Visibility and Permeability

Complementary Syntactical Attributes of Wayfinding

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Abstract

The paper investigated the process of spatial cognition through wayfinding taking into account the distinction between visibility and permeability relations. The study analyzed the Pinacoteca Art Museum in São Paulo by Paulo Mendes da Rocha, whose interior presents several visible but not permeable relations. Whereas permeability relations have been described using axial and convex maps, visual relations have been described using visibility graphs and overlapped isovists. Syntactical attributes of the spatial configuration have been measured, and a new correlation has been proposed. Different paths departing from the entrance have been and analyzed combining syntactical attributes and the visual information for the understanding of the configuration. The study has shown some evidence about the influence of visual information to the intelligibility of spatial configurations, suggesting the need for a methodological differentiation between visibility and permeability relations in wayfinding and spatial cognition.

1. Introduction

Space syntax theory and its techniques have been largely used to analyze spatial cognition aspects such as wayfinding and place-learning, processes where space and individuals interact. This interaction has been also explained using the concept of affordance, i.e., the possibilities of the environment made available for a particular user. In the Ecological Theory by Gibson (1986), the visual information for the perception of affordances is arranged in a structure known as the ambient optic array. Wayfinding is the exploratory movement choosing vistas from discreet ambient optic arrays. Place-learning would then comprise the apprehension of the structure of the environment through the successive organization of vistas. If the ecological theory offers a rich descriptive phenomenological vocabulary of spatial features, the model fails to relate the succession of features in a structured way. The structure of ambient optic arrays was partially described by Benedikt (1979) using isovists. According to Benedikt's description, the visual information available from a certain vantage point constitutes isovist attributes such as area – the amount of visualized space, perimeter – the surrounding enclosing surfaces, and occlusivity, corresponding to openings in the enclosure. Isovists have been used to model local geometrical properties related to the mental representation of the built environment (Meilinger et al, 2009) and aspects related to the interaction between geometry and movement (Batty, 2001). Local properties of space such as extension, permeability, complexity, order and closure are related to basic isovist measures (Franz and Wiener, 2005, Stamps, 2005).

Whereas the ecological model focuses on the local properties of space, described by the ambient optic array or isovists, space syntax concentrates on the relational properties of space. In the

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syntactical model spatial cognition starts from the perception of local properties of space and moves to a more global topological understanding of the environment (Haq and Zimring, 2001). The correlation of the local and global syntactical properties constitutes the intelligibility of a given spatial configuration (Hillier, 1996), which is not only a physical attribute of the environment, but an aspect of spatial cognition as well (Kim, 2001). The inherent intelligibility of a spatial complex influences exploratory movement and the understanding of its configuration (Brösamle and Hölscher, 2007, Yun and Kim, 2007). Whereas in an intelligible environment exploratory movement is more direct between origin and destination, conserving linearity and pausing in visually strategic places, in unintelligible environments wayfinding tends to be more distributed and indirect (Conroy-Dalton, 2001).
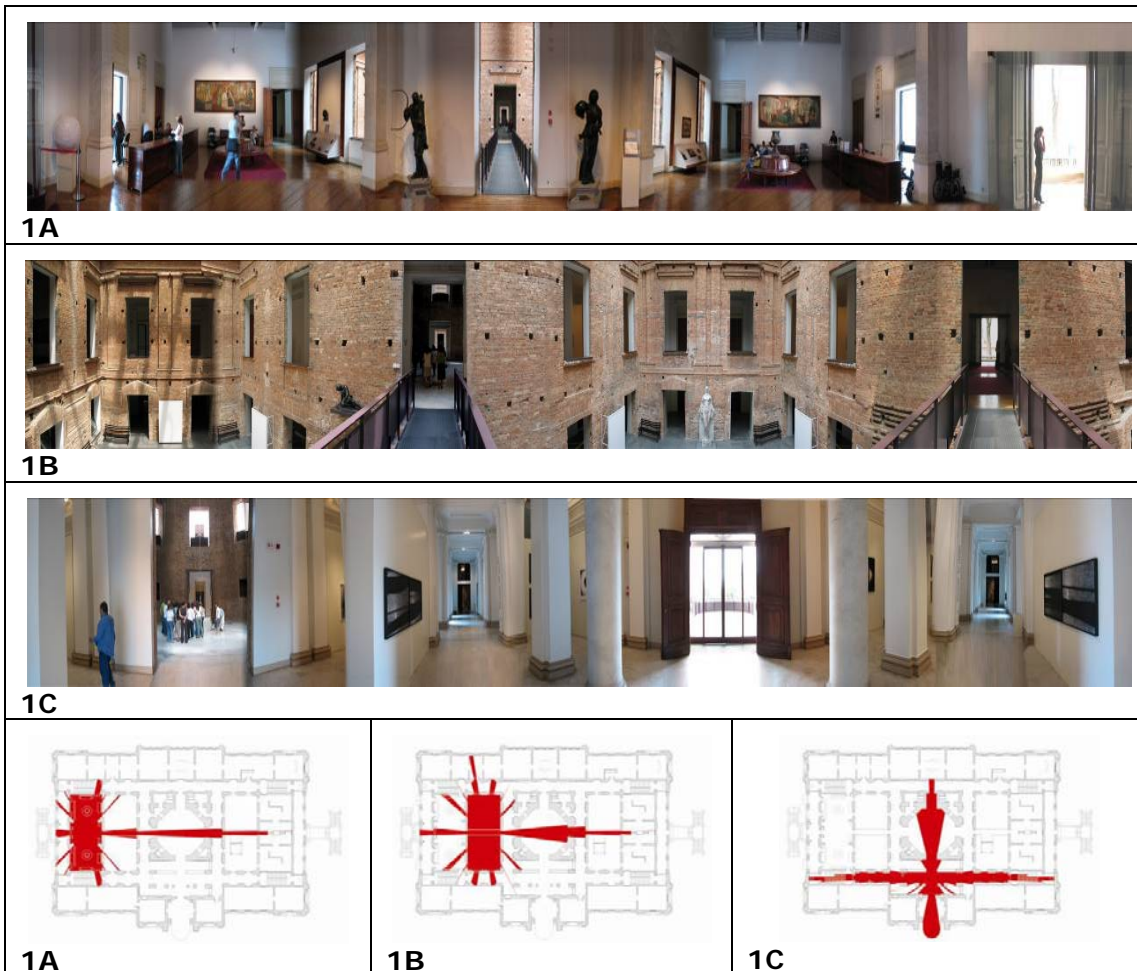

Image 1:
panoramic pictures of the museum and the corresponding isovists

According to Peponis et al. (1990) wayfinding behavior is in general straightforward, except when changes in direction allow the visualization of more space. Thus route decision is influenced by the amount of available visual information, the exploratory movement heads to the unexplored spaces, before returning to already visited places. Wayfinding depends first on local information, second on memory of the already explored spaces, and third on the ability to predict the unexplored areas which maximize new information (Penn, 2001). The recollection of visited spaces is influenced by the complexity of the chosen route and by the permanence of visual information along the path. The more permanent is the visual information during movement, the easier it will be memorized. In space syntax the measure of intelligibility is obtained correlating connectivity values to global integration values. Therefore in the process of wayfinding the number of local connections of a spatial unit is a predictor for overall syntactical properties of a given complex. Since the origin of the exploratory movement in buildings is usually its access point, syntactical depth from the entrance also influences wayfinding. The more syntactical steps from the entrance, it is very likely that the more complex a path will be, due to the amount of information to be memorized.

Although space syntax studies emphasize the association between visibility and permeability, the relations of visibility between spatial units not always correspond to permeable relations. Architectural elements such as windows, atriums and voids afford the visualization of contiguous spaces without the possibility of direct access. The Pinacoteca Art Museum in São Paulo by Paulo Mendes da Rocha is an example of a building where several interior views do not correspond to permeable relations. Image 1 shows some panoramic pictures of the building and the corresponding isovists: the entrance hall, whose visual relations constitute four permeable connections (Image 1A); the southern atrium, with several visual connections and only two permeable ones (Image 1B); and the eastern hallway, where all visual relations constitute permeable connections (Image 1C). In the analysis of museums isovists have been used model the viewing potential and accessibility of the exposed content (Peponis et al, 2004) and the visitor pattern of path choice and interaction with the exhibition (Kaynar, 2005). Peponis and Kaynar associated visibility to permeability which was the predominant features of the analyzed museums. This is not the case for the Pinacoteca, where an intense presence of non permeable but visible relations across spaces dominates.

The aim of this study is to investigate the conditions for wayfinding in the Pinacoteca Art Museum considering both permeable and visual relations as important attributes of the mental process involved in exploratory movement. The basic objective of this representation is to analyze the layout in terms of route intelligibility and to depict as to whether or not the connections that are exclusively visual add more structure and levels of prediction to the visitors route. The paper is divided in four parts. In the next section the material and methods will be defined. In the third section results will be presented and conclusions will be driven in the last part.

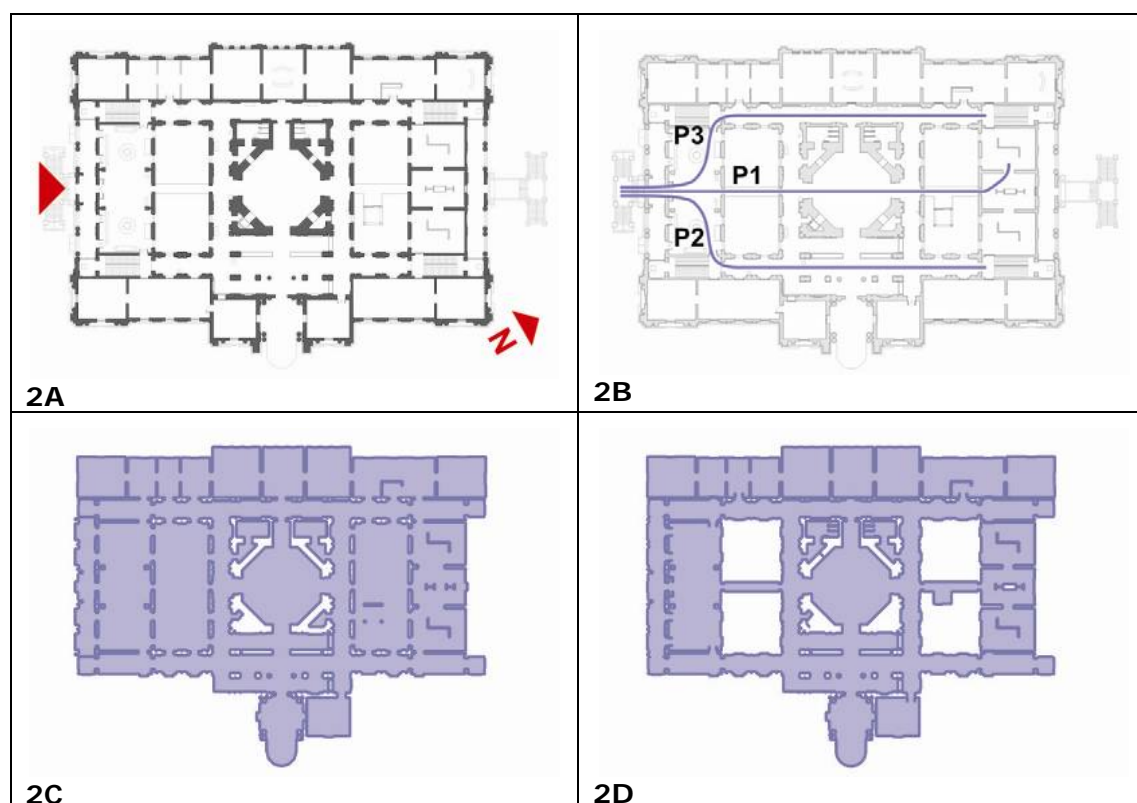## 2. Materials and Method

2A
2B
2C
2D

Image 2
plan of the access level, defined paths, visible space, permeable space

The Pinacoteca Art Museum in São Paulo was initially installed in a rectangular three story building from the 19th century, later reformulated by Paulo Mendes da Rocha. The access is at the intermediate level. Before the renovation the access was located at the eastern façade and the entrance hall corresponded to the actual eastern hallway (Image 1C). The main circulations lines of the access level comprised hallways surrounding two patios and a central roofed atrium. Paulo

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Mendes da Rocha displaced the main access to the southern side façade and created a central longitudinal circulation line. A slab was built in the central atrium and catwalks were installed in the patios, which were roofed and this way transformed in two atriums. The four existing staircases were complemented with two elevators (Image 2A). After the reformulation the visible space inside the building included the two atriums (Image 2C), which do not constitute permeable spaces (Image 2D), except for the crossing catwalks. Three paths departing from the main access and heading to the most distant part of the floor were analyzed (Image 2B): through the central axis of the building (P1), through the eastern hallway (P2) and through the western hallway (P3).

In order to analyze the permeability relations of the Pinacoteca, axial and convex maps have been used. The depiction of the visual relations was made using VGA and isovists. This involved the description of permeable and non permeable views with no differentiation in the same system. First, permeability (axial and convex) and visibility (VGA) representations have been compared to each other under five parameters: connectivity, global integration, depth from entrance and intelligibility. The fifth parameter, the correlation between the syntactical depth from the entrance and the global integration was used to analyze the topological influence of the entrance in the user movement.

Second, the three defined paths have been analyzed and compared to the whole configuration according to its syntactical properties and visual information. In order to analyze the availability and permanence of visual information along each path overlapped isovists have been used. For each path, 50 isovists have been drawn; using a graphic editor, the isovists have been overlapped and rendered transparent; the overlapped isovists have been split in three tones - dark, medium and light, corresponding to more permanent, intermediate and more ephemeral visual information during movement. The paths have been en suite, analyzed using convex and axial partitions. The number of spatial units directly accessible through each path, including the ones that constitute the path, have been quantified in relation to the whole configuration (percentages). The study deployed Mindwalk[1] to calculate the convex maps and Depthmap[2] to automatically generate axial maps (fewest line maps), visibility graphs and isovists.
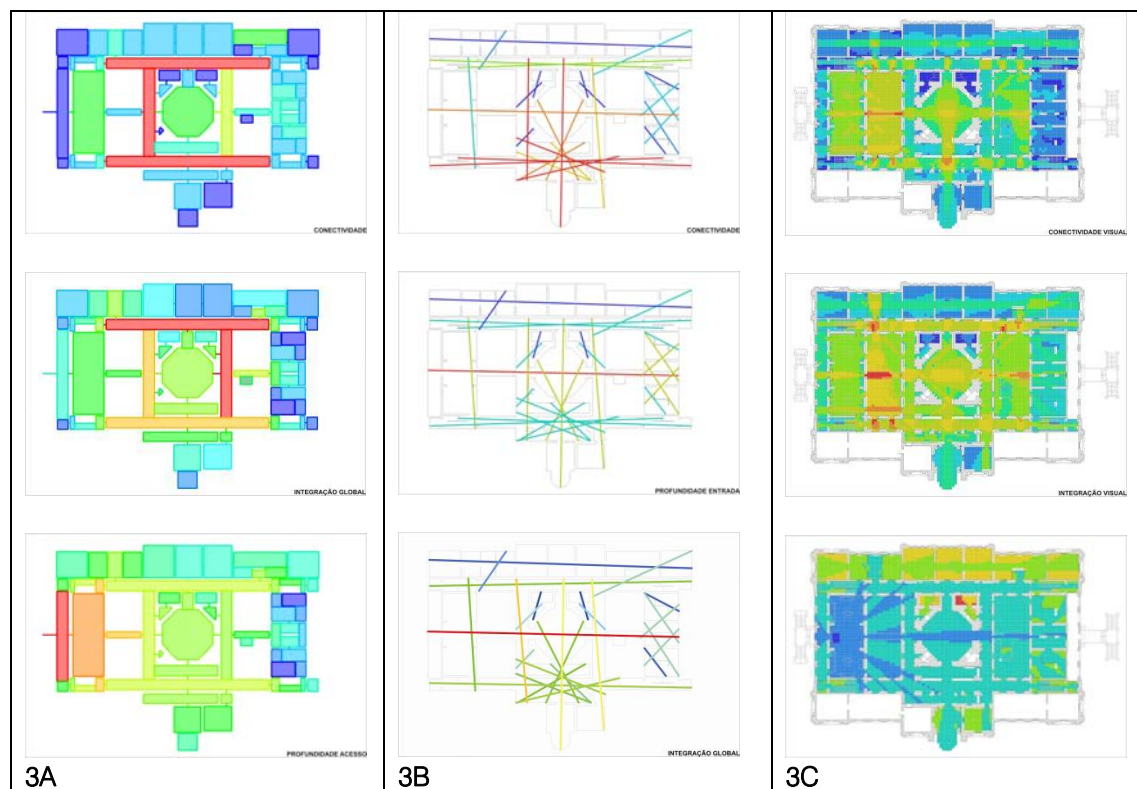
3. Results

3A   **3B**   **3C**

Image 3
convex maps, axial maps and VGA (connectivity, integration, depth from entrance)

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The convex analysis of the floor configuration showed the mode for connectivity values at 2 spaces, the mode for global integration at 0,57 and the mode for depth from entrance at 4 steps (Image 3A). The most integrated and connected convex spaces are the four hallways around the atrium (Image 3B). The convex organization has a low intelligibility, and global integration is equally correlated to both connectivity and depth from entrance ($r^2=0,47$).

In the axial analysis the access floor configuration has the mode for connectivity values at 2 lines, the mode for global integration at 1,57 and the mode for depth from entrance at 2 steps (Image 3B). The most integrated and connected axes are the northern and southern hallways and both longitudinal and transversal central axes (Image 3C). The axial organization has a high intelligibility ($r^2=0,78$) and a low correlation between global integration and depth from entrance ($r^2=0,47$). Using VGA the floor has the mode for connectivity values at 383 points, the mode for visual integration at 3,86 and the mode for depth from entrance at 5,29 (Image 3C). The most connected points are in the in the southern extension of the longitudinal hallways and in the former entrance hall. The most connected points corresponded to the major isovists formerly described. The most visually integrated points are in the southern and northern parts of the longitudinal hallways. There is a good correlation between visual integration and both connectivity ($r^2=0,69$) and depth from entrance ($r^2=0,57$).
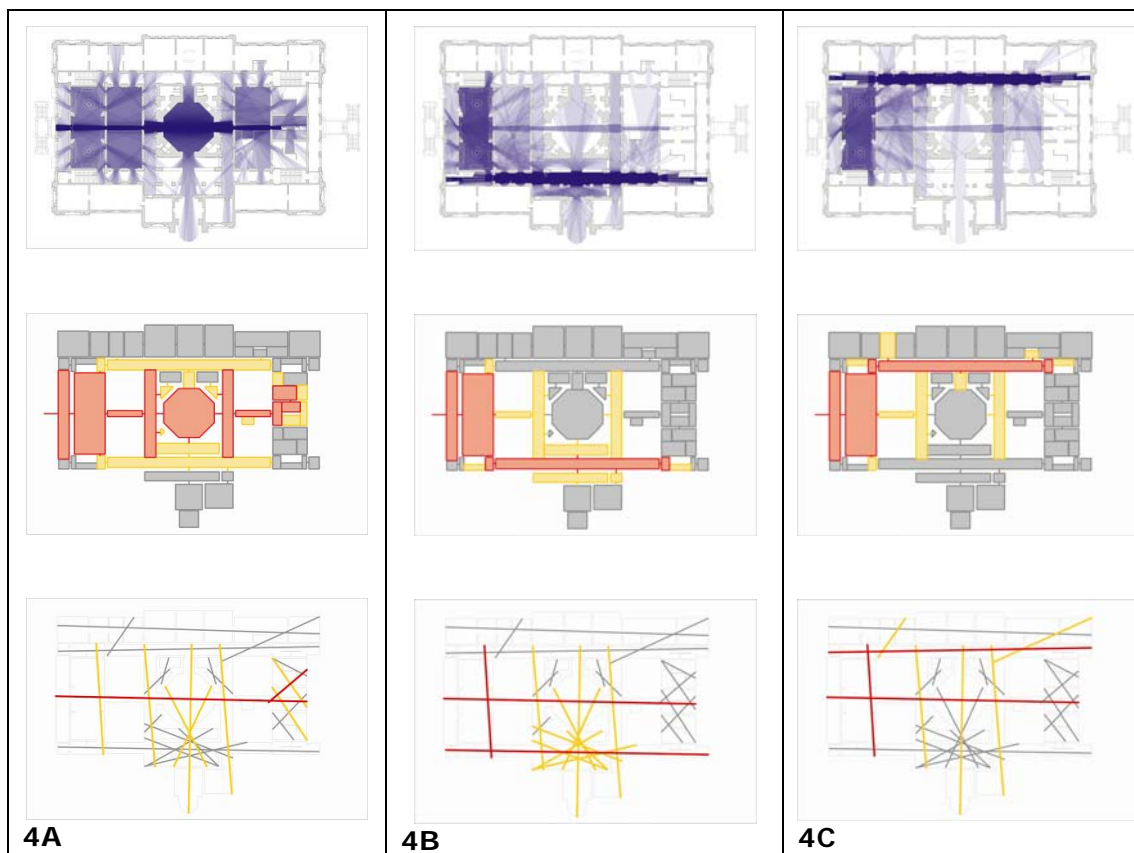

4A   4B   4C

Image 4:
central path P1, eastern path P2, western path P3 (overlapped isovists, convex map, axial map)

Follow the analysis of the central path P1 (Image 4A). In the overlapped isovist description the path allows the visualization of 61% of the floor area, 11% in a more permanent way. In the convex description the path offers direct access to 39% of the convex spaces with a low intelligibility ($r^2=0,47$). In the axial description on the other hand the central path offers●(R direct access to 36% of the axes, with a very high intelligibility ($r^2=1,00$).

The eastern path P2 allows the viewing of 58% of the floor area, 14% more permanent (Image 4B). In the convex description the path offers direct access to 23% of the convex spaces with a very high intelligibility ($r^2=0,91$). In the axial description on the other hand the central path offers direct access to 46% of the axes, with a low intelligibility ($r^2=0,47$).

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And the western path P3 allows the viewing of 59% of the floor area, 12% in a more permanent way (Image 4C). In the convex description the path offers direct access to 23% of the convex spaces, with a high intelligibility ($r^2=0,82$). In the axial description the central path offers direct access to 29% of the axes, with a high intelligibility as well ($r^2=0,92$).

4. Discussion

The results show higher values for the indelibility using the axial description than the convex description. Taking into account the axial description, the depth from entrance is not as good a predictor of global integration as connectivity. However, in the convex description, both connectivity and the depth from the entrance are poorly and evenly correlated to spatial integration. Comparing the two descriptions, the convex description appears to reveal a less intelligible picture than the axial one. This seems to imply that the spatial awareness is better related to lines or directions of movement than the sequence of convex spaces Visible relations described using VGA are less intelligible than the axial ones, but higher than the convex ones. Results have shown that, in VGA, both connectivity and depth from entrance are relatively good predictors of visual integration. This means that visual integration is correlated not only the amount of space viewed (connectivity) but as well the number of visual steps from entrance, which constitute changes in direction of a moving observer.

The analysis of the defined paths with the overlapped isovists showed that the central path (P1) allows the viewing of more floor space, although the other paths allow more permanent visual information. Whereas the central path gives direct access to the largest number of convex spaces, the eastern path (P2) gives access to the largest number of axes. The central path in the most intelligible axially, and the least intelligible convexly, a similar feature found for the floor configuration (considering all possible paths). The central path has the least axial depth from the entrance, a measure that is poorly correlated to global integration, but an important aspect for the memorization of the visited spaces: the axial shallowness of the central path is an important attribute as far as mnemonic aspects are concerned.

Conclusions

The study has shown some evidence that the availability and permanence of visual information may influence the intelligibility of spatial configurations. This suggests the need for a methodological differentiation between visibility and permeability relations in the analysis of spatial configurations especially when it comes to wayfinding and spatial cognition. This could motivate further studies aiming to expand the current space syntax methodology. For example, computational agents should be able to distinguish permeable relations from exclusively visible ones, in order to perform a more accurate simulation of human exploratory movements. This and other important aspects of the built environment such as materials, colors , illumination and textures can lead to better structured results correlating phenomenological aspects of the architecture of buildings to way finding and spatial cognition.

Notes
[1] Mindwalk is a a registered software by Lucas Figueiredo de Medeiros - Copyright © 2002 – 2005
[2] Depthmap is a registered software by University College London - Copyright © 2006 UCL

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