

Computational Fact Checking

Paolo Papotti

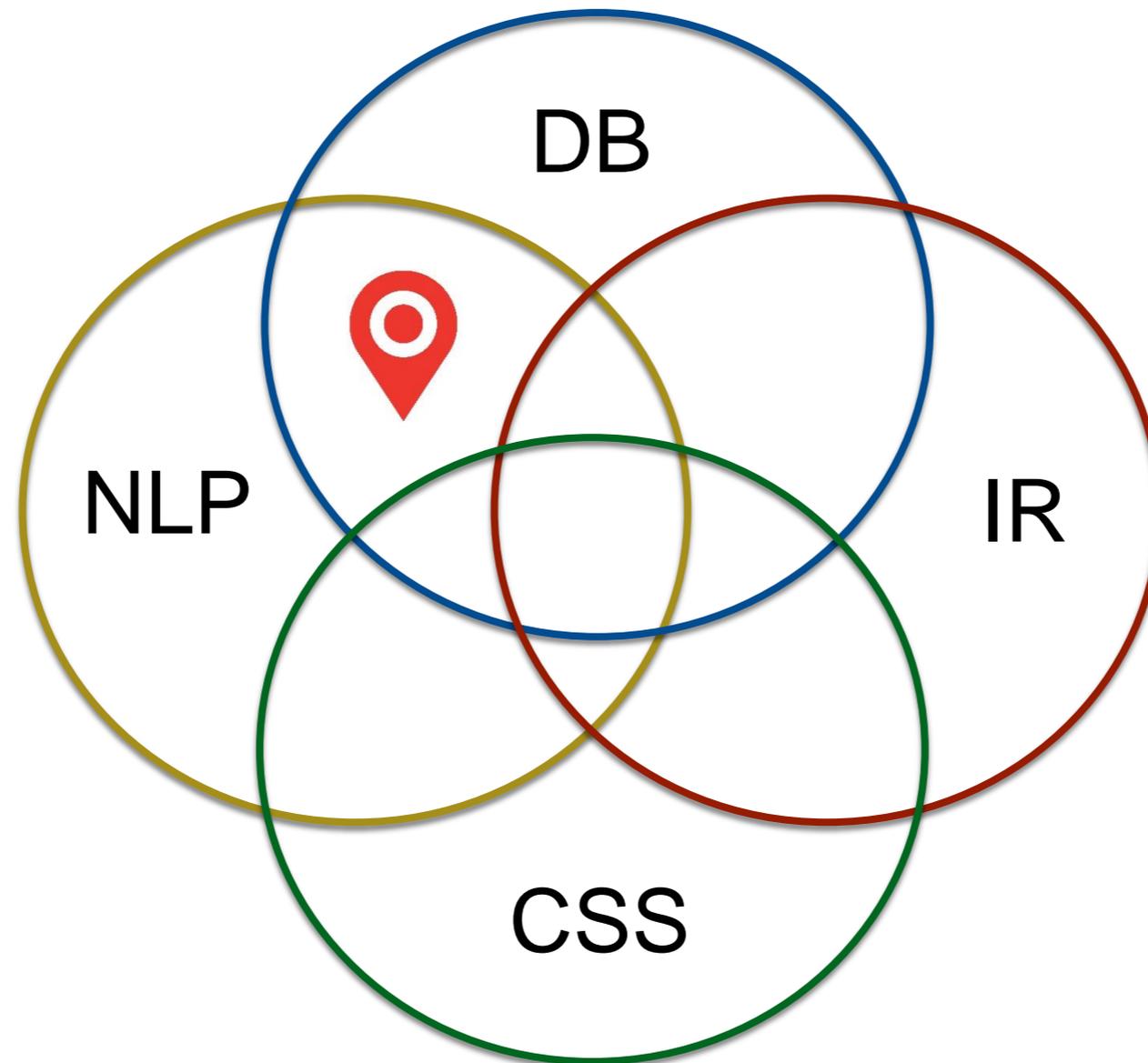


EDBT-INTENDED Summer School - 9th July 2022

Outline

- Motivation
- Pipeline
 - Worth checking → Evidence → Verification
- Data-driven verification
- Role of humans
- Ready for adoption?

Disclaimer





Voices

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Cameron Harris
electrical worker
Demczuk for The N

nytimes.com

*Faceboo
Violence*



Rohingya refugees
Bangladesh, in 2017
keep its platform fr
Myanmar. Adam De

By Alexandra Stev

Nov. 6, 2018

ncbi.nlm.nih.gov/pmc/articles/PMC6657116/

Journal List > Glob Pediatr Health > v.6; 2019 > PMC6657116

Global Pediatric Health



[Glob Pediatr Health](#). 2019; 6: 2333794X19862949.

PMCID: PMC6657116

Published online 2019 Jul 24.

PMID: [31384629](#)

doi: [10.1177/2333794X19862949](#)

Anti-Vaccine Decision-Making and Measles Resurgence in the United States

Olivia

Measles containing vaccine coverage second dose*, 2016

► Au

This

- 0–84%
- 85–94%
- 95–99%

Intro

- No data
- Not included

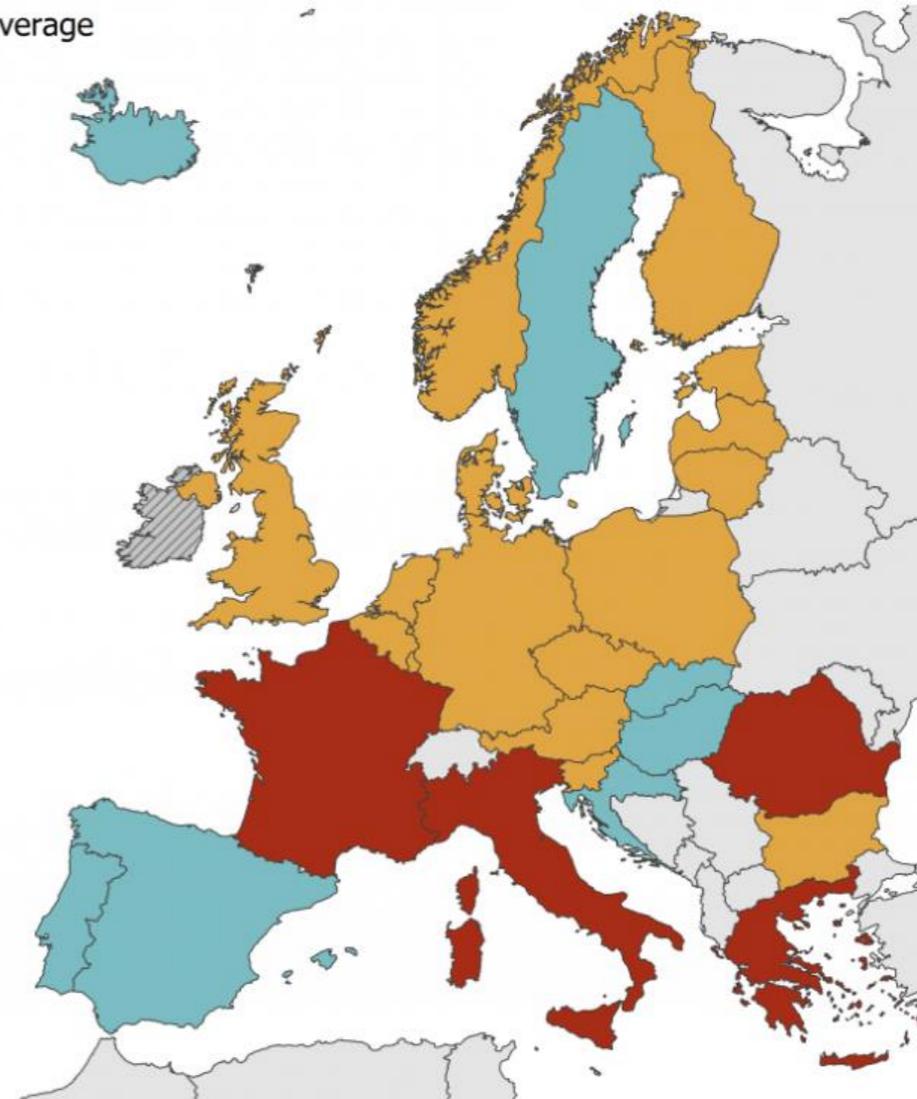
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State:

- Luxembourg
- Malta



*WHO, reported estimates

ECDC.

https://www.nytimes.com/2017/01/18/us/fake-news-hillary-clinton-cameron-harris.html?_r=0

[gove-boris-johns](#)

[theresa-may-a7533806](#)

Glob Pediatr Health

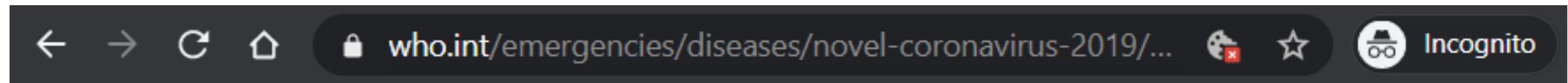
Glob Pediatr Health

COVID-19 Infodemic

“The outbreak has been accompanied by a massive *infodemic* - an over-abundance of information – some accurate and some not – that makes it hard for people to find trustworthy sources and reliable guidance when they need it.”



**World Health
Organization**



To help alleviate suffering and save lives, WHO has been working night and day in five key ways:

1. Helping build countries' capacity to prepare and respond
2. Providing accurate information and fight the infodemic, together with numerous partners
3. Ensuring supplies of essential medical equipment for frontline health workers.
4. Training and mobilizing health workers.
5. Accelerating research and development.

<https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen>

Checking claims



sun kills coronavirus

coronavirus when it falls on fabric it remains for 9 hours so washing clothes ...

sites.nationalacademies.org › covid-sunscreen ▾

Does sunlight kill the coronavirus? | National Academies

Claim: Since sunlight can kill the coronavirus, wearing sunblock is a bad idea during the coronavirus pandemic.

Fact check by National Academies: False. Scientists are still studying...

Feedback

Jeff Smith shared a link

Additional Reporting On This

Before you share this content, you might want to know that there is additional reporting on this from Snopes.com, Factcheck.org and Associated Press.

[Visit Snopes.com](#)

[Visit Factcheck.org](#)

[Visit Associated Press](#)

Cancel Post Anyway

Donald J. Trump @realDonaldTrump · 9h

There is NO WAY (ZERO!) that Mail-In Ballots will be anything less than substantially fraudulent. Mail boxes will be robbed, ballots will be forged & even illegally printed out & fraudulently signed. The Governor of California is sending Ballots to millions of people, anyone.....

[Get the facts about mail-in ballots](#)

22K 24.3K 86.7K

Donald J. Trump @realDonaldTrump · 9h

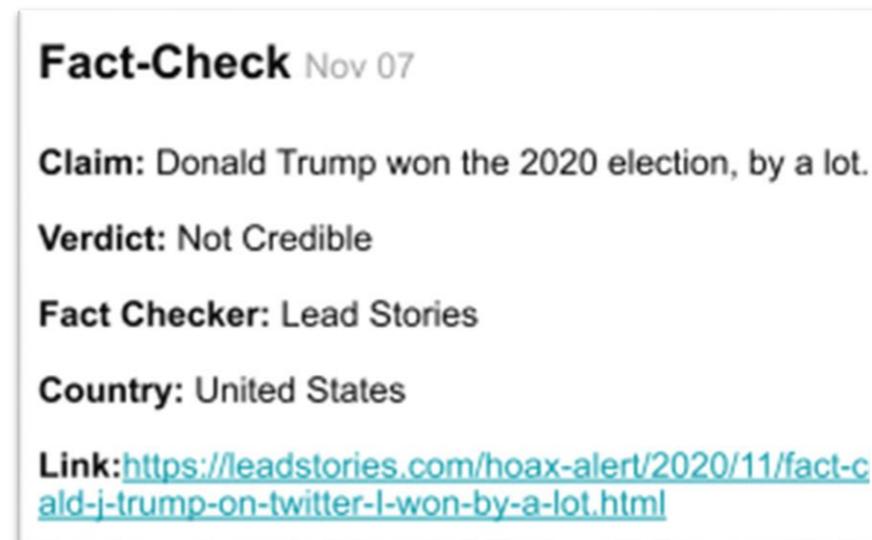
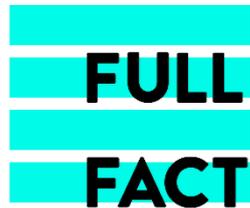
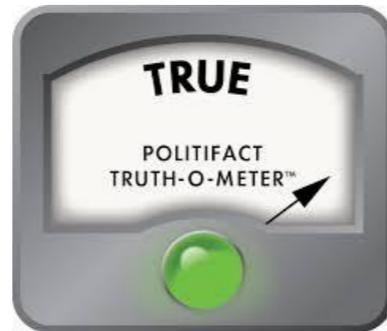
....living in the state, no matter who they are or how they got there, will get one. That will be followed up with professionals telling all of these people, many of whom have never even thought of voting before, how, and for whom, to vote. This will be a Rigged Election. No way!

[Get the facts about mail-in ballots](#)

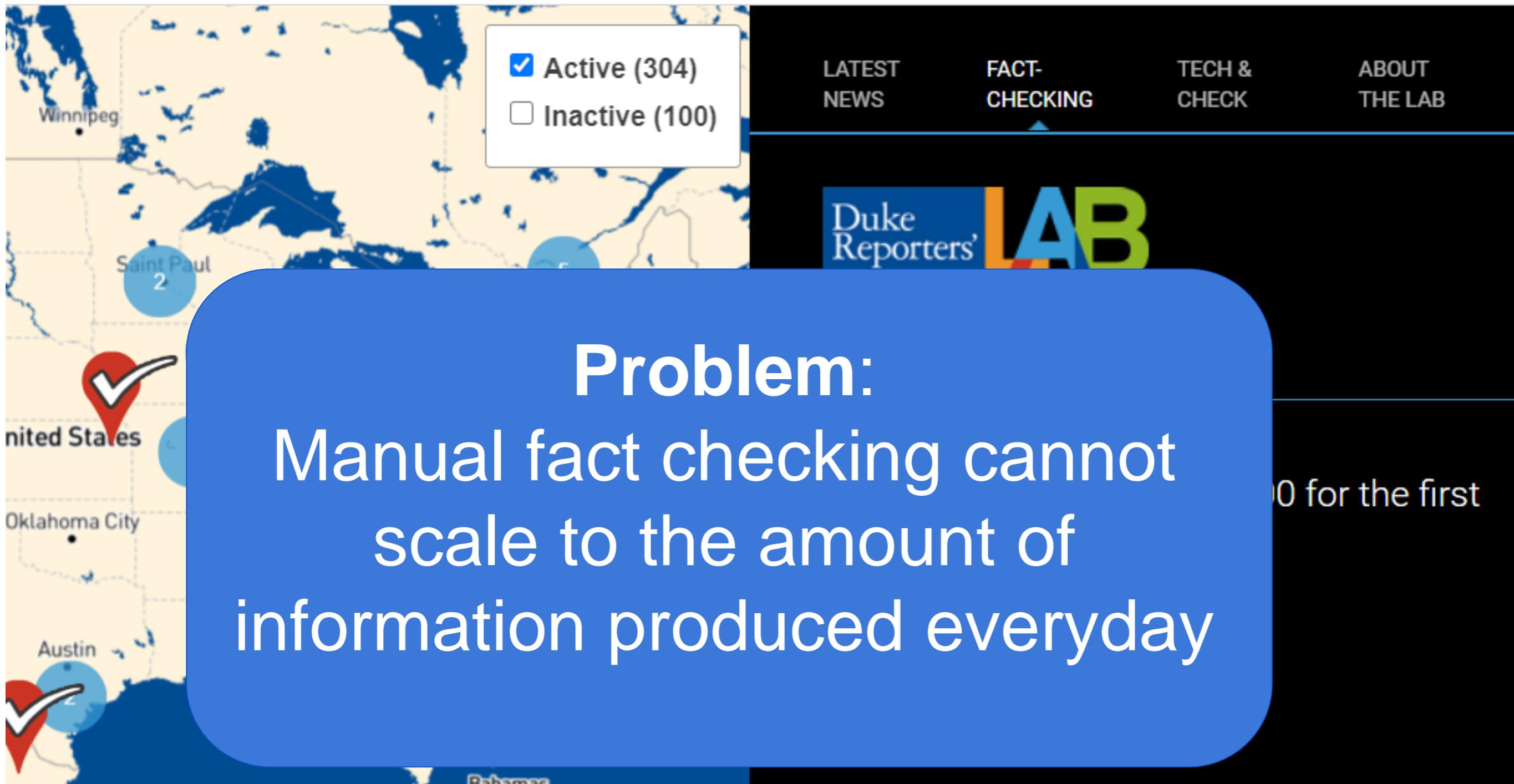
Fact checking entities

- Expert / Journalist
- Computational
- Crowdsourcing with end users

Expert based fact checking



Fact checking



The image is a screenshot of the Duke Reporters' LAB website. On the left, a map of the United States is shown with blue circles indicating the number of active cases in various cities. A legend box is overlaid on the map, showing a checked checkbox for 'Active (304)' and an unchecked checkbox for 'Inactive (100)'. On the right, a navigation menu is visible with the following items: 'LATEST NEWS', 'FACT-CHECKING' (which is highlighted with a blue arrow), 'TECH & CHECK', and 'ABOUT THE LAB'. Below the navigation menu is the 'Duke Reporters' LAB' logo. A large blue rounded rectangle is overlaid on the center of the image, containing the text: 'Problem: Manual fact checking cannot scale to the amount of information produced everyday'. To the right of this rectangle, the text '0 for the first' is partially visible.

<https://www.poynter.org/coronavirusfactsalliance/>

THE WALL STREET JOURNAL.

English Edition | May 25, 2020 | Print Edition | Video

Home World U.S. Politics Economy Business **Tech** Markets Opinion Life & Arts Real Estate WSJ Magazine

VIRUS

es

FINDING A JOB

BACK TO WORK Q&A

GOING OUTSIDE SAFELY

CAN I GET SICK AGAIN?

CHILDCARE & SUMMER CAMPS

CAN I TRAVEL?

STATE REOPENINGS

TESTS & TREATMENTS

WHAT 6 FEET LOOKS LIKE

EN ESPAÑOL

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TECH

Facebook's Fact Checkers Fight Surge in Fake Coronavirus Claims

Contractors battle bogus assertions about canine vaccines and free baby formula; 'We've maxxed out'



RECOMMENDED VIDEO

1. Coronavirus Update: China Scraps GDP Target, Trump's Swing-State Tour

<https://www.wsj.com/articles/facebooks-fact-checkers-fight-surge-in-fake-coronavirus-claims-11585580400>

2 months ago · posted by FB User

**Good News: Coronavirus Destroyed By Chlorine Dioxide – Kerri Rivera **



Good News: Coronavirus Destroyed By Chlorine Dioxide – Kerri Rivera
KERRIRIVERA.COM

2 months ago · posted by FB User



Good News: Coronavirus Destroyed By Chlorine Dioxide – Kerri Rivera
KERRIRIVERA.COM

40 8 26

2 months ago · posted by FB User

Chlorine Dioxide: the simple and so effective solution that Rockefeller's Big Phafma fears.



Good News: Coronavirus Destroyed By Chlorine Dioxide – Kerri Rivera
KERRIRIVERA.COM

19

According
Pub Med
47934



Dioxide – Kerri Rivera
KERRIRIVERA.COM

16 0 16

15 1 6



Good News: Coronavirus Destroyed By Chlorine Dioxide – Kerri Rivera
KERRIRIVERA.COM

4 0 9



Good News: Coronavirus Destroyed By Chlorine Dioxide – Kerri Rivera
KERRIRIVERA.COM

5 2 9

2 months ago · posted by FB User



Good News: Coronavirus Destroyed By Chlorine Dioxide – Kerri Rivera

2 months ago · posted by FB User

2 months ago · posted by FB User



Good News: Coronavirus

“up to 22 days for the platform to downgrade and issue warning labels on harmful misinformation content”

Expert based fact checking

Advantages

- High credibility
- Can handle nuanced claims
- Can produce detailed evidence of fact checking

Disadvantages

- Not scalable: few claims per day
- Slow: average fact checking time >7 days
- Possible human bias
- Not easy for niche domains

Fact checking entities

- Expert / Journalist
- Computational
- Crowdsourcing with end users

Computational fact checking

- The general problem:
Given some content, assess if it is true or false

SIGIR'19 Workshop: ROME 2019

on Misinformation,
and Credible Web



Digital and Technology

Health & Social Care

Local Government & Communities

Police & Criminal Justice

The Tackling Misinformation
Conference 2021: Communicating
Effectively to Improve Local
Services

Date: July 7, 2021

Location: Online

Event Type: Online



THE WEB
CONFERENCE

Workshop on Misinformation Integrity in Social Networks

EU Fact Checking & EU Fact Finding
The EU at your fingertips!

7-8 October 2021
Brussels

28-29 October 2021
Online

Call for Papers
2021 Workshop on NLP4IF:

FOR TRUTH AND TRUST

Events | February 17, 2021

EDMO Workshop – Artificial
Intelligence and fact-checking:
promises and perils

ROMCIR 2021
Workshop on REDUCING ONLINE MISINFORMATION
THROUGH CREDIBLE INFORMATION RETRIEVAL – Lucca |
Tuscany | Italy (Online Event) | April 1, 2021

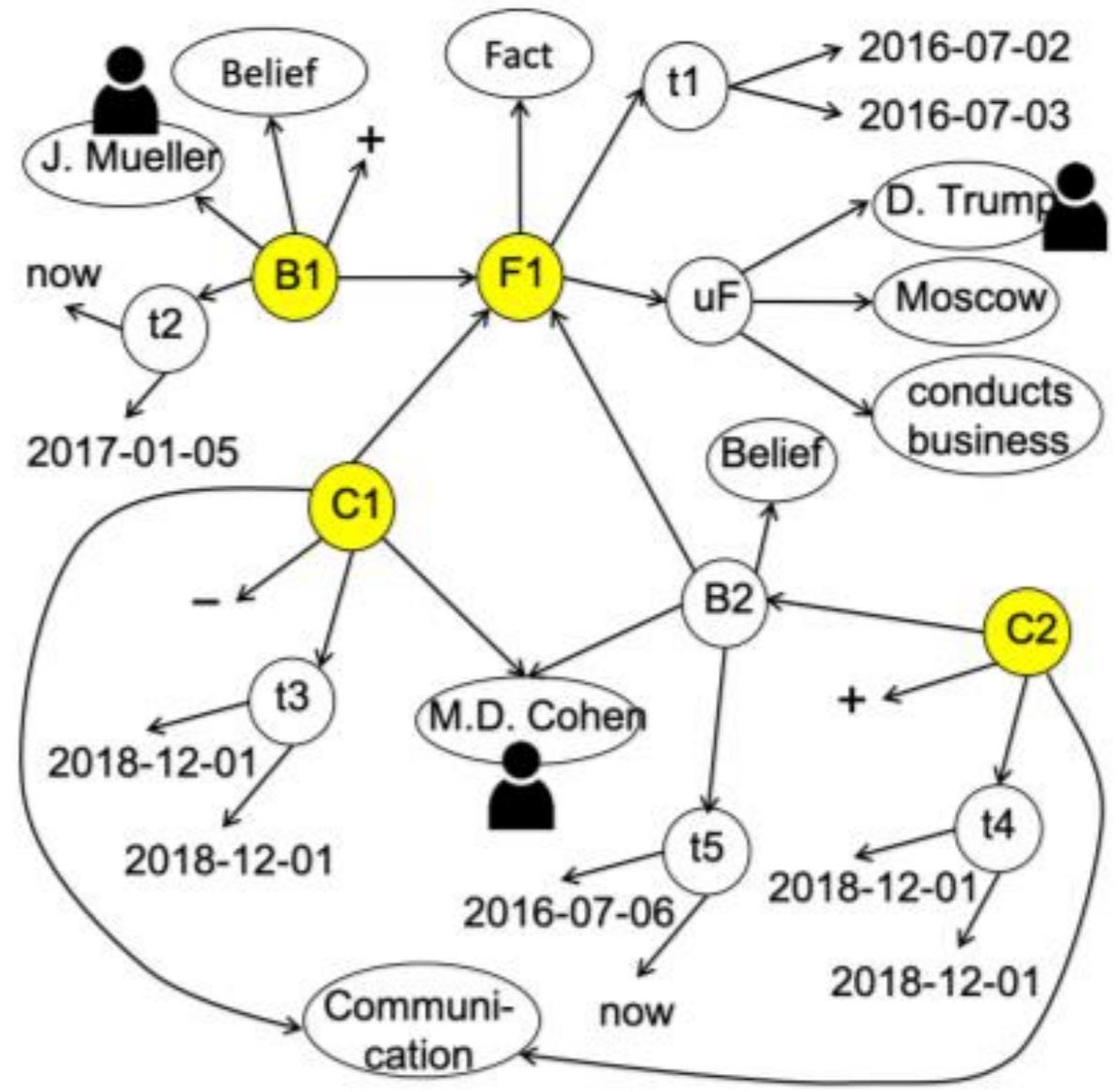
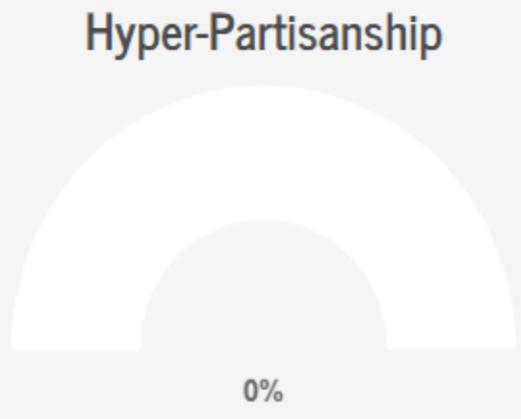
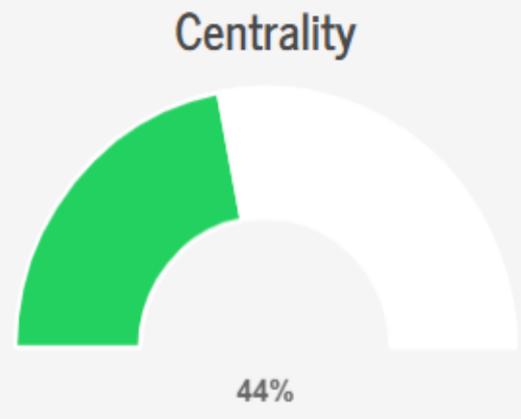
SIGKDD 2019 Workshop, August 5th, Anchorage, Alaska

ABOUT MISINFOCON



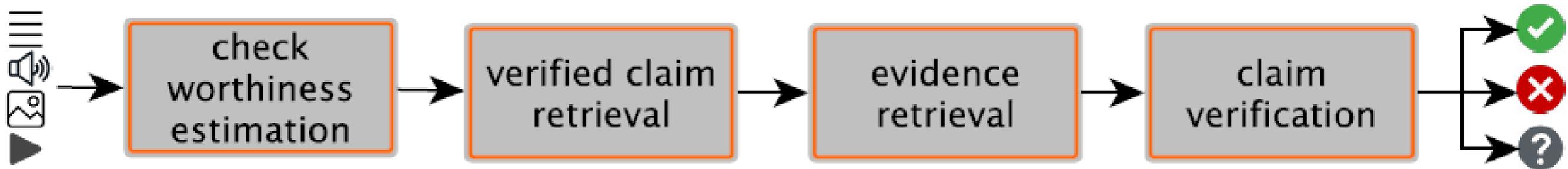
DAILYMAIL.CO.UK
Mail Online

MailOnline is the website of the Daily Mail, a newspaper in the United Kingdom, and of its sister paper The Mail on Sunday. MailOnline is a division of DMG Media, part of Associated Newspapers Ltd... (Wikipedia)



[Duroyon et al, 2019]

Computational pipeline



1. balance potential harm vs effort to check claim
2. quickly detect if viral claims have already been fact-checked (possibly in other language)
3. automatically retrieve relevant data from trusted sources
4. correct or incorrect
but also partially correct, not enough evidence, out-of-context...



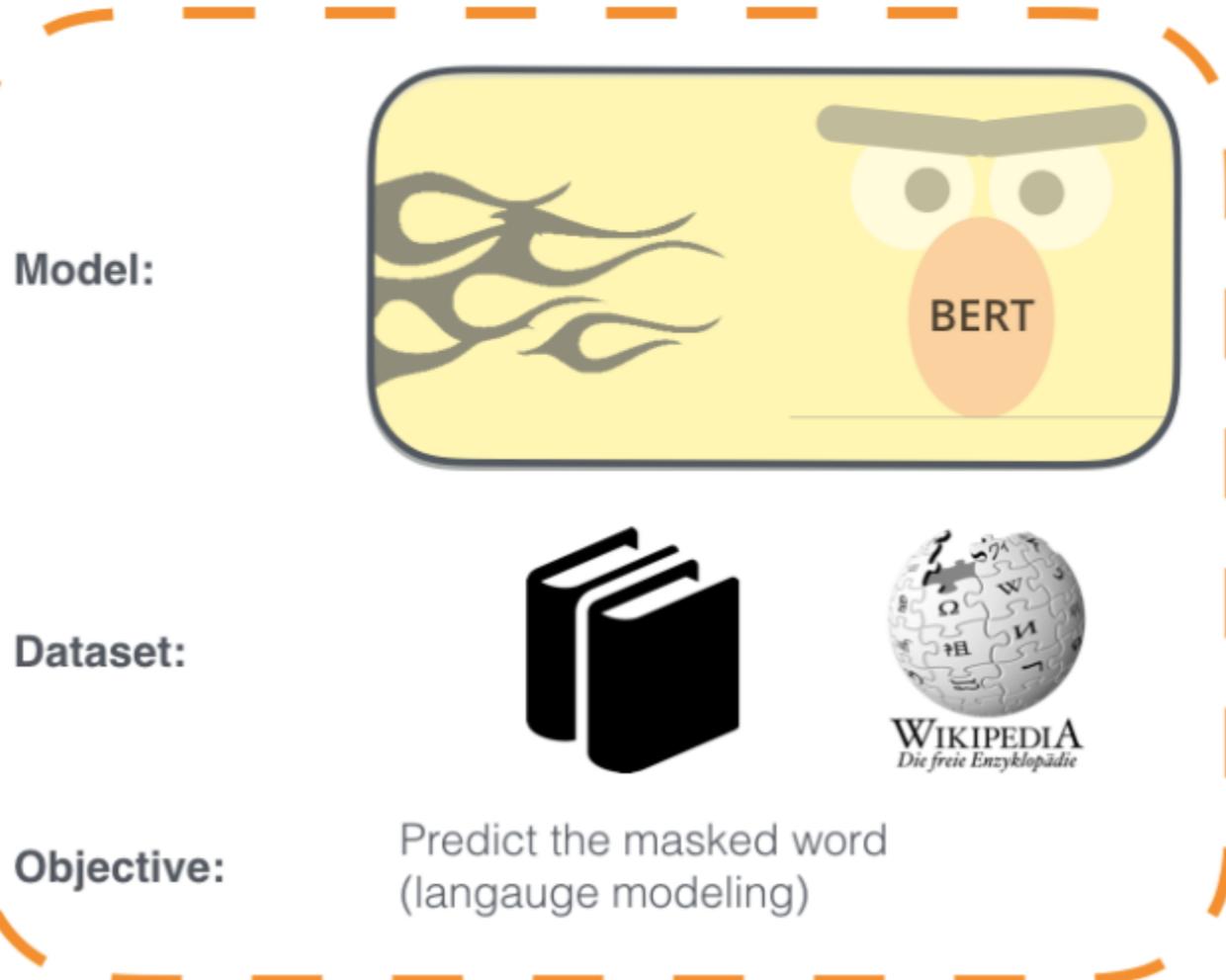
Find claims worth checking

- System produces a check-worthiness that provides fact-checkers ability to prioritize claims
- ClaimBuster [Hassan et al., 2017]
 - trained on manually annotated sentences (nonfactual, unimportant factual, checkworthy)
features based on sentiment, named entities, part-of-speech tags, words, and claim length
- More models based on pre-trained transformers such as BERT/RoBERTa [Wright and Augenstein, 2020]

1 - **Semi-supervised** training on large amounts of text (books, wikipedia..etc).

The model is trained on a certain task that enables it to grasp patterns in language. By the end of the training process, BERT has language-processing abilities capable of empowering many models we later need to build and train in a supervised way.

Semi-supervised Learning Step



2 - **Supervised** training on a specific task with a labeled dataset.

Supervised Learning Step

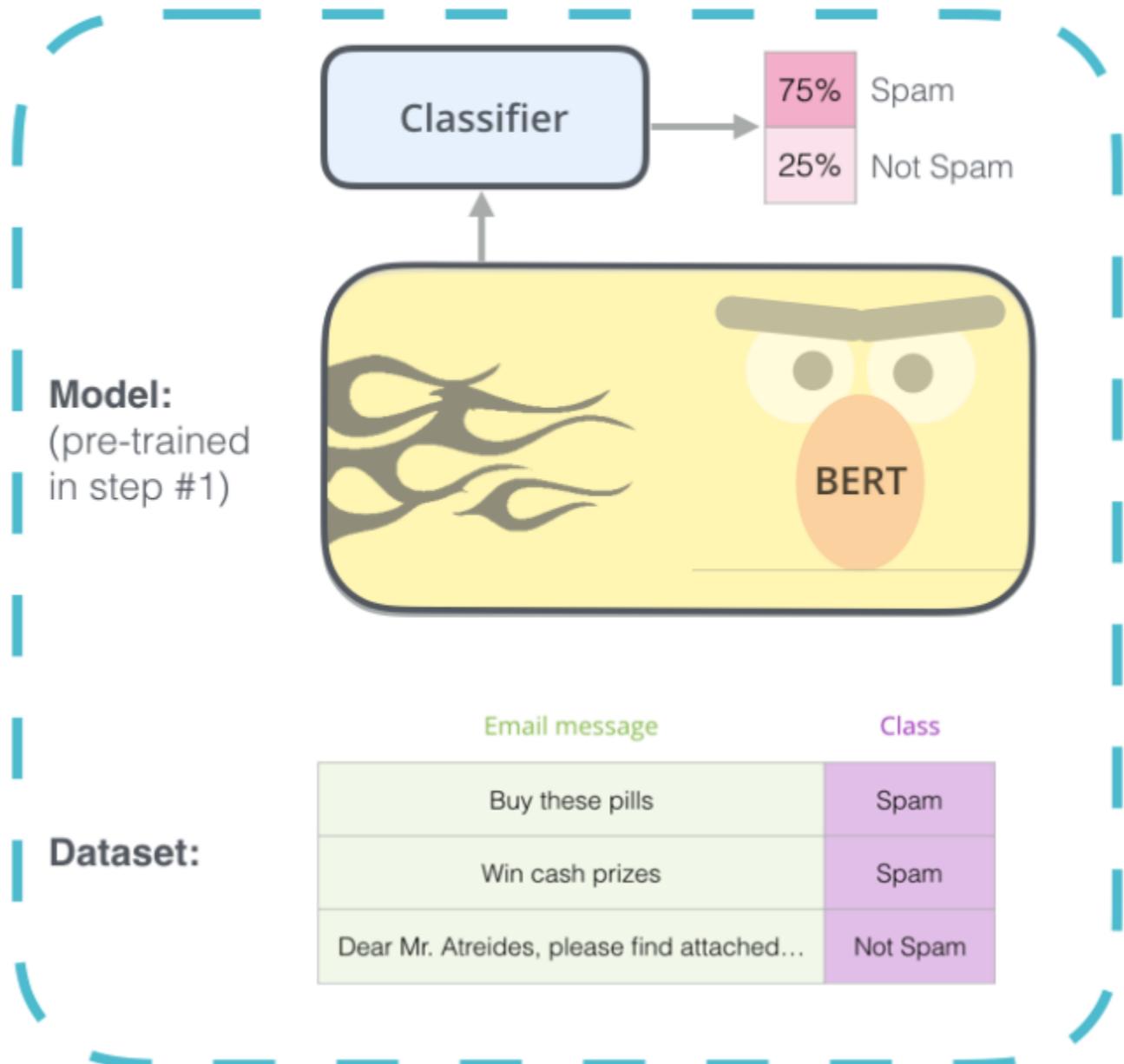
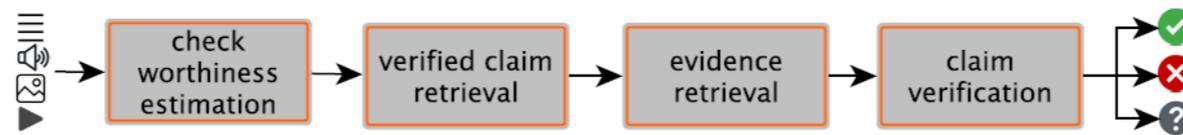


Fig. credits: <https://jalammar.github.io/illustrated-bert/>



Detect previously checked claims

- Misleading claims repeated in different channels and languages, independently of existing fact-checks published with ClaimReview
- Once a claim established as misleading, the spread of its variants could be minimized with **rapid** detection
- [Shaar et al. 2020] matching with BERT and BM25 Datasets:
 - tweets, which are to be compared to claims in Snopes
 - political debates, to be matched to claims in PolitiFact



Evidence retrieval

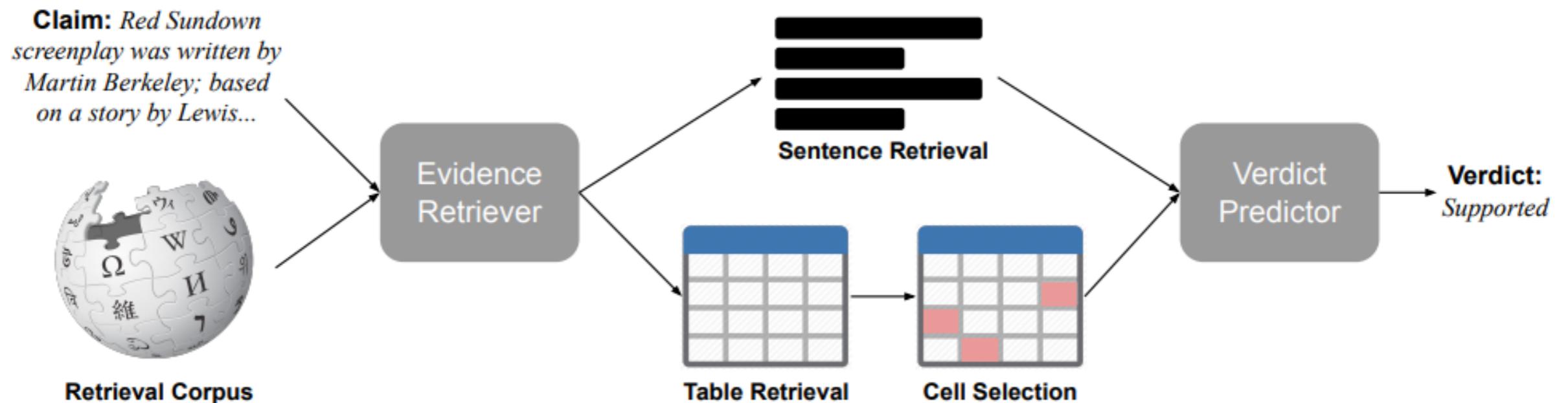
- Find external evidence to help human/system checkers decide factuality of input claim
- Evidence lie in large text documents, audio-visual recordings and streams, or in multiple languages
- Given claim and a (closed) data collection (1) rank relevant objects (docs), or (2) extract specific pieces of evidence, e.g., a text snippet or a recording
- **FEVER dataset** [Thorne et al., 2018] + **BM25/NER/BERT**



Automated verification

- Goal: internal tools presenting *evidence*, (*reasoning*) and *conclusion* regarding a claim, before the (human) fact-checker publishes article
- Non-explainable vs Explainable
 - + “General” claims, “Robust” to noise in data
 - Just a label as output
 - + Evidence of the arguments that support/refute
 - Stricter assumptions on claim and data

Standard “black box” verification



- Gather evidence + classifier (true/false/NEI)
- Can check “any” textual claim, can tolerate noise in corpus

Standard “black box” verification

Claim: Red Sundown screenplay was written by Martin Berkeley; based on a story by Lewis B. Patten, who often published under the names Lewis Ford, Lee Leighton and Joseph Wayne.

Evidence:

Page: [wiki/Red_Sundown](#)

e₁(Introduction):

Red Sundown	
Directed by	Jack Arnold
Produced by	Albert Zugsmith
Screenplay by	Martin Berkeley
Based on	Lewis B. Patten
...	

Page: [wiki/Lewis_B._Patten](#)

e₂(Introduction): He often published under the names Lewis Ford, Lee Leighton and Joseph Wayne.

Verdict: Supported

Well formed, factual, not
ambiguous sentence

A_C

High quality relevant
sources

A_S

Standard “black box” verification

Final Leaderboard

Rank	Team	FEVEROUS score	Accuracy	Evidence F1	Evidence Precision	Evidence Recall
1	Bust a move!	0.2701	0.5607	0.1308	0.0773	0.4258
2	Papelo	0.2592	0.5757	0.1187	0.0716	0.3460
3	NCU	0.2514	0.5229	0.1581	0.0991	0.3907
4	Z team	0.2251	0.4901	0.1312	0.0776	0.4264
5	EURECOM_Fever	0.2001	0.4779	0.1952	0.1373	0.3373

“Goal: internal tools presenting *evidence*, (*reasoning*) and *conclusion* regarding a claim, before the (human) fact-checker publishes article”

Computational fact checking

- General problem: Given some content, assess if it is true or false
- Focus today:
Given some **textual content** and some reference **data**, assess if the content is **true or false** and explain **why**
 - **≠ identifying check-worthy claims** [ClaimBuster]
 - **≠ matching claims to existing checks** [FullFact, ClaimReview]
 - **≠ model trust of the sources** [Tanbih]
 - **≠ propagation, mitigation and intervention** [“Combating Fake News: A Data Management and Mining Perspective” tutorial VLDB19]
- Effective, Scalable, **Interpretable**

Fact checking

The image shows a Google search interface. The search bar contains the text "Yassine Belattar pancarte \"Nous vous coloniserons\"". Below the search bar, there are navigation options: All, Images, News, Videos, Maps, More, Settings, and Tools. The search results show "About 306 results (0.31 seconds)".

The first search result is titled "Manif contre l'islamophobie : attentio" and includes a URL "https://www.liberation.fr > checknews > 2019/1". Below the title, it says "6 days ago - «Avec vos lois démocratiques, nous v" and "l'une tenue par l'humoriste Yassine Belattar, et l'au". The second search result is titled "Non, l'humoriste Yassine Belattar n'a" and includes a URL "https://factuel.afp.com > non-lhumoriste-yassi". Below the title, it says "Claim: L'humoriste Yassine Belattar brandit une pan" and "Claimed by: Sources multiples".

A fact-checking overlay is present on the right side of the page. It is titled "Additional Reporting On This" and contains the text: "Before you share this content, you might want to know that there is additional reporting on this from Snopes.com, Factcheck.org and Associated Press." Below this text are three links: "Visit Snopes.com", "Visit Factcheck.org", and "Visit Associated Press". At the bottom of the overlay are two buttons: "Cancel" and "Post Anyway".

In the search results, the text "Fact check by AFP Factuel: Faux" is circled in blue. The text "Feedback" is also visible below the fact-checking information.

Computational fact checking

- Given some **textual content** and some reference **data**, assess if the content is **true or false** and explain **why**
 - $\text{Check}(\text{claim}, \text{data}) =$
true/false label,
confidence value,
description of the subset of the data that implies the decision
- **Property** and statistical claims

Checking property claims

- Input textual claim:
“Elon Musk is the founder of Chevrolet”
- Output: FALSE because
“Chevrolet *was founded* in **1911** and Elon Musk *was born* in **1971**”

Checking property claims

Not in data. Count occurrences/text patterns/... on Web

vrolet”

- Output: **FALSE** because
“Chevrolet *was founded* in **1911** and Elon Musk *was born* in **1971**”

Concepts of person, company, birth year, founding year, logical contradiction

Checking property claims

- Input textual claim:
“Michael White’s alma mater is UT Austin”
- Output: FALSE because
“M. White *works* at UT Austin and
has Abilene Christian University and Yale
Divinity School as *alma mater*”

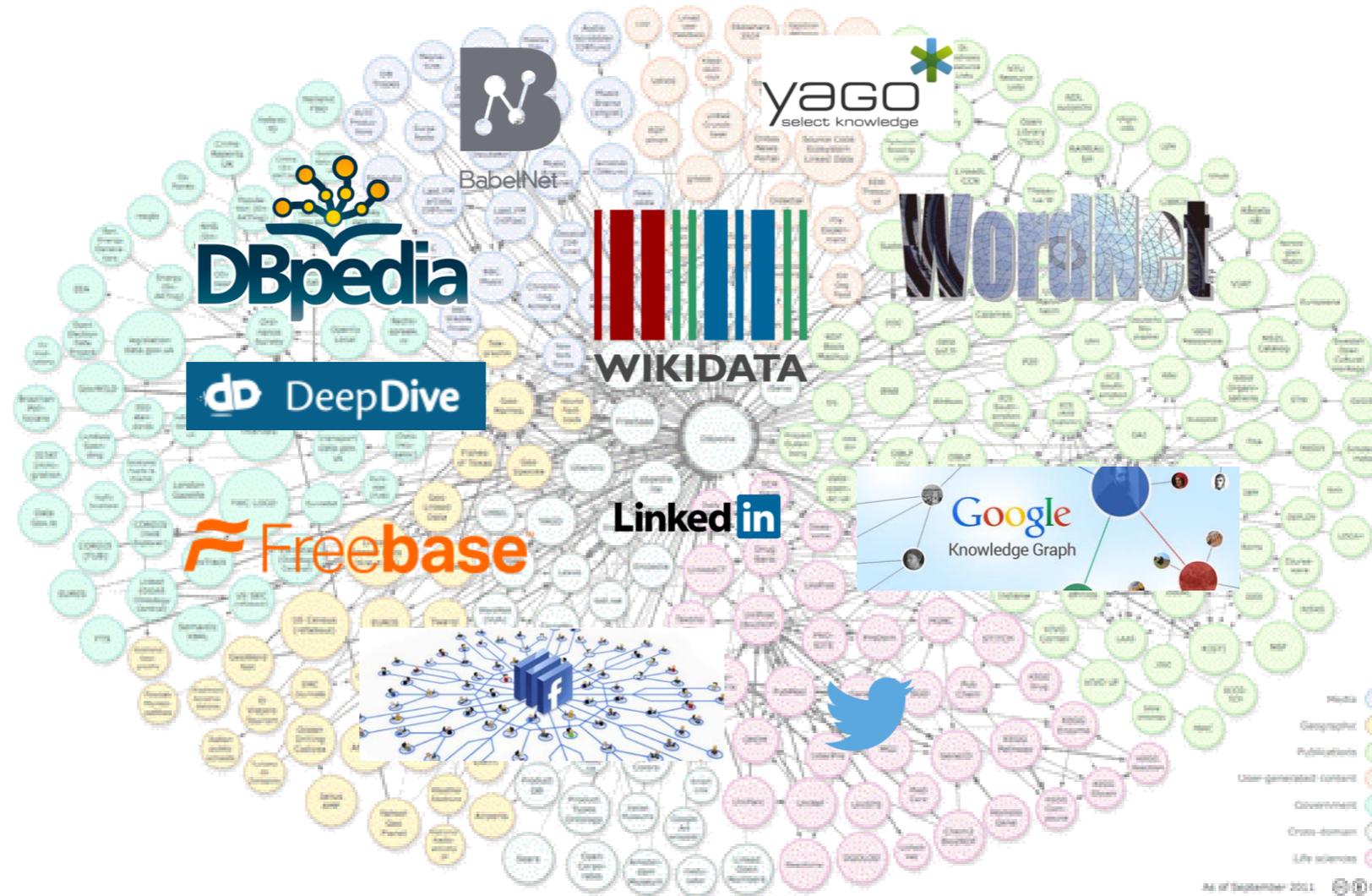
Checking property claims

- Input
 - Textual claim: “Michael White’s alma mater is UT Austin” →
almaMater(Michael White, UT Austin)

Ac



RDF Knowledge Graphs



Enterprise: Walmart, Amazon, KPMG, ...

RDF KGs

<Barack Obama> <spouse> <Michelle Obama> .

<Barack Obama> <birthDate> "1961-08-04" .

<Michelle Obama> <birthPlace> <Illinois> .

SUBJECT PREDICATE OBJECT

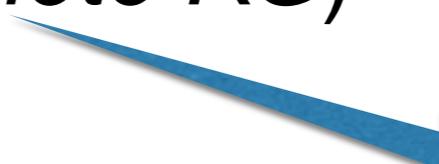
Name	# Entity types	# Entity instances	# Relation types
Knowledge Vault (KV)	1100	45M	4469
DeepDive [21]	4	2.7M	34
NELL [6]	271	5.19M	306
PROSPERA [20]	11	N/A	14
YAGO2 [16]	350,000	9.8M	100
Freebase [4]	1,500	40M	35,000
Knowledge Graph (KG)	1,500	570M	35,000

As

[Dong and Srivastava, 2015]

Computational fact checking

- Given some **textual content** and some reference **data**, assess if the content is **true or false** and explain **why**
- $\text{Check}(\text{claim}, \text{incomplete KG}) =$
true/false label,
confidence value,
description of the subset of the data that implies the decision

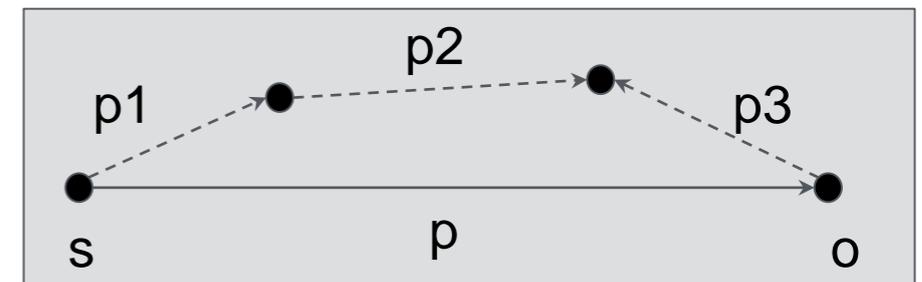


OWA

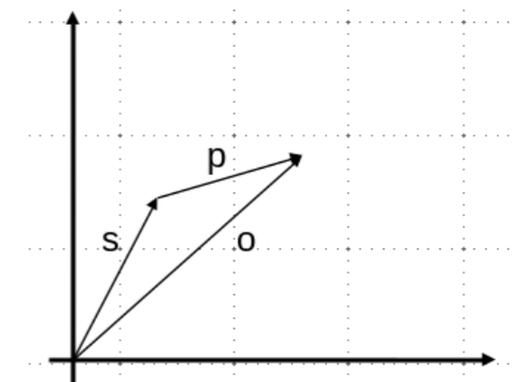
→ how to assess/explain if claim is **NOT** in KG?

Fact checking with KGs

- Structure-based: KL [1], KG-Miner [2], SFE [3]
- exploit the topological structure: fact modeled by predicate paths/proximity between subject and object



- Embeddings: TransE [4]
- relation in graph interpreted as a translation in a low dimensional vector space:
check $s+p=o$



[1] Ciampaglia et al., PloS one, 2015 [2] Shi et al., AAAI, 2016

[3] Gardner et al., EMNLP, 2015 [4] Bordes et al., NIPS, 2013

Explaining the decision

- Output

- “Michael White’s alma mater is UT Austin” is FALSE because

- Evi 1: employer(Michael White, UT Austin)

Evi 2: almaMater(Michael White, Abilene Christian Univ.)

almaMater(Michael White, Yale Divinity School)

- Approximate rules over the KG

0.1: almaMater(x,y), almaMater(x,z), $y \neq z \Rightarrow \perp$

0.3: almaMater(x,y), employer(x,y) $\Rightarrow \perp$

?

Negative rules

0.9 $\text{foundingYear}(x,z) \wedge \text{birthYear}(y,w) \wedge (z \leq w) \wedge \text{founder}(x,y) \Rightarrow \perp$

Atom = predicate from KG

[claim] founder(Chev., E.Musk)

[KG] foundingYear(Chev, 1911)

[KG] birthYear(E.Musk, 1971)

*x=Chev., z=1911, ...
At least one triple is
incorrect*

“negative” rules identify inconsistencies

1.0 $\text{President}(x, \text{USA}) \wedge \text{PlaceOfBirth}(x,y) \wedge y \neq \text{USA} \Rightarrow \perp$

0.9 $\text{isMarriedTo}(x,y) \wedge \text{hasChild}(x,y) \Rightarrow \perp$

[Ortona et al., 2018]

Horn rules discovery

0.7 $\text{hasChild}(x,z) \wedge \text{hasChild}(y,z) \Rightarrow \text{spouse}(x,y)$

*$\text{child}(\text{Barack}, \text{Sasha}) \wedge \text{child}(\text{Michelle}, \text{Sasha})$
 $\Rightarrow \text{spouse}(\text{Barack}, \text{Michelle})$*

“positive” rules address incomplete data

1.0 $\text{notableWork}(y,x) \Rightarrow \text{creator}(x,y)$ (Wikidata)

0.8 $\text{hasChild}(z,y) \wedge \text{isMarriedTo}(x,z) \Rightarrow \text{hasChild}(x,y)$ (Yago)

[Galárraga et al., 2013]

[Lajus et al, 2020]

Search Rules

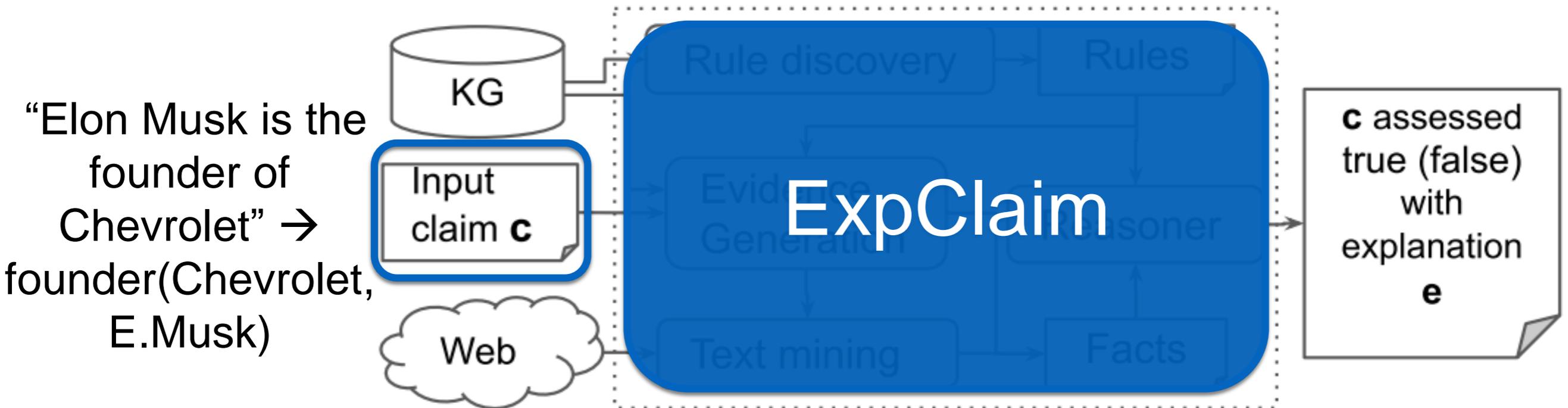
List out rules base on following criteria. Users can vote the **rule quality** and **rule confidence** by clicking the cell value.

Knowledge Base
 Predicate
 Rule Type
 Human Confidence from to

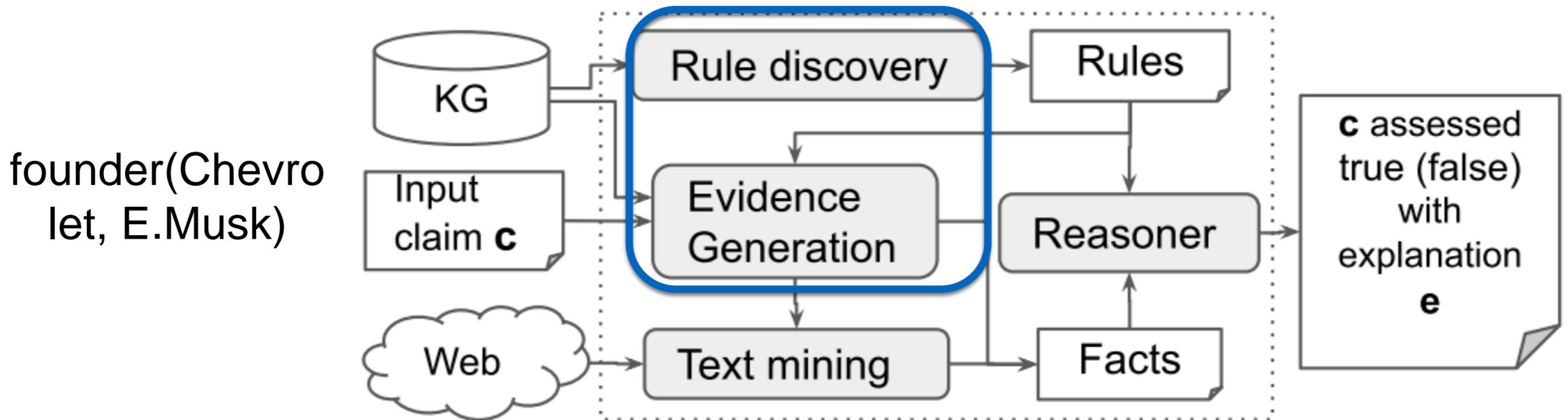
Search:

	Type	Rule	Quality Evaluation	Human Confidence	Computed Confidence	Operation
<input type="checkbox"/>	+	successor(subject,v0) & parent(v0,object) ⇒ spouse(subject,object)	5	0.45	0.28	<input type="button" value="Sample"/> SPARQL Query
<input type="checkbox"/>	+	predecessor(v0,object) & spouse(v1,v0) & successor(subject,v1) ⇒ spouse(subject,object)	5	0.15	0.25	<input type="button" value="Sample"/> SPARQL Query

ExpClaim system



Mine Logical Rules

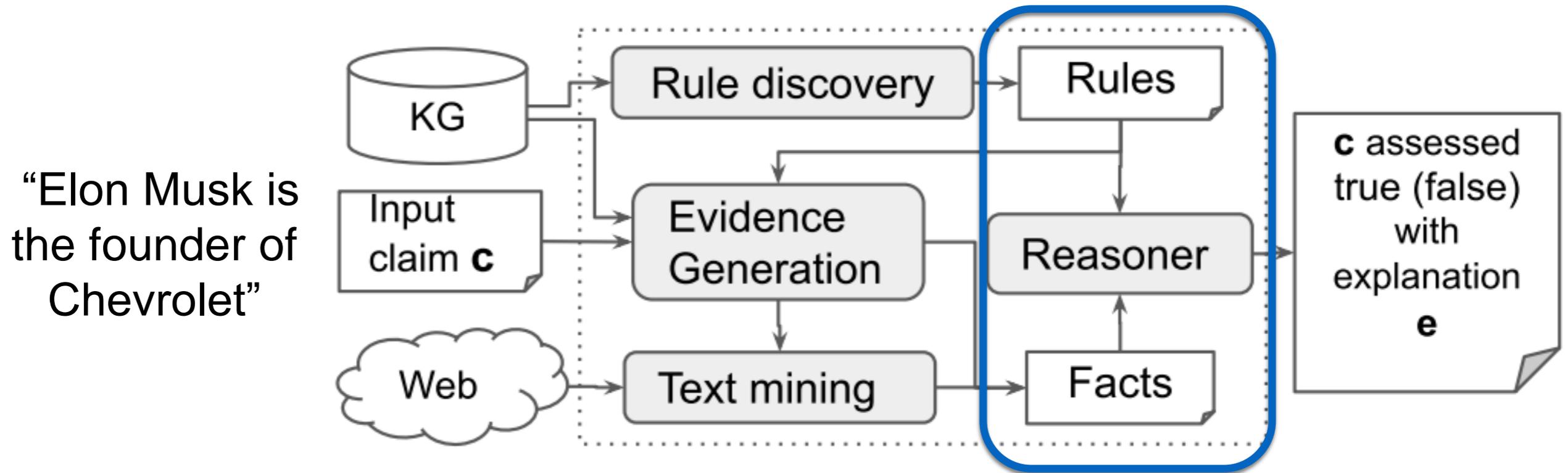


Gather rules and evidence (facts) from the KG

0.9 $\text{foundingYear}(x,z) \wedge \text{birthYear}(y,w) \wedge (z \leq w) \wedge \text{founder}(x,y) \Rightarrow \perp$

[K] foundingYear(Chev, 1911), [K] birthYear(E.Musk, 1971), [c] founder(E.Musk, Chev)

MAP Reasoning



A probabilistic extension of answer set programs with the concept of **weighted rules** derived from Markov Logic

[Lee et al., 2016]

```

FALSE : almaMater(Michael White, UT Austin)
        ← employer(Michael White, UT Austin)
        ← occupation(Michael White, UT Austin)
        ← almaMater(Michael White, Abilene
                    Christian Univ.), almaMater(Michael
                    White, Yale Divinity School)

```

- Baselines: text miner (CredE), link prediction (KGM), hard rules (ASP)

	<i>almaMat.</i>	<i>deathPl.</i>	<i>spouse</i>	<i>vicePres.</i>
CREDE	.41(.03)	.59(.06)	.44(.07)	.36(.15)
KGM	.73(.08)	.68(.01)	.86(.01)	.81(.03)
ASP	.70(.06)	.01(.01)	.31(.08)	.18(.16)
MAP	.88(.14)	.75(.15)	.87(.11)	.66(.22)
MAP+W	.88(.09)	.83(.11)	.86(.10)	.68(.18)

Computational fact checking

- Given some **textual content** and some reference **data**, assess if the content is **true or false** and explain **why**
 - $\text{Check}(\text{claim}, \text{data}) =$
true/false label,
confidence value,
description of the subset of the data that implies the decision
- Property and **statistical** claims

Checking statistical claims

Liz Wheeler  @Liz_Wheeler · Mar 20

U.S. death rate isn't 3.4%. It's 1.3% & falling.

Social distancing won't stop spread of COVID-19 unless it's done for 18mo.
(Won't happen.)

Economic damage is ALREADY hurting people.

So, in 2 months, we'll see economic devastation AND resurgent virus. How does that make sense?

386

1.4K

4.4K



Country	deaths	cases
IT	100	10000
FR	110	9900
USA	536	190000

- Rules (FDs, DCs) could be mined over relational data
In most cases values are there
Less rich schema: check a few claims (deaths < cases)
- What about *derived values* such as “death rate”?

Checking statistical claims

Liz Wheeler  @Liz_Wheeler · Mar 20

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does that make sense?

386

1.4K

4.4K

- Output: FALSE

<https://coronacheck.eurecom.fr/en>

How did we verify your statement? ✕

Claim: 0.013000000000000000
Inferred formula: a/b
Inferred formula value: 0.0

List of variables:

Variable name	
Table	total_deaths
Month	March
Country	USA
Value	5367

Variable name >20k claims checked

Table	
Month	
Country	USA
Value	188172

Problem model

- Scenario: textual claim **C**, and a set of relational tables **D** (e.g., <https://github.com/CSSEGISandData/COVID-19>) A_S
- A **claim** describes the comparison **op**($<$, $=$, $<>$, $>$) between the value of query **q** and a parameter **p**, when **q** is executed on **D**. A claim is *correct* if there if there exists **q(D) op p** for it A_C
 - “The number of new cases increased **100%** in March in France” → *explicit* claim
 - “The number of deaths increased in March in France” → *general* claim
- If there is no **q(D)** s.t. **op p**, then the claim is false (CWA)
- Challenges: (i) number of possible queries is huge, (ii) spurious match

Checking statistical claims

Liz Wheeler  @Liz_Wheeler · Mar 20

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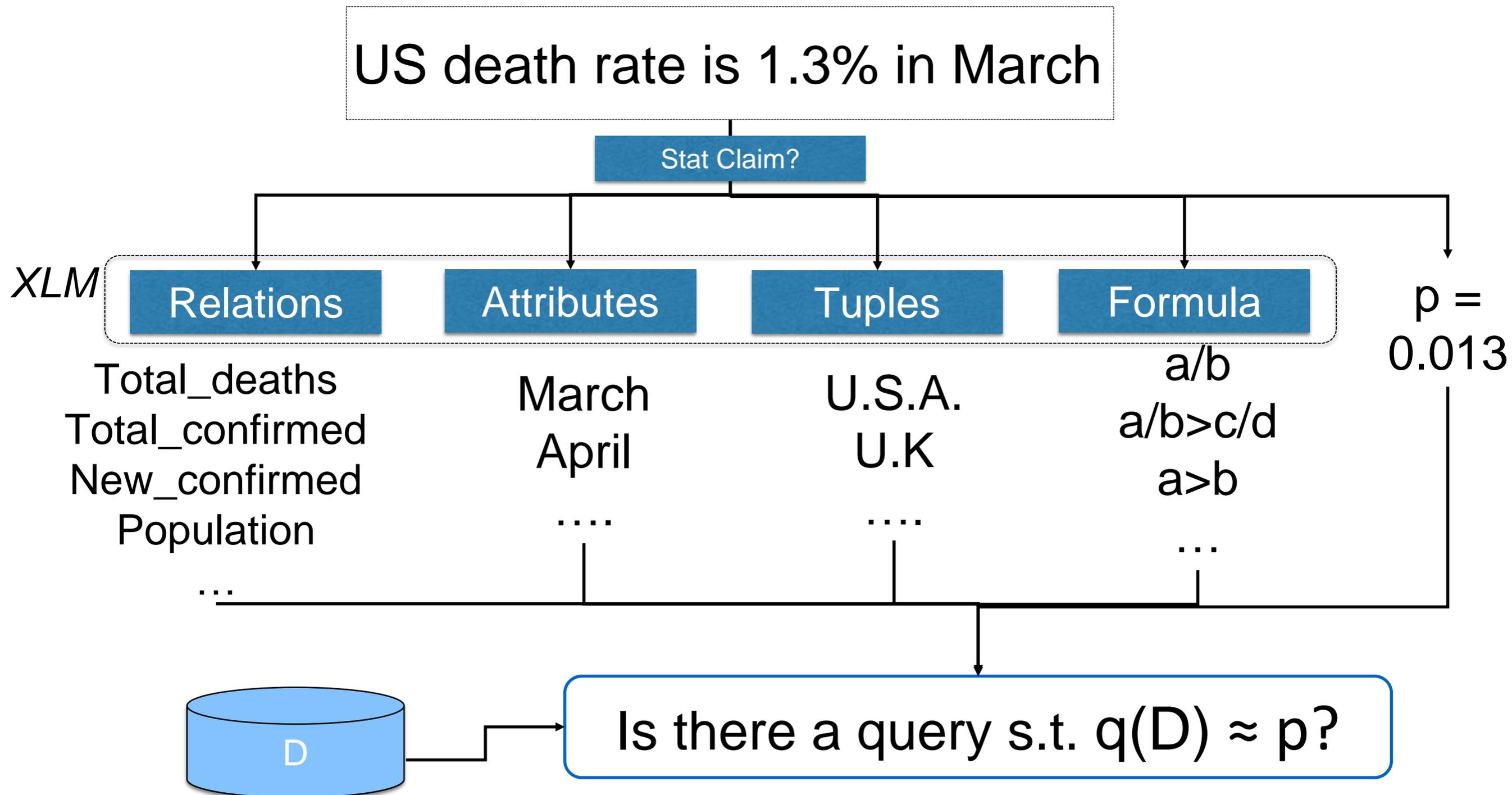
 4.4K



Country	deaths	cases
IT	100	10000
FR	130	9900
USA	536	190000

1. Lots of true queries:
look up: 100, 10000, 110....
ratio: 100/130, 130/9900, 9900/130 ...
2. 1.3% may come from 130/100!

From text to query elements to data driven check



User feedback

- “Yesterday the number of new cases in France decreased **a lot**”

New_confirmed,
14-15 Sept,
France,
 $(b-a)/a < ?$

- “In **Europe**, the number of new cases is decreasing this month”

New_confirmed,
Aug-Sept,
tuple ?
 $(b-a)/a < 0$

We are unable to verify your statement, please help us by picking the best matches out of the following options: ×

total_deaths-total_confirmed

new_confirmed-total_confirmed

total_deaths-total_recovered

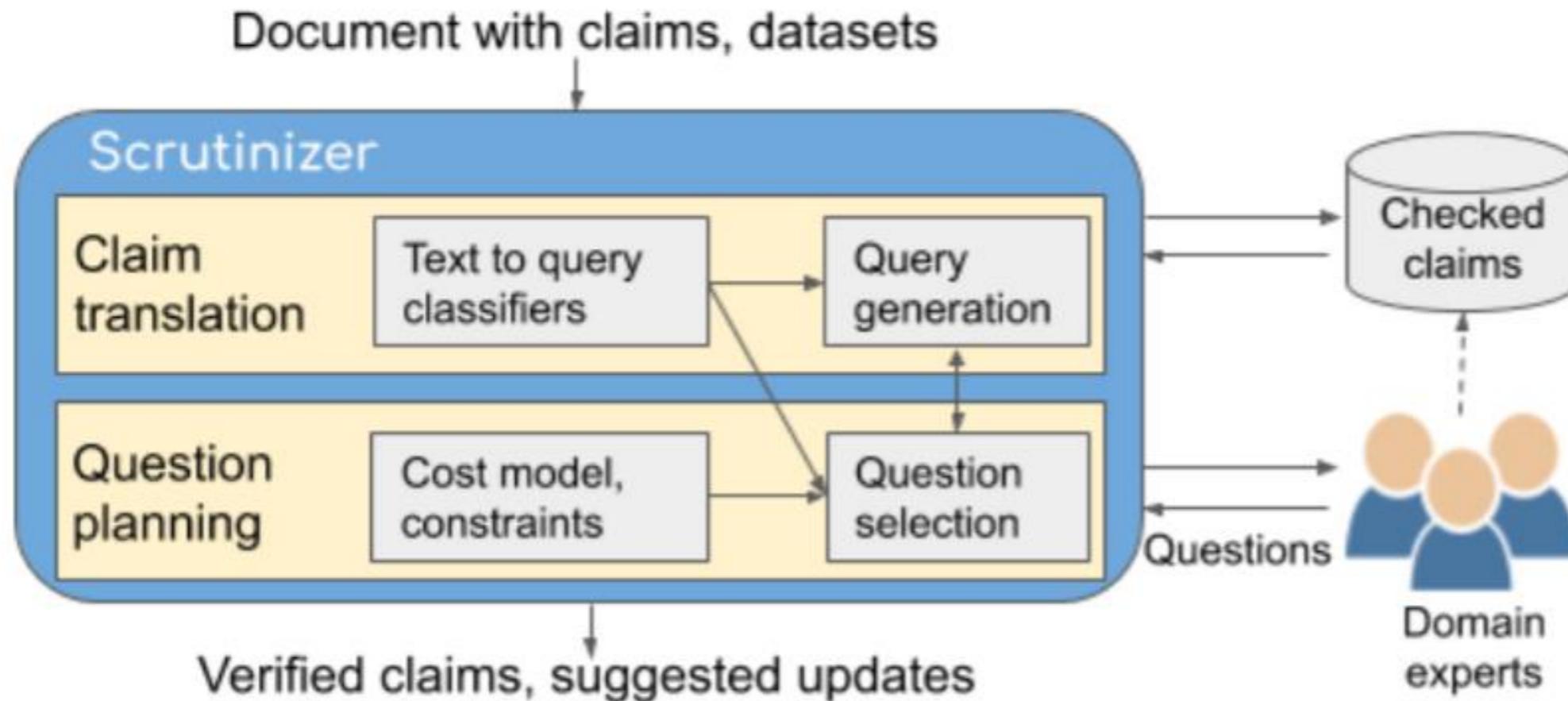
total_recovered-total_deaths

total_recovered-total_confirmed

Can you suggest any other dataset?

Close Next

Scrutinizer



International Energy Agency



Paris-based intergovernmental organization

Established in 1974, 30 member countries

Mission: serve statistics on energy sector

Within gross output sectors there is a shift in regional shares of total world production for individual industries. India gains a larger share of world nonmetallic mineral production, in part because of rapid growth in its domestic construction industry. India's share of world steel production also increases from 2012 to 2040, while China's share remains relatively flat. In the paper industry, China's share of world production increases as growth is slower in other regions, including in Russia and in other non-OECD Europe and Eurasia. For basic chemicals, the Middle East, China, and India have increasing production shares throughout the projection period. Finally, most non-OECD countries increase their shares of total world agricultural sector production through 2040, and most OECD countries have decreasing shares. Within gross output sectors there is a shift in regional shares of total world production for individual industries. India gains a larger share of world nonmetallic mineral production, in part because of rapid growth in its domestic construction industry. India's share of world steel production also increases from 2012 to 2040, while China's share remains relatively flat. In the paper industry, China's share of world production increases as growth is slower in other regions, including in Russia and in other non-OECD Europe and Eurasia. For basic chemicals, the Middle East, China, and India have increasing production shares throughout the projection period. Finally, most non-OECD countries increase their shares of total world agricultural sector production through 2040, and most OECD countries have decreasing shares.

Industrial sector delivered energy consumption varies by region, according to differences in industrial gross output, energy intensity (measured as energy consumed per unit of gross output), and the composition of industries. Enterprises are able to reduce energy consumption in a number of ways, including improving industrial sector processes to reduce energy waste and recover energy lost (often process heat), increasing the use of cogeneration, and recycling materials and fuel inputs to reduce costs and improve efficiency. In terms of industrial fuel use, natural gas and electricity are the fastest-growing forms of industrial energy use in the OECD region (Figure 7-2), with each energy source increasing by about 0.7%/year from 2012 to 2040. Consumption of liquids, coal, and renewable energy in the OECD industrial sector grows more slowly, averaging 0.4%/year (liquids), 0.3%/year (renewable energy), and 0.2%/year (coal). As a result, from 2012 to 2040, the natural gas and electricity shares increase from 28.7% to 30.3% (natural gas) and from 14.9% to 15.6% (electricity). As in OECD, the fastest-growing forms of industrial sector energy consumption in the non-OECD region from 2012 to 2040 are natural gas (2.2%/year) and electricity (1.6%/year). Non-OECD consumption of renewable energy also expands rapidly, by an average of 1.7%/year from 2012 to 2040, while consumption of liquid fuels and coal increases by 1.4%/year and 0.8%/year, respectively (Figure 7-3). Most of the world growth in industrial sector energy use occurs in the emerging non-OECD economies.

The strong rates of growth in industrial sector consumption of electricity and natural gas in both the OECD and non-OECD regions are attributable to increases in the other industrials group of nonenergy-intensive manufacturing (see Table 7-1). Although the other industrials are not energy intensive, they do make up approximately 30% and 36% of total OECD and non-OECD industrial sector delivered energy consumption, respectively. Moreover, the manufacture of bulk chemicals in the non-OECD region expands rapidly in the Reference case. Because nonenergy-intensive manufacturing—including both other industrials and other chemicals—relies heavily on electricity and natural gas, consumption of both energy sources shows strong growth in the OECD and non-OECD industrial sectors, in comparison with most other energy sources.

Biomass currently provides most of the renewable energy (excluding hydroelectricity) consumed in the industrial sector and continues to do so throughout the projection, largely because of its role in providing byproduct energy to the pulp and paper industry. OECD countries typically have either flat or declining growth in the pulp and paper industry, resulting in the slower growth

Figure 7-2. OECD industrial sector delivered energy consumption by energy source, 2012–40 (quadrillion Btu)

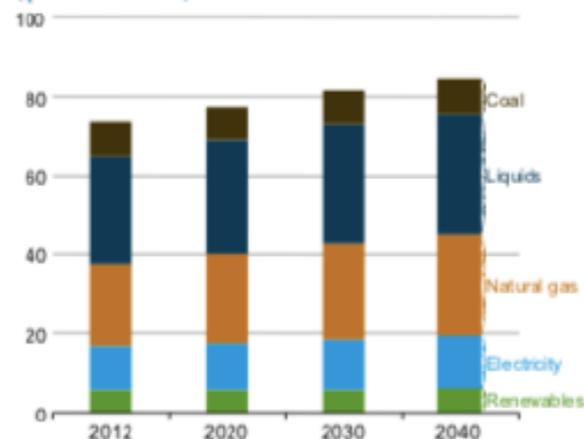
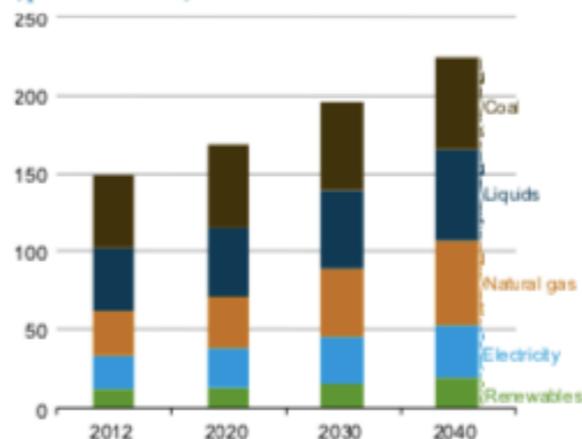


Figure 7-3. Non-OECD industrial sector delivered energy consumption by energy source, 2012–40 (quadrillion Btu)



of renewables compared with total industrial sector energy consumption. In most of the non-OECD countries, the pulp and paper industry grows significantly, with corresponding growth in industrial sector renewable energy use.

Coal becomes a less important source for industrial energy consumption in both the OECD and non-OECD regions in the IEO2016 Reference case. In the OECD industrial sector, coal use increases by 0.2%/year from 2012 to 2040, and its share of total delivered industrial energy consumption declines slightly, from 12% in 2012 to 11% in 2040. Similarly, in the non-OECD industrial sector, the coal share of total industrial delivered energy falls from 32% in 2012 to 27% in 2040. The iron and steel industry is the largest consumer of coal in the industrial sector, and as regions shift from coal-fired furnaces to electric arc furnaces, coal use for iron and steel production declines. In addition, several significant industrial manufacturing countries, including the United States and China, are initiating policies to reduce greenhouse gas (GHG) emissions from their industrial sectors by switching to electricity and natural gas and by improving energy efficiency in industries that produce large amounts of GHG emissions.

Energy-intensive industries

The following industries are considered to be energy-intensive: food, pulp and paper, basic chemicals, refining, iron and steel, nonferrous metals (primarily aluminum), and nonmetallic minerals (primarily cement). Together, they account for about half of all industrial sector delivered energy use. In 2012, OECD energy-intensive industries accounted for about 54% of the region's total industrial sector energy consumption, and non-OECD energy-intensive industries accounted for about 51% of the industrial sector total. Consequently, the quantity and fuel mix of future industrial sector delivered energy consumption will be determined largely by the overall levels of energy consumption in those seven industries. In addition, the same industries emit large quantities of carbon dioxide (CO₂), related to both their energy consumption (combustion emissions) and their production processes (process emissions). Figure 7-4 and Figure 7-5 show energy consumption shares of the energy-intensive industries compared with all industrial sector energy consumption (including feedstock consumption) in 2012 and 2040 for the OECD and non-OECD, respectively. The energy consumption shares of the energy-intensive industries are shown as percentages of total delivered energy consumption in the OECD and non-OECD industrial sectors.

Increases in energy efficiency and changes in industrial gross output affect the growth of industrial sector energy consumption. Anticipated energy efficiency improvements in the industrial sector temper the growth of industrial energy demand, particularly for the energy-intensive industries. Recycling is a key contributor to industrial energy efficiency improvements, especially in the pulp and paper, iron and steel, and nonferrous metals industries (see box on page 120).

Among the energy-intensive industries, the largest consumer of delivered energy is the basic chemicals industry, which in 2012 accounted for about 19% of total delivered energy consumption in the OECD industrial sector and about 14% in the non-OECD industrial sector. In both regions, the basic chemicals share of industrial energy use in the IEO2016 Reference case rises to about 20% in 2040 (Figure 7-4 and Figure 7-5). The chemicals industry in general uses petrochemical feedstocks, which are included in its energy use. In 2012, petrochemical feedstocks accounted for roughly 60% of the energy consumed in the chemicals sector (which includes both energy-intensive basic chemicals and nonenergy-intensive other chemicals). Intermediate petrochemical products (or building blocks), which go into products such as plastics, require a fixed amount of hydrocarbon feedstock as input. For any given amount of chemical output, depending on the fundamental chemical process of production, a fixed amount of feedstock is required, which greatly reduces opportunities for decreasing fuel consumption in the absence of any major shifts toward recycling and bio-based chemicals.

Figure 7-4. Energy-intensive industry shares of total OECD industrial sector energy consumption, 2012 and 2040 (percent of total)

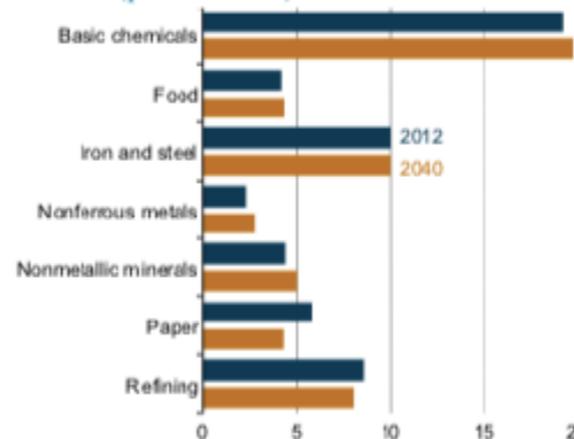
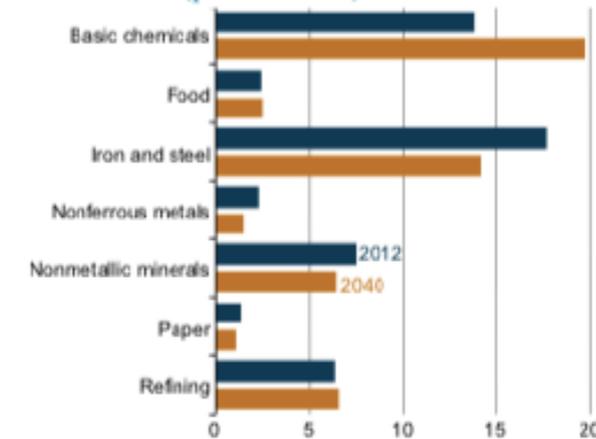


Figure 7-5. Energy-intensive industry shares of total non-OECD industrial sector energy consumption, 2012 and 2040 (percent of total)



Claims Marked Up

Within gross output sectors there is a shift in regional shares of total world production for individual industries. India gains a larger share of world nonmetallic mineral production, in part because of rapid growth in its domestic construction industry. India's share of world steel production also increases from 2012 to 2040, while China's share remains relatively flat. In the paper industry, China's share of world production increases as growth is slower in other regions, including in Russia and in other non-OECD Europe and Eurasia. For basic chemicals, the Middle East, China, and India have increasing production shares throughout the projection period. Finally, most non-OECD countries increase their shares of total world agricultural sector production through 2040, and most OECD countries have decreasing shares. Within gross output sectors there is a shift in regional shares of total world production for individual industries. India gains a larger share of world nonmetallic mineral production, in part because of rapid growth in its domestic construction industry. India's share of world steel production also increases from 2012 to 2040, while China's share remains relatively flat. In the paper industry, China's share of world production increases as growth is slower in other regions, including in Russia and in other non-OECD Europe and Eurasia. For basic chemicals, the Middle East, China, and India have increasing production shares throughout the projection period. Finally, most non-OECD countries increase their shares of total world agricultural sector production through 2040, and most OECD countries have decreasing shares.

Industrial sector delivered energy consumption varies by region, according to differences in industrial gross output, energy intensity (measured as energy consumed per unit of gross output), and the composition of industries. Enterprises are able to reduce energy consumption in a number of ways, including improving industrial sector processes to reduce energy waste and recover energy lost (often process heat), increasing the use of cogeneration, and recycling materials and fuel inputs to reduce costs and improve efficiency. In terms of industrial fuel use, natural gas and electricity are the fastest-growing forms of industrial energy use in the OECD region (Figure 7-2), with each energy source increasing by about 0.7%/year from 2012 to 2040. Consumption of liquids, coal, and renewable energy in the OECD industrial sector grows more slowly, averaging 0.3%/year (liquids), 0.3%/year (renewable energy), and 0.3%/year (coal). As a result, from 2012 to 2040, the natural gas and electricity shares increase from 28.7% to 30.3% (natural gas) and from 14.9% to 15.6% (electricity). As in OECD, the fastest-growing forms of industrial sector energy consumption in the non-OECD region from 2012 to 2040 are natural gas (2.2%/year) and electricity (1.6%/year). Non-OECD consumption of renewable energy also expands rapidly, by an average of 1.7%/year from 2012 to 2040. While consumption of liquid fuels and coal increases by 1.4%/year and 0.8%/year, respectively (Figure 7-3). Most of the world growth in industrial sector energy use occurs in the emerging non-OECD economies.

The strong rates of growth in industrial sector consumption of electricity and natural gas in both the OECD and non-OECD regions are attributable to increases in the other industrial group of nonenergy-intensive manufacturing (see Table 7-1). Although the other industrials are not energy intensive, they do make up approximately 30% and 36% total OECD and non-OECD industrial sector delivered energy consumption, respectively. Moreover, the manufacture of basic chemicals in the non-OECD region expands rapidly in the Reference case. Because nonenergy-intensive manufacturing—including both other industrials and other chemicals—relies heavily on electricity and natural gas, consumption of both energy sources shows strong growth in the OECD and non-OECD industrial sectors, in comparison with most other energy sources.

Biomass currently provides most of the renewable energy (excluding hydroelectricity) consumed in the industrial sector and continues to do so throughout the projection, largely because of its role in providing byproduct energy to the pulp and paper industry. OECD countries typically have either flat or declining growth in the pulp and paper industry, resulting in the slower growth

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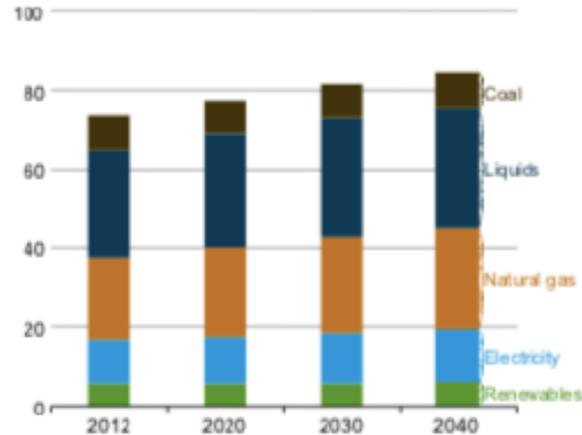
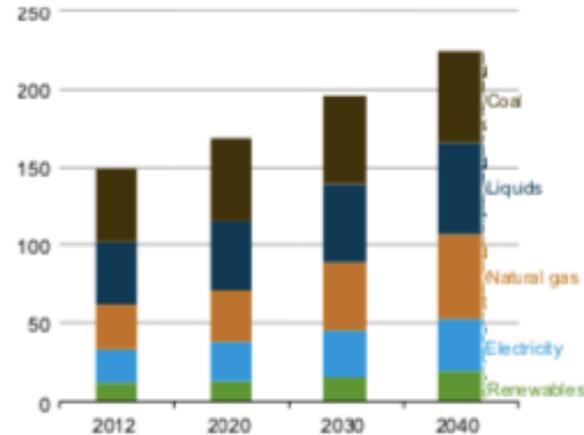


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of renewables compared with total industrial sector energy consumption. In most of the non-OECD countries, the pulp and paper industry grows significantly, with corresponding growth in industrial sector renewable energy use.

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Energy-intensive industries

The following industries are considered to be energy-intensive: food, pulp and paper, basic chemicals, refining, iron and steel, and nonferrous metals (primarily aluminum) and nonmetallic minerals (primarily cement). Together, they account for about half of all industrial sector delivered energy use. In 2012, OECD energy-intensive industries accounted for about 54% of the regions total industrial sector energy consumption, and non-OECD energy-intensive industries accounted for about 51% of the industrial sector total. Consequently, the quantity and fuel mix of future industrial sector delivered energy consumption will be determined largely by the overall levels of energy consumption in those seven industries. In addition, the same industries emit large quantities of carbon dioxide (CO₂), related to both their energy consumption (combustion emissions) and their production processes (process emissions). Figure 7-4 and Figure 7-5 show energy consumption shares of the energy-intensive industries compared with all industrial sector energy consumption (including feedstock consumption) in 2012 and 2040 for the OECD and non-OECD, respectively. The energy consumption shares of the energy-intensive industries are shown as percentages of total delivered energy consumption in the OECD and non-OECD industrial sectors.

Increases in energy efficiency and changes in industrial gross output affect the growth of industrial sector energy consumption. Anticipated energy efficiency improvements in the industrial sector temper the growth of industrial energy demand, particularly for the energy-intensive industries. Recycling is a key contributor to industrial energy efficiency improvements, especially in the pulp and paper, iron and steel, and nonferrous metals industries (see box on page 120).

Among the energy-intensive industries, the largest consumer of delivered energy is the basic chemicals industry, which in 2012 accounted for about 19% of total delivered energy consumption in the OECD industrial sector and about 14% in the non-OECD industrial sector. In both regions, the basic chemicals share of industrial energy use in the IEO2016 Reference case rises to about 20% in 2040 (Figure 7-4 and Figure 7-5). The chemicals industry is generally a petrochemical feedstock user, which are included in its energy use. In 2012, petrochemical feedstock accounted for roughly 60% of the energy consumed in the chemicals sector (which includes both energy-intensive basic chemicals and nonenergy-intensive other chemicals); intermediate petrochemical products (or building blocks), which go into products such as plastics, require a fixed amount of hydrocarbon feedstock as input. For any given amount of chemical output, depending on the fundamental chemical process of production, a fixed amount of feedstock is required, which greatly reduces opportunities for decreasing fuel consumption in the absence of any major shifts toward recycling and bio-based chemicals.

Figure 7-4. Energy-intensive industry shares of total OECD industrial sector energy consumption, 2012 and 2040 (percent of total)

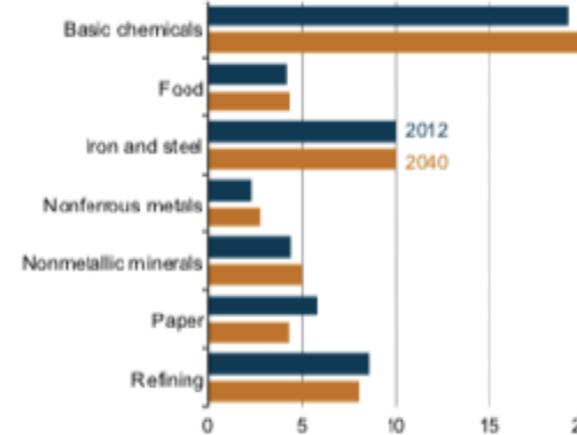
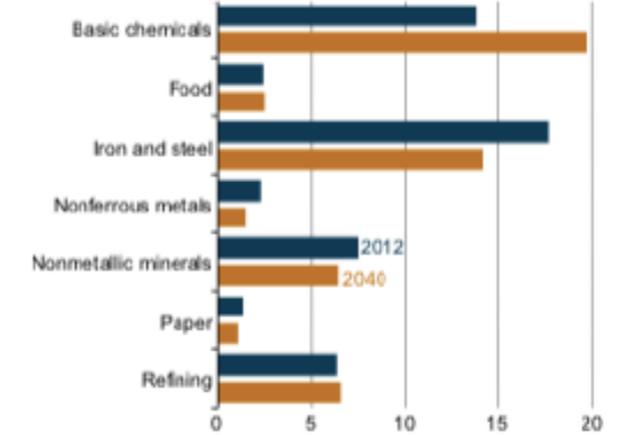


Figure 7-5. Energy-intensive industry shares of total non-OECD industrial sector energy consumption, 2012 and 2040 (percent of total)



Problem

- The pace of oil demand growth slows, and all of the 11.5 million barrels per day (mb/d) increase between 2017 and 2040 takes place in developing economies. Demand growth is consistently strong in the Middle East and India, particularly for trucks and petrochemical feedstocks. But it is China that becomes the world's biggest oil consumer and, by 2040, the largest net oil importer in history.

A_C

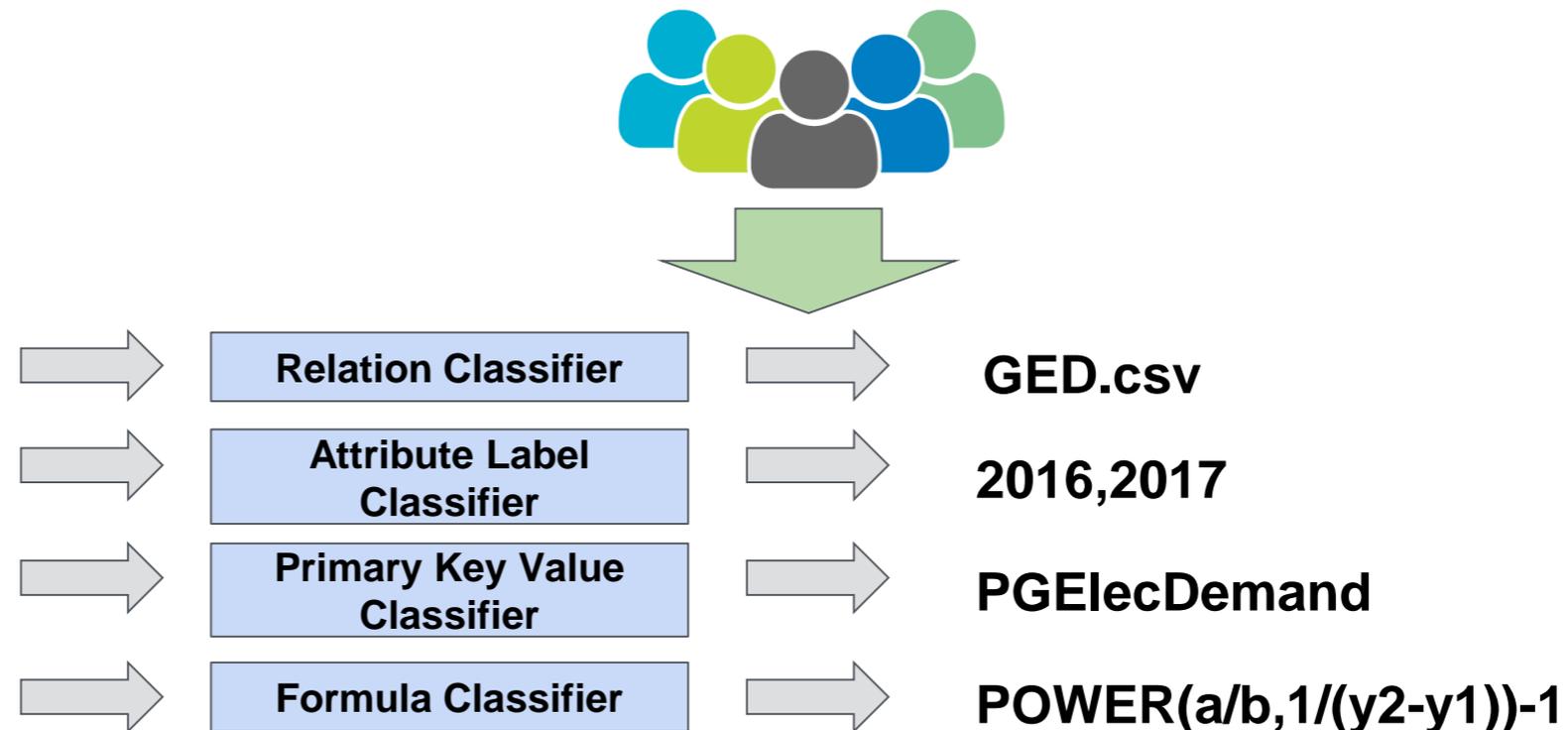
Index	2017	2018	...	2030	2040
PGElecDemand	22 209	22 793	...	29 349	35 526
PGINCoal	2 390	2 412	..	2 341	2 353
TFCelec	21 465	22 040	...	28 566	34 790
...

A_S

Claim Translation

- Large number of claims in batch
- Classifier accuracy is lower than CoronaCheck, bigger space for datasets, attributes, formulas
- We have access to the checkers

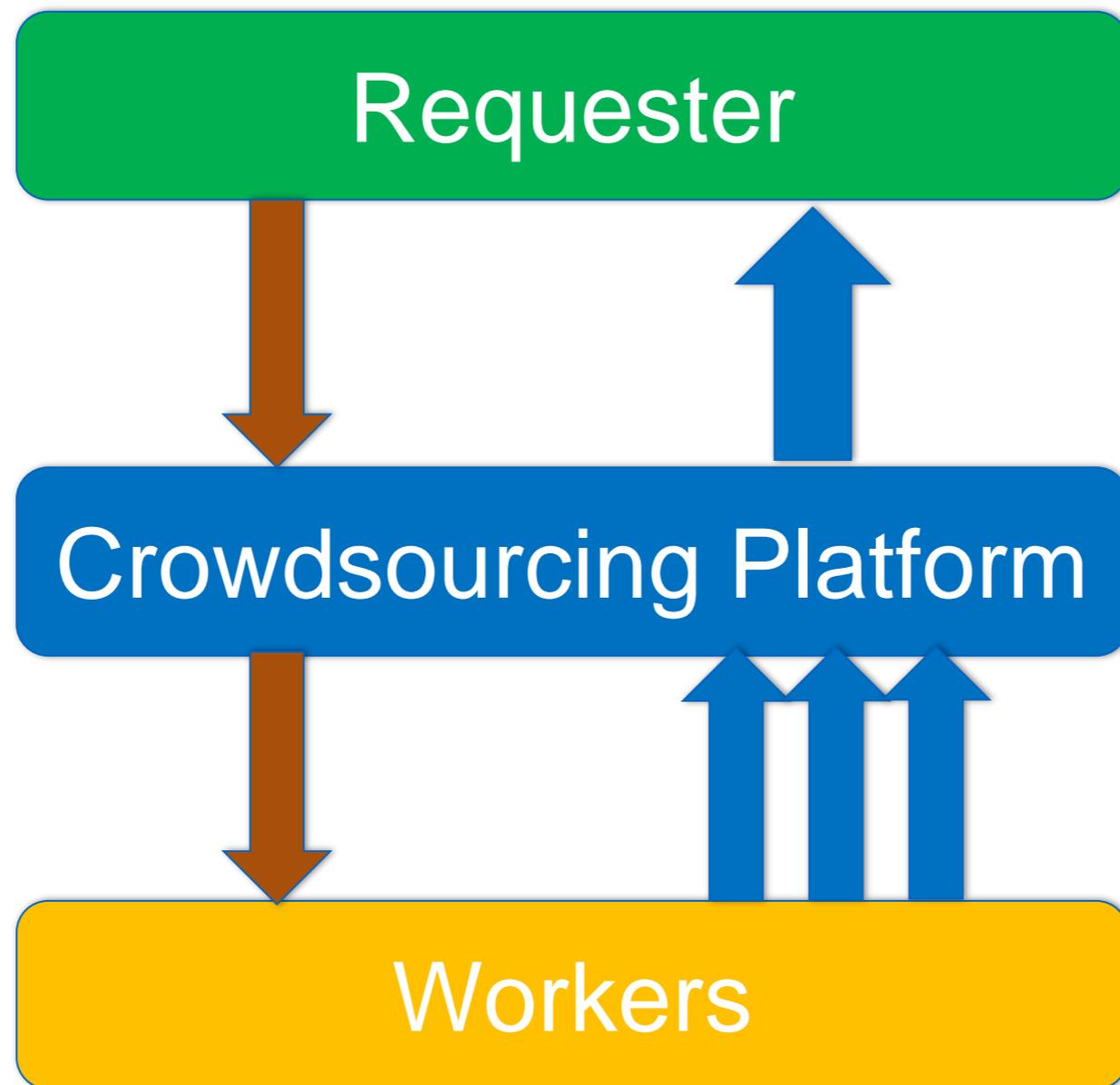
In 2017, global electricity demand grew by **3%**.



Scaling it up

- Thousands of claims
- Multiple experts in the process
- Hundreds of datasets

Crowdsourcing Workflow



Needs optimization

Which Question?

Even assuming that every household's energy consumption reaches the regional average around a dozen years after gaining access, the additional demand only amounts to **338 TWh** in 2030 in the Sustainable Development Scenario, or 1.1% of the global total.

What is/are the corresponding year(s)?

- 2015
- 2017
- 2020
- 2030
- 2040

Which Options?

Which Order?



Verify Cheapest Claims First?

Industrial sector energy consumption

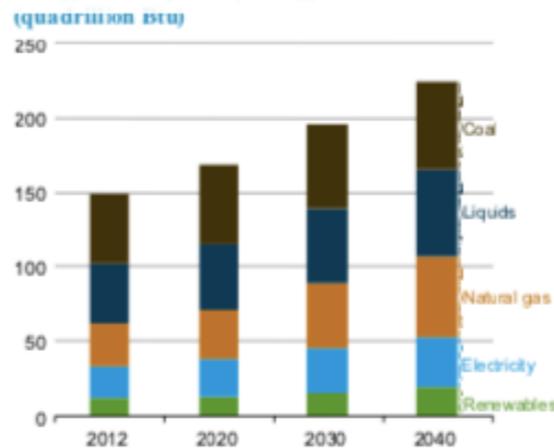
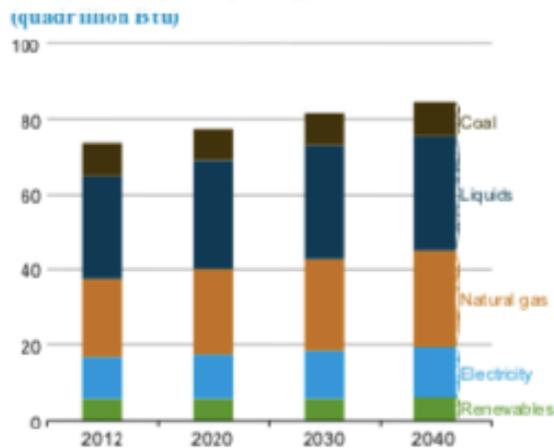
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The strong rates of growth in industrial sector consumption of electricity and natural gas in both the OECD and non-OECD regions are attributable to increases in the other industrial group of nonenergy-intensive manufacturing (see Table 7-1). Although the other industrial group is not energy intensive, they do make up approximately 30% and 36% of the OECD and non-OECD industrial sector delivered energy consumption, respectively. Moreover, the manufacture of basic chemicals in the non-OECD region expands rapidly in the Reference case. Because nonenergy-intensive manufacturing, including both other industrial and other chemicals, relies heavily on electricity and natural gas, consumption of both energy sources shows strong growth in the OECD and non-OECD industrial sectors, in comparison with most other industrial sectors.

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Consider Text Structure?



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U.S. Energy Information Administration | International Energy Outlook 2016

Industrial sector energy consumption

of renewables compared with total industrial sector energy consumption. In most of the non-OECD countries, the pulp and paper industry grows significantly, with corresponding growth in industrial sector renewable energy use. Coal becomes a less important source for industrial energy consumption in both the OECD and non-OECD regions in the IEO2016 Reference case. In the OECD industrial sector, coal use increases by 0.2%/year from 2012 to 2040, but its share of total delivered industrial energy consumption declines slightly, from 15.0% in 2012 to 14.7% in 2040. In the non-OECD industrial sector, the coal share of total industrial delivered energy falls from 32% in 2012 to 27% in 2040. The iron and steel industry is the largest consumer of coal in the industrial sector, and as regions shift from coal-fired furnaces to electric arc furnaces, coal use for iron and steel production declines. In addition, several significant industrial manufacturing countries, including the United States and China, are initiating policies to reduce greenhouse gas (GHG) emissions from their industrial sectors by switching to electricity and natural gas and by improving energy efficiency in industries that produce large amounts of GHG emissions.

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Increases in energy efficiency and changes in industrial gross output affect the growth of industrial sector energy consumption. Anticipated energy efficiency improvements in the industrial sector temper the growth of industrial energy demand, particularly for the energy-intensive industries. Recycling is a key contributor to industrial energy efficiency improvements, especially in the pulp and paper, iron and steel, and nonferrous metals industries. (See box on page 120.)

Among the energy-intensive industries, the largest consumer of delivered energy is the basic chemicals industry, which in 2012 accounted for about 19% of total delivered energy consumption in the OECD industrial sector and about 14% in the non-OECD industrial sector. In the non-OECD regions, the basic chemicals share of industrial energy use in the IEO2016 Reference case rises to about 20% in 2040 (see Figure 7-5). The chemicals industry is a major consumer of petrochemical feedstock, which accounts for about 60% of its energy use. In the non-OECD region, petrochemical feedstock accounted for roughly 60% of the energy consumed in the chemicals sector, which includes both energy-intensive basic chemicals and nonenergy-intensive other chemicals. Intermediate petrochemical products (or building blocks), which go into products such as plastics, require a fixed amount of hydrocarbon feedstock as input. For any given amount of chemical output, depending on the fundamental chemical process of production, a fixed amount of feedstock is required, which greatly reduces opportunities for decreasing fuel consumption in the absence of any major shifts toward recycling and bio-based chemicals.

Figure 7-4. Energy-intensive industry shares of total OECD industrial sector energy consumption, 2012 and 2040 (percent of total)

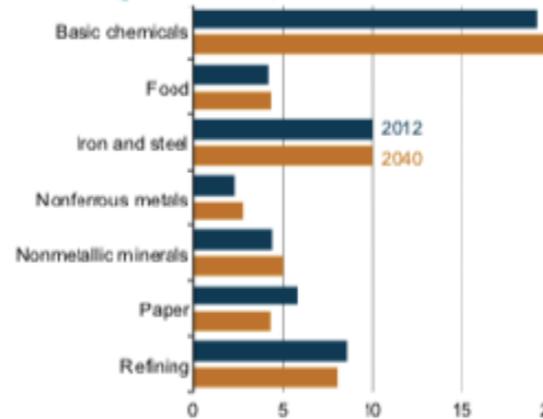
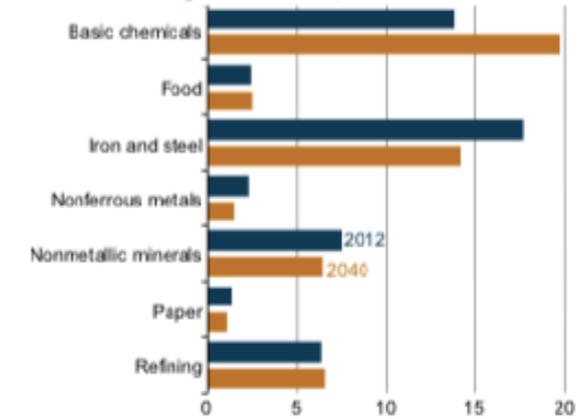


Figure 7-5. Energy-intensive industry shares of total non-OECD industrial sector energy consumption, 2012 and 2040 (percent of total)



U.S. Energy Information Administration | International Energy Outlook 2016

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Verify Interesting Claims First?

Energy claims evaluation

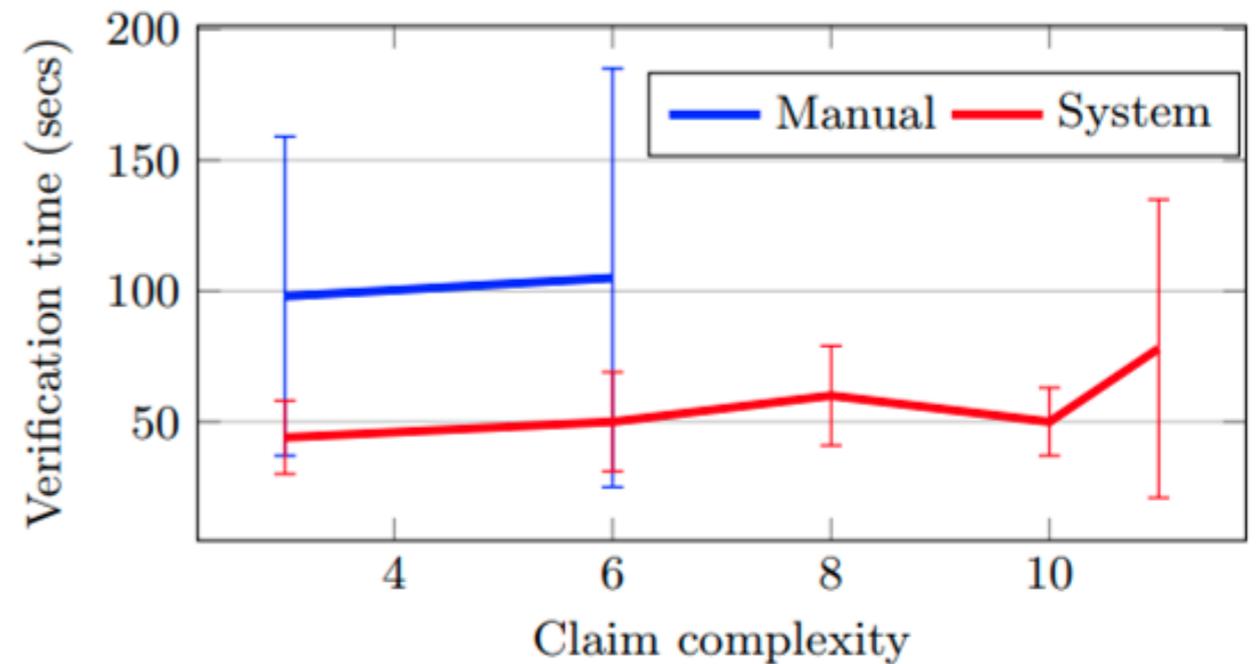
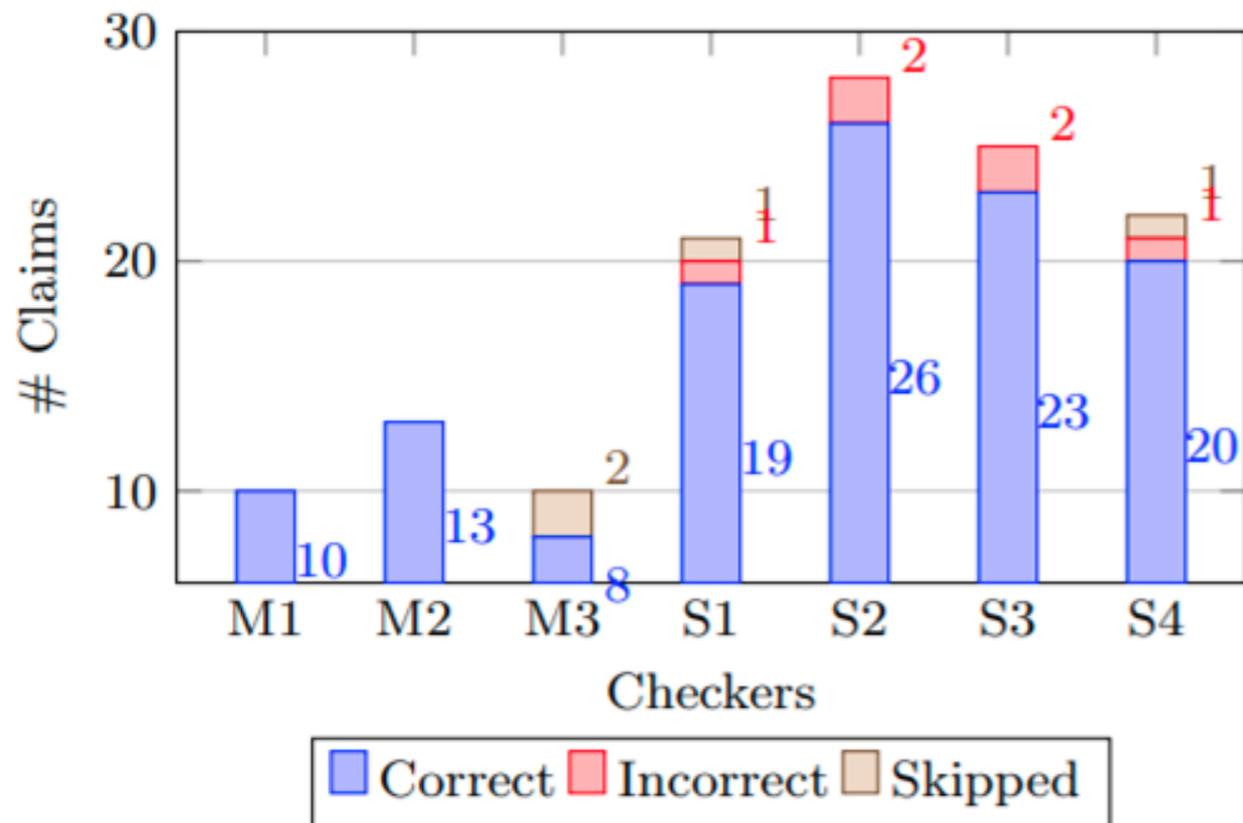


Figure 5: Number of claims verified in 20 minutes by checkers with the manual process (M1–M3) and with our system (S1–S4).

$$\text{CAGR} = \left(\frac{V_{\text{final}}}{V_{\text{begin}}} \right)^{1/t} - 1$$

Compound Annual Growth Rate

Experiments

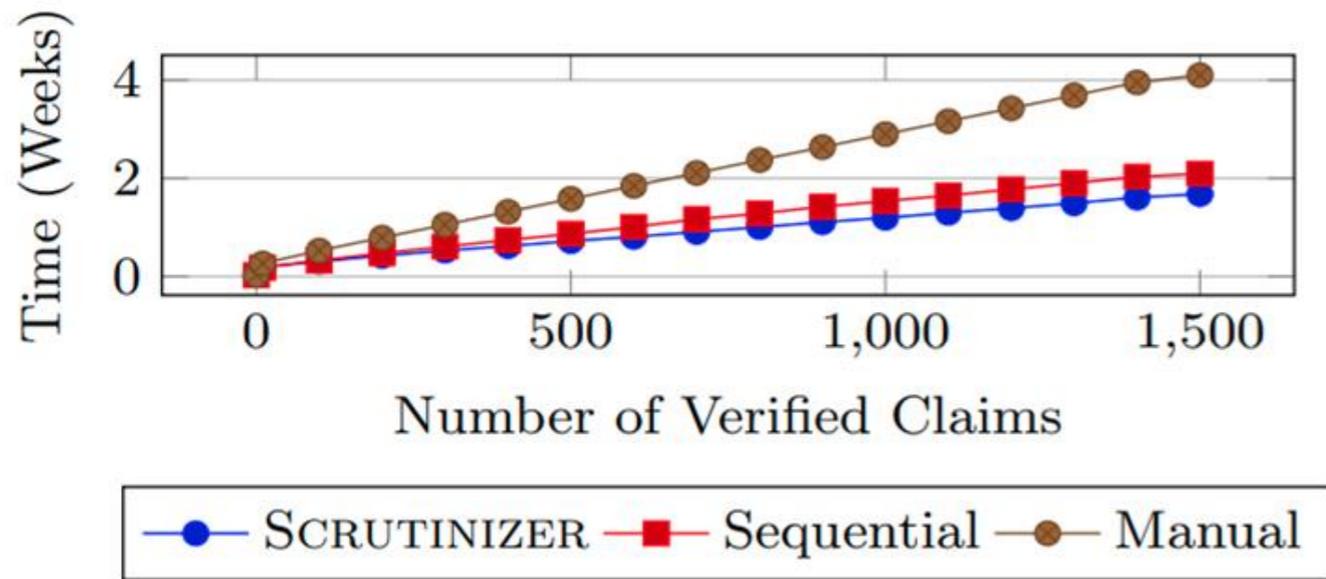


Figure 6: Accumulated verification time over verification period.

Table 4: Summary of simulation results.

	Manual	Sequential	Scrut.
Time (Weeks)	4.1	2.1	1.7
% Savings	-	49%	59%
Avg. Accuracy	-	40%	47%
Max Accuracy	-	46%	53%
Comp. (Mins)	-	14	28

Fact checking entities

- Expert / Journalist
- Computational
- **Crowdsourcing with end users**

Crowdsourced fact checking

TRUTHSQUAD ON HEALTHCARE



Orrin Hatch, U.S. Senator

“87 million Americans will be forced out of their coverage under new health care regulations from President Obama.”

Fact-check this quote:

Is this **true** or **false**?

True

False

Not Sure

WikiTRIBUNE

Evidence-based Journalism

Fiskkit

A better way to discuss the news

Paste article link here



Very few thriving projects

Crowdsourced fact checking

Advantages

- Leverage large number of users
- High scalability
- Faster response

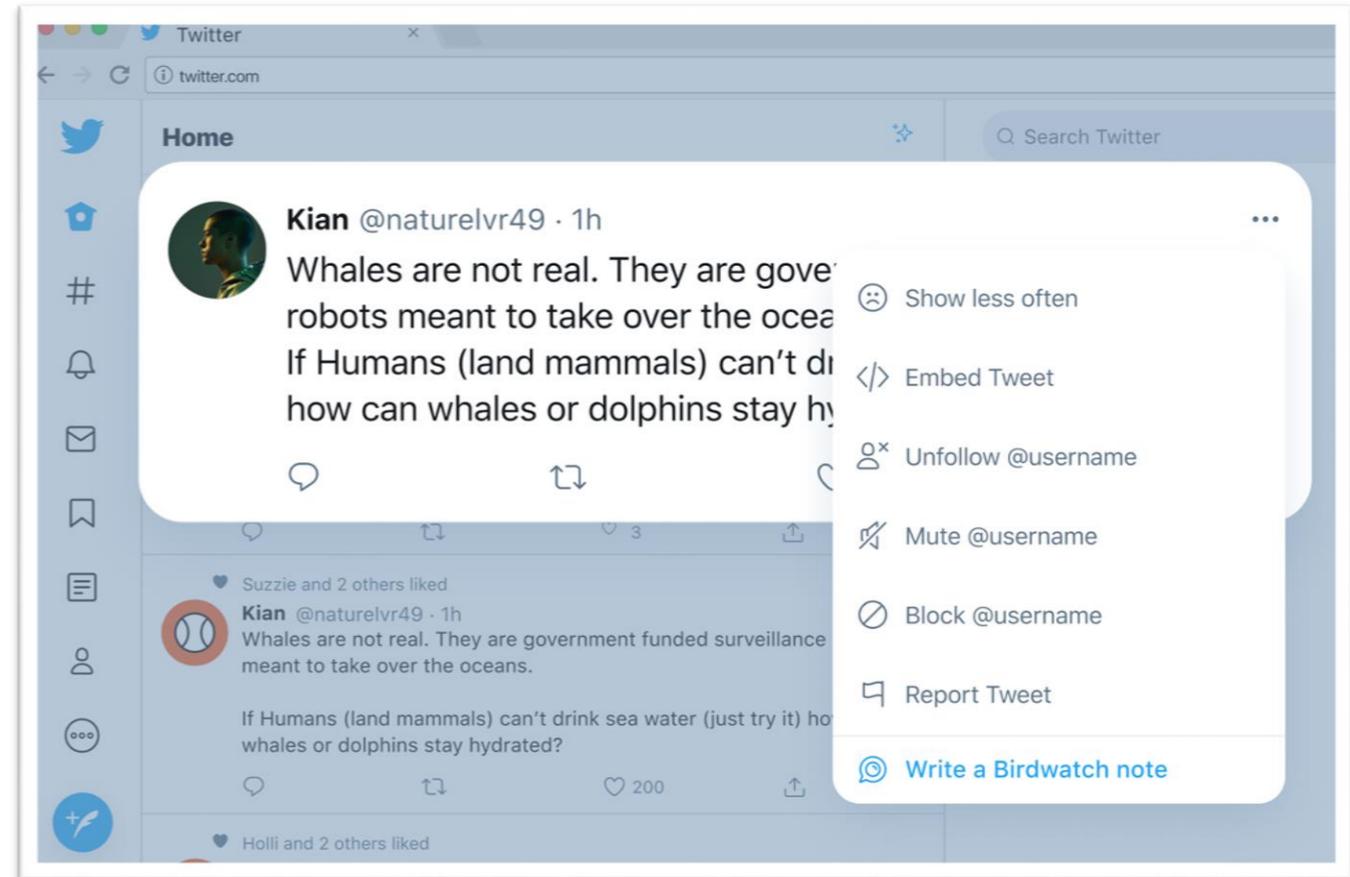
Disadvantages

- Lower credibility
- Risk of manipulation by partisans
- Need to be aware of human biases
- Imbalance in checking popular vs important topics

Birdwatch (Twitter)

- (US only) Community-Based Fact-Checking
- “Qualified” users fact-check tweets → notes
- and rate other notes → ratings

<https://twitter.github.io/birdwatch/>



Is this note helpful? Yes Somewhat No

What was helpful about it?

Cites high-quality sources

Easy to understand

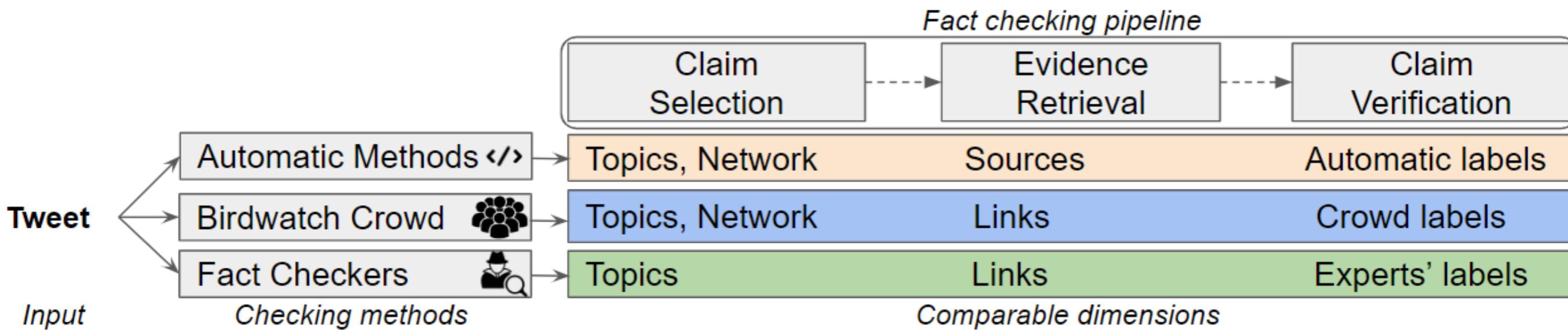
Directly addresses the Tweet's claim

Provides important context

Other

How is Birdwatch doing?

1. How are check-worthy claims selected by the crowd?
2. What sources are used to support a checking decision and how reliable are they?
3. Are crowd workers able to reliably assess the veracity of a tweet?

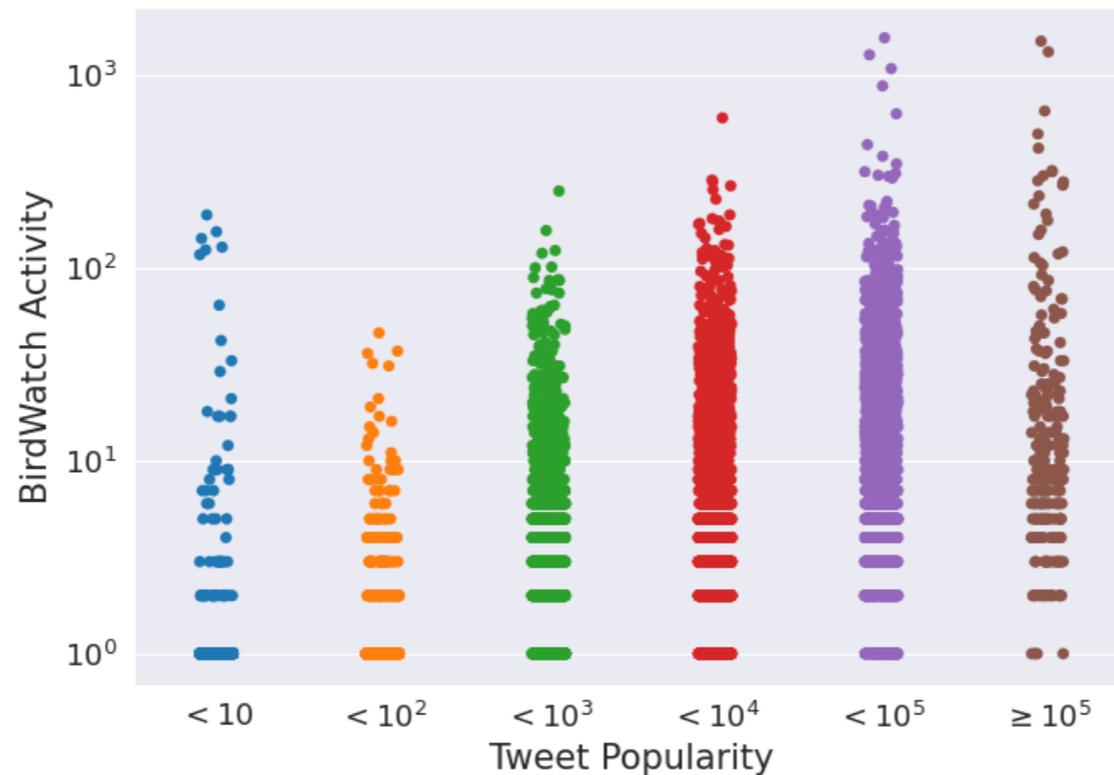


<div style="display: flex; justify-content: space-between; align-items: center;"> <div> <p>BirdWatch Example @birdwatchexample</p> </div> A </div> <p style="font-size: 18px; margin-top: 10px;">Trump won the election by a landslide.</p> <p style="font-size: 12px; color: gray;">9:34 AM · Dec 17 2021 · Twitter Web App</p> <div style="display: flex; justify-content: space-between; font-size: 12px; color: gray; margin-top: 10px;"> 96 Retweets 88 Quote Tweets 153 Likes </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> 🗨️ ↻ ❤️ 📤 </div>	<div style="display: flex; justify-content: space-between; align-items: center;"> ⚡ Note #1 B </div> <p style="font-weight: bold; margin-top: 5px;">Potentially Misleading Dec 17</p> <p style="font-size: 12px; color: gray;">According to numerous independent sources, Trump lost the election. Politifact, 1/6/21: https://www.politifact.com/factchecks/2021/jan/07/donald-trump/trump-clings-fantasy-landslide-victory-egging-supp/ "All 50 states and the District of Columbia have certified their election results, which Congress sought to finalize Jan. 6? There is no evidence that voter fraud affected that outcome."</p>
<div style="display: flex; justify-content: space-between; align-items: center;"> ⚡ Note #1 C </div> <p style="font-size: 12px; color: gray;">Given current evidence, I believe this tweet is:</p> <ul style="list-style-type: none"> <input type="checkbox"/> NOT_MISLEADING <input checked="" type="checkbox"/> MISINFORMED_OR_POTENTIALLY_MISLEADING <input type="checkbox"/> I believe this tweet contains a digitally altered photo or video. <input checked="" type="checkbox"/> Did you link to sources you believe most people would consider trustworthy? 	<div style="display: flex; justify-content: space-between; align-items: center;"> ⚡ Fact-Check D </div> <p style="font-size: 12px; color: gray;">Nov 07</p> <p>Claim: Donald Trump won the 2020 election, by a lot.</p> <p>Verdict: Not Credible</p> <p>Fact Checker: Lead Stories</p> <p>Country: United States</p> <p>Link: https://leadstories.com/hoax-alert/2020/11/fact-check-donald-j-trump-on-twitter-i-won-by-a-lot.html</p>

Dataset

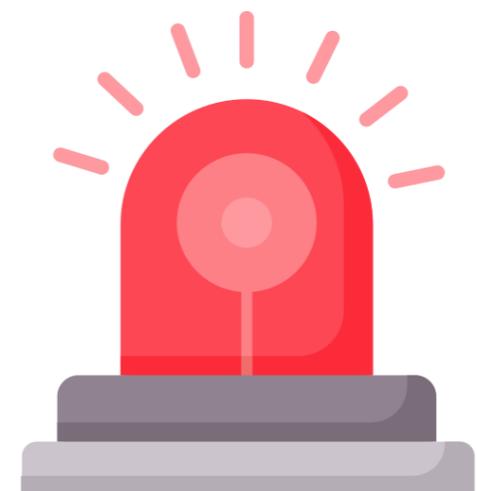
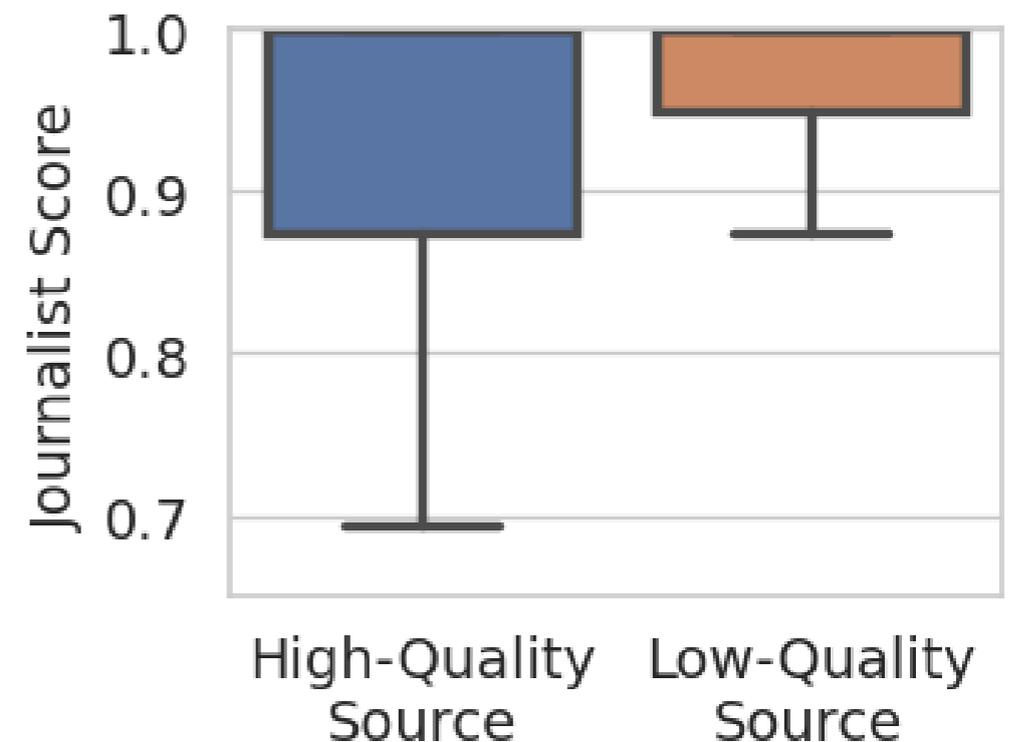
- Birdwatch (BW) up to Sept 2021: 16k notes, 87k ratings
- ClaimReview (CR) fact-checks: 77k
- Manual match by authors (500) and crowd (5.5k)
 - 2208 tweets (3043 notes) matching CR checks
 - <https://birdwatch.eurecom.fr/>

How are check-worthy claims selected by the crowd?



What sources support a decision and how reliable are they?

- BW: 13k links covering 2k domains
Skew: half links from 29 domains
- CR: 77k links covering only 73 domains of fact-checking groups and journalists



Are crowd workers able to assess the veracity of a tweet?

		BirdWatch				
		Notes		Tweets		
		MM	NM	MM	NM	Tie
Claim Review	credible	209	25	126	9	9
	mostly_credible	56	14	44	7	5
	not_credible	1983	184	1476	62	55
	not_verifiable	300	25	225	8	9
	uncertain	225	22	156	8	9

- majority of BW labels match the CR ones

Ready for adoption?

[IJCAI'21 survey <https://arxiv.org/pdf/2103.07769.pdf>]

Automated Fact-Checking for Assisting Human Fact-Checkers

Preslav Nakov^{1*}, David Corney², Maram Hasanain³, Firoj Alam¹, Tamer Elsayed³,
Alberto Barrón-Cedeño⁴, Paolo Papotti⁵, Shaden Shaar¹, Giovanni Da San Martino⁶

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{maram.hasanain, telsayed}@qu.edu.qa, papotti@eurecom.fr, dasan@math.unipd.it

Abstract

The reporting and analysis of current events around the globe has expanded from professional, editor-lead journalism all the way to citizen journalism. Politicians and other key players enjoy direct access to their audiences through social media, bypassing the filters of official cables or traditional media. However, the multiple advantages of free speech and direct communication are dimmed by the misuse of the media to spread inaccurate or misleading claims. These phenomena have led to the modern incarnation of the *fact-checker* — a professional whose main aim is to examine claims using

Such organizations are also potential beneficiaries of or leaders in automated fact-checking research. As misinformation became a major concern globally, tech companies, national and international agencies began work in the area. Recently, several international initiatives have also emerged such as the *Credibility Coalition*⁵ and *EUfactcheck*⁶. Along side some tools have also been made available such as Google Factcheck⁷ and Hoaxy⁸. Moreover, fact-checking is a common task in settings that go beyond online misinformation, as the verification of content accuracy is a priority for many organizations [Karagiannis *et al.*, 2020].

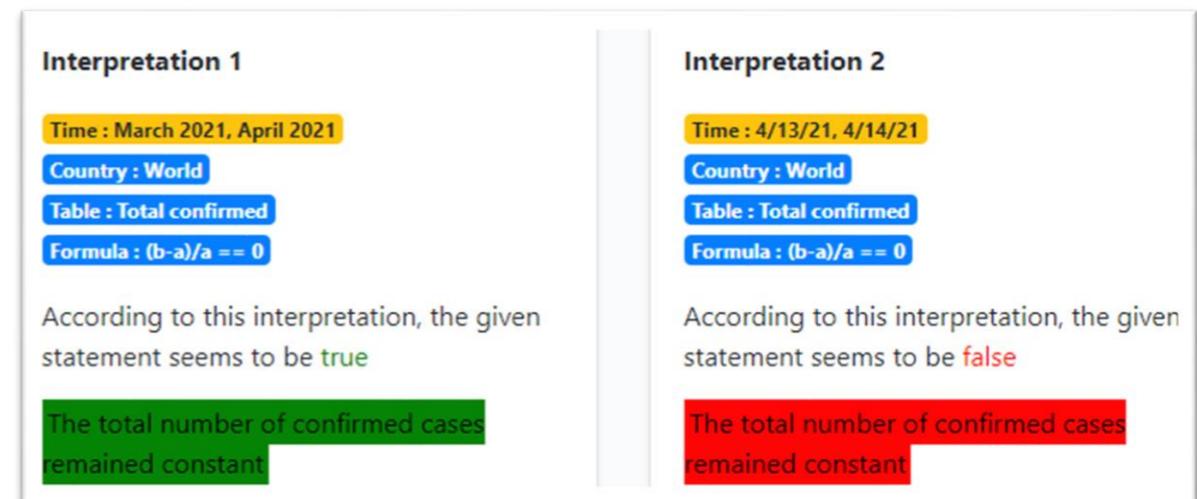
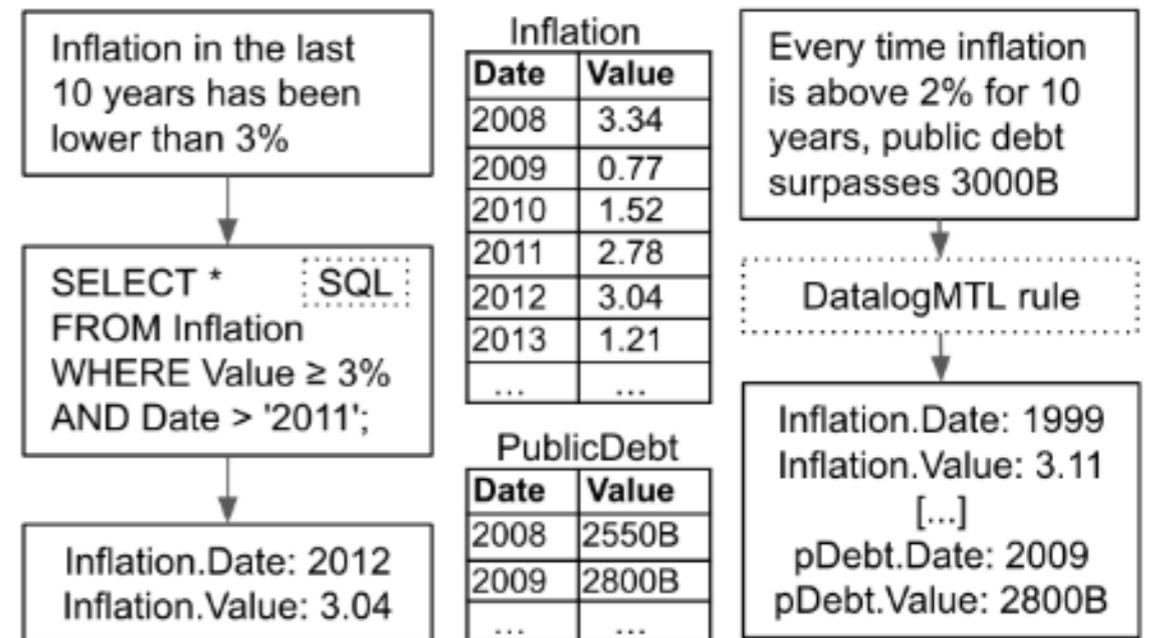
A large body of research is devoted to developing automatic systems for fact-checking [Vo and Lee, 2018; Shu *et al.*, 2017; Thorne and Vlachos, 2018; Firoj *et al.*, 2016;

Research directions

- Applicability & Usability
- More expressive power
[Mori et al, 2022] [Aly et al, 2021]
- Ambiguity in NL
[Veltri et al, 2022][Wenzel, 2019]
- Explanations in NL
[Atanasova et al, 2020]
[Kotonya and Toni, 2020]

A_C

A_C



Research directions

- Automatic methods poor with NL text (*Twitter slang*) and at matching *stale claims* → *crowd is good at this!* A_C
- Crowdsourcing and aut. methods fail with subtle textual claims → *experts are good at this!* A_C
- Experts are slow and rely on few sources → *crowd and aut. methods scale!* A_S
- Aut. method X is good on claims of type Y given clean data Z.... A_C
 A_S
- How to combine these approaches and methods?
Collaborative solutions [Qu et al 2021]

Research directions

- Automatic tools fact check in real-time all content, provide evidence, possible labels
- Platform users provide a first line of defense
- Experts provide quality checks in every step
- *Assuming we model trust and cost for all actors*
 - Design novel hybrid human-machine solutions that coordinate this joint effort!

(more) Research directions

- Multi language
- System bias
- Multimodality
- Explainability
- Real time
- ...



Yesterday

A few mins ago I wa
"information you ha
clicked the pop-up
If this is their latest
pretty pathetic, like
stupid pop-up and k
vaccines!

Additional reporti

Sometimes, different news
story. You can take a look
sites.

Content that you shared



SCIENCE FE
False: Cu
do not cau

[Learn more](#) about how fa



5 h · 🌐

Tired of fact checkers censoring posts claiming it's partly false when it's mostly true?! Follow the below mentioned cheat code. Go to settings>privacy>blocking>search for fact check/fact checkers and block them all. Since I have done this none of my stuff have been censored... I keep checking every once in a while since more popped up I have blocked like 50 so far. A way around censorship. Spread the knowledge.

Like

Share

119

12:35



for being so concerned about
one's post. Give me a break! You
to trust you?

46° 87% 08:51

ional Reporting

nal Reporting ntent from lnews.com

ifferent news sources
ng perspectives on the
. You can check out
orting from independent
checking sites.

you shared has been
by Science Feedback.



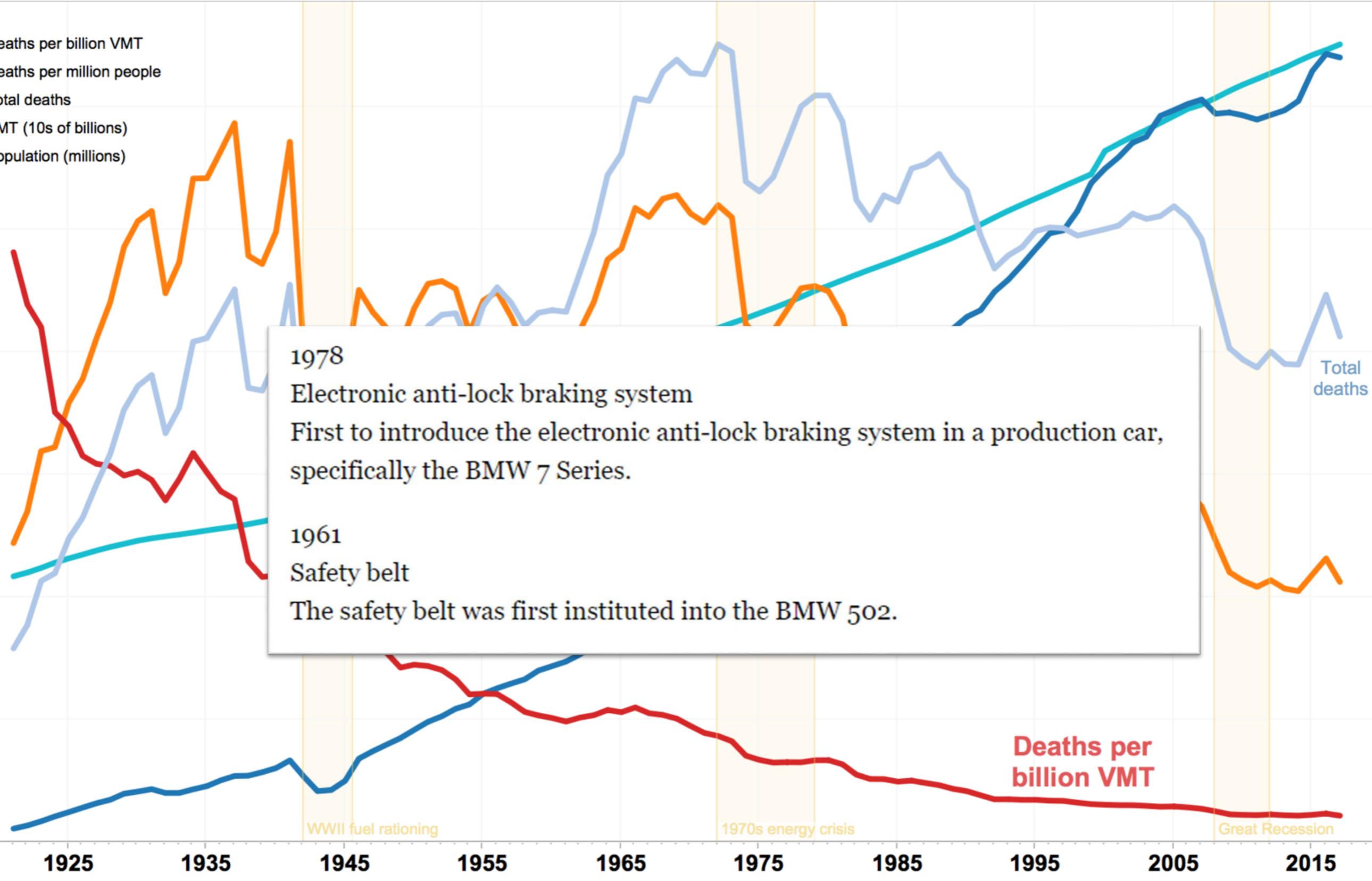
Science Feedback **Fact-Checker**

False: US measles outbreak due to unvaccinated Americans who

US motor vehicle

deaths per VMT, deaths per capita, total deaths, VMT, and population

- Deaths per billion VMT
- Deaths per million people
- Total deaths
- VMT (10s of billions)
- Population (millions)



1978
Electronic anti-lock braking system
First to introduce the electronic anti-lock braking system in a production car, specifically the BMW 7 Series.

1961
Safety belt
The safety belt was first instituted into the BMW 502.

Deaths per billion VMT

WWII fuel rationing

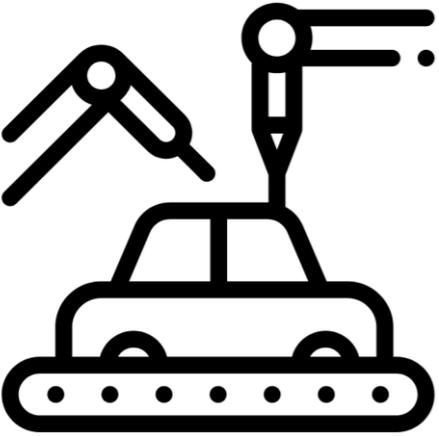
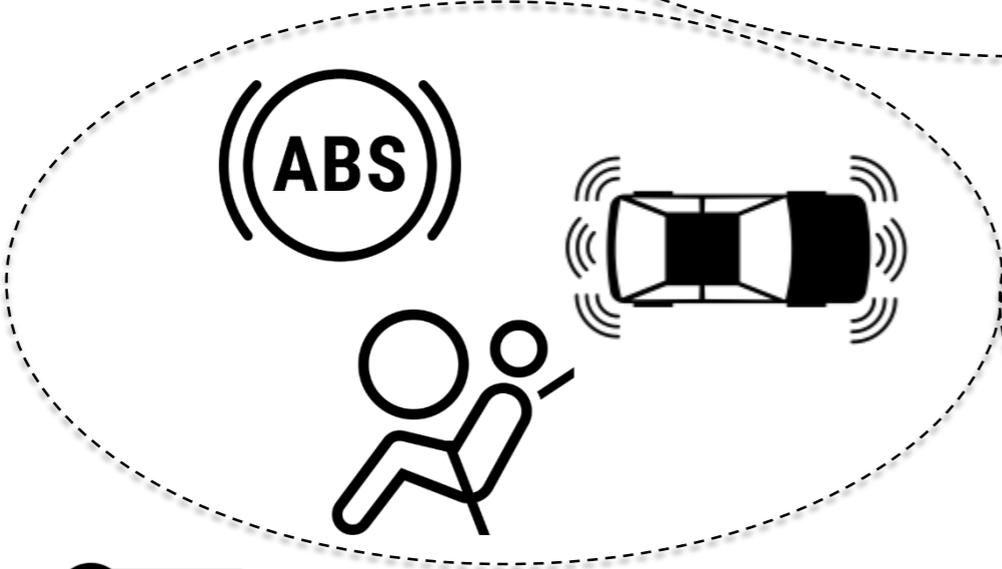
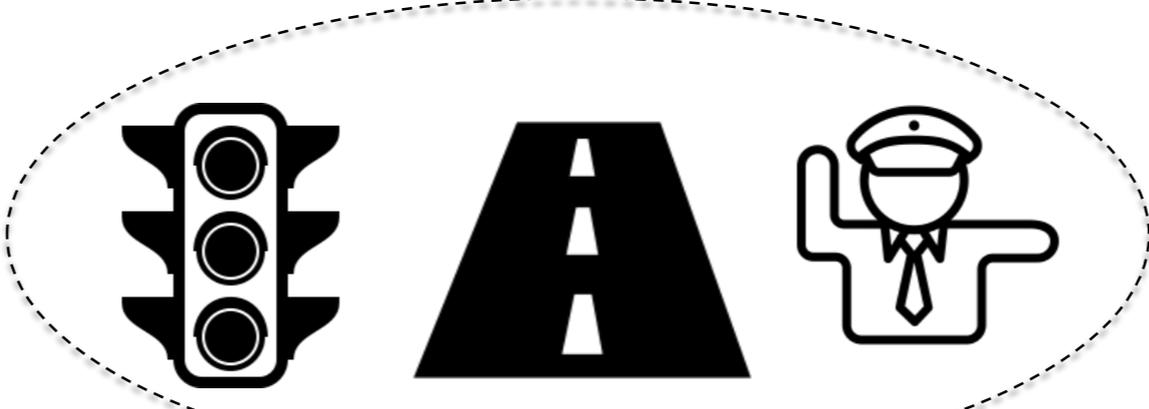
1970s energy crisis

Great Recession

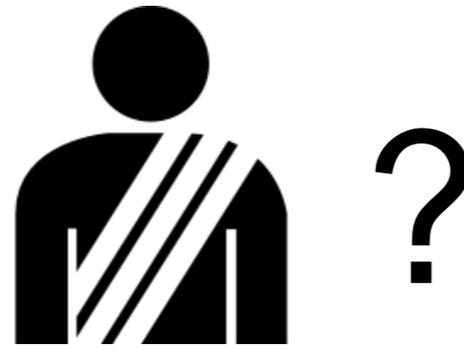
1925 1935 1945 1955 1965 1975 1985 1995 2005 2015

https://en.wikipedia.org/wiki/Motor_vehicle_fatality_rate_in_U.S._by_year

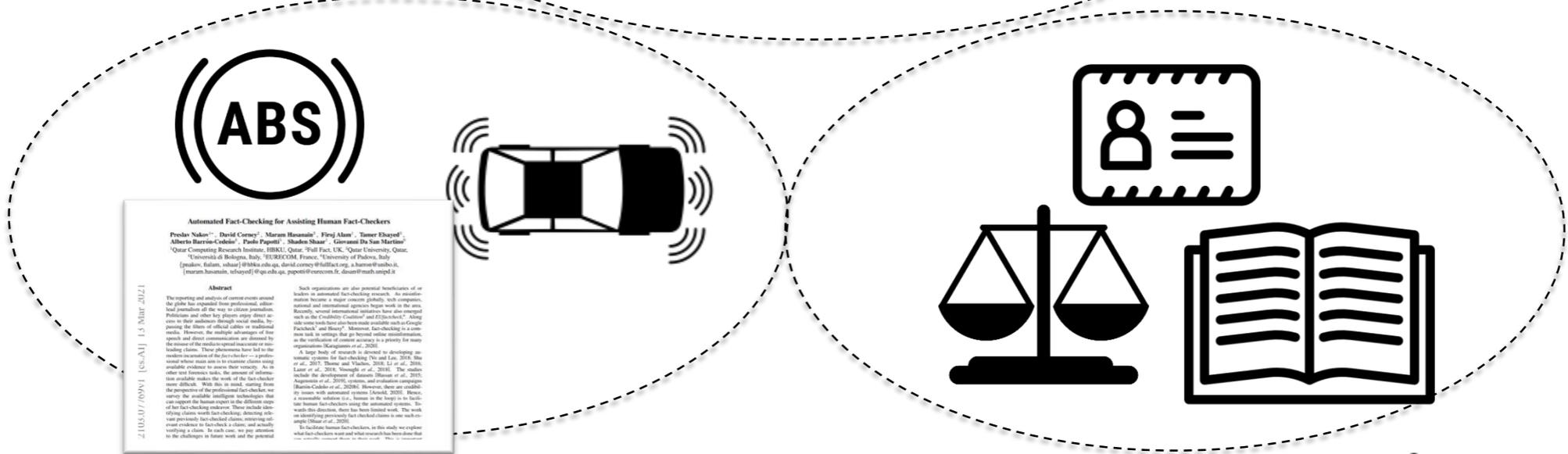
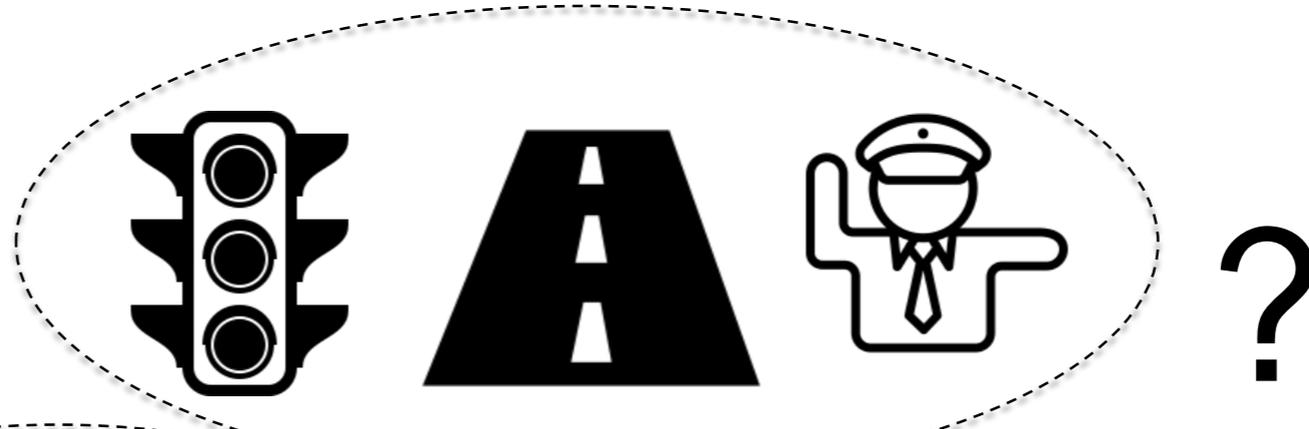
Actors and actions to reduce car deaths



Actors and actions to *reduce misinformation*



2021
EU: Digital Services Act
UK: Online Safety Act



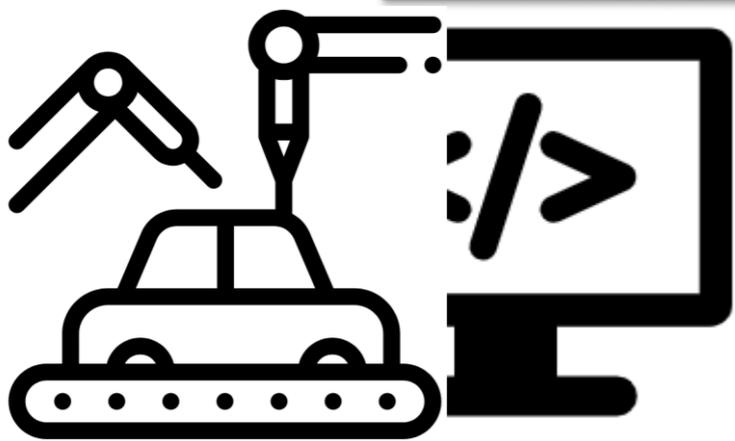
Automated Fact-Checking for Assisting Human Fact-Checkers
 Pradeep Nataraj¹, David Corney², Marwan Hassanein³, Fajr Alami⁴, Tamer Elshay⁵,
 Alberto Barrón-Cedeño⁶, Paolo Papotti⁷, Shaden Shaar⁸, Giovanni Da San Martino⁹,
 Qatar Computing Research Institute, HBKU, Qatar; ¹Full Fact, UK; ²Qatar University, Qatar;
³Università di Bologna, Italy; ⁴EURCOM, France; ⁵University of Padova, Italy;
 [pradeep.nataraj@qcri.org, david.corney@fullfact.org, a.hassanein@unibo.it,
 [fajr.alami@unibo.it, tamer.elshay@unibo.it, alberto.barron@unibo.it, paolo.papotti@unibo.it, shaden@fullfact.org, gda@qcri.org]

Abstract
 The reporting and analysis of current events around the globe has expanded from professional, editorial institutions all the way to citizen journalism. Politicians and other key players enjoy direct access to their audience through social media. By-passing the filters of official cables or traditional media. However, the multiple advantages of free speech and direct communication are offset by the spread of misinformation and disinformation. This paper presents the design and implementation of the fact-checker—a professional whose main aim is to verify claims using available evidence to assess their veracity. As in other user-driven tasks, the amount of information available makes the work of the fact-checker more difficult. With this in mind, starting from the perspective of the professional fact-checker we survey the available intelligent technologies that can support the human expert in the different steps of fact-checking evidence. These include identifying claims worth fact-checking, detecting relevant previously fact-checked claims, extracting relevant evidence to fact-check a claim, and actually verifying a claim. In each case, we pay attention to the challenges in human work and the potential

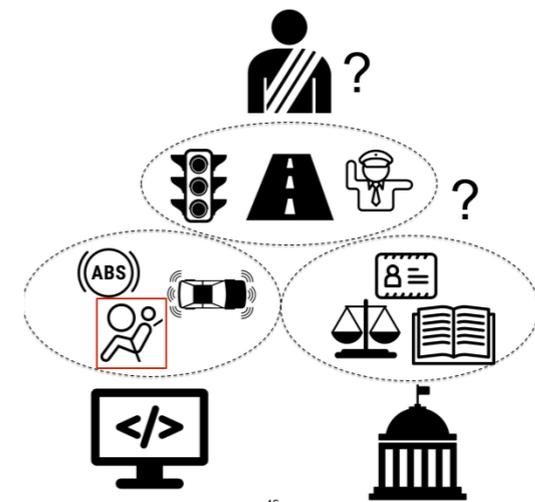
Such organizations are also potential beneficiaries of or leaders in automated fact-checking research. An immediate example is a major research project, both European and international agencies began work in the area. Recently, several international initiatives have also emerged such as the Credibility Coalition and ECheckmate. Along with some such initiatives have been made available such as Google Factcheck and Bing’s ‘Moment’. Moreover, fact-checking is a common task in settings that go beyond online communication, as the verification of content accuracy is a priority for many organizations (Kangramani et al., 2020).

A large body of research is devoted to developing automated systems for fact-checking (Yu and Lee, 2018; Liu et al., 2017; Thorne and Vlachos, 2018; Li et al., 2016; Lopez et al., 2018; Thompson et al., 2018). This paper includes the development of different systems (e.g., 2011; Aguilera et al., 2019), systems and evaluation campaigns (Barrón-Cedeño et al., 2020b). Moreover, there are initiatives aimed at supporting human fact-checkers (Koriat, 2005). Hence, a reasonable solution for human in the loop is to facilitate human fact-checkers using the automated systems. To this end, in this direction, there has been limited work. The work on identifying previously fact-checked claims is one such example (Thorne et al., 2020).

To facilitate human fact-checkers, in this study we explore what fact-checkers want and what research has been done that



- Data driven fact checking is happening
- More research and engineering is needed
- But it's not only about tech
 - Regulation + Education



<http://www.eurecom.fr/~papotti/>

 @paolopapotti

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