First Six Months of War from Ukrainian Topic and Sentiment Analysis

Clara Maathuis[1] and Iddo Kerkhof[2]
[1]Open University of the Netherlands, Heerlen, Netherlands
[2]Independent Researcher, Netherlands

clara.maathuis@ou.nl
email@iddo.eu

Abstract: Through technological advancements as well as due to societal trends and developments, social media became an active part and a catalysator of the ongoing conflicts and wars carried out in the physical environment. A direct example on this behalf are the cyber/information operations currently conducted in conjunction with the ongoing Russian-Ukrainian war. Due to such operations packaged in social media manipulation mechanisms like disinformation and misinformation using techniques such as controversies, fake news, and deep fakes, a high degree of confusion and uncertainty surrounds the events happened and users' behaviour and beliefs. These operations also impact the civilians directly affected in the battlefield or their dear and known ones. To tackle this issue, currently limited scientific and objective effort is dedicated in this direction due to, e.g., data, strategic, and emotional implications. It is then the aim of this research to capture the main topics discussed and the feeling expressed by Ukrainian Telegram users on the ongoing Russian-Ukrainian war in 2022 using a Data Science approach by building a series of Machine Learning models based on multi-channel data collected in the first six of months of war. Accordingly, this research directly aims to contribute to efforts on understanding real discourses and dynamics involved in the ongoing conflict through direct resources, producing and sustaining social media security awareness, and building resilience to social media manipulation campaigns using AI.

Keywords: information operations, machine learning, topic modelling, sentiment analysis, Ukraine war, Telegram.

1. Introduction

"We must learn to regard people less in the light of what they do or omit to do, and more in the light of what they suffer." (Dietrich Bonhoeffer)

As a socio-technical system initially built upon the web 2.0 standard using powerful engines facilitating content creation, exchange, interaction, and interpretation, the social media environment evolved to a space of opinions and a battlefield between either physical and/or digital agents (Dodonov et al., 2019) through e.g., discourses and narratives manipulation based on mechanisms such as disinformation and misinformation, radical ideologies, and even silencing alternatives of opinions conducting activities like influencing political decision-making, encouragement of anti-government movements/protests, influencing and confusing perceptions and actions of young generations to accept/follow radical agendas, planning and conducting cyber operations (Haroro, 2015; Alassad, Spann & Agarwal, 2021; Maathuis, 2022a). Such activities for influencing users' behaviours, attitudes, and beliefs in relation to the ongoing war in Ukraine are carried out in different social media platforms like Facebook, Twitter, and Telegram. However, while a vast number of studies investigate different dimensions of this conflict through strategic, financial, legal, and ethical lenses, limited attention to Ukrainian voices and perspectives is given (Vorbrugg & Bluwstein, 2022). Aforesaid research facilitates building transparent (intelligent) approaches for social opinion analysis, politics characterization, and user relationships understanding (Zhu et al., 2022; Maathuis, 2022b). This gap directly applies to Telegram analytics in relation to the ongoing war in Ukraine although this social media platform is still the dominant platform in the field (Höhn, Mauw & Asher, 2022; NPR, 2022). Hence, this aim of this research is to build intelligent mechanisms for capturing topics discussed and corresponding sentiments of Ukrainian Telegram users. This further translates to intending to find answers to the following research questions:

- RQ1: How to capture and analyze the topics discussed and sentiments associated with them in Ukrainian language from the first six months of conflict in Ukraine?

- RQ2: What are the topics discussed and corresponding sentiments of Ukrainians in the first six months of conflict in Ukraine?

To find answers to the above formulated research questions while acknowledging the multidisciplinary nature of this research, its societal role, and its underlying technical origins, a Design Science Research methodology is taken through a Data Science research approach having the following contributions:

- In respect with the technical nature, a mix of Machine Learning techniques is considered for building intelligent solutions for extracting and analyzing topics and their corresponding sentiments based on a dataset containing messages of Ukrainian speaking Telegram users in the first six months of war, i.e., from February 24, 2022, to August 23, 2022.

- In respect with the social nature, the topics extracted, and corresponding sentiments analysed are depicted and further related to corresponding academic and societal efforts.

The outline of this article is structured as follows. Section 2 tackles the context and related studies to this research focusing on both social as well as technical dimensions and approaches. Section 3 discusses the research approach taken, i.e., Design Science Research methodology in a Data Science setting. Section 4 section introduces the dataset built and the implementation of the two analytical mechanisms using different ML techniques, meaning topic modelling and sentiment analysis. Section 5 reflects on the results obtained. Conclusively, Section 6 discusses the findings of this research and future research perspectives.

2. Related Research

Given the vast flow of information in the social media discourses and narratives surrounding different conflicts, Alassad, Spann & Agarwal (2021) propose a method for identifying malicious behaviour with corresponding actors responsible for propagating this behaviour using methods like focal structure analysis for further gathering information about the actors conducting them and preventing future attacks. On malicious threats conducting social media manipulation campaigns and operations, Cinelli et al., (2019) argue that the nature of information threats is defined by social dynamics and cognitive layer of users involved since a noticeable tendency of users to interact with and reason about information adhering to their preferred narrative exists. In these lines, confirmation bias plays a role in users' decisions on grasping/spreading information, and to increase users' ability to tackling/countering {dis, mis}information and increase effective communication, smoothing polarization is mandatory. Among the methods to analyze and understand such aspects are AI-based methods like topic modelling and sentiment analysis. Waissbluth et al., (2022) conduct a domain-level analysis to investigate if a domain is complicit in distributing or amplifying disinformation based on Telegram and Twitter social media platforms for enhancing trust and sanity in online communities. On this behalf, Sokolova et al. (2016) execute a topic modelling and event identification analysis using LDA (Latent Dirichlet Allocation) on four datasets surrounding challenging social events from Kenya proving the effectivity of extracting and summarizing discourse topics for further supporting analytical and decision-making processes. Agüero-Torales, Salas & López-Herrera (2021) conduct an extensive literature review on sentiment analysis on social media discourses using deep learning techniques for capturing underlying ideas and commonalities on the solutions proposed acknowledging facts like cross-lingual interest and trend of using less complex learning architectures. Moreover, Ates et al., (2021) build a series of solutions for understanding the dynamics involved in the use of social media communities of gendarmerie and police organizations from Turkiye, Italy, France, and Spain. Applied in the context of the Covid-19 pandemic, Tsao et al., (2021) perform a systematic literature review on social media discourses and narratives capturing public attitudes, identifying infodemics, mental health issues, governmental responses, and health information quality with the issue of real-time surveillance and advancements of social manipulation mechanisms based on large and diverse social platforms datasets. Going further to the context of the ongoing war carried out in Ukraine, it is important to acknowledge the dynamics involved in war inside and through media channels acknowledging the role that media plays when reporting conflict events, i.e., crtiical observer, publicist, and constructor of strategies, tactics, and activities taken Thussu & Freedman (2012). On this behalf, Maathuis, Pieters & van den Berg (2018b) conduct an in-depth analysis of cyber operations carried out on different targets and multiple settings in Ukraine since 2014 and Vorbrugg & Bluwstein (2022) address the media attention to events happening in Ukraine acknowledging major events from 2014 and 2022, i.e., the annexation of Crimea and ongoing war, while further depicting media narratives and usual representations of Ukraine which tend to be single angled, e.g., the Euromaidan country, political divided civil society, and heroic freedom fighters. The authors further acknowledge the need to provide a place in current academic, practitioner, and media discourses to Ukrainian people for having a multi-angled and realistic perspectives of the ongoing events. This point directly resonates with the scope and motivation behind our research and article.

Furthermore, Agarwal, Punn & Sonbhadra (2022) analyze Twitter public sentiments before and during the start of the war, i.e., December 31, 2021 to March, 03, 2022. Alassad, Spann & Agarwal (2021) execute a topic modelling analysis on Twitter for capturing and understanding climate changing and global warming important topics and surrounding discourses written by both human users as well as bots. The results obtained show that

82.5% believe that climate change is a human-made or anthropogenic issue while the percentage of the users who believe in global warming being of human causation is much lower. At the same time, the authors find clearly polarized views with politicians being cited and trolled in corresponding online discussions. Ibar-Alonso et al. (2022) investigate the sentiments around green energy on Twitter content surrounding the beginning of the war in Ukraine. The results obtained reveal that the ongoing conflict changed society's sentiments about energy transition to green energy. Moreover, Ngo et al., (2022) analyze the public sentiment of Facebook users from 109 countries in relation to the economic sanctions applied to Russia which reveal an increase of public condemnation against this conflict. The crucial ingredient for building such models is data. Accordingly, Höhn, Mauw & Asher (2022) propose a Telegram repository created by these authors with content in Russian and Belarussian languages covering the presidential elections in Belarus and the protests carried out in the country after the elections. Haq et al., (2022) provide a Twitter dataset from the first week of the conflict between Russia and Ukraine with over 1.6 million tweets for building analytical and predictive solutions for understanding existing cyber/information influence campaigns conducted on both sides. Along these lines, Fung & Ji (2022) propose a dataset with Twitter and Weibo content from the same period of time for further analytical purposes, and Chen, E., & Ferrara (2022) bring a a rich dataset with over 63 million tweets between February 22, 2022, to March 8, 2022, for discourse analysis and social media manipulation detection solutions. Moreover, Park et al., (2022) propose a dataset starting from January 2021 up to May 2022 containing more than 21 million Russian social media posts and comments from Twitter and VKontakte (social platform seen as the Russian Facebook) for directly capturing discourses, topics, and corresponding Russian public sentiments. In this manner, Zhu et al., (2022) advance a dataset containing 300.000 posts and 9 million comments collectively from Reddit regarding military related discourses on the ongoing Russian-Ukrainian conflict.

Grounded on the studies above discussed, textual AI-based techniques show their potential when understanding public sentiments and extraction of relevant topics discussed in different social media narratives and discourses in general as well as in relation to the ongoing war in Ukraine. However, while research projects dedicated to social media platforms like Facebook and Twitter exist, limited attention and projects are dedicated to other social media platforms like Telegram. Hence, this is the knowledge gap identified and tackled in the present research focusing on the first six months of war in 2022.

3. Research Methodology

As this research aims at capturing topics and sentiments of Telegram Ukrainian speaking users by building a set of Machine Learning models and given the multidisciplinary nature of this research by merging AI, social media, and international relations domains, a Data Science approach is taken following the Design Science Research methodology (Shearer, 2000; Peffers et al., 2007; Peffers, Tuunanen & Niehaves, 2018; Maathuis, Pieters & van den Berg, 2018). Henceforward, the following research phases are involved:

In the first phase (Problem identification and aim definition), the problem to be investigated is established and its corresponding goal is defined. In these lines, seeing that Telegram is the most used social media platform in Ukraine and one of the most used ones in Russia during the ongoing war (Allyn, 2022), and the existing knowledge gap regarding the lack of discourse and sentiment analysis herein compared to other ones like Twitter and Facebook, this research aims to investigate discourses and sentiments of Ukrainian speakers in Telegram in the first six months of the ongoing conflict, i.e., since February 24, 2022 up to August 23, 2022.

In the second phase (Design and Development), the necessary data is collected, and corresponding discourse and sentiment analysis models are built. On this behalf, a series of ML-based models for multi-channel topic modelling and sentiment analysis are built and further presented in this research.

In the third phase (Evaluation and Communication), the results obtained are analysed and positioned in the ongoing discourses in a transparent and objective manner (Maathuis, 2022c). Moreover, the findings of this research are transmitted by means of this article and corresponding scientific presentations.

4. Dataset and Model Implementation

To achieve the aim of this research, data is collected from multiple Telegram channels between February 24, 2022, to August 23, 2022, i.e., the first six months of the ongoing war. The dataset contains 45897 unique messages with date and text body in Ukrainian. Accordingly, the translation is performed using the Google Translate API which uses different deep learning techniques such as natural language translation (Google Translate, 2022). Then the dataset goes through the data pre-processing phase where the duplicates,

punctuation, stop words (e.g., in, at) etc. are removed. Furthermore, Parts of Speech (PoS) tagging is applied for assigning a grammatical label corresponding the to grammatical function of the word in a sentence (e.g., verb, noun) and lemmatization is performed for shrinking words to their semantic root or base, i.e., lemma. Once the data is prepared, a series of Machine Learning models are built for analyzing the topics and sentiments of the users using topic modelling and sentiment analysis mechanisms.

In topic modelling, the underlying semantic structure of the text being analyzed is discovered by identifying and clustering the themes found as topics tackled (Zhao et al., 2021) which facilitates the interpretability and understanding of the core structure in the analyzed corresponding discourses (Blei & Lafferty, 2007). Herein, Non-negative Matrix Factorization with Kullback-Leibler Divergence algorithms are applied for shrinking the text analysed using a factor analysis method for issuing reduced weightage or significance for the less coherent words using the KL objective function (Lee & Seung, 2000; Blei, Ng & Jordan, 2003; Sokolova et al., 2016; Hien & Gillis, 2021). Accordingly, in Figure 1 are depicted segments of the implementation done for topic modelling.

```python
for topic_idx, weights_per_word in enumerate(topic_word_matrix):
    top_word_indexes = weights_per_word.argsort()[:-n_top_words - 1:-1]
    topic_words = [word_list[i] for i in top_word_indexes]
    weights = weights_per_word[top_word_indexes]
    ...
message_topic_matrix, topic_word_matrix = get_topic_matrixes_with_NMF(message_word_matrix, nmf)
assign_topics_to_messages(message_infos, message_topic_matrix)
topic_word_weight_matrix = get_topic_words_and_weights(topic_word_matrix,
                                                       word_list=word_list,
                                                       n_top_words=n_top_words)
```

Figure 1. Selection of topic modelling source code

In sentiment analysis, the underlying thoughts, opinions, attiutdes, emotions, and feelings of users on different cnocepts, processes, systens, or events are captured and classified as being, e.g., objective or subjective, positive, neutral, or negative (Birjali, Kasri & Beni-Hsssane, 2019; Ates, E. C., Bostanci, E., & Guzel, 2021). In this research, the sentiments are classified as positive and negative in respect to the topic and per day using the pre-trained classifier model and library Flair (Magajna, 2022). Correspondingly, Figure 2 illustrates segments of the implementation done for sentiment analysis.

```python
if sentence.tag == 'POSITIVE':
    message_info.sentiment_score = sentence.score
else:  # NEGATIVE
    message_info.sentiment_score = -1.0 * sentence.score
    ...
print('Starting sentiment analysis')
for message_info in message_infos:
    set_sentiment_score(message_info)
    count += 1
    show_progress(count)
print('\nFinished sentiment analysis')
```

Figure 2. Selection of sentiment analysis source code

5. Results

In previous section implementation choices and particularities considered in this research are discussed. Hence, due to space constraints a random selection of the results obtained based on applying both topic modelling and sentiment analysis mechanisms and corresponding algorithms is further depicted considering 9 topics per day and 300 topics for the whole period of six months together with their corresopnding sentiments. Accordingly, to show the progress and diversity of the topics discussed a selection is made from February 24, April, 24, June 24, and August 23 days and depicted in Figure 3.

Furthermore, corresponding sentiment scores with the count of messages per topics are computed and illustrated in Figure 4. Thenceforth, a selection of ten topics is captured from the entire period with nine words characterizing them together with their associated weights and sentiment scores plotted against the number of messages for showing the progress and diversity of the topics discussed. Moreover, the negative nature of the sentiment characterizing the whole period given the hardships experienced by Ukrainian people during this war is depicted in Figure 5. Accordingly, with dark blue are depicted the weights of words, with light blue is represented the number of messages, and with red are illustrated the sentiment scores. Conclusively, the

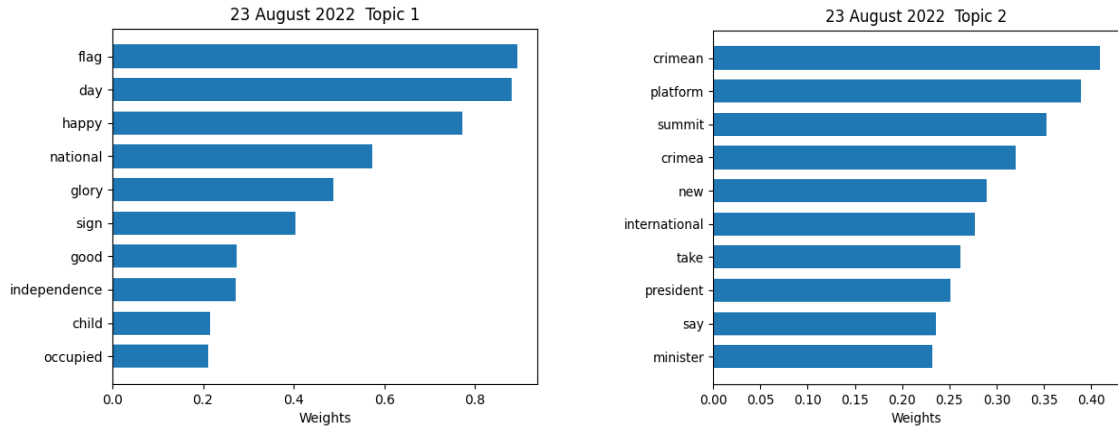sentiment score per day is captured in Figure 6.
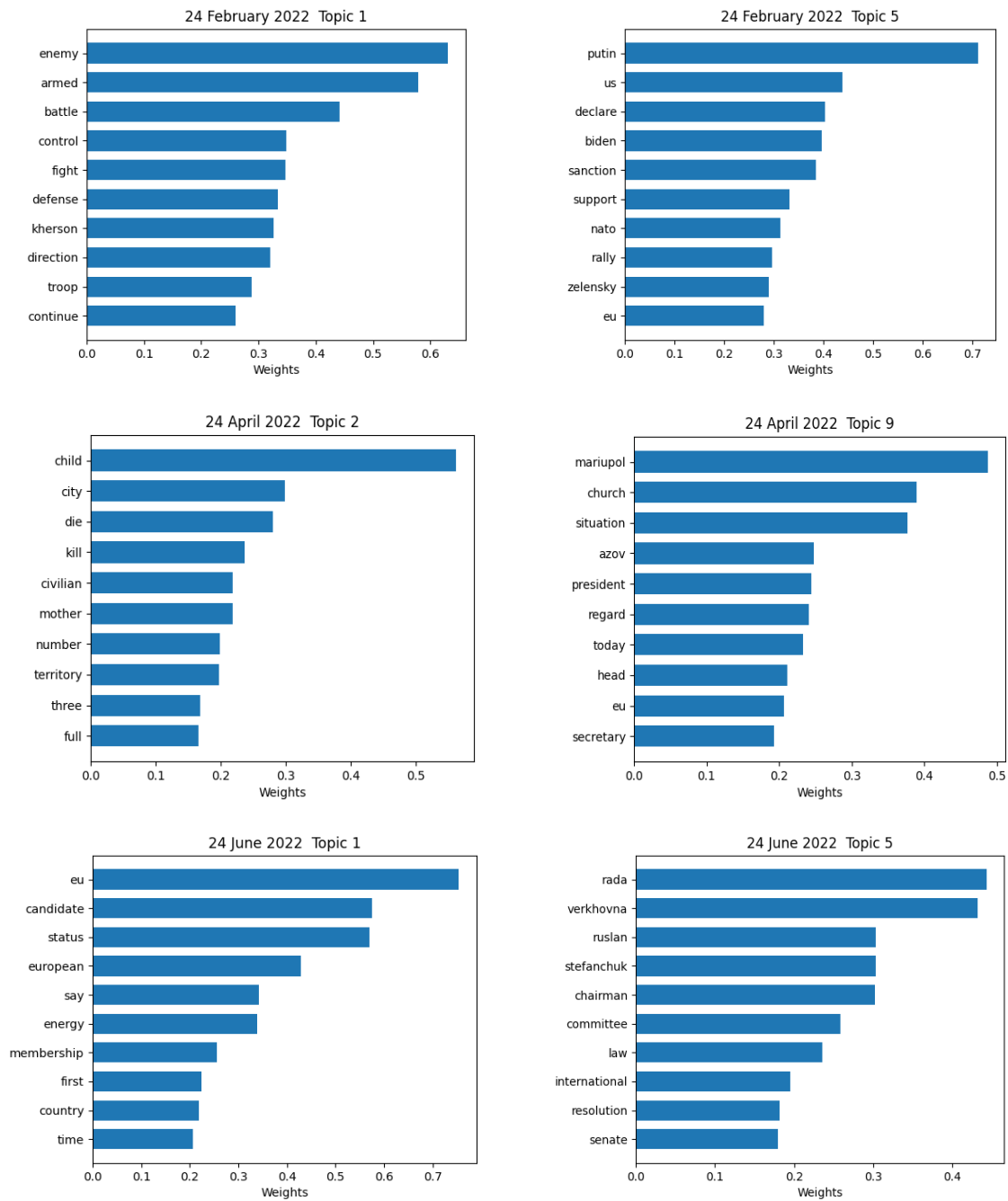
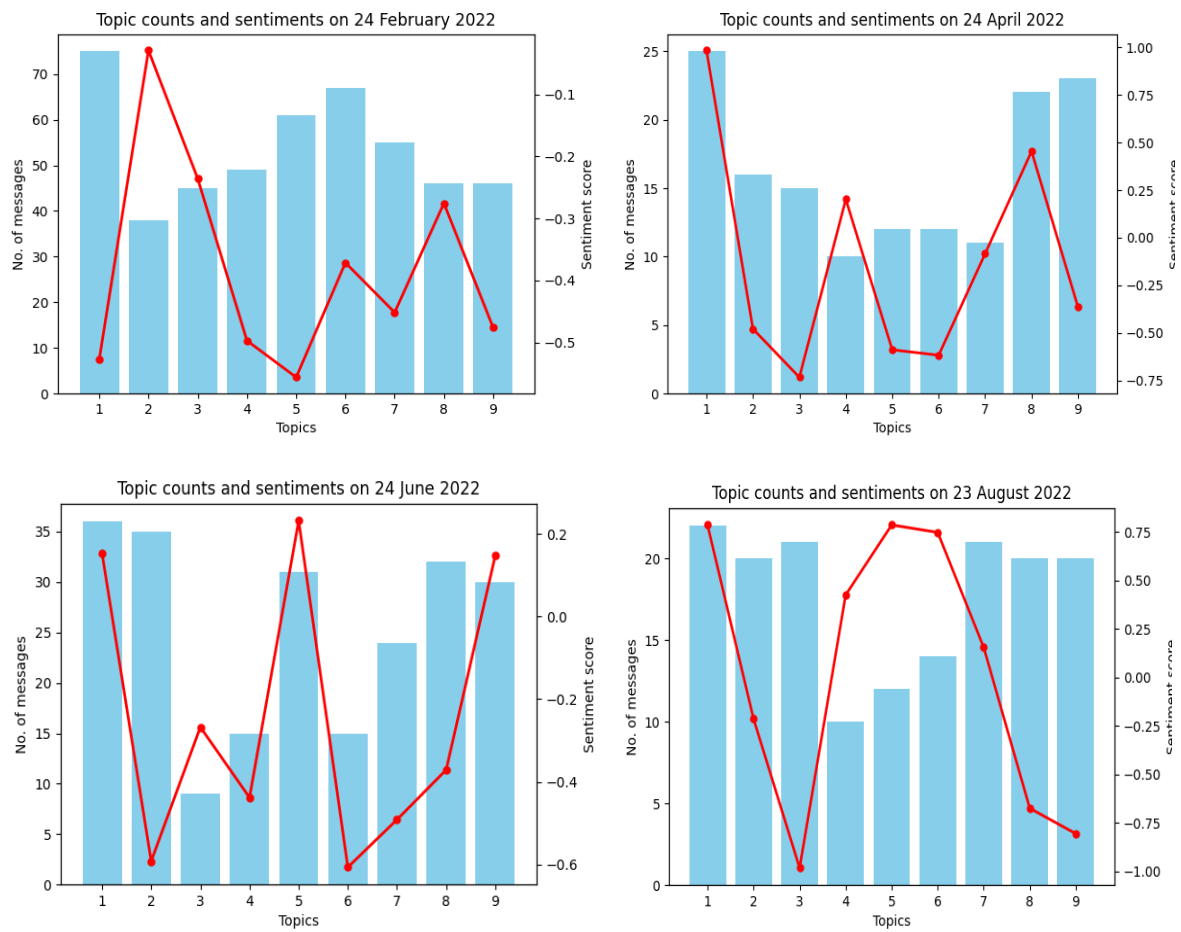**Figure 3. Topics discussed on February 24, April, 24, June 24, and August 23, 2022 (selection)**
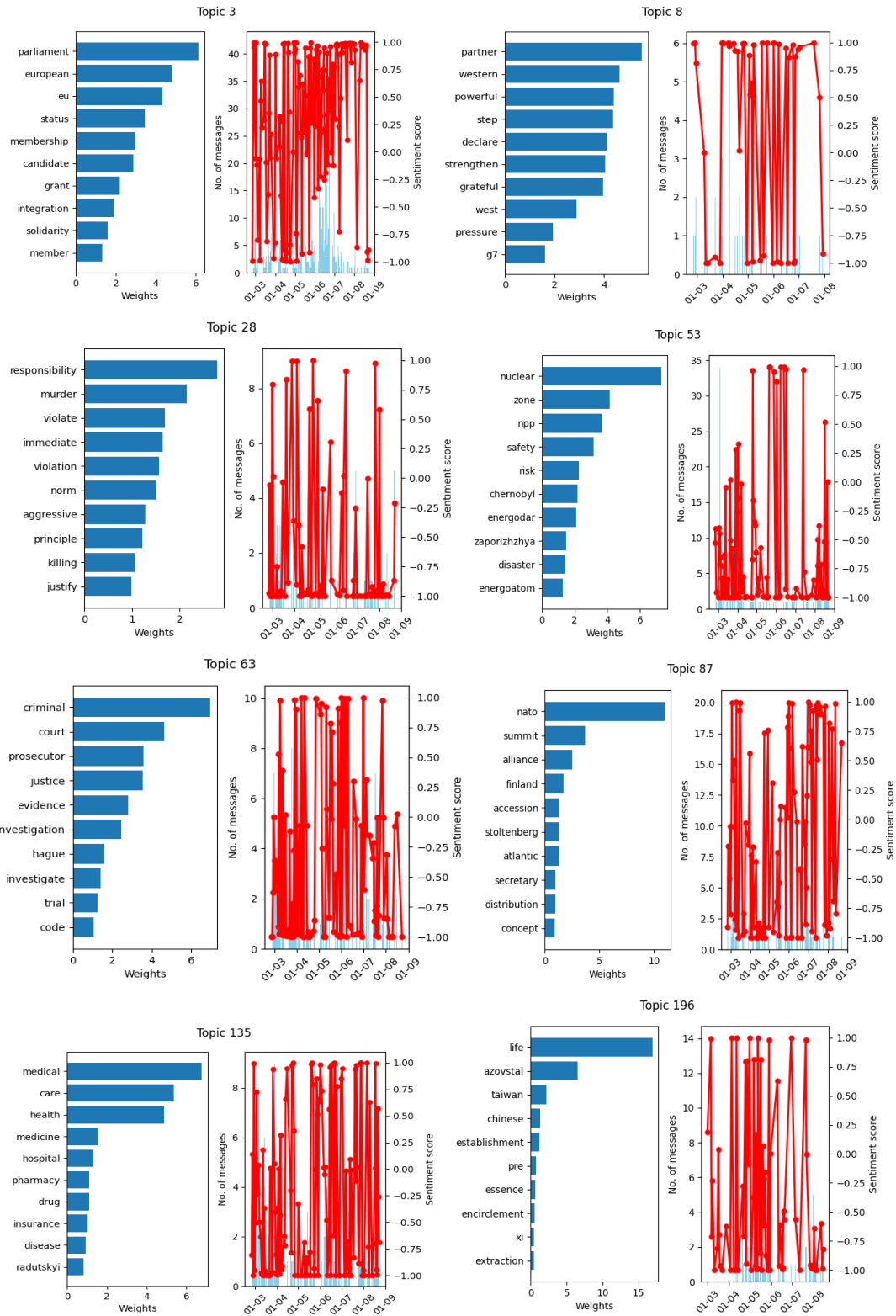

Figure 4. Topics count and sentiments for February 24, April, 24, June 24, and August 23, 2022
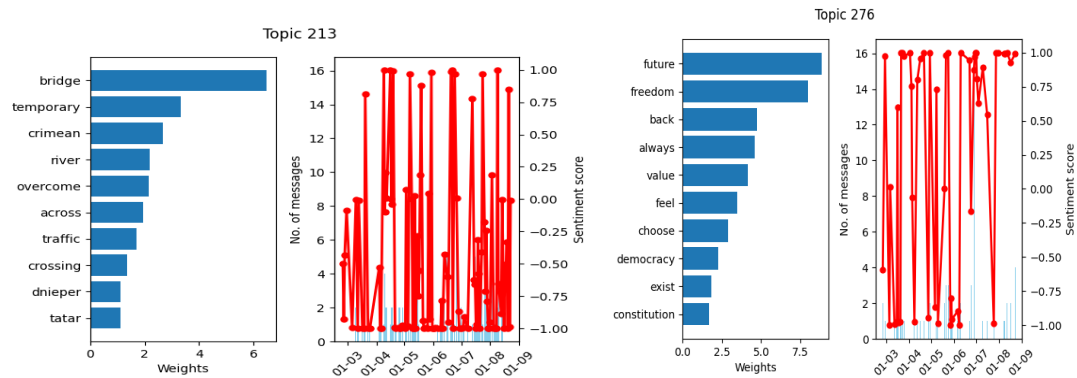
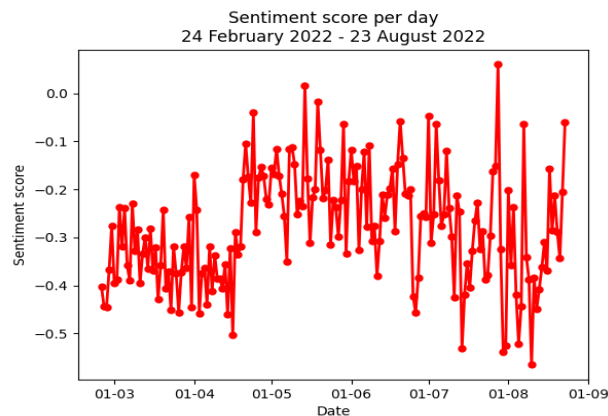**Figure 5. Selected topics for the entire analyzed period.**

Figure 6. Sentiment score per day for the entire analyzed period.

Based on the approach taken and results obtained, topics like *armed, Zelensky, child, Mariupol, European, resolution, nuclear, investigation, NATO, hospital, establishment, Crimean,* and *freedom* are identified and it can be seen that they match former as well as ongoing news coming from different media channels, interviews with both subject matter experts, political representatives, and field population as well as academic researchers and practitioners trying to understand and be solitaire from different disciplines, angles, and roles through, e.g., refugees relocation to safe places as well as strategic, financial, and medical support dedicated to diverse plans and activities inside Ukraine (UN Secretary General, 2022; UNHCR, 2022; UN News, 2022; EU, 2022a; NATO, 2022; Levy & Leaning, 2022; Rawtani et al., 2022; Ben Hassen & El Bilali, 2022; Kammer et al., 2022; Marchese et al., 2022). In particular, the topics identified reveal the struggle of Ukrainian people going through these difficult moments and inside the general negative tendency, their corresponding sentiments vary in a way depending on the situation and moment in time as it can be seen for instance at the beginning of the conflict in February as well as a slight increase in positivity around EU candidacy in June and the Independence Day of Ukraine in August.

6. Conclusions

In social media, the information is built, encapsulated, and further transmitted as content through different discourses and narratives that can reach at incredible speeds global audiences. While the corresponding content may contain real aspects and facts characterizing the real world, cyber world, or both, it can also contain altered or manipulated (segments of) information that changes the sense of information as a virtue (Nakayama, 2022) and corresponding user behaviour, beliefs, and attitudes (Maathuis & Chockalingam, 2022) through social manipulation mechanisms like disinformation and misinformation which exploit both technical as well as human (un)known vulnerabilities (Tsao et al., 2021). These facts can be seen in the ongoing war carried out in Ukraine, which is pulled in more directions (Mbah & Wasum, 2022) through different visions, expectations, and tackling mechanisms, different strategies and corresponding means are used for engaging a broad range of targets through both physical and digital methods. Correspondingly, activities like manipulated textual narratives regarding stories such as the Kyiv Ghost, fake live streams from the field showing realistic hard footages that seemed real to produce audience deception, and deep fakes with the President Zelensky to influence population

behaviour (Stănescu, 2022). Hence, to be able to understand the events and perspectives in a realistic way and further building (intelligent) solutions for tackling and/or countering such social media manipulation mechanisms, data containing Ukrainian voices is needed (Vorbrugg & Bluwstein 2022), but, to the best of our knowledge, its presence is limited in both academic and practitioner discourses and corresponding approaches.

For tackling this knowledge gap, this article builds an AI-based solution as an artefact constructed using the Design Science Research methodology taking a Data Science approach by aiming at gathering and analysing multi-channel Telegram Ukrainian discourses carried out in the first six months of war by Ukrainian speakers. It does that by formulating two research questions. For the first question, research is conducted for designing and developing a data gathering, translating, and analysing solution for Ukrainian discourses. Accordingly, 45897 messages are collected, translated, processed, and analysed. For the second question, research is conducted for building a set of ML based models for automatically extracting topics discussed and corresponding sentiments of users. Correspondingly, topic modelling and sentiment analysis models are built, and a selection of topics extracted, and corresponding sentiment values are presented. While these findings match media discourses about the main events characterizing this conflict, they further support and contribute to (i) the need of building and proposing conflict-related datasets (Vorbrugg, A. B., & Bluwstein, 2022; Chockalingam & Maathuis, 2022), and (ii) building (intelligent) solutions for tackling/countering social manipulation mechanisms using AI, they reveal in an open and transparent way discourses and sentiments of Ukrainian users regarding aspects surrounding the ongoing war in Ukraine from its first six months, they can represent a basis for (i) a further multidisciplinary analysis where strategic, social, and psychological aspects could be scrutinized through multi-angle lenses and corresponding perspectives, and (ii) designing and implementing social media security awareness simulation gaming solutions encouraging diverse audiences for gathering/strengthening the stones necessary for building a safe, secure, and responsible digital environment.

References

Agarwal, N. S., Punn, N. S., & Sonbhadra, S. K. (2022). Exploring Public Opinion Dynamics on the Verge of World War III using Russia-Ukraine war-Tweets Dataset.

Agüero-Torales, M. M., Salas, J. I. A., & López-Herrera, A. G. (2021). Deep learning and multilingual sentiment analysis on social media data: An overview. *Applied Soft Computing*, *107*, 107373.

Al-Rawi, A., Kane, O., & Bizimana, A. J. (2021). Topic modelling of public Twitter discourses, part bot, part active human user, on climate change and global warming. *Journal of Environmental Media*, vol. *2, no.* 1, pp. 31-53.

Alassad, M., Spann, B., & Agarwal, N. (2021). Combining advanced computational social science and graph theoretic techniques to reveal adversarial information operations. *Information Processing & Management*, vol. *58, no.* 1, pp. 102385.

Allyn, B. (2022). Telegram is the app of choice in the war in Ukraine despite experts' privacy concerns. https://www.npr.org/2022/03/14/1086483703/telegram-ukraine-war-russia

Ates, E. C., Bostanci, E., & Guzel, M. S. (2021). Machine Translation, Sentiment Analysis, Text Similarity, Topic Modelling, and Tweets: Understanding Social Media Usage Among Police and Gendarmerie Organizations. *arXiv preprint arXiv:2101.12717*.

Ben Hassen, T., & El Bilali, H. (2022). Impacts of the Russia-Ukraine war on global food security: towards more sustainable and resilient food systems?. *Foods*, vol. *11, no.* 15, pp. 2301.

Birjali, M., Kasri, M., & Beni-Hssane, A. (2021). A comprehensive survey on sentiment analysis: Approaches, challenges and trends. *Knowledge-Based Systems*, *226*, 107134.

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent dirichlet allocation. *Journal of machine Learning research*, vol. *3*(Jan), pp. 993-1022.

Blei, D. M., & Lafferty, J. D. (2007). A correlated topic model of science. *The annals of applied statistics*, vol. *1*, no. 1, pp. 17-35.

Chen, E., & Ferrara, E. (2022). Tweets in time of conflict: A public dataset tracking the twitter discourse on the war between ukraine and russia. *arXiv preprint arXiv:2203.07488*.

Chockalingam, S., & Maathuis, C. (2022). An Ontology for Effective Security Incident Management. In *International Conference on Cyber Warfare and Security*, vol. 17, no. 1, pp. 26-35.

Cinelli, M., Conti, M., Finos, L., Grisolia, F., Novak, P. K., Peruzzi, A., ... & Quattrociocchi, W. (2019). (Mis) Information Operations. *Journal of Information Warfare*, vol. *18, no.* (3, pp. 83-98.

Dodonov, A. G., Lande, D. V., Tsyganok, V. V., Andriichuk, O. V., Kadenko, S. V., & Graivoronskaya, A. N. (2019). Information Operations Recognition: From Nonlinear Analysis to Decision-Making. *arXiv preprint arXiv:1901.10876*.

European Union (2022a). The war in Ukraine and its implications for the EU. https://www.eeas.europa.eu/eeas/war-ukraine-and-its-implications-eu_en

European Union (2022b). Grant EU candidate status to Ukraine and Moldova without delay, MEPs demand.

Fung, Y. R., & Ji, H. (2022). A Weibo Dataset for the 2022 Russo-Ukrainian Crisis. *arXiv preprint arXiv:2203.05967*.

Google Translate (2022). Language Support. https://cloud.google.com/translate/docs/languages

Haq, E. U., Tyson, G., Lee, L. H., Braud, T., & Hui, P. (2022). Twitter dataset for 2022 russo-ukrainian crisis. *arXiv preprint arXiv:2203.02955*.

Haroro J. I. (2015): The strategic logic of Islamic State information operations, Australian Journal of International Affairs.

Hien, L. T. K., & Gillis, N. (2021). Algorithms for nonnegative matrix factorization with the Kullback–Leibler divergence. *Journal of Scientific Computing*, vol. *87*, no. 3, pp. 1-32.

Höhn, S., Mauw, S., & Asher, N. (2022). BelElect: A New Dataset for Bias Research from a "Dark" Platform. In *Proceedings of the International AAAI Conference on Web and Social Media*, vol. 16, pp. 1268-1274.

Ibar-Alonso, R., Quiroga-García, R., & Arenas-Parra, M. (2022). Opinion Mining of Green Energy Sentiment: A Russia-Ukraine Conflict Analysis. *Mathematics*, vol. *10, no.* 14, pp. 2532.

Kammer, A., Azour, J., Selassie, A. A., Goldfajn, I., & Rhee, C. (2022). How war in Ukraine is reverberating across world's regions. *Washington: IMF, March*, *15*, 2022.

Lee, D., & Seung, H. S. (2000). Algorithms for non-negative matrix factorization. *Advances in neural information processing systems*, *13*.

Levy, B. S., & Leaning, J. (2022). Russia's War in Ukraine—The Devastation of Health and Human Rights. *New England Journal of Medicine*, vol. *387*, no. 2, pp. 102-105.

Maathuis, C., Pieters, W., & van den Berg, J. (2018). Developing a cyber operations computational ontology. Journal of Information Warfare 17(3), 32-49.

Maathuis, C., Pieters, W., & van den Berg, J. (2018b). A knowledge-based model for assessing the effects of cyber warfare. In *Proceedings of the 12th NATO Conference on Operations Research and Analysis*.

Maathuis, C., & Chockalingam, S. (2022). Responsible Digital Security Behaviour: Definition and Assessment Model. In *European Conference on Cyber Warfare and Security*, vol. 21, no. 1.

Maathuis, C. (2022a). An Outlook of Digital Twins in Offensive Military Cyber Operations. ECIAIR 2022. In *European Conference on the Impact of Artificial Intelligence and Robotics*, vol. 4, no. 1.

Maathuis, C. (2022b). On Explainable AI Solutions for Targeting in Cyber Military Operations. In *International Conference on Cyber Warfare and Security*, vol. 17, no. 1, pp. 166-175.

Maathuis, C. (2022c). On the Road to Designing Responsible AI Systems in Military Cyber Operations. In *European Conference on Cyber Warfare and Security*, ol. 21, no. 1, pp. 170-177).

Magajna, T. (2022). Natural Language Processing with Flair: a practical guide to understanding and solving NLP problems with Flair. Packt Publishing.

Marchese, V., Formenti, B., Cocco, N., Russo, G., Testa, J., Castelli, F., & Mazzetti, M. (2022). Examining the pre-war health burden of Ukraine for prioritisation by European countries receiving Ukrainian refugees. *The Lancet Regional Health–Europe*, *15*.

Mbah, R. E., & Wasum, D. F. (2022). Russian-Ukraine 2022 War: A review of the economic impact of Russian-Ukraine crisis on the USA, UK, Canada, and Europe. *Advances in Social Sciences Research Journal*, vol. *9, no.* 3, pp. 144-153.

Nakayama, B. (2022). Democracies and the Future of Offensive (Cyber-Enabled) Information Operations. *The Cyber Defense Review*, vol. *7*, no. 3, pp. 49-66.

NATO (2022). NATO's response to Russia's invasion of Ukraine. https://www.nato.int/cps/en/natohq/topics_192648.htm

Ngo, V. M., Huynh, T. L., Nguyen, P. V., & Nguyen, H. H. (2022). *Public sentiment towards economic sanctions in the Russia-Ukraine war* (No. 1108). Global Labor Organization (GLO).

NPR (2022). Telegram is the app of choice in the war in Ukraine despite experts' privacy concerns. https://www.npr.org/2022/03/14/1086483703/telegram-ukraine-war-russia

Park, C. Y., Mendelsohn, J., Field, A., & Tsvetkov, Y. (2022). VoynaSlov: A Data Set of Russian Social Media Activity during the 2022 Ukraine-Russia War. *arXiv preprint arXiv:2205.12382*.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of management information systems*, vol. *24*, no. 3, pp. 45-77.

Peffers, K., Tuunanen, T., & Niehaves, B. (2018). Design science research genres: introduction to the special issue on exemplars and criteria for applicable design science research.

Rawtani, D., Gupta, G., Khatri, N., Rao, P. K., & Hussain, C. M. (2022). Environmental damages due to war in Ukraine: A perspective. *Science of The Total Environment*, *850*, pp. 157932.

Shearer, C. (2000). The CRISP-DM model: the new blueprint for data mining. *Journal of data warehousing*, *5*(4), 13-22.

Sokolova, M., Huang, K., Matwin, S., Ramisch, J., Sazonova, V., Black, R., ... & Sambuli, N. (2016). Topic modelling and event identification from Twitter textual data. *arXiv preprint arXiv:1608.02519*.

Stănescu, G. (2022). Ukraine conflict: the challenge of informational war.

Thussu, D. K., & Freedman, D. (Eds.). (2012). *War and the media: Reporting conflict 24/7*. Sage.

Tsao, S. F., Chen, H., Tisseverasinghe, T., Yang, Y., Li, L., & Butt, Z. A. (2021). What social media told us in the time of COVID-19: a scoping review. *The Lancet Digital Health*, vol. *3*, no. 3, pp. 175-194.

United Nations News (2022). Ukraine. https://news.un.org/en/focus/ukraine

United Nations Secretary General (2022). Statement by the Secretary General-on Ukraine. https://www.un.org/sg/en/content/sg/statement/2022-02-24/statement-the-secretary-general-%E2%80%93-ukraine

United Nations Refugee Agency (2022) Statement of the situation in Ukraine attributed to UN High Commissioner or refugees Filippo Grandi. https://www.unhcr.org/news/press/2022/2/621770524/statement-situation-ukraine-attributed-un-high-commissioner-refugees-filippo.html

Vorbrugg, A. B., & Bluwstein, J. (2022). Making sense of (the Russian war in) Ukraine: On the politics of knowledge and expertise. *Political geography*, 102700.

Waissbluth, E., Farid, H., Sehgal, V., Peshin, A., & Afroz, S. (2022). Domain-Level Detection and Disruption of Disinformation. *arXiv preprint arXiv:2205.03338*.

Zhao, H., Phung, D., Huynh, V., Jin, Y., Du, L., & Buntine, W. (2021). Topic modelling meets deep neural networks: A survey. *arXiv preprint arXiv:2103.00498*.

Zhu, Y., Haq, E. U., Lee, L. H., Tyson, G., & Hui, P. (2022). A Reddit Dataset for the Russo-Ukrainian Conflict in 2022. *arXiv preprint arXiv:2206.05107*.