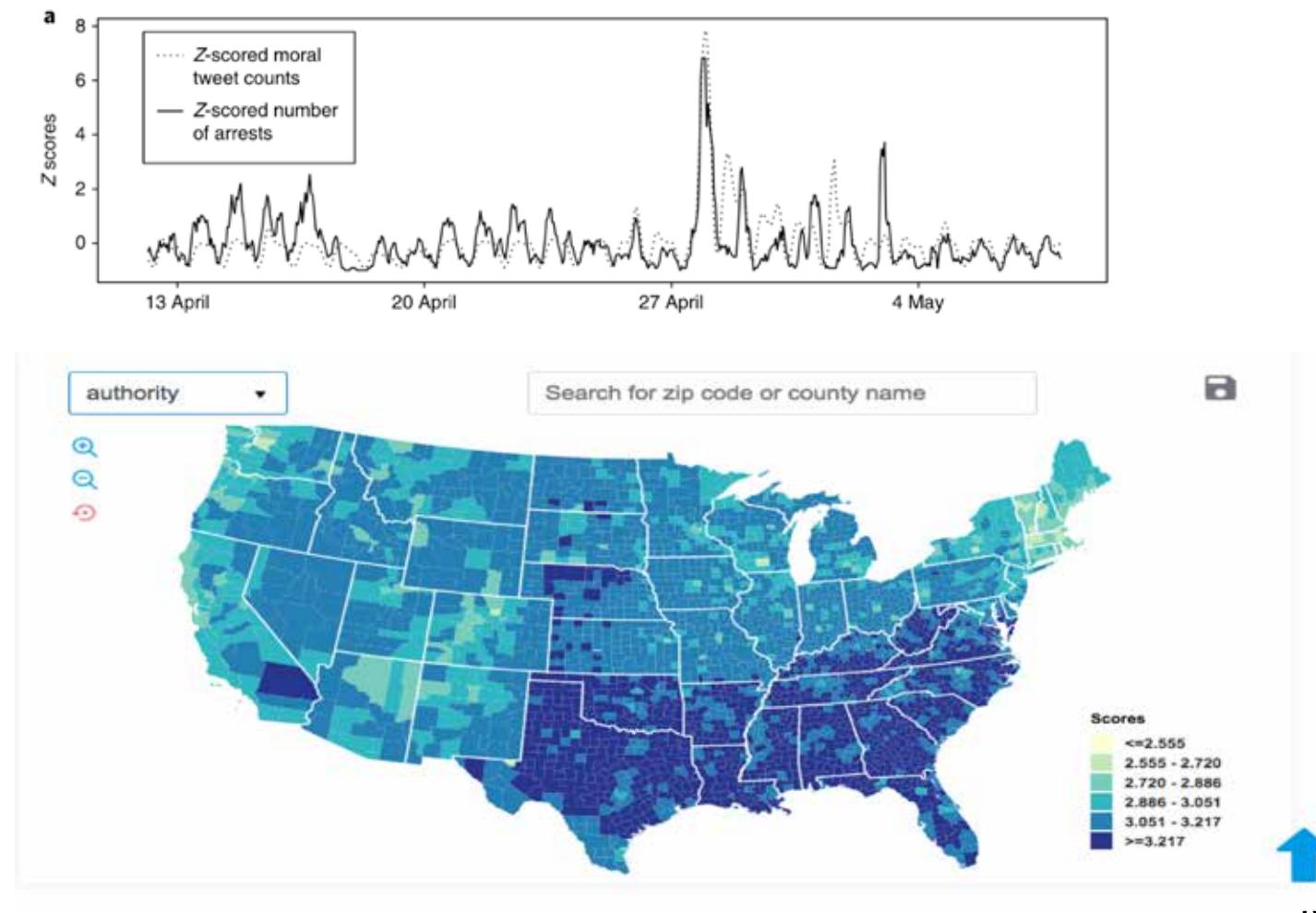
- https://blender04.cs.rpi.edu/~lim22/entity_demo/aida_index.html

Applications: Intelligence Analysis
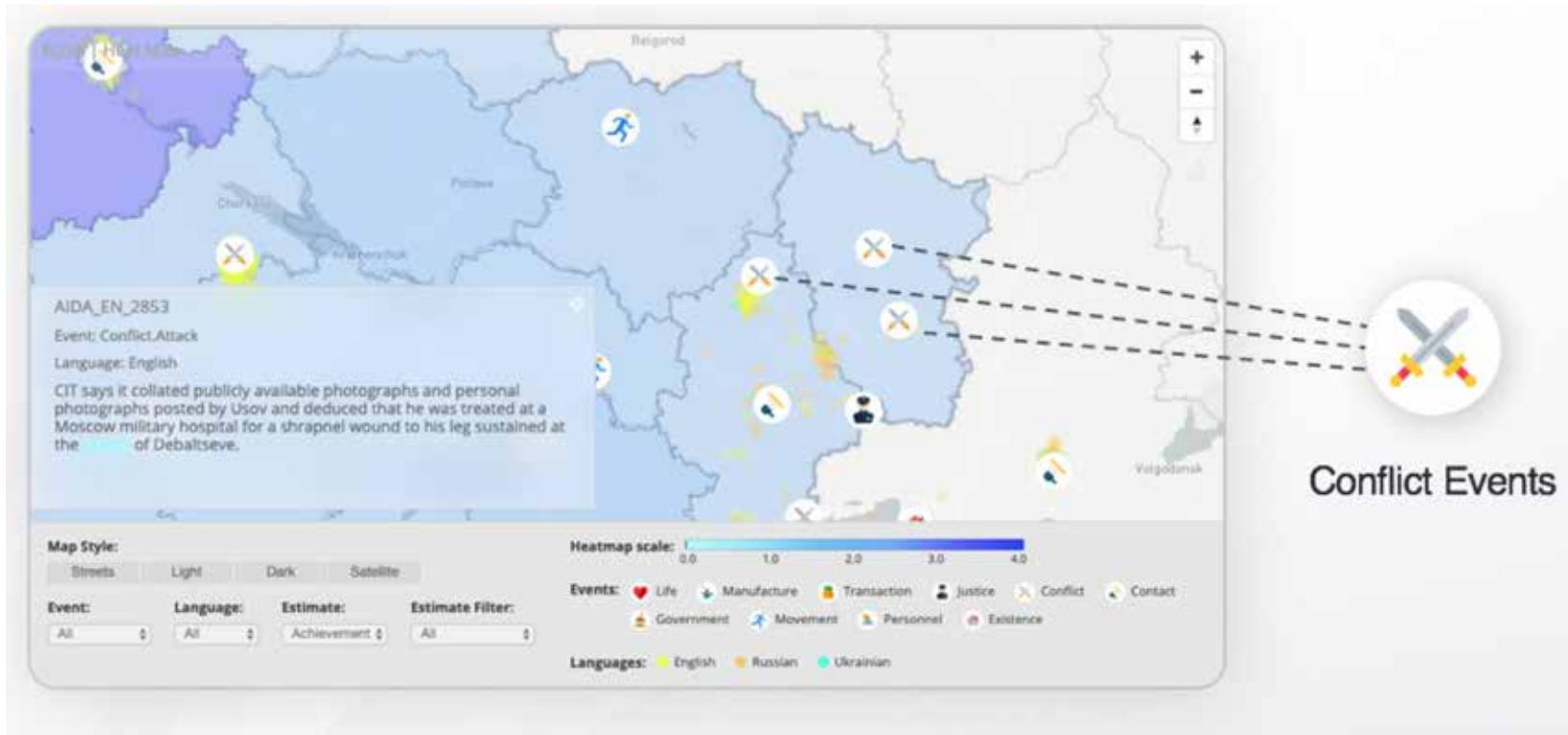
Applications: County-Level Moral Concerns

- (Mooijman et al., Nature Human Behavior 2018, June Cover)

Applications: Ukraine Event and Moral Value Map

- Achievement, Benevolence, Conformity, Hedonism, Power, Security, Self-direction, Simulation, Tradition and Universalism (Schwartz, 2012)

Older Kids at School
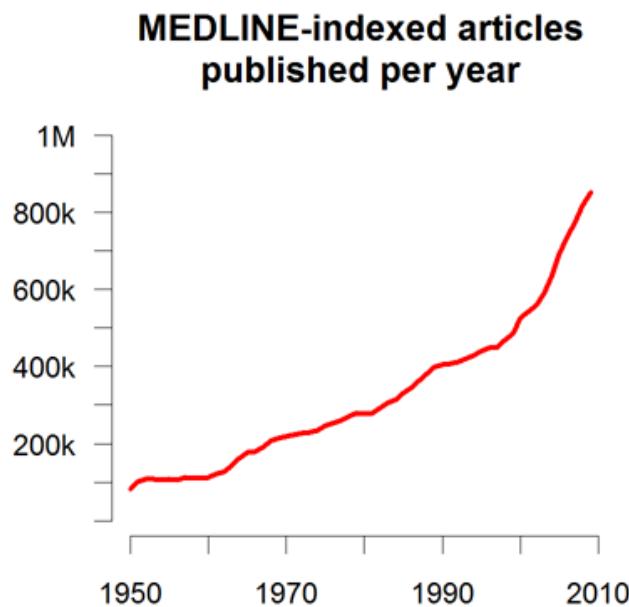
- Help ourselves out?

Problem: Too Much Data and Too Little Time
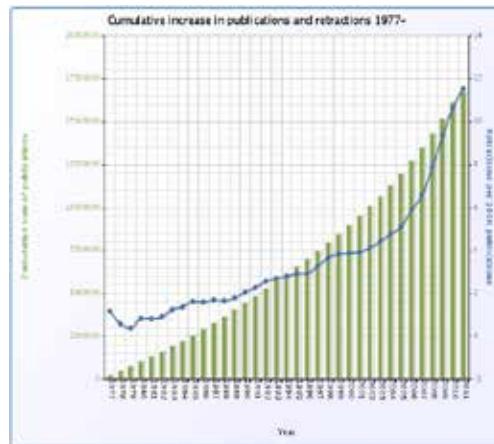
- More than 500K papers are published at PubMed every year, and more than 1.2 million new papers are published in 2016 alone, bringing the total number of papers to over 26 million (Van Noorden, 2014)

- Human's reading ability keeps almost the same across years: US scientists estimated that they read, on average, only 264 papers per year (1 out of 5000 available papers, the same across years)

Application in Speeding up Scientific Discovery
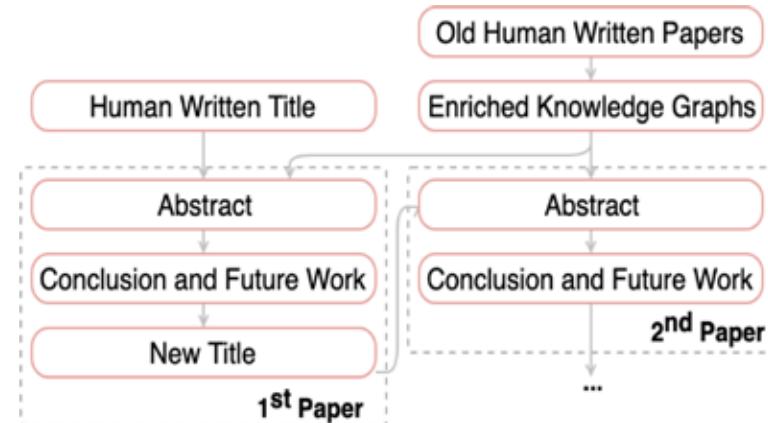
- Create New Ideas
  - Foster et al. (2015) shows that more than 60% of 6.4 million papers in biomedicine and chemistry published between 1934 and 2008 report findings that build on existing knowledge and provide additional innovations and improvements
  - PaperRobot predicts new links (ideas) based on a new representation for each entity by combining knowledge graph structure and unstructured contextual text

Application in Speeding up Scientific Production
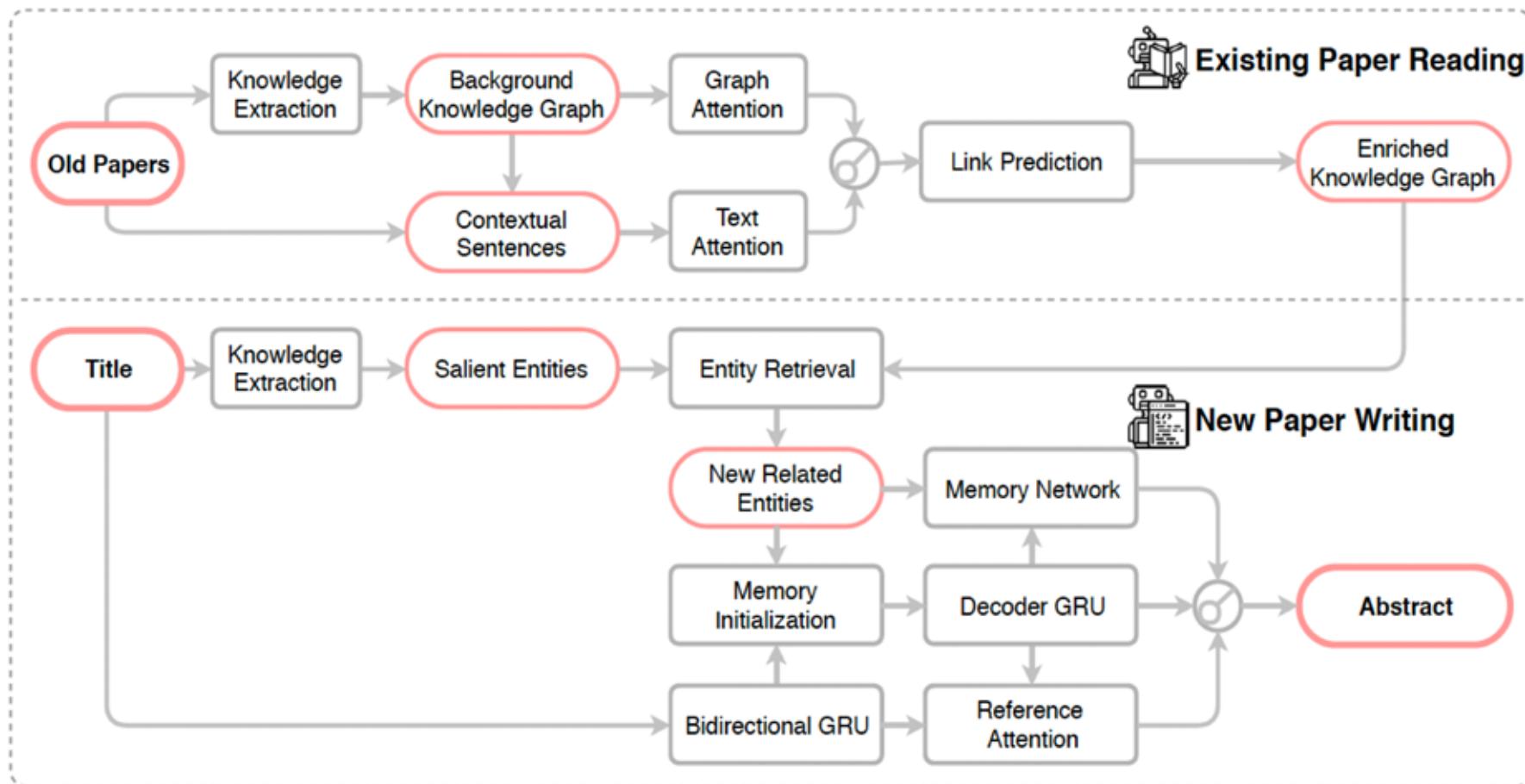
- Write a New Paper about New Ideas
  - Many scientists are, in fact, bad writers (Pinker, 2014):

    "I know many scholars who have nothing to hide and no need to impress.
    They do groundbreaking work on important subjects, reason well about clear ideas, and are
    honest, down-to-earth people. Still, their writing stinks."

  - PaperRobot automatically writes key elements of a new paper
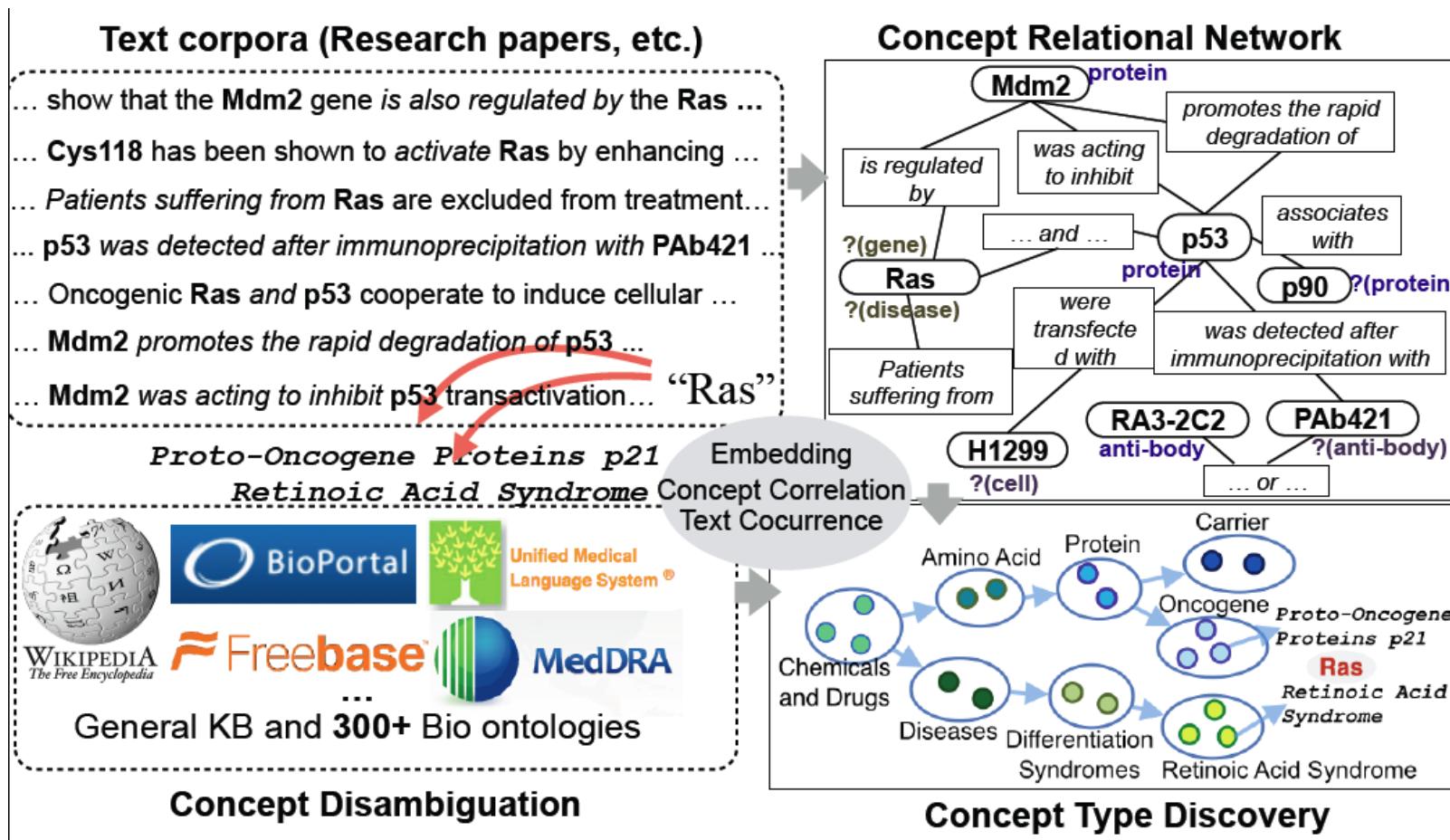
PaperRobot Overview

- (Wang et al., ACL2019)
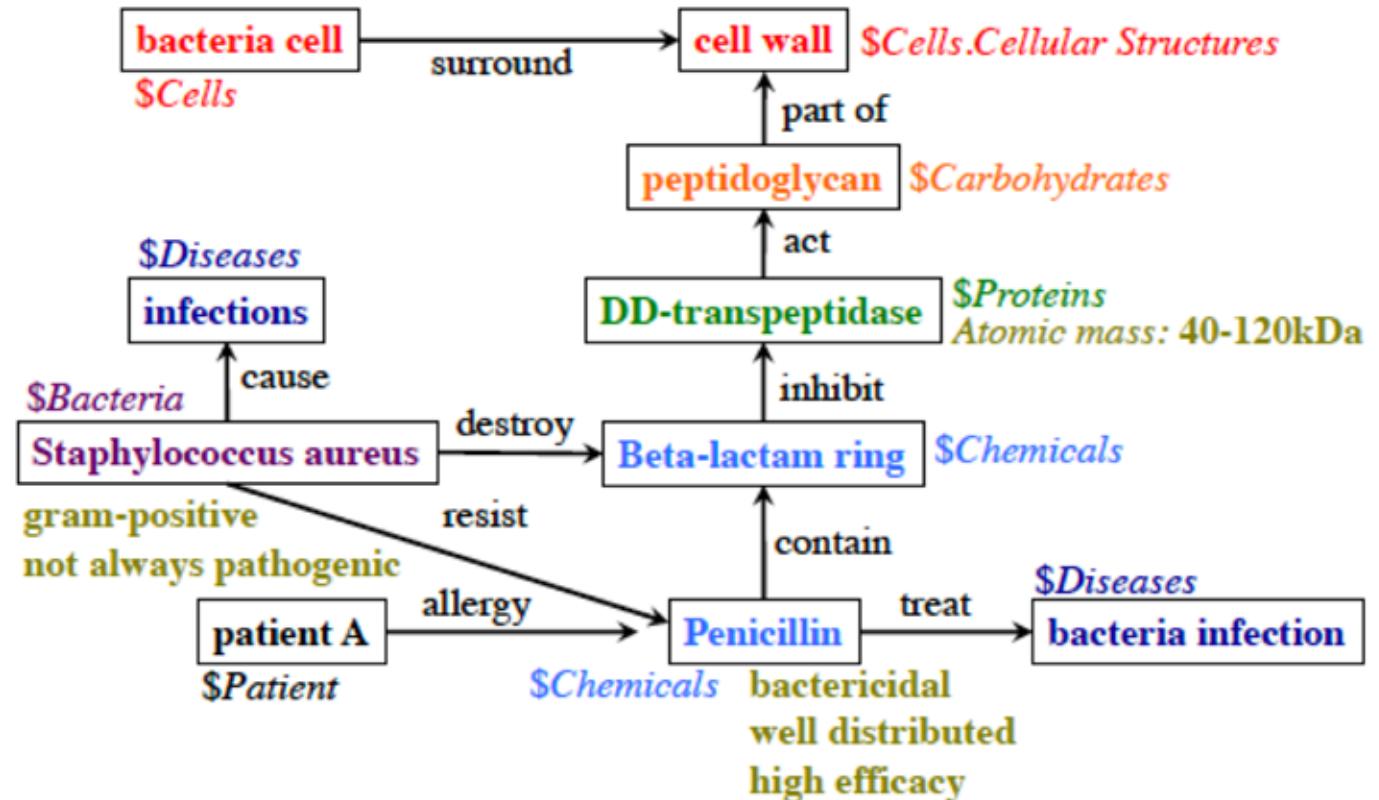
Build Knowledge Network to Accelerate Scientific Discovery
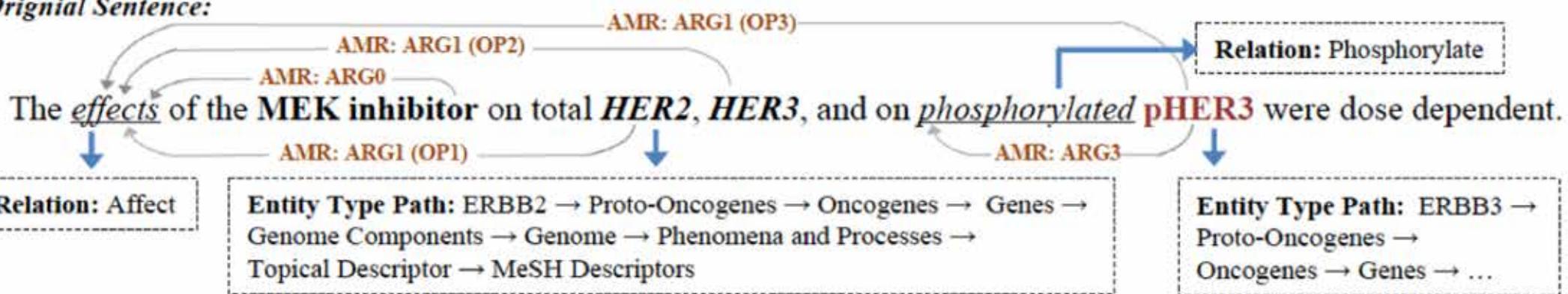
Biomedical Knowledge Graph Construction

- Entity Extraction and Linking

- Relation Extraction

- Event Extraction

Entity Extraction and Linking

Orignial Sentence:

The *effects* of the **MEK inhibitor** on total **HER2**, **HER3**, and on *phosphorylated* pHER3 were dose dependent.

- AMR: ARG1 (OP3)
- AMR: ARG1 (OP2)
- AMR: ARG0
- AMR: ARG1 (OP1)
- AMR: ARG3

Relation: Phosphorylate

Relation: Affect

Entity Type Path: ERBB2 → Proto-Oncogenes → Oncogenes → Genes → Genome Components → Genome → Phenomena and Processes → Topical Descriptor → MeSH Descriptors

Entity Type Path: ERBB3 → Proto-Oncogenes → Oncogenes → Genes → ...
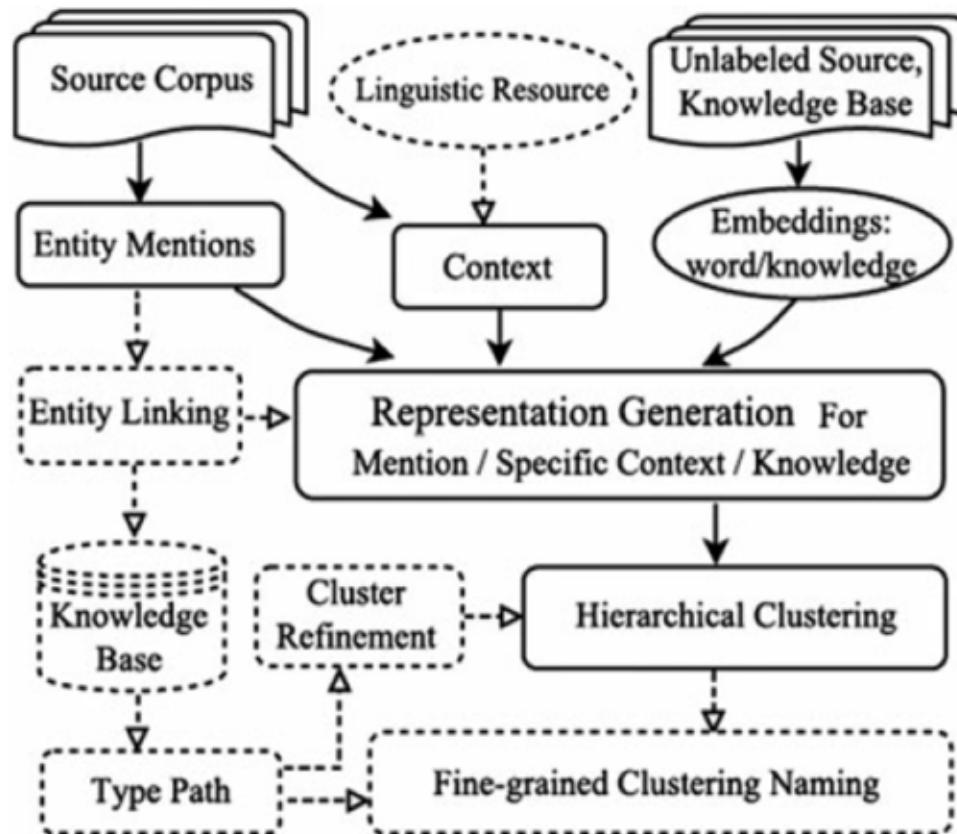
- Apply an entity mention extraction and linking system (Wei et al., 2013) to extract mentions of three entity types (Disease, Chemical and Gene)

- Obtain a MeSH3 Unique ID for each mention

- Link all entities to the Comparative Toxicogenomics Database (CTD) (Davis et al., 2016) and extract 133 subtypes of relations such as Marker/Mechanism, Therapeutic, and Increase Expression based on the MeSH Unique IDs

Entity Extraction and Linking: Unsupervised Approach
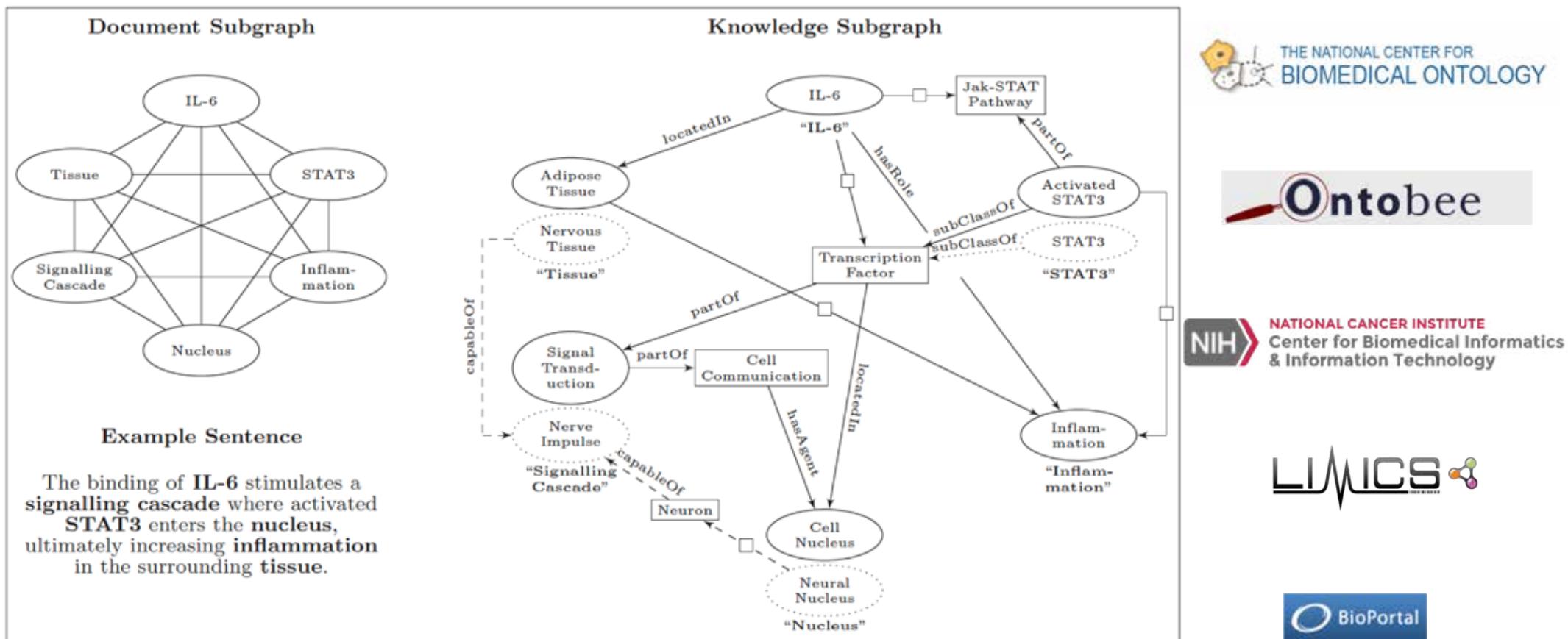
- Representation Generation:
  - Mention Representation (global contexts)
  - Specific context representation
  - knowledge representation (Knowledge graph)
- Fine-grained Typing
  - Type path extraction from KB
  - Hierarchical Clustering
  - Cluster Refinement
  - Fine-grained cluster naming

Abstract Meaning Representation for Mentions
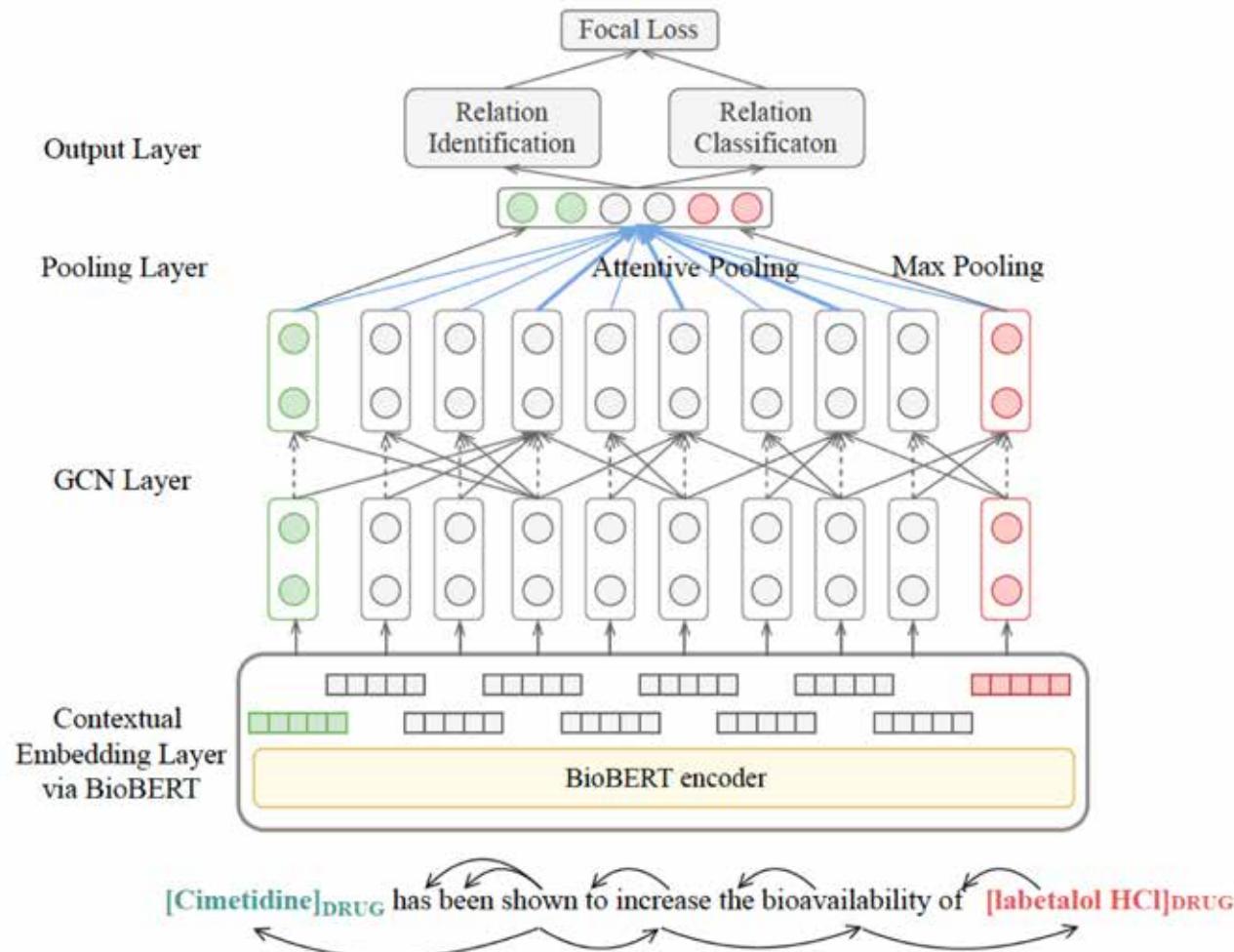
Entity Linking to 300+ Biomedical Ontologies

• Metrics: Salience, Similarity, Coherence (Pan et al., 2015, Wang et al., 2015)

Context-aware and Syntax-aware Relation Extraction

Relation Extraction Results
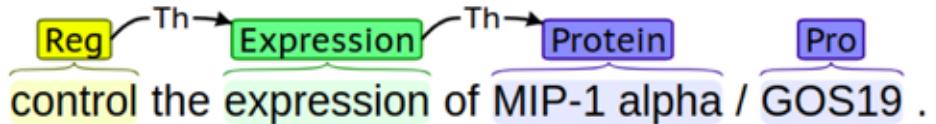
- Results on Drug-Drug Interactions dataset (Herrero-Zazo et al., 2013)

System	Prec	Rec	F1
CNN (Liu et al., 2016)	75.70	64.66	69.75
Multi Channel CNN (Quan et al., 2016)	75.99	65.25	70.21
GRU (Yi et al., 2017)	73.67	70.79	72.20
AB-LSTM (Sahu and Anand, 2018)	74.47	64.96	69.39
CNN-GCNN (Asada et al., 2018)	73.31	71.81	72.55
Position-aware LSTM (Zhou et al., 2018a)	75.80	70.38	72.99
RHCNN (Sun et al., 2019)	77.30	73.75	**75.48**
LSTM baseline	69.34	62.74	65.88
GCN baseline	71.96	67.14	69.47
−without attentive pooling	77.12	75.03	76.06
−without BioBERT	76.51	73.56	75.01
−without multi-task learning	76.01	71.92	73.91
Our Model	77.62	75.69	**76.64**

Supervised Event Extraction

task 1: Trigger labeling
task 2: Argument role labeling
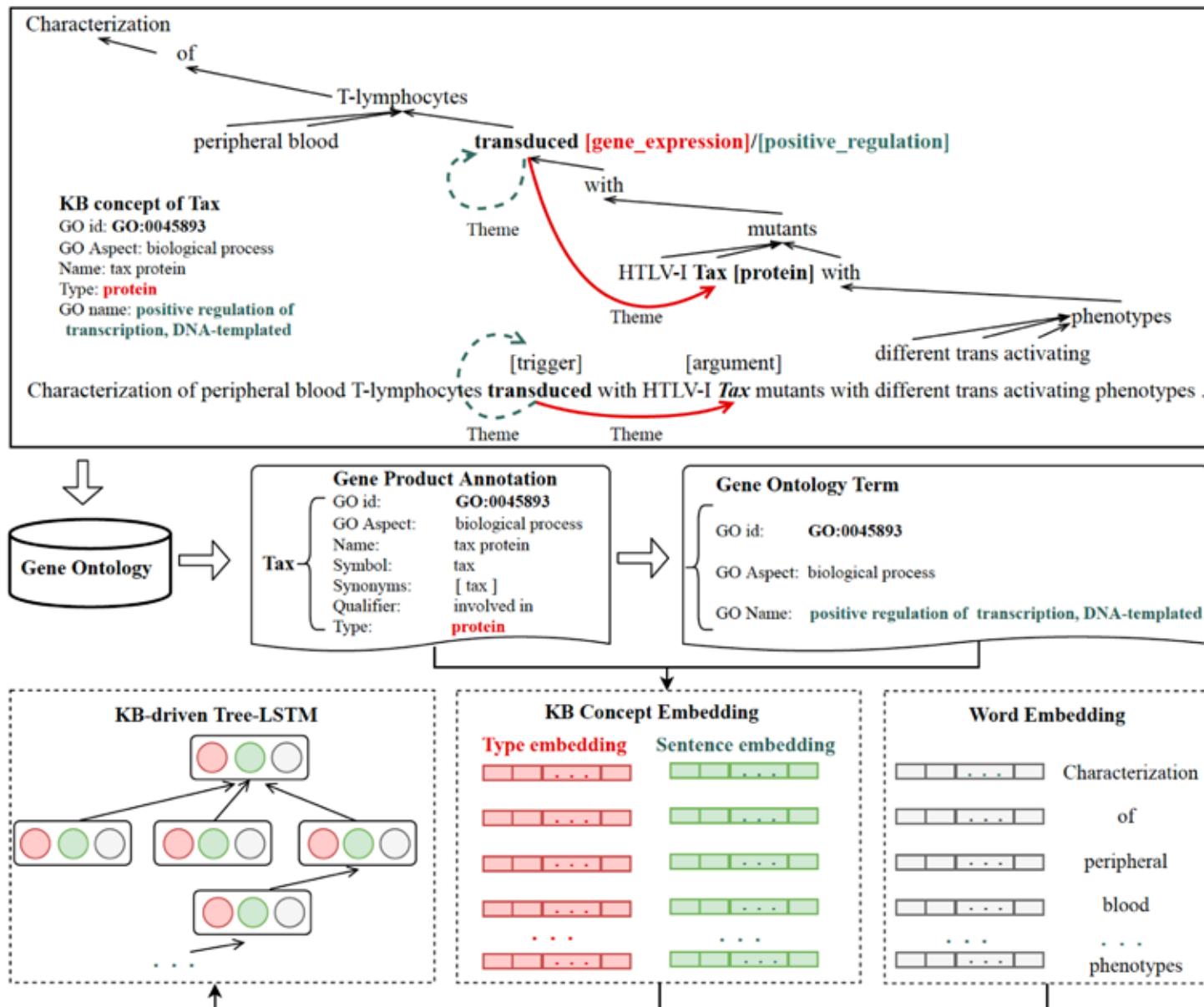
Therefore , it is important to understand the mechanisms which control the expression of MIP-1 alpha / GOS19 .

Event Type	Core Arguments	Event Type	Core Arguments
Gene expression	Theme(Protein)	Regulation	Theme(Protein / Event), Cause(Protein / Event)
Transcription	Theme(Protein)		
Protein catabolism	Theme(Protein)	Positive regulation	Theme(Protein / Event), Cause(Protein / Event)
Phosphorylation	Theme(Protein)		
Localization	Theme(Protein)	Negative regulation	Theme(Protein / Event), Cause(Protein / Event)
Binding	Theme(Protein)+		
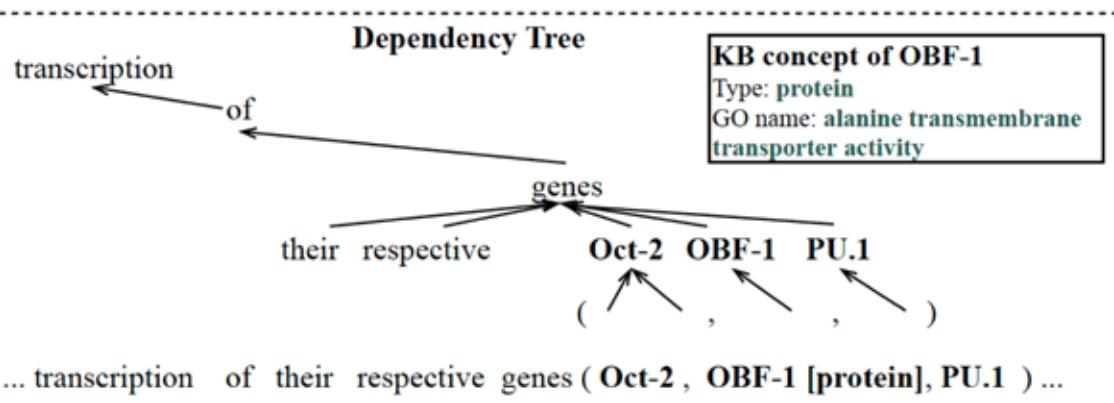
KB-driven Tree-LSTM

(Li et al., NAACl2019)

Trigger Labeling and Argument Role Labeling

Task 1. Trigger Labeling

Dependency Tree

transcription

of

genes

their respective   Oct-2   OBF-1   PU.1

(,   ,   )

KB concept of OBF-1
Type: **protein**
GO name: **alanine transmembrane transporter activity**

... transcription   of   their   respective   genes (**Oct-2** ,   **OBF-1 [protein]**, **PU.1**) ...

... transcription [transcription] of their respective genes (**Oct-2** , **OBF-1 [protein]** , **PU.1**) ...
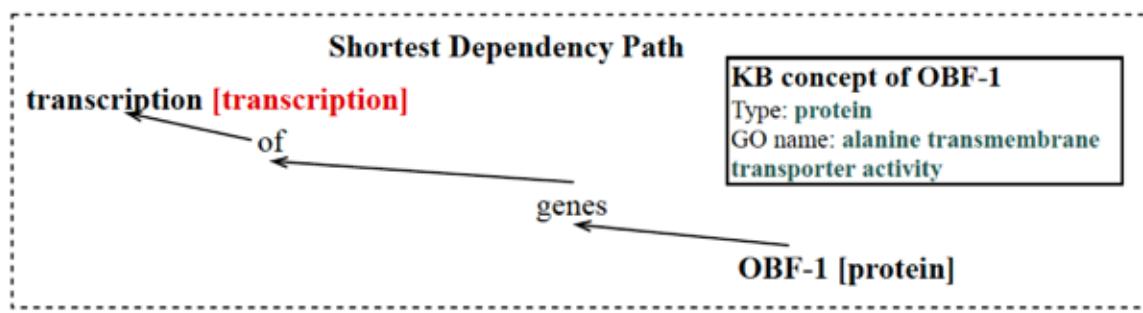
Task 1 input

Task 1 output

KB-driven Tree-LSTM

Task 2. Argument Role Labeling

Shortest Dependency Path

transcription [transcription]

of

genes

OBF-1 [protein]

KB concept of OBF-1
Type: **protein**
GO name: **alanine transmembrane transporter activity**

Task 2 input

◯ KB type embedding
◯ KB sentence embedding
◯ word embedding

Theme

... **transcription [transcription]** of their respective genes (**Oct-2** , **OBF-1 [protein]**, **PU.1**) ...

Task 2 output

27
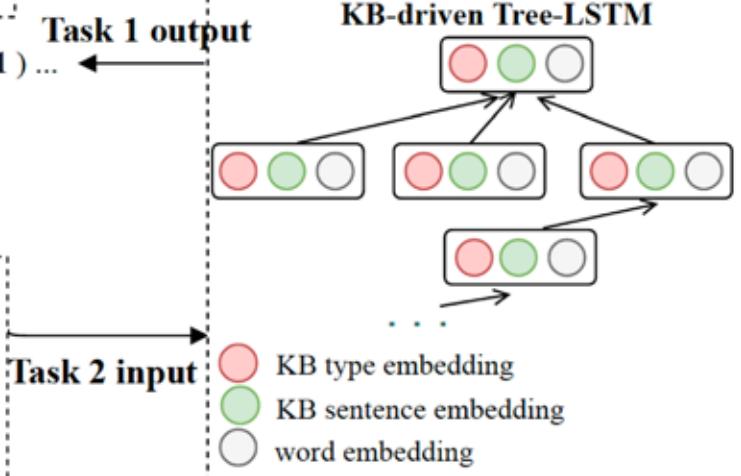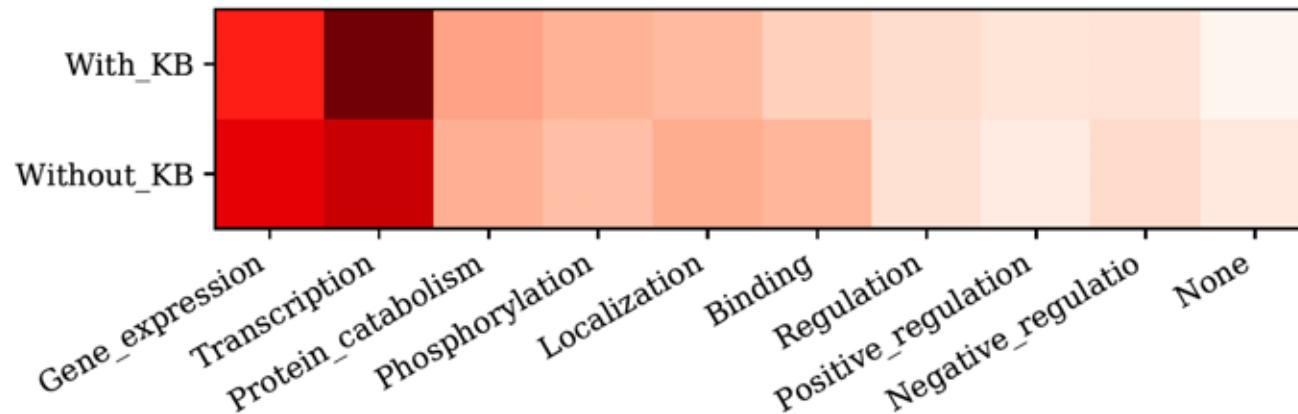
Event Extraction Results

- Results on Genia dataset (Kim et al.,2009, 2011; N´edellec et al., 2013)

System	Event Type	Rec	Prec	F1
KB-driven Tree-LSTM	Gene expression	74.35	87.24	80.28
	Transcription	69.54	82.31	75.39
	Protein catabolism	46.67	87.50	60.87
	Phosphorylation	81.62	87.28	84.36
	Localization	59.69	80.28	68.47
	Simple total	72.62	85.95	78.73
	Binding	37.68	53.16	44.10
	Regulation	36.62	53.61	43.52
	Positive regulation	41.37	57.90	48.26
	Negative regulation	46.06	52.39	49.02
	Regulation total	41.73	55.73	47.72
	Event total	**52.14**	**67.01**	**58.65**
Tree-LSTM	**Simple total**	71.22	83.41	76.83
	Binding	34.83	48.72	40.62
	Regulation total	39.78	53.54	45.64
	Event total	**50.28**	**64.56**	**56.53**
BiLSTM	**Simple total**	68.09	78.75	73.03
	Binding	38.49	43.05	40.65
	Regulation total	37.64	53.81	44.30
	Event total	**48.44**	**62.18**	**54.46**
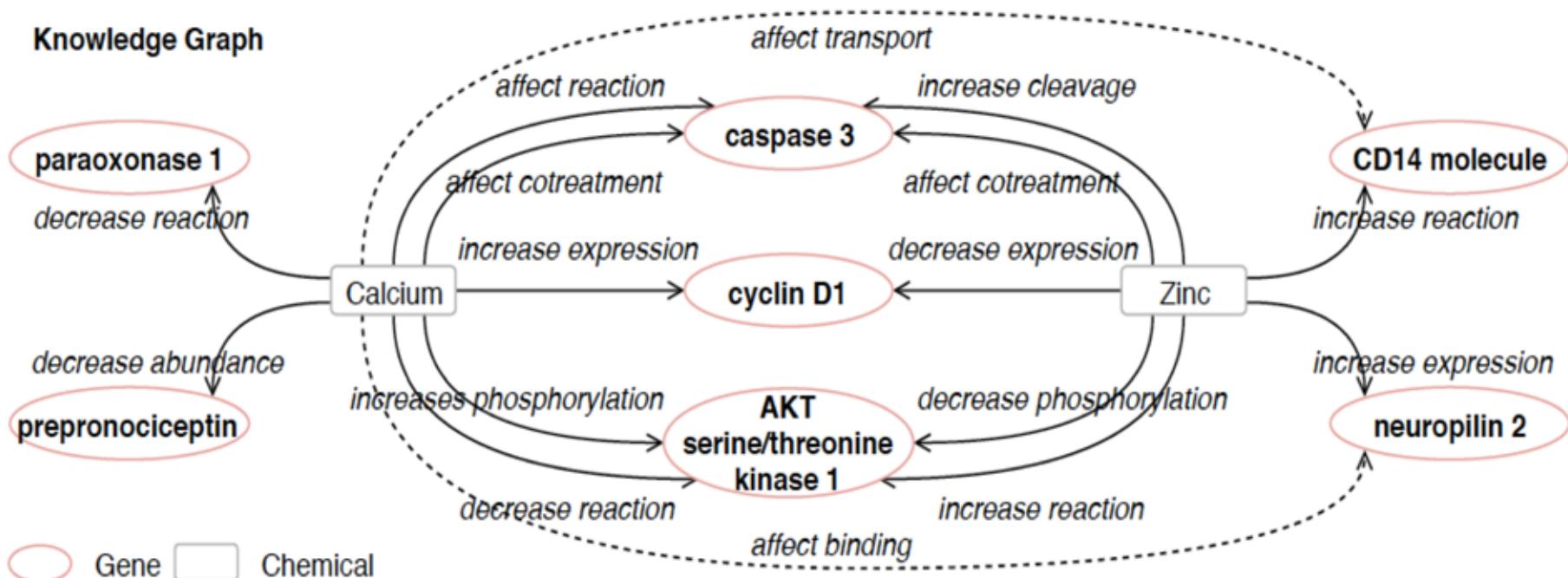
Impact of Background Knowledge on Event Extraction

... **transcription** [transcription] of their respective genes (**Oct-2 [protein]** , **OBF-1 [protein]**, **PU.1[protein]**) ...

KB concept embedding "*the function description positive regulation of transcription, DNA-templated*" provided by the biomedical entity **OBF-1** significantly enhances the probability of word transcription being predicted to a **Transcription** event type.

29

Link Prediction on top of Knowledge Extraction

Knowledge Graph

affect transport

affect reaction — caspase 3 — increase cleavage

paraoxonase 1

decrease reaction

affect cotreatment — affect cotreatment

increase expression — decrease expression

Calcium — cyclin D1 — Zinc

increase reaction

CD14 molecule

decrease abundance

increase expression

prepronociceptin

increases phosphorylation — AKT serine/threonine kinase 1 — decrease phosphorylation

neuropilin 2

decrease reaction — increase reaction

affect binding

◯ Gene ☐ Chemical

Contextual Sentence: So, Ca^{2+} possibly *promoted* caspases activation upstream of **cytochrome c** release, but inactivated **caspase** activity by calpain and/or fast depletion of ATP; whereas Zn^{2+} blocked the ***activation ofprocaspase-3*** with no visible change in the level of **cytochrome c**, and the block possibly resulted from its direct inhibition on **caspase-3** enzyme.

Link Prediction: Graph Structure Encoder

- For each entity, perform self-attention (Veliˇckoviˊc et al., 2018) and compute a weight distribution over its neighbors:

$$e_i' = W_e e_i, \quad n_{ij}' = W_e n_{ij}$$
$$c_{ij} = \text{LeakyReLU}(W_f(e_i' \oplus n_{ij}'))$$
$$c_i' = \text{Softmax}(c_i)$$

- Knowledge graph structure based context representation:

$$\epsilon_i = \sigma \left(\sum c_{ij}' n_{ij}' \right)$$

- Perform multi-head attention Ito capture various underlying relationships between each entity and its neighbors:

$$\tilde{e}_i = [\epsilon_i^0 \oplus \epsilon_i^1 \oplus ... \oplus \epsilon_i^M]$$

Link Prediction: Contextual Text Encoder

- Each entity *e* is also associated with a context description sentence

- Apply a bi-directional long short-term memory (LSTM) (Graves and Schmidhuber, 2005) network to get the encoder hidden states, then compute a bilinear attention weight for each token of the context sentence:

$$\mu_i = \boldsymbol{e}^\top \cdot \boldsymbol{W}_s \cdot \boldsymbol{h}_i$$

$$\boldsymbol{\mu}' = \text{softmax}(\boldsymbol{\mu})$$

$$\hat{\boldsymbol{e}} = \sum_{i=1}^{l} \mu_i' \cdot \boldsymbol{h}_i$$

- Gated combination:

$$\boldsymbol{g}_e = \sigma(\tilde{\boldsymbol{g}}_e), \quad \boldsymbol{e} = \boldsymbol{g}_e \odot \tilde{\boldsymbol{e}} + (1 - \boldsymbol{g}_e) \odot \hat{\boldsymbol{e}}$$

Repetition Removal

- Use a coverage loss to avoid any entity in reference input text or related entity receiving attention multiple times
- Design a new and simple masking method to remove repetition during the test time
  - Apply beam search with beam size 4 to generate each output
  - if a word is not a stop word or punctuation and it is already generated in the previous context, we will not choose it again in the same output

PaperRobot Output Example

Title	Snail transcription factor negatively regulates **maspin tumor suppressor** in **human prostate cancer** cells
Entities	Related: **nasopharyngeal carcinoma**; diallyl disulfide

Output	**Human (Neal et al., 2012)**	**System**	**Post-edited by Human**
Abstract	Background: **Maspin**, a putative **tumor suppressor** that is down-regulated in breast and **prostate cancer**, has been associated with decreased cell motility. **Snail** transcription factor is a zinc finger protein that is increased in breast cancer and is associated with increased tumor motility and invasion by induction of epithelial-mesenchymal transition (EMT). We investigated the molecular mechanisms by which **Snail** increases **tumor** motility and invasion utilizing **prostate cancer** cells. Methods: Expression levels were analyzed by **RT-PCR** and **western blot** analyses. Cell motility and invasion assays were performed , while **Snail** regulation and binding to **maspin** promoter was analyzed by luciferase reporter and chromatin immunoprecipitation (ChIP) assays. Results: **Snail** protein expression was higher in different **prostate cancer** cells lines as compared to normal prostate epithelial cells.	Background: **Snail** is a multifunctional protein that plays an important role in the pathogenesis of **prostate cancer**. *However,* it has been shown *to be* associated with poor prognosis. The purpose of this study *was* to investigate the effect of *negatively* on the expression of **maspin** in **human nasopharyngeal carcinoma** cell lines. Methods: *Quantitative real-time PCR* and western blot analysis were used to determine *whether the demethylating agent was investigated by quantitative* **RT-PCR** *(qRT-PCR) and* **Western blotting**. Results showed that the binding protein plays a significant role in the regulation of **tumor** growth and progression.	Background: **Snail** is a multifunctional protein that plays an important role in the pathogenesis of **prostate cancer**. It has been shown associated with poor prognosis. The purpose of this study is to investigate the negative effect of on the expression of **Maspin** in **human nasopharyngeal carcinoma** cell lines. Methods: Quantitative **RT-PCR** (qRT-PCR) and **western blot** analyses were used to determine *correlation of the two proteins expressions.* Results showed that the binding protein plays a significant role in the regulation of **tumor** growth and progression.
Conclusion and Future work	Collectively, our results indicate for the first time that **Snail** can negatively regulate **maspin** through direct promoter repression resulting in increased migration and invasion in prostate **cancer** cells. This study reveals a novel mechanism of how **Snail** may function and show the importance of therapeutic targeting of **Snail** signaling in future.	In summary, our study demonstrates that **Snail** negatively *inhibited* the expression of **Maspin** in **human nasopharyngeal carcinoma** cell lines *and in vitro.* Our results indicate that *the combination of the demethylating agent* might be a potential therapeutic target for the treatment of **prostate cancer**.	In summary, our study *in vitro* demonstrates that **Snail** negatively *inhibits* the expression of **Maspin** in **human nasopharyngeal carcinoma** cell lines. Our results *further* indicate that **Maspin** might be a potential therapeutic target for the treatment of **prostate cancer**.
New Title	Role of **maspin** in cancer (Berardi et al., 2013)	The role of *nasopharyngeal carcinoma* in the rat model of **prostate cancer** cells	The role of **Maspin** in the rat model of *nasopharyngeal carcinoma* cells

- It took the domain expert 40 minutes to edit 50 abstracts

BLEU1	**BLEU2**	**BLEU3**	**BLEU4**	**ROUGE**	**TER**
59.6	58.1	56.7	55.4	73.3	44.6

PaperRobot Ablation Test Results

Output	Without Memory Networks	Without Link Prediction	Without Repetition Removal
Abstract	Background: **Snail** has been reported to exhibit a variety of biological functions. In this study, we investigated the effect of negatively on **maspin** demethylation in **human prostate cancer** cells. Methods: Quantitative real-time PCR and western blot analysis were used to investigate the effects of the demethylating agent on the expression of the protein kinase (TF) gene promoter. Results: The results showed that the presence of a single dose of 50 μM in a dose-dependent manner, whereas the level of the BMP imipramine was significantly higher than that of the control group.	Background: **Snail** has been shown to be associated with poor prognosis. In this study, we investigated the effect of negatively on the expression of **maspin** in **human prostate cancer** cells. Methods: Cells were treated with a single dose of radiotherapy for 24 h, and was used to investigate the significance of a quantitative factor for the treatment of the disease. Results: The remaining controls showed a significant increase in the G2/M phase of the **tumor suppressor protein** (p<0.05).	Background: **Snail** is a major health problem in human malignancies. However, the role of **Snail** on the expression of **maspin** in **human prostate cancer** cells is not well understood. The aim of this study was to investigate the effect of **Snail** on the expression of **maspin** in **human prostate cancer** cells. Methods: The expression of the expression of **Snail** and **maspin** was investigated using quantitative RT-PCR and western blot analysis. Results: The remaining overall survival (OS) and overall survival (OS) were analyzed.
Conclusion and Future work	In summary, our study demonstrated that negatively inhibited the expression of the BMP imipramine in **human prostate cancer** cells. Our findings suggest that the inhibition of **maspin** may be a promising therapeutic strategy for the treatment.	In summary, our results demonstrate that negatively inhibited the expression of **maspin** in **human prostate cancer** cells. Our findings suggest that the combination of radiotherapy may be a potential therapeutic target for the treatment of disease.	In summary, our results demonstrate that **snail** inhibited the expression of **maspin** in **human prostatic** cells. The expression of **snail** in PC-3 cells by **snail**, and the expression of **maspin** was observed in the presence of the expression of **maspin**.
New Title	Protective effects of homolog on **human breast cancer** cells by inhibiting the Endoplasmic Reticulum Stress	The role of **prostate cancer** in **human breast cancer** cells	The role of **maspin** and **maspin** in human **breast cancer** cells

Repetition Removal Example

- **Before:** Background: The aim of this study was to compare the efficacy and safety of pain relief in **patients with knee osteOArthritis (OA).** Methods: This was a prospective cohort study of **patients with knee osteOArthritis (OA).** The primary endpoint was the proportion of **patients with knee osteOArthritis (OA)**.

- **After:** Background: The aim of this study was to compare the efficacy and safety of pain in patients with knee osteOArthritis (OA). Methods: This was a prospective, multicentre, multi-center, non-interventional, observational, randomized, controlled trial. The primary endpoint was the proportion of the knee and joint symptom of the physical functioning, and to evaluate the relationship between the two groups. Patients were randomly assigned to receive either a single dose of 0.5 mg twice daily (n = 30) or placebo (500 mg/day) for 52 weeks.

Repetition Removal Example

- Before: Background: The aim of this study was to compare the clinical outcome of myocardial infarction **(MI)** in patients with acute ST segment elevation **(MI)**. Methods: We retrospectively reviewed the clinical records of patients with acute ST segment elevation of **acute ST elevation myocardial infarction (MI).** Patients with **acute ST elevation myocardial infarction (MI)**, and **acute ST elevation myocardial infarction (MI)**, were included in this study. The primary endpoint was the proportion of patients with acute ST elevation myocardial infarction (MI) and coronary artery disease (CAD).

- After: Background The aim of this study was to compare the prevalence of myocardial infarction (MI) in patients with acute ST. Methods : The primary endpoint was the first time of the left anterior descending coronary artery , and to evaluate the clinical utility of Protocol . We performed a retrospective analysis of a prospective, randomized controlled trial. Patients were divided into two groups (n=6). The median follow-up period was defined as the presence of the right ventricle, and the level of cardiac catheterization was evaluated .

Data

- Background Knowledge Graph: papers from the PMC Open Access Subset

# papers	# entities	# relations
1,678,060	30,483	875,698

- Paper Writing

Dataset	# papers			# avg entities in Title / paper	# avg predicted related entities / paper
	Title-to-Abstract	Abstract-to-Conclusion and Future work	Conclusion and Future work-to-Title		
Training	22,811	22,811	15,902	4.8	-
Development	2,095	2,095	2,095	5.6	6.1
Test	2,095	2,095	2,095	5.7	8.5

Automatic Evaluation Results

- Perplexity: How well the language model predicts a word
- METEOR: Compute the percentage of overlapped ngrams based on stemming and synonymy matching

Model	Title-to-Abstract		Abstract-to-Conclusion and Future Work		Conclusion and Future Work-to-Title	
	Perplexity	METEOR	Perplexity	METEOR	Perplexity	METEOR
Seq2seq (Bahdanau et al., 2015)	19.6	9.1	44.4	8.6	49.7	6.0
Editing Network (Wang et al., 2018b)	18.8	9.2	30.5	8.7	55.7	5.5
Pointer Network (See et al., 2017)	146.7	8.5	74.0	8.1	47.1	6.6
Our Approach (-Repetition Removal)	13.4	12.4	24.9	**12.3**	31.8	7.4
Our Approach	**11.5**	**13.0**	**18.3**	11.2	**14.8**	**8.9**

Turing Test

- Human Subject Passing Rates (%) = Percentages show how often a human judge chooses our system's output over human's when it is mixed with a human-authored string

- If the output strings (e.g., abstracts) are based on the same input string (e.g., title), the Input condition is marked "Same", otherwise "Different"

Task	Input		Output	Domain Expert	Non-expert
End-to-End	Human Title	Different	Abstract (1st)	10	**30**
		Same		**30**	16
	System Abstract	Different	Conclusion and Future work	**12**	0
		Same		8	8
	System Conclusion and Future work	Different	Title	**12**	2
		Same		12	**25**
	System Title	Different	Abstract (2nd)	**14**	4
Diagnostic	Human Abstract	Different	Conclusion and Future work	12	**14**
		Same		**24**	20
	Human Conclusion and Future work	Different	Title	8	**12**
		Same		2	**10**

Which Abstract is Written by PaperRobot?

A. Background The aim of the present study was to investigate the effect of Cnidium Lactone on the expression of Mutant and histone deacetylase (HDAC) inhibitors in human prostate cancer (PC) . Material/Methods We evaluated the effects of Prostate Cancer on cell proliferation and invasion in vitro and in vivo . Cells were incubated with a single dose of 25 (50 mg/kg) , and 10 (100 mg/kg/day) , respectively . The primary endpoint was the ability of the mRNA and protein levels of transcription factor (VEGF) .

B. Background Cnidium Lactone is a natural coumarin compound that can inhibit a variety of cancer cell proliferation and induce cancer cell apoptosis . This experiment investigated the effect of cnidium Lactone on molecular marker expression in prostate cancer nude mice to study its effect in inducing apoptosis . Material/Methods We randomly and equally divided 30 male BALB/C nude mice inoculated with human prostate cancer cells PC-3 into a negative control group , a cyclophosphamide group (500 mg/Kg) , and cnidium Lactone groups at 3 doses (280 mg/Kg , 140 mg/Kg , and 70 mg/Kg) . The mice were weighed at 2 weeks after administration .
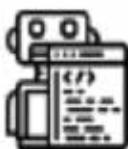
Which Abstract is Written by PaperRobot?

A. The use of nanoparticles in medicine is an attractive proposition . In the present study , Zinc oxide and silver nanoparticles were evaluated for their antidiabetic activity . Fifty male albino rats with weight 120 ± 20 and age 6 months were used . Animals were grouped as follows : control ; did not receive any type of treatment , diabetic ; received a single intraperitoneal dose of streptozotocin (100 mg/kg) , diabetic + Zinc oxide nanoparticles (ZnONPs) , received single daily oral dose of 10 mg/kg ZnONPs in suspension , diabetic + silver nanoparticles (SNPs) ; received a single daily oral dose of SNP of 10 mg/kg in suspension and diabetic + insulin ; received a single subcutaneous dose of 0.6 units/50 g body.

B. Rationale : Aliskiren is a rare disease characterized by a variety of hypertensive disorders . The aim of the present study was to evaluate the effectiveness of aliskiren , pharmacodynamics , and clinical outcomes in patients with hypertension . Methods We reviewed the medical records of ambulatory blood pressure (BP) , kinetics , and high-sensitivity C-reactive protein (CRP) levels in the treatment of corneal tissue . We performed a retrospective review of the English literature search of PubMed , EMBASE , and Cochrane Library databases . The primary outcome was established by using a scoring system.

Which Conclusion is Written by PaperRobot?

- **A.** In summary , the present study demonstrated that BBR could suppress tubulointerstitial fibrosis in NRK 52E cells . In addition , the effects of action on the EMT and HG of DN in the liver cell lines , and the inhibition of renal function may be a potential therapeutic agent for the treatment of diabetic mice . Further studies are needed to elucidate the mechanisms underlying the mechanism of these drugs in the future .

- **B.** We characterised KGN cells as a malignant tumour model of GCTs . Continuously cultivated KGN cells acquire an aggressive phenotype , confirmed by the analysis of cellular activities and the expression of biomarkers . More strikingly , KGN cells injected under the skin were metastatic with nodule formation occurring mostly in the bowel . Thus , this cell line is a good model for analysing GCT progression and the mechanisms of metastasis.

Which Conclusion is Written by PaperRobot?

- A. In reproductive-age women with ovarian endometriosis , the transcriptional factor SOX2 and NANOG are over expression . Future studies is need to determine their role in pathogenesis of ovarian endometriosis.

- B. In summary , the present study demonstrated that Hydrogen alleviates neuronal apoptosis in SAH rats . These results suggest that the Akt/GSK3β signaling pathway may be a novel therapeutic target for the treatment of EBI .
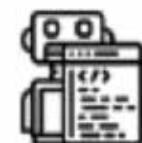
Which Conclusion is Written by PaperRobot?

- A. Our novel data strongly suggest that BMP-2 signaling modulates SOST transcription in OA through changes in Smad 1/5/8 binding affinity to the CpG region located upstream of the TSS in the SOST gene , pointing towards the involvement of DNA methylation in SOST expression in OA.

- B. In conclusion , the present study demonstrated that DNA methylation and BMP-2 expression was associated with a higher risk of developing Wnt/β-catenin pathway in OA chondrocytes . These results suggest that the SOST of Wnt signaling pathways may be a potential target for the treatment of disease .

Which Conclusion is Written by PaperRobot?

- **A.** VWF is an autocrine/paracrine effector of signal transduction and gene expression in ECs that regulates EC adhesiveness for MSCs via activation of p38 MAPK in ECs.

- **B.** In conclusion , our study demonstrated that HOTAIR transcript expression in NSCLC cells. These results suggest that the overexpression of metastasis may play a role in regulating tumor progression and invasion. Further studies are needed to elucidate the molecular mechanisms involved in the development of cancer.
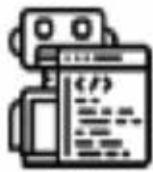
Which Title is Written by PaperRobot?

- A. The role of cancer stem cells to trastuzumab-based and breast cancer cell proliferation, migration, and invasion

- B. Long-term supplementation of decaffeinated green tea extract does not modify body weight or abdominal obesity in a randomized trial of men at high risk for Prostate cancer

Which Title is Written by PaperRobot?

- A. Efficacy and Safety of Artesunate in the Treatment of Uncomplicated Malaria: a Systematic Review and Meta-analysis

- B. Low RBM3 Protein Expression Correlates with Clinical Stage, PrognOStic Classification and Increased Risk of Treatment Failure in Testicular Non-Seminomatous Germ Cell Cancer

Remaining Challenges: Human output is usually more vivid

- Human: " Does HPV play any role in the initiation or prognosis of endometrial adenocarcinomas ? "
- System: " The role of HPV in the treatment of endometrial adenocarcinomas"

Remaining Challenges: Human output is usually more concrete

- Human written title:

- "**etumorType** , An Algorithm of Discriminating Cancer Types for Circulating Tumor Cells or Cell-free DNAs in Blood" create new entity abbreviations such as **etumorType** in this example

- System written title:

- Gastrointestinal Stromal tumor initiation : A Review of the Literature .

Did it Work for NLP?

- (Fortunately) we are still not publishing enough…

- The language model is not able to effectively copy out-of-vocabulary words and thus the output is often too generic

  - Title: *Statistics based hybrid approach to Chinese base phrase identification*

  - Abstract: *This paper describes a novel approach to the task of Chinese-base-phrase identification. We first utilize the solid foundation for the Chinese parser, and we show that our tool can be easily extended to meet the needs of the sentence structure.*

- The types of entities and relations in the NLP domain are rather coarse-grained, which often leads to inaccurate prediction of related entities

  - Title: *Extracting molecular binding relationships from biomedical text*

  - Abstract: *In this paper, we present a novel approach to the problem of extracting relationships among the **prolog program**. We present a system that uses a macromolecular binding relationships to extract the relationships between the abstracts of the entry. The results show that the system is able to extract the most important concepts in the **prolog program**.*

Ongoing Work: ReviewRobot

- A recent EMNLP2019 review

Reasons to accept

     1. Idea is interesting and convincing. 2, Solid experiments are conducted.

Reasons to reject

     1. Idea is too simple and tricky.

- Half of NIPS2016 papers would have been rejected if reviews are done by a different group
- Low human performance bar; should be easy to pass Turing Test than PaperRobot!

J R Soc Med. 2006 Apr; 99(4): 178–182.
doi: 10.1258/jrsm.99.4.178

PMCID: PMC1420798
PMID: 16574968

## Peer review: a flawed process at the heart of science and journals

Richard Smith
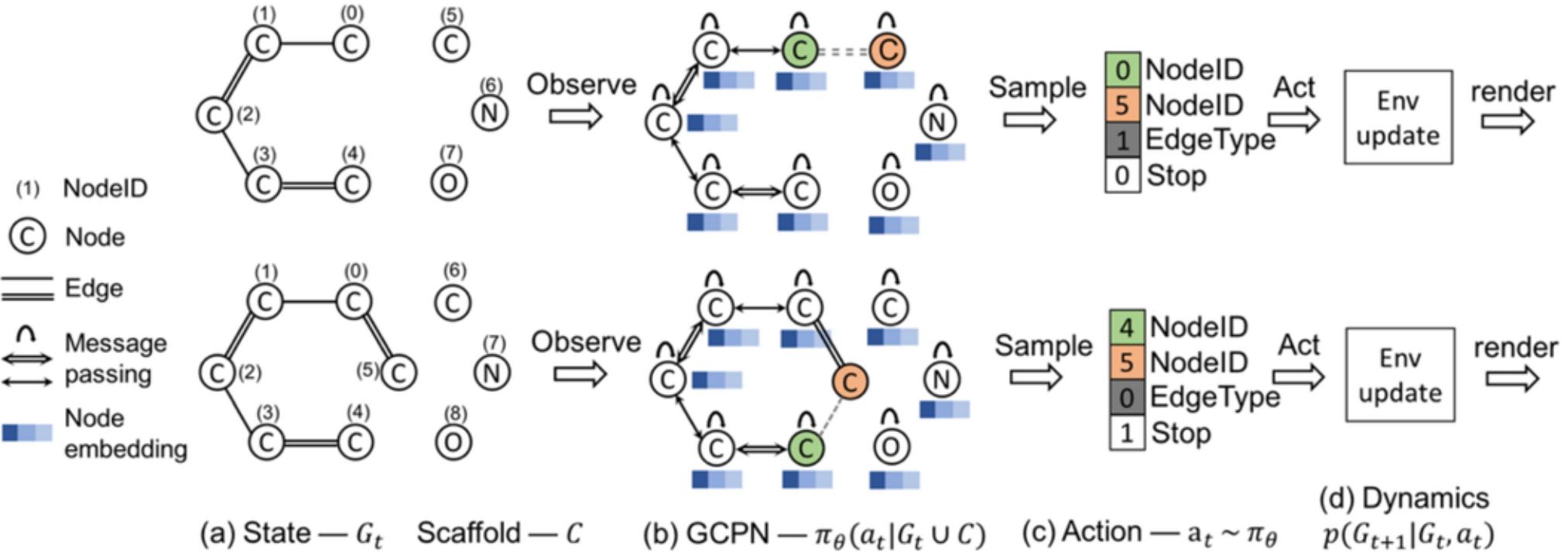
‣ Author information ‣ Copyright and License information Disclaimer

ReviewRobot: Paper Content based Baseline

- ACL 2017 from PeerRead dataset (Kang et al., 2018)
  - Train/dev/test: 248/12/15, score scale 1-5
  - Input: uncased whole paper; Output: aspect score

Model	Category	Average inter annotator agreement	System Accuracy
GRU with attention mechanism (without pretrained word embeddings)	Recommendation	0.7619	0.7143
	Substance	0.8095	0.8571
	Appropriateness	1.000	0.8571
	Comparison	1.000	0.4286
	Soundness	1.000	0.1429
	Originality	1.000	0.5714
	Clarity	0.8810	0.4286
	Impact	1.000	0.8571
	Reviewer confidence	0.9048	0.5714

Ongoing Work: Idea Generation from Scratch

(a) State — G_t Scaffold — C (b) GCPN — $\pi_\theta(a_t|G_t \cup C)$ (c) Action — $a_t \sim \pi_\theta$ (d) Dynamics $p(G_{t+1}|G_t, a_t)$

- (Leskovec et al., 2019)
- Generating graph from a starting node with graph RNN pic ("name tagging" → CRFs --> LSTM → ACE data)

Takeaways

- Biomedical domain is a promising application area for IE; some recent progress relies on
  - Capturing complex sentence structures
  - Incorporating properties in ontologies
  - Better semantic representations and neural network models
- PaperRobot is merely an assistant to help scientists speed up scientific discovery and production
  - Conducting experiments is beyond her scope, and each of her current components still requires human intervention
- Future Directions
  - Knowledge reasoning over complex and implicit contexts
  - Combine symbolic structured representations and distributional representations when semantic parsing for the domain is more mature
  - Incorporate more and deeper background knowledge from ontologies and literature (description, hierarchy, etc.)
  - Encode more reliability signals beyond frequency to enhance robustness

Thank you

- https://github.com/EagleW/PaperRobot