

Volunteered Citizen Contribution to Smart Cities

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Abstract

The urban planning and management needs a lot of spatial data. The data for the needs must be collected by land survey in most of the cases. When we talk about collecting data, there is a “must” to define: “What kind of data to collect?”. Certain rules are related to the acquired data for professional workflow implementation. The link between data capturing and data implementation can be found in the smart people contribution.

The target of the research is how to improve the spatial data registration, documentation and visualization with low-cost hardware and software in easy accessible platform for data capture and collection by involved citizens for volunteered information sharing. The possibility of applying comprehensible hardware and software for collecting geospatial data and integration into a contribution platform is explored.

The workflow shows that with the help of the citizen initiative, there are many data attributes that can be collected by publishing through free sources, such as: address number, type of street coverage, electrified pole coverage, utility equipment, et cetera.

1. Introductions

The basic concept of “smart cities” is improving the quality of life of citizens, increasing the competitiveness of European cities and industry, and achieving European energy and climate goals (European Commission, 2024). To achieve these objectives, it is necessary to have source data for infrastructure elements and a large amount of spatial information about the existing state of cities, since their development and the creation of amenities for citizens must be adjusted to different territorial characteristics. The improvement of the source spatial information allows to increase the quality of management and service in cities.

In many small settlements in Bulgaria, data on infrastructure elements are missing or incomplete. The investment in collecting such data will be large, and it will also be quite a lengthy process. For this reason, in addition to the state administration, citizens, non-governmental organizations, companies and all interested persons should be included in the activities.

The development of technologies and their affordable prices contribute to their use by ordinary people in their daily activities: such are smartphones and 360-degree panoramic cameras. For this reason, the idea of creating this article arose, with the goal is to develop and test a workflow for low-budget geospatial data collection. By implementing the developed and tested sequence, citizens interested in urban development will have the opportunity to voluntarily contribute to the management and quality of life processes.

2. Materials and Methods

The target for the research is how to improve the spatial data registration, documentation and visualization with low-cost hardware and software in freeware platform for data capture and collection by involved citizens for volunteered information sharing. But before we give the solution to the set goal, it is necessary to consider the quality of the whole process. It is closely related to conducting research and analysis: “What is the limit of the research?”, “What software products are most

suitable for our purpose?” and “What tools (hardware) do we need?”.

2.1 Determining the boundary of the study

Data capturing must be focused on certain territory. The urban territory of the village Momino Selo, Bulgaria was used in the study.

Another condition that must be considered is the extent and relevance of the territory covered by previous studies. There were several areas, covered before the study (Fig. 7). Only the main roads were captured and published by “Google Street View” in March 2012, June 2022, and June 2023 (Fig. 1). The analysis proves the usefulness of collecting data for the entire territory.

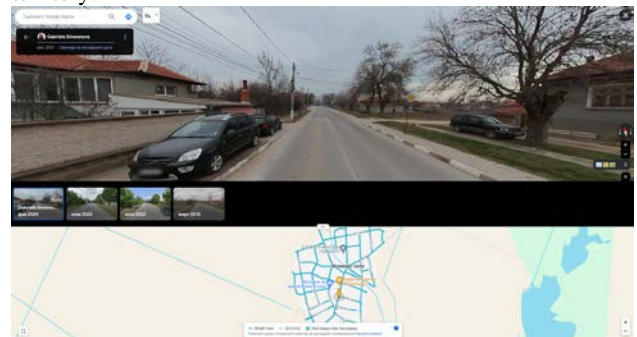


Figure 1. Google Street View data published in March 2012, June 2022, and June 2023.

2.2 Software platforms

The data have added value when it can be applied, visualized, shared, and retrieved by a wide range of users. The selection of a free sharing platform accessible by various devices and operating systems plays a key role in the benefits of the activity. “Google Street View Studio” was selected for data publishing, “Google Maps” is the connected application for visualization and finally “Google Earth Pro” is the tool for the geospatial metadata extraction.

2.3 Hardware equipment

There is a wide range of equipment that collects spatial data. The research focus is on low-cost solutions available to interested citizens to contribute to the improvement, maintenance, and development of the urban environment. Several rules must be followed for approved “Street View” data capture (Google StreetView).

2.3.1 Image quality: 7.5 MP or larger (3,840 x 1,920 px); 2:1 image aspect ratio; No gaps in image around horizon; No significant stitching errors; Adequate detail in light/dark areas; Sharpness: no motion blur, in focus; No distracting effects or filters, including in the image nadir.

2.3.2 Connectivity: All connected 360 photos must maintain a clear line-of-sight; Shoot at 1 meter spacing indoors and every 3m outdoors; Increase the chances of connecting with us by extending your collection to a street.

2.3.3 Appropriateness: Consent to show people and place; Geographically accurate placement; No computer-generated spaces or special effects, including image mirroring or warping; No attribution beyond nadir area; No hateful or illegal content. The choice of camera is between three models. The best integration in the process provides “Insta360 ONE RS 1-Inch 360 Edition”. Other options were the “Ricoh Theta Z1 51GB” and the “GoPro MAX 360” cameras. The “Insta360 ONE RS 1-Inch 360 Edition” camera is delivered with free desktop software which provides the required navigation data for successful upload. The average price of \$1000 places the tool as affordable and low-cost.

2.4 Workflow

The process is structured in four main stages. These stages are based on the participation of the interested volunteers and their expertise. A sequence diagram of the work was developed (Fig. 2).

The voluntary citizens can easily participate in one or more stages according to their own willingness.

The first stage, which envisages the collection of the data, has been developed with the assumption that it can be carried out by participants who do not possess expert skills in collecting geospatial data, do not have access to specialized equipment, but are willing to contribute to the development in a few easy and accessible steps. This stage is suitable for the volunteered participation of citizens.

The second stage is related to the software platform. Popular and well known platforms for web mapping are Google Maps and OpenStreetMap. User experience is a key factor to consider when choosing between the two platforms. The platform Google Maps was chosen due to the seamless sharing of panoramic views by users who do not have specialized software and skills to process personal data and information, but must follow simple rules when collecting and sharing the data. Similar platforms for panoramic view sharing are provided by Mapillary, KartaView and others.

The third stage is closely connected with the previous. The platform decides if to publish the collected data or not. Subsequently, the data is available for gathering geospatial information relative to the user's expertise.

The final stage in the workflow engages users with advanced levels of expertise in geospatial data mining. This stage provides opportunity to final deliverables with high quality.

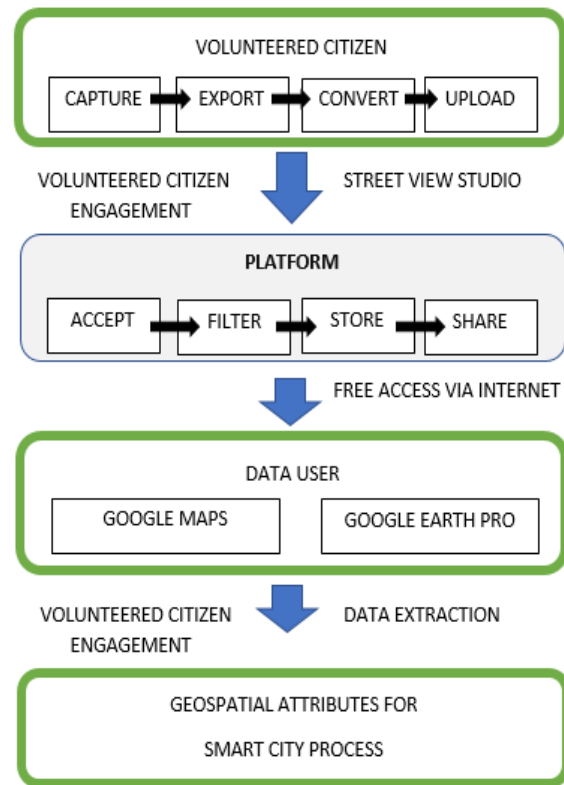


Figure 2. Basic stages in the work process.

2.4.1 Data capture: As noted above, the “Insta360 ONE RS 1-Inch 360 Edition” camera is selected. The workflow starts by attaching the camera to the vehicle, which can be seen in Figure 3. Choosing the right height of the camera relates to the environment specifics. The 2 meters mounting height allows for capturing information behind fences and is safe for traversing overgrown streets and low tree branches.



Figure 3. Attaching the camera to the vehicle.

To organize the process of data capture of all the streets in the selected territory, the “Locus Map” free application (Fig. 4) is used. With the app, the already photographed streets were recorded as a track. This helps to avoid data duplication. Also, after the step is completed, the motion trajectory data can be exported as *.kml or *.kmz file format. Another free app “Insta360” is used for the video capturing and camera control.

The connected tablet provides GNSS coordinates for the georeferencing of the video.

The territory has an approximate area of 900 decares. The filming of the entire village took about 1 hour and was carried out by a team of two people - a driver and a navigator who made the video. The collected video files are in specific *.insv file format.

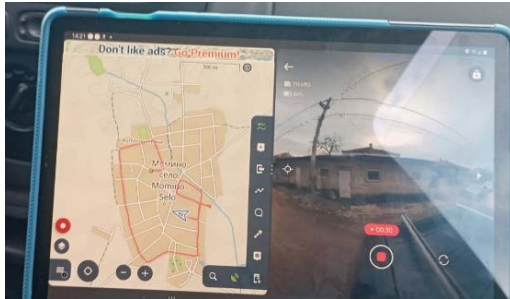


Figure 4. Workflow organization with Locus Map software

2.4.2 Export: The raw data is exported to PC. There are no specific requirements on the PC's hardware configuration. The raw files from the camera are stored on the PC's hard drive. The total size of all the files is 30.2GB.

2.4.3 Convert: "Insta360 Studio 2024" is the free software for converting the raw *.insv video files to *.mp4 video file and *.gpx track file. The original resolution is kept without any filters or specific processing. Procedure is to load all the files in the software, select and export. One hour of video is exported in 30 minutes.

2.4.4 Upload: The successful execution of the step requires free Google Account for the data upload via "Google Street View Studio". The good internet connection helps for the fast upload of the data. For each *.mp4 file additional *.gpx file (Fig. 5) is required by the online platform.

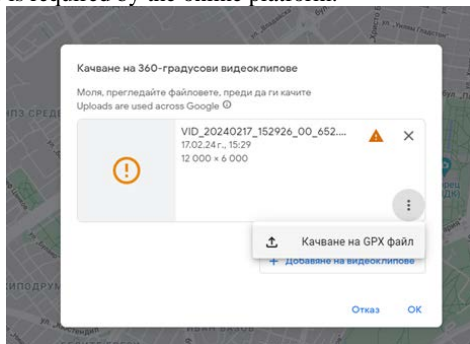


Figure 5. Upload a *.gpx file.

The uploaded *.gpx file shows the track for the video on the map (Fig. 6). The progress of the upload process is visualized on the screen. The complete village of Momino Selo was uploaded in less than 30 minutes.

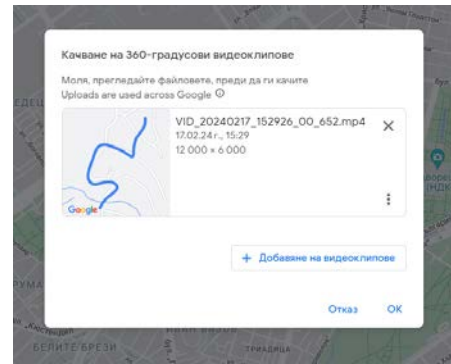


Figure 6. The uploaded *.gpx file.

With this step ends the first and more important part of the volunteered citizen engagement to Smart Cities.

2.4.5 Accept: If the information is correct and the *.gpx file covers the time stamps of the video, Google Street View Studio accepts the video and starts the processing procedure. The complete village is visible in less than 24 hours after the upload is finished.

2.4.6 Filter: Filters are necessary because "Google Street" has rules for sharing personal information and obscene content. All prohibitions and restrictions can be found at <https://support.google.com/contributionpolicy/answer/7400114?sjid=9482600753925020210-EU>. During the processing, "Google Street View" extracts certain frames from the video, connects the frames in path, covers the faces of the people and the vehicle registration plates in the frames (Fig. 7). The "processing" message appears in the video properties in the platform.

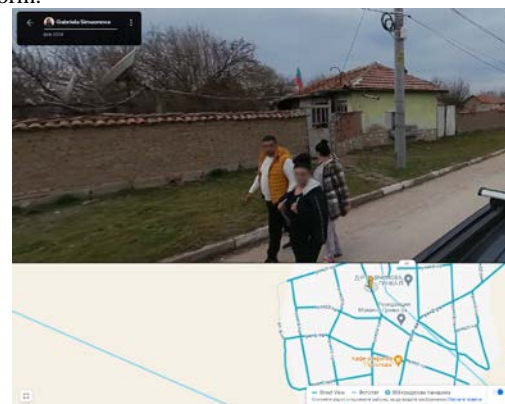


Figure 7. Mask on faces.

2.4.7 Store: The collected data is stored by "Google Street View" free of charge for the contributor and the users of the data. No limitation for the volume of the uploaded data is available now.

2.4.8 Share: Automatically generated email shows to the contributor the successful data upload. All the georeferenced panoramas are available in “Google Maps” and “Google Earth Pro” (Fig. 8). The data is available free of charge via internet connection.



Figure 8. Result of publishing data on “Google Maps”.

3. Application

3.1 Google Maps

According to the basic stages in the work process (Fig. 2), the raw panoramic data is processed, approved, published and accessible by potential users. The data type needed to meet the application requirements is presented as orientated georeferenced connected panoramic images. The required resources are mobile or stationary device with internet access. Google Maps offers several benefits for citizens to contribute:

3.1.1 Fill the map with missing geometry of streets and roads: In small towns there are many streets that are missing on the map. Also forest and field roads are not marked on all the maps (Fig. 9). Through the proposed method, citizens can supplement information while doing their daily activities or simply walking and resting.

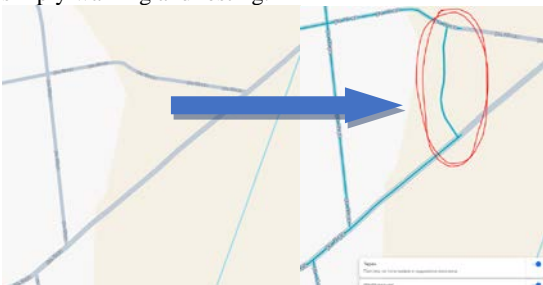


Figure 9. New road.

3.1.2 Fill the map with missing street name, address, and missing place: On Figure 10 is visible how addresses and street names can be extracted from the collected data.



Figure 10. Explore an addresses and street names.

3.1.3 Analyze the road structure and type: Road pavement analysis (Fig. 11) provides fundamental information for road design and renovation. Based on images, the extent, type of defect and the need for repair work on road surfaces can be determined.



Figure 11. Coverage analysis for roads type.

3.1.4 Check for missing road signs: Road signs play a vital role in road safety. It often happens that road signs are missing (Fig. 12), damaged or not in appropriate condition, and the reasons are different: weather conditions, vandalism, accidents, etc. The maintenance of road signs requires the resource of many people. By updating street view by citizens, the effort and resource of workers to monitor road signs can be minimized.



Figure 12. Missing road signs.

3.1.5 Check for missing buildings: The creation of cadastral maps is a long process compared to the pace at which construction is developing. Keeping them up to date is also not an easy process. Citizens can monitor (Fig.13) whether their building is displayed, whether there are discrepancies in the geometry, etc.

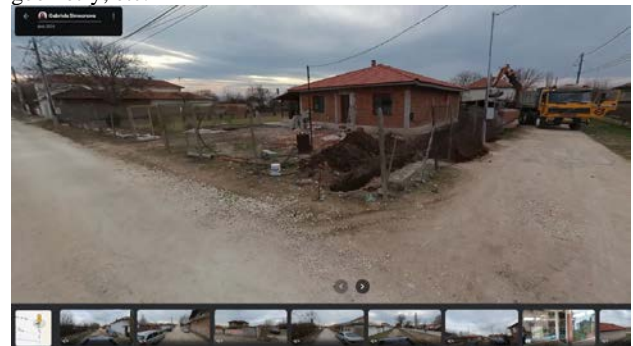


Figure 13. New finished construction in 2024.

3.1.6 Construction control: Monitoring construction and detecting changes to the implementation of a given project or already completed construction is a way to check the quality of implementation. The proposed approach is a low-cost quality control option. As change detection can be monitored earthworks, stockpiles, storage areas, execution of construction elements. Example for new buildings is observed in Figure 14.

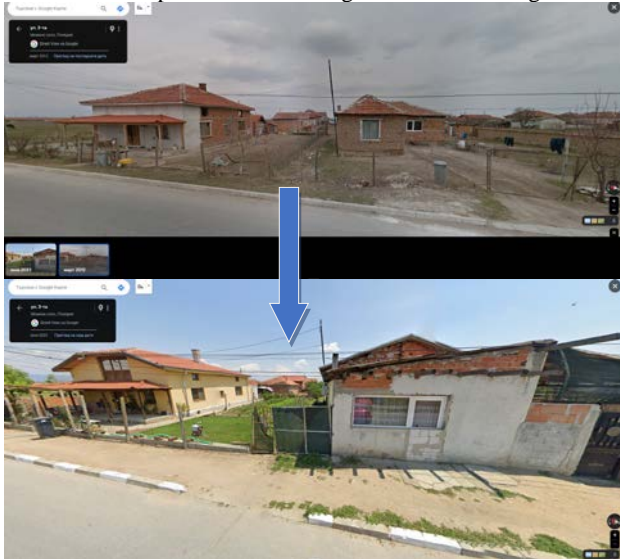


Figure 14. Illegal buildings control.

3.1.7 Infrastructure coverage (shafts, poles, streetlights):

Extraction of information about infrastructure objects for various purposes. Georeferenced attribute information is available such as pole ID (Fig. 15)

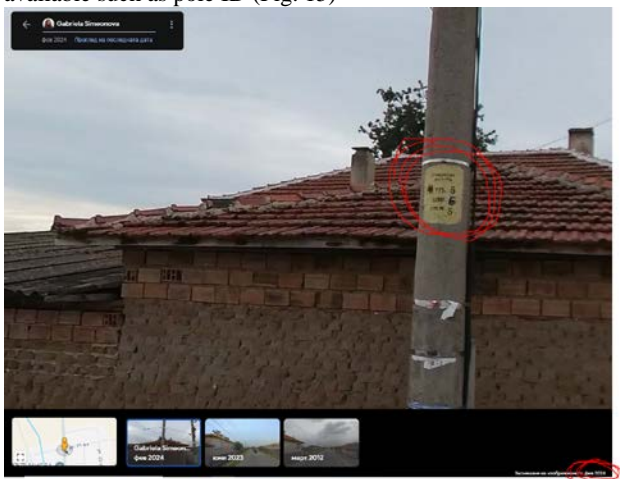


Figure 15. Identification of pole.

3.1.8 Risk analysis for dangerous trees, rivers, and other hazards:

The main objective of the management of these risks is the safety of people and the prevention of catastrophic accidents, which can lead to many economic losses and contribute to environmental degradation. Example for continuously blocked shaft is seen (Fig. 16)



Figure 16. Control and Hazards: feb.2024(left) and june.2023(right).

3.2 Google Earth Pro

Combining the collected georeferenced panoramas with powerful data extraction tool leads to advanced contribution by semi-experts and experts for smart city process. “Google Earth Pro” is freeware software that provides possibility for georeferenced data extraction with the accuracy for implementing the data in Geographic Information System (GIS). This kind of data mining is useful to the citizen volunteers in the process as well as to the experts in the city administration. The mentioned deliverables by using “Google Maps” can be combined with global coordinate system location. This step requires advanced knowledge on data analysis and processing by the user of the collected data. The required hardware resources are mobile or stationary device with internet access. The geometry in GIS is separated to points, lines and areas. “Google Earth Pro” supports:

3.2.1 Point measurement: By measuring single point and adding attribute information connected with the research is easy way to collect georeferenced spatial information (Fig. 17). There is no need to visit the site with expensive equipment by expert. The collected data is enough not only to register the issue. There are opportunities to check and validate the data by control systems in organization. Measured points, attributes and coordinates from the panoramas can be exported in *.kml or *.kmz file format. This export connects the citizen’s contribution with the experts for further analyse.

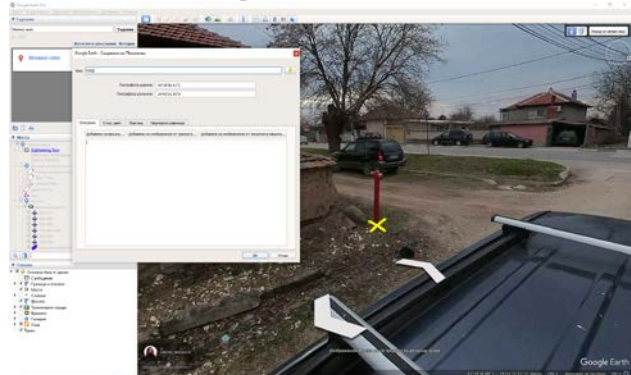


Figure 17. Single point measurement at coordinates 42°18'38.91"N, 24°53'32.52"E.

Another important deliverable is not only the location of the issue, but the time of registration. The time stamp is a must when we talk about location. The data is available with its location and time especially when we talk about change detection.

3.2.2 Line measurement: This type of data can be collected by careful mapping by experts. The error in the orientation of the images leads to recommendation for close range mapping. Example on mapping s ditch can be seen on Figure 18.

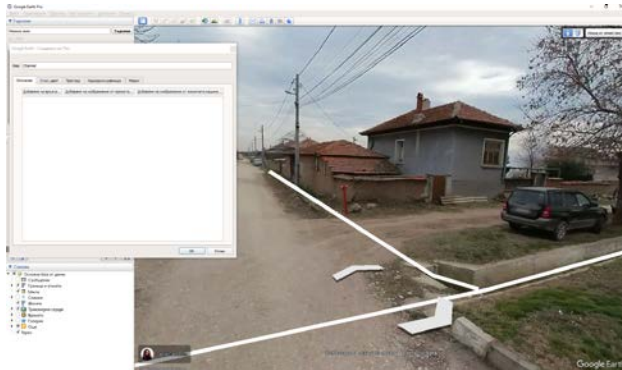


Figure 18. Linear mapping.

3.2.3 Area measurement: As the linear measurements, areas are recommended to be measured only close to the camera (Fig. 19). The method is suitable to measure but accuracy have to be established in further research.

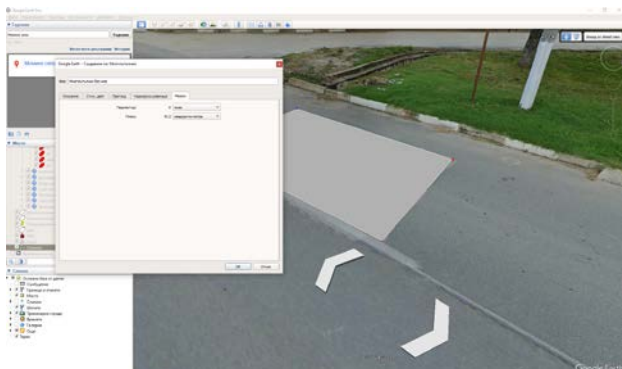


Figure 19. Area mapping.

3.3 Additional applications

The researchers try to implement the panoramic images in all the possible applications. Identification system for advertisements was developed (A. Zamir, 2011), Photogrammetric city modeling from panoramas was explored (A. Torii, 2009). Multi-view semantic segmentation method was developed (J. Xiao, 2009) for separating image regions for 3d city model.

4. Conclusion

The relationship between theoretical and actually researched practical applicability is at the heart of the study. The purpose was to create and test a workflow connected with low-cost solutions for data capturing and contribution in smart city process.

The complete process was part of the study. The process was separated to different stages by the involvement and the preparation of the participants.

A simple workflow was developed (Fig. 2). The results were tested and evaluated as suitable for contributing participants.

There were separated different parts, connected to specific stages of contribution: data capturing by all interested participants, data analysis by non-experts in geoformation, semi- and full- professional data extraction capabilities of experts.

The final deliverables can be obtained and used by communities, city administrations, designers and public institutions according their own needs.

The final result proves that all the volunteered citizens can be engaged in “Smart City” process by their own partnership on different stages, depending on the own expertise.

The developed process is a foundation for future upgrade and improvement.

5. References

A. Torii, M. Havlena, T. Pajdla, From google street view to 3D citymodels, in: *Computer vision workshops (ICCV Workshops), 2009 IEEE 12th international conference on*, IEEE, 2009, pp. 2188–2195.

A. Zamir, A. Darino, M. Shah, Street view challenge: Identification of commercial entities in street view imagery, in: *Machine Learning and Applications and Workshops (ICMLA), 2011 10th International Conference on*, Vol. 2, IEEE, 2011, pp. 380–383.

J. Xiao, T. Fang, P. Zhao, M. Lhuillier, L. Quan, Image-based street-side city modeling, in: *ACM Transactions on Graphics (TOG)*, Vol. 28, ACM, 2009, p. 114.

European Commission, https://commission.europa.eu/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en

Google Street View, <https://www.google.com/streetview/contribute/>