Computational annotation of architectural heritage

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Abstract

One of the most widely investigated computational methods in material culture enquiry, and specifically in architecture, archaeology and built heritage, regards the application of computation for the unsupervised annotation and classification of large datasets, or big unstructured data that otherwise would require a highly laborious supervised marking and analysis process by trained and skilled experts. In many of these operations, computer vision methods are used to analyse datasets in order to annotate them, e.g., the geo-reference of series of aerial photos, or the semantic analysis of digital assets in large repositories of libraries, museums, etc. Currently, computer vision-enabled operations can successfully classify objects by high level attributes across basic level categories, e.g., a chair, vase, column (Wang 2017). Arguably, the next step in the development of these methods is their application for unsupervised semantic analysis of more complex digital representations of objects, in terms of shape, but also to classify variations of geometric configurations that belong to complex assemblages of larger scale, i.e., architecture styles of buildings. This is typically done mostly by experts who identify a building's historic phases and components chronologically based on spatial and social context, technique of production, provenance, style and geometric or material features, e.g., colour (Historic England 2021). The application of logic and symbolic analysis through recursive mechanisms in architecture, has been used on several occasions in the past – by some researchers for plan configuration classification of historical architecture, for didactic purposes, while by others for the analysis of the unique characteristics of the design process of an architect who was prominent in the history of architecture (Steadman and Mitchell 2010; Stiny 2000).

Contextualised in the field of computation analytical methods in architecture, this paper will present the development of an online 3D interface for architectural annotation of built heritage and the study of monuments and buildings (https://annfass-srv.cs.ucy.ac.cy). This 3D interface assists in identifying a building's architectural components (e.g., arch, dome), understanding stylistic influences (e.g., Gothic, Byzantine), understanding its history, and in comparing it to other buildings of the same period.

Literature in computational methods for the analysis of building features and shape analysis relies on 2D representations, e.g., images, architectural drawings, floor plans etc., but recent technological advances have allowed researchers to acquire high quality 3D data (e.g., point clouds, meshes etc.) of monuments 'as built', which are more informative and descriptive representations than drawings or floor plans. Wide access to digital 3D documentation and representation methods and the evolution of deep learning methods in processing 3D data have been the source of inspiration for the development of the digital interface discussed in the paper. This online 3D interface relies on deep learning, using 3D Convolutional Neural Networks, to classify the architectural stylistic influences of heritage buildings and historically complex monuments with multiple construction phases based on 3D analysis instead of 2D image-based analysis. This process can contribute to educational activities, as well as facilitate the automated classification of datasets in digital repositories for scholarly research in digital humanities.

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References

Historic England, 2020. Architectural Investigation, https://historicengland.org.uk/research/methods/architectural-investigation, accessed 10 March 2021.

Steadman, P., Mitchell, L., 2010. Architectural morphospace: Mapping worlds of built forms. Environ. Plan. B Plan. Des. 37, 197–220. https://doi.org/10.1068/b35102t

Stiny, G., 2000. How to Calculate with Shapes. Cambridge MA, MIT.

Peng-Shuai Wang, Yang Liu, Yu-Xiao Guo, Chun-Yu Sun, and Xin Tong. 2017. O-cnn: Octree-based convolutional neural networks for 3d shape analysis. ACM 1471 Transactions on Graphics, 36.