



Developing Socio-computational Approaches to Mitigate Socio-cognitive Security Threats in a Multi-platform Multimedia-rich Information Environment

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Collaboratorium for Social Media and Online Behavioral Studies

Statewide research center headquartered in the University of Arkansas - Little Rock, USA

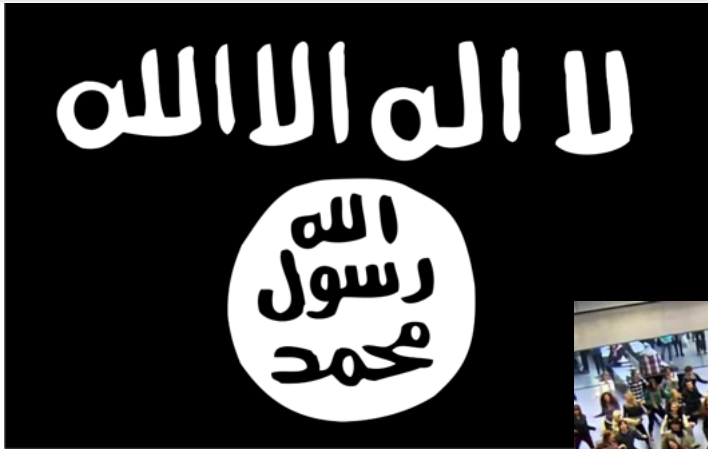
78 members (Canada, USA, St. Vincent & The Grenadines, Germany, France, Turkey, Nigeria, Iraq, Pakistan, India, Nepal, Bangladesh)

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- Characterizing multimedia information environment tactics and impact assessment
- Collective action-based framework to characterize coordinated cognitive attacks
- Characterizing information actors (producers and consumers) engaged in cognitive attacks

- NATO cyber influence operations
- uses to assist public affairs and

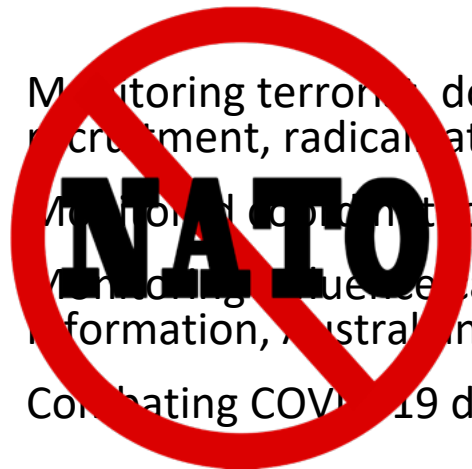


The Islamic State in Iraq & Levant (ISIL/ISIS/Daesh) 2015



Hackers Networks (DHNs) 2019

- Monitoring terrorism, domestic recruitment, radicalization, and
- Monitoring and countering disinformation
- Monitoring influence campaigns in information, industrial in DoD Strategy
- Combating COVID-19 disinformation



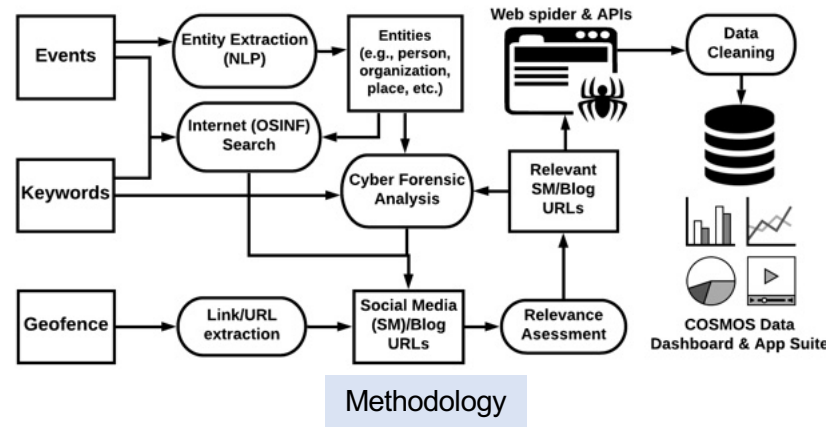
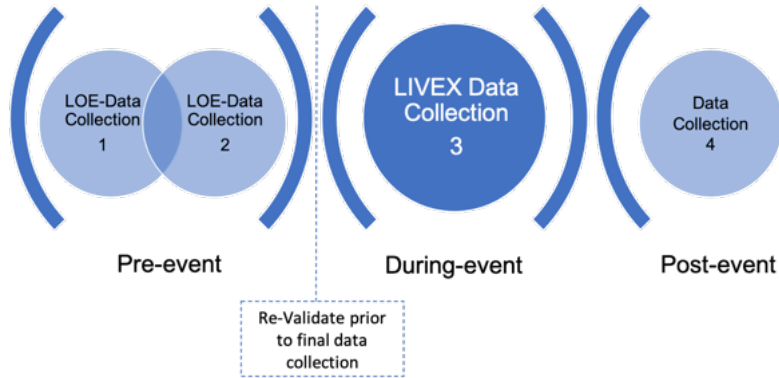
Anti-NATO Propagandist



Internet Trolls



Violent Protests

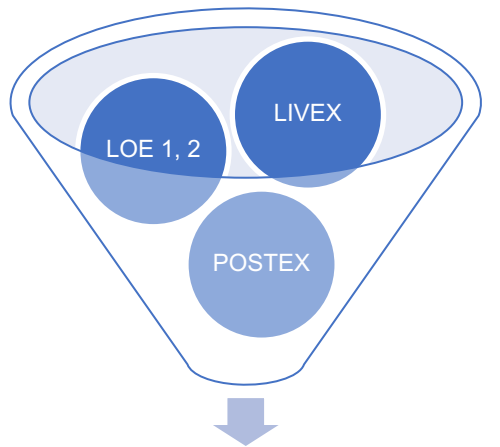


Sources include

- Events
- Keywords
- Geofence
- Entities
- OSINF/metadata through cyber forensics

Over 300 GB of data collected every day consisting of

- Text
- Images
- Audio
- Video
- Networks
- Metadata



Bottom-line Up Front (BLUF)



Dashboard

Multi-threaded, distributed, resilient, and scalable data collection framework has been developed, evaluated, and deployed.

Basic Filters - Dashboard

Advanced Filters – Narrative extraction and resonance with community, alarming shift in discourse of a blogger



- Environmental Impact
- Disturbs Local Economy
- Threatening Stability
- Mocking/ridiculing NATO
- NATO is aggressive
- NATO poking 'Russian Bear'
- NATO is a joke – Not a real threat
- 'Stop NATO' Protests/Astrourfing
- Mistreatment by NATO Troops

Set up indicators and warnings (I&W system)

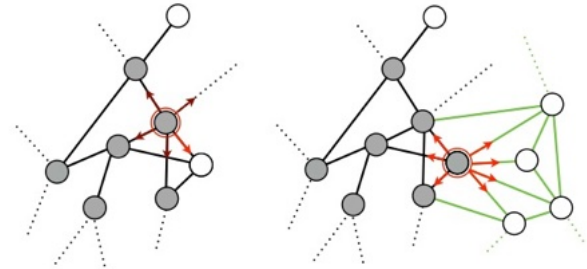
Real-time influence assessment

$$InfluenceFlow(p) = w_{in} \sum_{m=1}^{|I|} I(p_m) - w_{out} \sum_{n=1}^{|O|} I(p_n)$$

$$I(p) \propto w_{comm} \gamma_p + InfluenceFlow(p)$$

$$I(p) = w(\lambda) \times (w_{comm} \gamma_p + InfluenceFlow(p))$$

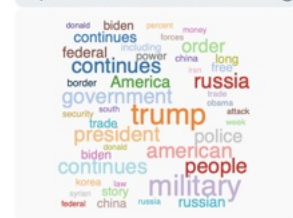
$$iIndex(B) = \max(I(p_i))$$



Vaccine Tracker Influence Analysis



Keywords of Katie J.M. Baker and 2 others



Activity Vs Influence of Katie J.M. Baker



Influential Posts of Katie J.M. Baker

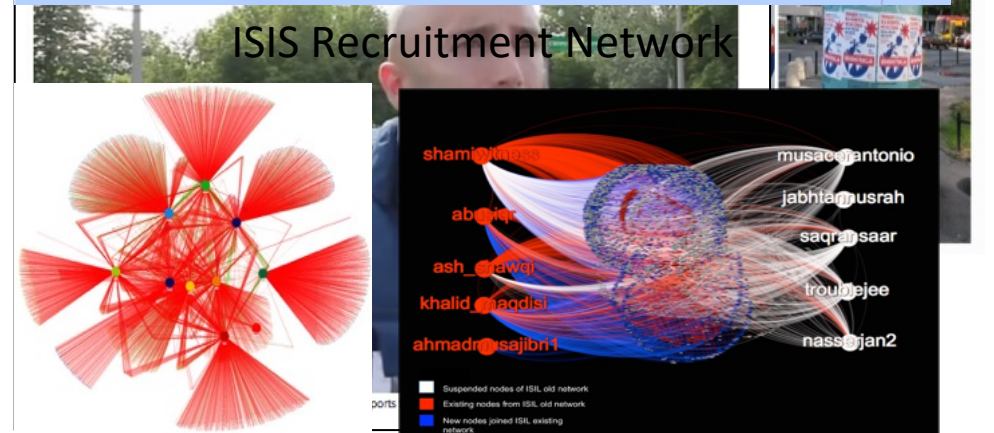
Post Title	Influence Score
About Buzzfeed	0.12
About Buzzfeed	0.13
A Man Attacked An Asian Woman Taking Out Trash At Night She Now Has Chemical Burns	0.11
Here S Why Facebook has been Marking About the Coronavirus As Spam	0.11
About Buzzfeed	0.12

How Oil Industry Videos Have Skirted Canadian Campaign Disclosure Rules

The Supreme Court on Monday refused to take up the Trump administration's that placed statewide limits on local law enforcement cooperation with federal immigration authorities. The Trump administration had asked the Supreme Court to review a lower court's opinion upholding the California Values Act. Justices Clarence Thomas and Samuel Alito two of the court's conservative justices voted to hear the case. Under the law SB local police are barred from notifying US Immigration and Customs Enforcement ICE that they are holding a suspect. They are also barred from transferring a detainee to ICE custody unless that person has been convicted of a felony under California law had been called for a felony within the next years or served time in

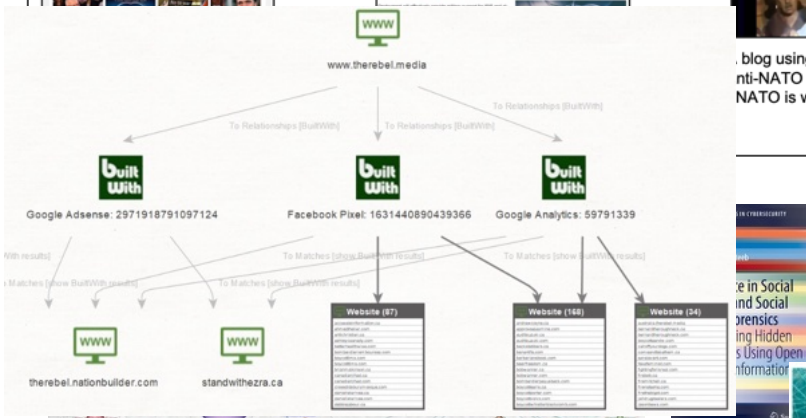


ISIS Recruitment Network

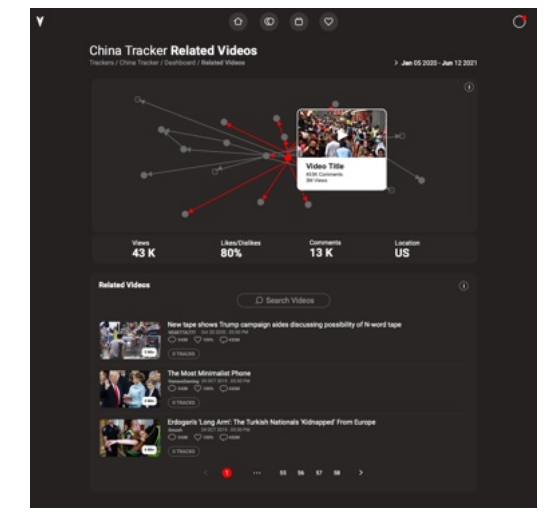
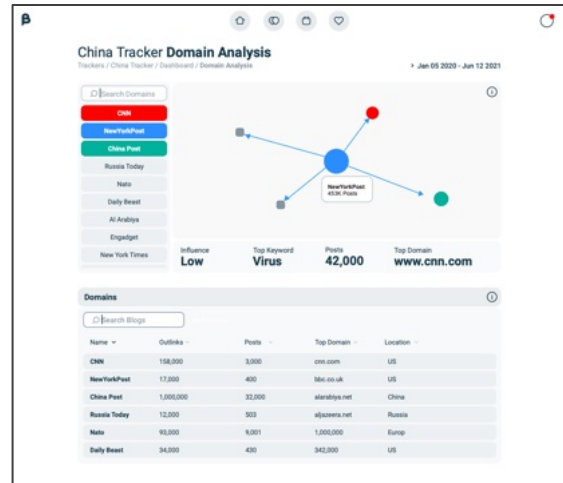


2016 exercise.

Influence Campaigns: Designated domains for controversial subjects to draw traffic to main site. Orchestrated use of Twitter hashtags and cross media campaigns to drive traffic to designated domains.



291 fake websites created using “Built with API” service with anti-Trudeau narrative. One such fake website “weresorryindia.com” amplifies anti-Trudeau narrative suggesting he is not a friend of the Canadian-Indian community. The website tops the results in search engines

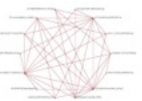


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Video ID: OM5v
Title: China vs U
South China Sea
Channel: Breaki



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South China
Morning Post
(SCMP)



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Strengthening Australia's Information Warfare Capabilities in Fighting Foreign Interference and Propaganda

Strategic Policy Grants Program 2020
Department of Defence

Aim Sinpeng
The University of Sydney

Nitin Agarwal
University of Arkansas, Little Rock

Justin Hastings
The University of Sydney

30 July 2021



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South China Sea

Philippine navy ships r
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Philippine navy ships naglague below and don't forget ...

US AND PHILIPPINES
'MILITARISATION' IN S
AmericaNewsSource · 388 views
US, Philippines said to be in tal

south china sea : Duterte
against China
Hot News · 3 views · 3 hours ago
Duterte just threatened to go o
https://goo.gl/F8gnAZ G+

Proud Philippine Navy
(photo)
World Of Defense · 254 views
More complete at news source

(SHTF) China Has Con
China Sea
MenoValer12SouthSide · 15 v
(BREAKING NEWS TV)

south china sea : Philip
Thitu Island
Hot News · 4 views · 4 hours ago
Philippines' President Duterte
https://goo.gl/F8gnAZ ...

Strengthening Australia's Information Warfare Capabilities Page | 25

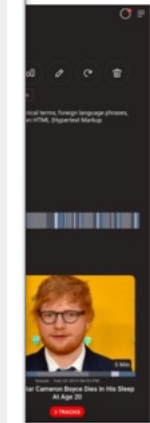
South Korea (Arirang News). Two channels of note – Defence Flash News and CIS News Network – are YouTube-based organisations based in the US and India respectively.

Defence's military exercises with US and its allies and deteriorating relations with China dominated YouTube comments

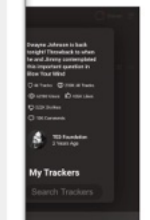


theory.

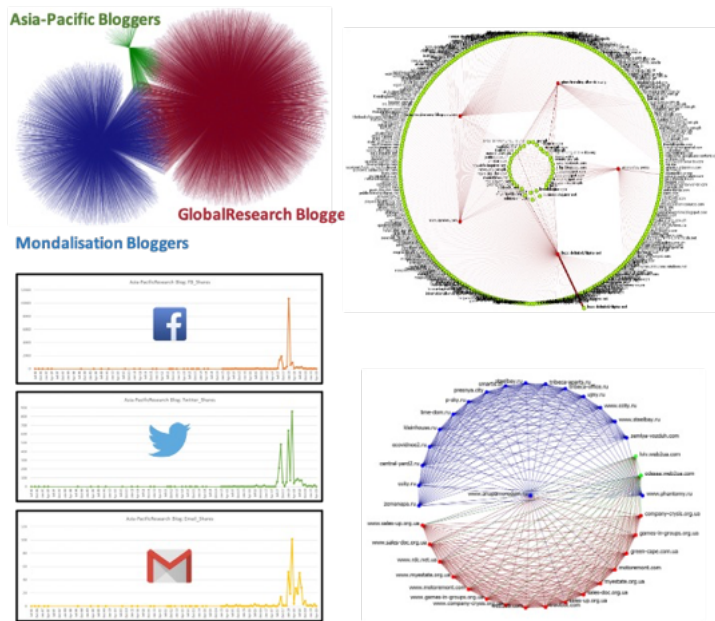
has been
Tracker



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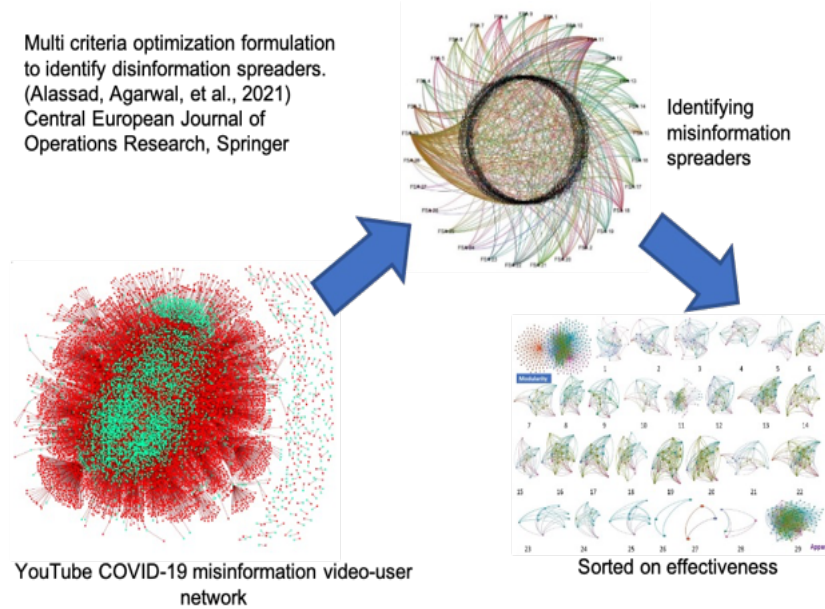
Coordinated bloggers



Anti-West/anti-US Indo-pacific bloggers

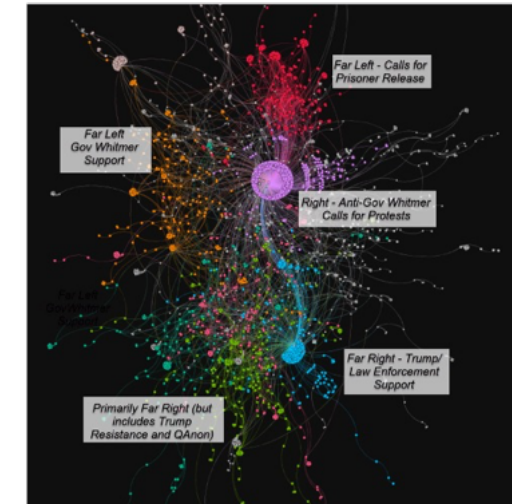
Coordinated YouTubers

Multi criteria optimization formulation to identify disinformation spreaders. (Alassad, Agarwal, et al., 2021) Central European Journal of Operations Research, Springer

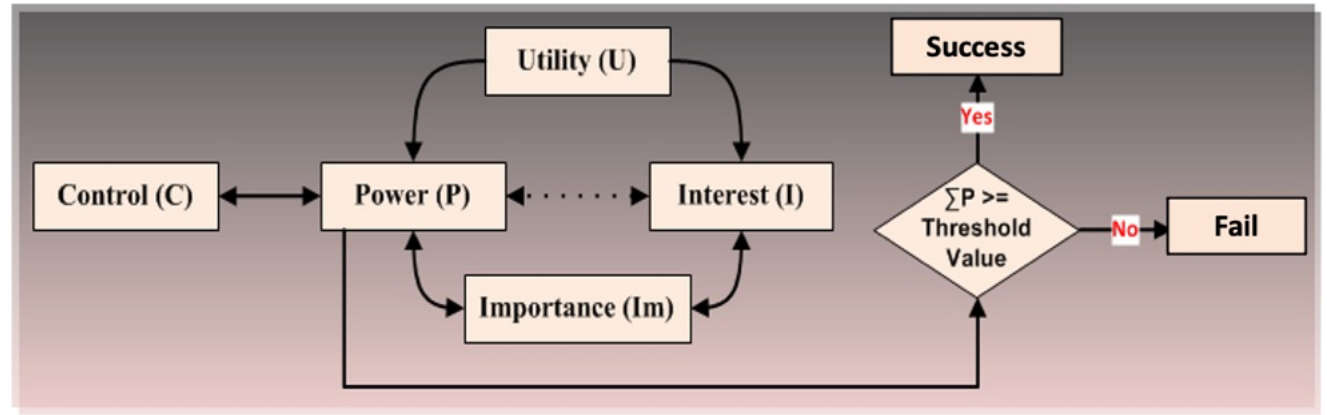
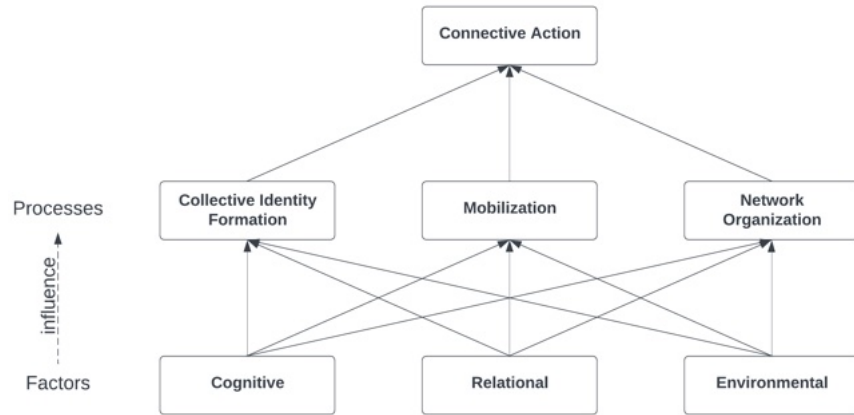


COVID-19 misinformation and conspiracy theory YouTubers

Coordinated Twitter users



Michigan lockdown protest network
 #LetMiPeopleGo, #MiLeg, #Endthelockdown, #MichiganProtest; April 1 to May 20; 16,383 tweets; 3,632 nodes; 382 groups (focused on 5 most powerful groups)
Research showed powerful coordination among conspiracy groups calling for protest and actions against Gov. Whitmer. FBI later unraveled a plot to kidnap Gov. Whitmer.



$$\max \sum_{i=1}^n \delta_i \quad (1)$$

Subject to

$$\delta_i = \{d\bar{c}_1 \ll d\bar{c}_2 \ll d\bar{c}_3 \ll \dots \ll d\bar{c}_i\} - \bar{d}c_j^0 \quad \forall i, j \quad (2)$$

$$d_i^c = \sum_j m_{ij} \quad \forall i \quad (3)$$

$$d_i^c \geq 2 \quad \forall i \quad (4)$$

$$D_i^c = \frac{1}{n} \sum_{i=1}^n d_i^c \quad (5)$$

$$D_i^c < d_i^c \leq D_i^u \quad \forall i \quad (6)$$

$$a_i^c = \frac{\text{\# of Triangles} \times 3}{\text{\# of Connected Triples of Nodes}} \quad \forall i \quad (7)$$

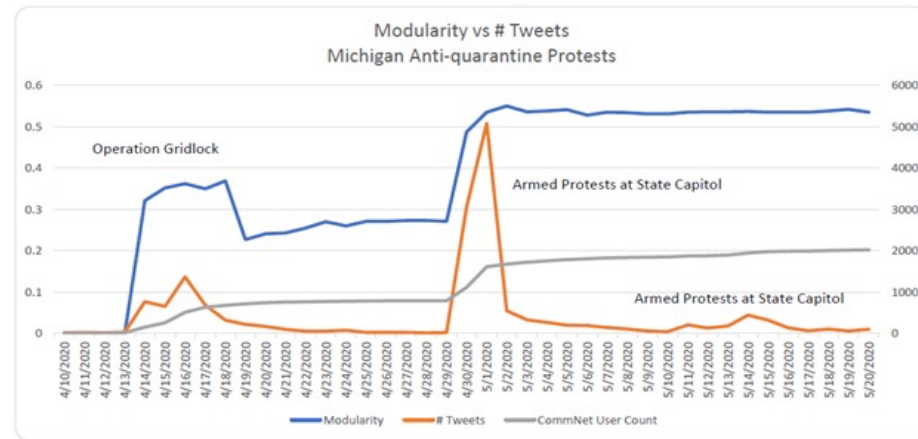
$$AC_i^c = \frac{1}{n} \sum_{i=1}^n a_i^c \quad (8)$$

$$AC_i^c < a_i^c \leq AC_i^u \quad \forall i \quad (9)$$

$$\bar{c}_i^c = \{c_1^i, c_2^i, c_3^i, \dots, c_j^i\} - c_j^0 \quad \forall i, j \quad (10)$$

$$\bar{c}_{i,n \times k} = \bar{c}_{\delta_i} \quad \forall i \quad (11)$$

$$F = \{c_0, c_j^0, c_{j+1}^0, \dots, c_k^0\} \quad \forall j, k \quad (12)$$



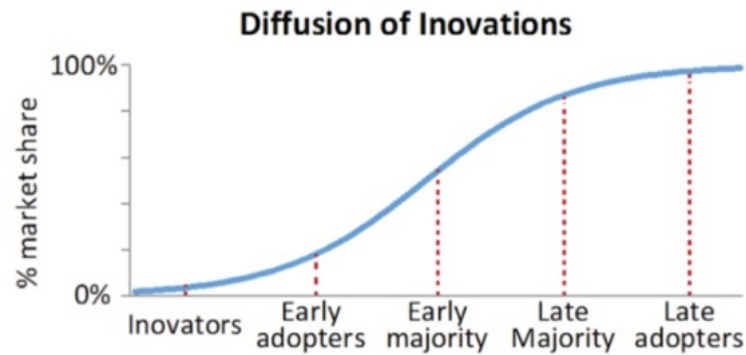
Communities	Political Category	No. of Users in Each Community	No. of Nodes	No. of Edges	Modularity	Average Weighted Degree	Average Betweenness Centrality	DCFM Power
Largest Community	Right	459	510	526	0.294	1.457	0	90.88
Second Community	Right	152	284	419	0.578	2.771	0	77.12
Third Community	Right	212	269	322	0.468	1.792	0	280.98
Fourth Community	Left	78	204	491	0.422	9.779	24.26	10.36
Fifth Community	Left	115	243	339	0.608	7.683	0.16	28.94

Table Y1 - Top 5 Largest Modularity-Based Communities

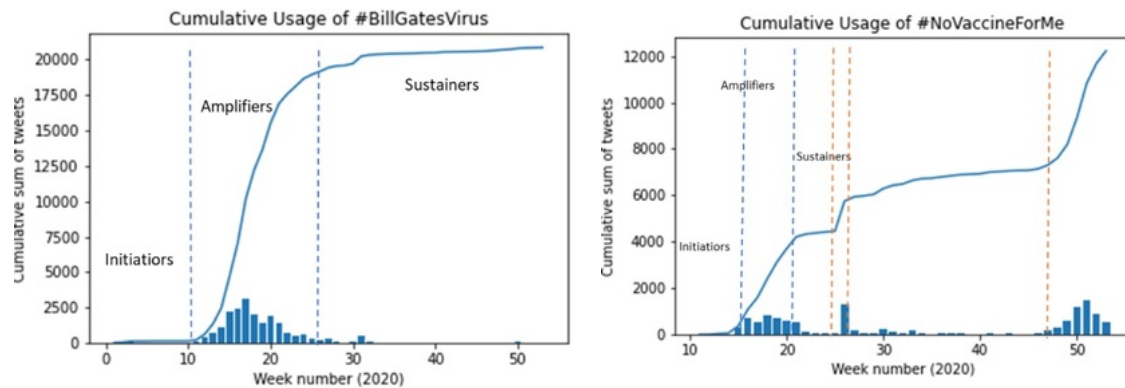
Agarwal, N. et al. (2020) Combining Advanced Computational Social Science and Graph Theoretic Techniques to Reveal Adversarial Information Operations . Journal of Information Processing and Management. Elsevier.

Agarwal, N. et al. (2021) Decomposition Optimization Method for Locating Key Sets of Commenters Spreading Conspiracy Theory in Complex Social Networks. Central European Journal of Operations Research. Springer.

Characterization of information producers



Rogers (1962). Diffusion of innovations.

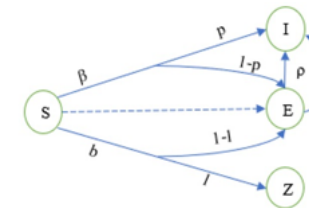


Spann & Agarwal (2022), OSNEM, Elsevier.

Characterization of information consumers

How misinformation spreads? Who should be inoculated?
Leveraging epidemiological modeling. Treat misinformation like an epidemic.

- S: Susceptible
- I: Infected
- Z: Skeptic
- E: Exposed

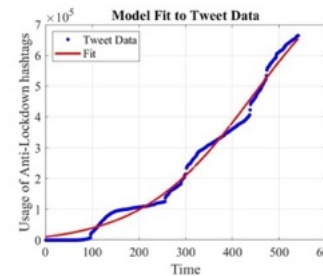


$$\frac{dS}{dt} = -\beta S \frac{I}{N} - bS \frac{Z}{N}$$

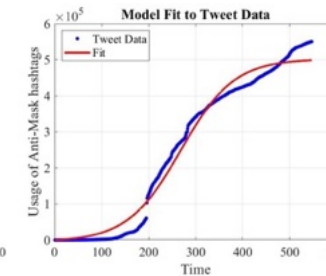
$$\frac{dE}{dt} = (1-p)\beta S \frac{I}{N} + (1-l)bS \frac{Z}{N} - \rho E \frac{I}{N} - \epsilon E$$

$$\frac{dI}{dt} = p\beta S \frac{I}{N} + \rho E \frac{I}{N} + \epsilon E$$

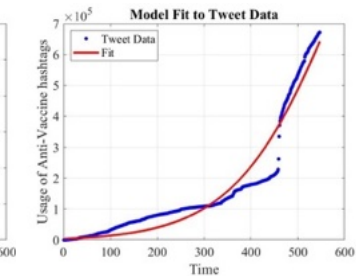
$$\frac{dZ}{dt} = lbS \frac{Z}{N}$$



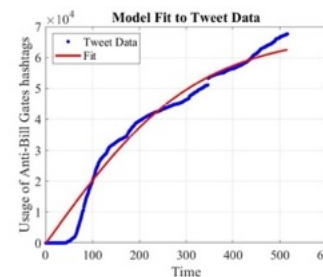
Anti lockdown 6.9% error



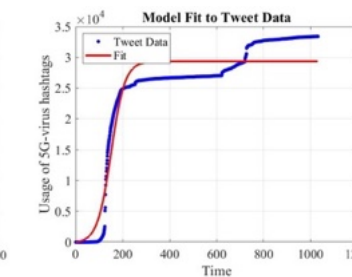
Anti mask 8.2% error



Anti vaccine 12.3% error



Anti Bill Gates 7.9% error



Anti 5G 9.5% error

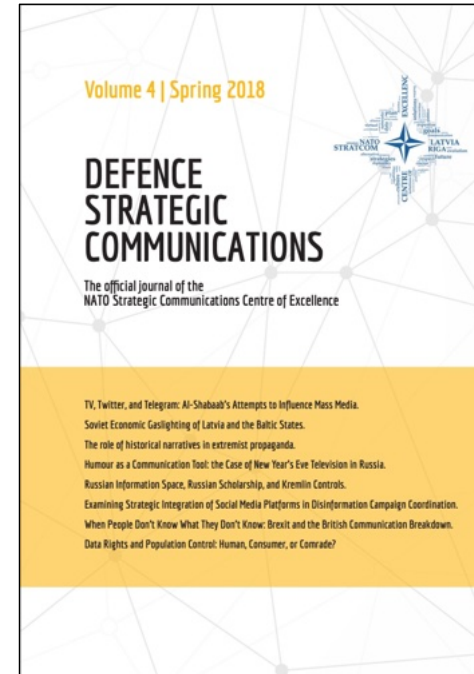
Maleki & Agarwal, HICSS 2022



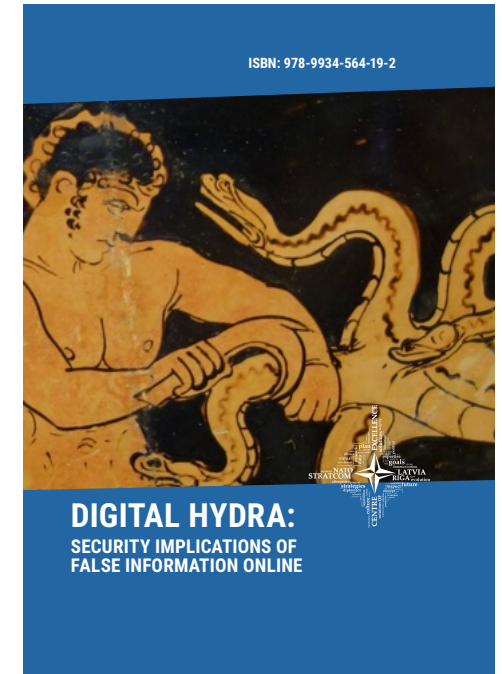
Research and Books



Published by Army University Press, in 7 volume book set on **Large-Scale Combat Operations**, in the book titled “Perceptions are Reality: Information Operations” (AUSA)



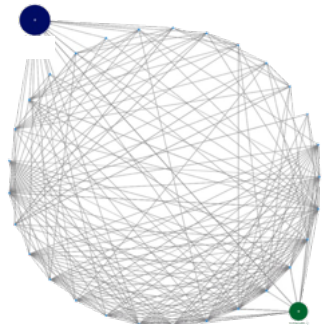
Examining Strategic Integration of Social Media Platforms in Disinformation Campaign Coordination. **Journal of NATO Defence Strategic Communications**



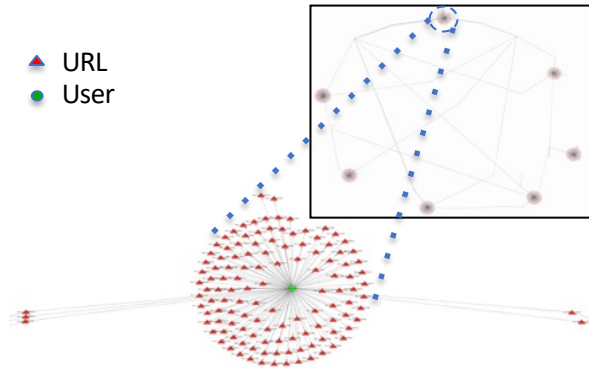
Blogs, Fake News, and Influence Operations. Digital Hydra: False Information Online as a Weapon, **NATO StratCom COE**.

From bots → botnets → social bots

Published by NATO StratCom COE



Mutual reciprocity.
IFYM & FMIF



▲ URL
● User

No mutual reciprocity.
Coordination in information network



Organizational hierarchy.
Core and peripheral bots



COORDINATION/BEHAVIOR COMPLEXITY



Crimean Invasion 2014



Dragoon Ride 2015

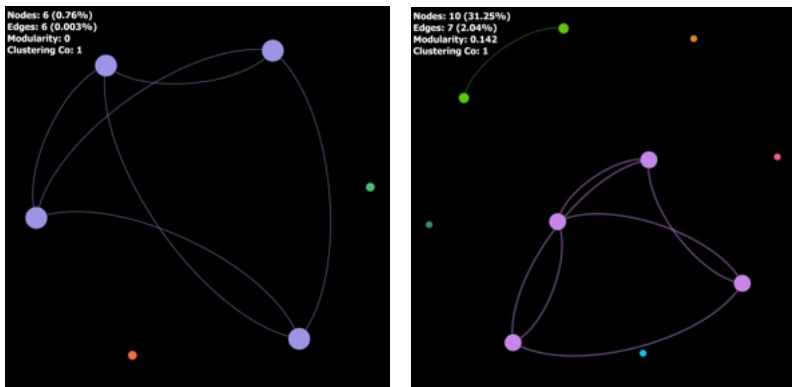


Trident Juncture 2015



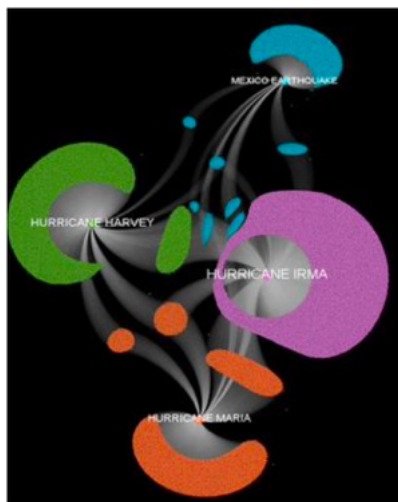
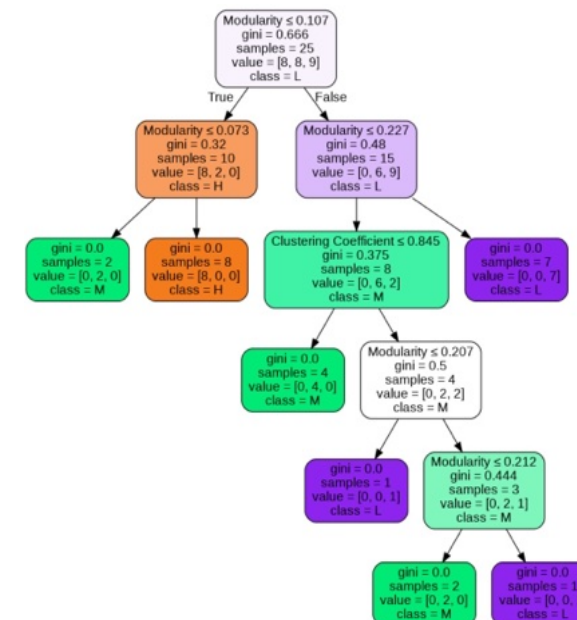
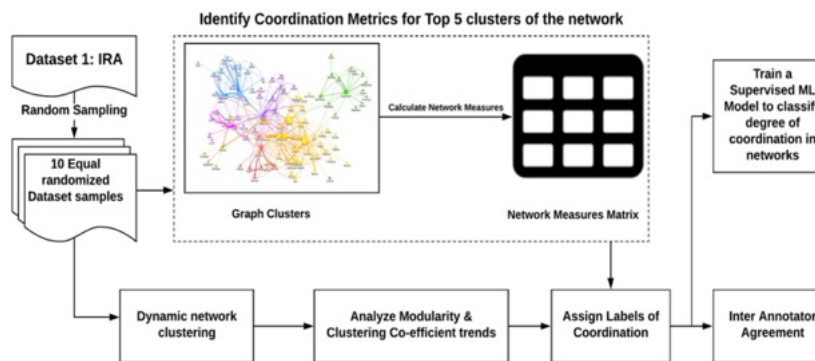
ISIS Propaganda 2016

Examining the Use of Botnets and their Evolution in Propaganda Dissemination. **Journal of NATO Defence Strategic Communications**



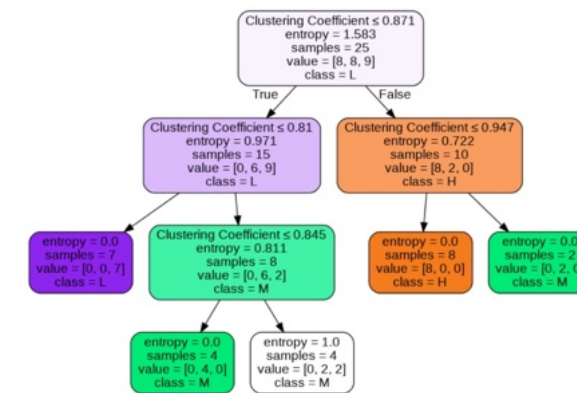
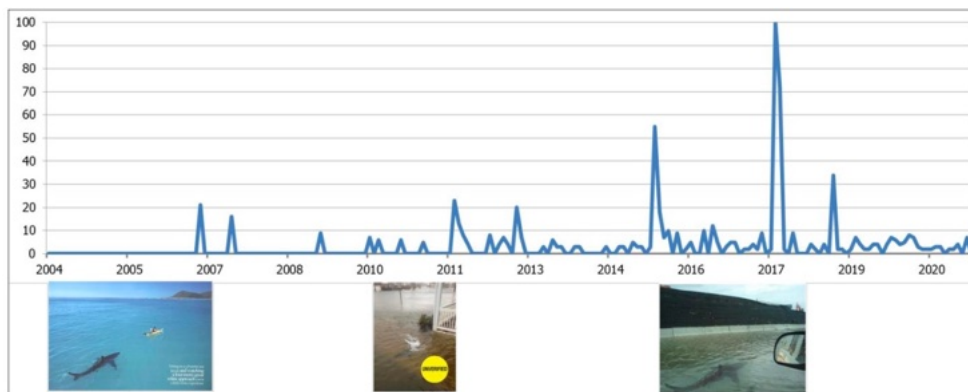
IRA Twitter bot data released by US Intelligence Agencies

Detecting coordination among Twitter social bots (Khaund & Agarwal, 2021) IEEE Transactions on Computational Social Systems (TCSS).

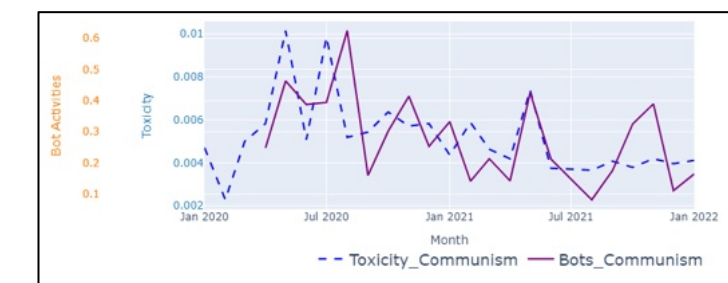
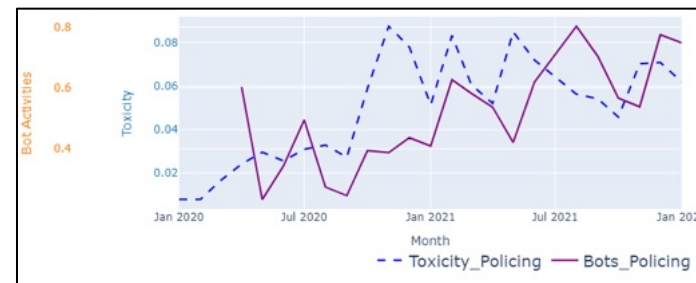
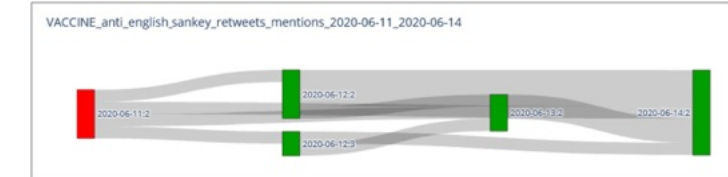
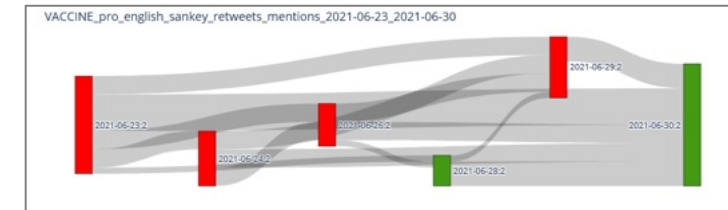
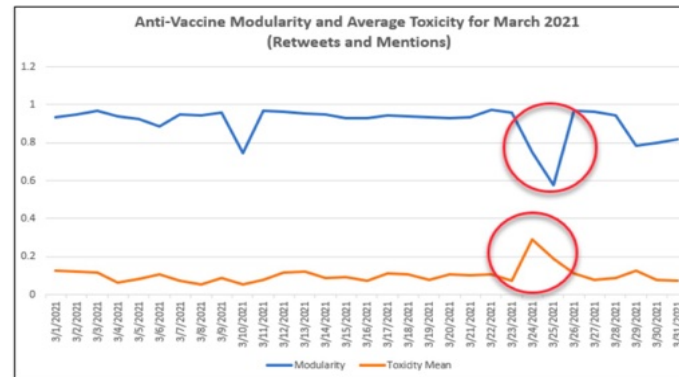
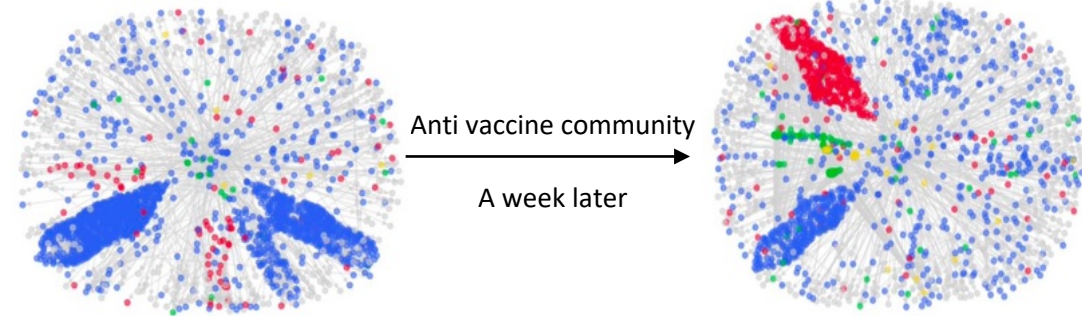


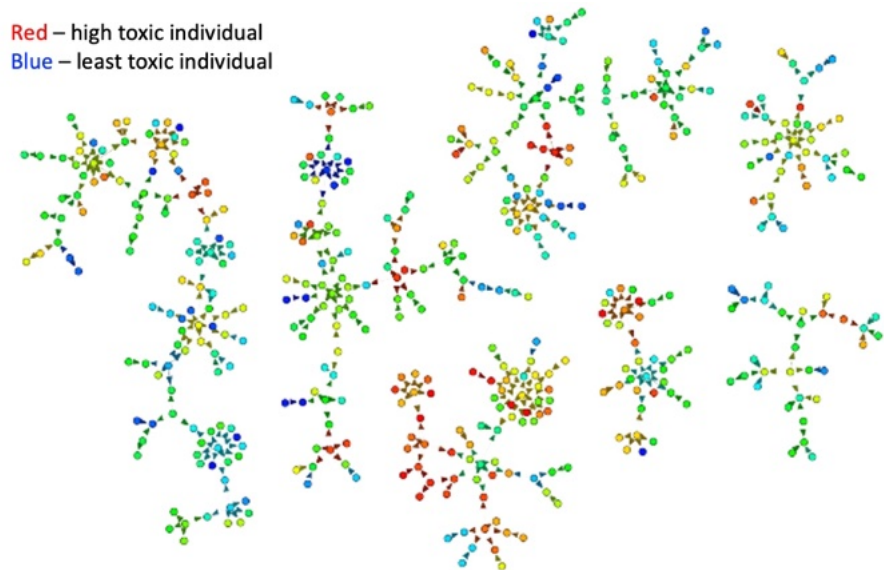
Language	Hashtag (Translation)
English	#DACA, #BlackLivesMatter
Spanish	#VenezuelaDemocraciaYDiálogo (Venezuela Democracy and Dialogue), #Cáncer (Cancer)
Arabic	(The demise Of Israel) #الارهاب (The Jews) #
French	#Nucléaire (Nuclear), #GendarmerieEnOpération (Gendarmierie Special Operations)
Mandarin	金正恩 (Kim Jong-un), 核试验 (Nuclear Test)

Bot coordinated misinformation during Hurricanes



- Toxic discourse causes disruption and polarization/ segregation among communities.
- Community splinters when toxicity rises.
- Granger causality test suggests the effect is strongest after two days.
- Bot activity found to be positively correlated with toxicity.
- Higher toxicity leads to community fracturing.
- This work shows a way to measure impact of bots.





Toxicity analysis on YouTube commenters. Toxic discourse causes disruption and polarization/segregation among communities, as seen above. We demonstrate that by removing highly toxic users from a network, hate speech reduces, online discourse improves, and fractured communities heal. Our findings offer guidance to policymakers within each online social network to make informed decisions about the information environment and derive appropriate and timely countermeasures to continue providing a healthy platform for their users.

STRS epidemiological model for toxicity propagation – Susceptible (S); Toxic (T); Recovered (R); Susceptible (S)

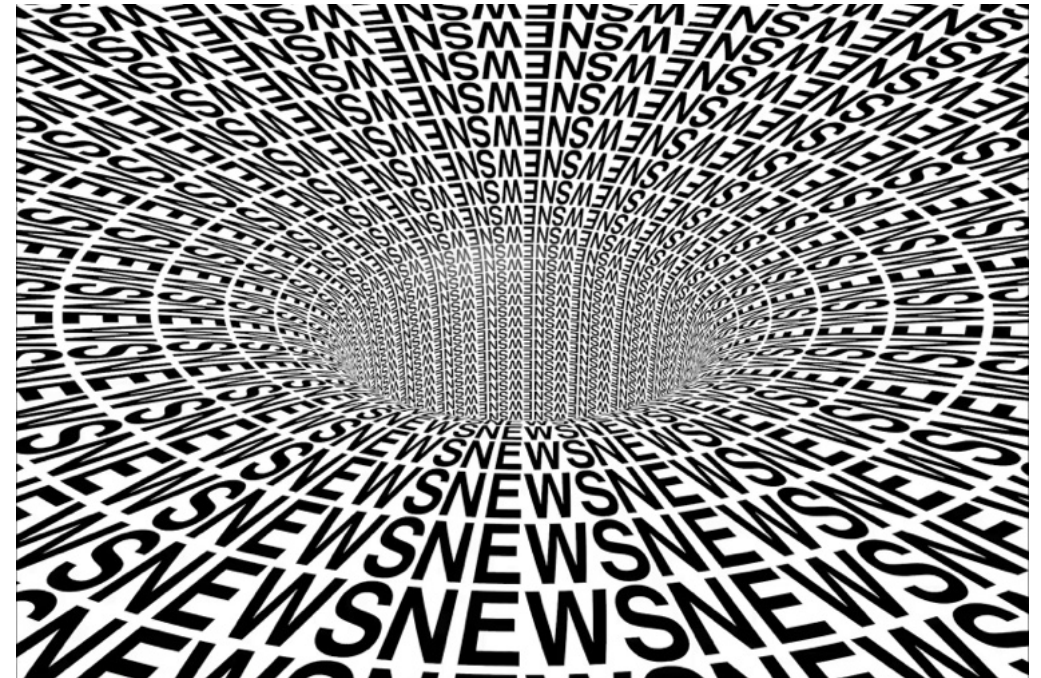
We demonstrate that by removing highly toxic users from a network, hate speech reduces, online discourse improves, and fractured communities heal. Our findings offer guidance to policymakers within each online social network to make informed decisions about the information environment and derive appropriate and timely countermeasures to continue providing a healthy platform for their users.

Experimental simulation	Toxicity score	Percentage reduction
Removal of top 10 users with high Betweenness centrality	0.720981759	0.21
Removal of top 10 users with high PageRank centrality	0.722317191	0.02
Removal of users with toxicity scores greater than 0.8	0.641927323	11.15

Agarwal et al. (2022). Applying an Epidemiological Model to Evaluate the Propagation of Toxicity related to COVID-19 on Twitter. The 55th Hawai'i International Conference on System Sciences ([HICSS](#)), January 4-7,, Maui.
 Agarwal, N. et al. (2021) Developing a Socio-Computational Approach to Examine Toxicity Propagation and Regulation in COVID-19 Discourse on YouTube. *Information Processing and Management Special issue on Dis/Misinformation Mining from Social Media*. Vol. 58, Issue 5, 2021. Elsevier.

Working with LinkedIn and Arkansas Office of the Attorney General

- AI-based recommendation algorithms that predict our shopping behaviors, books and articles to read, videos to watch lack transparency.
- Recommendation algorithm learns from behavioral data and perpetuates the underlying bias in its recommendations.
 - YouTube's recommendation algorithm is known to push its viewers down the conspiratorial rabbit hole by suggesting related videos.
 - On Facebook, ads to recruit delivery drivers for Domino's Pizza Inc. were disproportionately shown to men, while women were more likely to receive notices in recruiting shoppers for grocery-delivery service Instacart Inc.
- Explainable model could help in identifying causes of biased recommendations thereby enhancing the model's transparency.



- Channel characterization based on implicit algorithmic bias requires identification and measurement of bias.
 - Power law distribution fitting (exponent)
 - Gini coefficient - a single number that demonstrates a degree of inequality in a distribution of income/wealth.
- Characterization based on context -> COVID-19 context showed largest implicit algorithmic bias, marked in red.
- Characterization based on impact -> Implicit bias resulted in extremist content communities (far left and far right information bubbles).

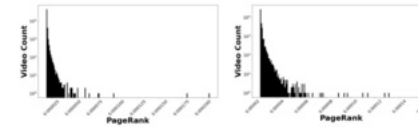


Fig. 1. Distribution of PageRank values in the recommendation graphs 1 (left) and 2 (right). We observe similar results in all recommendation graphs. The count of videos is represented in log scale on the y-axis.

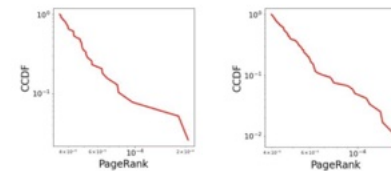
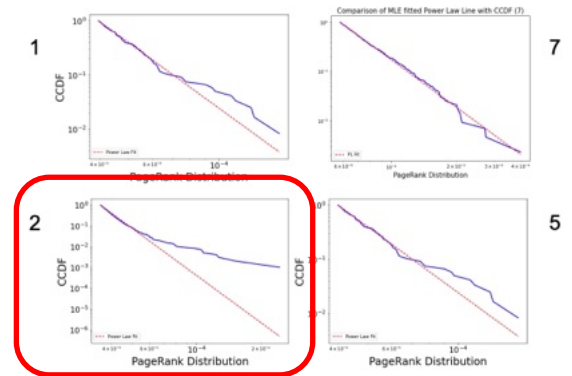
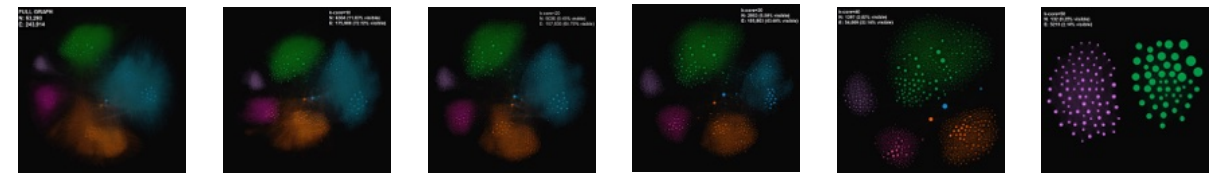


Fig. 2. Complementary Cumulative Distribution Function (CCDF) Plots of PageRank Scores in each Recommendation Graphs 1 (left) and 2 (right).

Topic drift and decrease in relevance was observed.

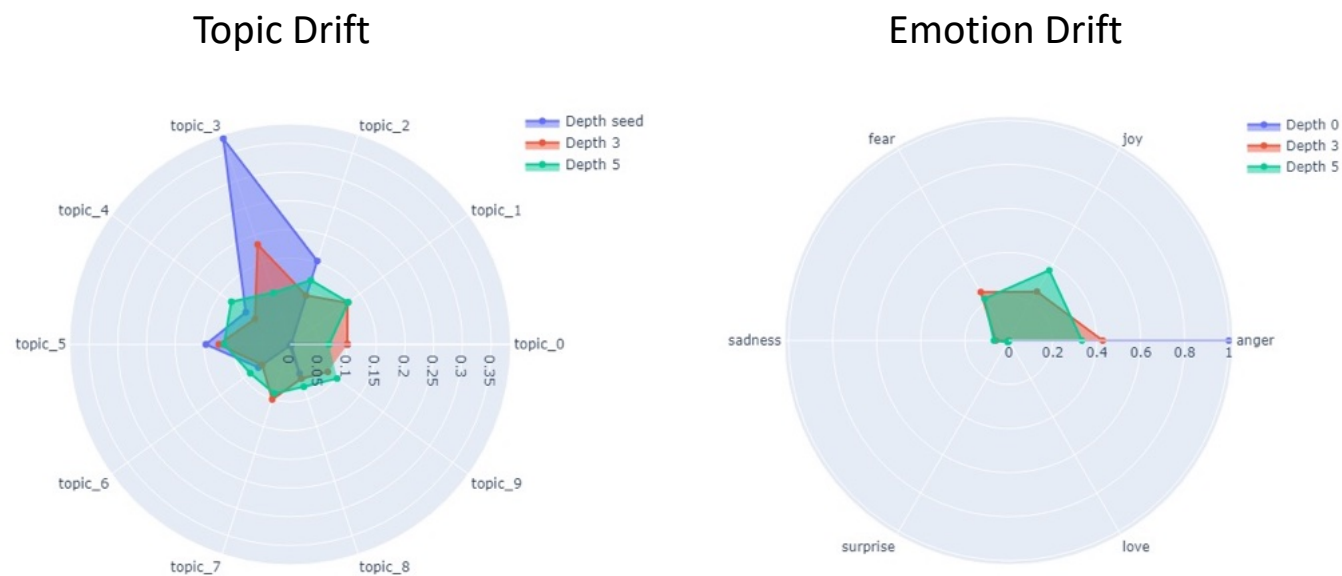
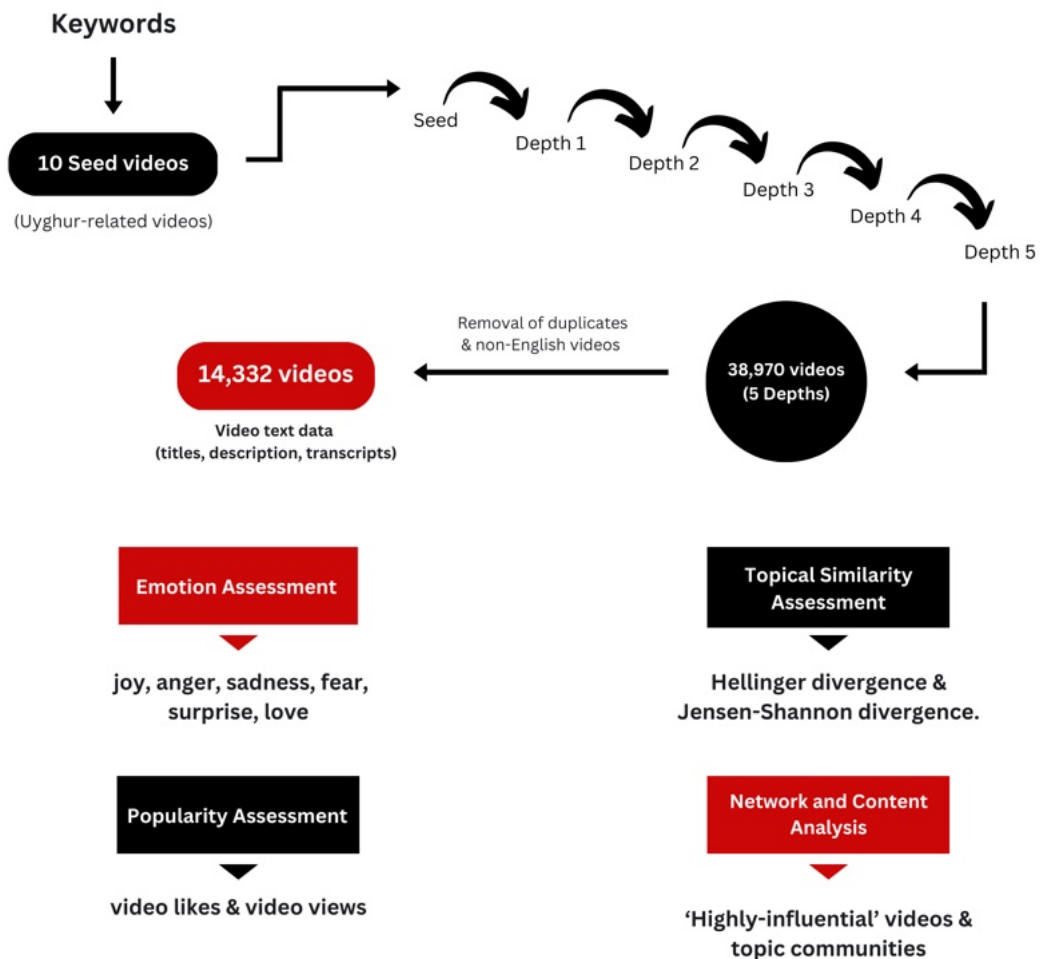


Top PageRank videos were removed weeks or months after their appearance in the recommendation network. Reason for content removal is violation of platform terms and services.



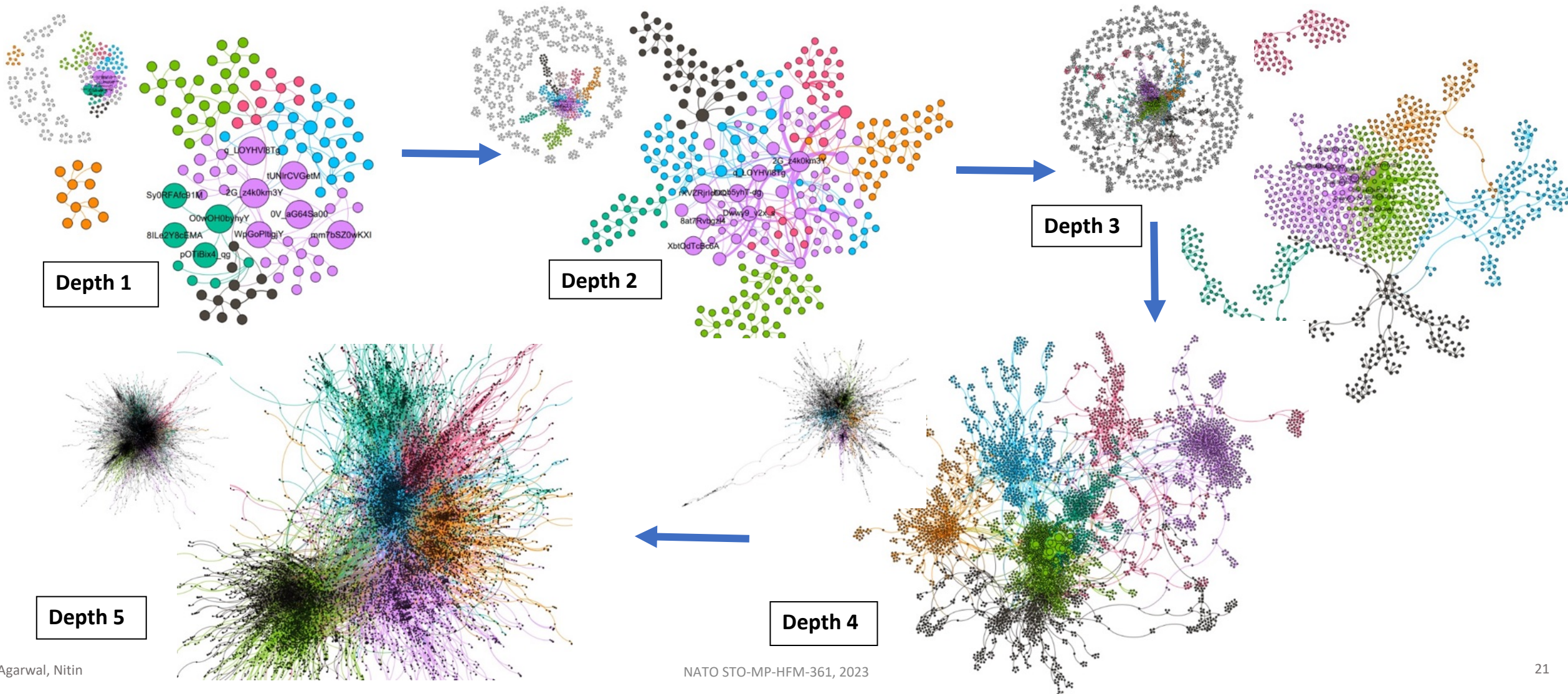
Far-left and far-right content communities/information bubbles resulting due to biased recommendations

Baris Kirdemir and Nitin Agarwal. Exploring Bias and Information Bubbles in YouTube's Video Recommendation Networks. The 10th International Conference on Complex Networks and their Applications (COMPLEX NETWORKS 2021), November 30 – December 2, 2021. Madrid, Spain



Agarwal et al. (2023). 45th European Conference on Information Retrieval (ECIR 2023), April 2 – 6, 2023, Dublin, Ireland.

Agarwal et al. (2023). 9th International Conference on Human and Social Analytics (HUSO 2023), March 13 – 17, 2023, Barcelona, Spain.



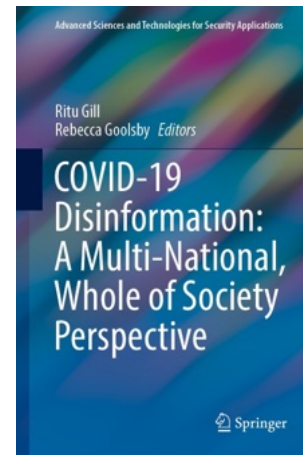
The collage features several key elements:

- Blogtrackers:** A dashboard for monitoring and suggesting content using current analysis.
- NATO Innovation Hub Website:** A page titled "CAN YOU SOLVE IT?" with the subtitle "The Invisible Threat: Countering Cognitive Warfare". It details the NATO Innovation Challenge, its purpose in addressing cognitive warfare, and lists organizing partners including the Department of National Defence (DND), Canadian Special Operations Forces Command (CANSOFCOM), IDEaS, ODU (Old Dominion University), and NATO Allied Command Transformation.
- Tweet:** A tweet from @NATOinnovation announcing the finalists: ADTAC, Beam Me Up, COSMOS, Deloitte, Influence Influencers, IIDR, Novacene AI, Preveny, Shumac, and Veriphix. It includes a link to watch the final live on 30 Nov at ow.ly/Ec2W50GSM0w with hashtags #WeAreNATO and #Innovation.
- Social Media Post:** A post with a line graph showing data trends over time, with a title partially visible as "Fast-Thinking Captain Saves 6,000-Ton Frigate with Unorthodox Grounding Order".

NATO member nations at Stratcom COE, US CYBER COMMAND, US Recognized as top 1000 teams in the 2021 NATO Innovation Hub Challenge on "The Invisible Threat: Countering Cognitive Warfare" from 132 teams across the 30 NATO member nations.



- COVID-19 Misinformation Tracker recognized by the **World Health Organization (WHO)** as one of the key technological innovations developed across the world to address COVID-19 pandemic.
- The capability was developed in partnership with the **Arkansas Office of the Attorney General**.
- The application leverages our work on socio-cognitive threat modeling, education, and awareness efforts to assist policymakers.



NATO Research and Technology Group (RTG HFM-293), 2022

Shared research with

- **U.S. Senator John Boozman** (Member, Senate Appropriations Committee)
- **U.S. Senator Ed Markey** (Member, Senate Committee on Foreign Affairs; Chairman, Subcommittee On East Asia, The Pacific, And International Cybersecurity Policy; Member, Subcommittee On Near East, South Asia, Central Asia, And Counterterrorism)
- **U.S. Senator Elizabeth Warren** (Member, Senate Committee on Armed Services, Subcommittee on Emerging Threats and Capabilities)

COSMOS Tools:

- **Blogtrackers** - <https://btracker.host.ualr.edu>
- **YouTubeTracker** - <https://vtracker.host.ualr.edu>
- **Focal Structure Analysis** - <http://fsa.host.ualr.edu/>
- **COVID-19 Misinfo Tracker** - <https://cosmos.ualr.edu/covid-19>



Blogtrackers

vtracker



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