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Enrico Cicalò *Editor*

Proceedings of the 2nd International and Interdisciplinary Conference on Image and Imagination

IMG 2019

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Preface

After the first edition hosted in Brixen by the Free University of Bozen, "IMMAGINI? International and Interdisciplinary Conference Image and Imagination between Representation, Communication Education and Psychology" has become a biennial and itinerant event that in 2019 arrived in Sardinia, in Alghero, hosted by the Department of Architecture, Design and Urban Planning of the University of Sassari. The event has preserved its international and interdisciplinary character, focusing in this new edition on graphic languages, on their being image and on their relationship with the imagination, on their use in the different fields of science and the arts, to explore the emerging fields of research and relevant experiments, the new interdisciplinary applications, highlighting their scientific relevance in relation to both their history and the contemporary context with its peculiarities, problems and potentialities.

Also, this edition of the conference was organized and supported by a network of researchers from different universities and disciplines. The event was sponsored by four Italian scientific societies: UID (Unione Italiana per il Disegno), SID (Società Italiana di Design), SIPED (Società Italiana di Pedagogia), AIP (Associazione Italiana di Psicologia) and AIAP (Associazione Italiana Design della Comunicazione Visiva).

The conference proposed the exploration of the *Graphic Sciences*, a name capable of synthesizing the variety of approaches and traditions with which the disciplines of graphic representation are declined in the international panorama of research and teaching.

The call for papers and for images was answered by 180 authors from 9 countries and 42 universities and research centres. About 70 contributions were presented in Alghero. The responses to the calls declined the proposed keyword in a plural way, outlining six major areas of interest of the hypothesized *Graphic Sciences*:

- graphic thinking and learning
- drawing, geometry and history of representation
- digital modelling, virtual and augmented relay, gaming

- graphic languages, writing and lettering
- graphic communication and digital media
- data and infographic visualization

These areas have made it possible to represent the complexity of genealogy and geography of what have been hypothesized to be the *Graphic Sciences* and that find different names and characterizations in the international research but that are united by their contents belonging to the sphere of production, analysis and interpretation of images in the most varied fields of application. This genealogy and geography of the *Graphic Sciences* has been represented in diagrammatic form through an image that has been used as a map and graphic index of the conference.

The IMG2019 conference was conceived not only as a collection of research presentations, but was itself a research experimentation aimed at verifying a hypothesis—i.e. the definition of a field of knowledge definable as *Graphic Sciences*—through a method—i.e. the collection and analysis of data from call submissions—to achieve a result—i.e. the verification of the possibility of defining and representing the hypothesized *Graphic Sciences* and its different fields of investigation—although not exhaustive and not definitive but that the next editions of IMG events will can deepen and further develop.

Contents

Display the Invisible. Automated Algorithms to Visualize Complex Phenomena

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Abstract. The artworks collected in the museums are characterized by formal and invisible values. These latter ones are generated over time and derived mainly from the historical, artistic, social and media history that characterized the exhibited artworks; informal properties are as important as the formal values of the work. The weighted relationship between these values helps to create an attractive weight of the artwork within the exhibition project. Therefore, it is an interesting subject for a correct foreshadowing of visitor flows. We illustrate automated procedures to show, through graphics, the complex phenomena triggered by the attractive weight of the collections.

The elements involved in this research are the exhibition area (the graphic field), the collection (the attractive elements) and the users.

The conceived procedure, once automated, becomes a prototype to support the exhibitor to control the exhibition design and eventually make it more efficient if compared to the quality of the displayed collections.

Keywords: Parametric graphics · Exhibition design · Digital museums · Interoperability · Algorithmic approach

1 Introduction

The UNI 10829:1999 norm "Heritage of historical and artistic interest - Environmental conditions of conservation - Measurement and analysis" refers to the activities of monitoring and analysis of the state of conservation of building components, plant engineering, safety of historical buildings, defining analysis sheets that record the microclimate and light conditions of the areas used for the conservation of museum assets.

The relationship between container-museum (Building Sheet/Environment Sheet) and content-collection (Object Sheet) can be qualified in the connection between the information systems produced (Ippoliti and Albisinni 2016), with clear management benefits (Manoli 2015). At the regard, a data management structured in a shared environment is proposed, where it is possible to link the disciplines that deal with the

Although the contribution was conceived jointly, Michele Calvano is the author of paragraphs 2, 3.1, 3.2; Michele Calvano and Michela Cirelli of paragraphs 3.3, 3.4, 4; Massimiliano Lo Turco of paragraphs 1 and 5.

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management and the design of the spaces and the museum collections (Acciaini and Appellini 2008). Today, Visual Programming Languages (VPL) is one of the tools used to enrich the models representing the building and the collections contained with shared data, following the most consolidated BIM procedures. As known, BIM platforms are more specifically designed for the semantic enrichment of the digital model of the building, but these procedures must be partly rethought for the modeling and information of the collections (Lo Turco et al. 2019).

The research proposes foreshadowing analyses of visitor flows conducted through algorithmic approaches, and the related possibility of verifying such foreshadowings ex post, through the arrangement of IT tools that record users' paths. The definition of criteria for the design and management of installations and user flows can be done through integrated information systems (Empler 2018; Bonacini 2014; Borin 2016): the development of dynamic models can be seen as a useful tool for evaluating alternative scenarios and experimenting with the effectiveness of installations and the design of different narrative paths, to optimize flows for security reasons.

Some territorial experiences related to Digital Urban Simulation have been analyzed, where the theme refers to the optimization of traffic flows within urban information spaces (GIS cartography). Changing the scope of application, the aim is to investigate the applicability of the method in the museum field, through procedures that allow the management and monitoring of the public in relation to events and exhibitions: once digital databases have been created, the information attributed can be used both for the construction of thematic routes within the museum spaces and for the setting up of new collections.

As part of the SMART MUSEUM (***S****emantic* ***M****odeling of collection* ***A****nd container* ***R****elated by information* ***T****echnology*) project, this prototype is applied to some rooms of the Egyptian Museum of Turin, with particular regard to the possibility of prefiguration of flows in some rooms dedicated to temporary collections and events.

The contribution will therefore focus on some critical evaluations of the possible graphic outputs of such processing, as well as the ways of expression and narration of complex phenomena to support the construction of the design thinking (Luigini et al. 2019).

2 Parametric Procedural Representations

The opportunity to translate thought into images is often articulated in intermediate operations synthesized by graphics that freeze changing ideas, so we create graphic representations that like the frames of a film return the dynamism of thought that becomes a sign. At the end of the process we identify a unidirectional path, dynamic during the act of production, but static in the composition of the product.

Nowadays, thanks to the introduction of new tools for the foreshadowing of the project, the dynamism of thought becomes an integral part of the final product through the recording of the procedures that generated it. The recording of the construction history allows us to see what is not visible at a first glance: we refer to the procedures for generating ideas that are revealed through images and graphics.

The clarification of the process allows a different critical conception of the project: by achieving similar results, the construction path can be different by showing a double creativity of the product: the first is shown in the form, and the second in the process. This last condition highlights the birth of new professional figures that fit into the design process called computational designers.

The possibility to creatively design processes allows to introduce variables during the process that allow the product to change even after the process is finished. The defined procedure is a common thread between the resulting images, linking them together in a mutant topological structure, appropriately defining the concept of typological algorithm (Calvano and Casale 2017).

The design of the processes activates new relations between data and geometries, allowing the data to become metadata of the geometries to which they are linked; the geometries then assume qualities that are formally invisible but that show qualitative differences between the elements that make up the figures. The need is therefore to visualize the invisible qualities of the shapes to make them evident on the geometries and in the space in which the phenomena occur (Fig. 1).

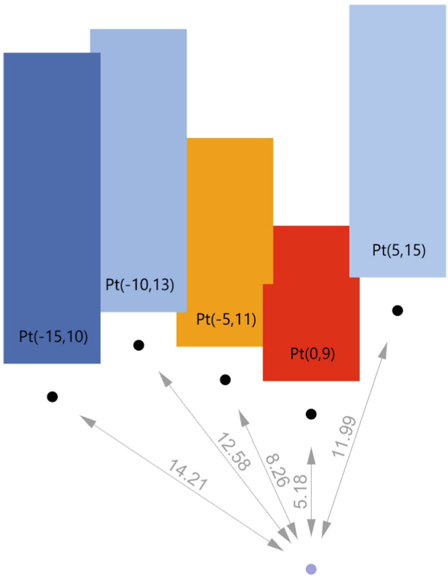

Fig. 1. Black points have an obvious quality: they are the absolute position in the two-dimensional chart field, but we can conceive a further quality that is the distance from an identified reference point

The research investigates the possibility of foreshadowing the flows of visitors within the museum environments set up.

The collections exhibited in the arranged areas - the content of the museum- are recognizable entities thanks to formal and aesthetic attributes that recall, in the mind of the observer, invisible properties that together with the previous ones give an attractive weight to the artwork; we mean, for example, the historical, patrimonial, media value but also the attractive value derived from possible previous surveys able to identify the interest that the single artwork had on the visitors during the past installations.

The design of an application for the prefiguration of flows in a museum environment involves the following phases:

– Definition of the graphic field of analysis.
– Visible and invisible data acquisition.
– Data Summary.
– Choice of visualization and analysis methods.
– Algorithms for flow simulation.
– Flow prefiguration.

One of the aims of the work is to automate the listed process by extracting the information relating to the container directly from the BIM model of the space examined. In this regard, starting from the creation of computerized digital models with high interactions that manage geometric, spatial and environmental information of the BIM type, it is possible, through parametric design software and algorithmic scripting, to include a wide network of information in the design model, useful to allow the management of data relating to the interactions between the architectural space (container) and the elements present within it (content).

3 Automated Procedures for the Graphic Representation of Complex Phenomena in Museums

The Visual Programming Language applied to advanced 3D modeling software allows to manage procedures for the visualization of complex phenomena. In this virtual environment it is possible to create associations between geometries and data by developing behaviors. The graphics able to describe behaviors are the result of algorithms that combine in mathematical functions the perceptive features of the human being in relation to the shape of the elements and the spatiality of the environments they are inserted in; for this reason, it is important to define the field in which the illustrative graphics of the phenomena are drawn.

3.1 The Definition of the Graphic Field

Informed architectural models not only convey the morphological characteristics of the models, they also represent a database: each architectural object contains, in a hierarchical way, the information that characterizes it, the union of which constitutes the entire architecture. An architectural element is also the void, characterized by morphological and environmental attributes. In our case it becomes one of the most important elements because the floor represents the graphic field.

Visual Programming Language procedures allow to acquire the BIM model of an architectural environment and collect information about its geometric characteristics.

Through the definition of construction algorithms we are able to deconstruct the environments to obtain the floor areas. This surface will be appropriately tessellated to produce an analysis mesh.

The surface is the "canvas" to project the graphic representations of phenomena generated by the relationships that are established between content and container, using the topological qualities of the mesh to generate a correspondence between the vertices of the surface and the invisible phenomena that occur in the examined environments. The mesh is generated through the connection between discrete elements, the vertices, connected by edges defining faces. The faces constitute the pixels of the working field, becoming the framework in which to represent and highlight the analyses (Fig. 2).

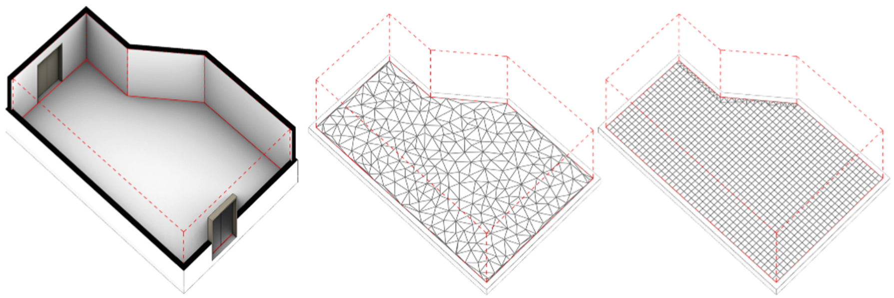

Fig. 2. From the architectural space to the tessellation of the graphic field

3.2 Algorithms for Data Display

The invisible attributes, when generated by point entities (as in the research application) occur with variable effects within a defined field. Both color and color variations are excellent tools for mesh depictions of these variations. The tool used to automate creative processes is Grasshopper, an efficient and open VPL platform.

The use of appropriate components of the programming language allows to evaluate the effect of phenomena that relate the elements on the scene (the environment and the elements contained).

The computer generally returns the phenomena using numerical values; the variation of the phenomenon within the graphic field is perceived thanks to the vertices of the mesh distributed homogeneously within the environment. Each point of the grid will then be characterized by parameters that show the position and the invisible attributes that summarize the analyzed phenomenon.

Appropriate relationships involving the use of chromatic gradients create graphic representations based on the association of calculated point values and an RGB colour range, translating quantitative measurements of a space into graphic illustrations of complex phenomena (Fig. 3).

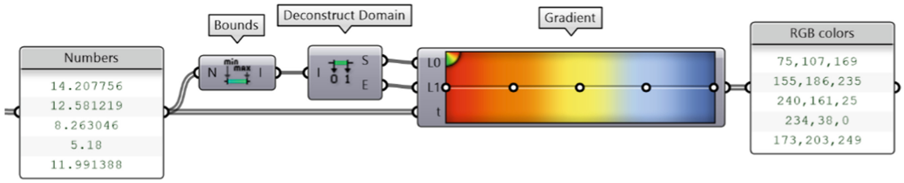

Fig. 3. Visual Programming Language procedure for remapping numerical values in RGB coloured gradients

Once the graphic field has been defined, it is necessary to identify the tools that allow to relate the perception of the user within environments characterized by phenomena; the methods analyzed are:

– Isovist - based on visual analysis.
– Force fields - based on physical knowledge of vector fields.

3.3 The Isovist

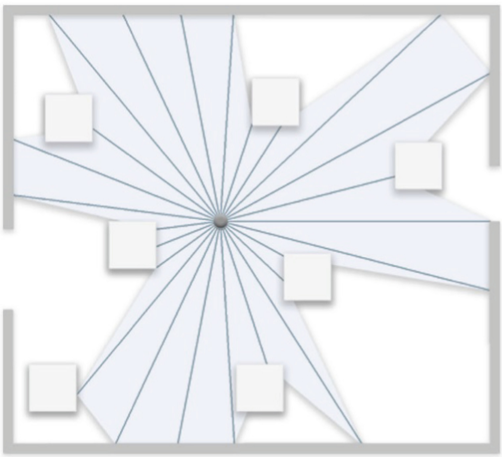

Fig. 4. Graphic construction for generating the isovist from a specific point

The isovist is a procedure used to statically simulate spatial experience through visual analysis: it allows to calculate the amount of visible space from any point within an environment and it provides a graphical synthesis of the perception of a part of the human visual experience in that particular space (Benedikt 1979).

The isovist in architectural applications is generally represented on a bidimensional plane; the graphic synthesis takes place by projecting a series of vectors from a point that represents the eye of the observer, connecting with a broken intersection between directions and geometries seen in space, obtaining the area appreciable from the view of the analyzed points (Nagy 2017) (Fig. 4).

The simulation of the visual experience takes place by means of the synthesis of the main parameters that determine its quality. The setting of the parameters varies according to the type of analysis that you wish to deal with. The properties examined are: the resolution and the view radius.

Resolution is similar to the characteristic of human vision called visual acuity, which is the ability of the human eye to receive as many details as possible. By increasing the resolution parameter, the number of directions diverging from the point of view increases. Therefore, the number of details intercepted in the scene increases, as well; the perimeter of the graph is more adherent to the intercepted elements (Fig. 5). Generally, a high resolution should be used for representations of a few environments, while for massive analysis or large surfaces is sufficient to set a low resolution value, optimizing the calculation time.

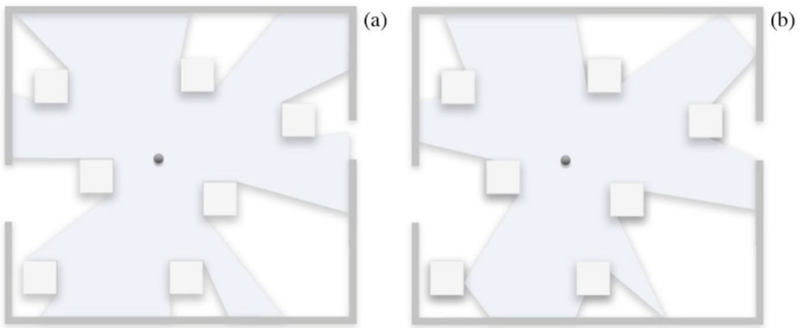

Fig. 5. Visible space surface with resolution = 1000 (a) and resolution = 25 (b)

The view radius is close to the sharpness of vision, therefore the ability to perceive distant objects. This parameter is adjusted by the size of the length of the visual ray, which allows the amount of space perceived by the user to be defined (Fig. 6). Sharpness is a parameter influenced by different environmental and human conditions. However, the representation is carried out on an average user with normal visual abilities and in the presence of a correct illuminance of a room, to allow the adequate perception of the details. High values of the examined parameter allow a clear vision of elements and details that are in positions even very far from the point of observation.

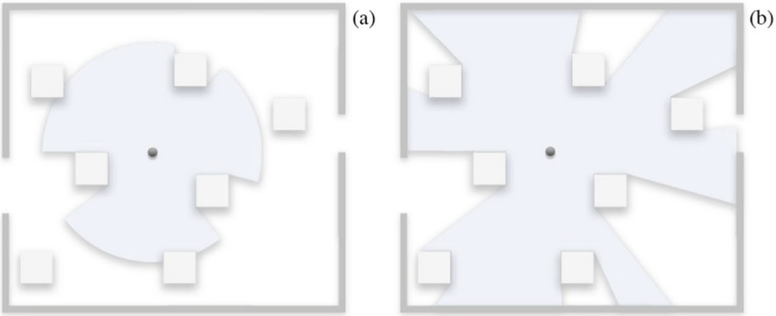

Fig. 6. Visible space surface with radius = 10 (a) and radius = 25 (b)

The isovist highlights that the morphological characteristics of the scene, therefore the size and shape of the environment and objects, greatly influence the perception of the area. The isovist's reiterative visualization in relation to different points of view and different configurations of the artworks inside the space, allows to analyze the quality of the space facilitating some design choices.

3.4 Vector Fields

In physics, a force-field is a vector field that describes the presence of a force at every point in space. It is a function that associates a vector to each position that has the intensity and the direction of the force. The force-field is a concept introduced in the 18th century to describe the distance interaction between objects.

In summary, we can state that when entities with attributes within a space are introduced, they influence the environment by creating invisible phenomena. Within the procedure, the analysed entities are the collections, whose position is represented by points; each object contains attributes linked to its historical, patrimonial and media value and, if necessary, to its appreciation over time.

The assessment of the variation of the force-field is made following discretization in points of the environment, as defined in paragraph 3.1. The vertices of the introduced regular mesh become sample points for the detection of the quality of the force-field. The perturbations created with force fields assume formal results that are used in the field of design to generate new textures on surfaces. In the presented research, they are used to generate conceptual graphic maps to show the relational variations between objects (museum collections) contained in an environment (exhibition hall), identifying balanced arrangements of the elements located in a particular space.

The located elements differ in morphology but also in associated attributes creating a vector field. It is a field that we can analyze in VPL, assuming the rules of electromagnetic fields: the different charges present in space, influence each other, characterizing the space investigated. Using the electromagnetic field paradigm, the elements contained in the environment are reduced to dimensionless entities "loaded" by the metadata that characterize the considered geometries. Metadata values are weighted by two parameters that qualify the force fields: intensity and decay.

The *intensity* of the charge generated by a point entity is a parameter defined in relation to the characteristics of the associated metadata: points with numerically high associated properties will have high charge values, generating a wider attractive force field than points with lower numerical indices. The association between charge and metadata of a point allows to quantify the "attractive weight of an object" within an environment, creating a hierarchy of contents.

The *decay*, on the other hand, represents the speed with which the effects of the charge decrease within the field. The higher the decay value, the faster the effect of the charge will decrease.

The representation of the vectorial field is done using the mesh of the graphic area: the vertices become the application points of the vectors that, through the module, the direction and the direction synthesize locally the value of the field. The presence of vectors is necessary for the construction of lines that follow the indications of the oriented segments, allowing the valid graphics of the phenomenon through "lines of force" (Fig. 7).

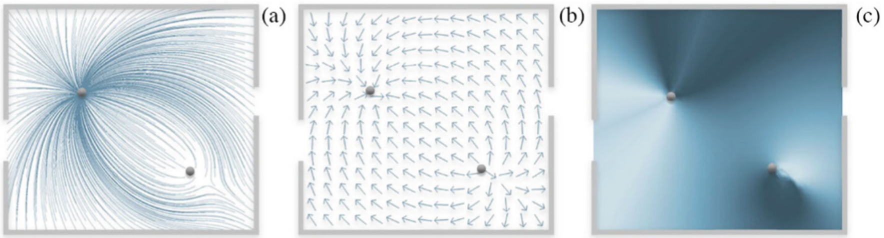

Fig. 7. Display of lines of force (a), tensors (b) and direction of force of the force-field generated by a charge with attractive force and a charge with repulsive force with equal intensity: charge 1 = −60, decay 1 = 0.3; charge 2 = +60, decay 2 = 0.3

The density of the force lines is directly proportional to the force field strength. These lines identify a first graphic representation of the phenomenon generated by the relation between charge and metadata (i.e. the level of influence produced by the elements contained in an environment).

The use of the force-fields in relation to the properties of metadata associated with the elements contained in an environment allows us to evaluate how a user would be led to interact with the space and with the collections present in it. The graphic representations obtained are thus a further tool to be used alongside the analysis of the Isovist, to facilitate design choices and optimize the creative process (Fig. 8).

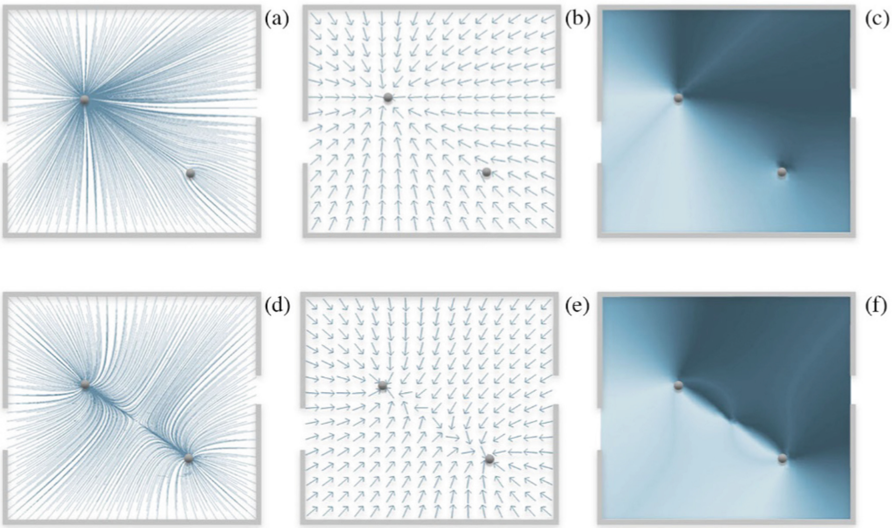

Fig. 8. Display of lines of force (a), tensors (b) and direction of forces in the force field generated by charges of equal attraction force: charge 1 = −60, decay 1 = 0.3; charge 2 = −60, decay 2 = 0.3. Representation of the force-fields generated by attractive charges with variable intensity: charges with unbalanced intensity values (a, b, c), charges in equilibrium condition (d, e, f)

4 The Area for Temporary Exhibitions

The procedure shown is intended to be a tool to be made available to registrars and curators responsible for the layout definition, to optimize and facilitate the phases of design and management of artworks in an exhibition. For this reason, the proposed analyses are applied below to the room for temporary exhibitions of the Egyptian Museum of Turin, considering a hypothesis of setting up. The experimentation is useful to validate the procedure, in order to verify the quality of the setting and suggest any changes to the proposed layout.

The first step involves the interaction between the BIM model of the exhibition hall and the VPL environment; through the procedures here illustrated, the graphic field is extracted as a mesh surface. The density of the topological mesh will influence the display resolution of the analyses. In addition to the acquisition of the exhibition hall, it is necessary to introduce a first layout of the exhibition to start the analysis; after this, the procedure will suggest changes and improvements.

4.1 Analysis of the Visual Quality of the Room

In order to evaluate the quality of the space, it is necessary to analyse the viewpoints in relation to the different points of view. The observer now is a moving point within the space. Four points of the path were analyzed: the entrance and some nodal points inside the environment (Fig. 9).

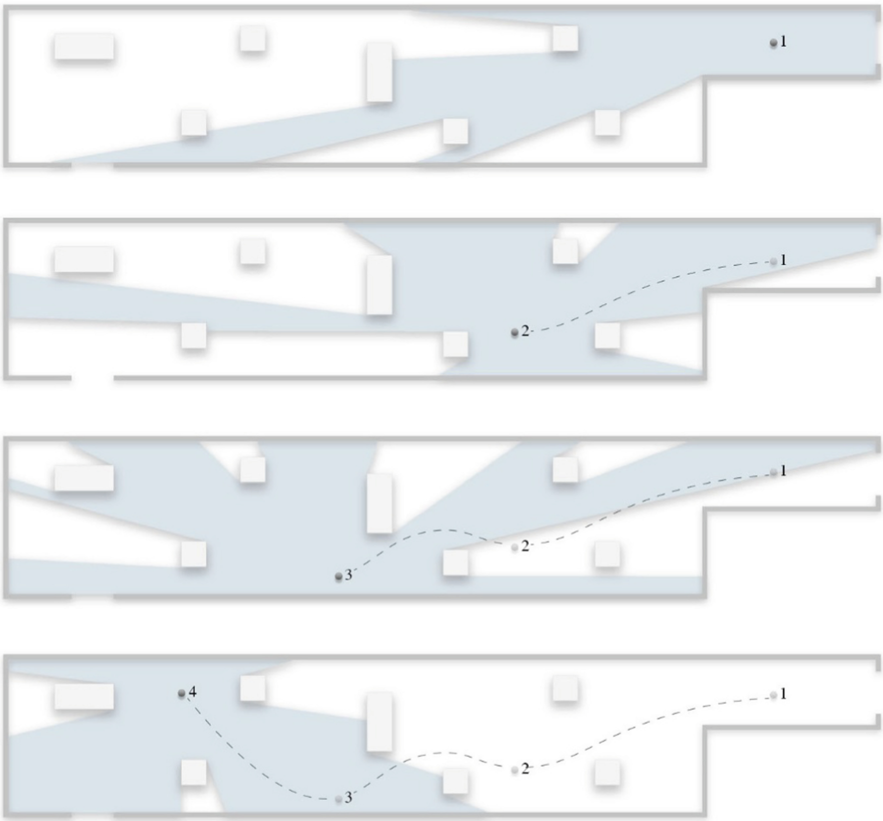

Fig. 9. Analysis of the visual aspects for the four points identified in the path of the exhibition hall

For each movement identified, the portion of the surface seen by the user is calculated; then, the obtained representations are graphically interpolated to identify the portions of the surface visible from all the points of the room (Fig. 10).

The final representation allows to easily visualize the areas of the environment that enjoy an optimal visibility, because they are seen by the greatest number of points along the path initially planned by the designer. The chance to display a graphic map that identifies areas with optimal visual characteristics allows to critically evaluate the proposed layout and, by repeating the process for each movement of the collections, to explore alternative scenarios, obtaining the best configuration.

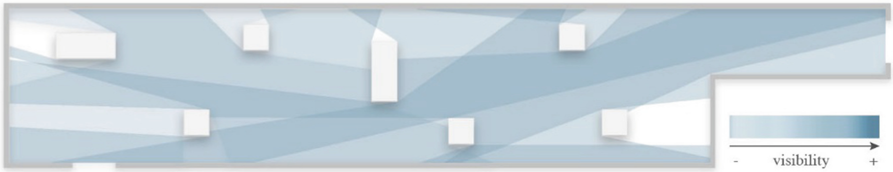

Fig. 10. Graphic map of the areas with optimal visibility of the temporary exhibition hall of the Egyptian Museum of Turin

4.2 The Attractiveness of the Exposed Collections

It is necessary to treat the artworks as punctual elements within the work environment to evaluate the force-field, since it is the invisible properties contained in the metadata of the collection that are the main variables that define the variation of the field.

Each artwork in the room is associated with a point charge: in other words, it is a point characterized by an attractive charge, directly related to the attributes of the object is applied. The attributes constitute the attractive power of the artwork: that can be considered as “the interest” it arouses in the observer. The attractiveness of a work is a complex characteristic that involves multiple aspects and it is the result of the analysis of different parameters, to finally identify the overall attractive value of the work. The parameters considered are: t*he patrimonial value, the media value and the attractive value derived from previous surveys.*

The patrimonial value is obtained by means of the object sheets and represents the evaluation of the economic value of the work. The media value is calculated through the analysis of the amount of online searches related to the work through the use of specific platforms such as Google Trends. As for the attractive value derived from previous surveys, we use the interest that the single artwork has had on visitors during previous exhibitions. The data is derived from the monitoring of the work and the activity of users in previous exhibitions, through the installation of special devices. This last parameter is an experimental and dynamic data, linked to specific monitoring protocols that are still being fully studied.

The data collected are summarized in a scale of values mapped in a numerical domain ranging from 1 to 100. The value = 1 represents a minimum level of attractiveness and the value = 100 means the maximum level of attractiveness; this scale is adopted for each parameter. The obtained values are the starting values to be inserted in the algorithm. Each artwork will be associated to 3 partial attraction values that will be individually represented and analyzed, interpolated only in the final phase to obtain the global attractiveness value. In order to obtain an attractive force-field it is necessary to consider the values related to the intensity of the charge with a negative sign. On the contrary, for positive numbers, repulsion forces are generated. A work with a high level of attractiveness will have a charge value tending to 100 and a decay value close to 0 (Fig. 11).

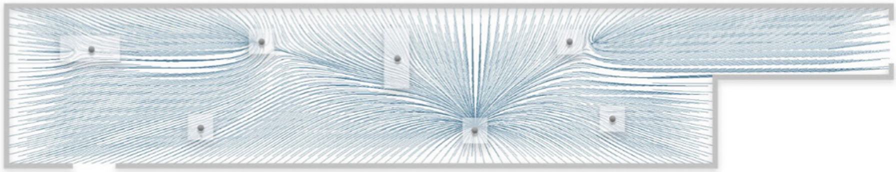

Fig. 11. Display of lines of force of the field generated by: work 1: c = −20 d = 0.7, work 2: c = −2 d = 0.9, work 3: c = −10 d = 0.9, work 4: c = −10 d = 0.8; work 5: c = −60, d = 0.3; work 6: c = −40, d = 0.5; work 7: c = −10, d = 0.8. c = charge d = decay

Through the evaluation components of the generated force-field, it is possible to define the intensity value of the applied field at each single point of the working mesh, thus generating the correspondence between the points of the surface and the values of the force-field. After this, it is possible to produce graphic maps based on a range of RGB colours to the calculated point values. As shown below (Fig. 12), the areas with colours tending to red represent the points where an attractive force of high intensity is applied. In the presence of artworks with a high level of attractiveness located in close proximity, blue areas have been created. The force of the field in these areas is very low because the points there located are attracted by two charges close together at the same time, causing the balance of forces and the consequent annihilation of the attraction. This last graphic representation shows the intensity of the attraction force of the charges, i.e. the level of influence of the artworks on the user.

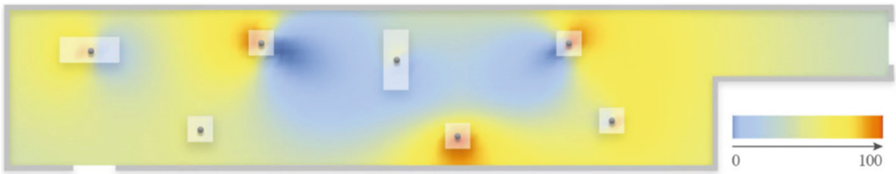

Fig. 12. Graphic chromatic map of the level of influence of the collections

5 Conclusions and Future Developments

The research deals with defining automated procedures to show, through graphics, the complex phenomena that trigger in the increasingly close relationship between container and content. The first elaborations have allowed to graphically visualize the invisible phenomena present in a museum space set up; this was done through the identification of algorithmic processes, aimed at ensuring an effective museum experience.

The second part of the research refers to the definition of the level of attractiveness of the artworks: the new parameters associated with the collections relate to the context, stimulating the behaviour of the agents within the set up environment. This will allow to prefigure the activity of the visitors in relation to the importance of the exhibited elements, providing useful reflections to think about possible alternative layouts.

The analysis of the behaviour of the flows involves the use of virtual agents to simulate the perception and behaviour of human beings in the museum, when they are stimulated by visual and perceptual events (Antonucci 2007) in complex spaces.

In the subsequent research phases the real behaviour of users will be recorded by monitoring the activity of visitors to the temporary exhibition. Once this second part of the work has been completed, it will be possible to fully define an experimental procedure for subsequent validation following this tool in future installations.

This procedure, once automated, may be a useful product to support the exhibitor to control the design of the exhibition and eventually to make it more efficient with respect to the topology and quality of the exhibits.

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