Towards Smart Urban Resilience: A Linked Data Approach*

Tianyang Lu[1 [0000−0002−0899−0403]], Shuai Wang[1 [0000−0002−1261−9930]], and Zhisheng Huang[1 [0000−0003−3794−9829]]

[1]Department of Computer Science, Vrije Universiteit Amsterdam, Amsterdam
shuai.wang|z.huang@vu.nl, angelalu0818@gmail.com

Keywords: smart city ontology · linked data · resilience data management

1 Introduction

Many cities in Ukraine were devastated since February of 2022. The mission of resilience of these cities calls for international collaboration, coordination, and reconstruction, which needs the integration and management of data and resources. Linked data technology can be used for the representation and understanding of open data from multiple sources. While there is some work [1] about smart cities, building information modeling, and geospatial data management, there are few studies on resilience data and knowledge management. This thesis tries to meet such requirements by taking advantage of existing data and knowledge management technologies about smart cities, road networks, households, infrastructure, ecosystems, resilience, etc. Our research question is: how can we use linked data technology to enable damage reporting of infrastructure and public facilities in Ukrainian cities?

To provide an ontology for the representation of information about city, damage and resilience, we first investigate relevant existing ontologies. Existing smart city ontologies include the KM4City [4], the Smart City Ontology 2.0 [3], the Urban Infrastructure Ontology [6], etc. Since the invasion, some organisations have been publishing open data. This includes a dynamic map named 'Eyes on Russia: The Russia-Ukraine Monitor Map' [5]. It is crowd-sourced by the Centre for Information Resilience as part of the 'Eyes on Russia' project, offered by several groups including Cen4infoRes, Bellingcat, etc. The team is devoted to recording, archiving, investigating and providing reliable information to the world. However, our examination shows that none of the ontologies can cover all aspects. We propose to use an integrated ontology for the representation of damaged areas, objects, and related information.

2 Integrating Ontologies

To best capture information about damage and resilience, we integrate ontologies of different kinds. KM4City (Knowledge Model for City) [4] is an ontology

* This submission is a thesis abstract (type D submission). It is an extended abstract of the thesis co-supervised by the co-authors, Shuai Wang and Zhisheng Huang.

developed for a system for data ingestion and reconciliation of smart cities issues such as road graph, services available on education, medical and other aspects. Due to its quality and wide use, we consider it as a very useful ontology and and wide use, we consider it in our studies. Urban infrastructure assets such as roads and water pipes play an important role in the smart city system. L. Wei et al. propose a knowledge based decision support system for urban infrastructure inter-asset management, namely Urban Infrastructure Ontology (UIO) [6]. We include another well-used ontology, the Smart City Ontology 2.0 (SCO2) [3]. As for the resilience aspect, we use the Empathi ontology [2] that focuses on the crisis management and the promotion of planning, preparation, and strategies of crisis, which aims at gathering and organizing knowledge about emergency management including natural disasters and anthropic events. Finally, we extend with 57 additional entities to best capture information of the live dataset and their sources. These additional entities include violence level, source of evidence (link to evidence), media link, etc. The resulting ontology consists of 12.5K entities and 52.9K triples.

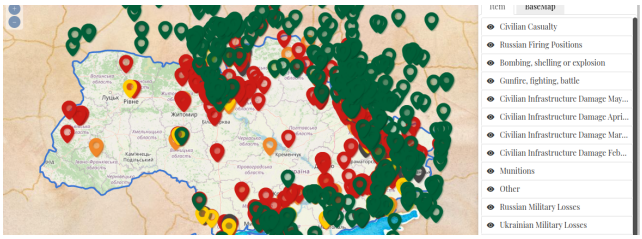

Fig. 1. A screenshot of the web app

3 Web Application

To demonstrate the use of our integrated ontology, we develop a web application. We use the Ukrainian data set of OpenStreetMap[1] for the representation of the 'Eyes on Russia' project [5]. Its geospatial data in GeoJSON format was combined with a map of Ukraine's boarder provided by the Geofabrik[2] platform for visualisation. The web application is developed for the reporting and tracking of damage and repair of households, roads, and ecosystems in urban areas of Ukrainian cities. Each damaging event is complemented by coordinates (longitude and latitude), title, description, city, town, etc. The dataset as well as each data entry can be downloaded as linked data in RDF format. The ontology and the web App are open source[3]. We would like to further extend it with data about Ukraine's social and geographical information for future use.

[1] Retrieved on 26th August, 2022 from `https://www.openstreetmap.org/relation/60199`.

[2] Retrieved on 26th August, 2022 from `https://download.geofabrik.de/europe/ukraine.html`.

[3] `https://github.com/OpenData4Ukraine/resilienceontology`

References

1. Antonio De Nicola and Maria Luisa Villani. Smart city ontologies and their applications: a systematic literature review. *Sustainability*, 13(10):5578, 2021.
2. Manas Gaur, Saeedeh Shekarpour, Amelie Gyrard, and Amit Sheth. empathi: An ontology for emergency managing and planning about hazard crisis. In *2019 IEEE 13th International Conference on Semantic Computing (ICSC)*, pages 396–403. IEEE, 2019.
3. Nicos Komninos, Anastasia Panori, and Christina Kakderi. The smart city ontology 2.0: Assessing the components and interdependencies of city smartness. 2021.
4. Paolo Nesi, Claudio Badii, Pierfrancesco Bellini, Daniele Cenni, Giacomo Martelli, and Michela Paolucci. Km4city smart city api: an integrated support for mobility services. In *2016 IEEE International Conference on Smart Computing (SMARTCOMP)*, pages 1–8. IEEE, 2016.
5. Benjamin Strick. Eyes on russia: The russia-ukraine monitor map. `https://www.info-res.org/post/eyes-on-russia-documenting-conflict-and-disinformation-in-the-kremlin-s-war-on-ukraine`, July 2022.
6. Lijun Wei, Heshan Du, Quratul-ain Mahesar, Kareem Al Ammari, Derek R Magee, Barry Clarke, Vania Dimitrova, David Gunn, David Entwisle, Helen Reeves, et al. A decision support system for urban infrastructure inter-asset management employing domain ontologies and qualitative uncertainty-based reasoning. *Expert Systems with Applications*, 158:113461, 2020.