









Applications, Remaining Challenges, Future Directions and Resources

Event-Centric Natural Language Processing (Part VI)

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ACL Tutorials

Event-Centric Natural Language Processing

Where are We and What's Next



Applications

- Writing History Book
- News Understanding and Recommendation
- Disaster Relief
- Intelligence Analysis
- Accelerating Scientific Discovery
- Remaining Challenges and Future Directions
 - ☐ External Knowledge Acquisition, Reasoning and Incorporation
 - □ Document-Level Event Extraction
 - ☐ Multimedia Information Extraction and Verification
- Grand Vision
- Resources

Application 1: Writing a History Book



- Organize chapters by major events clusters and order them on a timeline
- Each chapter looks like a Wikipedia page
 - ☐ The description is organized by multimedia timeline with detailed source and evidence information, links to original news articles
 - Detailed participants (arguments) and their roles,
 and their connections and relations
 - ☐ Infobox shows event-event relations: temporal, causal and hierarchical
- Never-ending updating over time; put up to the wild for human editing and curation

Protests against the government [edit]

4 December 2011 [edit]

On 4 November 2011, during the annual Russian March event, representatives of "The Russians" movement declared a protest action unapproved and took place on 4 December at 21:00 in Moscow. The statement of non-recognition of electoral results spread widely. Cit said to have occurred during the elections. Alexander Belov declared the beginning of the "Putin, go away!" campaign. [37] The protest a Alexander Belov, Dmitry Dyomushkin, George Borovikov were arrested along with dozens of other nationalists. The head of the banned observer. Mass detentions of other public organizations occurred in Moscow. According to police some 258 persons have been detained.

5-7 December 2011 [edit]

On 5 December, around 5,000 opponents of the government began protesting in Moscow, denouncing Vladimir Putin and his government began protesting in Moscow, denouncing Vladimir Putin and his government Putin step down, whilst some demanded revolution. [15][39] Alexey Navalny, a top blogger and anti-corruption activist who branded Putin postings on his LiveJournal blog and Twitter account. Navalny's agitation was denounced by United Russia as "typical dirty self-promotion account. [40][41]

Many pro-government supporters, including the pro-Putin youth group Nashi, were mobilized on 6 December at the site of the planned Nashi on Manezhnaya Square. [43] and an 8,000-strong rally of the Young Guard on Revolution Square. [44] About 500 pro-United Russi expected anti-government protests. It emerged that 300 protesters had been arrested in Moscow the night before, along with 120 in St. slogans against Putin, [15] whilst anti-government protesters at Revolution Square clashed with riot police and interior ministry troops. To Square and dozens of arrests were reported, including Boris Nemtsov, an opposition leader and former deputy prime minister, [48] and A charged. At least one Russian journalist claimed he was beaten by police officers who stamped on him and hit his legs with batons. [50] place. After three and a half hours, the Moscow protest came to an end. [51]

Attempts to stage a large protest in Moscow on 7 December fizzled out due to a large police presence in the city. [13]

10 December 2011 [edit]



Rally in Bolotnaya Square in
Moscow on 10 December 2011

Via a Facebook group "Суббота на Болотной площади" (Saturday at Bolotnaya Square), [52] December. [53][54] Prior to the demonstration newspapers commented that tens of thousands o Moscow, [55][56] and, similarly, over 5,000 in St. Petersburg. [57] A permit had originally been iss Square. By 8 December, more than 30,000 [52] had accepted the Facebook invitation to attend. demonstration was authorized by the Moscow government for the demonstration which took pla made by Putin that police and security forces would be deployed to deal with anyone participat was peaceful and without attempts by the state to prevent or disrupt it. [59][60] Rapper Noize M specially from Paris for the occasion. [61] Guerrilla theater by FEMEN and the circulation of a pt protests. [62][63]

Example Chapter: 2019 Hong Kong Protests



The first big protests

On 9 June, an estimated one million people marched to the government headquarters to show they were against the proposed bill.



Protesters storm parliament

On 1 July, the anniversary of Hong Kong's handover from the UK to China, the Legislative Council (LegCo) building was stormed by protesters who sprayed graffiti on the walls, displayed the colonial-era flag and defaced Hong Kong's regional emblem.



One week later, on 7 July, tens of thousands marched in Kowloon - an area popular with mainland tourists - in a bid to explain their concerns. Until this point the protests had received little if any coverage in state-run mainland media.

On 9 July, Carrie Lam reiterated that the extradition bill was "dead" urging protesters to stop their actions. She still refrained from fully withdrawing the bill.

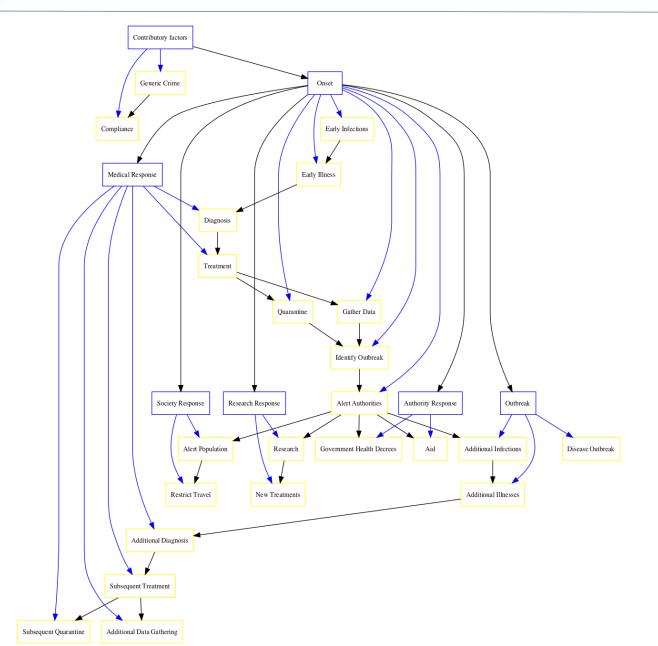
On 21 July, protesters defaced China's Liaison Office in Hong Kong.

Example Chapter: ISIS attacks



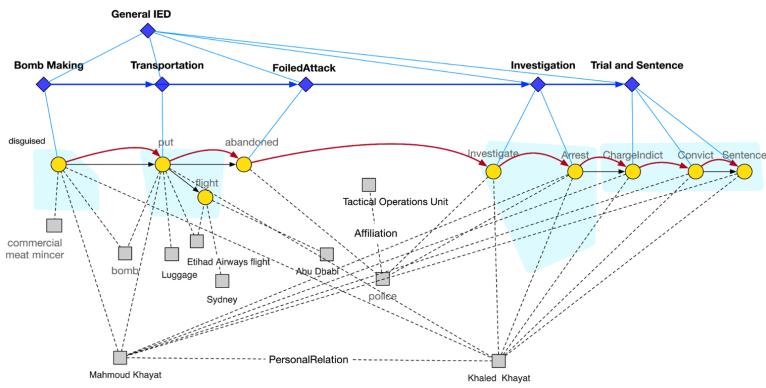
Example Chapter: COVID19 Pandemic





Example Chapter: Entity State Tracking



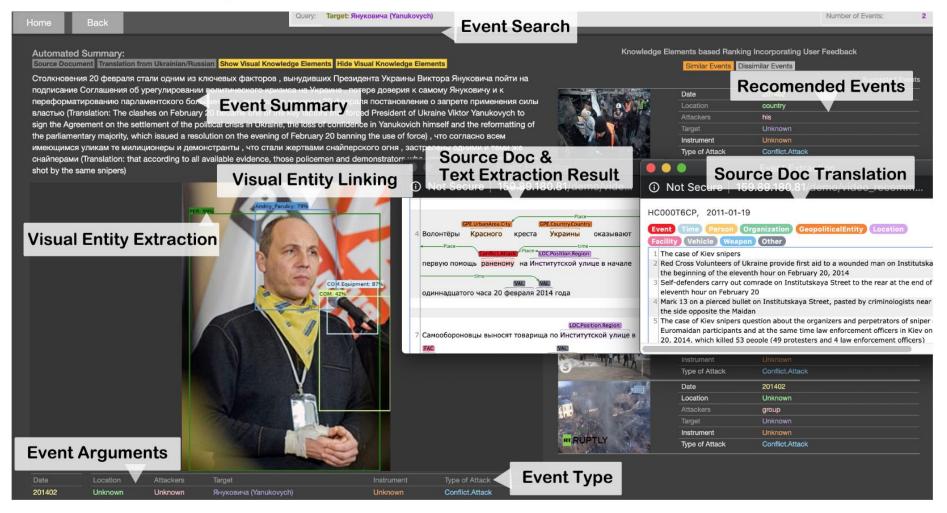


Tracking attackers Mahmoud Khayat and Khaled Khayat:

Timestep	1	2	3	4	5	6	7	
Event	disguise	put	abandon	investigate	arrest	charge	convict	sentence
Location	Sydney							

Application 2: News Understanding and Recommendation (Li et al., ACL2020Demo)





(Li et al., ACL2020 Best Demo Paper Award)

GitHub: https://github.com/GAIA-IE/gaia

DockerHub: https://hub.docker.com/orgs/blendernlp/repositories

Demo: http://159.89.180.81/demo/video_recommendation/index_attack_dark.html

Event-centric Question Answering



Identifying event orders and predicting future events

Heavy <u>snow</u> is <u>causing disruption</u> to <u>transport</u> across the UK, with heavy <u>rainfall bringing flooding</u> to the south-west of England. Rescuers <u>searching</u> for a woman <u>trapped</u> in a <u>landslide</u> at her home in Looe, Cornwall, <u>said</u> they had <u>found</u> a body.

Q1: What events have already finished?

A: searching trapped landslide said found

Q2: What events have begun but has not finished?

A: snow causing disruption rainfall bringing flooding

Q3: What will happen in the future?

A: No answers.

warm-up

Q4: What happened before a woman was trapped?

A: landslide

Q5: What had started before a woman was trapped?

A: snow rainfall landslide

Q6: What happened while a woman was trapped?

A: searching

Q7: What happened after a woman was trapped?

A: searching said found

User-provided

Ning, et al. TORQUE: A Reading Comprehension Dataset of Temporal Ordering Questions. EMNLP, 2020

• 3.2k news snippets with 21k human-generated questions querying temporal relationships

Q: Who will drop Japan as a trading partner in August 2019?

earlier than timestamp (2019-08-01)

(1/1/19) Apart from the fact of being one another's closest neighbors, the people of South Korea and Japan have a remarkable amount in common. Economically, they are among one another's biggest trading partners. And yet, time and again, relations between Seoul and Tokyo are marked, not by mutual support and co-operation but by anger, reproach and exasperation.

A) South Korea [0.41]

B) Syria [0.28]

C) South Africa [0.15]

D) Portugal [0.16]

Q: Will primary schools in Europe admit non-vaccinated children around September 2019?

earlier than timestamp (2019-09-01)

(3/8/18) Public officials and health experts had given several warnings: Do not allow a student in school if they had not been vaccinated against measles.

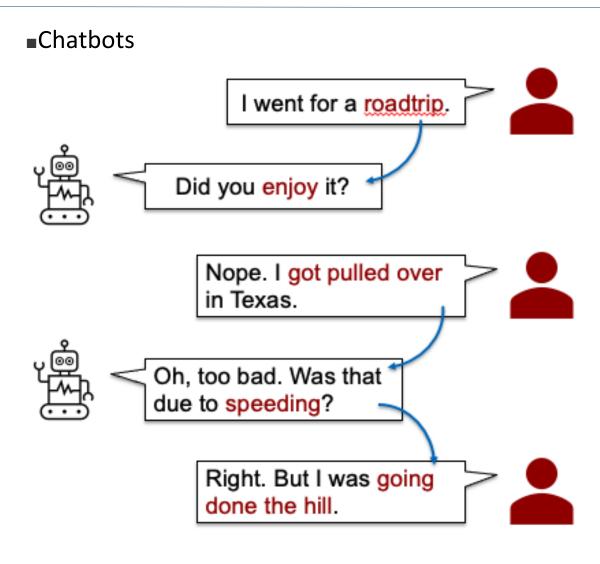
(6/27/19) Fines for parents refusing measles jab. Parents will be fined up to \in 2,500 if they don't vaccinate their children against measles under draft legislation in Germany which also *threatens* exclusion from crèches, nurseries and *schools*.

Yes [0.38] / No [0.62]

ForecastQA: A Question Answering Challenge for Event Forecasting

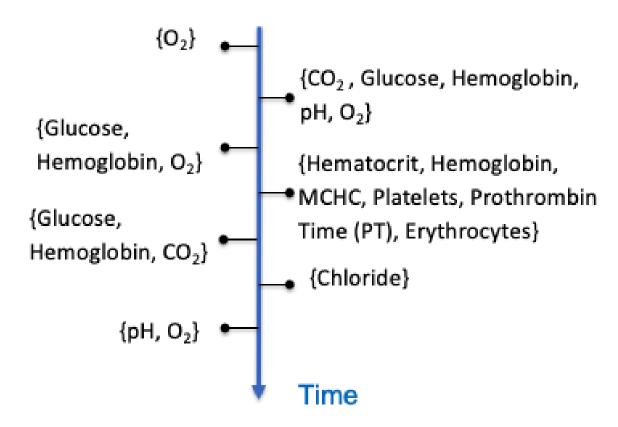
Event-centric Dialogue Systems





Can event processes improve the consistency of utterance generation/retrieval?

Clinical event processes

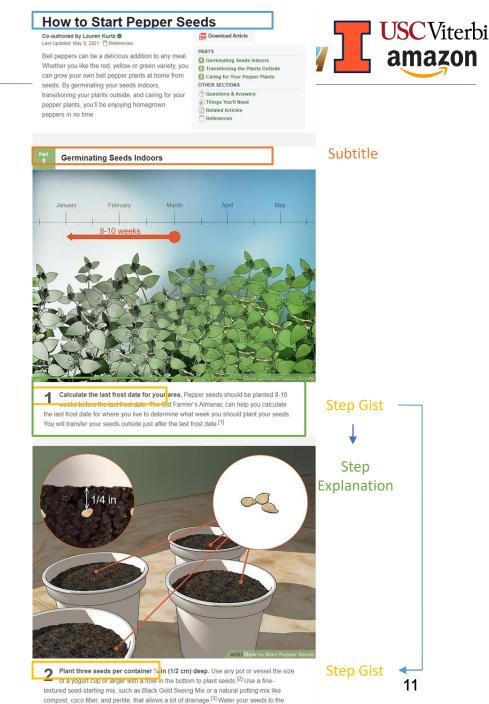


Diagnostic prediction, phenotype prediction, ...

- Transfer learning can important (naturally lack of data)
- Structured prediction can be important (dependency of phenotypes, disease labels)

Event-centric Dialogue Systems: Gardening Alexa

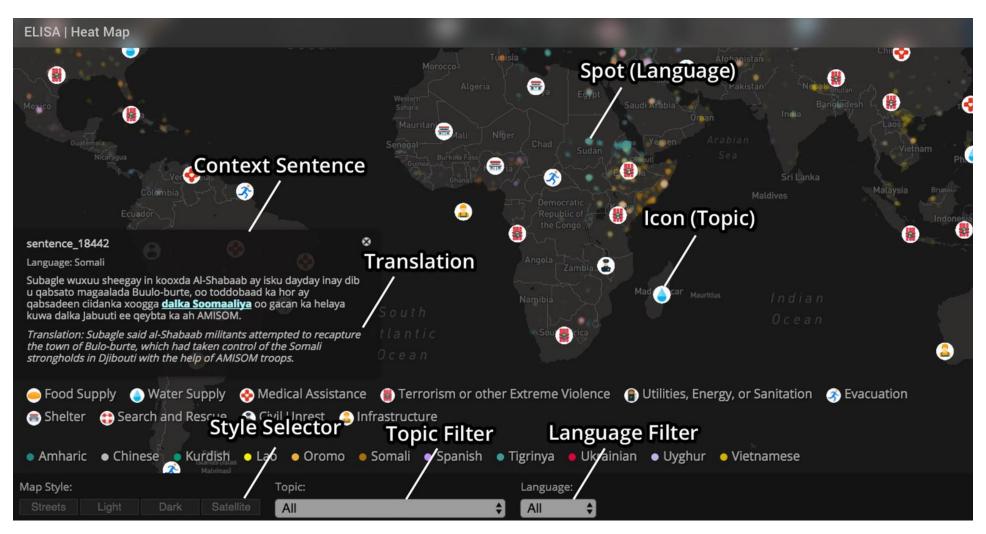
- Step Prediction
 - Given a task title and the previous step gist, automatically generate the next step gist
- © Explanation Generation
 - ☐ Given a task title and the previous step gist, automatically generate the next step gist (detailed instructions in natural language and illustrative images)
- Our approach is highly generalizable and capable of predicting procedures for unseen tasks or concepts



point of dampness but not saturation.

Applications 3: Disaster Relief (Zhang et al., NAACL18Demo)

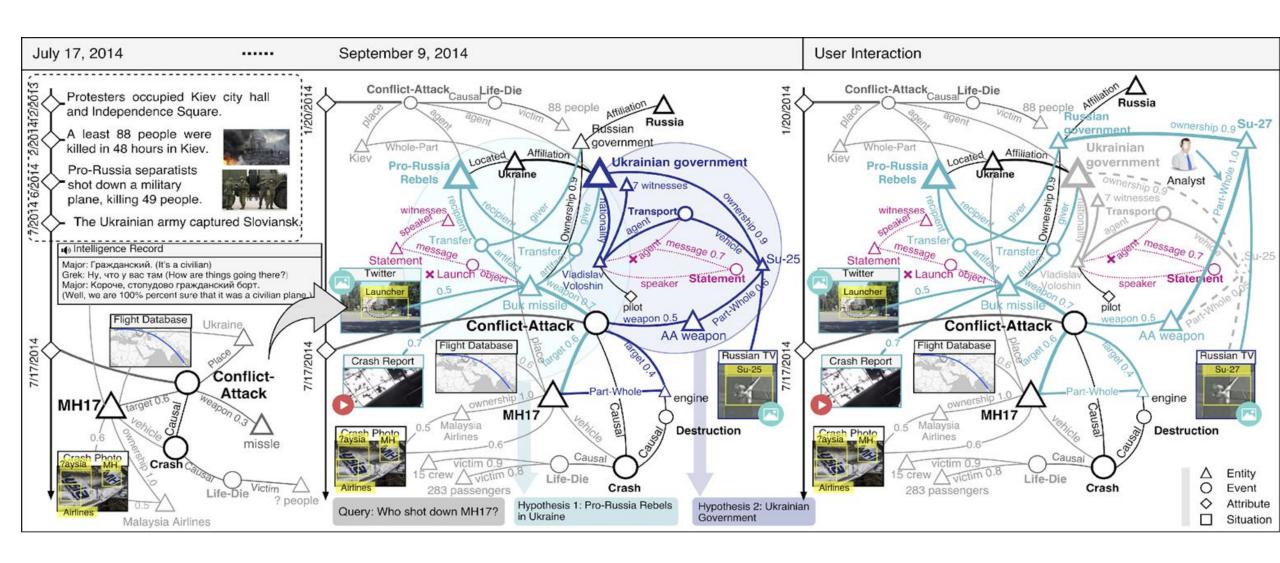




- Re-trainable Systems: http://159.89.180.81:3300/elisa-ie/api
- Demos: http://159.89.180.81:3300/elisa ie
- Heat map: http://159.89.180.81:8080/

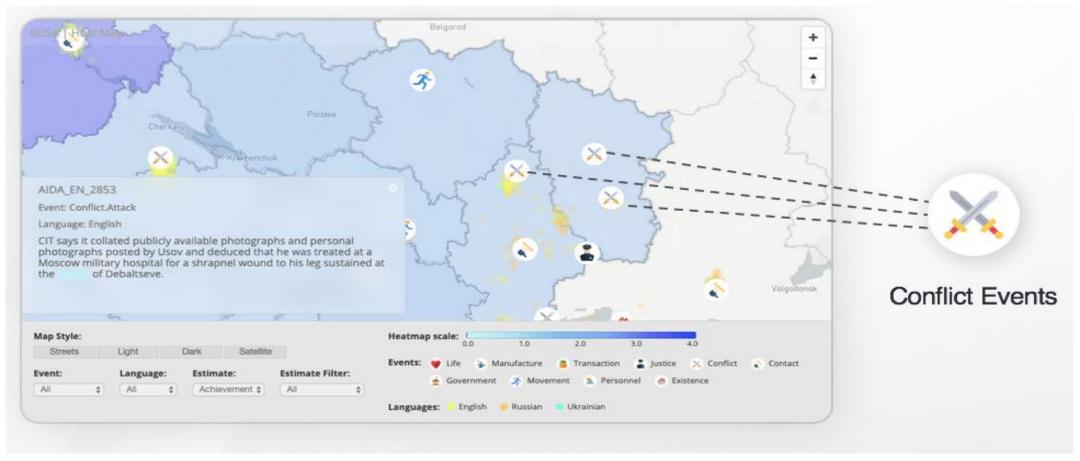
Applications 4: Intelligence Analysis





Applications 4: Intelligence Analysis





http://162.243.120.148:8080/

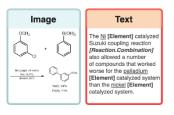
 Achievement, Benevolence, Conformity, Hedonism, Power, Security, Self-direction, Simulation, Tradition and Universalism (Schwartz, 2012)

Application 5: Accelerating Scientific Discovery





NeurIPS'19, WWW'20, KDD'20, ACL'20



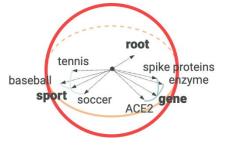
Scientific Literature



Chemical Ontology & Existing Databases



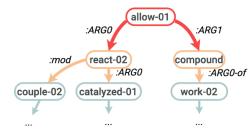
NAACL'19, EMNLP'19, ACL'19, ACL'20



Hierarchical Spherical Embedding

KB concept of Ni					
Name: Nikel Chemical Symbol: Ni Atomic Number: 28 Type: chemical element	Element category: transition metal Appearance: lustrous, metallic, and silver with a gold tinge				

Ontology Enriched Text Embedding



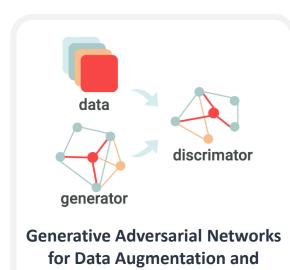
Cross-media Structured Semantic Representation

KNOWLEDGE BASE

AAAI'19, ACL'20

Graph neural networks

Joint entity/relation/event extraction
and ontology construction



Distant Supervision



Multimedia Knowledge Base

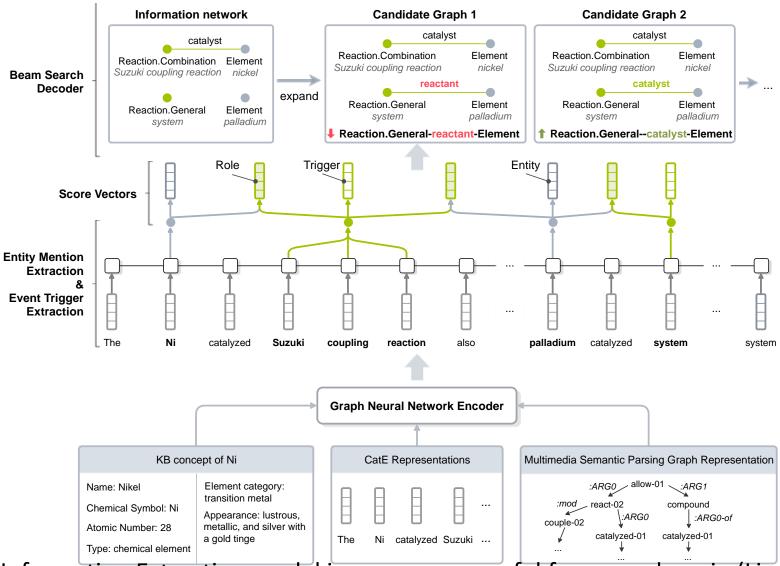


Multimedia Search and Summarization

■ Extending to other scientific domains including Molecular Synthesis and Agriculture under two new NSF institutes

Fine-grained COVID-19 Event Extraction

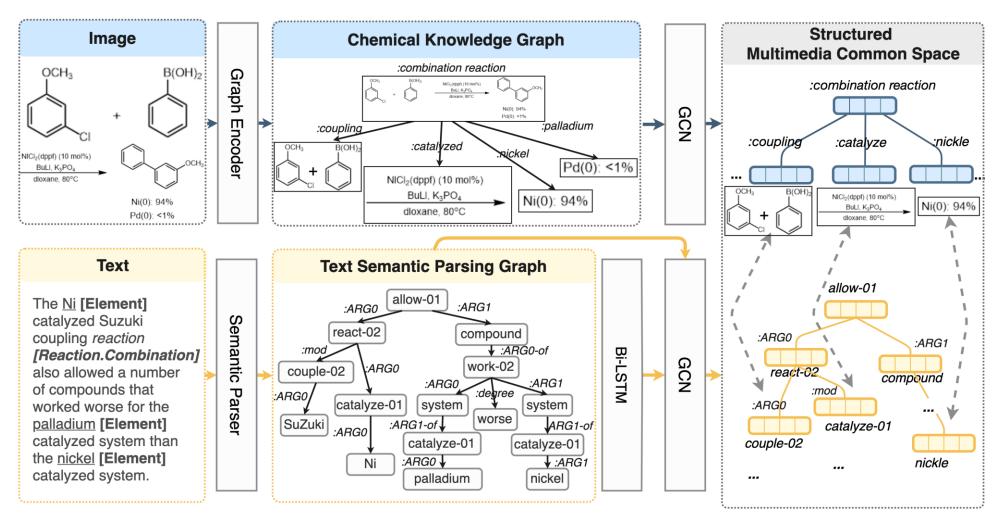




■ Joint neural Information Extraction model is proven successful for news domain (Lin et al., ACL2020)

Fine-grained COVID-19 Event Extraction

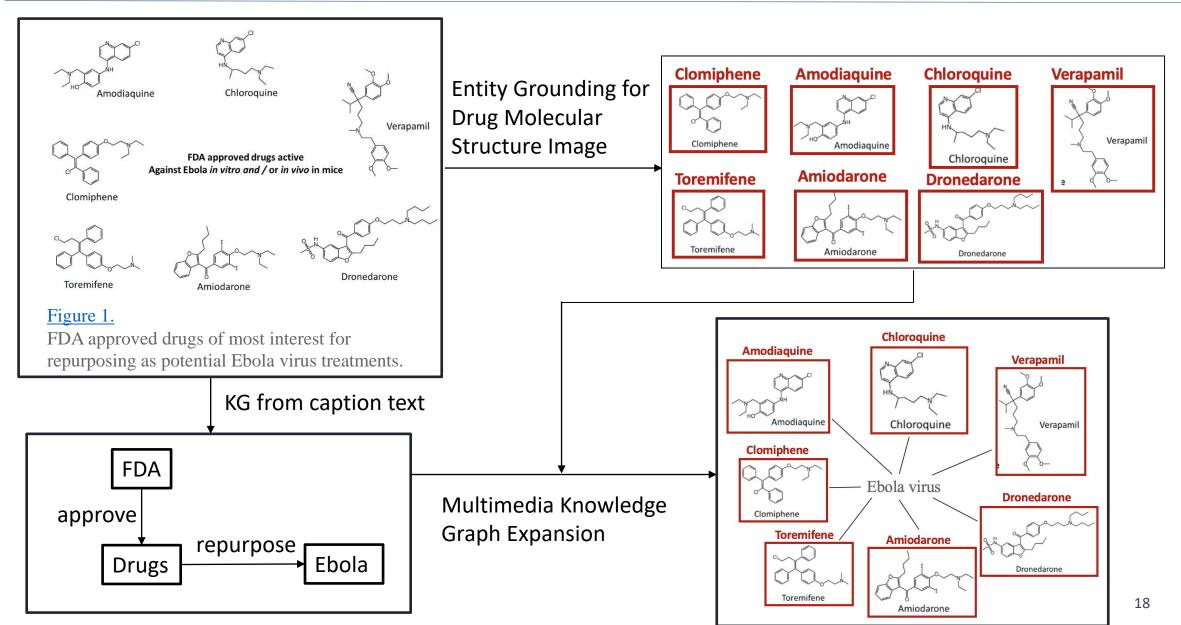




■ Multimedia Common Semantic Space Construction is proven successful for news domain (Li et al., ACL2020)

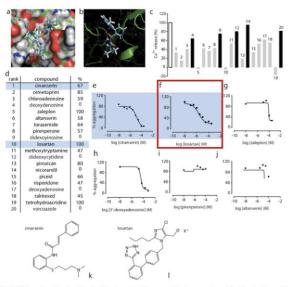
Multimedia Knowledge Graph Construction for Drug Repurposing



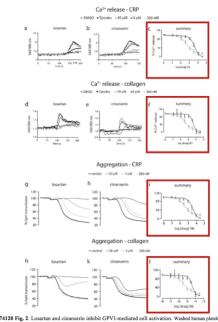


Drug Repurposing Report Generation (In vitro Data available?)

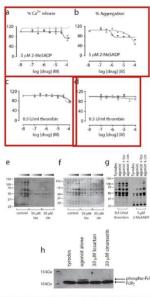




Sre: PMC4074120 Fig. 1. In silico identifies GPVI antagonist. Representative image capture of in silico docking into GPVI using Glide, with space filling model is shown in a, and H-bonding to relevant side chains is detailed in b. The 20 highest ranking compounds were screened for effects on Ca2+ release by the GPVI-specific agonist CR2+XL (10 mg/ml) (c and d, % refers to percent inhibition of Ca2+ release). Maximum Ca2+ release is shown in white, compounds that inhibited Ca2+ release by ,50% or more are in grey, and the remainder in black. Commercially available compounds that inhibited CR2+xL-induced Ca2+ release. 50% were further screened by light transmission aggregometry to identify compounds displaying dose-dependent inhibition (e1). Examples are shown of weak antagonism (g and h) and false positives (i and j). Cinanserin (i) and losartan (k) were taken on for further struct.



See: PMC4074126 Fig. 2. Losartan and cinanserin inhibit GPVI-mediated cell activation. Washed human platelets were loaded with fun2-NM and screened for drug-mediated inhibition of Ca2+ releases by 1 mg/min (EPX-XL (n = 3, 6 SEM, representative traces and summany, a-c-) and 1 mg/min collagen (n = 3, SEM, representative traces and summany, d-ft) losartan (sk) and cinanserin (m). To measure aggregation, washed human platelets were incubated with drug for one minute prior to the addition of 1 mg/mil CRP-XL (representative traces and summany shown in g-1). To mg/min collagen (representative traces and summany shown in g-1).

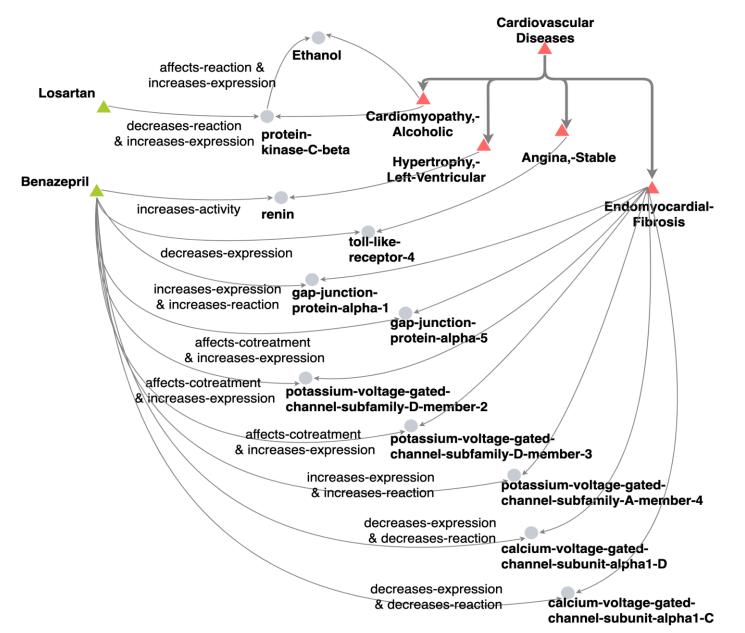


See: PMC4074129 Fig. 3. Losartan and cinamserin demonstrate selectivity for GPVI. Ca2e release and aggregations were carried out with 5 md of the Pail and PAIR recognition with 5 md of the PAIR and PAIR recognition against thrombia (c. Ca2e release and d. aggregation). Losartan (Ni. cinametrin (m), n = 3, 6 SEM. For global tyrosine phosphopylation, against thrombia (c. Ca2e release and d. aggregation). Losartan (Ni. cinametrin (m), n = 3, 6 SEM. For global tyrosine phosphopylation, washed human platelless were incubated with drug or vehicles of the control of 1 mg/mit CREA. or collages. Sample seep relation 10, 30, 60 e70 seconds, indicated by the graduated bars with time increasing to the righty in ice cold 26 byte buffer and separated on 4-12% NaPuge gels under fencing conditions. Tyrosine phosphopylation was visualized with 4G10 and phosphopylation (p. Mosphopylation) and cinametrin reduce CRP.XL (e-0) and collages-(f) induced global tyrosine phosphopylation, but have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McADP induced global tyrosine phosphopylation (p. Mosphopylation). But have no effect on thrombia or 2-McA

Disease	Cardiovascular disease
PMID, PMCID	Evidence Sentences
22800722 PMC7102827	The in vitro half-maximal inhibitory concentration (IC50) values of food-derived ACE inhibitory peptides are about 1000-fold higher than that of synthetic captopril but they have higher in vivo activities than would be expected from their in vitro activities Germinal ACE depends on chloride to a lesser extent compared with the C domain of sACE. Cushman and Cheung reported an optimal in vitro ACE activity of rabbit rung acetone extract in the presence of 300 mM NaCl at pH 8.1-8.3

Has the drug shown evidence of systemic toxicity?





Where are We and What's Next



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- > Remaining Challenges and Future Directions
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Event Extraction Challenges: Scene Understanding



- Three Young Boys,ages 2, 5 and 10 survived and are in critical [injure] condition after spending in 18 hours in the cold.
- This was the Italian ship that was taken -- that was captured [transfer-ownership] by Palestinian terrorists back in 1985 [die_time] and some may remember the story of Leon clinghover, he was in a cheal chair and the terrorists shot him and pushed him over the side of the ship into the Mediterranean [die_place] where he [die_victim] obviously, died.
- Then police say the baby's mother pulled out a kitchen knife [die_instrument] opinion on the 911 tape you can hear Williams tape say "go ahead kill me."



Scenario = ISIS attack → Event = bombing instead of concert

Long-Tail Triggers and Arguments



Rare Triggers

	his men back to their compound
	A suicide bomber detonated explosives at the entrance to a crowded
	medical teams carting away dozens of wounded victims
	Today I was let go from my job after working there for 4 1/2 years.
	This morning in Michigan, a second straight night and into this morning, hundreds of people have been rioting in Benton harbor.
Rai	re Arguments
	We've seen in the past in Bosnia for example, you held elections and all of the old ethnic thugs [election_person] get into power because they have organization and they have money and they stop the process of genuine building of democracy.
	He called the case and I'm quoting now, a judge's worst nightmare, but he noted that Maryland Parole Boards and the facility where Michael Serious was held, the institution made what the judge called the final decision on whether to release serious [release-parole_person].

- □ Last week Williamson, a mother of four, was found stabbed to death at a condominium [die_place] in Greenbelt, Maryland.
- □ A source tell US Enron is considering suing its own investment bankers for giving it bad financial advice [Sue_crime].

Highly Ambiguous Triggers



- Ellison to spend \$10.3 billion to **get [org-acquisition]** his company.
- I want to take [transport] this opportunity to stand behind the Mimi and proclaim my solidarity.
- He's left [transport] a lot on the table.
- Stewart has found the road to fortune wherever she has traveled [transport].
- And it's hard to win back that sort of brand equity that she's lost [end-position].
- Still hurts [attack] me to read this.
- We happen to be at a very nice spot by the beach where this is a chance for people to get [transport] away from CNN coverage, everything, and kind of relax.
- He bought the machinery, moved [transport] to a new factory, rehired some of the old workers and started heritage programs.

Event Coreference Resolution Challenges



- Super-event and subevent are often mistakenly identified as coreferential
 - □ These same imposters were later filmed **shooting** handguns and automatic weapons in the direction of the building just minutes after they had switched sides .
 - □ Right sector goons started the **fire** by throwing Molotov cocktails through the windows
- A sequence of subevents are often mistakenly considered as coreferential
 - Nor does the author speculate on why the police stood by while people hurled themselves from windows to escape the fire or were savagely **beaten** by right wing extremists on the pavement in front of the building .
 - □ Its true that Washington supports Neo-Nazi extremists who **burned down** the Odessa Trade Unions House .

Remaining Challenges for Multimedia Extraction: wrong localization



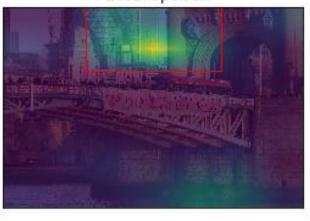
Predicted event: CONFLICT | DEMONSTRATE, ground truth: CONFLICT | DEMONSTRATE

Predicted verb: parading

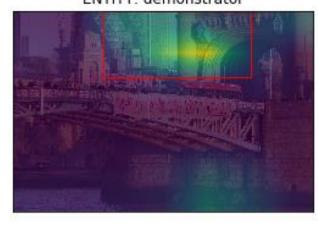
ENTITY: people



PLACE: open air



ENTITY: demonstrator



Predicted event: CONFLICT||DEMONSTRATE, ground truth: CONTACT||MEET

Predicted verb: parading

ENTITY: people



PLACE: street



ENTITY: troops



Remaining Challenges for Multimedia Extraction: too many instances



Predicted event: CONFLICT | DEMONSTRATE, ground truth: CONFLICT | DEMONSTRATE

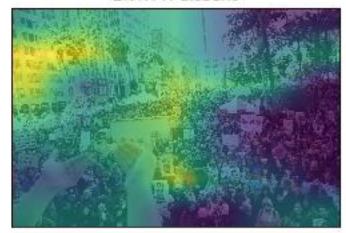
Predicted verb: parading

ENTITY: people

PLACE: street



ENTITY: dissent

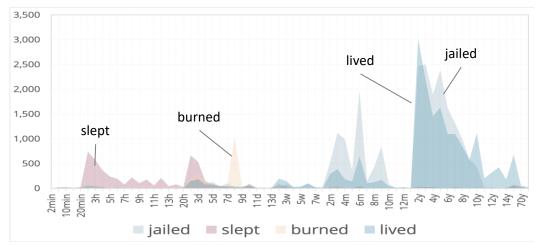


Future Direction 1: Knowledge Acquisition and Reasoning



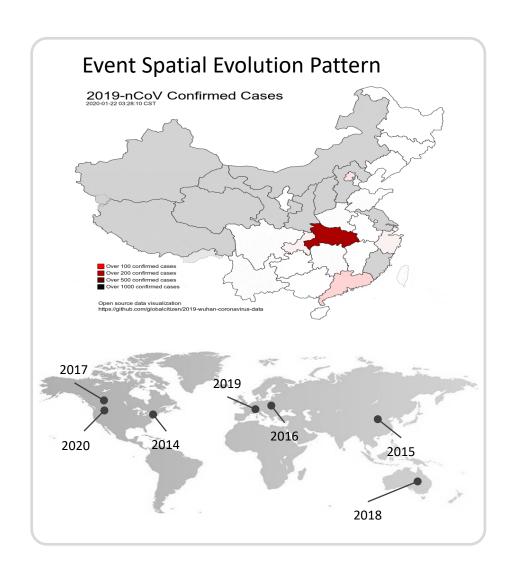
Discover from Google N-grams using lexical patterns

$$\square$$
 Verb + for + Time / Spent + Time + Verb-ing



Discover from Wikipedia event infoboxes and categories

Date	1 September 1939 – 2 September 1945 (6 years and 1 day) ^[a]
Categories:	World Wars World War II Conflicts in 1939
Conflicts in	1940 Conflicts in 1941 Conflicts in 1942
Conflicts in	1943 Conflicts in 1944 Conflicts in 1945
Global con	flicts Modern Europe Modern history Nuclear warfare



Future Direction 1: Knowledge Acquisition and Reasoning

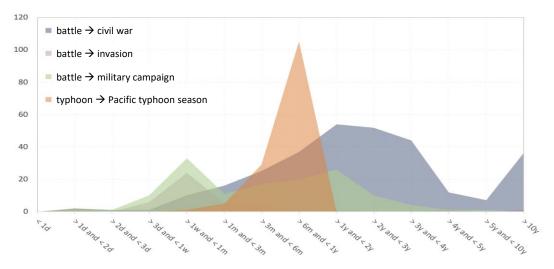


- Exploit Wikipedia/Wikidata
 - layout, category (event type), part of relation, has cause, has immediate cause, has contributing factor, has effect, immediate cause of, start/end time
 - Mining external links in Wikipedia articles and edit history;
 measuring the similarity of two temporal histograms

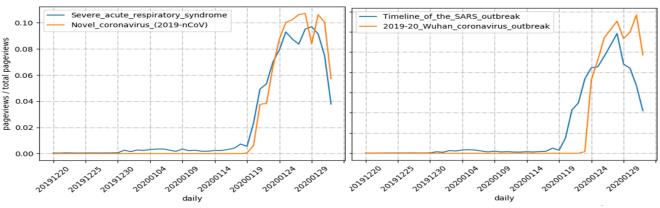
Hierarchical/Causal Composition



Cross-event Time Gap Pattern Discovery



Wikipedia Pageview Co-burst



But How to Encode such Symbolic Knowledge?



- 1. Use symbolic semantics to represent input structure (e.g., edges in AMR graphs) and distributional semantics to represent nodes (e.g., concept nodes in AMR)
 - ☐ Use in composition based classifiers such as CNN and GCN
 - ☐ Use in composition based methods like Tree/Graph NN.
 - Match sub-structures using soft-similarity on nodes and hard similarity on edges/structure
- 2. Combine graph embedding (e.g., knowledge graph embedding, social graph embedding) with text embedding to:
 - □ Extend the coverage (Graph embedding provides additional 'neighbors'.)
 - Validate
 - □ Allow flexible matching

How to Combine?



- 3. Use symbolic structure to enforce output structure
 - inter-dependency between labels and constraints (e.g., we use Bi-LSTM + CRFs for name tagging, where CRFs layer is used to capture the inter-dependency among labels, I-ORG cannot appear after B-PER, Lin et al., ACL2020)
- 4. Convert distributional semantic representation to symbolic semantic representation (to show to a user / to edit / to perform symbolic inference later)
 - □ ground/map the distributions of concepts to taxonomy/ontology/knowledge bases
 - perform hierarchical clustering on event trigger words based on their distributional semantic representations, and then select the centroid entity or predicate lexical dictionary in Propbank/Ontonotes/VerbNet to assign a name to the event type (Huang et al., 2016)
- 5. "reason with symbolic, compute with distributional"
 - ☐ Use local prediction/scoring based on distributional representation + global inference based on symbolic representation (Li et al., EMNLP2020)

Future Direction 2: Document-Level/Corpus-Level Event Extraction



So we can answer questions like "Why did Rachel break up with Ross?"

Seven people **convicted** *last week* in *Vietnam*'s biggest-ever criminal trial, including two former senior government officials, have requested an **appeal** of the verdicts, a court official said Tuesday.

The trial by a *Ho Chi Minh City* court was seen as a litmus test of the communist government's resolve to fight widespread corruption.

The ``godfather" of organized crime, *Truong Van Cam*, better known as Nam Cam, was convicted of seven crimes, including murder. He was **sentenced** to face a firing squad, and his lawyer has said he also plans to appeal.

Hanh, also a former member of the powerful Communist Party Central Committee, was convicted of receiving US\$8,500 in bribes from Nam Cam's family to secure the crime boss' early release from labor camp in 1990s. Hanh was sentenced to 10 years in jail.

Chien was convicted of receiving a stereo set worth 27 million dong (US\$1,750) from Nam Cam's family and sentenced to six years in jail.

—> Where was Hanh / Chien sentenced?

Future Direction 3: Multi-view Event Summarization



Claime	Arrested protesters should be released.			Claims:	The protests are not necessary.		
Claims:	C	arrie Lam s	hould resign.	Claims:	Violent protesters should be arrested.		
Profile:	Birth Place: Hong Kong		Age: below 30	- Profile:	Birth Place: not Hong Kong		Age: Above 50
	Education: above college		Participate in protest? No		Education: Below secondary school Participat		Participate in protest? No
Premises		Evidence		Premises		Evidence	
Extradition Law will weaken autonomy and judicial		Police violently attacked protesters.		Protests on Extradition Law		The target of Extradition Law is only on felon criminals.	
independe		Government ignored requests from protesters about revoking the amendment.		amendment are not necessar		The Law is not proposed by the Beijing government.	
Beijing government will undermine certain freedom.		N/A		Most of the protests are violent.		Protesters blocked traffic.	
	e certain freedom.					Protesters attacked the police.	

Future Direction 3: Knowledge-element Level Information Consistency Checking



Context

- Time
- Location
- Quality
- Perplexity
- Background
- Censorship

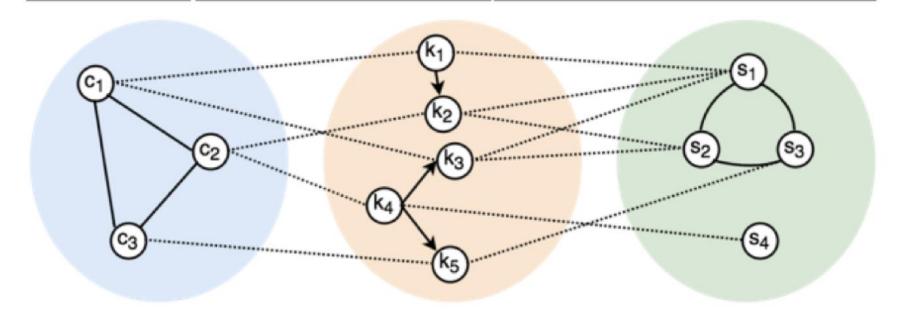
Knowledge Element

- Confidence
- Provenance
- Salience
- Novelty
- Temporal/Causal/Subevent/ Conflict relations between knowledge elements

Source (Narrator/User)

- Emotion
- Sentiment
- Aspect
- Confidence
- Political Stance
- Social Norm
- Language

- Perceived Control
- · Moral value
- Power
- Expertise
- Deception
- Data Modality
- Human Feedback



16 Dissertation Topics about Information Extraction Lamazon

http://blender.cs.illinois.edu/naacl/IEPhDDissertationTopics.pdf



16 PhD Dissertation Topics on Information Extraction

Mohit Bansal (UNC & Amazon Scholar)
Dan Bikel (Google)
Luna Dong (Amazon)
Eduard Hovy (CMU & DoD)
Heng Ji (UIUC & Amazon Scholar)
Dan Roth (UPenn & Amazon Scholar)

Where are We and What's Next

- Applications
 - ☐ Writing History Book
 - ☐ News Understanding and Recommendation
 - □ Disaster Relief
 - ☐ Intelligence Analysis
 - ☐ Accelerating Scientific Discovery
- Remaining Challenges and Future Directions
 - External Knowledge Acquisition, Reasoning and Incorporation
 - Document-Level Event Extraction
 - Multimedia Information Extraction and Verification
- ➤ Grand Vision
- Resources

Detailed Event-Centric Challenges

- Representing times events if he purpose of reasoning about it is still an open problem
- There are other challenges that we still don't have good enough formulations for:
- Semantic clarity
 - What does it mean for a relation to be temporally qualified by some temporal argument T?
 - All time points? At least one? None outside?

- H In 1944 US and Germany were at war;
 - John got married in 1944;
 - Jim was born in 1944.
- Expressiveness
 - M
 The great depression started before FDR took office.
 - WWI started before FDR took office.

The lion had a large meal and slept for 24 hours.
 When did it eat? Exactly 24 hours?
 The lion didn't sleep after having a large meal.
 [Negated]
 The lion may have had a large meal before sleeping.
 [Uncertain]
 If the lion has a large meal, it will sleep for 24 hours.
 [Hypothetical]
 The lion typically sleeps for 24 hours after having large meals.
 [Repetitive]
 After having a large meal, lions may sleep longer.
 [Generic]

- Mary graduated from college in 1969 (or 1971)
- John believed in 1995 that Mary attended college in the 1960s
- Mary did not attend college in the 1970s (but at some other time)

· Reasoning about Events often regulared the ability to tonsider and plan

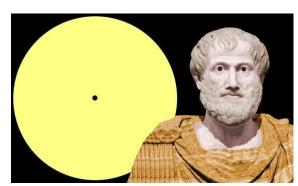
around implicit events and reason about quantities and ti

Will we make it to dinner before the movie?

Did Aristotle have a laptop?

See [Geva et al. TACL'21]

Mayor Rahm Emanuel now has raised more than \$10 million toward his bid for a third term – more than five times the total raised by his 10 challengers combined, campaign finance records show.





Grounding

- There is a need to ground in order to reason about events.
 - Temporally, Spatially
 - Multimodal: Where is this event? (and When did it happen)?

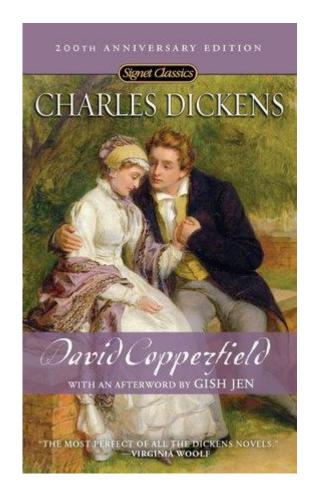


- Manchester Bomber Believed Muslims Were Mistreated, Sought Revenge
 - What is the event?
 - When/where did it happen?
- The visit to Berlin took place just after the collapse of the wan.
 - What is the event?
 - When/where did it happen?

High Level Event-Centric Challenges

CliffsNotes

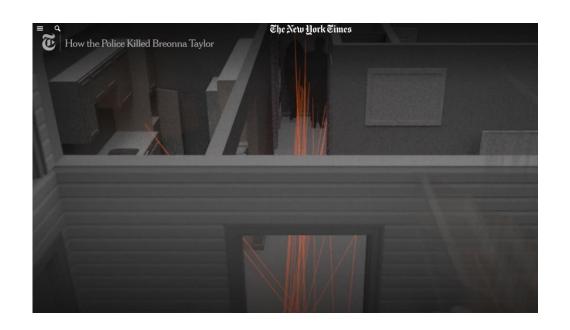
- How can we support readers in better ways?
 - The novel features the character <u>David Copperfield</u>, his journey of change and growth from infancy to maturity, as many people enter and leave his life and he passes through the stages of his development. (Fiction, and you know it)
 - London and England in the 19-th century; socioeconomic state, child exploitation; schools, prisons, emigration to Australia (**True historical facts**)
- Currently, we can't even tell the difference
 - What are the computational tasks we should think about?



Event Reconstruction

- The NYT put together a reconstruction video of the killing of Breonna Taylor.
 - Reconstruction is done by
 - Analyzing written evidence
 - Transcripts from interviews with witnesses, policemen, neighbors
 - Analysis of physical evidence collected in the scene
 - It took weeks to produce
- Can this be automated to form a reconstruction of a (chain of) events?
 - Ideally, this should be automated as a support tool for analysts
 - Requires multimodal capabilities
 - Understanding and reasoning about quantities & geometry
 - Reasoning about uncertainty
 - Reasoning about (possible) conflicting events/reports
 - Notion of multiple perspective & trustworthiness

Thank You!



Multimodal + 3D reconstruction:

https://www.nytimes.com/video/us/100000007348445/breonna-taylor-death-cops.html



THANK YOU