



Navigation and Search in 3D Visualizations of Large Unstructured Picture Collections

an Empirical Study

Olivier CHRISTMANN – Noëlle CARBONELL

Nancy-Université, LORIA, CNRS & INRIA, *France*

Context and Motivation (1)



- Size of photo collections is rapidly growing
 - Photos are stored locally (100 gigabytes \approx 25 000 pictures) or on websites (*Flickr*, *Picasa Web Album*)
- Retrieving specific photographs is becoming difficult

2 main approaches for assisting search in large photo collections:

- Providing annotation facilities to encourage query-based search
 - Providing multi-scale interactive visualizations (MIVT) to facilitate navigation and visual search
- This study is a contribution to the second approach



Context and Motivation (2)

Current displays: static 2D views with matrix layouts

- Weak gaze guidance, due to lack of salient areas
- Inefficient scrolling control

→ Limited effectiveness and efficiency of visual search and navigation



Few 3D MIVTs dedicated to unstructured photo collections

Limitations (compared to 2D views): occlusions, static



Our goal

Influence of the specific features and interaction metaphors of dynamic 3D MIVTs on visual search effectiveness, efficiency, and comfort?

Our proposal

Two 3D views suggesting 2 interaction metaphors: locomotion and manipulation

Generic 3D Representation (1)



Outer view (OV)

Specific features

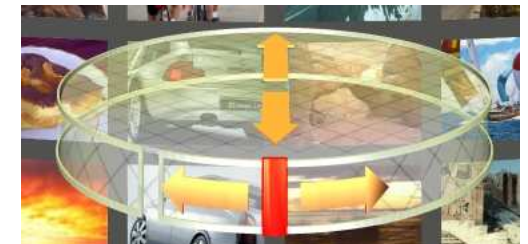
- Vertical “slit”
- 3D miniature cylinder indicates current view point (red bar)
- Variable speed rotation



Inner view (IV)

Interaction

- Rotation activation
- Distance adjustment
- Zoom



Generic 3D Representation (2)

Visual differences between the two views

- **Size of items**



Inner view

center



Outer view

center

- **Item shape deformations**

Largest items are not distorted in the outer view



Inner view



Outer view

Influence of geometrical properties on interaction metaphors?

- Outer view convexity → direct manipulation
- Inner view concavity → feeling of immersion

Photo Collections

- Colour photos collected from websites
- Two categories: “objects” and “landscapes”

Experimental Procedure (1)

Design and setup

- Application domain: photograph browsing
- 869 photos: 11 rows and 79 columns
- 150 thumbnails visible at once
- Identical interaction facilities
- Wall screen: 1.00 x 0.75 m
- Implementation: *AReVi* (ENIB, France)

Participants

- 20 gender-balanced, experienced computer users (graduate or PhD students)
- Narrow age range: from 21 to 34 years (avg: 25.15 – SD: 3.13)
- Normal sight (based on Bioptor test kit – Stereo Optical Company, Inc.)

Experimental Procedure (2)

Visual tasks

- Visual search tasks frequently used while browsing photos:
 - Search for a photo with specific features (photo and location unknown) - **T1**
 - Search for a familiar photo (photo and location known) - **T2**
- Experimental search task: find a unique target photo in a collection
- 10 search tasks of each type, T1 and T2, for each of the two views

Task 1

- Unambiguous written description of the target
- Search for the target
- Animated graphical demonstration of the correct solution

Task 2

- Visual presentation of one of the targets used for T1
- Search for the target

Results (1): *Working Hypotheses and Measures*

Working hypotheses

- **H1**: better performances with OV (more effective gaze channeling)
- **H2**: better support of target's location memorization with IV (feeling of immersion)

Measures *

- Preferences (questionnaires and debriefing transcripts)
- Performance measures (interaction logs):
 - average visual search time **T**
 - average number of successful target selections **S**
 - average number of scrolled columns **C**
- Analysis of exploration strategies:
 - average rotation speed **R**
 - positions of zoomed pictures on the screen
- Visual acuity tests

* Averages computed over all participants for all T1 tasks (resp. T2 tasks)

Results (2): Performances

T1 tasks

- less errors with IV ($p=.011$)
 - shorter average search time with IV ($p=.093$)
- IV is more effective for retrieval of unfamiliar photos

T2 tasks

- participants' performances are similar with the 2 views (easier and shorter tasks)
- Better support of visual exploration of picture collections with IV

		T1 tasks (10)			T2 tasks (10)			
		T	S	C	T	S	R	C
Mean	IV	821 (200)	7.8 (1.9)	587 (220)	441 (172)	9.3 (0.8)	1.79 (.53)	654 (330)
(SD)	OV	939 (193)	6.7 (1.6)	622 (233)	485 (164)	9.3 (0.8)	1.43 (.41)	561 (219)
Wilcoxon test		$z=1.680$ $p=.093$	$z=2.536$ $p=.011$	$z=0.784$ $p=.433$	$z=1.195$ $p=.232$	$z=0.000$ $p=1.000$	$z=3.771$ $p<.0005$	$z=1.344$ $p=.179$



Results (3): *Preferences*

All participants (save one) judged the 3D views positively with respect to 2D views

- **Subjects preferred the 3D view**
 - 10 preferred IV (group GI)
 - 4 preferred OV (group GO)
 - 6 could not choose between the 2 views (group GH)
- **Strong influence of static visual features on preferences** (debriefings)
 - OV: enlargement of items in the central columns
 - IV: overview of a large number of items
 - IV: enlarged items on the “incoming columns” during scrolling
- **Weak influence of interaction metaphors**

Results (4): Visual exploration strategies

Two main exploration strategies:

→ visual attention focused on **incoming (I)** or **central (C)** column(s)

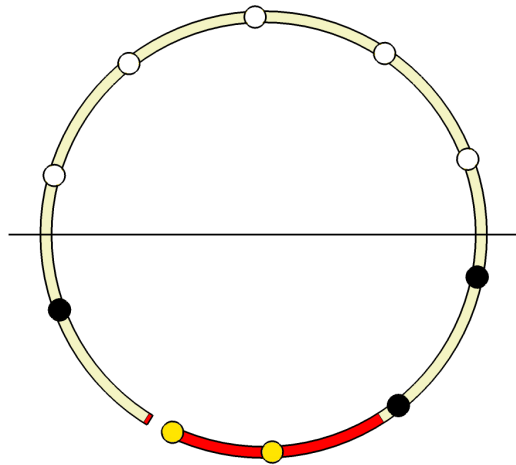
Group		GI group										GO group				GH group					
Participant		1	5	6	8	11	14	15	17	19	20	7	9	10	16	2	3	4	12	13	18
Strategy	IV	<i>I</i>	<i>I</i>	<i>I</i>	<i>I</i>	<i>I</i>	<i>C</i>	<i>C</i>	<i>I</i>	<i>I</i>	<i>I</i>	?	<i>I</i>	<i>C</i>	<i>C</i>	<i>I</i>	?	?	<i>I</i>	<i>I</i>	
	OV									<i>C</i>	?	<i>C</i>	<i>C</i>	<i>I</i>	<i>I</i>	<i>I</i>	<i>C</i>	?	?	<i>C</i>	<i>I</i>

→ Greater influence of dynamic features on visual exploration strategies

- 2 static visual features: perspective distortions of item shape and size
- 1 dynamic feature: horizontal scrolling

Results (5): *Spatial memory support*

- Analysis of rotation directions chosen for locating 3 T2 targets



In red, the user's initial viewpoint

In black, the 3 selected targets

- Only 6 subjects out of 20 used shorter paths to targets
- On average, shorter paths chosen **2.5** times with IV vs **1.75** times with OV



Conclusions

- Participants' preferences mainly influenced by the views' static visual features
 - Participants' individual performances varied from one view to the other noticeably
 - The dynamic feature of the views had a greater influence on participants' visual exploration strategies than their static characteristics (perspective distortions)
 - The inner view seems to better support visual search tasks than the outer view:
 - Half participants (10) preferred IV, while 4 participants only preferred OV
 - Better performances with IV for T1 tasks (disagreement with H1)
 - But similar performances with both views for T2 tasks (disagreement with H1)
 - Potential to better support spatial memory (agreement with H2)
- Both views should be proposed to users, as none appears to prevail over the other, regarding preferences and performances



Current work

We are conducting an experimental study:

- meant to compare the support provided by of IV and OV to visual search in large unstructured picture collections, with that of standard 2D displays
- based on the same:
 - experimental protocol, tasks and setup
 - performance measures, and
 - subjective judgment elicitation procedures as those implemented in this study
- using more elaborate observation techniques (e.g., eye tracking data), in order to better understand users' visual navigation and search strategies