

ArenaBox - Leveraging Language Models and Multimodality for Sustainability Oriented Tech Mining of Intermediary Organizations on Twitter?

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Abstract

Our study explores how to augment tech mining using pre-trained models on multimodal unstructured data. Tech Mining, "a special form of "Big Data" analytics, aims to generate practical intelligence using text-mining and other analytical & visualization applications for analyses of Science, Technology & Innovation (ST&I) information resources. Intellectual Property (IP) information (i.e. scientific literature, patents, trademarks or design filing data) is one of the many important sources of ST&I information in Tech Mining methods and applications" (Corken and Radauer 2022). One limitation in current approaches to tech mining of tweets is processing scant characters while simultaneously handling noise and multimodality (verbal, visual, affect). Multimodality (Höllerer et al. 2018; van Leeuwen 2017; Zilber 2017) requires taking multimodal data seriously, e.g. emojis, images, hyperlinks and words in tweets, especially when forecasting patterns in time series data (Taylor and Letham 2017; Zhu and Porter 2002). This project thus adopts a multimodal approach that explores pre-trained language models (Zhou et al. 2020; Li 2022), particularly transformers (Dai et al. 2019; Nguyen et al.) that support semi-automatic text classification and topic prediction tasks. We performed these experiments on digital trace data such as social media tweets, images and news articles). Our prototype setup instantiated in the ArenaBox is an accessible natural language processing toolkit/research pipeline that can augment empirical exploration and mapping of emergent innovation actors, strategies, practices, topics, and logic in tweets. Future work may also extract information using named entity approaches in mining technology-specific events as temporal patterns over time. ArenaBox, accompanied by a multimodal dataset, is a robust and accessible proxy for mapping innovation concepts that diffuse between actors (organizations) in innovation ecosystems/multi-actor networks. Informed by recent work in innovation network research and the crucial role of intermediary discourse (Boon et al. 2011; Lukkarinen et al. 2018; van Lente et al. 2003; Van Lente 2011) in institutional change and

sustainability transitions, we have been exploring the question : ***What characterizes robust metrics for leveraging transformers and multimodal data in classifying and predicting topical concepts organizations use, particularly systemic intermediaries in the European Innovation context?***

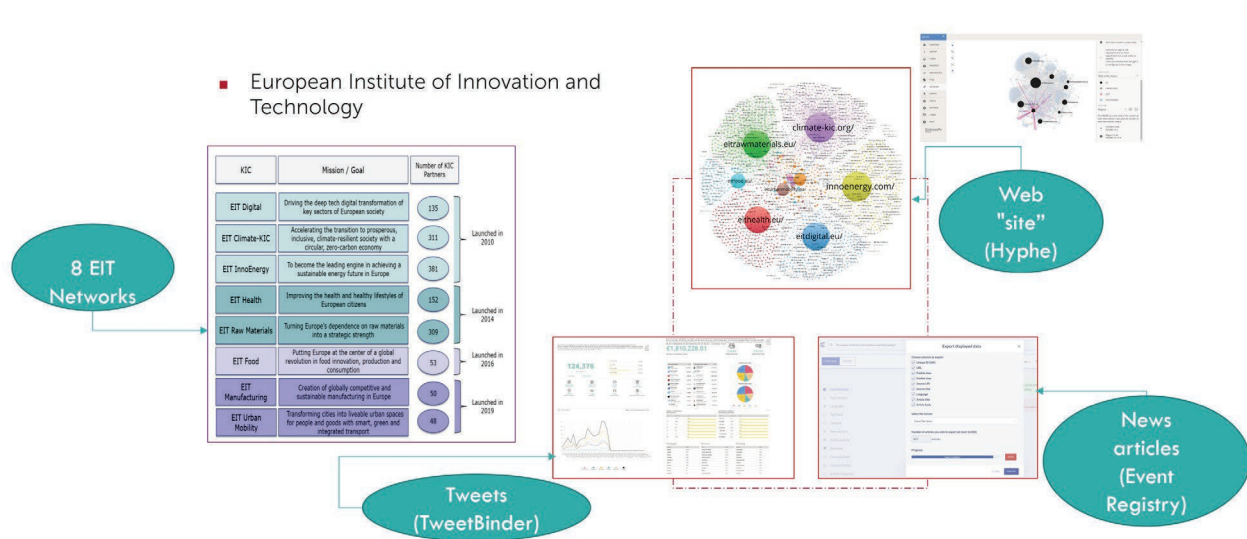


Figure 1 ArenaBox Dataset Framework

ArenaBox is a prototype framework (Figure 1) that demonstrates how such language models can augment tech mining using social media from Twitter to scale our understanding of innovation intermediaries and mediating processes radically. Multimodal analysis (Douwe Kiela et al. 2019) and multilabel classification of social media data (verbal and visual text) is still uncharted territory for tech mining research. However, multimodality as a research stream has been explored as relevant for understanding complex innovation processes. Our preliminary exploratory results show that Twitter data text classification improves over manual approaches in understanding multimodal text's structural and temporal dimensions. Furthermore, this language model approach scales when human researchers cannot manually code verbal or visual registers. Our approach and dataset are thus crucial to bringing zero shot applications to tech mining, e.g. in understanding the who (Actors and entities), the what (resources, actor roles and practices) and their discursive agency over time. Our ongoing work thus leverages multimodality in bringing more insights to tech mining literature and elaborates on open questions and limitations in predicting future events to gain relevant and robust tech mining insights on, e.g. innovation diffusion in sustainability-oriented innovation networks. We invite further attention to taking a multimodal approach to the tech mining of tweets, particularly for high-quality "forecasts" for time series data on social media.

Publication bibliography

Boon, Wouter P.C.; Moors, Ellen H.M.; Kuhlmann, Stefan; Smits, Ruud E.H.M. (2011): Demand articulation in emerging technologies: Intermediary user organisations as coproducers? In *Research Policy* 40 (2), pp. 242–252. DOI: 10.1016/j.respol.2010.09.006.

Corken, Rich; Radauer, Alfred (2022): "TechMining at digital crossroads – advances in technological foundations and application in key areas of interest" -. Call for papers - World Patent Information - Journal - Elsevier. Available online at <https://www.journals.elsevier.com/world-patent-information/call-for-papers/techminingat-digital-crossroads-advances-in-technological-foundations-and-application-in-keyareas-of-interest>, updated on 8/7/2022, checked on 8/7/2022.

Dai, Zihang; Yang, Zhilin; Yang, Yiming; Carbonell, Jaime; Le, Quoc; Salakhutdinov, Ruslan (2019): Transformer-XL: Attentive Language Models beyond a Fixed-Length Context. In. Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics: Association for Computational Linguistics.

Douwe Kiela; Suvrat Bhooshan; Hamed Firooz; Davide Testuggine (2019): Supervised Multimodal Bitransformers for Classifying Images and Text. In *ViGIL@NeurIPS*. Available online at <https://www.semanticscholar.org/paper/0a7620afb12870a5df0e178dd175d37a5cbc8c0c>

Höllerer, Markus A.; Daudigeos, Thibault; Jancsary, Dennis (2018): Multimodality, Meaning, and Institutions: Editorial. In Thibault Daudigeos, Markus A. Höllerer, Dennis Jancsary (Eds.): *Multimodality, meaning, and institutions*, vol. 54. First edition. Bingley, UK: Emerald Group Pub Ltd (Research in the Sociology of Organizations, volume 54A), pp. 1–24.

Li, Hang (2022): Language models. In *Commun. ACM* 65 (7), pp. 56–63. DOI: 10.1145/3490443.

Lukkarinen, Jani; Berg, Annukka; Salo, Marja; Tainio, Pasi; Alhola, Katriina; Antikainen, Riina (2018): An intermediary approach to technological innovation systems (TIS)—The case of the cleantech sector in Finland. In *Environmental Innovation and Societal Transitions* 26, pp. 136–146. DOI: 10.1016/j.eist.2017.04.003.

Nguyen, Dat Quoc; Vu, Thanh; Tuan Nguyen, Anh: BERTweet: A pre-trained language model for English Tweets. In Qun Liu, David Schlangen (Eds.): Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing: System Demonstrations. Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing: System Demonstrations. Online. Stroudsburg, PA, USA: Association for Computational Linguistics, pp. 9–14.

Taylor, Sean J.; Letham, Benjamin (2017): Forecasting at scale. In *PeerJ Preprints*. DOI: 10.7287/peerj.preprints.3190v2.

van Leeuwen, Theo (2017): Multimodality in Organization Studies: Afterword: Emerald Publishing Limited (*Research in the Sociology of Organizations*, 54), pp. 235–242.

van Lente, Harro; Hekkert, Marko; Smits, Ruud; van Waveren, Bas (2003): Roles of Systemic Intermediaries in Transition Processes. In *International Journal of Innovation Management* 07 (03), pp. 247–279. DOI: 10.1142/S1363919603000817.

Van Lente (2011): Systemic intermediaries and transition processes, p. 36.

Zhou, Xuhui; Zhang, Yue; Cui, Leyang; Huang, Dandan (2020): Evaluating Commonsense in Pre-Trained Language Models. In *AAAI* 34 (05), pp. 9733–9740. DOI: 10.1609/aaai.v34i05.6523.

Zhu, Donghua; Porter, Alan L. (2002): Automated extraction and visualization of information for technological intelligence and forecasting. In *Technological Forecasting and Social Change* 69 (5), pp. 495–506. DOI: 10.1016/S0040-1625(01)00157-3.

Zilber, Tammar B. (2017): A Call For "Strong" Multimodal Research in Institutional Theory: Emerald Publishing Limited (*Research in the Sociology of Organizations*, 54), pp. 63–84.