EIGENPLACES FOR SEGMENTING EXHIBITION SPACE

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Motivation

Circulation of museum objects

(What to display)

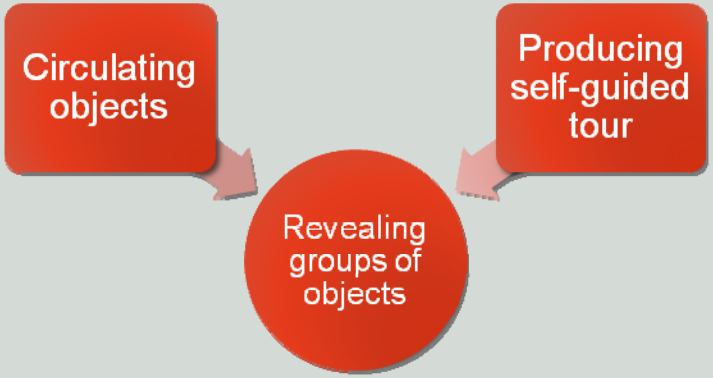
- Galleries and museums in the virtual worlds such as the Kimono gallery in Second Life (Ritsumeikan University)
- Real museums

Self-guided tours

(Who goes where)

- What information
- How long for description

Research Question



Segmenting Exhibition Space

Segmenting Exhibition Space

- Adopt Eigenplaces and theory of graph spectra
- Reflect on primary behaviors of visitors
- Use dwell time for implicitly indicating the visitors' attention[1]
  - Dwell time is the amount of time a visitor spends observing a particular exhibit.

Koran, J. J., Foster, J. S., Koran, M. L., The relationship among interest, attention and learning in a natural history museum, Proceedings of the Annual Visitors Studies Conference, 239-244, 1989

Our proposed algorithm

Input: a set of visitor dwell time

	E_1	E_2	E_3	...	E_n
V_1	Time				
V_2					
...					
V_m					

V: Visitor i
E: Exhibit j

Segmenting Exhibit Space Algorithm(SESA)

Given a set of visitor dwell time associated with various exhibits, our segmentation algorithm consists of the following steps:

1. Compute a visitor association with each exhibit by using the Logarithmic transformation of visitor dwell time.
2. Construct an association matrix representation, X, where each row referred to as a summary of a visitor's association with various exhibits during a given time slot.
3. Perform Singular Value Decomposition (SVD) of the association matrix X.

$$X = U \cdot \Sigma \cdot V^T \tag{2}$$

4. Compute the significance score ($score$) that is correlated with the percentage of power in the original matrix X captured in the rank-k reconstruction by using the equation below:

$$\text{Score}(\%) = 100 \times \frac{\sum_{i=1}^{k} \sigma_i^2}{\sum_{i=1}^{Rank(X)} \sigma_i^2} \tag{3}$$

5. Indicate a set of primary Eigenplaces $\mathbf{v}_i$ with a desired significance score.
6. Partition the exhibits with the set of primary eigenplaces.

After Applying Our Proposed Approach (SESA)

- Any two exhibits are in the same cluster by considering the components of an eigenplace that denotes the exhibit in the associate cluster.

Table 1: Eigenvalues and the corresponding eigenvectors for the MIT exhibition space

Score(%)	Eigenvalues		Eigenplaces (exhibits)											
			ξ_1	ξ_2	ξ_3	ξ_4	ξ_5	ξ_6	ξ_7	ξ_8	ξ_9	ξ_{10}	ξ_{11}	ξ_{12}
55.91	35.80	$\mathbf{v_1}$	-0.2	-0.3	-0.3	-0.2	-0.4	-0.3	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3
64.11	13.70	$\mathbf{v_2}$	-0.6	-0.4	0.0	-0.1	0.2	0.2	-0.1	0.2	0.4	0.3	0.0	-0.1
71.31	12.85	$\mathbf{v_3}$	0.2	-0.3	-0.4	-0.4	0.4	0.3	0.4	-0.2	-0.2	-0.2	0.0	0.2
78.08	12.45	$\mathbf{v_4}$	-0.2	0.1	0.3	0.2	0.4	0.2	0.3	-0.1	-0.2	-0.2	-0.4	-0.6
84.18	11.82	$\mathbf{v_5}$	0.1	-0.1	0.1	0.0	-0.2	-0.2	0.5	0.3	0.2	0.1	-0.7	0.3
88.52	9.97	$\mathbf{v_6}$	-0.3	-0.1	0.1	0.3	0.0	0.2	-0.1	-0.4	-0.5	0.3	-0.2	0.5

Score: Majority degree of common observation-time patterns of visitors
Eigenvalues: Primary observation-time patterns of visitors

EXPERIMENTS ON TWO USE CASES

Ritsumeikan Digital Archiving Pavilion (RDAP) in Second Life (SL)

- The data set obtained from [Sookhanaphibarn and Thawonmas, 2010] based on the four animal metaphors.

MIT Museum

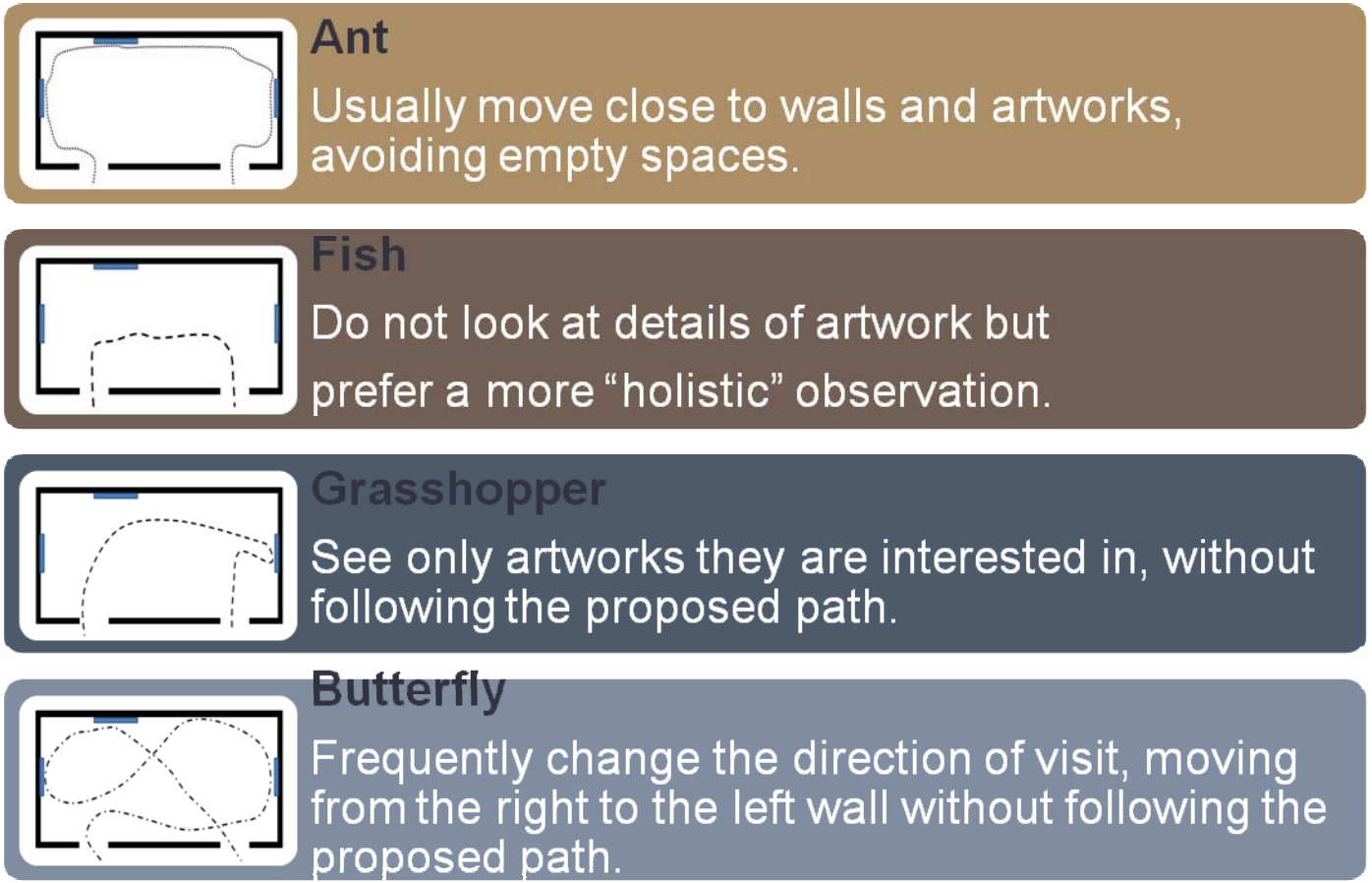
- The data set obtained by Sparacino as addressed in [Sparacino, 2001] for developing “The Museum Wearable project”.

K. Sookhanaphibarn and R. Thawonmas. Visualization and analysis of visiting styles in 3d virtual museums. In Digital Humanities 2010, Conference Abstracts Book . London UK, 2010.

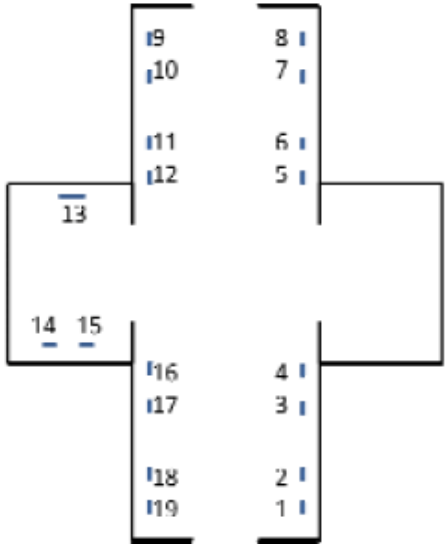
F. Sparacino. Sto(ry)chastics: a Bayesian network architecture for combined user modeling, sensor fusion, and computational storytelling for interactive spaces, PhD thesis, School of Architecture and Planning, MIT, USA, 2001.

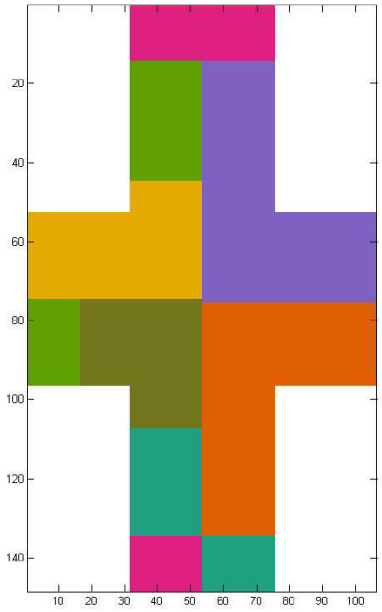
Case 1: Virtual Kimono Gallery in SL

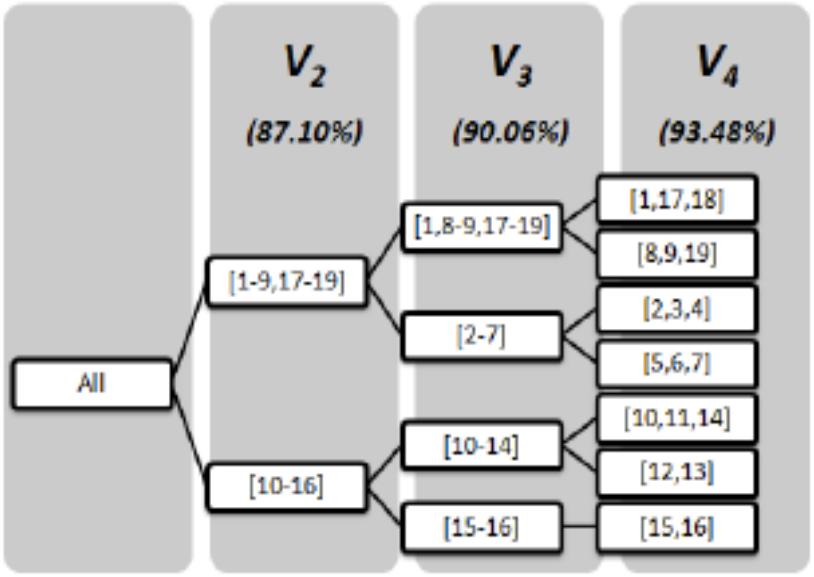
- Data set: Synthesized the visitor trajectories based on the metaphor of four animals:



Clusters would be rather related to the four visiting styles.

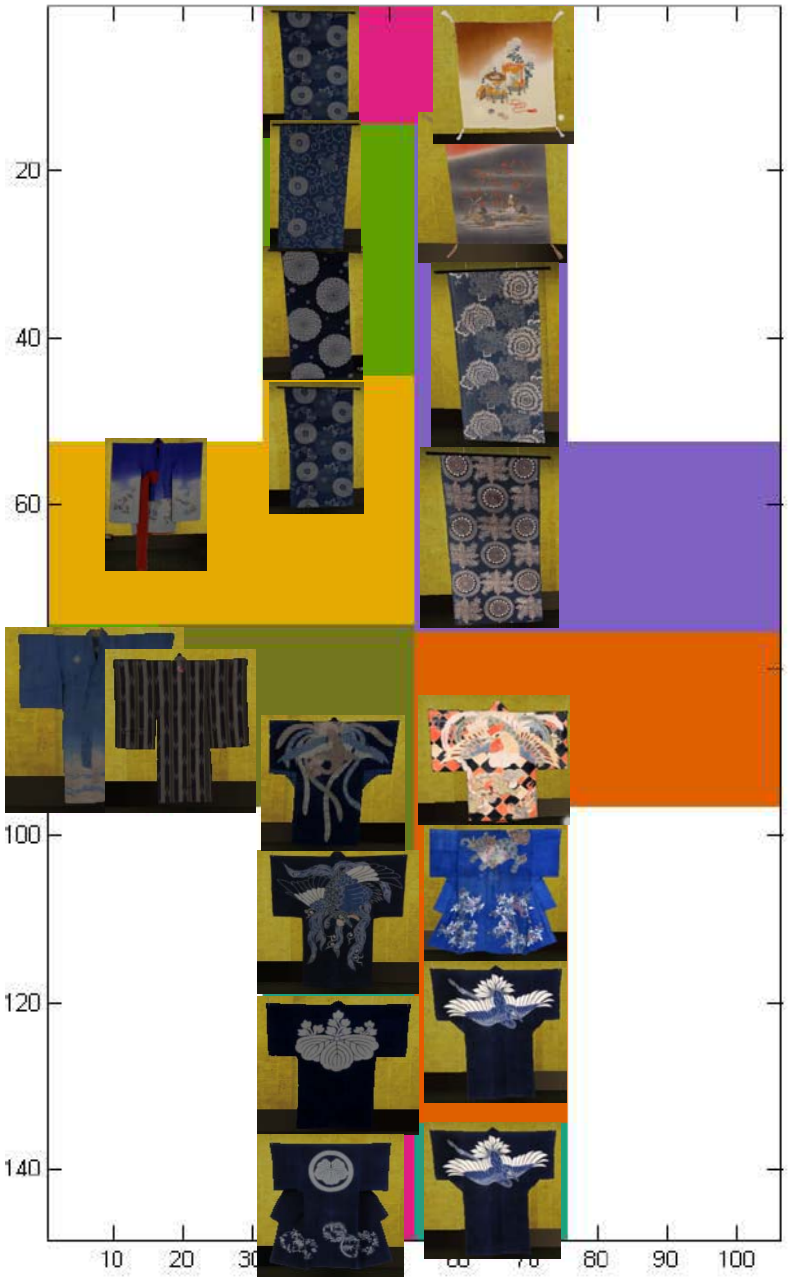






$V_{2:}$ This results from the butterfly visitors who likely skip only a few.

$V_{3:}$ This results from the fish visitors who preferred to observe the atmosphere, they often stopped near the entrance of hallway and the end.

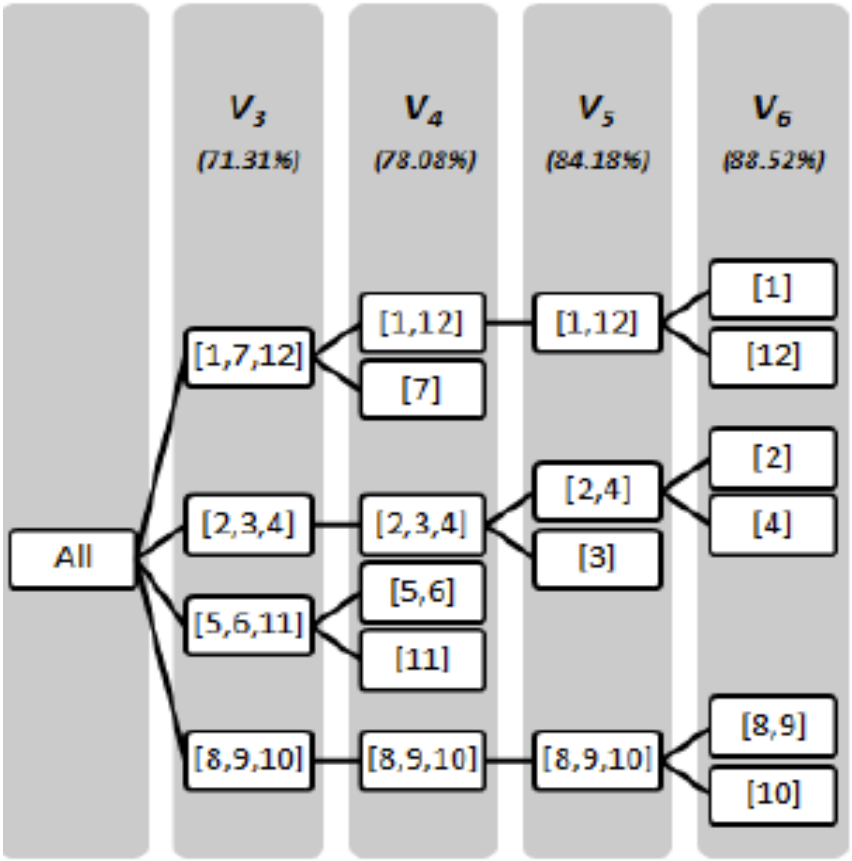

20
40
60
100
120
140
10
20
80
90
100

Case 2: MIT Real Museum

Data set:

- Visitor tracking information from 45 visitors.
- Dwell time in seconds that visitors stayed in front of objects.
- Visiting in a linear sequence.
- 12 objects in total.

Cluster tree of exhibits in the MIT



Cluster tree of exhibits in the MIT

Group of objects

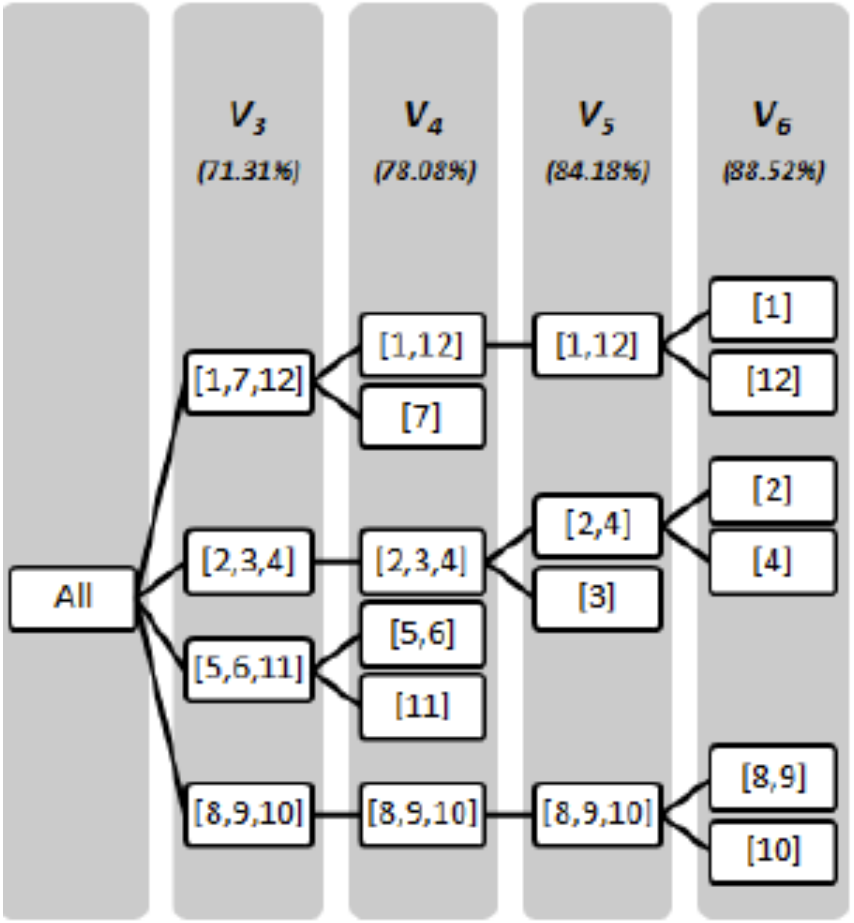
- Strong relevance of 84.18%.

For object circulation,

- Not separating groups but replacing a group of them with others

For exhibition arrangement,

- the first and last exhibits as an analogous to the introduction and conclusion parts.



Conclusion and Future Work

What we did:

- Propose an approach for segmenting exhibition space
- Introduce how to adopt Eigenplaces and theory of graph spectra for developing our approach
- Use dwell time for identifying a degree of visitor attention and exhibit interesting

What we will do:

- Conduct a user evaluation in virtual galleries
- Apply to attractions/ places recommendation for a limited- time visit