Interacting with Subterranean Infrastructure Linked Data using Augmented Reality

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Abstract. Subterranean infrastructure damages caused by excavation works of all kinds are costly and potentially dangerous for workers. Such damages are often caused by poor subterranean data or inappropriate use of the existing data. We aim to provide solutions and services that will hinder obstacles related to the use of subterranean infrastructure data to ensure less damage and less time spent on finding and integrating data about subterranean infrastructure. The result of the work reported in this paper is an augmented reality application that can provide users the ability to see what subterranean infrastructure is located at a given physical location. In this paper we demonstrate a method to create such an application using Linked Data technologies.

Keywords: Linked Data, data integration, subterranean infrastructure, augmented reality

1 Introduction

A large part of urban infrastructure networks lies underground, delivering products and services to the society. Subterranean infrastructures include water and sewerage elements, gas conduits, telecommunication and electrical cables, etc. The urban infrastructure network grows continuously, and the increasing number of subterranean infrastructure elements, along with the low depth of the network elements under the ground results into frequent damages caused by contractors during excavation or rehabilitation work. Subterranean infrastructure damages can cause serious injuries to workers and result in direct and indirect economic costs.

A person who manages an excavation or rehabilitation work has a duty to take actions to avoid damaging underground infrastructure when conducting excavation activities. In order to reduce the time needed to explore the subterranean infrastructures, we developed an Augmented Reality application for real-time on-site visualization of subterranean pipe and cable infrastructures, called the Subterranean Infrastructure Map App and Service (SIM). SIM is specifically targeting mobile workers within property development, contractors and maintenance in Norway. The purpose is to ease planning and reduce damages to subterranean infrastructures due to poor or inaccessible data while doing excavation work. The SIM application uses augmented reality technology to present subterranean urban infrastructure elements data provided as Linked Data.

2 Approach

For the purposes of developing the SIM application prototype, we used geospatial vector data about water and sewerage infrastructure elements provided by the Bergen municipality in Norway.

The publication of water and sewerage infrastructure elements data as Linked Data was performed with the help of the proDataMarket platform – a cloud-based platform for data cleaning, data transformation and data hosting, among other capabilities. The proDataMarket platform consists of several software components including DataGraft[3][1,2] and Grafterizer[3]. Grafterizer facilitates raw data cleaning and preparation and mapping data to Linked Data vocabularies in order to generate a semantic RDF graph, whereas DataGraft provides a user interface that enables user data and account management, user assets cataloguing and dataset and database management. Data cleaning and preparation activities for subterranean infrastructure data included generating and assigning unique identifiers to entities, geospatial data conversion and adding concept names in English in addition to Norwegian. The set of data cleaning and preparation tasks can be recorded as a reusable transformation that allows to add new data to the endpoint in a convenient way.

The most important advantage of using semantic Web technologies for the purposes of the SIM application is the fact that annotated water and sewerage infrastructure data is made available in a both machine-readable and human-understandable format. Furthermore, this approach alleviates further extension of the knowledge base with data about other subterranean infrastructure elements (such as gas conduits, telecommunication and electrical cables which are not covered in the current prototype).

To describe the entities of urban infrastructure we developed the proDataMarket urban infrastructure domain ontology[4]. The ontology is part of the proDataMarket ontology[4] and covers water and sewerage system elements. After mapping of the data to the defined ontology classes and properties, we generated and published the water and sewerage infrastructure elements data as Linked Data using DataGraft. DataGraft provides Linked Data as RDF dump (supporting several RDF formats such as RDF/XML, Turtle, N-triples, N-Quads, N3, TriX and TriG), and via a SPARQL endpoint, enabling other third-party applications to use the data. The SIM application issues a geospatial SPARQL query[5] to the SPARQL endpoint and downloads subterranean infrastructure data that exists at the user location. These data are then used to visualize the

[3] `https://datagraft.io/`

[4] `http://vocabs.datagraft.net/proDataMarket/0.1/UrbanInfrastructure`

[5] `http://www.opengeospatial.org/standards/geosparql`

underground grid of pipes and cables as well as to provide information about a given pipe or cable.

3 Demonstration Outline

During the demonstration, we will introduce the DataGraft platform as an enabler for publishing SIM data, and the SIM augmented reality application prototype. The usage scenario will demonstrate how to transform raw urban infrastructure data and how to publish it with the help of the DataGraft platform, and show how the published data can be applied for the real-time visualization using Augmented Reality with SIM. By holding the iPad up in front of a street, SIM application users can clearly see the subterranean infrastructure network at a given physical location and retrieve relevant information about infrastructure element (see Figure 1). Relevant information could be an element's depth, the element's owner as well as the age and material of the element.

Fig. 1. The subterranean infrastructure network view

GPS accuracy is crucial for identifying the precise location of the infrastructure element in order to prevent damage. To increase the accuracy it is possible to use an external GPS receiver. But even though the GPS is accurate enough, a small error with the heading will still create unwanted results. In addition, to create a good Augmented Reality experience, the service needs to know the height above mean sea level. To accommodate these challenges, SIM has a calibration functionality that can move the infrastructure network grid according to a given heading. It also has a call to Google Elevation Service to retrieve the infrastructure network grids height so that it does not rely on elevation data. If the augmented experience is still not sufficient, SIM also includes a two-dimensional map so that the user can have an overview of the pipe grid (see Figure 2).

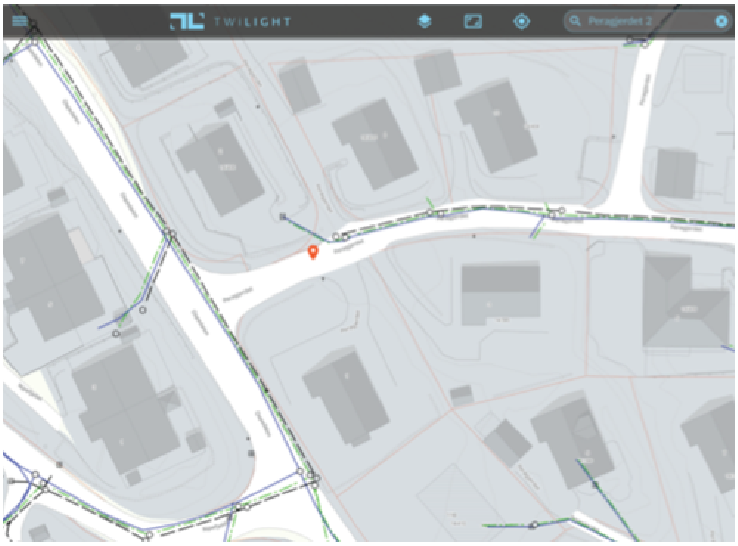

Fig. 2. The subterranean infrastructure network two-dimensional view

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