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Artificial Intelligence Algorithms for the Analysis of User Experience in Palazzo Braschi Museum

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Abstract

Analysing visitors' behaviour in museums and cultural sites is a key element to manage spaces and artworks arrangement. Museum stakeholders and curators may benefit from technology to improve the visit experience. This paper presents the preliminary results of the ARTEMISIA project, which aims to exploit Artificial Intelligence (AI) techniques to study, design and develop a methodology to interpret visitors' behaviour within a museum context. The Museum of Rome (Italy) Palazzo Braschi was selected for the project's first stage. The objective is to combine existing research with analytical techniques using data acquired from new generation stereo cameras (users' stand-still positions, viewpoint direction, movements) and other biases commonly used in the retail market (users' flow towards corridors, level of attention, etc). Mapping, and further predicting, users' patterns in regard to the museum arrangement may help to suggest changes in the space (new indications, updated storytelling or changes in thematic configuration). AI algorithms analyse data gathered from motion sensors in order to obtain a grid of references of all criteria related to users' experience (UX) and the effect of a museum visit on them, identifying new forms of visitors profiling and leading to the development of customised applications in public and private contexts.

CCS Concepts

• ***Computing methodologies*** → *Artificial Intelligence; Computer Vision; Interest point and salient region detection;*

1. Introduction and Research aims

A museum visit is a complex experience involving users' senses in different ways: from sensory-perceptual feedback to emotions, from social and cultural attitudes to users' familiarity with technology. Such features influence the experience in cultural venues. Indeed, users' trajectories and visit's styles are affected by several factors, needed to plan exhibitions, visit pathways and, in general, the museum accessibility [LKS*17, PSFSG16]. Understanding visitors' behaviour and mapping their visit patterns indeed help institutions to design spaces and artefacts' arrangement with the goal of supporting user's exhibition interpretation and enjoyment. Among existing techniques and strategies, Artificial Intelligence (AI) offers an effective tool for analysing and predicting individual behaviour and visit flows [CCCO21]. This paper introduces preliminary results of the ARTEMISIA project, which aims to study the User eXperience (UX) of the Museum of Rome through the detection of individual behaviour with remote sensor systems and subsequent data processing employing AI techniques. The final purpose is to obtain standard applications for visitors' monitoring, route planning and cultural marketing approaches for the institutions, starting with the museum hosting the project's initial stage. Such applications might feed the cultural market with new procedures and methods, connecting processes innovation and behavioural sensing tools.

2. Case study: the Museum of Rome

The ARTEMISIA project is carried out in the Museum of Rome placed in the historical building Palazzo Braschi (Rome, Italy). The palace was built in the late 18^{th} century and it was the headquarters of numerous political institutions until 1952, when it became the location of the Museo di Roma, conceived as a repository of artistic and cultural testimony of the capital's transformation [Ric89]. Nowadays, the museum's second and third floors host the permanent exhibition related to the history of Rome between the 17^{th} and 20^{th} centuries. Two rooms were chosen for the project experimentation located on the second floor: the first at the itinerary starting point (Room 1) and the second close to the exit stairs (Room 6).

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3. Methodology

The project's first stage concerns the analysis of visitors' behaviour in Palazzo Braschi and it has been carried out using AI techniques built on data acquired from latest generation motion sensors, namely a system composed by stereo cameras (Figure 1 shows two example images of the selected rooms). The sensors record visitors' transit in a completely anonymous way, storing text data in a protected server for a customised limited period of time. Such sensors are equipped with AI and Computer Vision algorithms required to gather and track basic information regarding visitors, such as identity number, timestamp, position and head orientation on the horizontal plane. Through stereo vision, it is possible to map the 3D space, gather visitors' height and gender [BK99, IWU06].

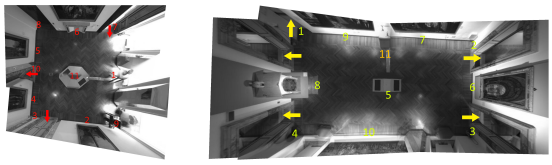

Figure 1: *Sensors point of view in (a) Room 1 and (b) Room 6 where numbers are the points of interest (POIs) and arrows are the passages.*

Research papers usually identify museum visitors' behaviours according to animal names (e.g. 'the ant' accurately following a standard path, 'the butterfly' occasionally stopping at a few attractive points, etc.) [KBZ12, CCCO21]. Similarly, in order to understand visitors' behaviour in Palazzo Braschi, an unsupervised clustering technique was employed on visitors' trajectories, needed to separate them in groups. The clustering algorithm does not require the number of groups to be known in advance, using the "agglomerative hierarchical clustering" approach which allows the 'closest' trajectories to be clustered together according to a specific criterion (the 'ward method' is chosen for the experiments). A survey on clustering algorithms can be found in [XW05]. For each museum's room, trajectories are generated from the collection of the recorded position data. In detail, the ARTEMISIA model displays lines representing visitors' trajectories, black dots representing the rooms' points of interest (POIs) such as artworks (paintings and sculptures), room's furniture, showcases and multimedia installations. As parallel investigation of the sensor-based data, UX evaluations with surveys in the museum have been carried out applying multi-partitioned analysis [PPP16]. The analysis was built by anonymous observations and interviews conducted on 100 randomly chosen museum visitors. Although the number of samples of the two methods is not comparable (100 users vs. approximately 500 detected trajectories per day), the parallel analysis is required as a comparative model to capture behaviours and attitudes that sensors may not reveal. Merging the results is valuable to draft out users' patterns and behavioural models which may not be clear with an individual analysis.

4. Results

In the following section, quantitative processing with AI algorithms on sensor data is presented, followed by a qualitative analysis of user experience.

4.1. Quantitative results

The results of preliminary elaborations involved data acquired during the first three months of recording (April - June 2023) at the Museum of Rome. The results of behaviour analysis in Room 6 for a single day (a Sunday, 500 detected trajectories) are shown below. In Figure 2, a set of clusters is represented, corresponding to 4 different visitors' behaviours in Room 6 of Museum of Rome:

- Behaviour n.1 (red): the majority of users examine the room;
- Behaviour n.2 (blue): the majority of users focus on north-west doors; this datum may also be influenced by the multiple passages of users to move from the room to another one;
- Behaviour n.3 (purple): the majority of users focus on artworks n.7 "Clemente XI conferisce il cappello cardinalizio a Giulio Alberoni" (1724, P. L. Ghezzi) and n.9 "Innocenzo X conferisce il cappello cardinalizio a Fabio Chigi" (1724, P. L. Ghezzi), also considering the passage from the east-north door to the exit one;
- Behaviour n.4 (yellow): the majority of users observe the two artworks in the area n.10 "Arrivo al Quirinale dell'ambasciatore veneto Nicola Duodo" (1714, unknown) and "Ingresso a Roma da Porta del Popolo dell'ambasciatore veneto Nicola Duodo" (1714, unknown); however, it is relevant to consider the users' shift towards the north exit door and west-south door.

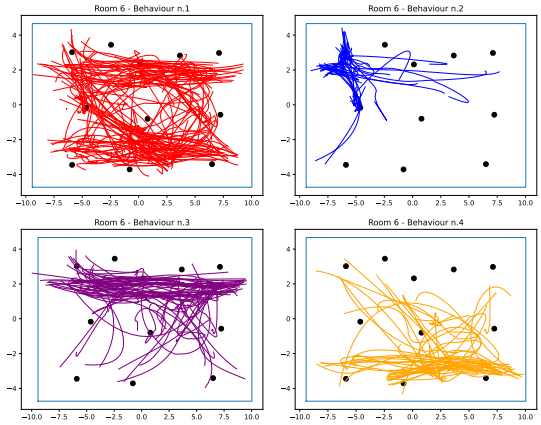

Figure 2: *Results of trajectory clustering for Room 6. Black dots represent the room's points of interest (i.e. artworks, passages).*

The linear incidence of users' flow (south or north) may be related to the presence of the central multimedia installation and the seats which both occupy a large part of the available room space.

4.2. Qualitative UX analysis

The results of the preliminary UX evaluations with in situ surveys are here described, highlighting information comparable with the sensors' outcomes, confirming or simply unveiling users' behaviours. Upon 51 observations and 48 direct interviews made in 7 random days, the majority of users were balanced in gender, mainly travellers (80%), visiting the museum in groups (76%). This datum was useful to read uncertain sensors' results: indeed, sensors could not discriminate between two users if too close to each other, registering a single ID instead of two or more. Moreover, the average

time spent in museum' rooms was less than 3 minutes (51%) and the visit path was not-linear (66%), confirming sensors data. Generally, users were curious and proactive (80%) during their visit, being attracted by the artworks (50%), as well as panels (37%). Finally, the visitors observed the artefacts by continuously moving back and forth (36% close and 29% far), as detected by the sensors.

5. Conclusions

The ARTEMISIA project exploits AI models with the purpose of studying and identifying which users' biases may influence the cultural context flow, contents' understanding, accessibility, interaction and overall appreciation. The project relies on the state-of-the-art UX analyses in museums and it proposes new procedures to predict and direct visitors' pathways, to assist exhibitions planning and cultural marketing approaches. Both the UX analysis and the sensors' data AI elaboration (besides providing two different and relevant sets of information) will concur to the definition of a new general model, in order to strengthen the reliability of data detection and design new approaches for the identification of users' behaviour and emotional impact. With the aim of advancing the UX analysis in Palazzo Braschi, future activities will focus on the extraction of visit features and on the areas of greatest interest in the room. Furthermore, through marketing automation tools, this set of criteria and indexes could open up museum management to new audience and visitor engagement policies.

Acknowledgments

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