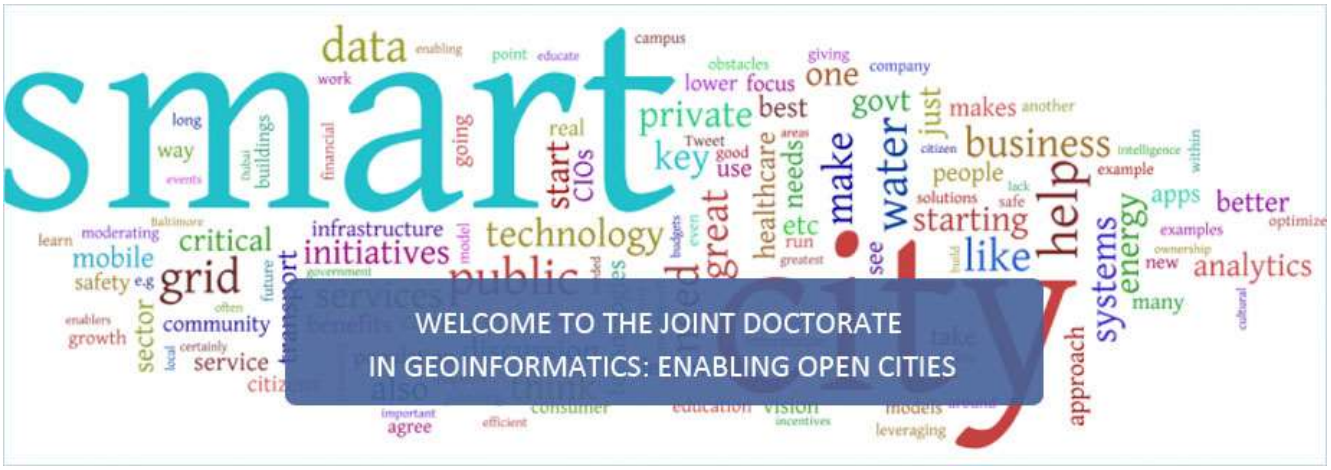

KD 10 Public Open City Toolkit prototype

GEO-C - JOINT DOCTORATE IN GEOINFORMATICS: ENABLING OPEN CITIES

FUNDED BY THE EU - GRANT AGREEMENT NUMBER 642332 — GEO-C — H2020-MSCA-ITN-2014.

NOVEMBER 12, 2018

AUTHORS: DEVANJAN BHATTACHARYA (UNL), SERGIO TRILLES (UJI), CARLOS GRANELL (UJI), AURIOL DEGBELO (WWU)

EXECUTIVE SUMMARY

This report summarises contributions of the ESRs to the Open City Toolkit (OCT). All the contributions cover the three main research areas that drive the GEO-C project: empowering citizens, analytical methods and tools, and citizen-centric services. In addition, the contributions are publicly accessible through the OCT catalogue, which hosts links to other data repositories (e.g. Zenodo), provides links to running instances of the deployed applications, and links to the associated source codes (e.g. GitHub). Reflections on the lessons learned during the development of the OCT are provided towards the end of the document.

1 INTRODUCTION

This report is the third of three key deliverables describing the implementation of the Open City Toolkit (OCT) within the GEO-C project. The first deliverable “KD 5 Toolkit outline” described the vision, target audience, key innovations as well as planned components of the OCT. The second deliverable “KD 9 Internal Open City Toolkit prototype” described in further detail these components and the resources developed by the Early Stage Researchers (ESRs). This deliverable describes the final state of the OCT components and reflects on lessons learned during its development over the past four years.

The Open City Toolkit is accessible at http://geo-c.eu/opencitytoolkit being a catalogue and entry point to a number (38 as of November 2018) of public resources: a variety of datasets (12), applications and services (17), guidelines (7) and modules enabling greater transparency (2). These were developed by the ESRs and GEO-C post-docs and research staff. This report KD10 briefly presents all components, pointing where applicable at further documents where detailed information about them can be found. A list of publications related to the Open City Toolkit is provided in Appendix. Each of the ESRs contributed component(s) to the Open City Toolkit. ESR02 left the project after 14 months, which was not enough time to contribute components. ESR16 took over the position of ESR02, but is at a too early stage for the contribution of components. The contributions of the other fourteen ESRs are described in Section 3. The infrastructure serving as a basis and frame for these components is briefly introduced next.

2 OCT INFRASTRUCTURE

The OCT is composed of three basic modules (Figure 1), i) **Catalogue**; ii) **Transparency module**; and iii) **Interactive Guideline Tool** (IGT). The **Catalogue** stores all contributions of the ESRs and is used as a centralised access point to discover all contributions. The **Transparency module** relies on the registration of applications and datasets to provide re-use information about open datasets. The **Interactive Guideline Tool** is a means for transferring and delivering the knowledge acquired during the project to the target audience of the OCT. Interactive guidelines aim at converting scientific outputs into understandable documents explaining the main lessons learned during the project to citizens, city councils, private companies and researchers. Finally, the OCT features four main types of components: datasets, guidelines, services and apps. Figure 1 illustrates the relationships between the OCT components.

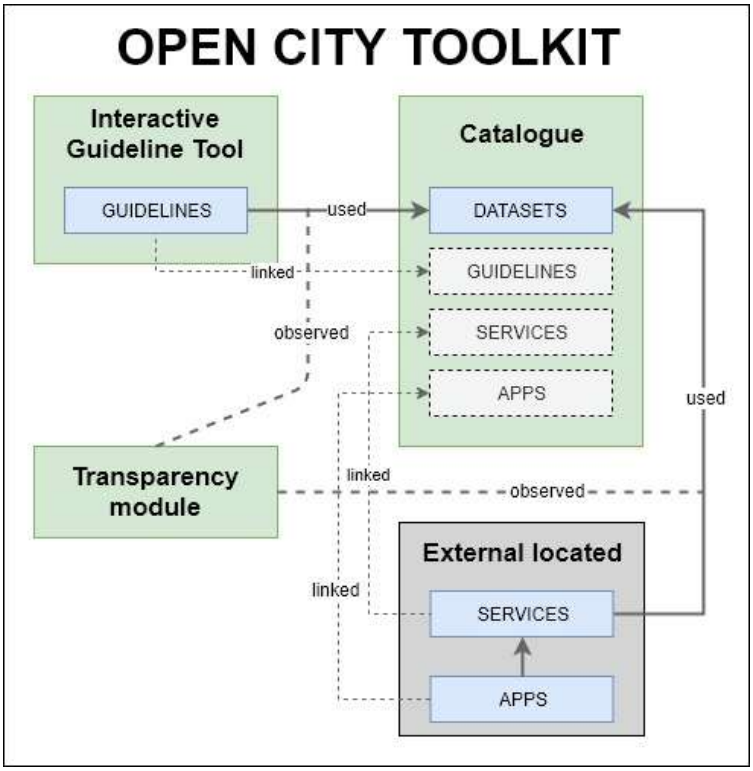

Figure 1: Relationships between the OCT components

3.1 OCT Catalogue

As mentioned above, the OCT catalogue is the entry point to access all OCT resources. In terms of functionality, the OCT catalogue provides functionalities to support the discovery, browsing, access, edition, and visualization of OCT resources, i.e. datasets, services, apps and guidelines. A CKAN-based implementation met our requirements since CKAN comes with built-in facilities for managing, browsing, and exploring resources. We have used existing CKAN extensions, customised them, and integrated them into the live instance of the OCT catalogue (http://giv-oct2.uni-muenster.de:5000/). Examples of installed extensions are data viewers (pdf, image and text), chart viewers using different visualizations, RDF vocabularies, local storage, API for reading and connecting to google analytics, usage statistics, and the creation of documentation page. Implementation details and CKAN extensions used in the OCT catalogue are described in project-related publications [60, 62]. Figure 2 presents a screenshot of the main page of the OCT catlogue, and Figure 3 shows example datasets available in the catalogue.

3.2 OCT Transparency module

There is an increasing number of open government datasets available[1], but finding information about the re-use of these datasets is still a challenge. Some open data portals (e.g. the European Data Portal[2] or the U.S.'s Open Government Data Portal[3]) list examples of applications which use open data, but little is known about the frequency of use of these datasets. Knowing (a) open datasets which are being used in applications as well as (b) the frequency of use of these open datasets, could provide vital information about the impact of existing open datasets and help data

[1] See https://opendatainception.io/ (last accessed: November 7, 2018) for a list of open data portals.
[2] See https://www.europeandataportal.eu/en/using-data/use-cases
[3] See https://www.data.gov/impact (last accessed: November 7, 2018).

providers better assess the demand of open data (i.e. who need which open data for what). The transparency OCT transparency module has provided the technology to enable (a) and (b), contributing thereby to advance the current state-of-the-art on open data re-use. It comes with a dashboard-like visualization of (i) registered applications on the platform, (ii) types of datasets that they search, (iii) datasets which they re-use, and (iv) the frequency of use of these datasets (see Figure 4). A live version of the OCT transparency module is accessible at http://giv-oct.uni-muenster.de:8080/. Further information about the OCT transparency module is available in project-related publications, and the reader is referred to these for further details:

- [72] presents the application programming interface enabling the realization of the frequency tracking features at the technical level;
- [73] gave example applications connected to the module, and the process of their development;
- [74] presented an evaluation of the usability of the application, as well as its usefulness.

Figure 2: A screenshot of the main page of OCT Catalogue

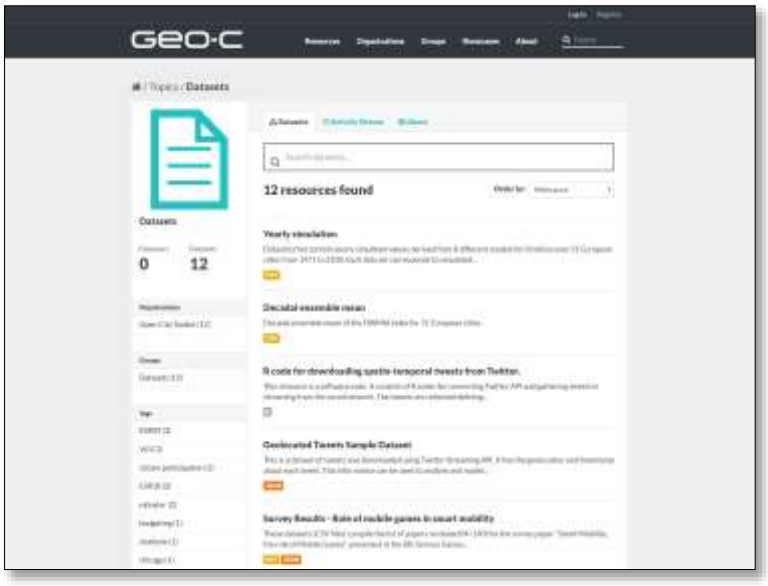

Figure 3: Example datasets from the OCT Catalogue

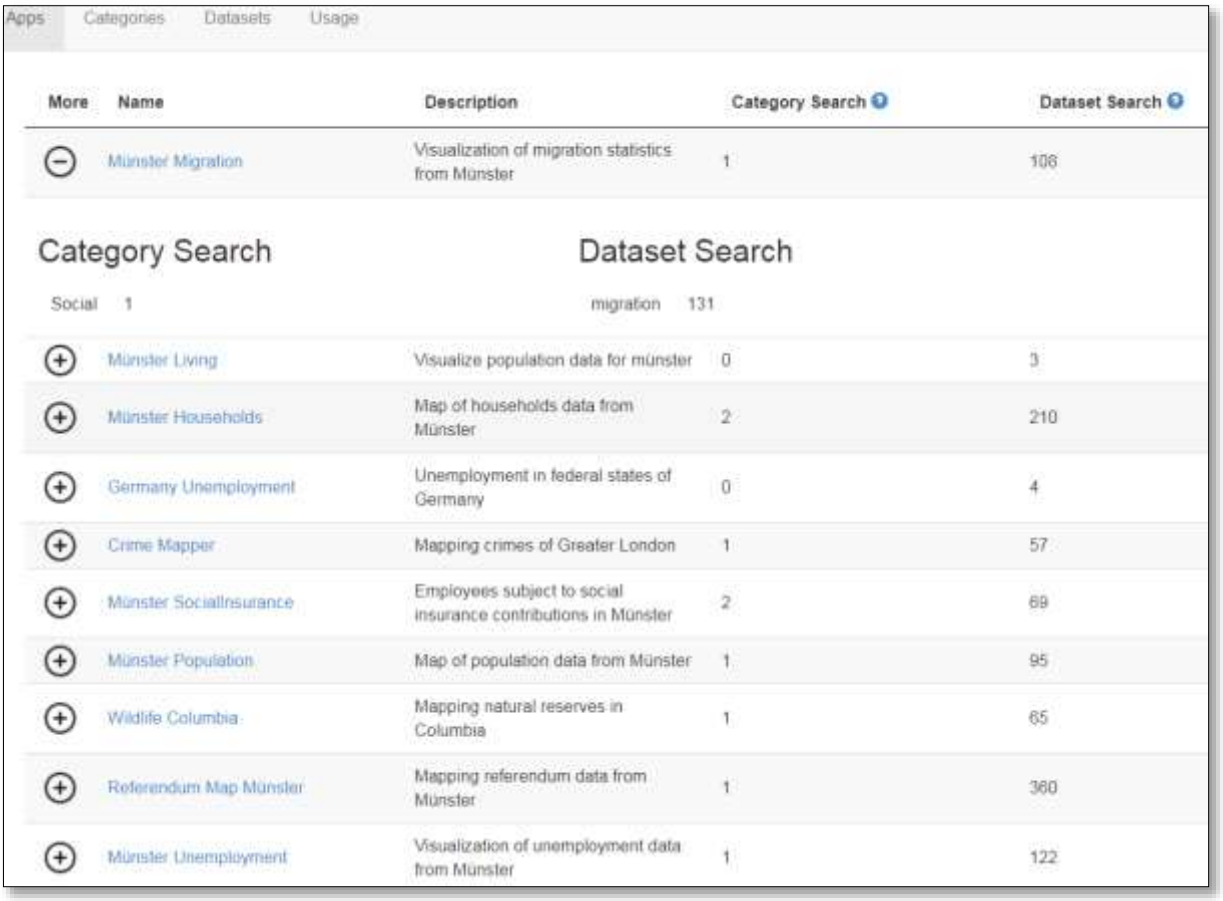

Figure 4: Dashboard visualization about datasets usage provided by the OCT transparency module

3.3 OCT Interactive Guideline Tool

Text is currently the main form to document the results of tools & software. Nevertheless, user interaction can stimulate thinking. Interactive guidelines are suggested as a novel way of exploring content and insights from past work. As their name suggests, they are guidelines (i.e. they walk the user through a story), and they are interactive (i.e. designed to provide different outputs depending on the actions of the user).

A story in this context refers to a problem-solution pattern. The problem is a task that is currently challenging to solve, whereas a solution involves a combination of datasets and software to solve the problem (i.e. improve the current situation). Interaction, in this context, denotes user interface elements which enable the user to move through different aspects of the story. Interaction involves testing the software and visualizing a dataset (for instance) to readily get an idea of how to solve the problem by oneself. Documentation of impact of the solution and it is scaling up give the user an idea of the portability of interactive guidelines (i.e. what to reasonably expect when it comes to using the solution in another context).

By providing such a tool, we intend to create a bridge between all stakeholders (councils, citizens, companies) and research outcomes and practices. Besides, by incorporating city transformation guidelines and providing a set of useful examples for developers and users alike, we aim to facilitate the transition towards smarter cities. Finally, by providing it as open source, any

interesting party—be it city authorities, researchers, businesses, practitioners or citizens themselves—can easily obtain, use and/or build on it.

3.3.1 Conceptual architecture

In this subsection, we present the conceptual architecture to materialise our IGT approach (Figure 5). The main component of the IGT tool is called "Visual storytelling design", and has the functionality to create/edit and compose the outline of a guideline. It is featured with: 1) the creation of guidelines in a simple and interactive way; 2) a catalogue of functional, interactive elements to support the generation of content of guidelines ; 3) the definition of external data sources to be used in the interactive elements; 4) the availabilty of guidelines templates, with predefined structure and visual style.

Each design has an associated template, which defines the story through a predefined structure and a visual style. Apart from the template, external data sources or datasets are specified, which will be available inthe guideline and be used by different interactive guideline elements. These interactive elements can be inserted during the guideline creation depending on the way the creator intends to combine them. Five different blocks have been predefined, which are: *charts*, *code*, *maps*, *text*, and *P5.js*. In the following, each of them is described:

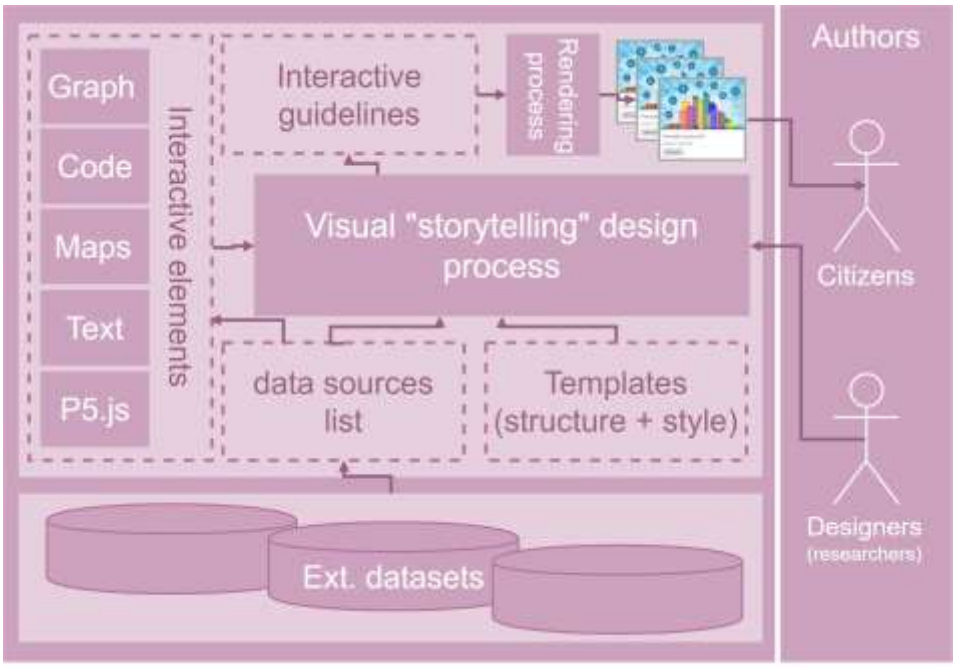

Figure 5: Architecture of the OCT interactive guidelines tool

- **Charts**. The guideline creator uses this block to visualize a previously defined dataset as a chart. It supports different graphical representations, such as Pie, Bar or Line charts.
- **Maps**. This block can is useful to visualize geographic data using a map. The geographic data has been previously defined using an external data source.
- **Code**. This block enables to add and run some code snippets.
- **Text**. This basic block can visualize enriched text with some media elements, such as images, videos, links, etc.
- **P5.js**. This last block can run p5.js code. It can generate interactive components of any p5.js element from its large variety of libraries.

All these blocks (except text) offer some interactive possibilities as well as the possibility to visualize the results or outputs. After a guideline creation, the guideline can be stored by the final users or stakeholders.

3.3.2 IGT development

From a technological point of view, the IGT is based on a web tool encoded in javascript using the Meteor framework and is deployed at http://elcano.init.uji.es/guidelines. Meteor is a full-stack framework that intregrates several JavaScript libraries (e.g. npm, Angular or React). It works both on client and server sides, and has some features that help to create scalable and collaborative applications. Meteor uses the subscription/publication model, and it provides reactive templates, which are ideal for managing real-time interactions between users in a collaborative way. In our use case, it is ideal to offer collaborative features so that editors and readers are editing and seeing the same content. This improvement adds to the IGT an innovative capability, where any change from the editor mode is automatically refreshed in the client side without any page refresh. From the server side, the IGT is based on Node.js and MongoDB, and the client uses React, and the logic application is written in JavaScript.

The IGT can manage (create, edit or delete) guidelines subject to valid users permissions. It works like a Content Management System (CMS) where users can add new content, in this case, guidelines. The key component is the guideline itself. The definition of a guideline is based on Kajero[4], which is designed to create single documents, called notebooks. In this way, IGT integrates the Kajero approach to define a guideline and and extends it to enable new functionality to manage these guidelines as earlier detailed.

Technically, each guideline is encoded as a markdown file (like a regular text file). In markdown format, special tags are addted to the main content to, for example, tag the sections of a guideline, and to keep information about the author, last update, title and the list of data sources used. To improve the creation of new guidelines, the IGT tool provides some predefined templates with a different structure. Each guideline can be exported as a regular markdown file to edit offline, which may be uploaded again after some edits. Besides, a guideline contains a collection of interactive elements (codified as JavaScript snippets).

The main page lists all open-access guidelines in a cards view (Figure 6). The title, author, update date and a featured image appear on each guideline card. When a card is selected, a new window opens which shows the guideline itself. Further information on the guidelines are available in project-related publication to appear [74].

[4] http://www.joelotter.com/kajero/ (last accessed: November 8, 2018).

Figure 6: Catalogue of interactive guidelines showing examples of OCT interactive guidelines

3 CONTRIBUTIONS TO THE OCT BY THE ESRS

Six main themes were of interest in the project, as described in [62, 75]. These themes were (subthemes are listed under each of the main theme):

1. **Empowering Citizens**
    a) Deep participation
    b) Data literate citizenry
2. **Analytical Methods and Tools**
    a) Pairing quantitative and qualitative data
    b) Adoption of open standards
3. **Citizen-Centric Services**
    a) Personal services
    b) Persuasive interfaces.

The description of each ESR's contribution is highlighted under specific impact terms viz. Problem, Solution, OCT Component Type, Web-Links, Target audience, Re-use steps, and Relevant publications if any. The web-links and publications are shown under reference section. This section gives an overview of ESR contributions to the OCT arrranged according to the six themes and twelve sub-themes presented above.

3.1 Empowering citizens

- **Deep Participation**

The idea of **deep participation** is about raising awareness and enabling communities to have their say in matters related to city life.

ESR01 has focused on using public displays for facilitating public participation and to elevate it from low levels to higher levels in an urban planning process [4]. One contribution of ESR01 to the OCT is a dataset about citizens' perspectives regarding the use of ICT (Information and Communication Technologies) for public participation. Around 100 citizens' responses from Muenster, Germany, were collected. The dataset components are available at [19, 20]. Both city councils and researchers can use this dataset to get a better idea about the kinds of information technologies preferred by citizens. The dataset is available as .pdf and .html files. These can be downloaded on your local computer, and explored using word processing software.

ESR04 has looked into the concept of Sense of Place, which is tightly linked to how citizens feel and perceive their surrounding environments. City managers normally use hierarchical administrative boundaries to deliver their policies and actions. For instance, participatory processes in planning decisions or decision-making processes about communal spaces are framed and regulated according to administrative boundaries [3,18]. ESR04 contributes to OCT through an application which makes possible to get the measurement and spatialization of citizens' perceptions towards places where meaningful relationships take place, and spaces of engagement. It is a web-map based survey for use by city councils, citizens, planning and participatory sector, available at [26, 27]. This application is open source therefore re-usable to spatialize other concepts of interest. A related publication is available at [28].

ESR05 investigates the determinants of the adoption of online citizen public participation (e-participation). E-participation is the involvement of citizens in consultation and decision processes along with the government using ICT [1,2]. ESR05 has contributed three components to OCT. The first component addresses the problem of understanding the drivers of e-participation adoption that were already tested in the literature. An investigation of the drivers of e-participation as a systematic review of the literature was done. The data-set used for the review and a guideline about how to use the dataset are contributions to the OCT. The meta-analysis data set [29] and Guideline [30] can be utilized by researchers, local governments, students in social sciences and information systems. For the meta-analysis data set one can follow the guideline [30] and the publication [31]. The second component by ESR05 to the OCT intends to address the problem that drivers of e-participation adoption are not clearly defined in the theory. The solution provided is data [32], collected from citizens who used e-participation, used as input to evaluate a research model. This dataset of e-participation survey in Portugal could be useful for researchers, local governments as well as students in social sciences and information systems. The third component from ESR05 is addressing the issue of ambiguity with respect to the geographic distribution of spendings related to online participatory budgeting. The solution to this issue is a tool called online participatory budgeting, which helps to understand where the proposals and votes have the higher frequency. It is a dataset of participatory budgeting geolocated results [33] and useful for researchers, local governments, students in social sciences and information systems. One can use any geographic information system to open the files.

- **Data Literate Citizenry**

Data literate citizenry is concerned with fostering digital inclusion and data literacy skills to enable citizens to interpret and understand the processes and services that drive smart cities.

ESR03's research aimed to explore how mixed participatory approaches could be rethought in Human–Computer Interaction (HCI) to facilitate (young) forced migrants' engagement in the design of (geospatial) services supporting their (re)settlement [5]. ESR03 contributes to the OCT through three components. The first component tackles the problem that newcomers, particularly forced

migrants, upon arrival in Münster are facing challenges accessing/using information with geospatial characteristics in host cities. The solution offered is an initial prototype of the “WelcomeMS” service, which presents relevant geospatial information for forced migrants through a navigation support. It is a Web-App which is mobile-responsive. It is targeted for users such as forced migrants, developers, activists, and civil institutions. The code is open source accessible from a GitHub repository [21]. It can be forked or downloaded, and modified depending on the particular needs of the users.

The second component deals with the problem that forced migrants upon arrival in Münster are facing challenges navigating an unfamiliar host city with the available geo-visualization resources available (paper maps or navigation apps). Navigation becomes a problem fundamentally on decision points where the current orientation methods available in geo-visualizations are not enough. The solution created is another prototype aiming to explore and enhance the “augmented navigation” features from the WelcomeMS app was done. The GeoWelcome App provides three types of geovisualizations: Map+Augmented Picture View, Map+Augmented Reality, and only map. The service allows to access these three geovisualizations at once. It is a mobile app aimed for use by forced migrants, researchers and developers, and is available at [22], the code is open source accessible from this GitHub repository. It can be forked or downloaded and modify depending on the particular needs of the users. A related publication regarding forced migrants and their challenges and needs in host cities is available at [23].

The third contribution to the OCT by ESR03 is based on the problem that navigation is hindered for forced migrants, fundamentally at complex decision points during pedestrian navigation in the city. Also, limited information regarding culturally and socially relevant landmarks upon arrival for this population group is needed. A solution trying to address this is a collection of pictures gathered together with young forced migrants in Münster regarding relevant routes, origin, destination and decision points, as well as landmarks upon their arrival in the host cities. The dataset is available at [24] and is aimed at forced migrants. The data can be download freely from Zenodo for analysis. A related publication regarding the process how these geospatial points were collected can be found at [25].

3.2 Analytical Methods and Tools

- **Pairing Quantitative and Qualitative Data**

Pairing quantitative and qualitative data is about developing novel analytical techniques and tools to integrate data from diverse sources, both quantitative (objective measurements) and qualitative (subjective perceptions, opinions). ESR08 investigated approaches to enable air quality monitoring at the city level [6]. His research focused on identifying methods which can help monitor air quality at a higher spatial resolution in cities. ESR08 contributes to the OCT by providing three components. One current issue is that modelling air pollution at city scale requires a significant amount of datasets and these are hard to collect. The method developed in ESR08’s work relies on open data and Land Use Regression (LUR), and his result is provided as an R script (service) [45] to help mitigate this issue. The users could be city councils and companies who want to develop air pollution monitoring services. The developed LUR model and optimization method is available as the R script and can be used for any area of interest just by replacing the data set values. More details are in [46,47].

In addition, ESR08 has developed a Shiny App [48] (app) which could be useful for City councils and companies who want to develop air pollution monitoring services. The developed shiny app for LUR variable extraction is available on GitHub and can be downloaded for reuse. The app requires the R script and input data set for extracting the variables required for LUR creation.

The third component helps to identify possible locations to place monitoring stations in a city for a number of possible stations, so that the mean prediction error for LUR estimation is minimized. It is a R Script (service) [49], useful to decision makers (City council and companies) for planning air pollution monitoring station network setup. The optimization method is available as R script on

GitHub which can be used for any area of interest for identifying possible locations for placing the monitoring stations. The optimization method can also be used for planning crowdsourcing approaches for air quality monitoring using low-cost sensors.

ESR09 investigated and developed climate downscaling procedures for urban areas [7]. ESR09 contributes two components to the OCT. One current problem is that many climate impact modelers simply cannot handle large multi-model climate ensembles. Climate services are typically focused on global, European, or national level while the specific domain of urban space is typically not addressed. ESR09 provides coherent data for all European Capitals in open, easily accessible manner (open data, accessible through common internet browsers) and easy-to-handle form (CSVs) [50,51]. This contribution of ESR09 is a Dataset. It can be used by urban public and private decision makers, climate impact researchers. The second contribution was motivated by the fact that climate change represents global, seeming impersonal and difficult to relate to issue. The visualization capabilities of climate services are often static and still quite poor. The solution proposed here is an application that makes climate change processing understandable. The tool communicates climate change implications “locally”, virtually into people’s backyards and provides elaborated interactive visualization capabilities. Having all the Europe capitals in one place allow people easily to relate and imagine the future conditions. It is a Web Portal App [52] which could be used by urban public and private decision makers, NGOs, activists, and general public by just availing it at [52].

ESR10 focuses on developing spatio-temporal statistical models for analysing, describing, and understanding urban dynamics framed as human activity and mobility. The contributions from ESR10 to OCT are a dataset and a code scripted for the problem statement that social media data has become a source of information for monitoring and sensing the cities, hence proving a way for getting information about dwellers in cities for analyzing urban dynamics which has not been fully utilized. Hence the solution is to develop R codes for connecting Twitter API and gathering geolocated tweets in streaming process. The service is available to be downloaded at [53]. It could be used by data scientists, urban planners, experts etc. It is utilized by running codes using the programming environment R. The dataset is providing solution to the problem of collecting geolocated social media data about cities for understanding where are citizens and when they perform their activities. The curated dataset is available at [54], and targets use from Data scientist, Urban planners etc. The way to use it is to download files [53, 54], Transform and join GeoJSON files in a table, and use spatio-temporal information to make analysis in R programming environment.

ESR12 centred on the analysis of spatiotemporal interactions of crime data to predict crime hotspots in cities [8]. The OCT contributions of ESR12 are two components as a service and a guideline. Current techniques to analyze pattern (traffic accidents, street crimes, etc) in the city do not consider the street network, and that might lead to less trustable and reliable outcomes. A new method has been introduced which considers the street network and provides a better understanding of the spatial distribution of patterns within cities. This service is available at [59] and the related publication at [8]. The service is aimed at researchers. The reusability steps are as follows. Install R and RStudio and the R package "spatstat". Then download the code from link [59] and one can use the provided code. The second component is a guideline on reusing the techniques of analyzing patterns through R-code. It aims at helping non-experts to apply the R-code and the method provided as a service [59]. The guideline is available at [61]. It can help decision makers and researchers from different fields. The usability instructions are at [61] where one can follow the steps described. Again the related publication is [8].

- **Adoption of Open Standards**

Adoption of open data standards refers to the use of standards in a broader sense to ensure interoperability and facilitate the re-use of data.

ESR06 developed a generic participatory sensing framework, especially addressing flexibility and usability requirements from non-expert users [9]. ESR06's contribution intends to tackle the issue that despite a long list of participatory sensing applications, they still suffer from some drawbacks such as single functionality, lack of context-awareness and lack of incentive for the participants. At the same time, the process of creating and managing a data collection process is a challenge for ordinary users. The solution developed is a generic user-oriented participatory sensing framework that eases the process of creating, launching and managing flexible participatory sensing campaigns and allows a two-way communication between the data collectors and the campaign authors as well as real-time visualization of the collected data. This contribution is available as a web app and a mobile app, both downloadable through the OCT link [34] and a functionalities video is available at Youtube [35]. The components are useful for: City authorities - to deploy the framework in the city to collect relevant data, Developers – to modify/extend the framework, and also Citizens – to interact with the framework to create campaigns and/or collect required data. To re-use the products: for the web app, a copy can be downloaded from the GitHub link and with necessary customizations can be deployed in an ICT infrastructure. More details are available at [36]. For the mobile app, one can download and install the mobile app from Google play store (Android devices). The iOS version of the mobile app will be available in the future. More details are available at [37-39].

As two cities never have the same socio-economic-cultural substrate, the identification of the actual barriers that limit geographic data reuse in a city is a prerequisite prior to any intervention [10,11]. ESR11 contributes two components to OCT on the account that nowadays local data authorities are facing reusability issues of the open geographic data. The reusability issue could be seen from two perspectives: properly promote the available local data and engage the data users' communities in an effective way. ESR11's solution is a conceptual framework to help local data authorities to re-shape their current open data strategies to include data users' requirements and move towards to a bottom-up approach. The component is an Open Data Reusability Handbook (Guidelines) which can be accessed at [55]. The guidelines are aimed at local open data authorities and can be used in a HTML format [55, 56]. The second component is a survey dataset to get a better understanding about why data users are going away uninterested, and they are not involved with the local open data strategies. A publicly shared online survey was created to collect and rank the most concerning barriers in several cities, gathering 195 responses that helps to identify what the current issues faced by local data users are. Barriers were collected for data users in several cities (specially in Bogota, Medellin and Cali in Colombia and Valencia in Spain) [57]. These barriers could provide useful information to local open data authorities or open data strategy directors. The online survey had 20 questions that could be used by local open data strategy directors to get a better understating about barriers are more relevant in specific city which. The dataset is already available the CKAN website in a CSV format, and can be downloaded for re-use [57, 58].

3.3 Citizen-centric Services

- **Personal Services**

For **personal services**, the focus is on the design, exploration and development of customized and focused services that are able to adapt to the peculiarities and needs of individual citizens.

ESR13 explored this by designing Location-Based Services (LBS) with the focus on protecting location privacy of users [12]. Location information is essential to LBS, but it also has the potential to reveal sensitive information to malicious agents. To preserve location privacy, ESR13 explored methods to integrate location privacy protection in the process of LBS development. ESR13

contributes two components to OCT both of which are guidelines. To address privacy threats associated with the storage of location information, her work proposes an approach based on privacy-by-design principles and introduce a conceptual model to facilitate the implementation of those principles. In addition, she investigated the role of location data management in the context of privacy preservation and proposed the concept of temporal and spatial ephemerality to improve location privacy in the context of a location-based service. The guideline is available at [63], and could be useful to developers and service providers. Following the approach of adding two extra components to the architecture of location-based services can be used to manage location privacy while developing a service. More information is available at [64]. The second component of ESR13 is a guideline which proposes a list of practical steps that users can take to protect their location privacy. For example, it makes sense for users to check the settings for all the apps and their smartphone in general to see which app request access to their location, and to turn it off for those that they don't trust or that should work without having it. The guideline is available at [65], and is aimed to help all end users of location-based services who have concerns regarding their location privacy, can be helped by following these practical steps. The re-use steps are the guideline steps that can be considered by all users interested in protecting their location privacy.

A second line related to personal services explores synergies between mobile devices, context-aware systems, and social behavior and ontologies. ESR14 explored the application of social roles and relationships to the world of context-aware, location-based mobile devices to enable opportunistic communication among nearby devices and/or services [13,14]. ESR14 contributes one component to the OCT namely a location-based REST service [66]. This resource is a codebase created to enable a communication platform where device-to-device interaction could be possible. This platform relies on an ontology model that exploits social concepts and role theory to permit an opportunistic communication among nearby devices and/or services [67].

- **Persuasive Interfaces**

Regarding **persuasive interfaces**, the main idea is to present information in such a way that citizens are persuaded to change their behavior and take actions accordingly.

ESR07's research considered methods to help citizens fully embrace cycling as a transportation mode [15]. ESR07 contributed three components to the OCT. Research in location-based services, cycling promotion, and serious games produces several scientific publications. However, from the geo-informatics perspective, an integrated description of the research state of the art is needed. There is a lack of research in the existing solutions for promoting urban cycling through mobile devices. To know more about the problem a dataset (his first OCT contribution) was created through a survey compiling scientific publications, published between 2014 and 2017, reporting on the use of location-based servers, cycling promotion, and serious games. The analysis of the compiled papers allowed to describe the role of mobile games in the promotion of smart mobility when it comes to urban cycling. The dataset can be beneficial to researchers interested in urban cycling, mobile applications, location-based services, and gamification. It is available on GitHub and Zenodo [40,41]. One of the uses of the data could be to visualize the different features of the compiled papers, and compare the compilation with future comparable surveys. More details can be seen at [42]. The second OCT component from ESR07 is 'Cyclist Geo-C', an Android mobile application. It can be used by urban cyclists willing to track their trips, or cycling advocacy groups willing to understand cycling patterns in their cities. The use is straight forward: download the application from the Google Play Store or OCT repository [43,44] and install it like any other app, track the bicycle trips for more than one week, request access to the recorded data, and visualize the data using GIS tools. The third contribution to OCT by ESR07 is a dataset describing bicycle trips in three European Cities: Castello in Spain, Muenster in Germany, and Valletta in Malta. It has been generated in association with the second contribution described above. It follows the same guidelines as described for the previous contribution. It is available from Zenodo and the OCT catalogue [40,41], and could be useful to urban cyclists willing to track their trips and cycling advocacy groups willing to understand cycling patterns at their cities. Interested users can access the dataset and visualize it using GIS tools.

ESR15's research intends to improve citizens' awareness in the urban space. He explores the concepts of empathy and affective atmospheres to better understand the relationship among people, technology and spaces/places [16-18]. ESR15 contributes three components to the OCT: an app, a dataset and a guideline. The first component, an app, is to test the possibilities to create emotional and empathic relationships with objects using natural language processing. It also allows to connect to an application programming interface (API), track the interactions in a local database and can be deployed it any mobile device through Telegram API. The app is available for download at [68]. It can be useful to researchers and interaction designers who want to test capabilities of enabling relations with humans. Re-use of this app needs a deployment in a public server to test (including NodeJS and MongoDB), and a proper Telegram BOT API connection for the desired account. More information at [69]. The second component is a dataset [70] that helps to understand how to analyze the data of conversations obtained by the chatbot application. The dataset features examples of outputs obtained and processed by the methods explained in the research paper [69]. It is targeted for researchers and developers working in bot development willing to test other platforms and new methods can use it to understand the conversations. It consists a set of anonymized conversation logs (in Spanish) and database structure in JSON. The third component is a guideline to design affective and empathic cities. The guideline is available at [71], and its target audience include architects, designers, policy makers and urban planners can follow the guidelines in the process of taking decisions. Re-use steps can easily happen by following the steps presented in the guideline.

4 DISCUSSION

This OCT was jointly developed by the 14 ESRs, with assistance and input from three postdoctoral researchers and 13 supervisors. This section reflects on the development process from two perspectives: the perspective of the OCT developer, and the one of the OCT Catalyst. The OCT developer is the main role played by the ESRs over the last three years, namely produce one or many OCT components; the OCT catalyst refers here to the role played by postdoctoral researchers and supervisors who provided the infrastructure to enable smooth work by the ESRs.

4.1 Reflections from the OCT Developer

An online survey was conducted where ESRs were asked to anonymously give their opinion about: (i) one thing to definitely keep about the OCT; (i) one thing that should definitely be changed about the OCT; and (iii) any further comment/suggestion. The feedback collected here did not crystallize into a single feature of the OCT, which all ESRs wanted to keep. Instead, several features were listed in the ESRs' feedback. Some suggested to definitely keep the very idea of having an open city toolkit: providing a unique output for all works done by the 15 ESRs; the general idea of showing heterogeneous outputs from a multi-disciplinary research program as a connected whole; and 'cities' as one of the clients of the OCT. Aspects to 'definitely keep' also included openness, transparency, the focus on the public as main user, and the OCT being Open Source. Finally, one ESR seems to have appreciated the fact that the OCT is a central web repository.

Regarding things to 'definitely change', there were varied responses ranging from the way it was created over aspects of the final products. Many ESRs reported to miss a stronger integration of the components and would do something to change that. In addition one ESR suggested to rethink the process of defining the types of components, adopting a bottom-up approach rather than a top-down one (this is commented below).

Final, voluntary comments from the ESRs include the further promotion of participatory events during the process of building the OCT, and the need to have an eye of limited time resources while completing a 3-years PhD program.

4.2 Reflections from the OCT Catalyst

Bringing together 14 researchers to advance a research theme is exciting, but comes with the challenge of defining team rules to be followed by everyone so that the 'joint product' can successfully emerge. One wants here a frame that is neither too restrictive to prevent to ESRs from being creative in their own work, nor too generic to prevent any meaningful sense of common goal to emerge. One approach is to define a 'common societal scenario', where all should find a practical problem which can be translated into a research problem. This is the approach followed for example by [76]. Another approach is to specify the types of products that could be produced and the constraints that apply to them. This is the approach which was followed in this work, and the ESRs were asked to produce one or many components belonging to the category: dataset, app, service or guidelines. These categories were defined top-down instead of bottom-up as one of the ESRs would have wished because of the necessity to anticipate components instead of passively waiting for them. For example, ESRs need about a year to get familiar with the topic and propose a roadmap for their thesis work. They then need about another year to bring implementation work to a decent status. A bottom-approach, given the four years of the projects is thus not practical. Instead a combination of top-down (i.e. definition of component types set) and bottom-up (ESRs coming up with example of these components emerging from their own topic) seems the most sensible. Beside the type of components which were pre-defined, all ESRs were requested to make their components visible through the OCT Catalogue, and the documentation of the components in the Catalogue was done initially according to a pre-set template, and followed by internal peer-reviews within the ESRs. Overall, this approach seems to have enabled ESRs to be creative and develop their own components, but may have the limitation that it does not favour the production of joint-components. Joint-components at the practical level (i.e. joint-dataset, joint-service, joint-app or joint-guideline) have not taken place, but this does not seem to have negatively influenced the production of joint-publications (e.g. [18, 39, 77]). One way of further promoting collaboration at the component level in future doctoral training programs could be the organizations of projects over a short amount of time (e.g. four to twelve weeks), where ESRs jointly work on a given joint-product. One should note here that some components may be more easily amenable to collaboration (e.g. survey dataset) than others (e.g. an app would ideally require two or more ESRs to know the same programming language, which could be more challenging to realize practically). These short-term projects could, for example, take place in lieu of some courses, and if possible be optional, to give ESRs a great degree of flexibility regarding the final path followed during their doctoral training.

5 REUSE OF THE RESULTS

As discussed in "D8.5 Updated Data Management Plan", all project contributions are freely available for re-use. The contributions are available on the following platforms (which are known for their being very reliable when it comes to the accessibility of their hosted resources).

- Zenodo: https://zenodo.org/communities/geoc [all datasets available are tagged with an open licence]
- GitHub: https://github.com/geo-c [unless otherwise stated all code is available for re-use under an Apache v2 License]
- Youtube: https://www.youtube.com/channel/UCWnzB40te4NpqeeaoY9NuDQ [short introductory videos of some of the applications are available there to provide interested users with a glimpse of the functionalities]

The idea of a Dev Corner was emitted at the beginning of the project, but was discontinued and merged with a documentation of re-use steps in the OCT Catalogue and/or GitHub. Interested

users are thus referred to the GitHub repositories for the re-use steps of each application, and get in touch anytime with the author of the respective applications.

6 APPENDIX

OCT-related publications

- Degbelo, A., Granell, C., Trilles, S., Bhattacharya, D. and Wissing, J. (2019) 'Tell me how my open data is re-used: increasing transparency through the Open City Toolkit', in *Open Data | Open Cities*. [**Presents the OCT Transparency Module and the OCT Guideline Tool**]
- Granell, C., Bhattacharya, D., Casteleyn, S., Degbelo, A., Gould, M., Kray, C., Painho, M. and Trilles, S. (2018) 'GEO-C: Enabling open cities and the Open City Toolkit', in *Proceedings of the International Conference on Free and Open Source Software for Geospatial Applications (FOSS4G 2018) - Academic Track*. Dar es Salaam, Tanzania, pp. 61–68. [**Presents components of the OCT**]
- Degbelo, A. and Kauppinen, T. (2018) 'Increasing transparency through web maps', in Champin, P.-A., Gandon, F. L., Lalmas, M., and Ipeirotis, P. G. (eds) *Companion of Proceedings of the Web Conference 2018 - WWW '18*. Lyon, France: ACM Press, pp. 899–904. [**Presents example apps of the OCT Transparency Module**]
- Degbelo, A., Trilles, S., Kray, C., Bhattacharya, D., Schiestel, N., Wissing, J. and Granell, C. (2016) 'Designing semantic application programming interfaces for open government data', *JeDEM - eJournal of eDemocracy and Open Government*, 8(2), pp. 21–58. [**Presents the API underlying the OCT Transparency Module**]
- Degbelo, A., Bhattacharya, D., Granell, C. and Trilles, S. (2016) 'Toolkits for smarter cities: a brief assessment', in García, R., Caballero-Gil, P., Burmester, M., and Quesada-Arencibia, A. (eds) *UCAmI 2016 - 10th International Conference on Ubiquitous Computing & Ambient Intelligence*. Las Palmas, Gran Canaria, Spain: Springer International Publishing, pp. 431–436. [**Presents features of the OCT Catalogue and gaps addressed by the OCT**]
- Degbelo, A., Granell, C., Trilles, S., Bhattacharya, D., Casteleyn, S. and Kray, C. (2016) 'Opening up smart cities: citizen-centric challenges and opportunities from GIScience', *ISPRS International Journal of Geo-Information*, 5(2), p. 16. [**Presents the vision of the OCT**]

7 REFERENCES

[1] Naranjo Zolotov, M., Oliveira, T., and Casteleyn, S., 2018c. E-participation adoption models research in the last 17 years: A weight and meta-analytical review. *Computers in Human Behavior*, 81, 350-365. https://doi.org/10.1016/j.chb.2017.12.031

[2] Naranjo Zolotov, M., Oliveira, T., Cruz-Jesus, F., and Martins, J., 2018a. Satisfaction with e-participation: A Model from the Citizen's Perspective, Expectations, and Affective Ties to the Place. In: *Trends and Advances in Information Systems and Technologies*. Cham: Springer International Publishing, pp. 1049-1059.

[3] Acedo, A., Painho, M., and Casteleyn, S., 2017. Place and city: Operationalizing sense of place and social capital in the urban context. *Transactions in GIS*, 21(3), pp. 503-520.

[4] Du, G., Degbelo, A., Kray, C., 2017. Public displays for public participation in urban settings: a survey. In *6th ACM International Symposium on Pervasive Displays*. Lugano, Switzerland, ACM, https://doi.org/10.1145/3078810.3078825

[5] Bustamante Duarte, AM., Brendel, N., Degbelo, A., Kray, C. (2018b). Participatory Design and Participatory Research: An HCI Case Study with Young Forced Migrants. *ACM Transactions on Computer-Human Interactions*, 25, 1, Article 3, 39 pages. https://doi.org/10.1145/3145472

[6] Gupta, S., Mateu, J., Degbelo, A., and Pebesma, E., 2018. Quality of life, big data and the power of statistics. *Statistics & Probability Letters.* https://doi.org/10.1016/j.spl.2018.02.030

[7] Smid, M., and Costa, A. C., 2017. Climate projections and downscaling techniques: a discussion for impact studies in urban systems. *International Journal of Urban Sciences (in press)*, https://doi.org/10.1080/12265934.2017.1409132

[8] Moradi, M. M., Rodríguez-Cortés, F. J., and Mateu, J., 2017. On kernel-based intensity estimation of spatial point patterns on lin-ear networks. *Journal of Computational and Graphical Statistics*. https://doi.org/10.1080/10618600.2017.1360782.

[9] Khoi, N.M., Rodríguez-Pupo, L.E., and Casteleyn, S., 2017. Citizense—A generic user-oriented participatory sensing frame-work. In: *Selected Topics in Mobile and Wireless Networking (MoWNeT 2017)*, pp. 1-8.

[10] Benitez-Paez, F., Degbelo, A., Trilles, S., and Huerta, J., 2018. Roadblocks hindering the reuse of open geodata in Colombia and Spain: A data user's perspective. *ISPRS International Journal of Geo-Information*, 7(1), 6.

[11] Benitez-Paez, F., Comber, A., Trilles, S., and Huerta, J., 2018. Creating a conceptual framework to improve the re-usability of open geographic data in cities. *Transactions in GIS* (in press). https://doi.org/10.1111/tgis.12449.

[12] Ataei, M., and Kray, C., 2017. Ephemerality Is the New Black: A Novel Perspective on Location Data Management and Location Privacy in LBS. In *Progress in Location-Based Services 2016*. Lecture Notes in Geoinformation and Cartography, Springer, pp. 357-373.

[13] Kamberov, R., Granell, C., Santos, V., 2017. Sociology Paradigms for Dynamic Integration of Devices into a Context-Aware System. *Journal of Information Systems Engineering & Management*, 2(1), 2.

[14] Kamberov, R., Granell, C., and Santos, V., 2018. Use Case Scenarios of Dynamically Integrated Devices for Improving Human Experience in Collective Computing. In: *Trends and Advances in Information Systems and Technologies (WorldCist 2018)*. Naples, Italy. Springer, vol. 746, pp. 581-592.

[15] Pajarito, D., and Gould, M. (2017). Smart Mobility, the Role of Mobile Games. In: *Serious Games (JCSG 2017)*. Springer, vol 10622, pp. 44-59.

[16] Portela, M., and Granell-Canut, C. (2016). Methods to Observe and Evaluate Interactions with Everyday Context-Aware Objects. In: *Ubiquitous Computing and Ambient Intelligence*. Canary Is-lands, Spain, Nov 2016. Springer, vol. 10069, pp. 385-392

[17] Portela, M., and Granell-Canut, C. (2017a). A new friend in our Smartphone? Observing interactions with chatbots in the search of emotional engagement. In *Proceedings of 18th International Conference Human Computer Interaction*. Cancun, Mexico, Sep 2017. ACM, Article 48

[18] Portela, M., Acedo, A., and Granell-Canut, C. (2018). Looking for "in-between" places. *Media Theory Journal,* 2(1).

[19] Dataset: http://giv-oct.uni-muenster.de/surveys/oxfordbarracks072016.html

[20] Degbelo, Auriol; Du, Guiying; Kray, Christian (2016) Survey results of Datasets Offered by Current Open Data Portals [Data set]. Zenodo. https://zenodo.org/record/1239387#.Wvw5ky-ZOqA

[21] Dataset: https://github.com/geo-c/OCT-WelcomeMS

[22] App: https://github.com/geo-c/OCT-RefugeeApp

[23] Bustamante Duarte, AM., Degbelo, A., Kray, C. (2018). Exploring Forced Migrants (Re)settlement & the Role of Digital Services. The 16th European Conference on Computer-Supported Cooperative Work (ECSCW). Nancy, France. June 4-8,2018.

[24] Dataset: https://zenodo.org/record/997211#.Wvw_oi9g1sM

[25] Bustamante Duarte, Ana M., Brendel, Nina., Degbelo, Auriol., Kray, Christian. 2018. "Participatory Design and Participatory Research: An HCI case study with young forced migrants". ACM Transactions on Computer-Human Interaction (TOCHI). Volume 25, Issue 1 Art.3, 1-39.

[26] Web site: https://placeandcity.com

[27] Repository: giv-oct2.uni-muenster.de:5000/dataset/sense-of-place-and-social-capital

[28] Acedo, A., Mendoza, G., Painho, M., and Casteleyn, S., 2017. One tool to spatialize all : sense of place , social capital and civic engagement. In: A. Bregt, T. Sarjakoski, R. Lammeren, and F. Rip, eds. Societal Geo-Innovation : short papers, posters and poster abstracts of the 20th AGILE Conference on Geographic Information Science. Wageningen: Wageningen University & Research.

[29] Meta-analysis data set: https://doi.org/10.5281/zenodo.1248027

[30] Guideline: http://giv-oct2.uni-muenster.de:5000/dataset/meta-analysis-of-technology-adoption

[31] Zolotov, M. N., Oliveira, T., & Casteleyn, S. (2017). E-participation adoption models research in the last 17 years: A weight and meta-analytical review. Computers in Human Behavior.

[32] E-participation survey in Portugal: https://doi.org/10.5281/zenodo.1248066

[33] Participatory budgeting geolocated results: http://giv-oct2.uni-muenster.de:5000/dataset/participatory-budgeting-dataset-from-lisbon-municipality

[34] ESR06 OCT link: http://giv-oct.uni-muenster.de:5000/dataset?tags=ESR06&q=esr06

[35] ESR06 Youtube: https://www.youtube.com/watch?v=zbCEs43UmVE

[36] ESR06 Web app http://giv-oct.uni-muenster.de:5000/dataset/citizense-campaign-manager/resource/64dbbe39-db50-40c3-b8b7-c0b184d6fe1b

[37] ESR06 Mobile app : http://giv-oct.uni-muenster.de:5000/dataset/citizense-mobile-app/resource/fb462e20-066d-487a-9b9f-2b0dca6fe5ae

[38] Khoi, Ngo Manh, Luis E. Rodríguez-Pupo, and Sven Casteleyn. "Citizense—A generic user-oriented participatory sensing framework." In Selected Topics in Mobile and Wireless Networking (MoWNeT), 2017 International Conference on, pp. 1-8. IEEE, 2017.

[39] Khoi, N. M., S. Casteleyn, M. M. Moradi, and E. Pebesma. "Do Monetary Incentives Influence Users' Behavior in Participatory Sensing?." Sensors (Basel, Switzerland) 18, no. 5 (2018).

[40] Zenodo: https://zenodo.org/record/840352#.Wvw9__xKi00

[41] OCT: http://giv-oct2.uni-muenster.de:5000/dataset/survey-table-smart-mobility-role-of-mobile-games

[42] Pajarito D; Gould M. Paper Survey Table - Smart Mobility - role of mobile games. DOI: 10.5281/zenodo.840352

[43] OCT repository: http://giv-oct2.uni-muenster.de:5000/dataset/cyclist-app

[44] Google Play: https://play.google.com/store/apps/details?id=geoc.uji.esr7.mag_ike

[45] R script in Github: https://github.com/geohealthshivam/OCT-Scripts

[46] Shivam Gupta, Edzer Pebesma, Jorge Mateu, Auriol Degbelo. Air Quality Monitoring Network Design Optimisation for Robust Land Use Regression Models. Sustainability 2018.

[47] Gupta S, Mateu J, Degbelo A, Pebesma E. Quality of life, big data and the power of statistics. Statistics & Probability Letters. 2018 Feb 27.

[48] R script in Github: https://github.com/geohealthshivam/LUR-Variable-extraction-app

[49] R script in Github: https://github.com/geohealthshivam/AQ-MND-optimisation

[50] Data: http://giv-oct2.uni-muenster.de:5000/dataset/yearly-model ;

[51] Data: http://giv-oct2.uni-muenster.de:5000/dataset/decadal-simulation

[52] Web Portal App: https://cgranell.shinyapps.io/03-cordex-dashboard/

[53] Service: http://giv-oct.uni-muenster.de:5000/dataset/twitter-spatio-temporal-datasets-and-r-codes

[54] Dataset: http://giv-oct.uni-muenster.de:5000/dataset/geolocated-tweets-sample-dataset

[55] Guideline: https://elcano.init.uji.es/documents/qaBFbFxqPB2tQrf97

[56] Benitez-Paez, F, Comber, A, Trilles, S et al. (1 more author) (2018) Creating a conceptual framework to improve the re-usability of open geographic data in cities. Transactions in GIS. ISSN 1361-1682 (In Press)

[57] Dataset: http://giv-oct2.uni-muenster.de:5000/dataset/survey-cities-open-data-portals-current-status

[58] Benitez-Paez, F.; Degbelo, A.; Trilles, S.; Huerta, J. Roadblocks Hindering the Reuse of Open Geodata in Colombia and Spain: A Data User's Perspective. ISPRS Int. J. Geo-Inf. 2018, 7, 6.

[59] Service: https://github.com/GeoTecINIT/Guideline-/tree/master/R%20code

[60] Degbelo, A., Bhattacharya, D., Granell, C. and Trilles, S. (2016) 'Toolkits for smarter cities: a brief assessment', in García, R., Caballero-Gil, P., Burmester, M., and Quesada-Arencibia, A.

(eds) UCAmI 2016 - 10th International Conference on Ubiquitous Computing & Ambient Intelligence. Las Palmas, Gran Canaria, Spain: Springer International Publishing, pp. 431–436.

[61] Guideline: https://elcano.init.uji.es/documents/qnkxCSLhPNkLXBe55

[62] Granell, C., Bhattacharya, D., Casteleyn, S., Degbelo, A., Gould, M., Kray, C., Painho, M. and Trilles, S. (2018) 'GEO-C: Enabling open cities and the Open City Toolkit', in *Proceedings of the International Conference on Free and Open Source Software for Geospatial Applications (FOSS4G 2018) - Academic Track*. Dar es Salaam, Tanzania, pp. 61–68.

[63] Guideline: https://elcano.init.uji.es/documents/Gp7F27TPadG2fxvdD

[64] Publication: http://geo-c.eu/pubs/2016_Atai_LBS.pdf

[65] Link: https://elcano.init.uji.es/documents/zdpNx7gos2CikSGFg

[66] Service: http://giv-oct2.uni-muenster.de:5000/dataset/location-based-rest-service

[67] Kamberov, R., Granell, C., Santos, V. (2017). Sociology Paradigms for Dynamic Integration of Devices into a ContextAware System. Journal of Information Systems Engineering & Management, 2(1), 2. DOI: 10.20897/jisem.201702

[68] App: https://github.com/GeoTecINIT/GeoTec-Bot-

[69] Portela, M., & Granell-Canut, C. (2017, September). A new friend in our smartphone?: observing interactions with chatbots in the search of emotional engagement. In Proceedings of the XVIII International Conference on Human Computer Interaction (p. 48). ACM.

[70] Dataset: https://github.com/GeoTecINIT/GeoTec-Bot-Logs

[71] Guideline: http://giv-oct2.uni-muenster.de:5000/dataset/guidelines-for-enhancing-affective-cities

[72] Degbelo, A., Trilles, S., Kray, C., Bhattacharya, D., Schiestel, N., Wissing, J. and Granell, C. (2016) 'Designing semantic application programming interfaces for open government data', JeDEM - eJournal of eDemocracy and Open Government, 8(2), pp. 21–58.

[73] Degbelo, A. and Kauppinen, T. (2018) 'Increasing transparency through web maps', in Champin, P.-A., Gandon, F. L., Lalmas, M., and Ipeirotis, P. G. (eds) Companion of Proceedings of the Web Conference 2018 - WWW '18. Lyon, France: ACM Press, pp. 899–904. doi: 10.1145/3184558.3191515.

[74] Degbelo, A., Granell, C., Trilles, S., Bhattacharya, D. and Wissing, J. (2019) 'Tell me how my open data is re-used: increasing transparency through the Open City Toolkit', in Open Data | Open Cities. [Accepted for publication].

[75] Degbelo, A., Granell, C., Trilles, S., Bhattacharya, D., Casteleyn, S. and Kray, C. (2016) 'Opening up smart cities: citizen-centric challenges and opportunities from GIScience', ISPRS International Journal of Geo-Information, 5(2), p. 16. doi: 10.3390/ijgi5020016.

[76] IRTG International Research Training Group on Semantic Integration of Geospatial Information: https://irtg.ifgi.de/about/organization/common-scenario/

[77] Do people develop activities at places in which citizens have a sense of place?. Acedo, A.; Santa, F.; Painho, M.; and Henriques, R. In Mansourian, A.; Pilesjö, P.; Harrie, L.; and von Lammeren, R, editor(s), Geospatial Technologies for All : short papers, posters and poster abstracts of the 21th AGILE Conference on Geographic Information Science, volume 745, pages 1049–1059, 2018.