TOURISM, NATURAL PROTECTED AREAS AND OPEN SOURCE GEOSPATIAL TECHNOLOGIES

Massimiliano Cannata[a],*, Daniele Strigaro[a], Alessio Spataro[a], Federica Marotta[b], Cristiana Achille[b]

[a] Institute of Earth sciences (IST), University of Applied Sciences and Arts of Southern Switzerland (SUPSI), Switzerland.
(massimiliano.cannata@supsi.ch, daniele.strigaro@supsi.ch, alessio.spataro@supsi.ch)
[b] 3D Survey Group, ABC Lab, Politecnico di Milano, Italy.
(federica.marotta@polimi.it, cristiana.achille@polimi.it)

Commission IV, WG IV/4

KEY WORDS: Tourism, Park Management, Monitoring, 3D survey, istSOS.

ABSTRACT:

The Covid-19 outbreak has greatly impacted society behaviours fostering proximity tourism and valorising the social role of peri-urban natural protected areas as key locations for outdoor activities. FOSS and FOSS4G can play a critical role to support the value creation for these sites. This work evaluates its application in the context of two different protected areas for the creation of 3D digital products, the monitoring of touristic fluxes and the conduction of parks management activities. To this aim three solutions that copes with the mentioned aspects are presented and gaps, weakness and limitations evaluated. The investigated solutions consists in: the data workflow from survey to 3D rendering using Blender and GIS plugin; the touristic fluxes monitoring system based on a machine learning algorithm for image recognition from captured video data streams and istSOS; and finally the park assets management system which is based on PostGIS and OpenLayers.

1. INTRODUCTION AND CONTEXT

The Covid-19 outbreak has greatly impacted society behaviours fostering proximity tourism and valorising the social role of peri-urban natural protected areas as key locations for outdoor activities (Cabello et al., 2021). This shift in habits calls for an adaptation in the next years of the offerings and management of these areas to respond to users' expectations of positive experience opportunities in near-by locations (Lebrun et al., 2021). In the context of digital transformation and peri-urban protected areas, this research investigates the contribution that open geospatial technologies can provide in the creation of new economic, social and cultural values to propose solutions and identify gaps or open issues.
This research is framed in within the Interreg INSUBRI.PARKS (www.insubriparksturismo.eu) which includes five regional natural parks located in the Insubria area located across the Italian and Switzerland states. Within this project the parks of *Spina Verde, Campo dei Fiori, Pineta, Gole della Breggia* and *Parco del Penz* are currently collaborating in the creation of a regional touristic network that is capable to offer a wide range of experiences and opportunities and can propose a set of touristic inter-parks products with a potentially international value. In this context, this paper focused on the technological activities carried out in the *Parco Gole della Breggia* and *Parco del Penz* and in collaboration with the *Mendrisiotto Turismo* regional touristic office and the other three parks with the aim of fulfilling existing and individuated open issues of not covered opportunities.
From the discussion with local tourism organisations and park administrators, we have identified three specific aspects that are of particular concern:

1. The creation of 3D digital products.
2. The monitoring of touristic fluxes.
3. The conduction of parks management activities.

This work presents the intermediate results of the development and testing of explored solutions with respect to the open source software and the above mentioned aspects.
The following section 2 will describe the case studies, and for each of the three investigated aspects the applied approach and used tools. In section 3 the outcomes of the tested solutions are presented while in section 4 results are discussed.

2. MATERIAL AND METHODS

2.1 Case studies

The adopted methodology is the "case study approach", in which real cases are used to design, develop, implement, collect and analyse data to extrapolate information that contributes to a deeper knowledge of the matter. Specifically for this research the *Parco Gole della Breggia* and the *Parco del Penz* has been selected. In fact, while being two natural protected areas closely located in the southern part of Switzerland, in the Canton Ticino, they greatly differ for in-place management structure, available offers and users' type and therefore represents different needs.
The *Parco Gole della Breggia* with its river gorges represents, from a scientific point of view, a naturalistic and geological jewel. In particular, the geological outcrops constitute an exceptional document that almost continuously covers the successive geological events over a period of approximately 100 million years, between the Jurassic and the Tertiary. In particular, the section between the Jurassic and the Cretaceous is unique in its genre in the whole Alpine arc. It constitutes a document of considerable scientific interest worldwide. From another point of view, the area witnesses the impact of the industrialization

* Corresponding author

https://doi.org/10.5194/isprs-archives-XLVIII-4-W1-2022-81-2022

on the natural environment with a suggestive landscape where excavated slopes and galleries and an imposing structures of a disused cement factory have been redeveloped and renovated as part of a unique territorial and cultural project. Today the area is considered an area with high tourist-recreational use in a highly inhabited and urbanized context.
The *Parco del Penz* is a natural area characterized by a wooded hill (from 240 to 562 meters above sea level) where the deciduous forest predominates here with tree species typical of acid reaction soils. The main species are the black locust and chestnut but beech, oak, hornbeam, larch, fir, cherry, birch are also present. From a fauna perspective, the park hosts three biotopes (wetlands) where important protected indigenous amphibians breed and more than 480 different species of mushrooms. The geology is characterized by the *gonfoliti*, which is an amalgams of rocks transported from the alpine regions located 60-70 kilometers away following the tectonic upheavals of the Tertiary (20 millions years ago). Thanks to the soil, an intense viticultural activity has developed close to the two agglomerates of Pedrinate and Seseglio shaping the landscape with wine yards. The park is mostly visited for its 25 km network of trails and scenic panoramic views, on the hill, and on the lower part for its cycle and cardio fit paths as well as dog areas. The main points of interest are the oratory of *S. Stefano* which is one of the oldest Christian devotion place in the area dating far beyond it first written mention dating back to the 1545, and the southern point of Switzerland marked with boundary stone 75B. The two parks are quite different since the *Parco del Penz* organizes guided visiting tours, hosts events and is more touristic attractive while the *Parco del Penz* is currently perceived as an open area with self organized events and activities (trekking, running, etc.). However, both have in charge the maintenance of the network trails.

2.2 3D digital products

In addition to a more traditional use for conservation scopes and activity planning (Marotta et al., 2021), 3D models can be used to offer positive experiences thanks to an enhanced understanding of specific intangible aspects (Bec et al., 2019). For example, in the case study of the *Parco Gole della Breggia*, it might be difficult for a tourist to fully realise the extent of the anthropic impacts on nature. The area is geologically relevant for the visible calcareous formation dated hundreds of millions of years old. From 1961 to 2003, the Breggia shores hosted a large cement plant that strongly modified the territory. Today, only a small part of the plant is still in place as a testimonial of the anthropic impact and as an element of industrial archaeology.
To support the perception of the real anthropic impact, and to understand the historical evolution of the project area, we decided to implement three digital models representing the territory at three key epochs:

- before the cement plant construction. It refers to the beginning of the 1960s;
- at the maximum expansion of the plant. It refers to the beginning of the 1980s;
- at the present state.

The perimeter of the area to be represented was chosen to visualize at a synoptic level the territory and appreciate its conformity, especially when represented through digital models. The

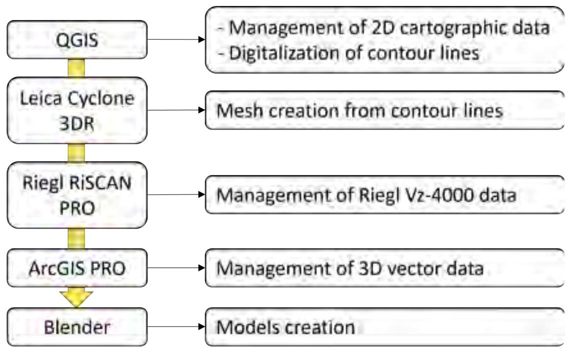

Figure 1. Employed software and implemented workflow for the creation of 3D models.

perimeter thus covers an area of 130 ha and includes both the natural elements - the gorges and the riverbed - as well as the buildings in the vicinity and other aspects showing changes both from the anthropological and morphological point of view, such as the slope from which rock was quarried for cement productions and a natural water reservoir - the Ghitello lake.
After demarcating the area of interest, cartographic data by accessing the Swisstopo federal office of topography (Swisstopo, 2022), which made available free of charge the basic geodata starting from March 2021. In particular, to reconstruct the actual model we collected the raster of national cartography, Digital Terrain Model (DTM), Digital Surface Model (DSM), orthophoto and the 3D vector buildings. Thanks to the cartography of the 1954 and 1982, it was possible to elaborate models for these epochs. Referring to earliest model, the cartography was employed to digitize the contour lines with a 20 m step to reconstruct the previous territory conformation. To this aim, QGIS open source software was chosen (QGIS, 2022). Once the contour lines were produced, they were imported into Leica Cyclone 3DR software (Leica Cyclone 3DR, 2022) to be interpolated and obtain the mesh model of the terrain. As for the present-state model, in addition to all the above mentioned cartographic data, a laser scanner survey was carried out to obtain additional 3D data of the area. Long range Laser Scanner Riegl Vz-4000 was employed to acquire 12 scans in three days. The possibility to cover very wide areas with a single scan allowed us to reduce the total number of scans to be acquired. Riegl RiSCAN PRO software (Riegl RiSCAN PRO, 2022) is necessary to process the collected data.
The next step involved the creation of the models, trying to make them as realistic as possible so that they could be easily used for dissemination purposes. To this aim, Blender software was chosen (Blender, 2022). Blender is the free and open source 3D creation suite, supporting the entirety of the 3D pipeline - modeling, rigging, animation, simulation, rendering, compositing and motion tracking, even video editing and game creation. Firstly we took advantage of the GIS addon, which allows dealing with georeferenced data, both in raster and vector format. Focusing on the present-state model, we were able to import the DTM, the orthophoto and 3D vector file related to the buildings to obtain some preliminary results. It should be pointed out that all georeferenced data needed to be firstly managed into a GIS software to be visualized properly into Blender. QGIS was then used for 2D data, while it was not possible to use it for the management of the 3D vector file involving the buildings. For this reason, it was necessary to use ESRI ArcGIS Pro software (ESRI ArcGIS Pro, 2022). Figure 1 reports the implemented workflow for the creation of 3D models.

2.3 Monitoring of touristic fluxes

The monitoring of touristic flux is important for the correct management of the natural protected areas to assure the Tourism Carrying Capacity (TCC) of trails is not exceeded, to assure adequate economic resources are allocated to maintain the assets, to understand the tourist behaviours and consequently develop strategies and plans to maximise the touristic value of the park (Rogowski, 2020). While different solutions were proposed to this scope (accelerometers on iron plates and proximity radar sensors) it is important to capture specific tourist characteristics, like for example the presence of animals, the direction and the use of bicycles or cars. To this aim, Machine Learning models can help to automate the collection of such information by image analyses and object detection (Zhao et al., 2019). OpenDataCam (OpenDataCam Development Team, 2022) is a very active open source software released with MIT license designed to quantify and track object movements in urban environments. The software take advantage of the YOLOv4 (Bochkovskiy et al., 2020) neural network algorithm which is one of the most efficient solution for real-time object detection and recognition. The software is specifically designed for Linux-based systems using Nvidia CUDA-GPU (Compute Unified Device Architecture - Graphic Processing Unit) enabled hardware. The software analyses a video stream detecting objects and tracking their positions on the image coordinate system. OpenDataCam offers an API and a Web application served with a nodejs (NodeJS Development Team, 2021); the Web interface permits to see the video stream and to create on top of it lines which are then used to count passages of detected objects. Together with object tracks the detected passages are finally stored in a local MongoDB (Mongodb Development Team, 2015) database.
The OpenDataCam software has been installed on a NVIDIA Jetson Nano (Kurniawan, 2021) equipped with a Sony IMX219 camera. In order to remotely collect observed passages a NB-IoT communication component has been connected and a specific script has been implemented (see figure 2).

Figure 2. Prototype sensor to monitor touristic fluxes.

From a technical view, the data flux is implemented as follow (see figure 3: a scheduled script collect data from the local MongoDB using the available API, process the data natively in JSON format and publish the data to an MQTT (Message

Figure 3. Data flux and adopted technological components. *Parco del Penz.*

Queuing Telemetry Transport, (Mileva et al., 2021)) broker based on VernMQ (Bender et al., 2021). An istSOS (Cannata et al., 2015) instance that is subscribed to the broker collects and store the observations that are therefore accessible using the OGC SOS (Sensor Observation Service) open standard (Bröring et al., 2012). A Grafana (Chakraborty and Kundan, 2021) service with an istSOS plugin generate then the graphical representation of the monitored touristic flux (see figure 3).

2.4 Digital Management of Protected areas

Protected areas are currently managed using different tools that are very often scarcely digitised. This approach does not exploit the potentiality of digitalization and does not foster the capacity to extract insights from data. While different open source project management software exists, none is specifically designed to address natural area management processes. For this reason a novel application, based on an open source platform has been developed and implemented.
To identify park-managers' requirements, several meetings and interviews with INSUBRI.PARKS partners have been conducted. As a result, the management of the following elements has been identified as a need:

1. Users.
2. Points of Interest.
3. Notifications.
4. Working Tasks.
5. Events.
6. Bookings.
7. Tourist Fluxes.

Users are platform consumers characterized by a profile which includes contact, role and username. The *Points of Interest* are intended as the park asset, including elements that may be of particular tourist interest (e.g.: biotopes or geological folds), park infrastructures (e.g.: picnic tables or toilets) or key important elements (e.g.: drinking water access or food retails). *Notifications* are warnings, recommendations, complains, suggestions or reports made by park users or collaborators to identify issues (e.g.: interrupted pathways, broken bench or missing indications). *Working tasks* are activities assigned to park's collaborators according to a defined work plan and including details for management analytic (e.g.: estimation of trail maintenance costs or activity ranks by working hours). *Events* are park organized activities like guided tours, exhibitions or fests. *Bookings* are related to the management of all the contacts and the correspondence with clients for renting physical spaces. *Tourist fluxes* will represents data and indicators calculated from the monitoring system presented in 2.3. As additional requirement, all this elements should be manageable

Figure 4. Architecture of digital management proposed solution.

from a Web user interface.
To cope with these needs we have identified the following microservice architecture (see figure 4) for implementing a cloud solution, which on the back-end is based on the usage of PostgreSQL/PostGIS as a database and the Hasura GraphQL Engine (Hasura Development Team, 2022) as a GraphQL API service. The authentication and authorization are managed by Keycloack (Christie et al., 2017), an identity and access management service. Attachments and files are manages by means of the multi-cloud object storage Minio (Borchardt et al., 2021). On the client side, the application is built using the Vue.js framework (bin Uzayr et al., 2019) and a number of Vue components including: vue-layers (Vladimir Vershinin, 2022b) which brings the powerful OpenLayers API to the Vue.js, Vue Apollo which integrates the Apollo library for declarative queries, vue-keycloack (Vladimir Vershinin, 2022a) which wraps the official Keycloak JS adapter for single sign-on.

3. RESULTS

3.1 3D digital products

Some preliminary results of the 3D model corresponding to the present state of *Parco Gole della Breggia* obtained with the Blender GIS addon are shown in figure 5, where the DTM is texturized with the actual orthophoto and buildings are successfully imported, assigning a realistic texture to the roofs. Once the base of the model and the buildings were imported, the Blender Sapling Tree Generator addon was used to make the model realistic through the insertion of user-customizable trees in the scene. Other completion elements were then added by downloading 3D models directly from the Internet in .obj format. In the lower part of the image, a detail of the cement plant building present in the Swisstopo open data is reported after been texturized and surrounded by 3D models of humans, trees and other completion elements to make it as realistic as possible. As for the 3D data acquired with Laser Scanner Riegl Vz-4000, to date the obtained point cloud has not yet been used in the final global model. However, after been processed with Riegl RiSCAN PRO software, the surveyed portion involving the cement plant building has been uploaded on the DACD-SUPSI server to be visualized with Potree (figure 6), a free open-source WebGL based point cloud renderer for large point clouds (Potree Development Team, 2022). The dataset is composed by 220,500, 00 points acquired

3.2 Monitoring of touristic fluxes

The proposed prototype solution has been tested in a controlled environment (within the DACD-SUPSI Campus in Mendrisio)

Figure 5. Up: 3D view of the model involving the area of *Parco Gole della Breggia* created with Blender. Down: detail of a textured building with the insertion of 3D elements.

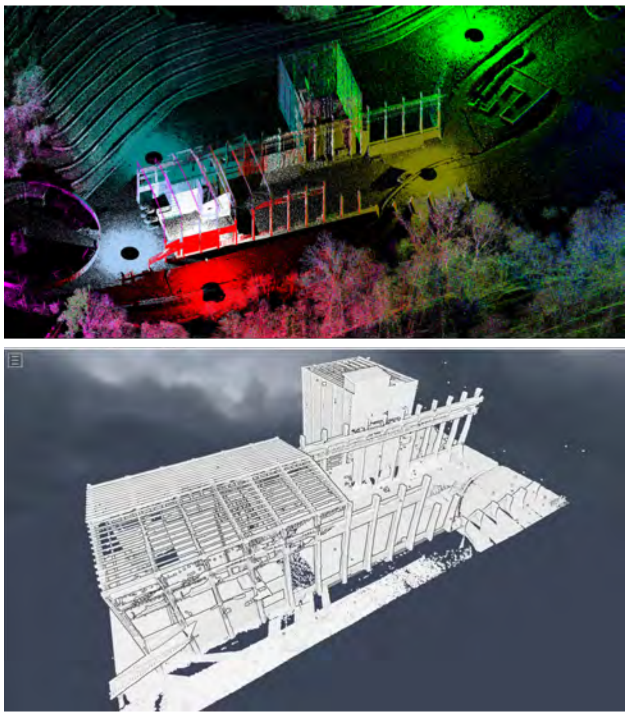

Figure 6. Up: a detail of the scans acquired with Laser Scanner Riegl Vz-4000 of the cement plant building. Down: the final unique point cloud of the building visualized with Potree on the DACD-SUPSI Tokyo server.

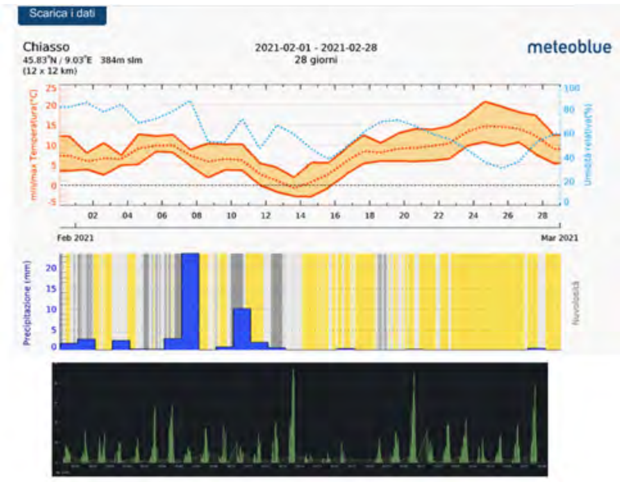

Figure 7. Temporal comparison of weather data and visitors passages at the *Parco del Penz*. Weather data published by www.meteoblue.com

to identify the algorithm behaviours and the solution reliability. The first thing noted during the experimentation is that the algorithm required a camera view that is sufficient close to identify with enough resolution the people but with enough wide area to permit the tracked object to stay for at least a few seconds in the scene. The second worthy note is that tracked object is counted a single time until it remains in the scene: it means people passing forward and back without exiting the camera view count a single passage. Two installations have been set up on the 24th September 2021. One was installed at *Parco del Penz* in *Via Sottopenz* in correspondence to one of the park entrance at the lower side. The other at the *Lago del Ghitello* access road which is one of the point of interest of the *Parco Gole della Breggia*. Data was collected using the IoT system described in section 2.3.

During the monitoring period we had three major issues that led to intervention need and lost of data. The first issue occurred on the 28th December 2021 and was related to the driver of the communication device which for unknown reason get stacked and required a reboot. Fixing this issue took us almost one month and since the communicator device is used to set the correct TIMESTAMP of the internal system clock, collected data did not have associated a correct temporal dimension and was not therefore possible to recover them. The second issue happened on the 11th March 2022 and was related to file system with full storage space. In fact, the MongoDB continued growing keeping information on passages and paths and our implemented software didn't account for a recurrent data cleaning. Also in this case data went lost for another period of one month. Collected unique pedestrian passages at both the installations reproduce the expected frequency variations for the day and night cycles, weekly peaks at the week-end and reduction at working-days, and increase/decrease following weather conditions (rain, cloud and temperature). In fact, looking at figure 7 that illustrates recorded weather conditions (Meteoblu weather archive) we can clearly individuate the Saturday and Sunday day (6-7, 12-13, 19-20, 26-27) characterized by higher frequency. We can also note the impact of climate conditions that in the cloudy and rainy Sunday of the 7th leads to lower visitors compared to the sunny 13th or 20th. On the 14th, 15th, 16th we can notice low frequency despite the sunny and dry days that may be justified by the low temperatures. Despite this data loss, the system has successfully collected data for 5 months registering 13,336 unique pedestrian passages, 693 cars and 184 bicycles in the *Laghetto del Ghitello* and 3,8471 unique pedestrian passages, 2,013 cars and 2,415 bicycles in the *Via Sottopenz*.

Figure 8. Web interface of the Park Assets Management (PAM) platform.

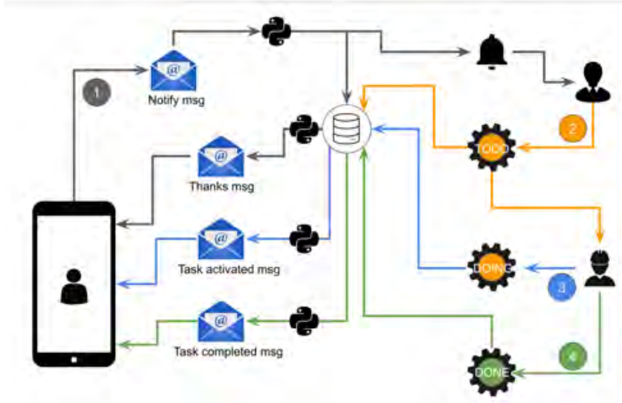

Figure 9. PAM notification system: (1) users make a notification and receive confirmation message; (2) the administrator associate it with a task; (3) the operator activate the task and the user is notified; (4) the operator complete the task and the user get a thank you message.

3.3 Digital Management of Protected areas

The developed solution described in section 2.4 is named Park Assets Management (PAM). As illustrated in figure 8, the implemented solution presents on the left a main menu to access all the identified elements.

When the Map is selected the user can visualize all the geolocated elements. Selecting one element, depending on its type, the related data panel containing a form for data inspection or modification is shown on the right. The user can create new elements by right click the map and selecting the appropriate menu voice; in this case the clicked coordinates are used to initially position the element. The data panels permits a finer localization of the elements with a small map with higher zoom level.

Accessing the task item from the main menu, a calendar is shown to plan the user's activities. The visualization is set by default for the current week but it can be changed in month, 4 days and day view. Consistently with the map, selecting an existing activity or creating a new one, a data panel is shown to create, edit and delete tasks. A second visualization option is by table. In this modality, the user can specify filters to quickly

identify tasks by title, assignee, status, period, overdue; selecting an element the data panel is shown.
Notifications are accessible by table where filters are available to search specific notes. As illustrated in figure 9, these elements are created automatically from user's e-mails and they get a notification confirming the reception of the message. Park administrator can then associate a task to one or more notifications. Once a task is started, the notifiers associated with the created task get notified that the matter is under resolution. When the task is then completed, the notifiers get a final thank you message with the information that the issues has been solved. Since many notifications could be spam, the administrator can mark them as spam reducing noise from the list of notified matters.
Events are visualized in chronological order in a grid of cards illustrating a picture, the title, the location name, the starting date, the cost and the associated tags. Eventually, similarly to tasks, events can be visualized in a calendar. On event's selection the data panel is shown. The users menu item, let the administrator manage the registered users with associated role and contact information. User's information is synchronized with *Keycloak* by means of a *Python* script.
Bookings are going to represent in a calendar with color representation depending on the venue. On selection of the events a data panel, that permits to log information due to exchanging communication and to see associated checklist status is being shown.
Monitoring, wll encapsulates a *Grafana* dashboard representing the data recorded at sensor for flux monitoring. The user has the ability to select a time period to visualize data and the option to download data to be further elaborated with other tools.

4. DISCUSSION AND CONCLUSION

This manuscript has presented the application of different open source technologies to develop digital tools to support touristic promotion and management of protected natural areas. In particular the authors have addressed three specific products: the creation of 3D digital products, the monitoring of touristic fluxes and the management of park assets.
With respect to the 3D product elaboration, the article reported the results obtained so far, illustrating and testing the workflow to be followed for the final realization of the three models to observe the anthropogenic changes in the *Parco Gole della Breggia*. It can be noticed that some proprietary software were used to achieve the reported results. This is because their high performance and ease of use make them preferable to open source alternatives - this is the case of the mesh creation with Leica Cyclone 3DR starting from the digitized contour lines - or because there is not always an alternative to them. For this second case, two examples are the processing with RiSCAN PRO software of the data coming from the Laser Scanner Riegl Vz-4000, and the management of 3D vector file constituting the buildings coming from the Swisstopo federal office of topography. We were able only to visualize them with QGIS software, whereas the editing was possible using ESRI ArcGIS Pro, which turned out to be extremely fast and handy.
As for Blender software, the vast community behind the project ensures that the learning material available on the Web is extremely rich and easy to find, which makes the software, at a first glance not at all user-friendly, easier to use. Moreover, people who contribute to the growth of the project make it possible to improve or extend some of the official Blender functionalities through the creation of numerous addons, crucial for a more rapid models creation. Time spent to realize these first preliminary results is estimated to be a few weeks, considering that we started using Blender within the INSUBRI.PARKS project. To give an example, understanding that georeferenced data needed to be processed with a GIS software before being imported into Blender was not straightforward. The next steps regard the import of the point cloud deriving from the Laser Scanner survey into Blender in order to complete the 3D model of the area: having a look at the cement plant building present in the Swisstopo open data reported in figure 5, it is immediate to observe that the representation is inadequate and does not represent current reality. Considering then that among the many Blender addons there is also one dedicated to models navigation in Virtual Reality. Future works will involve the implementation of such configuration to create immersive environments for further dissemination of the results. Lastly, the possibility to navigate with dedicated hardware the created models with Potree visualizer would make the obtained results even more accessible.
For the quantification of touristic fluxes, while the used software is open source the main component, *opendatacam*, which is released with MIT license relies on a proprietary hardware that is characterized by ©NVIDIA GPU and a proprietary API (CUDA). While taking advantage of the computational power of this proprietary solution, the resulting products have a vendor lock-in which may limit its availability. This is the case, for example, in a pandemic situation where JETSON NANO is not available on the market and if ordered it may be delivered in more than 4 months without any guarantee. This is not a normal situation, but other concurrent conditions may arise in the future to limit its applicability. Apart this 'hardware' lock-in, the solution is based on open source, in fact JETSON NANO mounts a Linux system and all the implemented components have been released as open source. The solution, once fixed the identified issues, has demonstrated its validity in terms of stability, data completeness (no major data gaps exists except for maintenance) and data quality (). A limitation of the proposed solution is an inner characteristic of the approach that, using real-time image processing from video stream, requires a constant GPU processing which is energy intensive. As a result, the sensor requires a wire current connection and cannot therefore be installed in remote locations without a power line. A very positive aspect of the solution is that no image or sensitive data is recorded; in fact, the video stream is processed on the fly and only the counting or the geometric track of elements are stored. This avoids dealing with bothering processes for permissions and data security guarantee.
The PAM application is based on a plethora of open source components and libraries that ranges from geospatial libraries to web frameworks and components to web services. In most of these solutions standards permit to connect and mesh these technologies: GeoJson, GraphQL, Http, SOS are just the most prominent part. The proposed solution is just at its first preliminary release and certainly requires to be adopted to be deeper debugged and finalized. Nevertheless, the most functional features have been implemented and are available. Related to the use of GraphQL server, it has been revealed a positive surprise. While complicating a bit the definition of queries (at least for those that are more familiar with SQL) the HASURA solution eliminates the need of implementing a specific Web Service acting as a bridge between the database and the interface. The connection with *Keycloak* single sign-on additionally ensures the data protection with a granular data permission assignment. Particularly advantageous is the use of *subscriptions* which are based on web-sockets and that enable

automatic updates of data on client side related to a subscribed queries. This avoid the need of data re-fetch after updates or insertions.
The implemented solution for notification handling enables an automatic interaction with users that are engaged with park maintenance and updated on follow-up derived by their notifications. Due to its nature of open source, while currently supporting only email, the approach could be extended to other communication means such as for example the open *Twitter, Viber* and *Slack* or proprietary *Whatsapp, Facebook* and *Skypee*. Alternatively a specific mobile application could be developed to personalize and loyalize frequent park users. The only limitation with e-mails is that when pictures are shared by e-mail the Android and IoS systems remove the geo-tags for privacy concerns: this prevents the geolocalization of notification from image *EXIF* metadata.
PAM constitutes the base application for data sharing among parks and for data analytics. For example, it should allow the collection of important information for the management of daily activities and seamlessly record series of geolocalized tasks with related cost and working-time leading to yearly reports on maintenance costs, efforts, and issues heatmap. Similarly, the analyses of touristic fluxes as demonstrated shows usage patterns that may be essential to effectively plan and prioritize policies, activities and strategies.

In short, we have demonstrated how open source software can be meshed to satisfy touristic requirements toward a digital transformation. Nevertheless, some proprietary components are still required for their unique characteristics or efficiency. Additionally, the implemented solutions also demonstrats how the geospatial open source software, even though important, are just one of the many components that are required to build-up the digital transformation.

ACKNOWLEDGEMENTS

This research has been funded by the European Union within the INTERREG Interreg V-A Italia-Svizzera 2014-2020 program as part of the project INSUBRI.PARKS - ID 605472: *"I parchi della fascia insubrica per lo sviluppo culturale ed ecoturistico del territorio transfrontaliero"*. The authors thanks all the project partners for taking part in the identification of needs and providing precious feedbacks. We thank in particular the *Chisasso municpiality* and the *Parco Gole della Breggia* for their active logistic support and the *Organizzazione Turistica del Mendrisiotto e basso Ceresio* for their strategic view.

References

Bec, A., Moyle, B., Timms, K., Schaffer, V., Skavronskaya, L., Little, C., 2019. Management of immersive heritage tourism experiences: A conceptual model. *Tourism Management*, 72, 117–120.

Bender, M., Kirdan, E., Pahl, M.-O., Carle, G., 2021. Open-source mqtt evaluation. *2021 IEEE 18th Annual Consumer Communications & Networking Conference (CCNC)*, IEEE, 1–4.

bin Uzayr, S., Cloud, N., Ambler, T., 2019. Vue. js. *JavaScript Frameworks for Modern Web Development*, Springer, 523–539.

Blender, 2022. Blender Official Webpage. https://www.blender.org/ (30 May 2022).

Bochkovskiy, A., Wang, C.-Y., Liao, H.-Y. M., 2020. Yolov4: Optimal speed and accuracy of object detection. *arXiv preprint arXiv:2004.10934*.

Borchardt, J., Dunn, R., Kato, S., 2021. minimo: a linked data and metadata storage system for small labs. *Journal of Open Source Software*, 6(60), 2979.

Bröring, A., Stasch, C., Echterhoff, J., 2012. OGC sensor observation service.

Cabello, J. M., Navarro-Jurado, E., Thiel-Ellul, D., Rodríguez-Díaz, B., Ruiz, F., 2021. Assessing environmental sustainability by the double reference point methodology: the case of the provinces of Andalusia (Spain). *International Journal of Sustainable Development & World Ecology*, 28(1), 4–17.

Cannata, M., Antonovic, M., Molinari, M., Pozzoni, M., 2015. istSOS, a new sensor observation management system: Software architecture and a real-case application for flood protection. *Geomatics, natural hazards and risk*, 6(8), 635–650.

Chakraborty, M., Kundan, A. P., 2021. Grafana. *Monitoring Cloud-Native Applications*, Springer, 187–240.

Christie, M. A., Bhandar, A., Nakandala, S., Marru, S., Abeysinghe, E., Pamidighantam, S., Pierce, M. E., 2017. Using keycloak for gateway authentication and authorization.

ESRI ArcGIS Pro, 2022. ESRI ArcGIS Pro Official Webpage. https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview (30 May 2022).

Hasura Development Team, 2022. Hasura GraphQL Engine. https://github.com/hasura/graphql-engine (24 May 2022).

Kurniawan, A., 2021. Introduction to nvidia jetson nano. *IoT Projects with NVIDIA Jetson Nano*, Springer, 1–6.

Lebrun, A.-M., Su, C.-J., Bouchet, P., 2021. Domestic tourists' experience in protected natural parks: A new trend in pandemic crisis? *Journal of Outdoor Recreation and Tourism*, 35, 100398.

Leica Cyclone 3DR, 2022. Leica Cyclone 3DR Official Webpage. https://leica-geosystems.com/products/laser-scanners/software/leica-cyclone/leica-cyclone-3dr (30 May 2022).

Marotta, F., Teruggi, S., Achille, C., Vassena, G. P. M., Fassi, F., 2021. Integrated Laser Scanner Techniques to Produce High-Resolution DTM of Vegetated Territory. *Remote Sensing*, 13(13), 2504.

Mileva, A., Velinov, A., Hartmann, L., Wendzel, S., Mazurczyk, W., 2021. Comprehensive analysis of MQTT 5.0 susceptibility to network covert channels. *Computers & security*, 104, 102207.

Mongodb Development Team, 2015. Mongodb. https://www.mongodb.com (24 May 2022).

NodeJS Development Team, 2021. Node. js. https://nodejs.org (24 May 2022).

OpenDataCam Development Team, 2022. OpenDataCam 3.0.2 – An open source tool to quantify the world. https://github.com/opendatacam/opendatacam (24 May 2022).

Potree Development Team, 2022. Potree - Rendering Large Point Clouds in Web Browsers. https://github.com/potree/potree/ (30 May 2022).

QGIS, 2022. QGIS Official Webpage. https://www.qgis.org/it/site/ (30 May 2022).

Riegl RiSCAN PRO, 2022. Riegl RiSCAN PRO Official Webpage. http://www.riegl.com/products/software-packages/riscan-pro/ (30 May 2022).

Rogowski, M., 2020. Monitoring System of tourist traffic (MSTT) for tourists monitoring in mid-mountain national park, SW Poland. *Journal of Mountain Science*, 17(8), 2035–2047.

Swisstopo, 2022. Swisstopo Official Webpage. https://www.swisstopo.admin.ch/ (30 May 2022).

Vladimir Vershinin, 2022a. Vue-Keycloack. https://github.com/dsb-norge/vue-keycloak-js (24 May 2022).

Vladimir Vershinin, 2022b. Vue-Layers. https://github.com/ghettovoice/vuelayers (24 May 2022).

Zhao, Z.-Q., Zheng, P., Xu, S.-t., Wu, X., 2019. Object detection with deep learning: A review. *IEEE transactions on neural networks and learning systems*, 30(11), 3212–3232.