Evolutionary Time Lines, Hypothesis of an AI+AR–Based Virtual Museum

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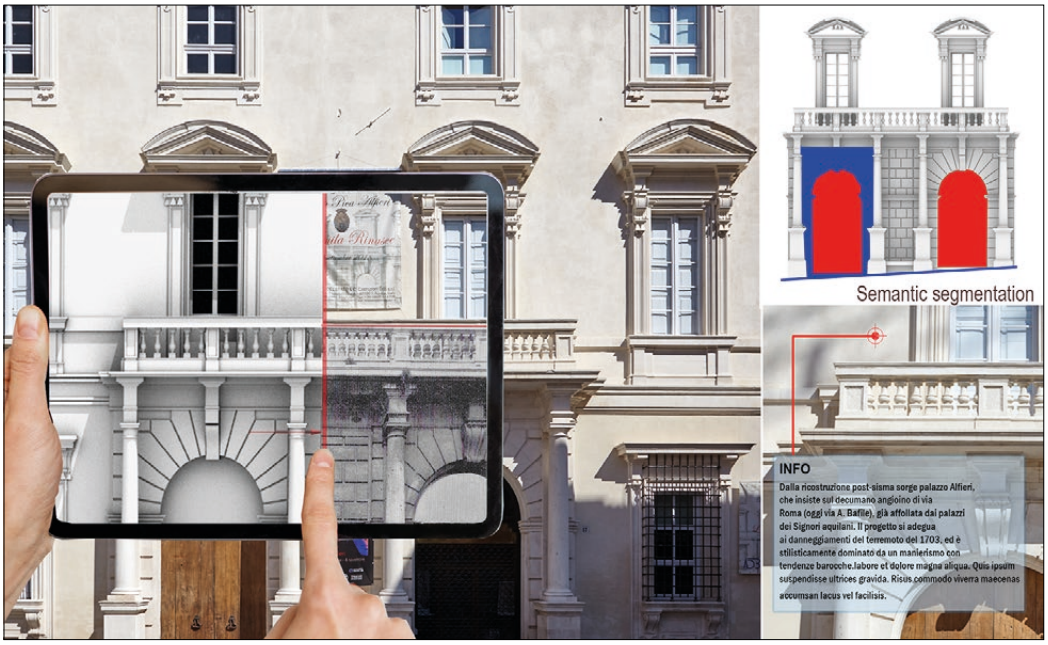
Abstract

The contribution related to the processes of knowledge and enhancement of cultural heritage, based on the potential offered by Artificial Intelligence and Augmented Reality, proposes an analysis of the situation of L'Aquila's buildings ten years after the 2009 earthquake. The research, conducted on the basis of integrated surveys carried out before and after the earthquake, focuses on the application of AR/VR devices through the implementation of AI. The aim is to propose a solution able to promote the use of the historical buildings of L'Aquila, activating at the same time the dynamics of cultural regeneration in the area, through the use of an App that uses AR+AI systems; a tour that can show with immediacy the urban architectural evolution, solving in part the intrinsic difficulties posed by the current situation of precarious visibility and accessibility of some noble buildings, subject to restoration, with the aim of highlighting the evolution of transformations, stylistic and structural changes produced by the different and stratified post–earthquake reconstructions.

Keywords
segmentation, heritage, machine learning, augmented reality, data libraries.



doi.org/10.3280/oa-686.40

Introduction

A recurring seismic history hangs over the urban context of L'Aquila, which after each catastrophic event finds the strength to rebuild its buildings, reworking the architecture often derived from the transformations produced by similar disasters in the past. L'Aquila's historical process of formation and change is in fact characterised by phases of renewal that can be traced back in some way to the historical sequence of the seismic events it suffered. The historical phases of the city's evolution lead us to consider the dualism between natural events and anthropic responses as a guiding thread for analysing the events on which the constituent moments of the urban context were formed and regenerated, specifically regarding civil construction. The reading carried out through the filter of the seismic recurrence defines the antecedent to investigate the metamorphosis of L'Aquila's buildings, to understand today's situations considered in the pre– and post–earthquake comparison. Based on historical investigations and surveys that integrate current data with the situation prior to the 2009 earthquake, comparative representations are proposed to allow us to perceptively reconstruct the evolutionary time–lines of some historical Aquila buildings selected as exemplary models. The result is a documentary and informative material that, starting from the original project, makes possible to visualise the subsequent transformations, to appreciate at the same time, scrolling visually on a tablet or smart phone through an App that uses AR and AI systems, the design, the articulation of the facade analysed through semantic models, the current and past images that allow a dynamic knowledge of the artistic and cultural heritage under examination, proposing the monitoring and enhancement of a fragile architectural context, to be preserved and disseminated experimentally already said before (fig. 1).

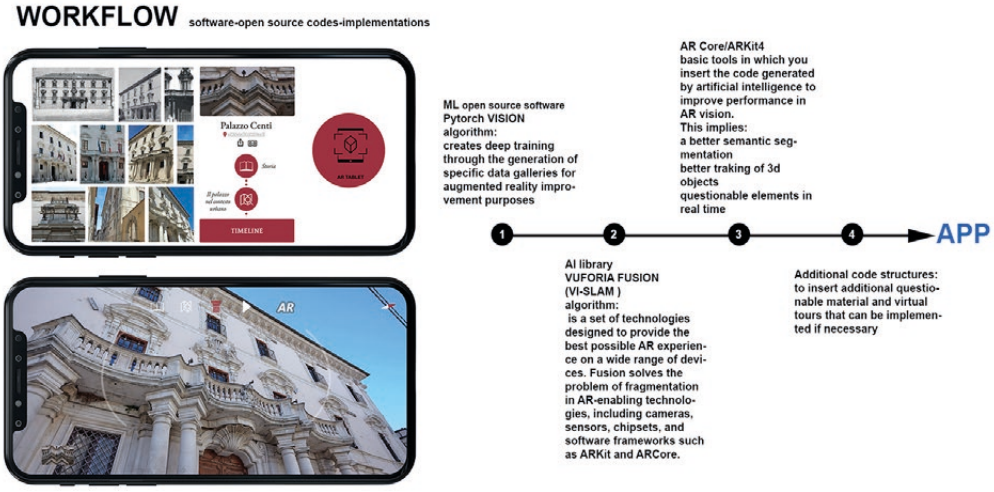


Fig. 1. Development workflow, acquisition and use of data to build a deep learning model with Pytorch Vision, subsequent implementation on ARCore platform for editing the Augmented Reality SDK App.

Machine Learning and AI, the Potential of an Evolving Technology

The paradigms of cybernetic learning are progressively influencing, thanks to the techno–evolution of computing powers and a better accessibility to web networks, predictive models on the acquisition of notions through which man seems to approach 'Data Science' more and more easily, reinforcing the link between human and artificial intelligence in order to achieve innovative approaches to cognitive insights.
The AI, basically applicable when a machine imitates the 'cognitive' functions suitable to structure a logical system to 'learn' and 'find solutions', is nowadays employed in diversified application fields, domotics, intelligent writing, social computing etc., but we can identify its consistent support in the graphic–visual fields of Computer Vision and applicable in disciplines such as Geomatics and Architecture, where multidisciplinary studies, theoretical and practical, are slowly opening towards the analysis and dissemination of Heritage. In spite of these premises, in a purely visual environment it is highly destabilising to think that

a computer can generate 'images', albeit nowadays very unimaginative compared to human creativity, or superimpose almost imperceptibly for example one face on another. Although the inevitable dystopian scenarios conjured up by the idea of cybernetic intelligences coldly replacing human minds instil a recurring doubt, as happens when any new technology is applied in the early stages, for now this suggestion remains a dispute without concrete scientific foundations, tempered by the benefits that artificial intelligence itself seems to offer today, as a support for an artificial logic that can better direct the more emotional human spirit towards concrete solutions. This is the specific application of a class of algorithms that automates the construction of analytical models by offering computers the possibility of learning in complete autonomy without being explicitly programmed. The use of algorithms, which learn through iterative procedures from data input, allows hardware to automatically identify operations to be activated without explicit programming. It is in such an environment, where augmented reality and artificial intelligence can collaborate effectively together, that it is possible to put algorithms together with models consisting of samples that can perform tasks autonomously without the need for complex programming steps.
ML models use self–generated data from which patterns and correlations are learned, while AR is able to merge physical environments with digital content. Augmented Reality and Machine Learning, relatively young technologies that are actually shaping new operational models, thanks to the large amount of available data, now seem to finally bridge the gap between the physical and the virtual world.

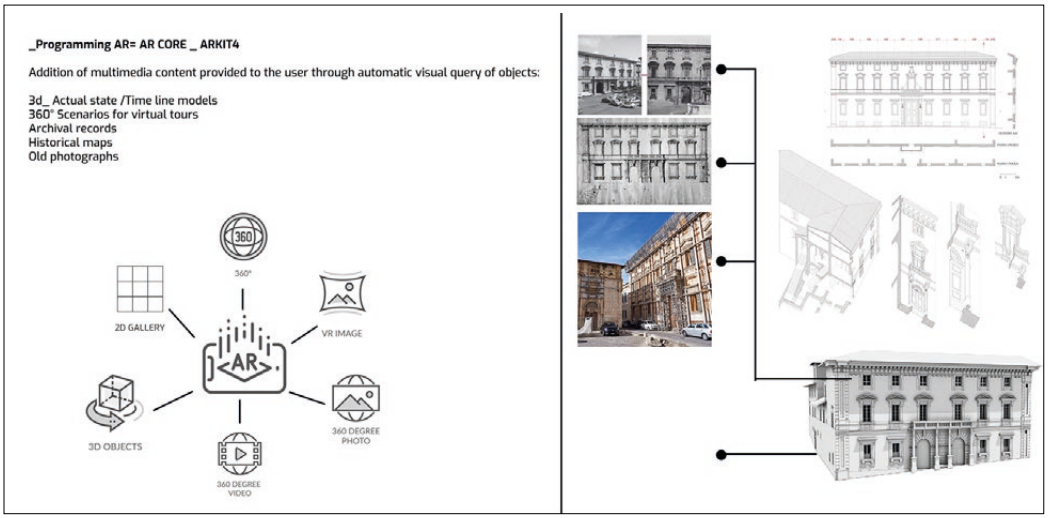


Fig. 2. Programming of ARCore for Android and eventual conversion for ARKIT 4 for the Apple platform. Construction of time–line gallery of the historical buildings of L'Aquila (3D models, photographs, 2D drawings).

Creation of a Prototype for the Historiographic and Stratigraphic Contextualisation of L'Aquila Heritage

The article proposes an application case study, still under development, in which the integration between the two AI+AR technologies is experimented, proposing the use of an App aimed at promoting and enjoying the historical buildings of L'Aquila, activating transversally dynamics of tourist and cultural regeneration in the territory.
Through the use of ARCore systems and the support of PytorchVision system on Faster R–CNN, an interactive tour via smartphone is defined that can show with simplicity and immediacy the architectural–urban evolution of the L'Aquila context. Partially solving the intrinsic difficulties posed by the current situation of precarious visibility and accessibility and providing an accurate visual time line of some noble palaces protagonists of the numerous restorations and superfetations, with the aim of highlighting the evolution of stylistic and structural changes produced by the numerous post–earthquake reconstructions. The involvement of Machine Learning can currently be considered the best tool to speed up the development of Apps for the valorisation of Heritage, as it precedes automated processes to the creation of complex algorithmic codes, aimed at the recognition of ques-

tionable assets and functional to an easier loading in 3D space of explorable digital contents. The results of recent technological research have greatly increased the possibilities and relevance of virtual museology, visibly elevating it from the uses for real museums for which it was once intended. With the introduction of augmented reality, a navigable virtual reproduction is proposed in existing environments through the use of an app for smartphones or tablets, configuring a new concept of diffuse virtual museum, which focuses mainly on the easier usability of a wider and heterogeneous public, together with a better enhancement and promotion of cultural capital that is in part precluded (fig.2).
A virtual experience including three–dimensional reconstructions and interactive insights makes available to the visitor assets that are not accessible or no longer exist, such as works that have been lost or remodelled over time. Moreover, the non–place in which the virtual museum is set up allows the materials of interest to escape from their spatial–temporal constraints, offering a time–line that provides a view of the conditions of the buildings in the various periods of interest, and to be accompanied by multidisciplinary in–depth analyses and thematic–bibliographical links that can integrate the superficial reading, responding in a proactive and coherent manner to the needs of the users concerned. In the case study, these possibilities prove to be particularly valuable in relation to the virtual 'AR' use of buildings affected by disasters or subject to heavy renovation, which are therefore destined to leave no trace of their changes as they do not have a comprehensive, easily accessible and constantly updated digital dossier. In general, visitors who interface with the virtual experience have a better chance of consulting the works, operating in total freedom of observation and enlargement of the selected material, they are free to choose the level of detail and duration of the consultation, and can follow a suggested thematic path or create their own. AR thus constitutes a digital enrichment of physical reality through the superimposition of the former on the latter, providing the user with additional information relating to the surrounding environment. Unlike pure virtual reality, augmented reality uses devices that do not mask physical reality, so as to enable enhanced interaction with it through virtual technologies.
This technology also makes use of more or less sophisticated tools necessary to create a correlation with physical reality, which generally consist of common portable devices such as smartphones and tablets. AR tools do not require total isolation from the surrounding environment, but their use presupposes the user's visual contact with them. This relationship is established thanks to a basic principle of augmented reality, namely that of overlay: the camera integrated in the device frames a given object, the processing system recognises it and activates a new level of communication that overlaps and integrates perfectly with reality, increasing the amount of detailed data in relation to that object. Applying the use of Artificial Intelligence to the editing dynamics of an AR system, the development processes can take several hours of calculation and powerful hardware; despite the time consumed, the results obtained simplify the work of configuring the SDK for mobile devices. For the case study, which is still in the development phase, Pytorch Vision was chosen, an open source resource that, by providing 'training' models based on Artificial Intelligence, allows developers to immediately use image datasets for production, without the need to compile additional complex code to process quality models through a progressive workflow. Both Core ML and TensorFlow Lite models are then automatically generated through pre–compilation, making the subsequent development of apps with ARCore functionality for the Android system more stable, Google technology that allows mobile devices to detect the framed environment, recognise it, and provide interactive AR information. These tools basically offer the possibility to reduce the production time by increasing the quality and consequently the interactivity with the user, amplifying his interest in artefacts related to the enhancement of Cultural Heritage.
The mobile app encompasses in a single instance the diffuse virtual museum experience with wide compatibility at the level of devices and operating systems, always relating in a coherent and recognisable way to the user. The multimedia content consists of galleries of images documenting the historical evolution of the buildings and their changes in time, organised thematically or chronologically, through interactive timelines, in order to adapt to

the needs of the user. These can be supplemented by videos or audio clips that guide the reading of the buildings according to the segmentation inherited from Machine Learning models. The section devoted to digital reproductions also contains technical drawings and 3D models of the buildings, arranged in a space that can be framed in perfect superimposition with the real buildings, which unfortunately are partly inaccessible and covered by scaffolding for safety purposes, useful for a more careful examination of their original globality or for a closer look at the architectural decorations and structural elements that are difficult to observe from street level.

Conclusions

The contribution outlines in an experimental way a methodological workflow developed to monitor and enhance the knowledge and the transformations suffered by the architectural heritage of the buildings of L'Aquila, inextricably linked to the seismicity of the places, to the typical fragility and resilience of the context. The resulting surveys, historical investigations and analytical comparisons have defined the basis for the organisation of the knowledge that, in the integration of AI+AR technologies, has found the formula for optimising and using the data for dissemination purposes in possible new heritage promotion projects.

References

Abdel–Hamid Ossama, Abdel–Rahman Mohamed, Jiang Hui, Penn Gerald (2012). Applying convolutional neural networks concepts to hybrid NN–HMM model for speech recognition. In *ICASSP, IEEE international conference on acoustics speech and signal processing*. Piscataway, USA: IEEE Publisher, pp. 4277-4280.

Cooper Gordon, Jacobs Marco, Dipert Brian (2018). Computer Vision for Augmented Reality in Embedded Designs. https://www.edge-ai-vision.com/2018/08/computer-vision-for-augmented-reality-in-embedded-designs/ (1 July 2020).

Hu Han, Lin Steve (2019). Getting a better visual: Reppoints detect objects with greater accuracy through flexible and adaptive object modeling. https://www.microsoft.com/en-us/research/blog/getting-a-better-visual-reppoints-detect-objects-with-greater-accuracy-through-flexible-and-adaptive-object-modeling/ (10 November 2020).

Khan Asifullah, Sohail Anabia, Zahoora Umme, Qureshi Aqsa Saeed (2020). A Survey of the Recent Architectures of Deep Convolutional Neural Networks. In *Artificial Intelligence Review*, 53, pp. 5455-5516.

Lampropoulos Georgios, Keramopoulos Euclid, Diamantaras Konstantinos (2020). Enhancing the functionality of augmented reality using deep learning, semantic web and knowledge graphs: A review. In *Visual Informatics,* 4 (1), pp. 32-42.

Wang Jingdong, Sun Ke, Cheng Tianheng, Jiang Borui, Deng Chaorui, Zhao Yang, Liu Dong, Mu Yadong, Tan Mingkui, Wang Xinggang, Liu Wenyu, Xiao Bin (2020). Deep High–Resolution Representation Learning for Visual Recognition. In *IEEE Transactions on Pattern Analysis and Machine Intelligence*, pp.1-16.

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