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Citizen science and WebGIS for outdoor advertisement visual pollution assessment

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1. Introduction

Citizen science has the potential to improve communication and understanding relating to peoples' lives. As online maps increasingly became research tools (Fox & Hendler, 2011) simultaneously, the citizen science actions start to adopt WebGIS applications to support research fields such as ecology (e.g. Bell et al., 2008; Dickinson et al., 2012; Kelling et al., 2009; Miller-Rushing, Primack, & Bonney, 2012) and urban studies (Cuff, Hansen, & Kang, 2008; Paulos, Honicky, & Hooker, 2008). Furthermore, the increasing complexity of urban environments leads not only to the necessity of accurate and real-time spatial information, but also generates new mapping challenges. Besides interesting topics such as *citizens well-being* (Mac Kerron & Mourato, 2013), *citizens emotion* (Gartner, 2012; Hauthal & Burghardt, 2016; Pánek & Benediktsson, 2017) *public preferences* (Jankowski, Czepkiewicz, Młodkowski, & Zwoliński, 2016) or *cityscape perception* (Salesses, Schechtner, & Hidalgo, 2013) we focus our attention on compounded effect of clustering, excess and disorder of out of home (OOH) advertisements in urban landscapes, or *visual pollution* (definition discussed in Section 2.2).

It turns out that the *visual pollution*, described among others by Iveson (2012); Gomez (2013); Portella (2014) Bonenberg (2015) and Chmielewski, Lee, Tompalski, Chmielewski, and Wężyk (2016) so far haven't been taken up as a citizen science task. Moreover, there are no existing online tools for visualizing this urban phenomenon. As far as we are concerned, a cityscape visual pollution caused by OOH media needs to be investigated not only in the traditional way by landscape studies but also by citizens participating in research through WebGIS tools. To achieve this, we have designed a cloud-based WebGIS application to collect, analyse and display crowdsourced data of opinions on visual pollution. We also propose an original mapping approach to visual pollution with the use of basic urban structural units (discussed in Section 2.3) instead of a typical crowdsourced point symbol or heat map style.

The reliability (Brown, 2012; Brown, Weber, & de Bie, 2015; Goodchild & Li, 2012; Lechner, Brown, & Raymond, 2014; Sui, Goodchild, & Elwood, 2012) and usefulness (Jankowski et al., 2016; Laatikainen, Tenkanen, Kyttä, & Toivonen, 2015) of crowd sourced mapping platforms seems to be accepted, but there are still some technical and hardware infrastructure conditions that limit the widespread implementation of citizen science mapping applications. Typically, a GIS server based infrastructure, enterprise geodatabases, server-side software, and professional programming skills are necessary to launch real time analytical functions of crowdsourced mapping data (e.g. Auer, MacEachren, McCabe, Pezanowski, & Stryker, 2011; Bugs, Granell, Fonts, Huerta, & Painho, 2010; Jankowski et al., 2016; Kalabokidis et al., 2013; Kulkarni, Mohanty, Eldho, Rao, & Mohan, 2015). Alternatively a simpler way is to run citizen science on SaaS (software as service) WebGIG platform, but then the choice of the right SaaS platform can also be a cloudy task as SaaS providers offers price dependent capacity and very basic (if any) geoprocessing (some pros and cons of different SaaS solutions are highlighted in Section 2.4). Therefore, in the most recent works, Smith (2016) as well as Kong, Zhang, and Stonebraker (2015) pointed out the necessity of such analytical function as well as user friendly interface development as inherent for citizen science web map experiences. Contrary to typical Public Participation Geographic Information Systems (PPGIS), real time feedback to participants on how their data contributes to the analysis and final scientific outcomes is crucial for citizen science projects (Newman et al., 2012). To meet those three criteria (WebGIS geoprocessing, IT architecture simplicity, user friendly and intuitive interface) we have designed a cloud-based online mapping application supported by desktop GIS plugin.

Our solution is based on the Esri cloud SaaS platform - ArcGIS Online (AGOL), which ensures Webmap wizard, data storage and end-user friendly interface. A link between the cloud and desktop GIS is hosted by a Python script implemented as toolbox for ArcMap. Our toolbox allows the mapping application administrator to download, quality check,

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geoprocess and sum up the crowd sourced data and finally serve it back as updated Webmap content. Through this application architecture, citizens are able to receive immediate results on their collaborative efforts as citizen scientists.

The objective for this paper is to present a new solution for providing desktop GIS geoprocessing services through a cloud-based WebGIS using OOH media visual pollution in Lublin city (E. Poland) as a use case. The motivation behind this use case is to support the decision makers who are interested in public participation in urban design.

2. Research background

First a brief overview on the evolution of online mapping approaches is presented to reveal a new paradigm of socio-spatial research and to outline the challenges facing WebGIS applications. Next, we define visual pollution and review scientific approaches to this phenomenon to understand how it may be measured and mapped. Finally, we expound two questions: why visual pollution should be studied through citizen science and why the urban structural units (USU) system is appropriate for visual pollution mapping.

2.1. Beyond web mapping 2.0

Since the emergence of Web 2.0 the user can not only passively accept the content provided by a narrow bulk of authors (Web 1.0) but also interact with customized online maps (Atabekova, Belousov, & Shoustikova, 2015). Introduced by Open Geospatial Consortium (OGC) a Web mapping Server (WMS) standard as well as the Google API interface (for example), allows users to integrate various geographic data sources and to create Web 2.0 online maps as map mash-up (Purvis, Sambells, & Turner, 2006) or map hack (Erle, Gibson, & Walsh, 2006) strategies. Currently Web mapping 2.0 is expressed as PPGIS, citizen science and social media geotags. Web content generated by *Twitter* or *Flickr* communities creates more than just Big Data (Laney, 2001) It has also established a new paradigm for socio-spatial research (Jiang & Thill, 2015) called by Lansley and Longley (2016) the *geography of Twitter*, and used it successfully in recent human geography studies (e.g. Feick & Robertson, 2015; García-Palomares, Gutierrez, & Mínguez, 2015; Luo, Cao, Mulligna, & Li, 2016; Nguyen et al., 2016; Steiger, Westerholt, Resch, & Zipf, 2015; Yang & Mu, 2015).

Initially, 2.0 web maps were used only at the end of a research process to visualize results. As scientific data started to be visualized in a dynamic manner (e.g. bird migration map by Shamoun-Baranes et al., 2016) or supplied with detailed statistics (e.g. luminocity3d.org/by Smith, 2014) online maps became a part of the research workflow (Fox & Hendler, 2011; Tsou, 2011; Zastow, 2015).

Beyond the "read/write" capabilities of Web 2.0 a new "infer" ability has emerged as the feature of early stage Web 3.0 (Mavridis & Symeonidis, 2015) also known as Semantic Web (Morris, 2011). This brings a new perspective for mapping applications, moving from collecting, displaying and comparing spatial variables to spatial data analysis and modeling.

Among several proprietary cloud mapping platforms (Mapbox, GoogleEarth, GIS Cloud) as well as open source solutions like Carto or QGIS-cloud (Zastow, 2015), AGOL is still left behind in the international literature. This constantly developed platform (Smith, 2016) becomes a natural extension of the most popular desktop GIS application (ArcMap). The connection with a desktop application enables the geoprocessing tools to implement a WebGIS without the added cost and complex IT architecture. Moreover, among plenty of AGOL applications four of them are dedicated to smart surveys, an inherent element of citizen sciences. There is *GeoForm* (a configurable application template for form based data editing), *Survey123* (a field dedicated application for collecting, analyzing and reporting surveys), *Crowdsource Polling* (a template for users adding feedback, proposals, votes and comments) and *GeoPlanner* (a tool for making alternative planning scenarios). For that reason we consider this mapping platform to be valuable for citizen science tasks especially when simplicity and cost reduction are expected.

Typically, Semantic Web solutions are based on a three tier system architecture: the presentation layer (client layer), the logic layer (application layer), the data layer (Evangelidis, Ntouros, Makridis, & Papatheodorou, 2014; Yong, Zhang, Wang, & Liu, 2015). However, the spread of cloud-based WebGIS platforms (SaaS model) has moved logic and data layers to the cloud as a single tier. Since then, WebGIS projects can be developed in a less complicated way only with the use of SaaS. AGOL is a link with desktop GIS. This 2-tier (SaaS & desktop) (Fig. 1) architecture creates a new IT architecture possibility explored in this paper.

2.2. Visual pollution as a use case

Visual pollution is a term used to describe the compounded effect of disorder, excess and clutter of various object and graphic in the landscape. For example, the source of visual pollution may be: wind turbines (Furze, 2002; Jensen, Panduro, & Lundhede, 2014), abandoned buildings (Cercleux, Merciu, & Merciu, 2016), building facades (Portella, 2014) lighting features (Chalkias et al., 2006), street furniture (Falchi et al.,

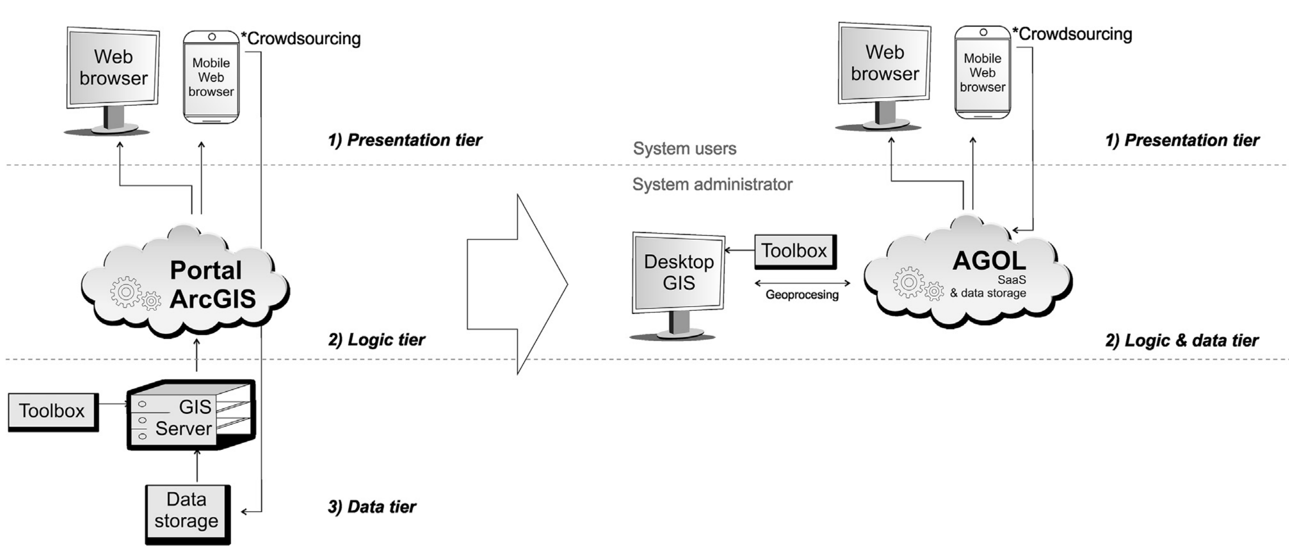

Fig. 1. Typical 3-tier system architecture (left) compared with SaaS & desktop GIS architecture (right) on the example of Esri solutions.