“Generation of semantic layouts for interactive multidimensional data visualization”

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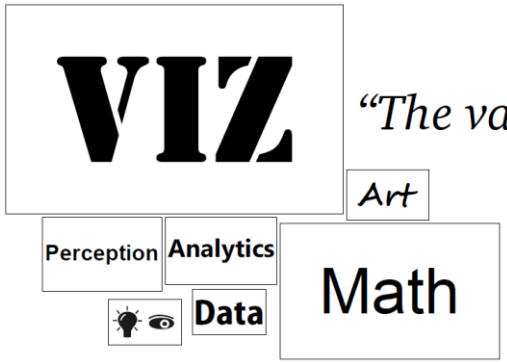
Outline

- ❑ Motivation
- ❑ Semantic layout arrangement
- ❑ ***ProjSnippet***
- ❑ MIOLA
- ❑ ***Dealing with multiple requirements***
- ❑ Conclusion

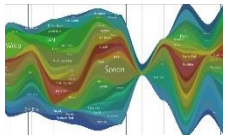


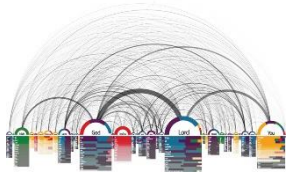
*"The value of an **idea** lies in the using of it."*
(Thomas A. Edison)

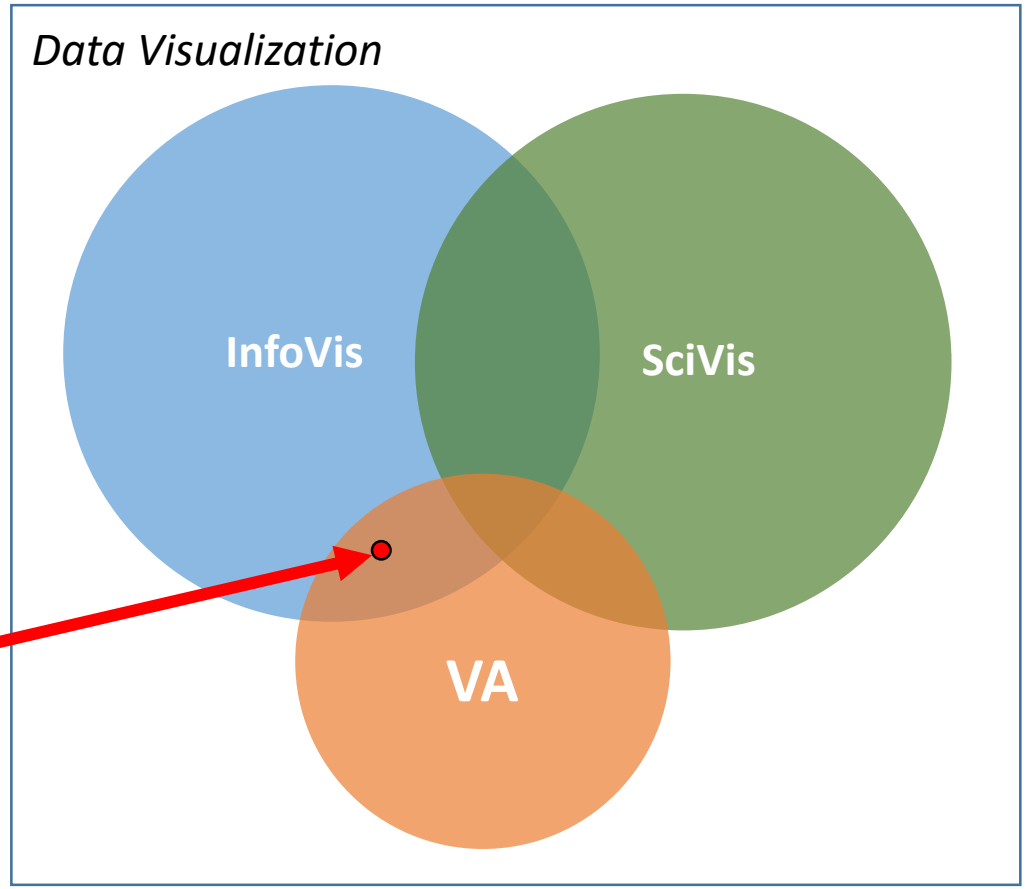
Background

"it's infovis when the spatial representation is chosen, and it's scivis when the spatial representation is given"

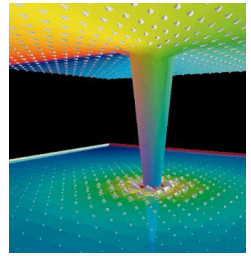
Information visualization handles abstract data structures such as trees or graphs.

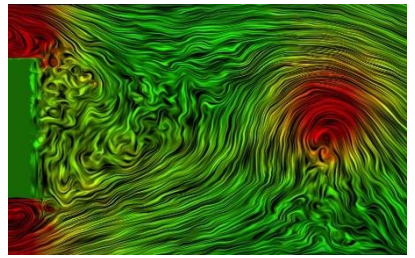






Scientific visualization deals with data that has a natural geometric structure (e.g., MRI data, wind flows).





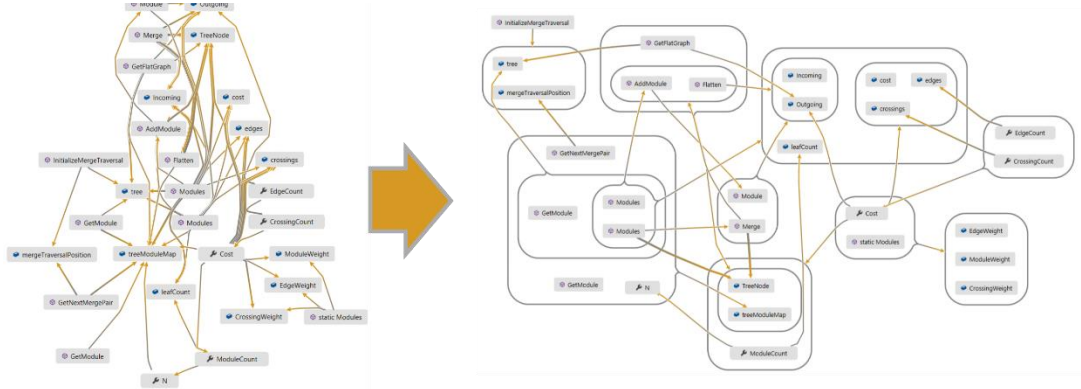
According to [1], **Visual Analytics** is the science of analytical reasoning supported by interactive visual interfaces.

[1] Thomas, J., Cook, K.: Illuminating the Path: Research and Development Agenda for Visual Analytics. IEEE-Press (2005)

Motivation

Arranging geometric primitives to generate meaningful layouts is a major task in visualization.

Graph Visualization



[Dwyer et al.. 2014]

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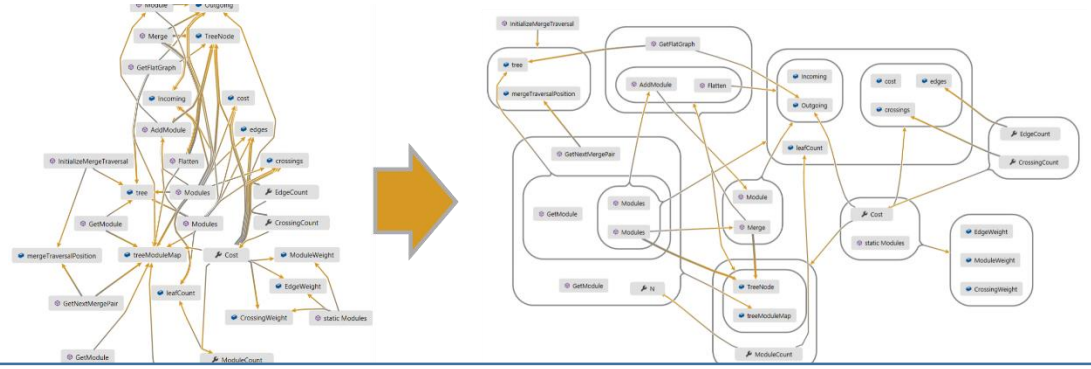

Space-Filling

[Duarte et al. 2014]

[Pinho et al. 2010]

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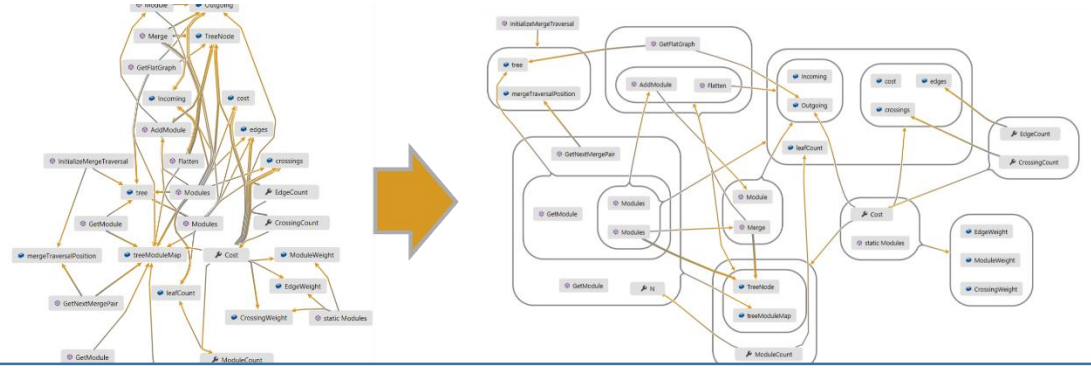

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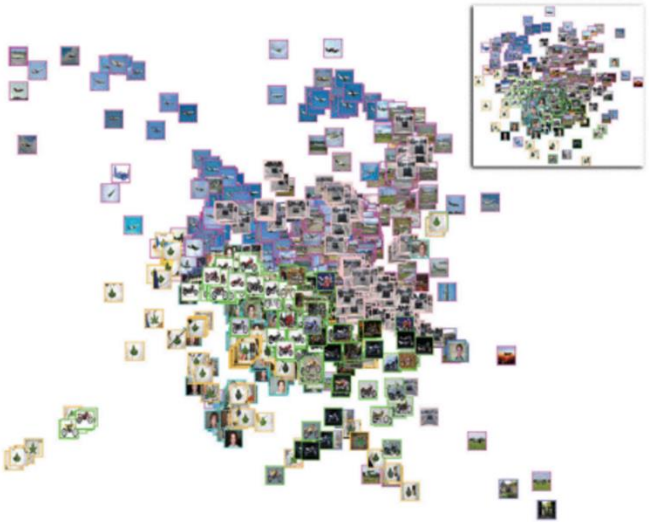
Image Galleries

[Reinert et al. 2013]



[Paulovich al. 2011]

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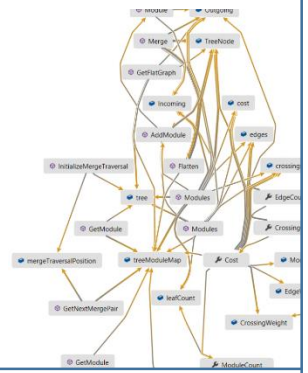
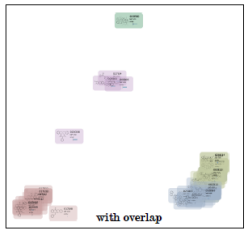
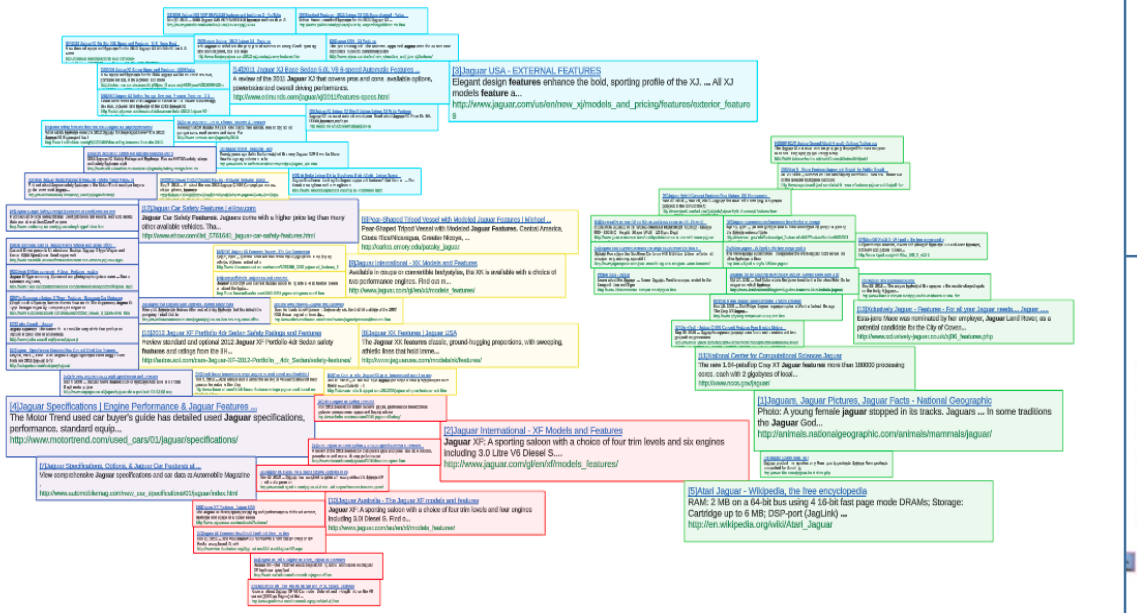


Space-Filling

Snippet-based



[Strobelt et al. 2012]



[Gomez-Nieto et al. 2015]

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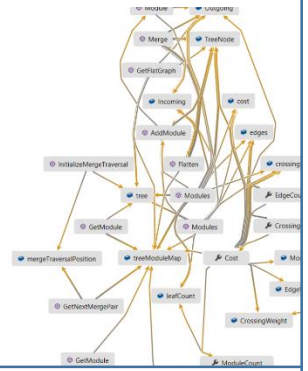

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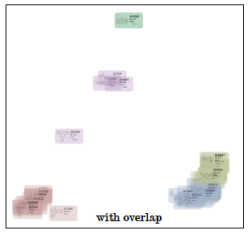

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Wordclouds

[Xu et al. 2016]

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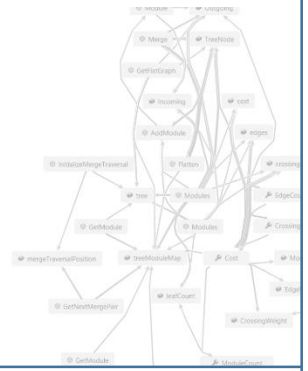

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Motivation

The number of requirements that must be handled simultaneously makes the problem hard to solve

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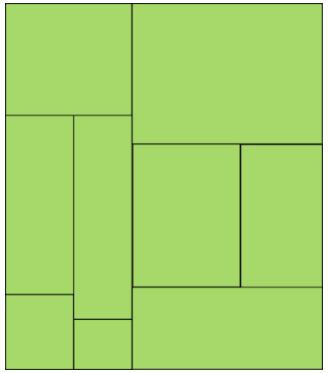
Optimal Usage of Area



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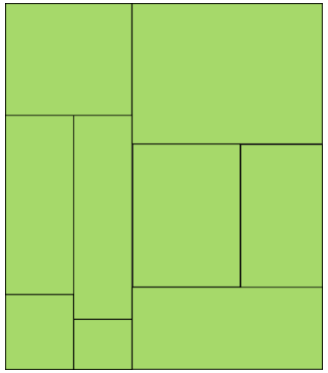
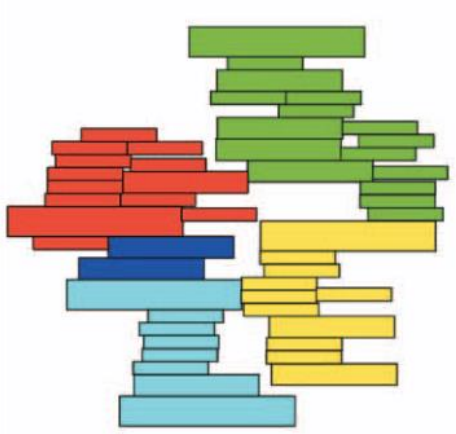


Semantic/Similarity Preserving



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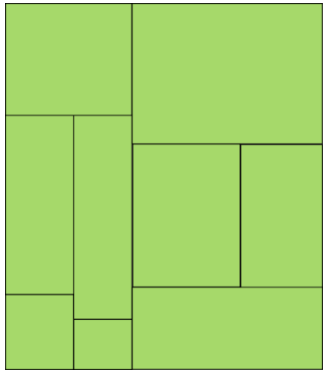

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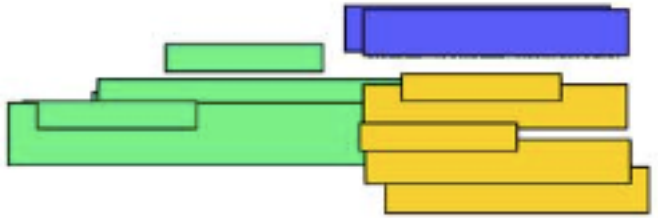
Prevent Overlaps



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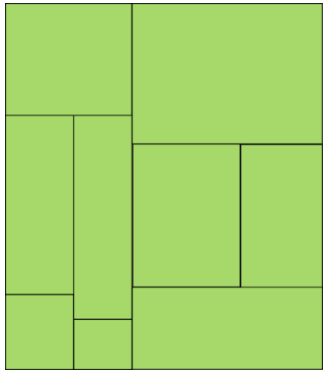

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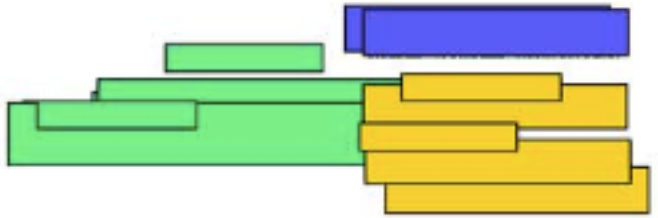
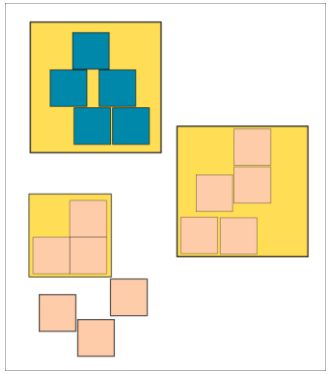


Hierarchical Ensembles



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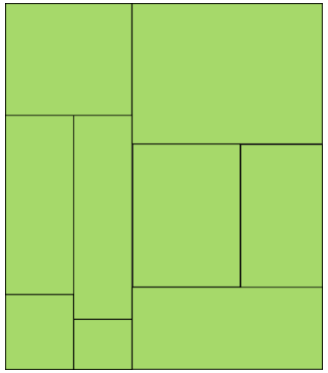

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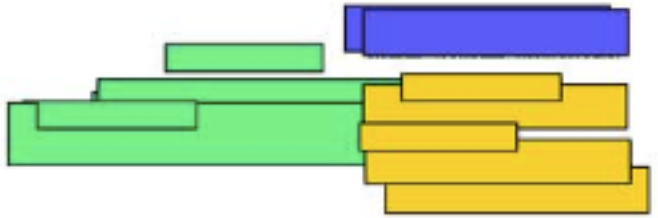

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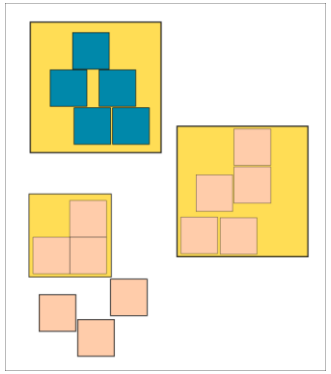

Object Scaling

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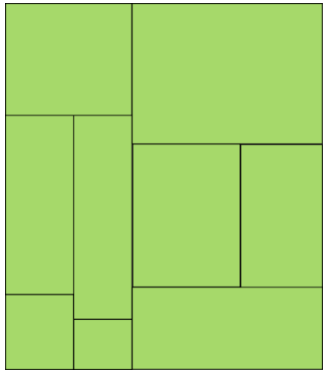

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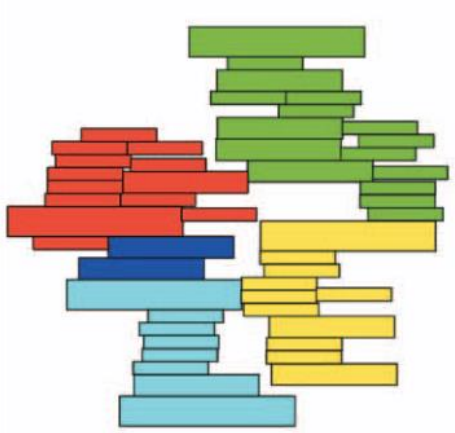

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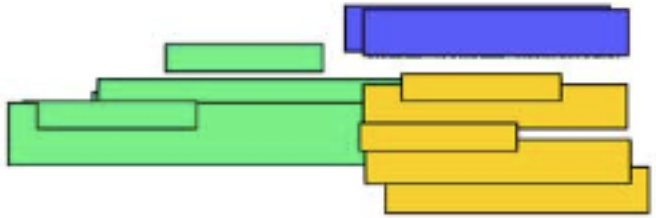
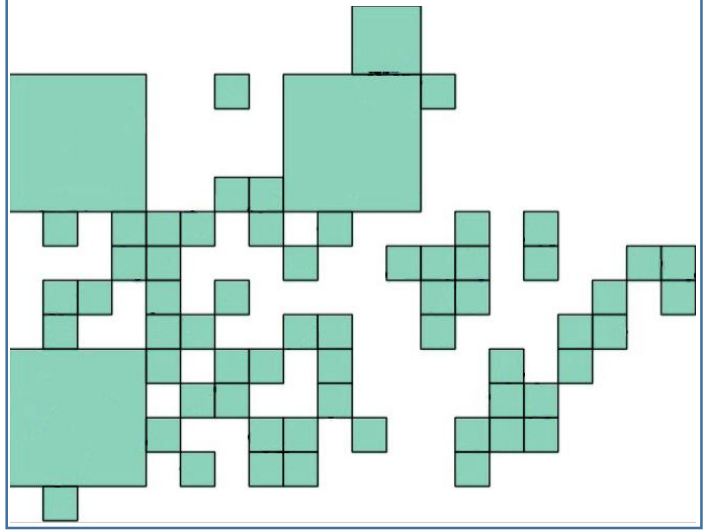


Grid Like Alignment



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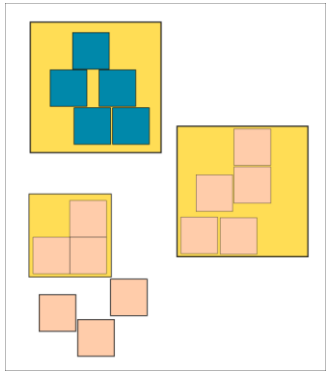

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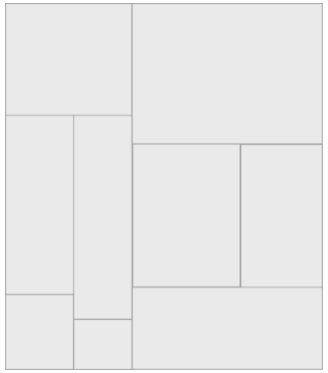

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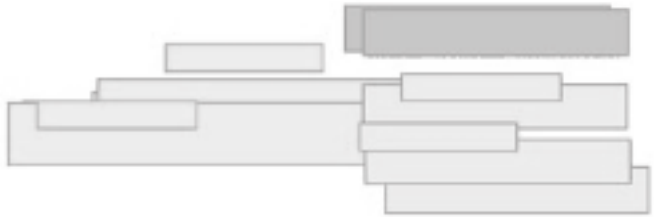

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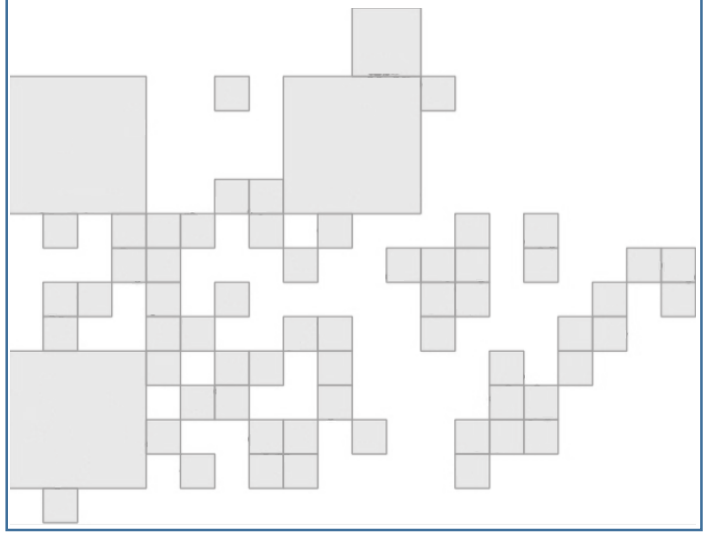

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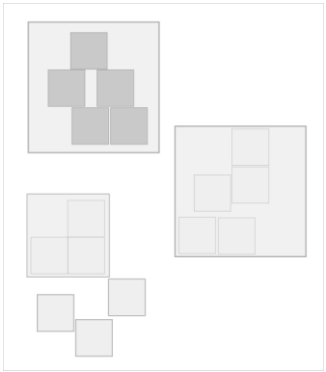

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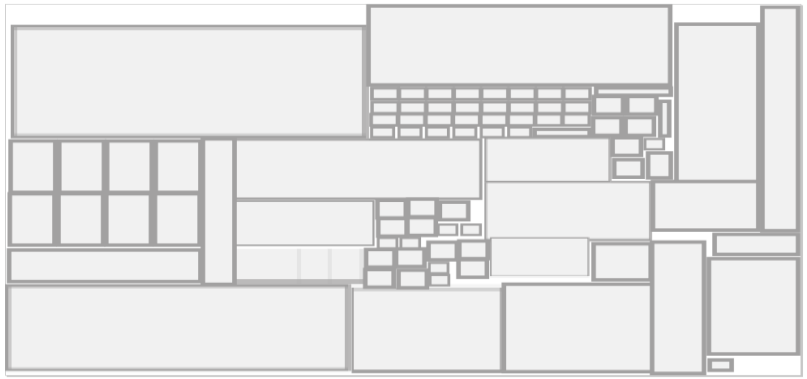

Motivation

Handling many requirements is not an easy task:

- Requirements can be conflicting

  (Readability demands large objects, which, in turn,

  occupy large amount of display area, impairing scalability)

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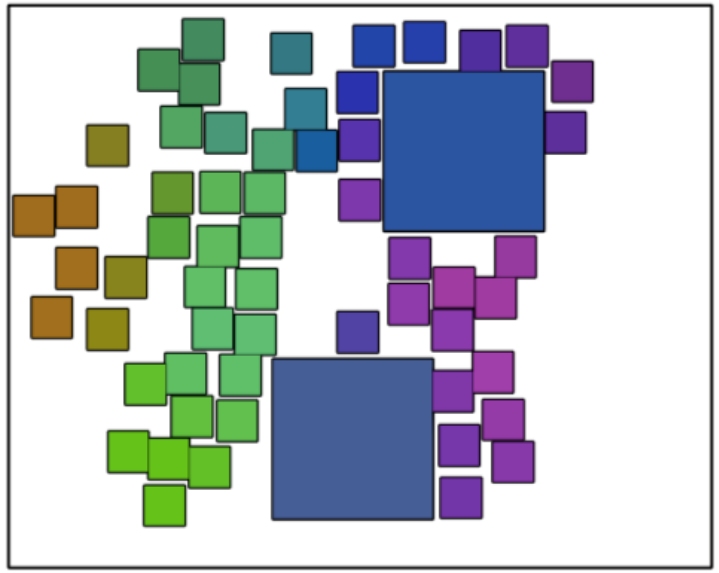
- Defining a cost function made up of several terms can lead to complex and inefficient optimization procedures

Motivation

Given such difficulties, most existing methods opt to handle a reduced number of requirements, hampering usefulness and applicability in several scenarios.



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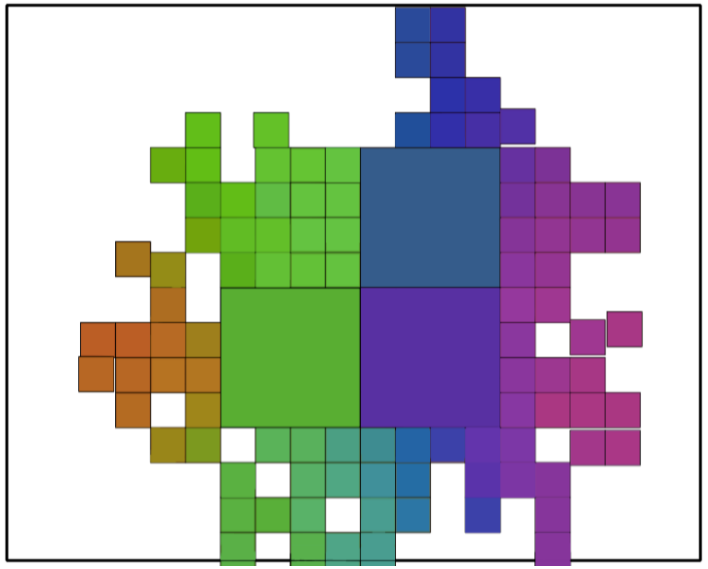
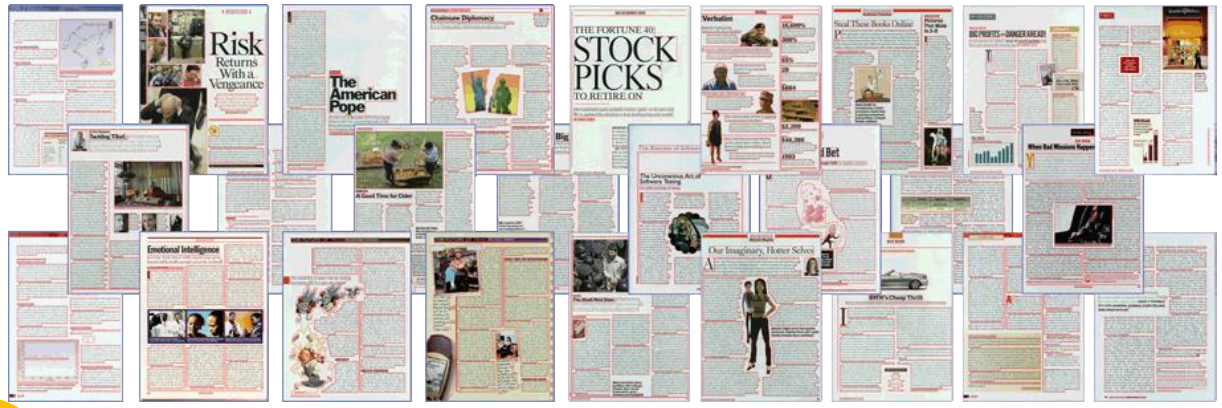
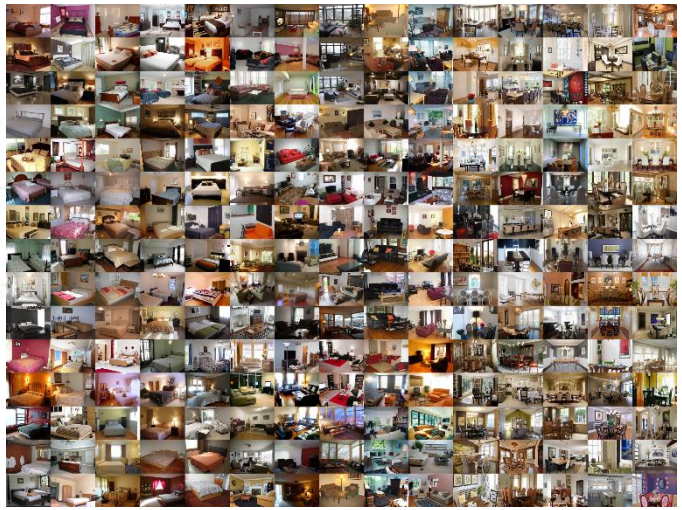


Semantic Preserving
Grid-like structure
Compactness


Risk
Returns With a Vengeance
The American Pope
THE FORTUNE 40:
STOCK PICKS
TO RETIRE ON
Emotional Intelligence

Data

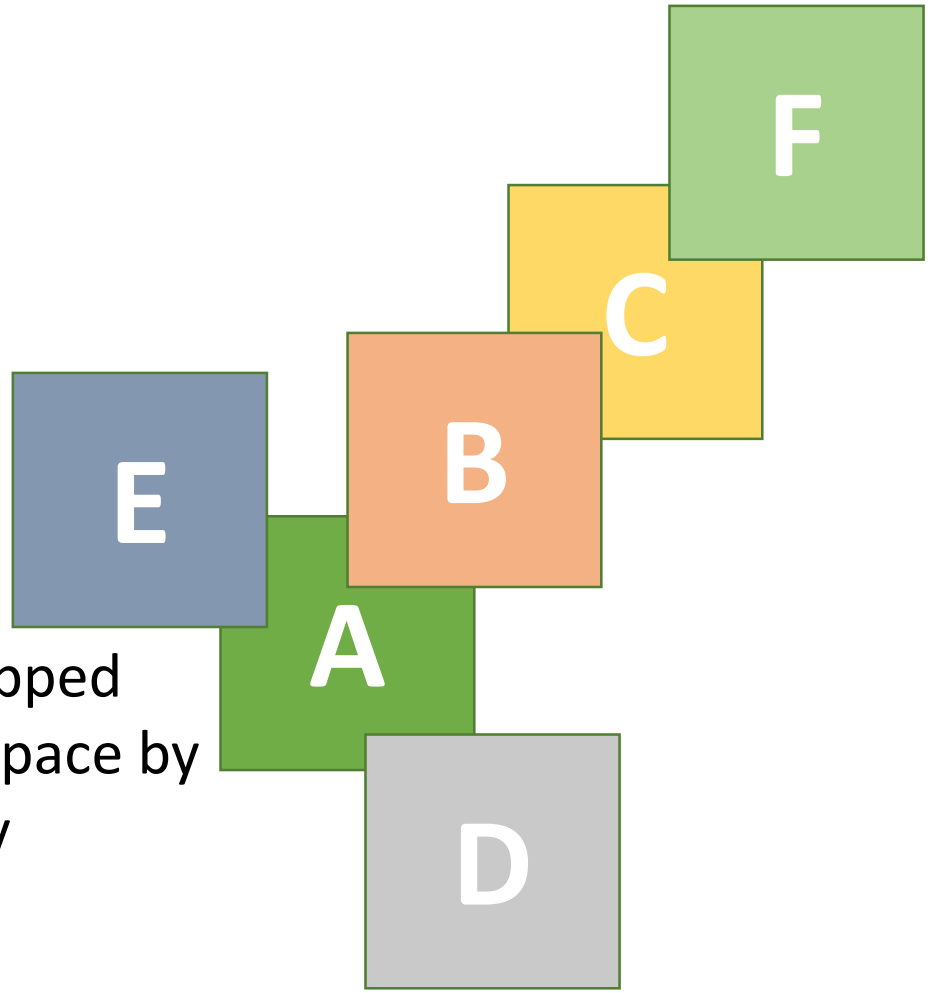

#ElCascabel Aprendan de Franco y del Franquismo, inútiles, el Subsecretario más tonto le daba sopas con Honda a cualquier político actual
Jarque @rjarqueg · 26 de may.
#ElCascabel Prefiero la solución que nos ofrecieron resueltamente Mola, Franco, Yagüe...
#ElCascabel Yo en uso de mi libertad de expresión me voy a dedicar a cantar por los campos de fútbol de España el himno de las Waffen SS
Jarque @rjarqueg · 24 de may.
#24M13tv La democracia inorgánica es sin duda el peor de los sistemas de gobierno, dominan los poderosos con el voto de los ignorantes
#LMLacalle Es inútil, ¿son galgos o podencos? El personal solo entiende la ley del palo y tente tieso
Jarque @rjarqueg · 24 de may.
#24M13tv las elecciones las ganan los medios de comunicación al servicio de los enemigos de España destructores de nuestra identintidad




Project development meeting
3:00 PM - 5:00 PM
Phone
Tue 31
Doug
Games
Yearly accounts review
Building 1940
Thursday to Friday
Calendar
Tue 31
ESPN
SCORECENTER
People
Photos
College soccer game
West Mercer
Tomorrow 5:00 PM - 7:00 PM
Calendar
Tue 31

Similarity

OVERLAP REMOVAL



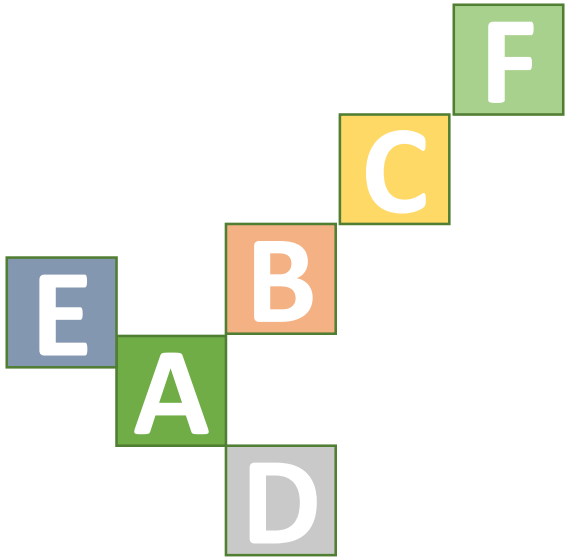
Data mapped into 2D space by similarity

Option 1 of N

- Compact.
- Structured.
- Original shape missed.

Option 2 of N

- Original shape preserved.
- Scaled (! Compact)
- Non-Structured



Option 3 of N

Trade-off shape preservation and compactness

Semantic layout arrangement

We denominate to Semantic Layout Arrangement the task of efficiently placing a set of **geometric instances** which summarizes a multidimensional dataset, into a **fixed-size display area**, subject to **preserve, as much as possible the semantic relation among instances**.

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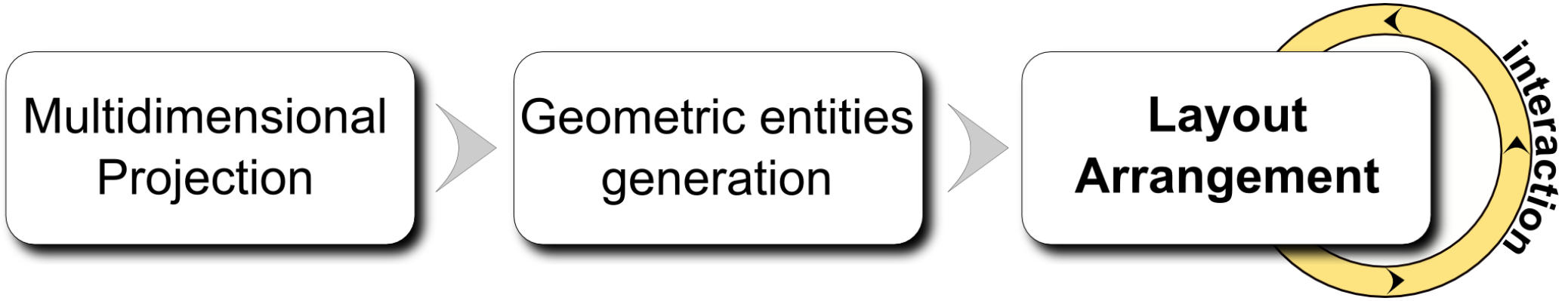

Main contributions

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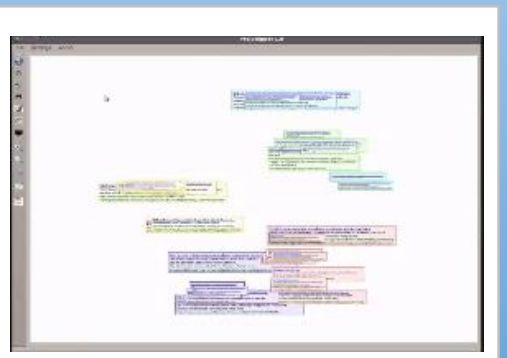

Similarity Preserving Snippet-Based Visualization of Web Search Results

Main contributions

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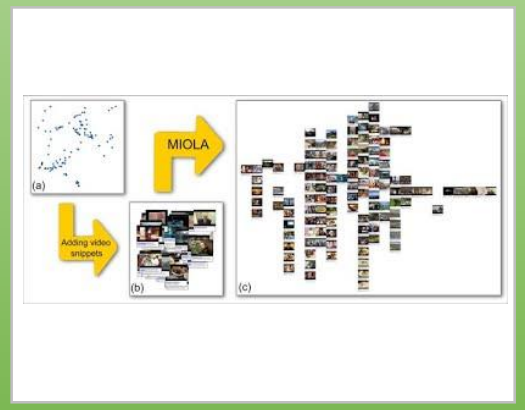

Mixed Integer Optimization for Layout Arrangement

Main contributions

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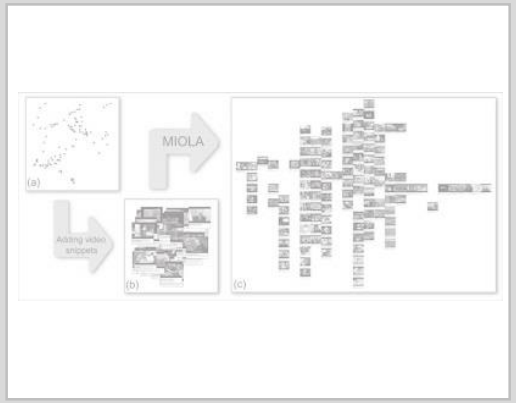
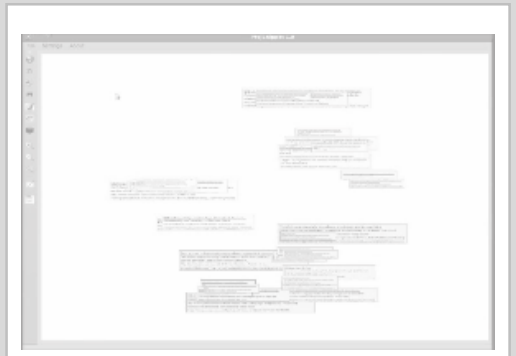


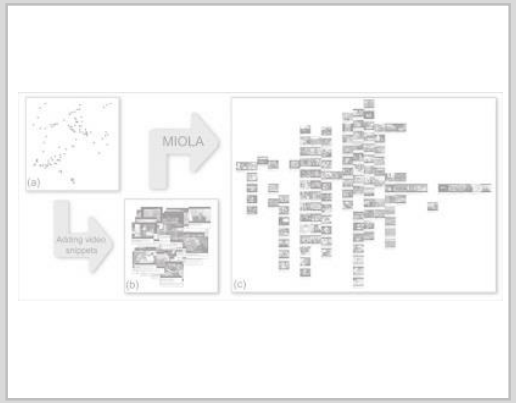
Mixed Integer Optimization for Layout Arrangement

Dealing with Multiple Requirements in Geometric Arrangements

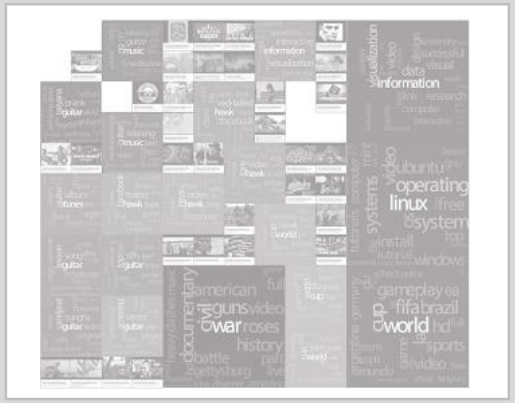
Main contributions



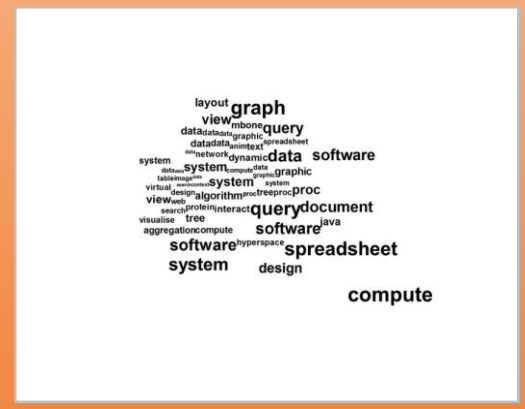
Similarity Preserving Snippet-Based Visualization of Web Search Results



Mixed Integer Optimization for Layout Arrangement

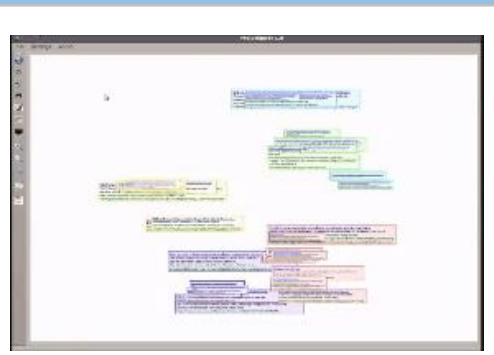


Dealing with Multiple Requirements in Geometric Arrangements

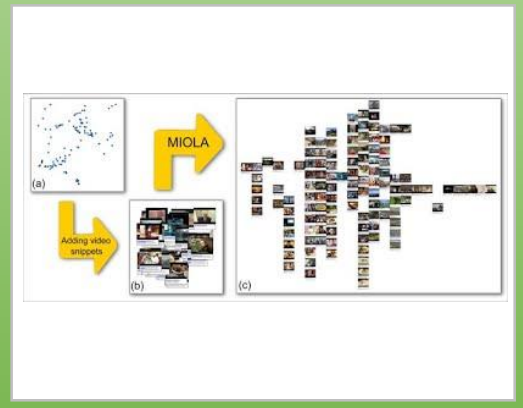


Semantically Aware Dynamic Layouts

Main contributions

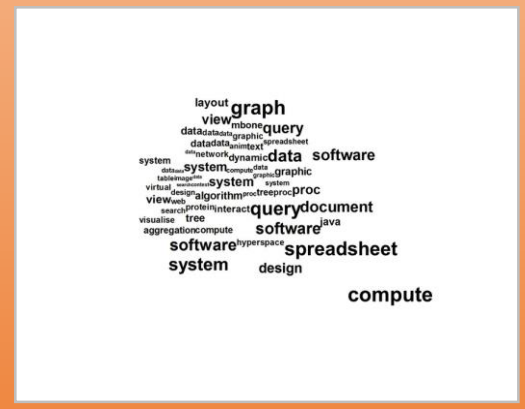


Similarity Preserving Snippet-Based Visualization of Web Search Results



Mixed Integer Optimization for Layout Arrangement

Dealing with Multiple Requirements in Geometric Arrangements

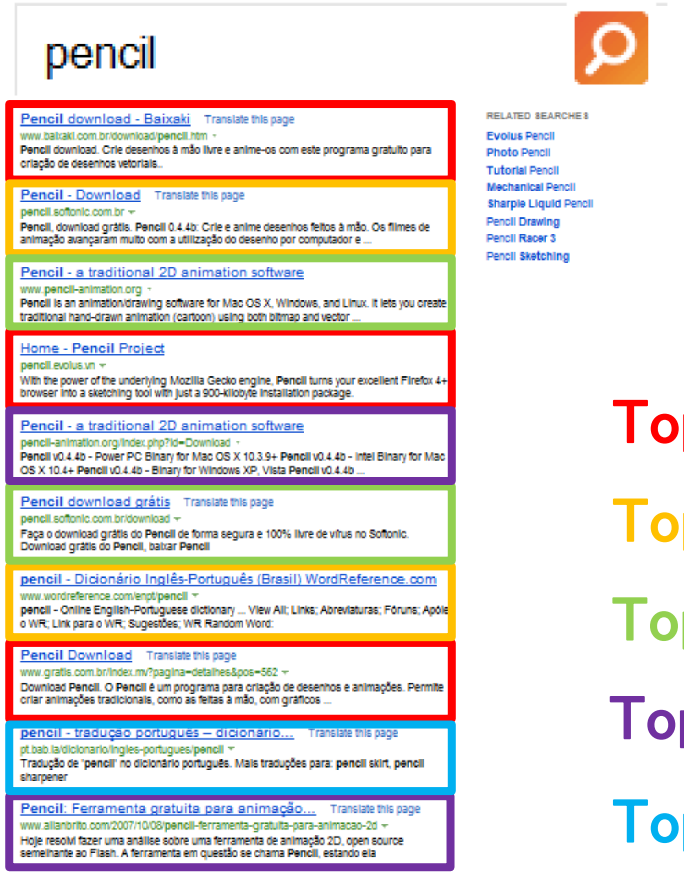


Semantically Aware Dynamic Layouts

Similarity Preserving Snippet-Based Visualization of Web Search Results

- IEEE Transactions on Visualization and Computer Graphics 2014
- Invited paper at IEEE Vis 2014 (InfoVis: Documents, Search & Images)

Introduction The Problem and Motivation



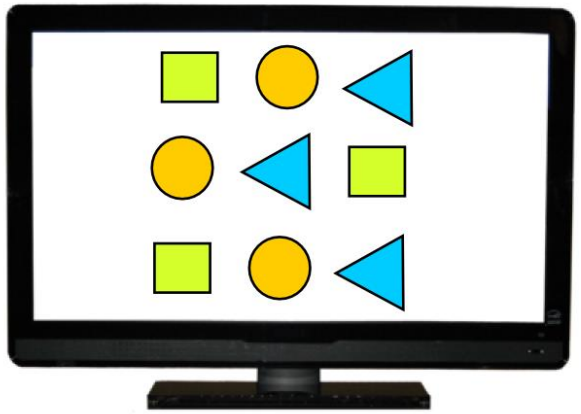
Topic 1

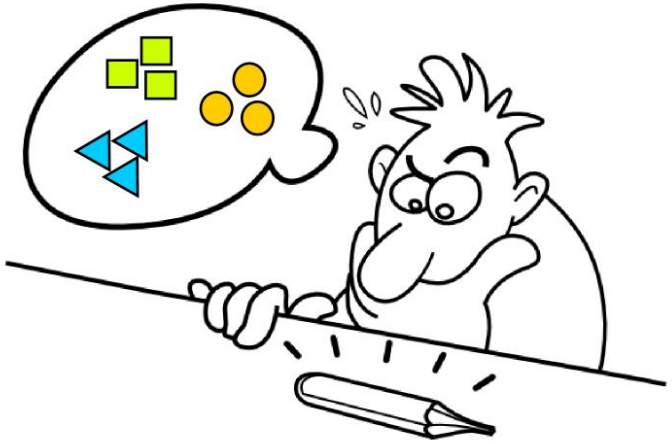
Topic 2

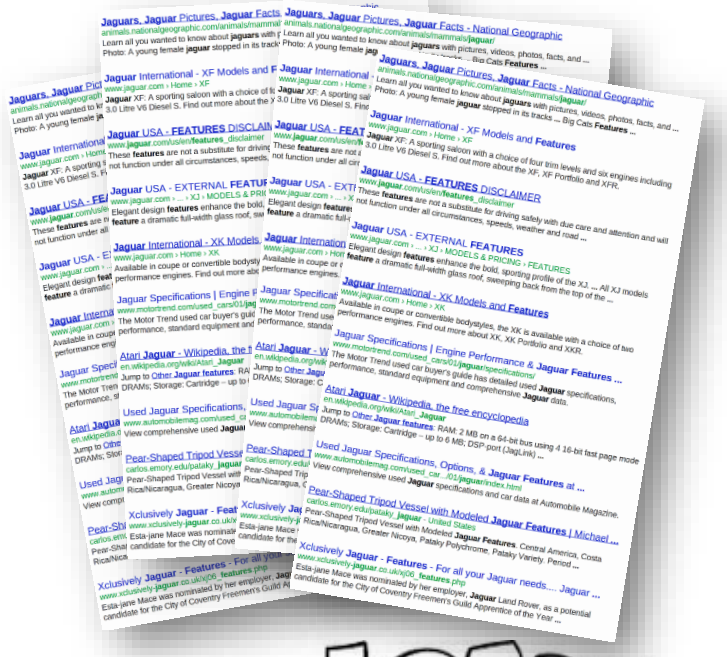
Topic 3

Topic 4

Topic 5







Introduction to our work

The proposed technique, **ProjSnippet,** is innovative in its ability of displaying groups of similar documents and their rank in the search, while preserving the simple and familiar textual snippet paradigm.

- **ProjSnippet** is **NOT** conceived to substitute the list of snippets, but it is an additional resource to improve user experience in specific situations.

ProjSnippet Pipeline

ProjSnippet Optimization

The energy function that steers the layout arrangement is made up of two components

$$E = (1 - \alpha)E_O + \alpha E_N$$

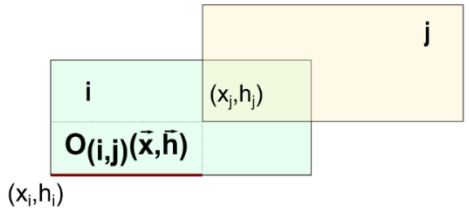
E_O accounts for overlapping between primitives.
E_N preserves neighborhood relations.
The parameter $\alpha \in [0, 1]$ balances the relative contribution of each component for the total energy E.

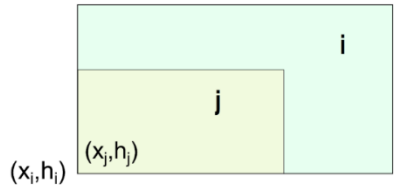
ProjSnippet Optimization $E = (1 - \alpha)E_O + \alpha E_N$

The energy term E_O is then defined as:

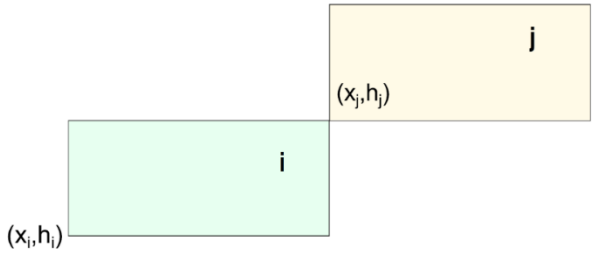
$$E_O = \frac{2}{n(n+1)} \sum_{i=1}^{n} \sum_{j=i+1}^{n} \left[O_{i,j}(\vec{x}, \vec{h}) O_{i,j}(\vec{y}, \vec{v}) \right]$$

Notice that the function $O_{i,j}(\vec{x}, \vec{h})$ is zero (minimal) if there is no horizontal overlapping between rectangles i and j. The function $O_{i,j}(\vec{y}, \vec{v})$ is defined similarly.





$O_{(i,j)}(\bar{x},\bar{h})=1$



$O_{(i,j)}(\bar{x},\bar{h})=0$

ProjSnippet Optimization $E = (1 - \alpha)E_O + \alpha E_N$

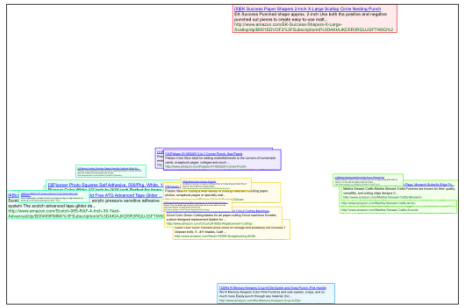
$$\vec{\delta_x} = L\vec{x}^0, \qquad \vec{\delta_y} = L\vec{y}^0.$$

The neighborhood energy is then defined by:

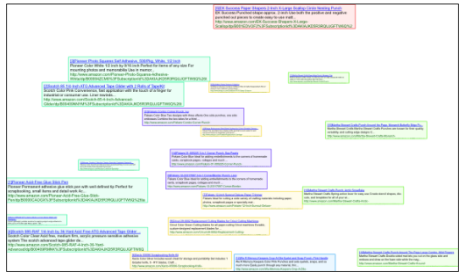
$$E_N = \frac{n^2}{2\left(\left\|\vec{\delta_x}\right\|^2 + \left\|\vec{\delta_y}\right\|^2\right)} \left(\left\|L\vec{x} - w\vec{\delta_x}\right\|^2 + \left\|L\vec{y} - w\vec{\delta_y}\right\|^2\right).$$

E_N is minimal when the differentials $L\vec{x}$ and $L\vec{y}$ are proportional to the initial differentials $\vec{\delta_x}$ and $\vec{\delta_y}$. In other words, the energy E_N is minimized when neighborhood relations are preserved during optimization. The unknown w is a relaxation paramenter (is optimized together with $\vec{\delta_x}$ and $\vec{\delta_y}$).

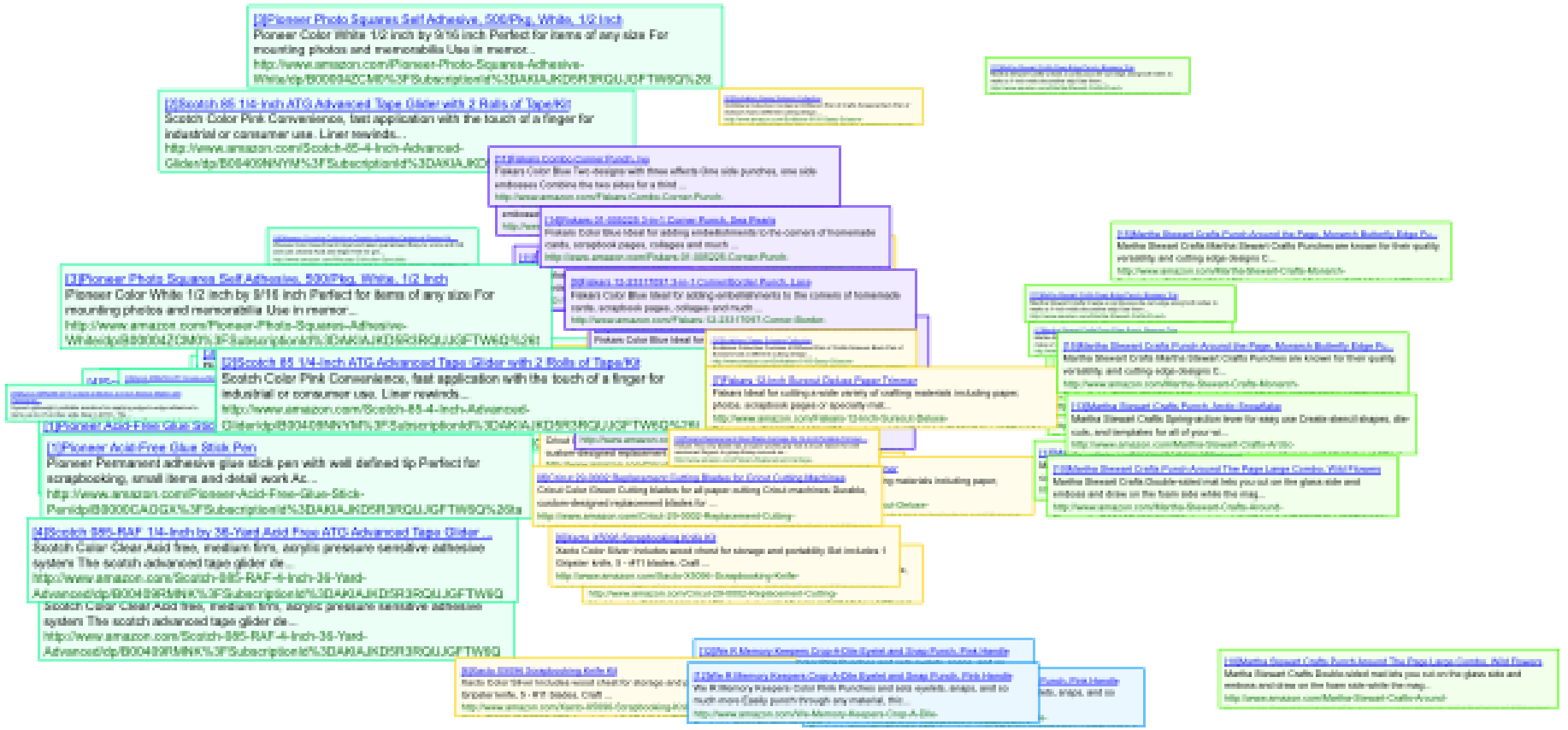
ProjSnippet Optimization $E = (1 - \alpha)E_O + \alpha E_N$

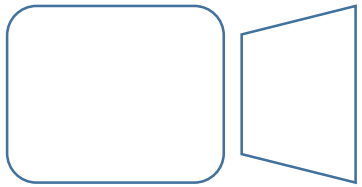


Original



Only E_O



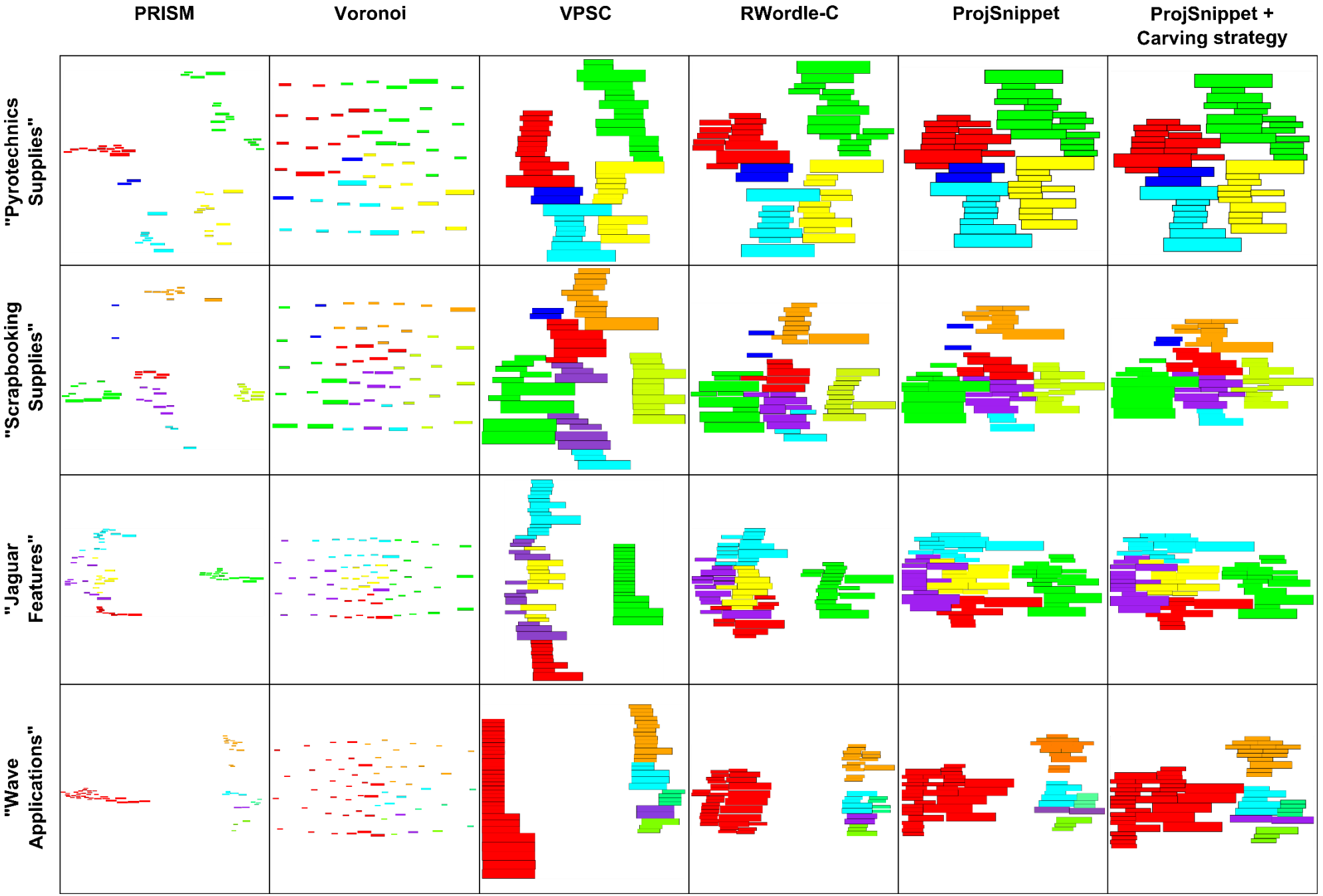


Evaluation

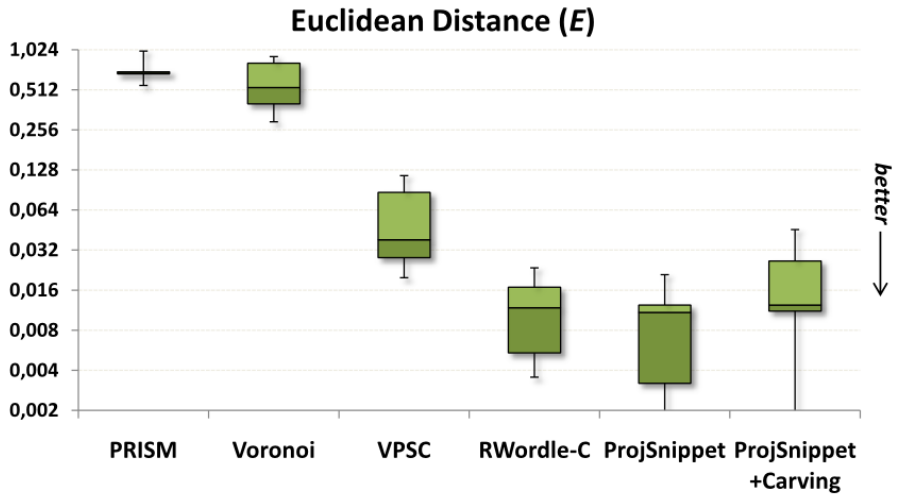
Comparing with *Overlap Removal Methods*

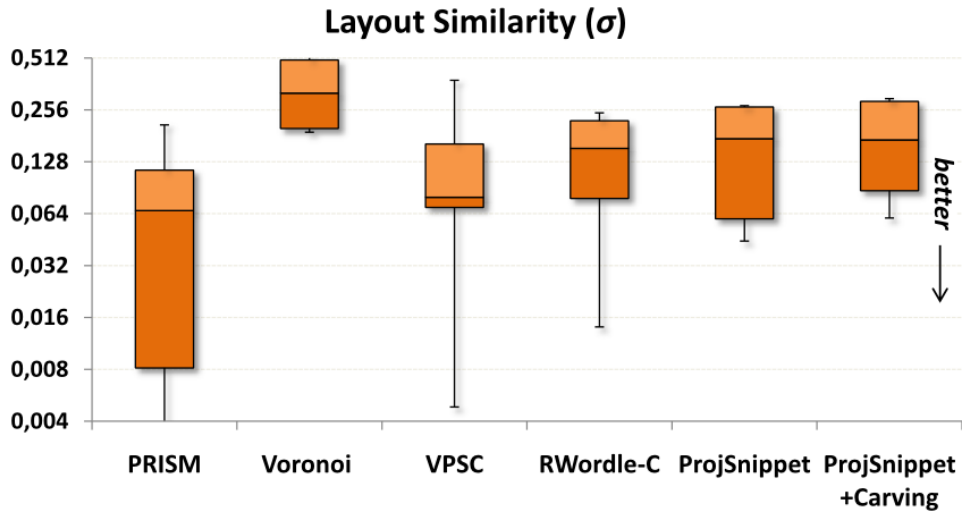
PRISM
[Gansner et al. 2009]
VPSC
[Dwyer et al. 2007]

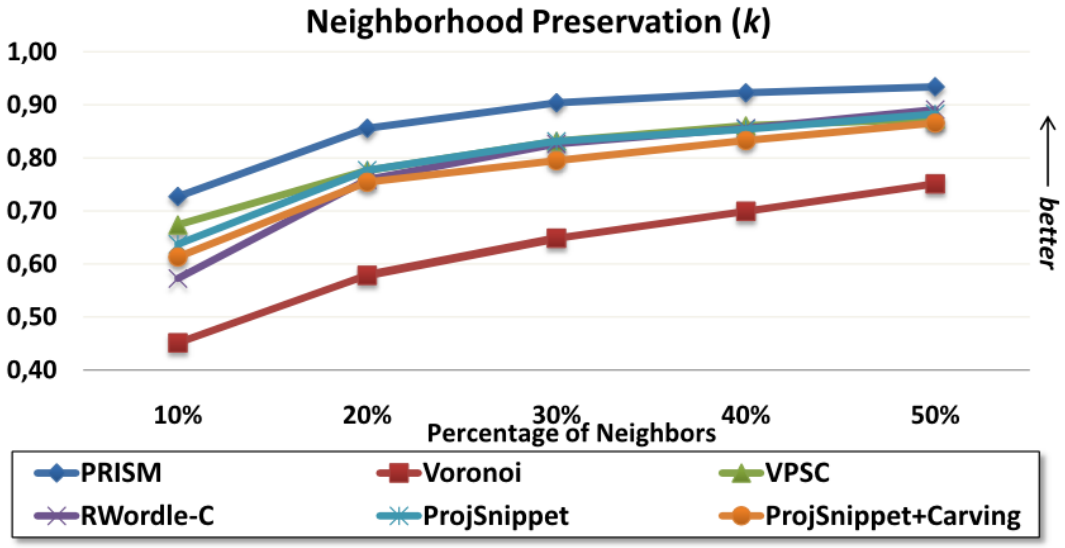
RWordle-C
[Strobelt at al. 2012]

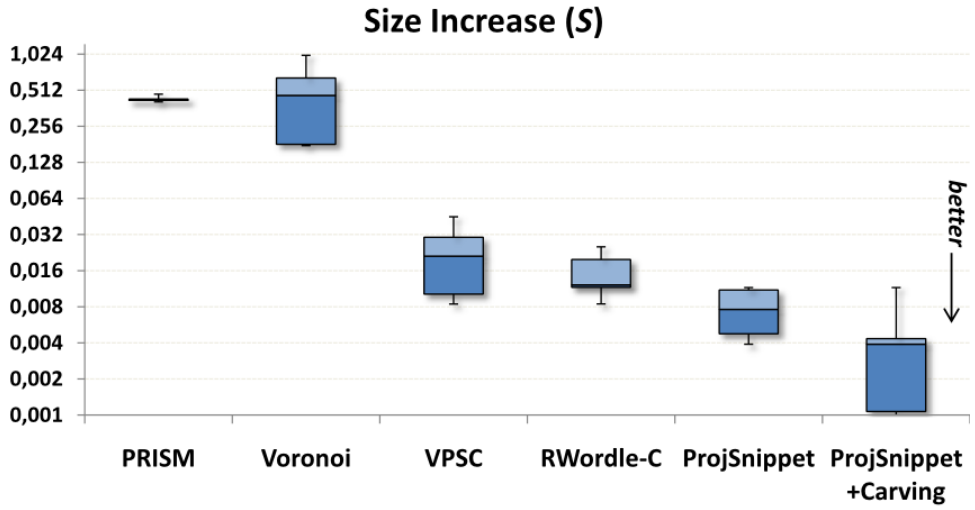


Comparisons Metrics









Comparisons First conclusion

Global comparison of overlap removal methods regarding the four metrics simultaneously (using LAMP **[Joia et al., 2011]**).

[Joia et al., 2011] P. Joia, F. Paulovich, D. Coimbra, J.A. Cuminato and L.G. Nonato. “Local Affine Multidimensional Projection”. *IEEE Trans. on Vis. and Comp. Graph. (IEEE Visualization'2011),* 17(12):2563-2571, 2011

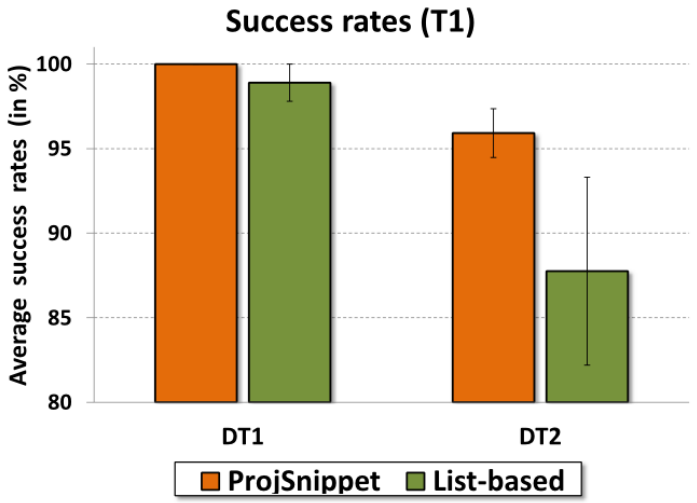
User Study Background

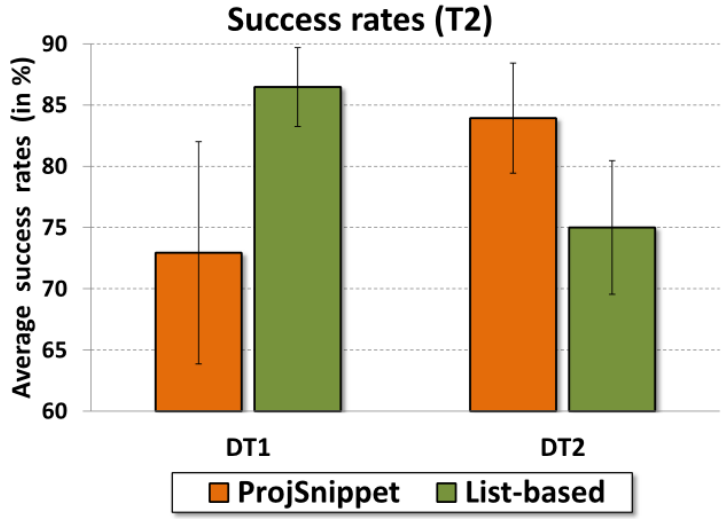
	Hyphotesis	x
Study 1	H: *Users of ProjSnippet will spend less time to answer questions that require a global analysis of the query results (T1, T2, T3 and T4), with no significant loss in correctness*	list-based interface

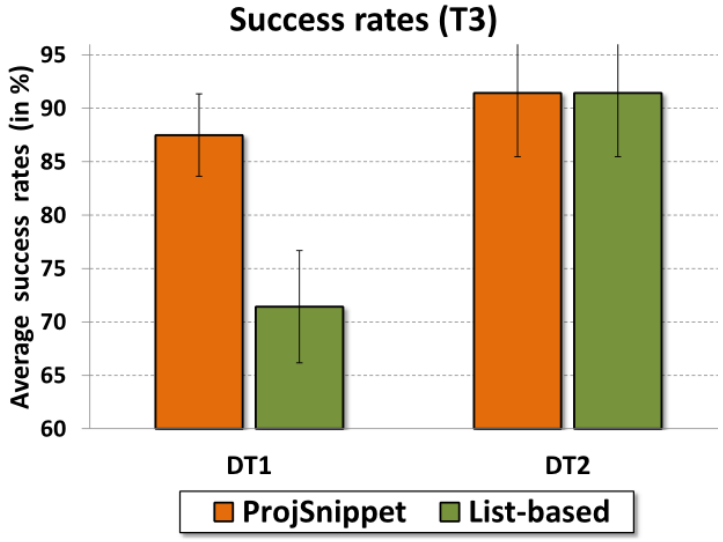
User Study Results x list-based approach

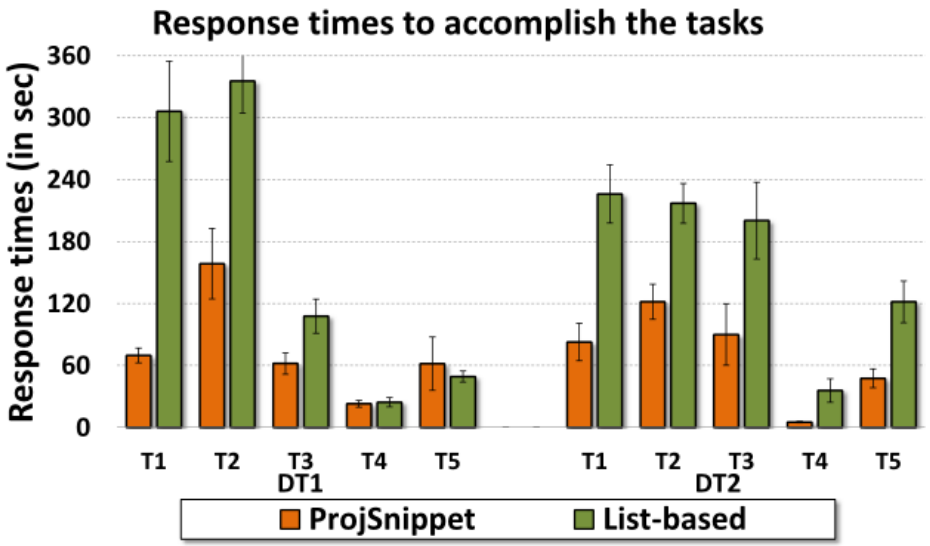
Task questions in user tests.

	Task Target	Question
T1	Identify groups of related sites	**DT1:** How many websites report on chemical supplies for pyrotechnics?
		DT2: How many sites depict content on the "Jaguar XJ" car model?
T2	Identify groups of related sites	**DT1:** Which sites present books, guides or papers about pyrotechnics?
		DT2: Which sites depict content on the "Jaguar XK" car model?
T3	Identify groups of related sites	**DT1|DT2:** How many different topics you can identify in the returned results?
T4	Find different sites addressing similar content	**DT1:** Find three websites announcing "T-Shirt for Dogs".
		DT2: Find two websites that refer to the animal "Jaguar".
T5	Find a particular site	**DT1:** Find a website that addresses the topic "wick cannon fuse".
		DT2: Find a website that includes the expression "Jaguar Features".









User Study Background

	Hyphotesis	x
Study 2	H: *Users of ProjSnippet will achieve better success rates than users of other layouts when answering questions that require a global analysis of the query results (T1, T2 and T3).*	Overlap removal methods

User Study Results x overlap removal methods

Task questions in user tests.

	Task Target	Question
T1	Identify groups of related sites	**DT1:** How many websites report on chemical supplies for pyrotechnics?
		DT2: How many sites depict content on the "Jaguar XJ" car model?
T2	Identify groups of related sites	**DT1:** Which sites present books, guides or papers about pyrotechnics?
		DT2: Which sites depict content on the "Jaguar XK" car model?
T3	Identify groups of related sites	**DT1|DT2:** How many different topics you can identify in the returned results?
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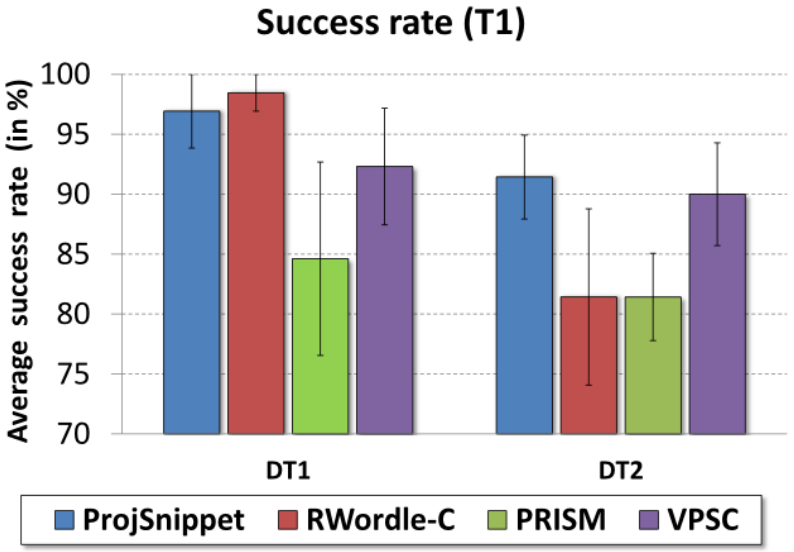
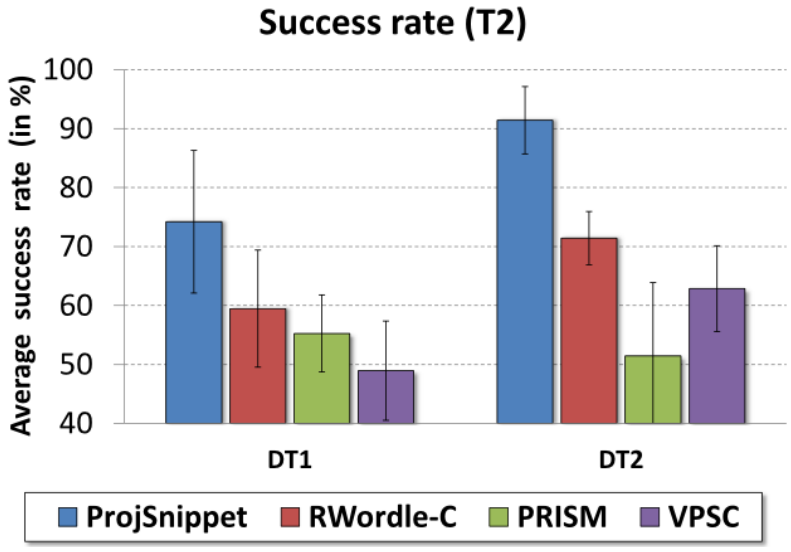
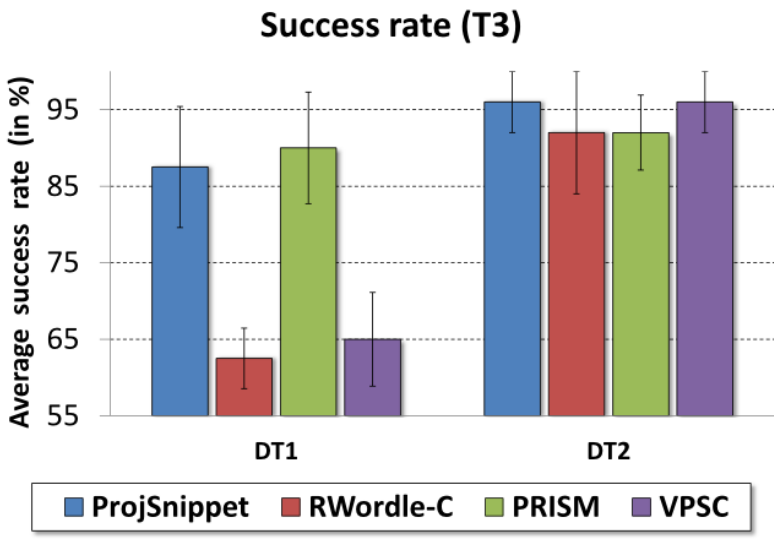
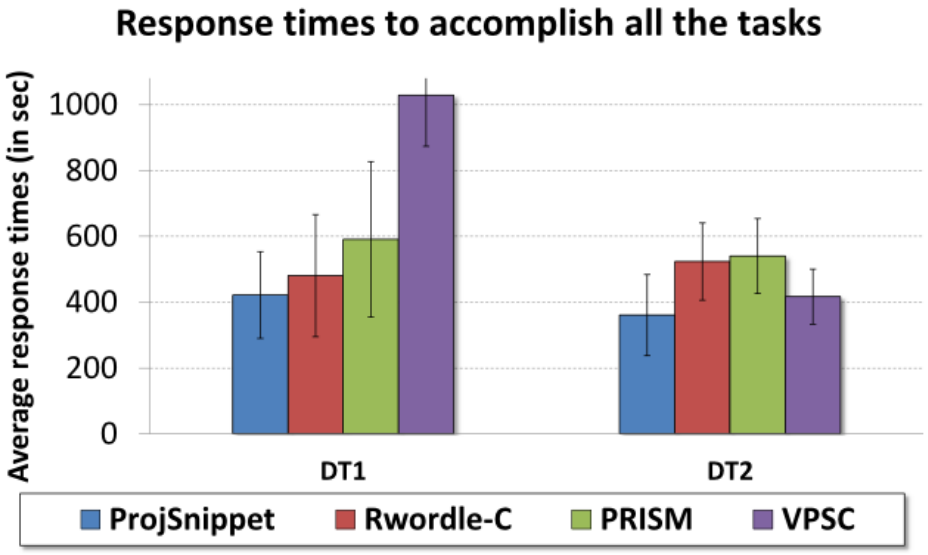








Conclusions Contributions

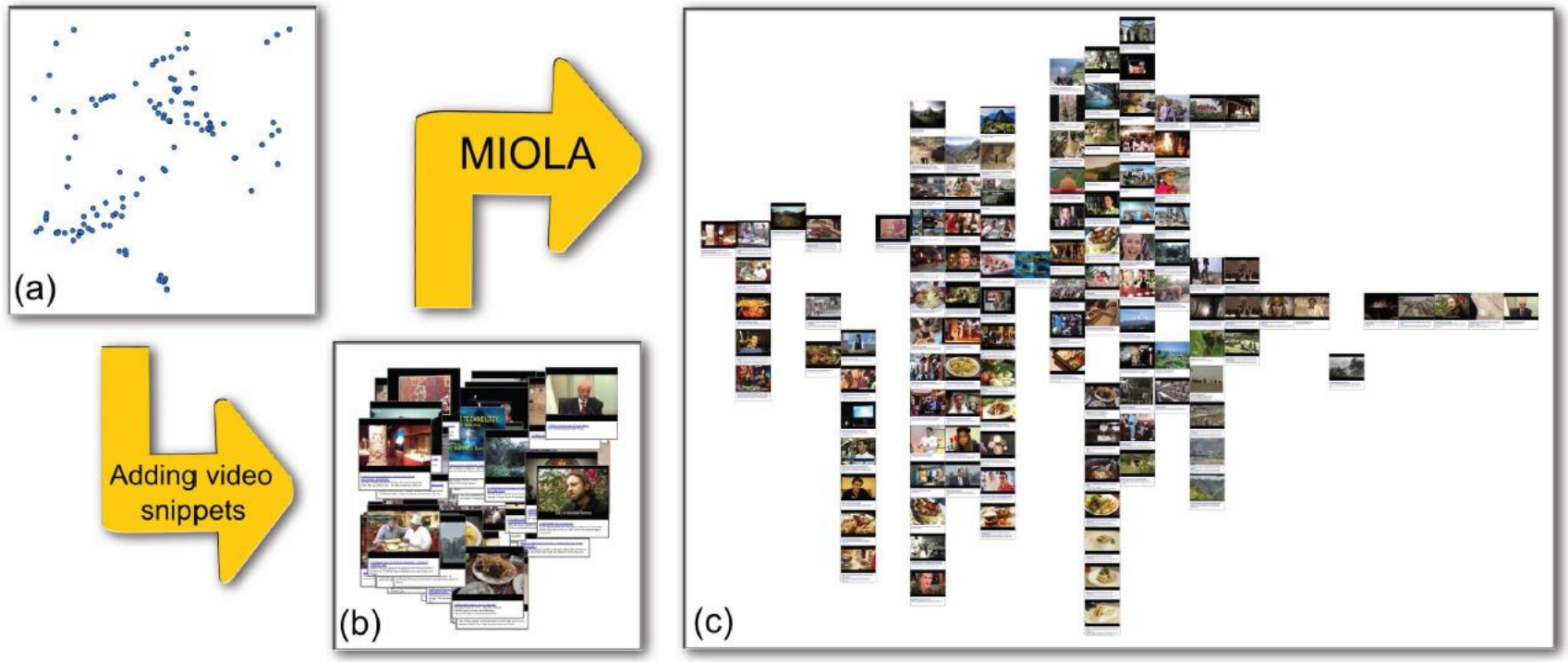
- Simple and intuitive visual metaphor for visualizing web search results.
- Novel optimization based technique for 2D layout arrangement.
- Overlap free and neighborhood preserving method.
- Outperforms most existing overlap free methods.
- Can be used in some other applications than web search results visualization.

Conclusions Limitations

- The visual layout of ProjSnippet can be affected by both the size of screen and the number of snippets exposed simultaneously.
- The preprocessing is quite satisfactory, but there are some outliers.
- Clustering in visual space will produce good results as long as the projection technique does a good job in preserving neighborhoods.

Mixed Integer Optimization for Layout Arrangement (MIOLA)

- Conference on Graphics, Patterns and Images (SIBGRAPI 2013)
- Best paper award in CG&Vis category



Contributions:

✓ A new mathematical formulation for the problem of arranging 2D rectangular boxes so as to place similar entities close while avoiding overlaps.

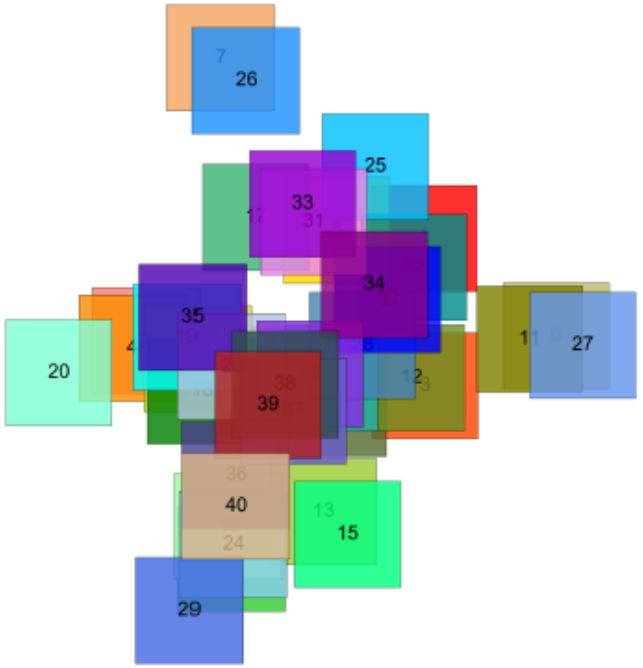
✓ MIOLA combines flexibility and capability in generating different layouts while still solving the overlap removal problem.

✓ An easy-to-implement tool for handling and exploring datasets in the context of visualization.

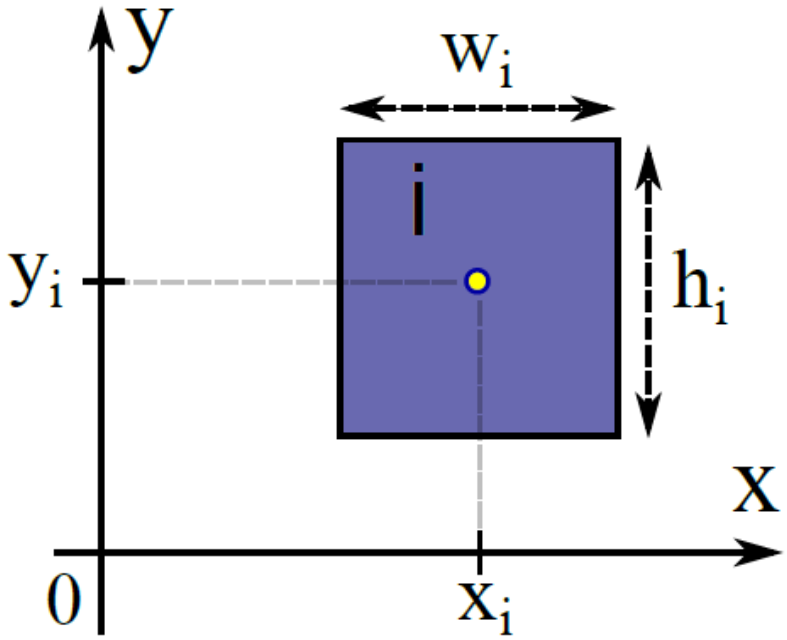
Problem statement

$B = \{B_1, B_2, ..., B_n\}$: set of boxes initially arranged in a 2D space.

- $B_i = (x_i, y_i, w_i, h_i)$, where (x_i, y_i) : **centroid**, $w_i > 0$: **width** and $h_i > 0$: **height** of B_i .



Example of a layout with overlaps.



Geometric representation of a box.

Problem statement

- Lower/upper bounds of visualization window:

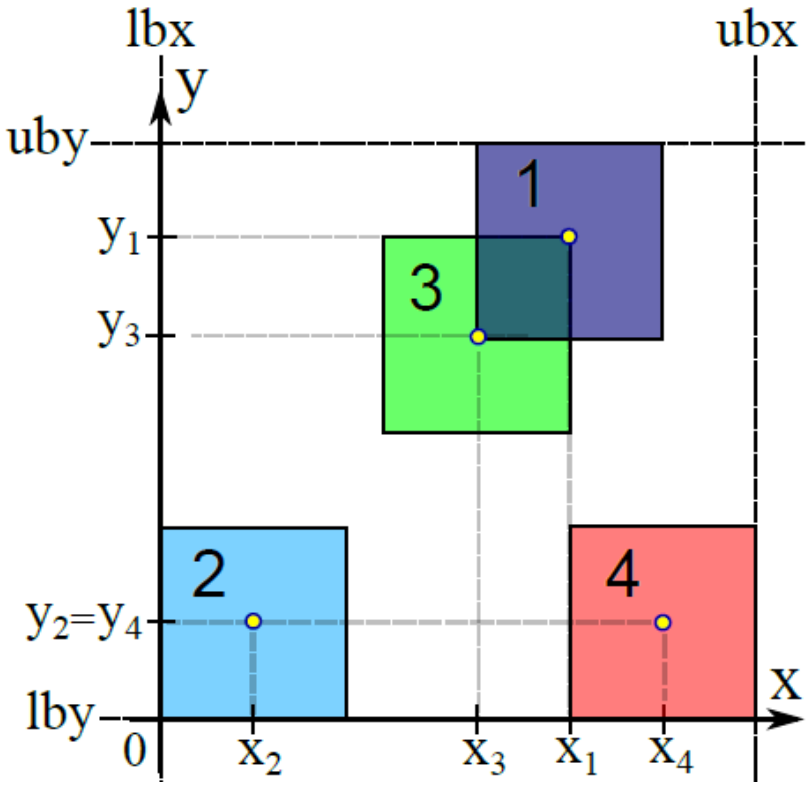
$$\frac{w_i}{2} + lbx \leq x_i \leq ubx - \frac{w_i}{2} \text{ and } \frac{h_i}{2} + lby \leq y_i \leq uby - \frac{h_i}{2}$$

- Two boxes B_i and B_j **do not overlap** if, and only if:

$$|x_j - x_i| \geq \frac{w_i + w_j}{2}$$

or

$$|y_j - y_i| \geq \frac{h_i + h_j}{2}$$

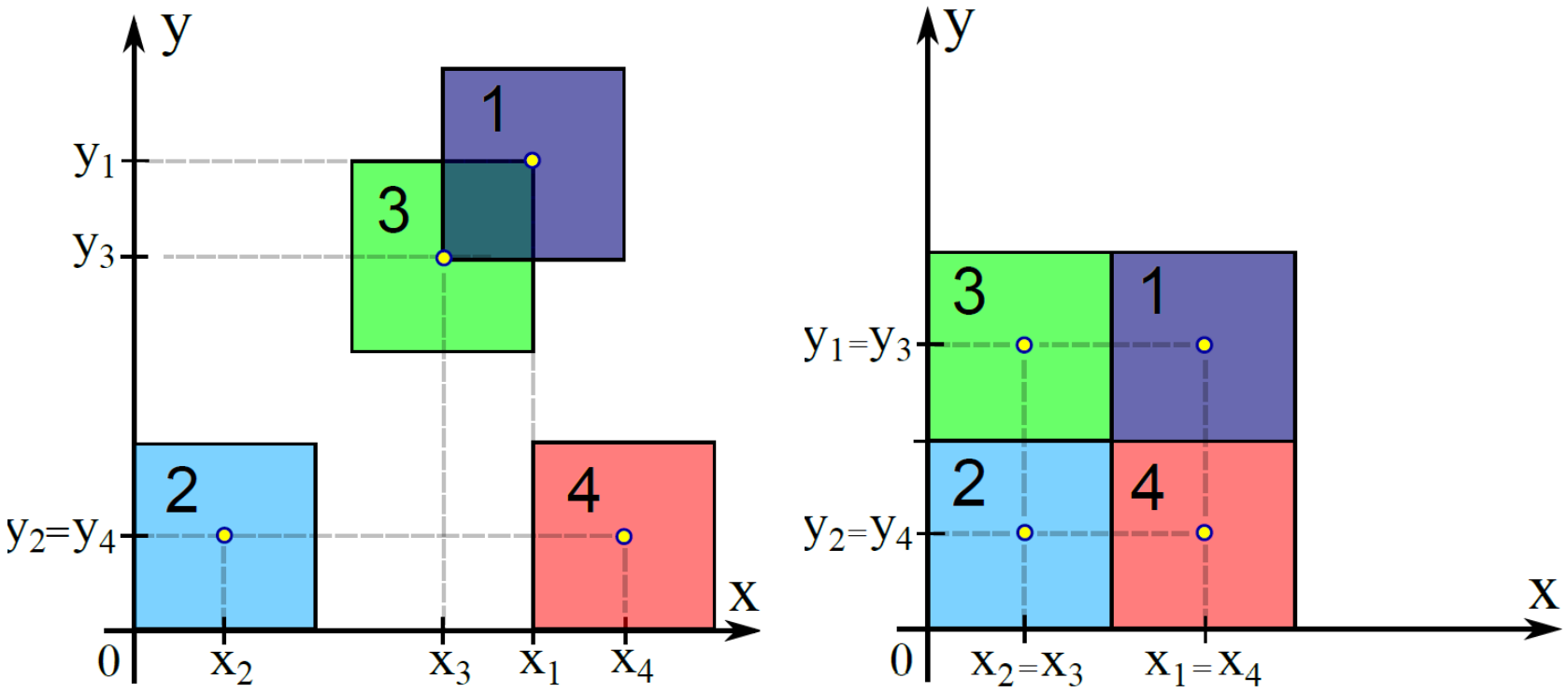


Set of four boxes within a given canvas.

Problem statement

- **Key point:** preservation of neighborhood structures through **preservation of relative order** of the boxes:

$$x_{p_1} \leq x_{p_2} \leq \ldots \leq x_{p_n} \ (x \ orthogonal \ order)$$
$$y_{q_1} \leq y_{q_2} \leq \ldots \leq y_{q_n} \ (y \ orthogonal \ order)$$
$$p, q : \{1, 2, \ldots, n\} \rightarrow \{1, 2, \ldots, n\} \ (\text{permutations of indices})$$



Input layout and orthogonal order preservation: $x_{pi} <= x_{pi+1}$, $p_1=2$, $p_2 = 3$, $p_3 = 1$, $p_4 = 4$ (similarity for y).

Mixed integer optimization formulation

Mixed-integer quadratic optimization problem:

$$\min_{z} \quad f(\mathbf{z}) = \frac{1}{2}\mathbf{z}^T Q\mathbf{z} = \sum_{i=1}^{n}\sum_{j=i+1}^{n} Dist^2(B_i, B_j)$$

$$\text{subject to} \quad \begin{cases} A\mathbf{z} \leq \mathbf{b} \\ \mathbf{lb} \leq \mathbf{z} \leq \mathbf{ub} \end{cases}$$

$$\mathbf{z} = \begin{bmatrix} \mathbf{x} \\ \mathbf{y} \\ \mathbf{r} \end{bmatrix}, \quad \begin{array}{l} \mathbf{x} = (x_1, x_2, ..., x_n)^\top \in \mathbf{R}^n \\ \mathbf{y} = (y_1, y_2, ..., y_n)^\top \in \mathbf{R}^n \end{array}$$

$$\mathbf{r} = (r_{12}, \ldots, r_{1n}, r_{23}, \ldots, r_{2n}, \ldots, r_{n-1n})^\top, \; r_{ij} \in \{0, 1\}$$

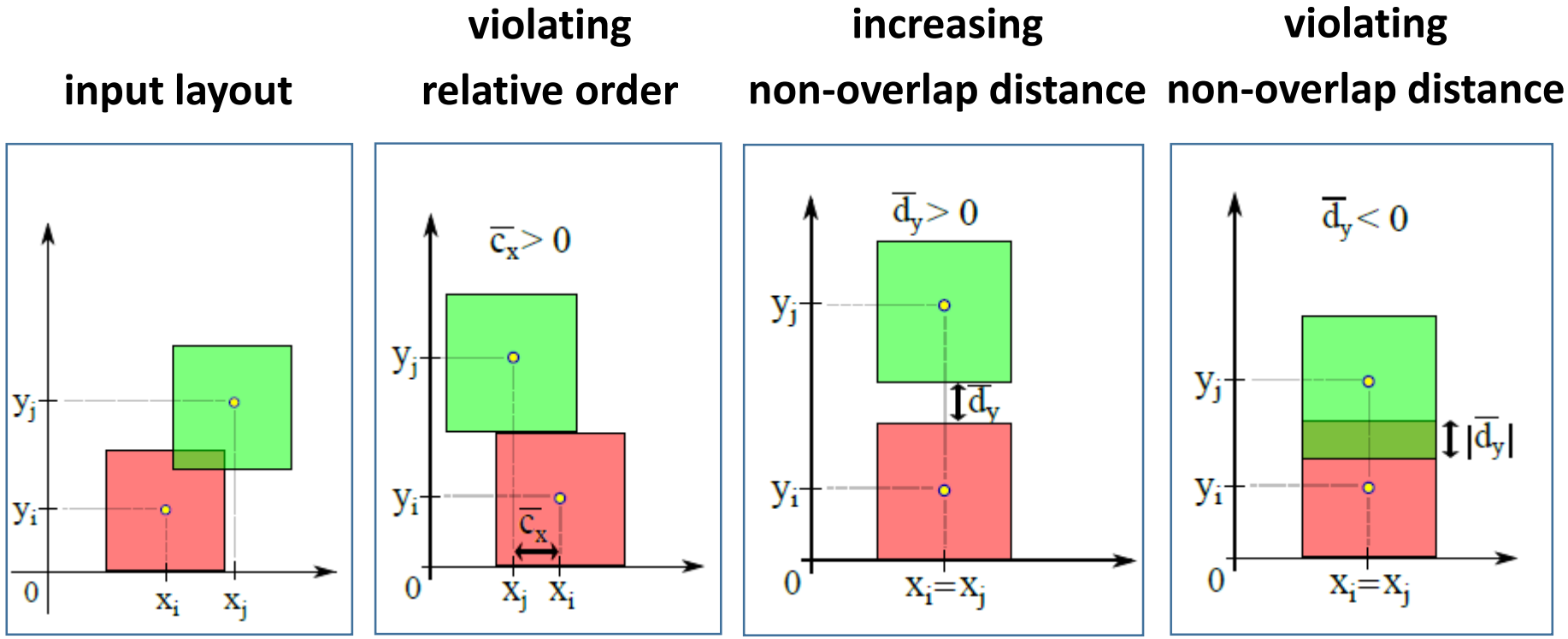
Dist(.): distance function
z: sought solution
lb and **ub:** window bounds
[A|b]: constraints

$$Q = \left(\begin{array}{c|c|c} \begin{bmatrix} L & 0 \\ 0 & L \end{bmatrix} & & 0 \\ \hline & & \\ 0 & & 0 \end{array} \right),$$

$$L = nI_d - ones(n, n)$$

Relaxation of constraints

MIOLA's constraint relaxation provides **flexibility, adaptability, clustering and easy-to-read layouts** just by simply adding constants into the constraints of the problem.

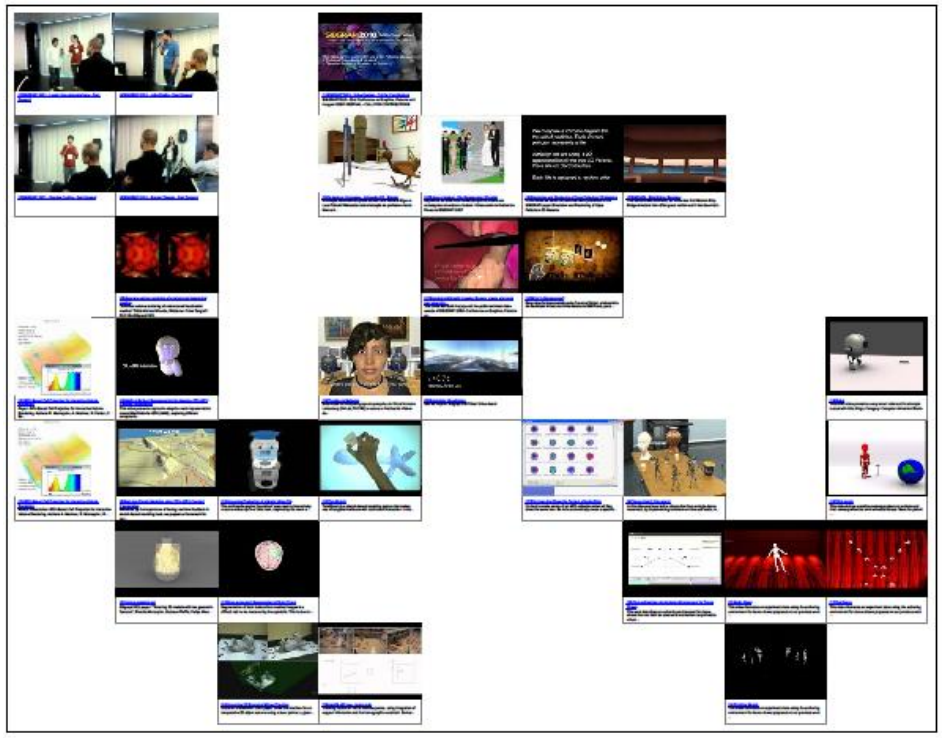


A variety of configuration can be obtained when relaxing MIOLA's constraints.

Visualization of video snippets

Result of MIOLA when applying on a content layout taken from Youtube's search engine (query = SIBGRAPI).

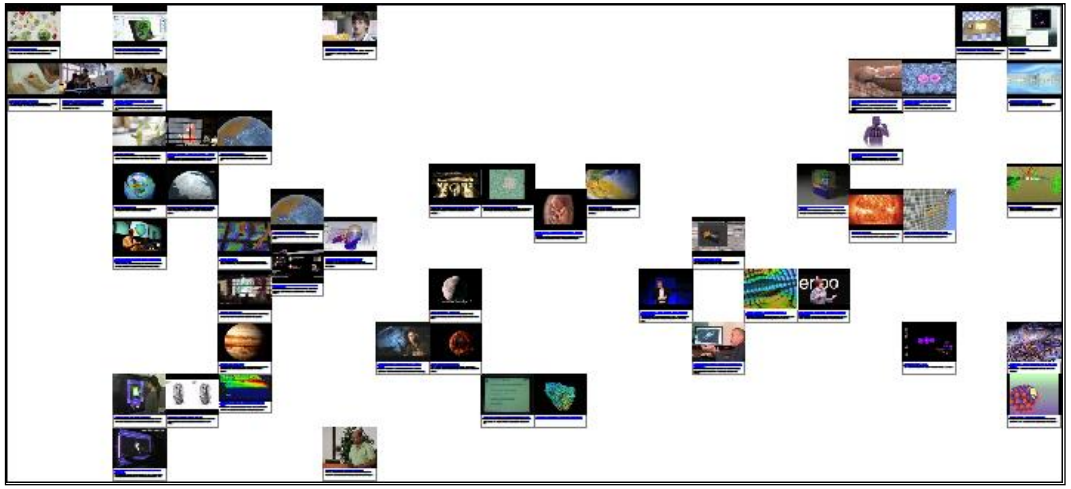
(a) Input layout



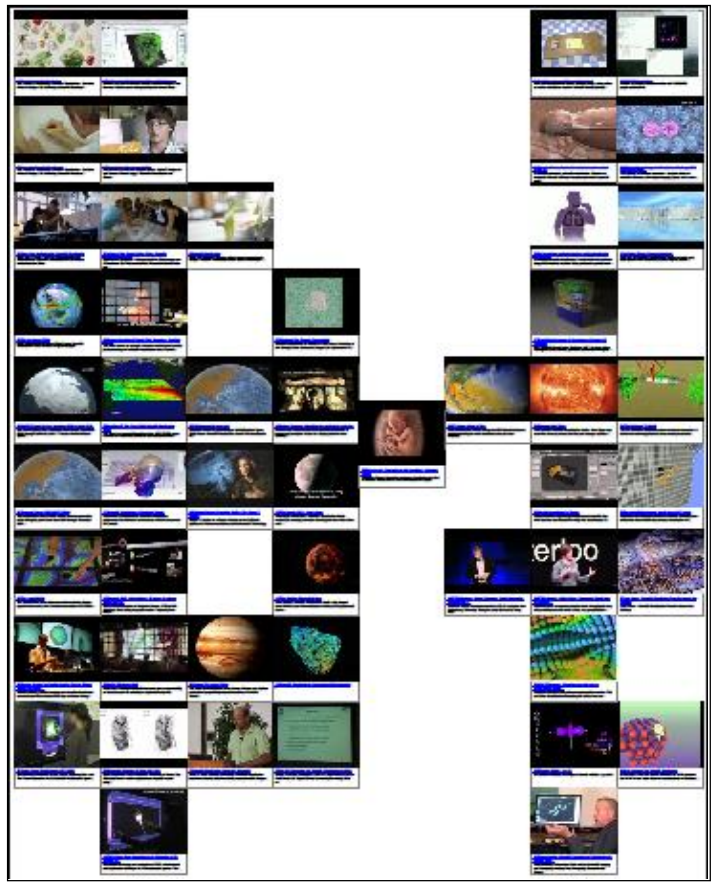
(b) Optimized layout after applying MIOLA without relaxation constants

Flexibility and adaptability

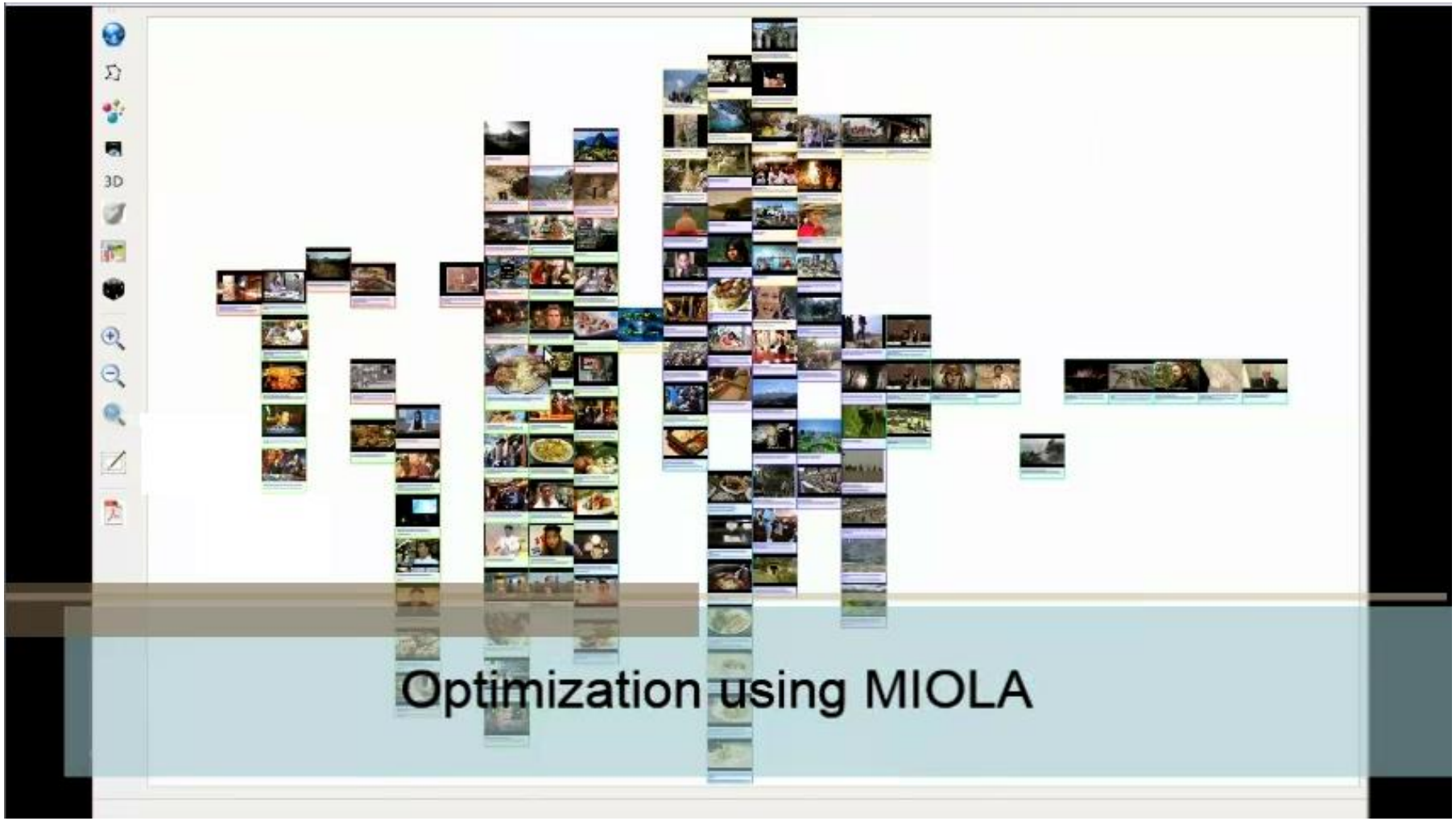
(a) Original layout



(b) Optimized layout without relaxation



(d) Optimized layout with moderate compactness and relative order relaxation



Available on YouTube

http://goo.gl/eK5yUl

MIOLA x existing methods

VPSC:

T. Dwyer, K. Marriott, and P. J. Stuckey, “Fast node overlap removal,” in Graph Drawing. Springer, pp. 153–164, 2006.

PRISM:

E. R. Gansner and Y. Hu, “Graph drawing,” ch. Efficient Node Overlap Removal Using a Proximity Stress Model, pp. 206–217, 2009.

Voronoi-based:

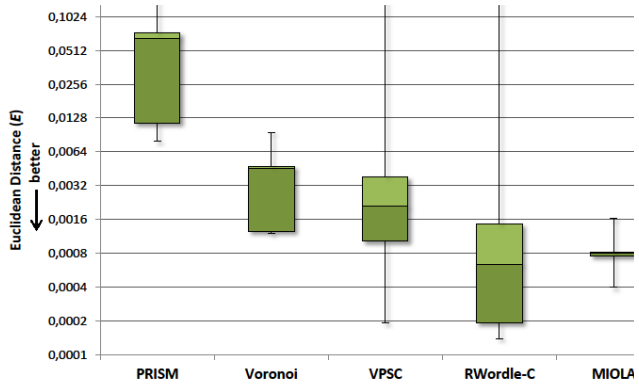
Q. Du, V. Faber, and M. Gunzburger, “Centroidal voronoi tessellations: Applications and algorithms,” SIAM Review, vol. 41, no. 4, p. 637, 1999.

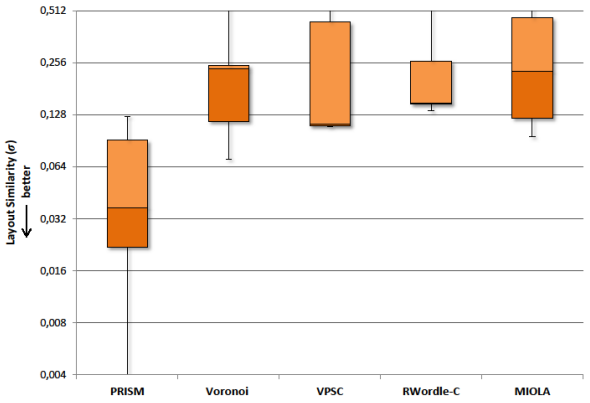
Rwordle-C:

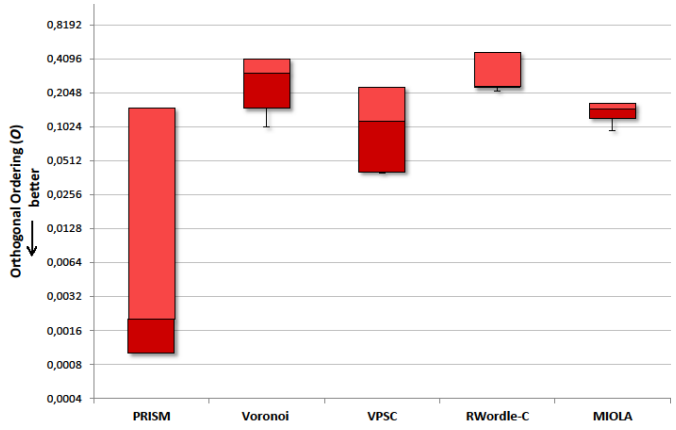
H. Strobelt, M. Spicker, A. Stoffel, D. Keim, and O. Deussen, “Rolledout wordles: A heuristic method for overlap removal of 2d data representatives,”in Computer Graphics Forum, vol. 31, pp. 1135–1144, 2012.

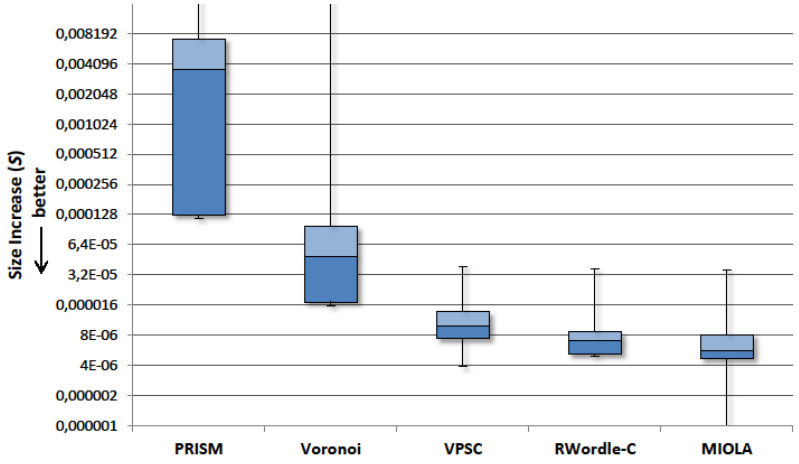
MIOLA x existing methods

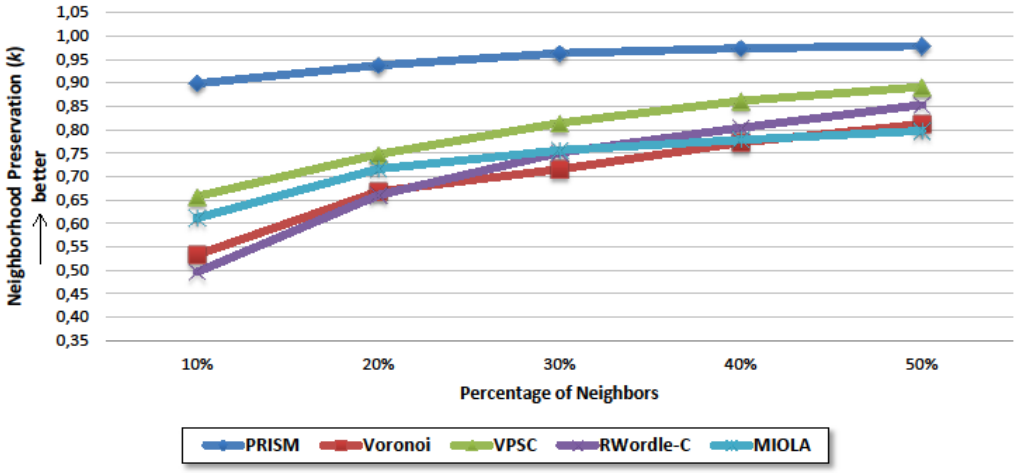
Quantitative comparison





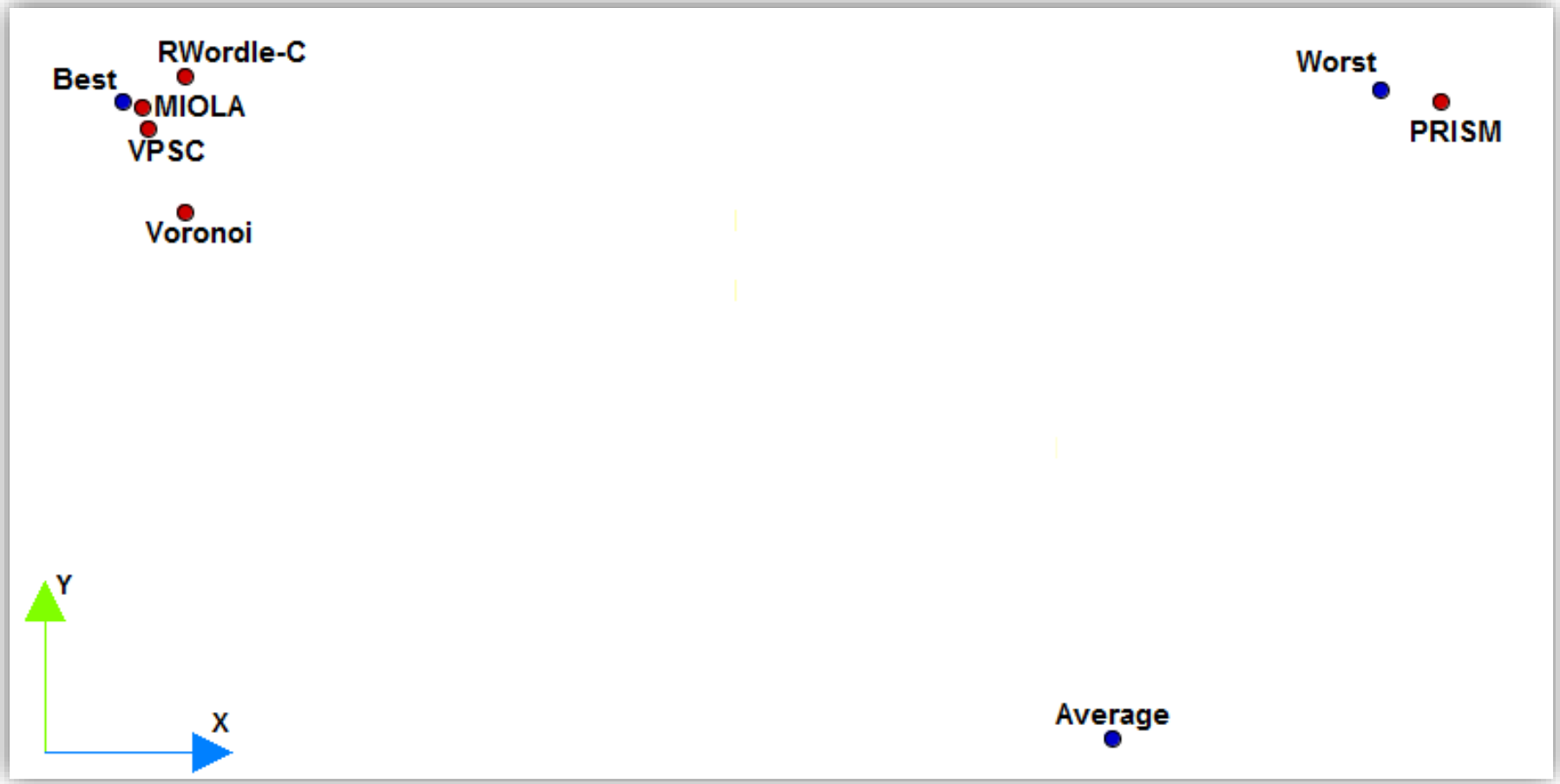






MIOLA x existing methods

[Joia:2011] P. Joia, D. Coimbra, J. Cuminato, F. Paulovich, and L. Nonato, "Local Affine Multidimensional Projection," IEEE TVCG, pp. 2563–2571, 2011.



Comparison of overlap removal techniques respecting the five metrics simultaneously using ***LAMP*** **[Joia:2011]**. Red points represent the evaluated techniques while the blue points show the worst, average and best points produced artificially taking into account the results of all techniques.

Dealing with Multiple Requirements in Geometric Arrangements

- IEEE Transactions on Visualization and Computer Graphics 2016
- Invited paper at IEEE Vis 2016 (InfoVis: Scalable Algorithms)

Contribution

Contribution

A novel methodology for building layouts from geometric primitives which is able to deal with a wide range of requirements simultaneously:

Contribution

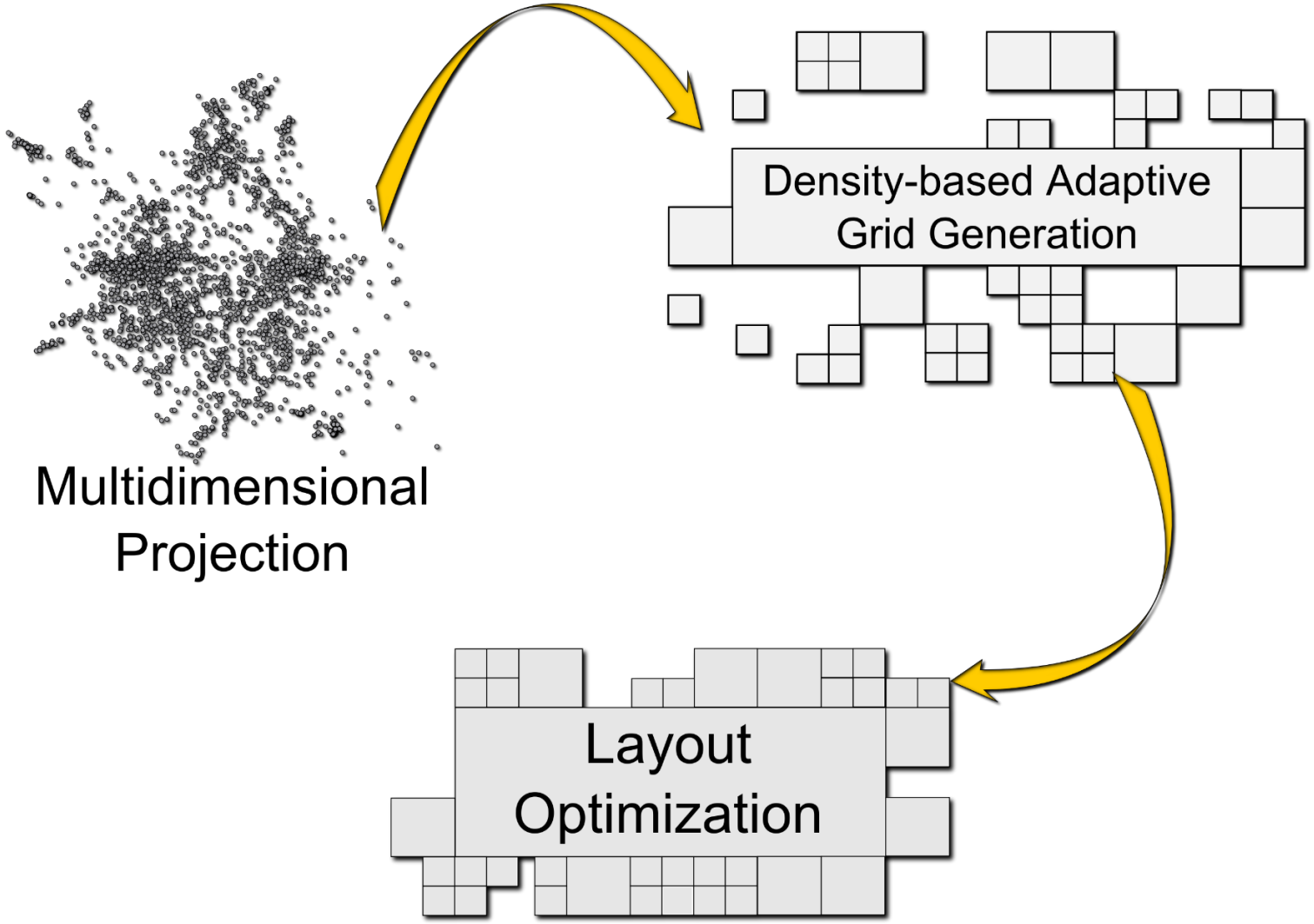
A novel methodology for building layouts from geometric primitives which is able to deal with a wide range of requirements simultaneously:

- Optimal use of display area
- Grid-like arrangement
- Semantic preserving
- Prevent overlaps
- Hierarchical
- Makes objects as large as possible

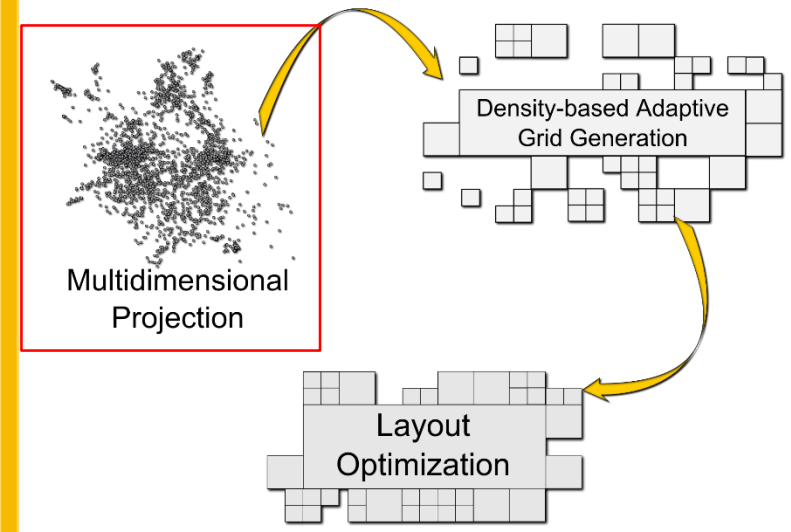
Contribution

The proposed method relies on a new optimization scheme that makes use of a reduced number of unknowns, thus rendering the layout optimization process computationally efficient.

The Proposed Approach

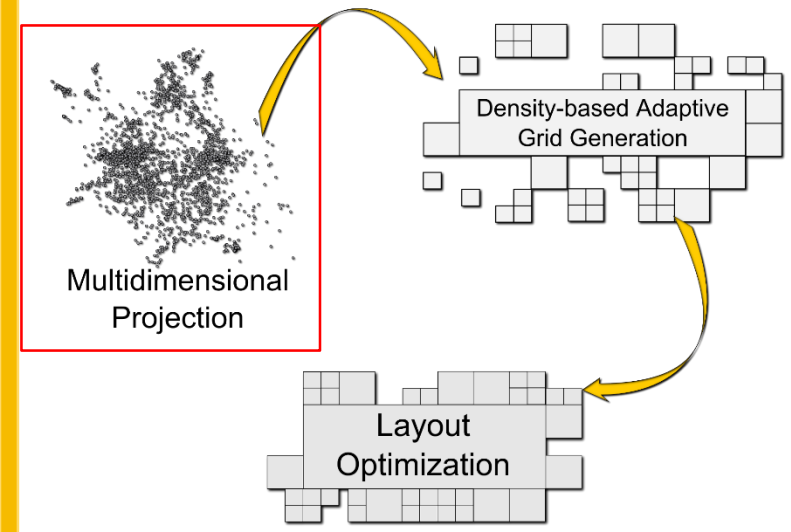


The Proposed Approach



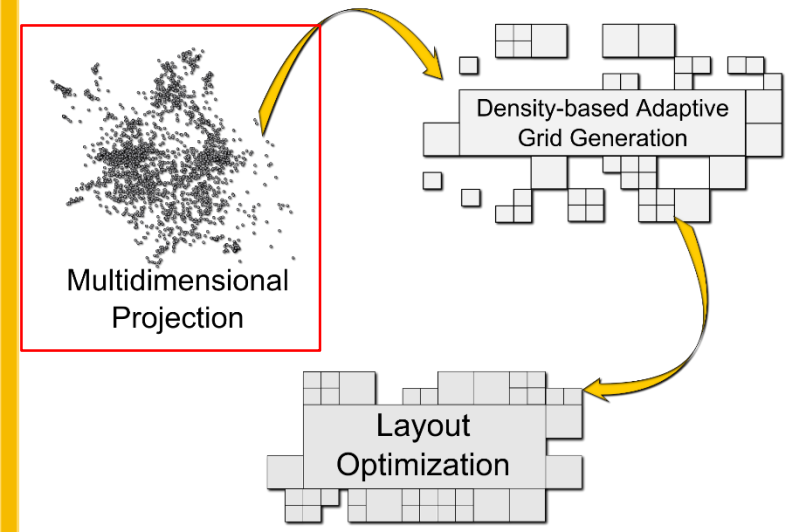
- Geometric objects are associate with multidimensional data

The Proposed Approach



- Geometric objects are associate with multidimensional data
- Least Square Projection – LSP [Paulovich et al. 2008]

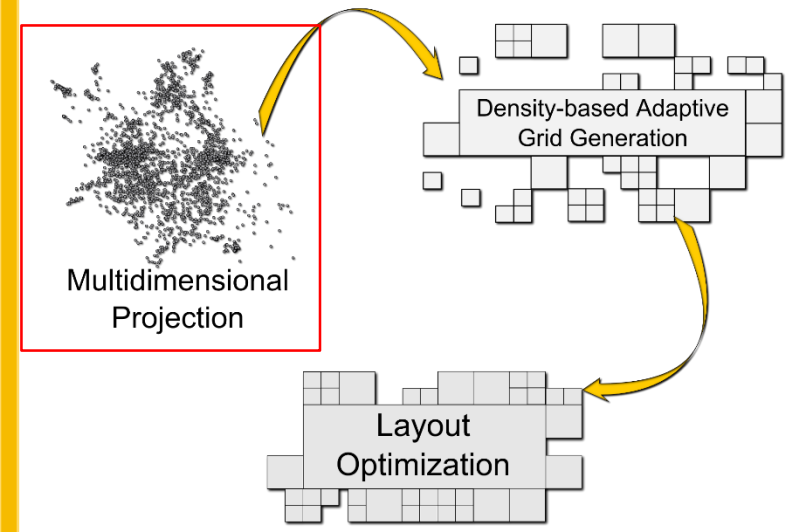
The Proposed Approach



- Geometric objects are associate with multidimensional data
- Least Square Projection – LSP [Paulovich et al. 2008]
- Defines neighborhoods in the visual space

  (semantic relation between objects)

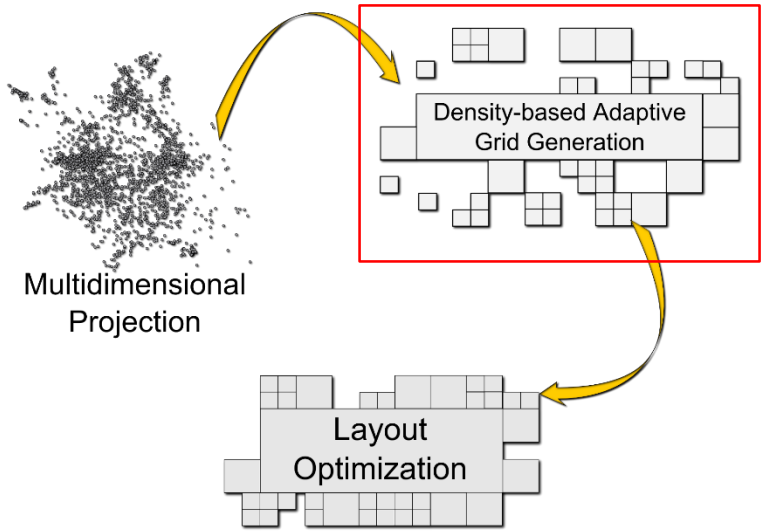
The Proposed Approach

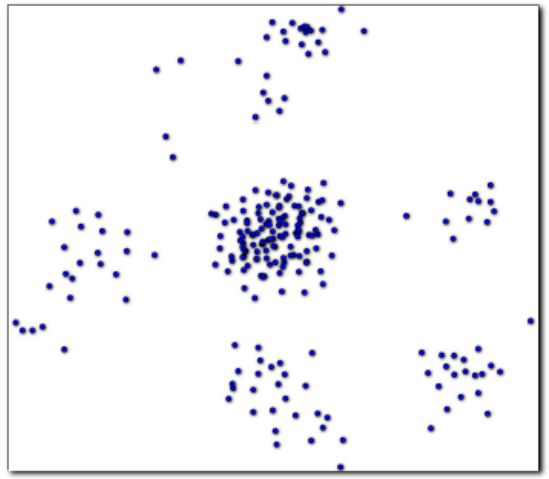


- Geometric objects are associate with multidimensional data
- Least Square Projection – LSP [Paulovich et al. 2008]
- Defines neighborhoods in the visual space

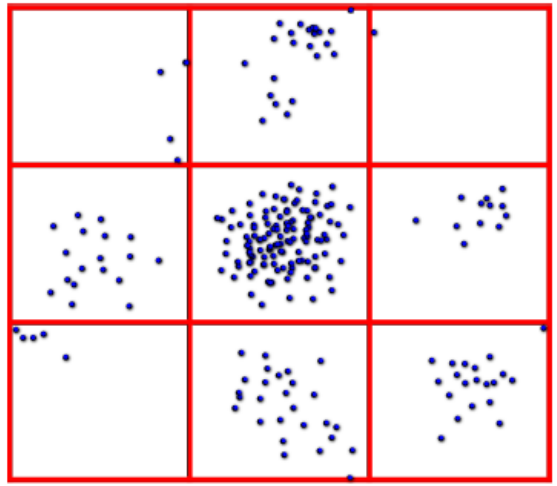
  (semantic relation between objects)
- Density used to steer the hierarchy construction

The Proposed Approach

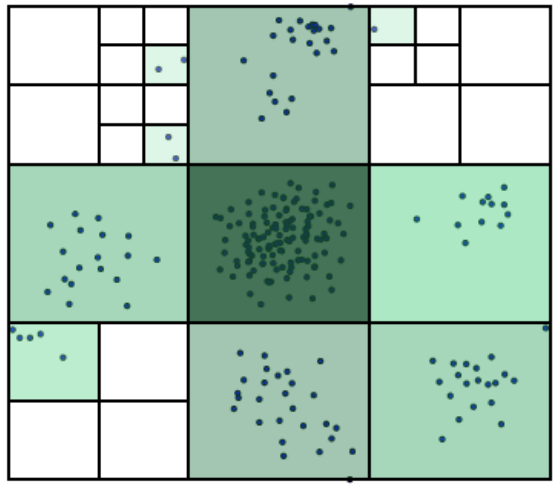




(a)



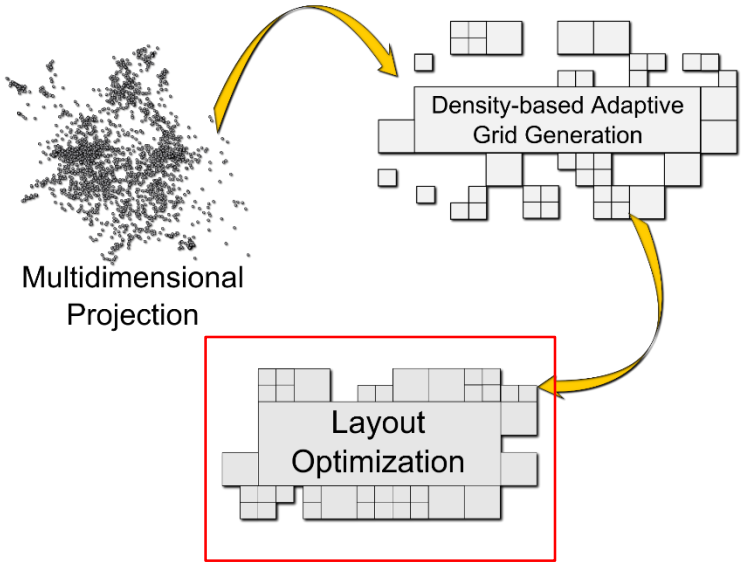
(b)

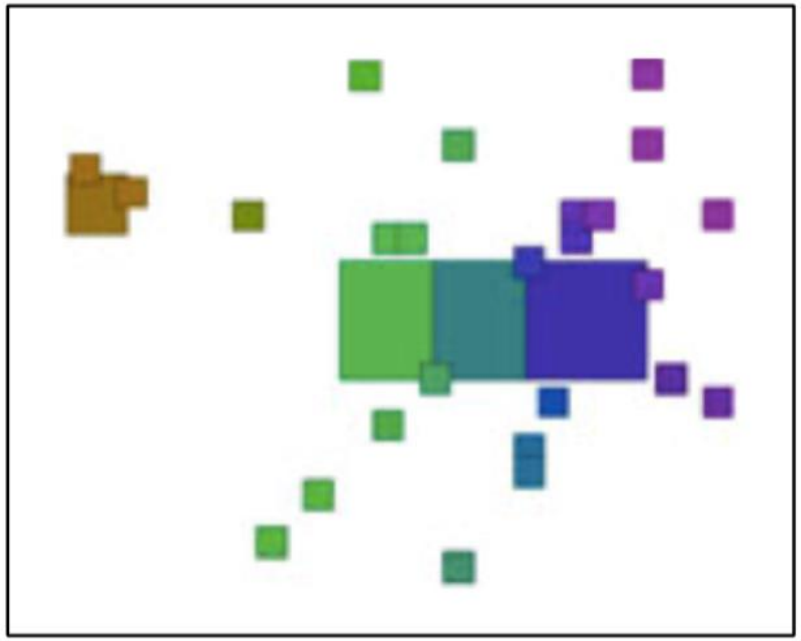


(c)

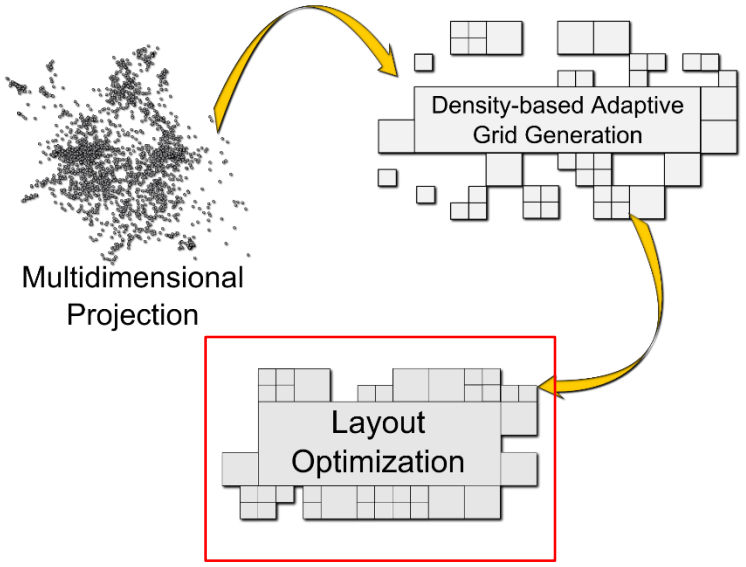
(d)

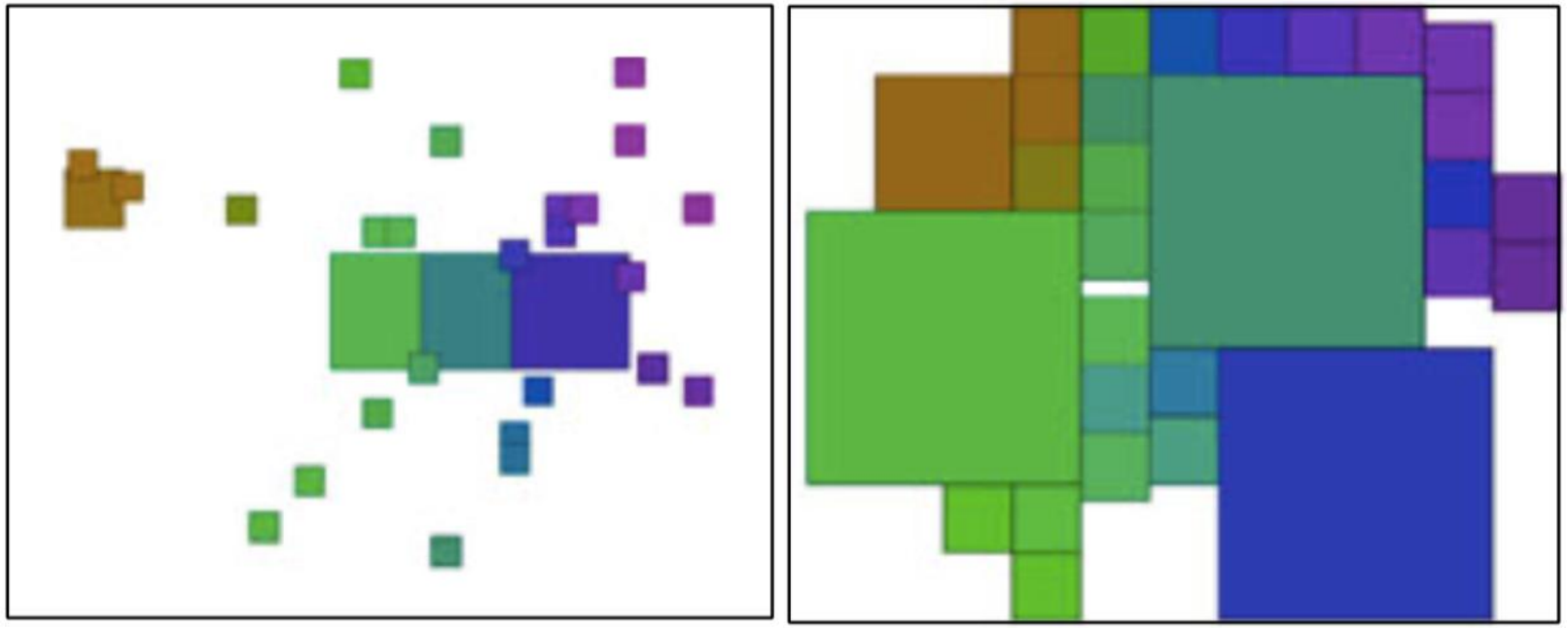
The Proposed Approach





The Proposed Approach





Optimization Model

$$\text{minimize} \quad E(\mathbf{z}) = E_{comp}(\mathbf{z}) + E_{rezise}(\mathbf{z}),$$

$$\text{subject to} \quad A\mathbf{z} \leq \mathbf{b}, \quad \mathbf{z} = [\mathbf{x} \ \mathbf{y} \ \mathbf{r} \ \delta]^{\top},$$

$$\mathbf{x} = (x_1, x_2, \ldots, x_N)^{\top} \in \mathbf{R}^N$$

$$\mathbf{y} = (y_1, y_2, \ldots, y_N)^{\top} \in \mathbf{R}^N$$

$$\mathbf{r} = (r_{12}, \ldots, r_{1N}, r_{23}, \ldots, r_{2N}, \ldots, r_{N-1N})^{\top}, r_{ij} \in \{0, 1\}$$

$$\delta_0 \leq \delta \leq \min(W, H),$$

Optimization Model

compactness

$$\text{minimize} \quad E(\mathbf{z}) = E_{comp}(\mathbf{z}) + E_{rezise}(\mathbf{z}),$$

$$\text{subject to} \quad A\mathbf{z} \le \mathbf{b}, \quad \mathbf{z} = [\mathbf{x}\ \mathbf{y}\ \mathbf{r}\ \delta]^\top,$$

$$\mathbf{x} = (x_1, x_2, \ldots, x_N)^\top \in \mathbf{R}^N$$

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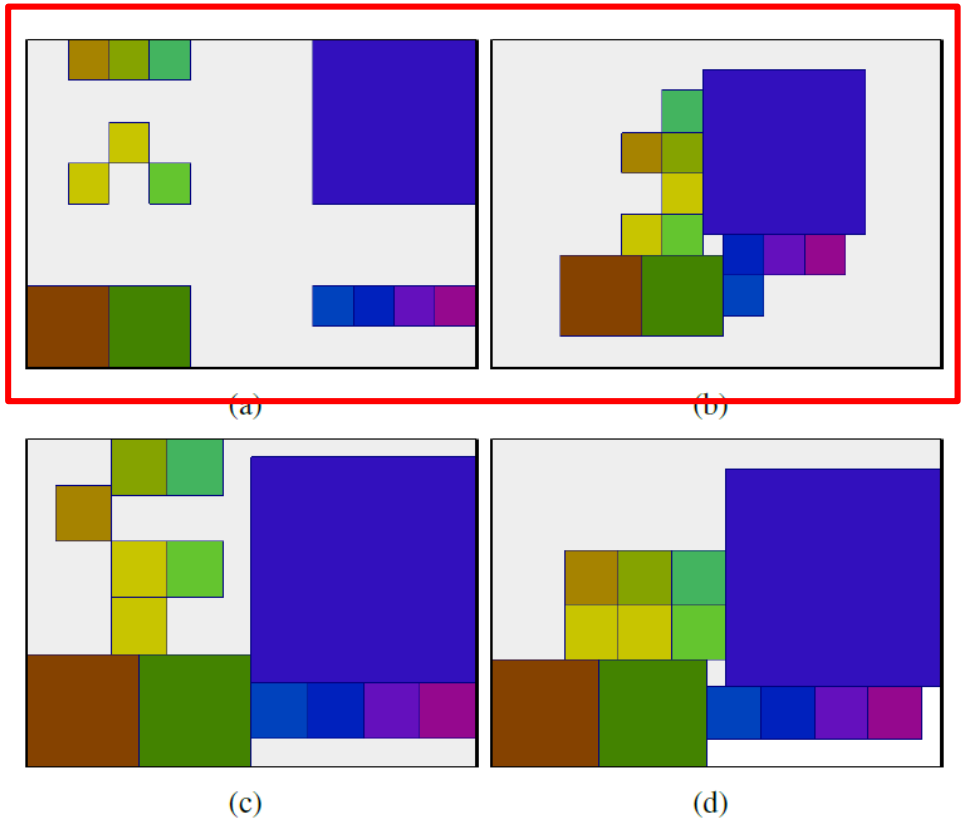
$$\delta_0 \le \delta \le \min(W, H),$$



Optimization Model

scaling

$$\text{minimize} \quad E(\mathbf{z}) = E_{comp}(\mathbf{z}) + E_{rezise}(\mathbf{z}),$$

$$\text{subject to} \quad A\mathbf{z} \leq \mathbf{b}, \quad \mathbf{z} = [\mathbf{x}\ \mathbf{y}\ \mathbf{r}\ \delta]^\top,$$

$$\mathbf{x} = (x_1, x_2, \ldots, x_N)^\top \in \mathbf{R}^N$$

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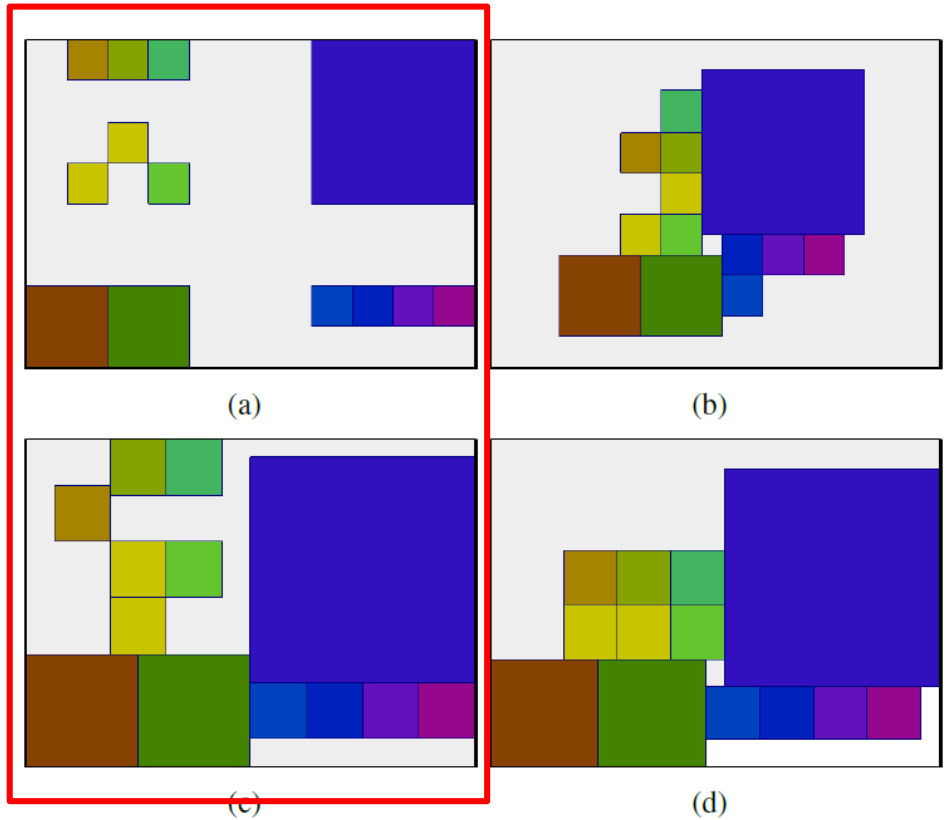
$$\mathbf{r} = (r_{12}, \ldots, r_{1N}, r_{23}, \ldots, r_{2N}, \ldots, r_{N-1N})^\top, r_{ij} \in \{0, 1\}$$

$$\delta_0 \leq \delta \leq \min(W, H),$$



Optimization Model

$$\text{minimize} \quad E(\mathbf{z}) = E_{comp}(\mathbf{z}) + E_{rezise}(\mathbf{z}),$$

$$\text{subject to} \quad A\mathbf{z} \le \mathbf{b}, \quad \mathbf{z} = [\mathbf{x}\ \mathbf{y}\ \mathbf{r}\ \delta]^\top,$$

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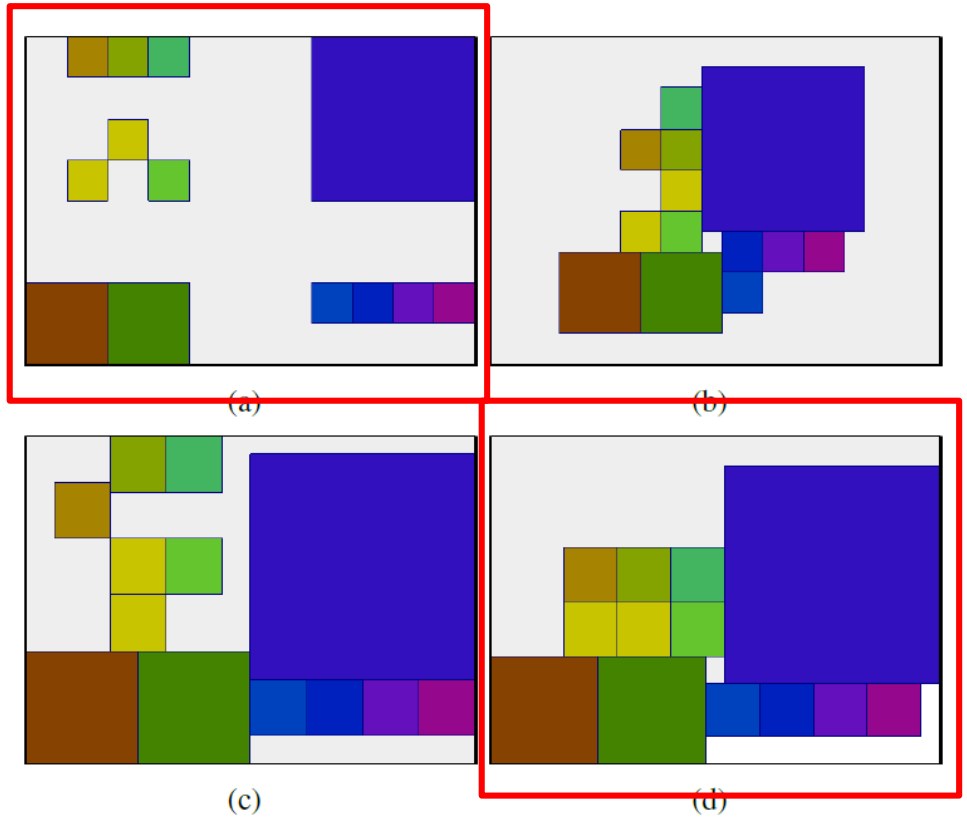

Optimization Model

center of the objects

$$\text{minimize} \quad E(\mathbf{z}) = E_{comp}(\mathbf{z}) + E_{rezise}(\mathbf{z}),$$

$$\text{subject to} \quad A\mathbf{z} \leq \mathbf{b}, \quad \mathbf{z} = [\mathbf{x} \ \mathbf{y} \ \mathbf{r} \ \delta]^\top,$$

$$\mathbf{x} = (x_1, x_2, \ldots, x_N)^\top \in \mathbf{R}^N$$

$$\mathbf{y} = (y_1, y_2, \ldots, y_N)^\top \in \mathbf{R}^N$$

$$\mathbf{r} = (r_{12}, \ldots, r_{1N}, r_{23}, \ldots, r_{2N}, \ldots, r_{N-1N})^\top, r_{ij} \in \{0, 1\}$$

$$\delta_0 \leq \delta \leq \min(W, H),$$

Optimization Model

$$\text{minimize} \quad E(\mathbf{z}) = E_{comp}(\mathbf{z}) + E_{rezise}(\mathbf{z}),$$

$$\text{subject to} \quad A\mathbf{z} \leq \mathbf{b}, \quad \mathbf{z} = [\mathbf{x}\ \mathbf{y}\ \mathbf{r}\ \delta]^\top,$$

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$$\delta_0 \leq \delta \leq \min(W, H),$$

Overlaps

Optimization Model

scaling factor

$$\text{minimize} \quad E(\mathbf{z}) = E_{comp}(\mathbf{z}) + E_{rezise}(\mathbf{z}),$$

$$\text{subject to} \quad A\mathbf{z} \le \mathbf{b}, \quad \mathbf{z} = [\mathbf{x}\ \mathbf{y}\ \mathbf{r}\ \delta]^\top,$$

$$\mathbf{x} = (x_1, x_2, \ldots, x_N)^\top \in \mathbf{R}^N$$

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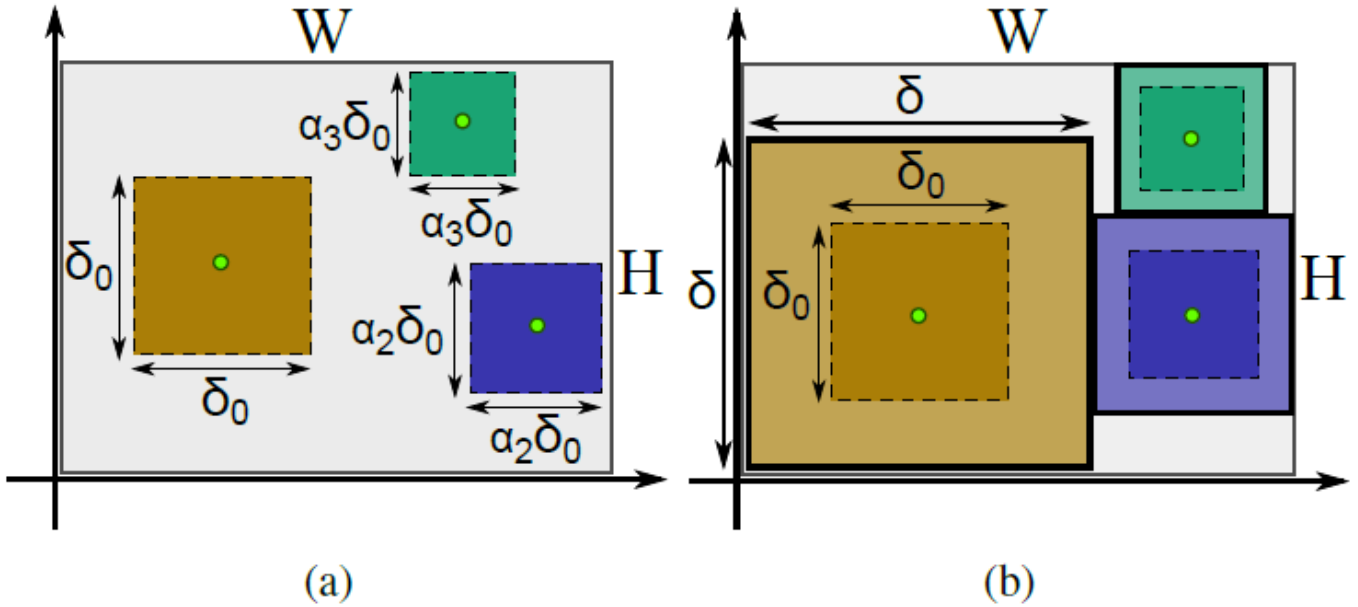
$$\delta_0 \le \delta \le \min(W, H),$$



Optimization Model

Compactness Energy Term

$$E_{comp}(\mathbf{z}) = C \sum_{(i,j)} (x_i - x_j)^2 + (y_i - y_j)^2,$$

Makes objects as close as possible

Area Usage Energy Term

$$E_{resize}(\mathbf{z}) = (\delta - \min(W, H))^2,$$

Makes objects as close as large as possible

Optimization Model

Compactness Energy Term

$$E_{comp}(\mathbf{z}) = C \sum_{(i,j)} (x_i - x_j)^2 + (y_i - y_j)^2,$$

Makes objects as close as possible

Area Usage Energy Term

$$E_{resize}(\mathbf{z}) = (\delta - \min(W, H))^2,$$

Makes objects as close as large as possible

Constraints do the trick to avoid overlaps and ensure ortogonality

Optimization Model

Constraints

$$\text{minimize} \quad E(\mathbf{z}) = E_{comp}(\mathbf{z}) + E_{rezise}(\mathbf{z}),$$

$$\text{subject to} \quad A\mathbf{z} \leq \mathbf{b}, \quad \mathbf{z} = [\mathbf{x}\ \mathbf{y}\ \mathbf{r}\ \delta]^\top,$$

$$\mathbf{x} = (x_1, x_2, \ldots, x_N)^\top \in \mathbf{R}^N$$

$$\mathbf{y} = (y_1, y_2, \ldots, y_N)^\top \in \mathbf{R}^N$$

$$\mathbf{r} = (r_{12}, \ldots, r_{1N}, r_{23}, \ldots, r_{2N}, \ldots, r_{N-1N})^\top, r_{ij} \in \{0, 1\}$$

$$\delta_0 \leq \delta \leq \min(W, H),$$

Optimization Model (constraints)

From the original order of the objects we generate a system inequalities:

$$x_1 \leq x_2 \leq \cdots \leq x_n \Rightarrow x_i - x_j \leq 0, \ \forall \ i < j$$

$$y_1 \leq y_2 \leq \cdots \leq y_n \Rightarrow y_i - y_j \leq 0, \ \forall \ i < j$$

Optimization Model (constraints)

From the original order of the objects we generate a system inequalities:

$$x_1 \leq x_2 \leq \cdots \leq x_n \Rightarrow x_i - x_j \leq 0, \ \forall\, i < j$$

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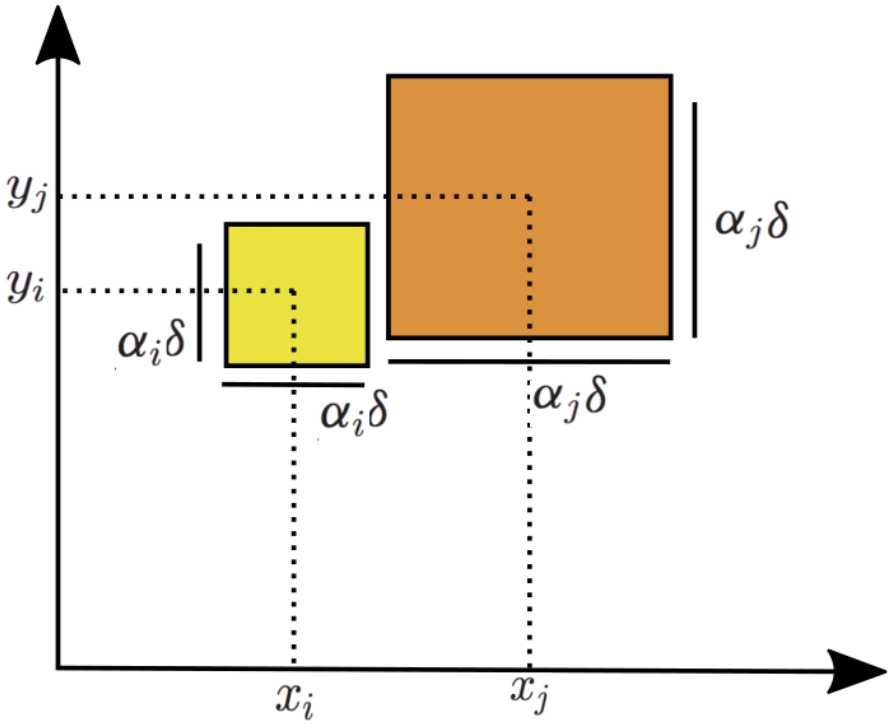


To prevent overlaps we modify the right side as:

$$x_i - x_j \leq -\frac{(\alpha_i + \alpha_j)}{2}\delta,$$

or

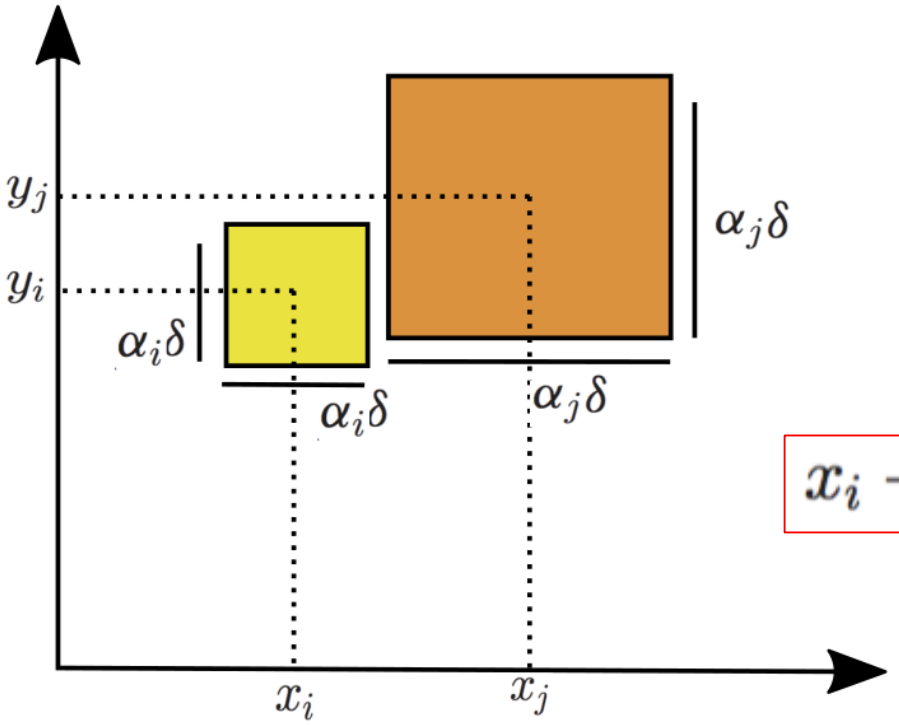
$$y_i - y_j \leq -\frac{(\alpha_i + \alpha_j)}{2}\delta,$$

Optimization Model (constraints)

From the original order of the objects we generate a system inequalities:

$$x_1 \leq x_2 \leq \cdots \leq x_n \Rightarrow x_i - x_j \leq 0,\ \forall\ i < j$$

$$y_1 \leq y_2 \leq \cdots \leq y_n \Rightarrow y_i - y_j \leq 0,\ \forall\ i < j$$



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or

$$y_i - y_j \leq -\frac{(\alpha_i + \alpha_j)}{2}\delta,$$

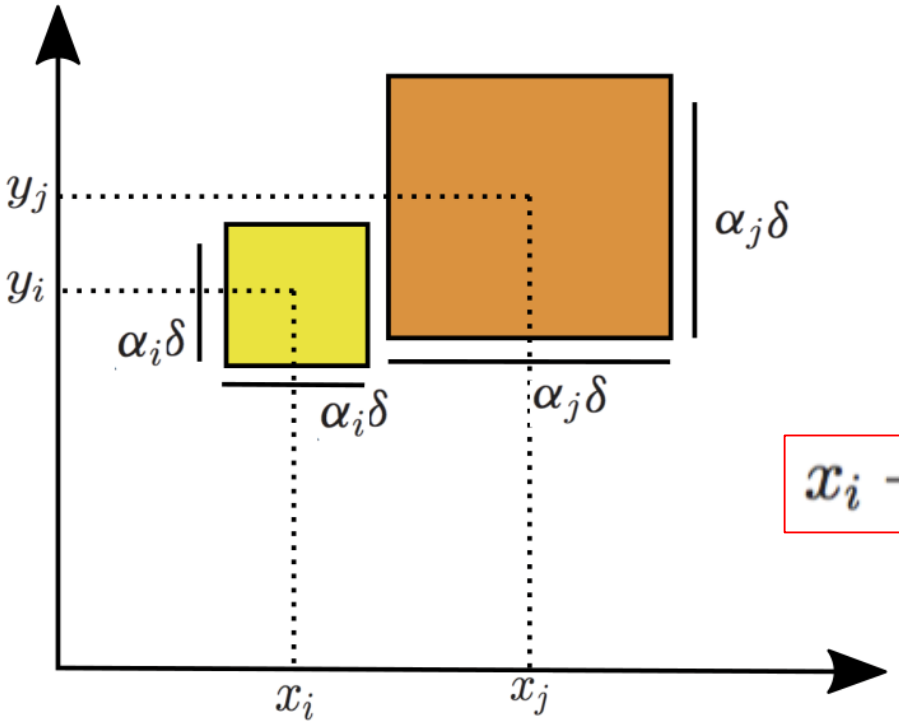
$$x_i - x_j \leq \alpha_{ij}\delta + Mr_{ij} \Leftrightarrow y_i - y_j \leq \alpha_{ij}\delta + M(1 - r_{ij}),$$

Optimization Model (constraints)

From the original order of the objects we generate a system inequalities:

$$x_1 \leq x_2 \leq \cdots \leq x_n \Rightarrow x_i - x_j \leq 0,\ \forall\ i < j$$

$$y_1 \leq y_2 \leq \cdots \leq y_n \Rightarrow y_i - y_j \leq 0,\ \forall\ i < j$$



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$$y_i - y_j \leq -\frac{(\alpha_i + \alpha_j)}{2}\delta,$$

$$x_i - x_j \leq \alpha_{ij}\delta + Mr_{ij} \Leftrightarrow y_i - y_j \leq \alpha_{ij}\delta + M(1 - r_{ij}),$$

$$\mathbf{Az \leq b}$$

Optimization Model (computational aspects)

- The formulation is a **Mixed Integer Quadratic Programming (MIQP) Problem**

- We use ***Gurobi Optimization Package*** ***(http://www.gurobi.com)***.

Results and Comparisons

Comparisons (metrics and data sets)

4 metrics:

- ✓ Orthogonal Ordering (O)
- ✓ Neighborhood Preservation (K)
- ✓ Area Usage (A)
- ✓ Orthogonal Alignment (L)

5 Overlap-free methods

- ✓ RWordle
- ✓ PRISM
- ✓ VPSC
- ✓ MIOLA
- ✓ ProjSnippet

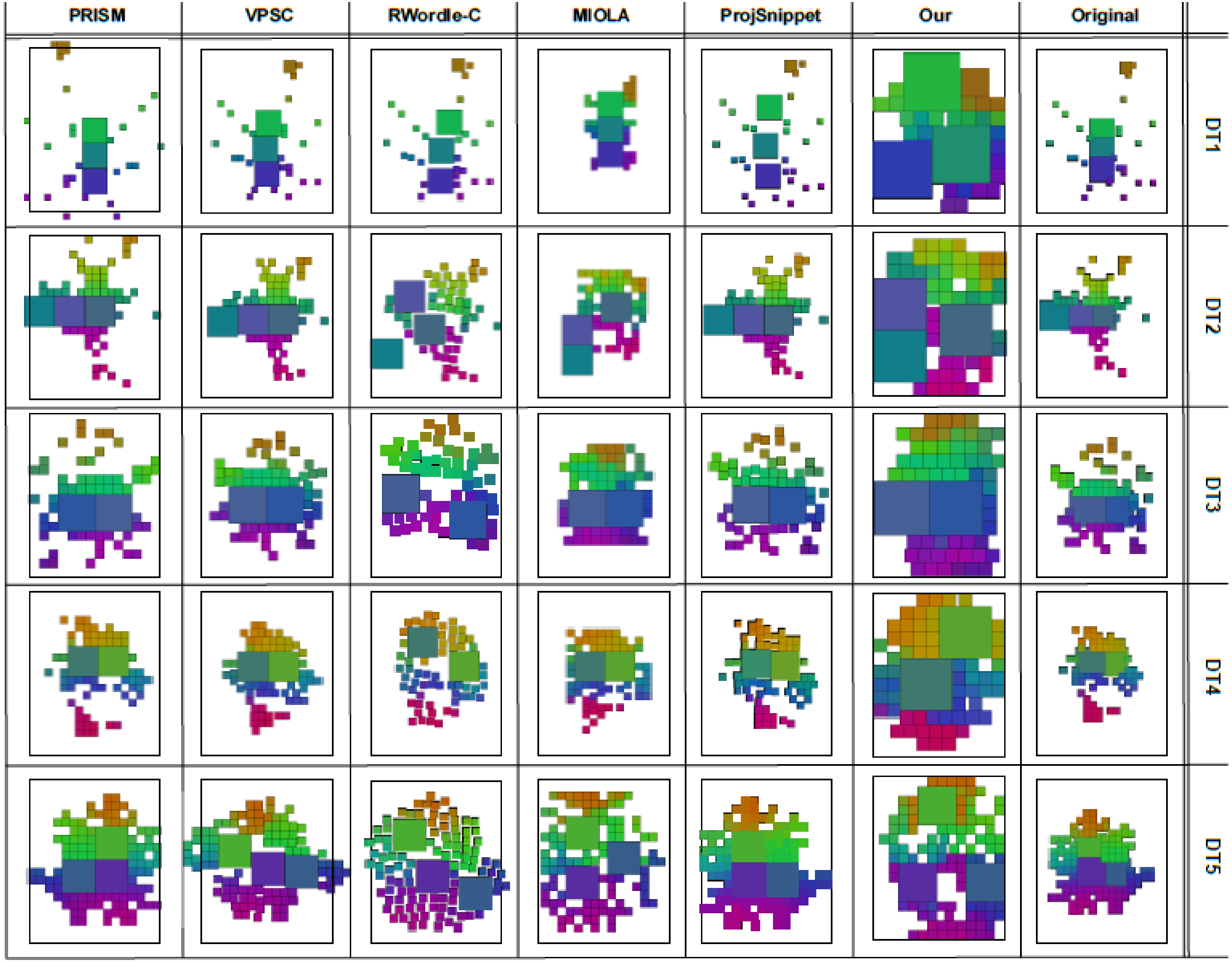
3 Board-based methods

- ✓ IncBoard
- ✓ SSM
- ✓ IsoMatch

Data sets

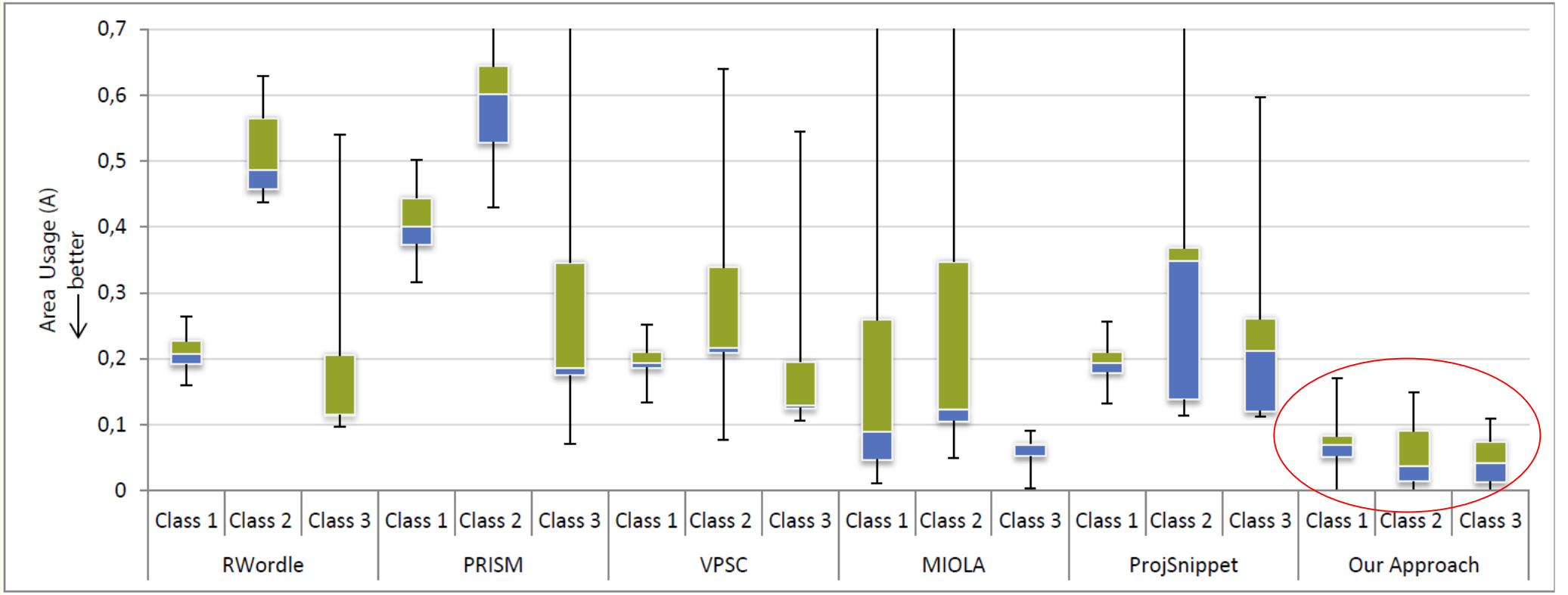
- ✓ Random
- ✓ Real

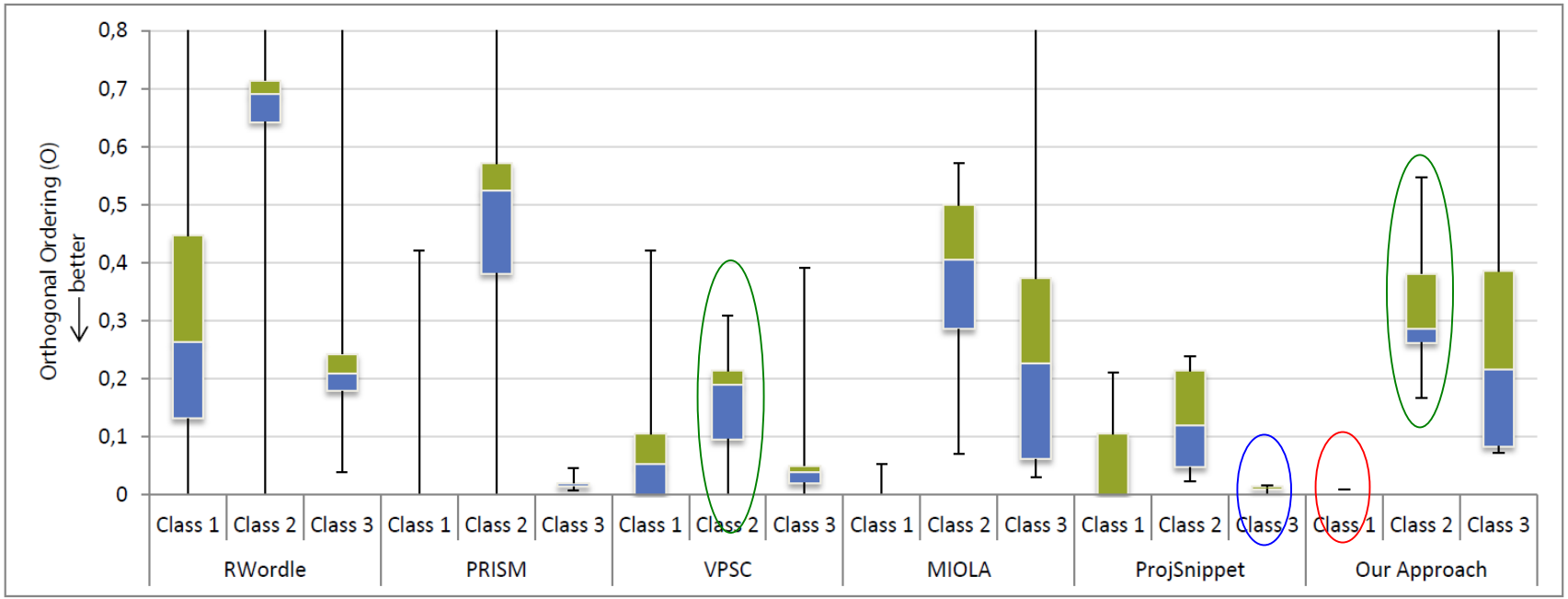
Qualitative comparison



Qualitative comparison

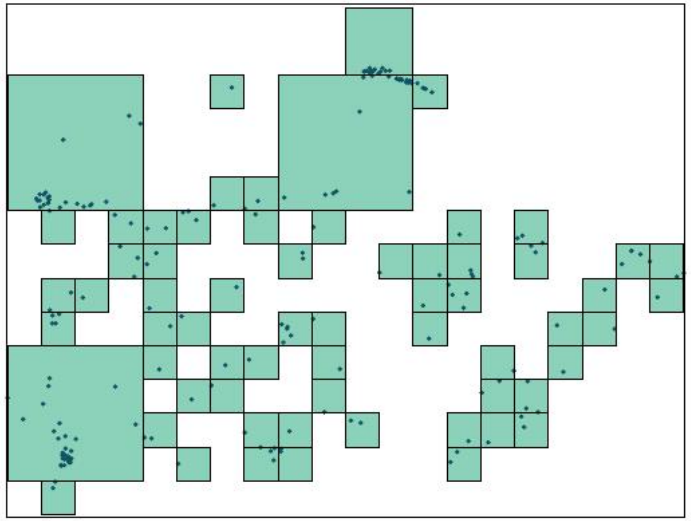
Quantitative Comparison



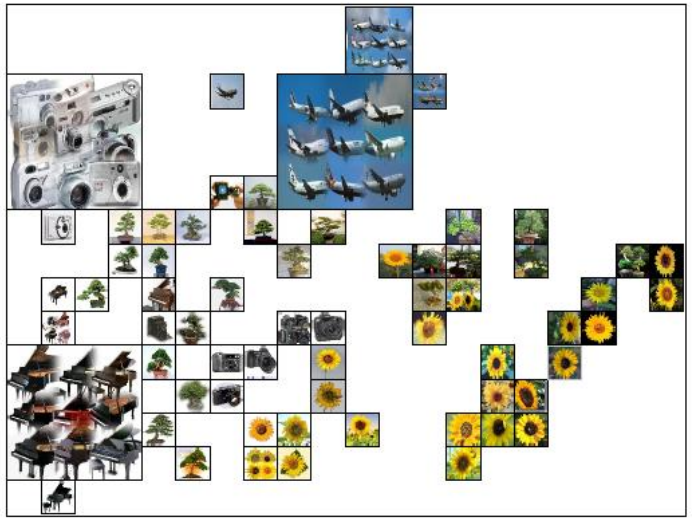


Applications

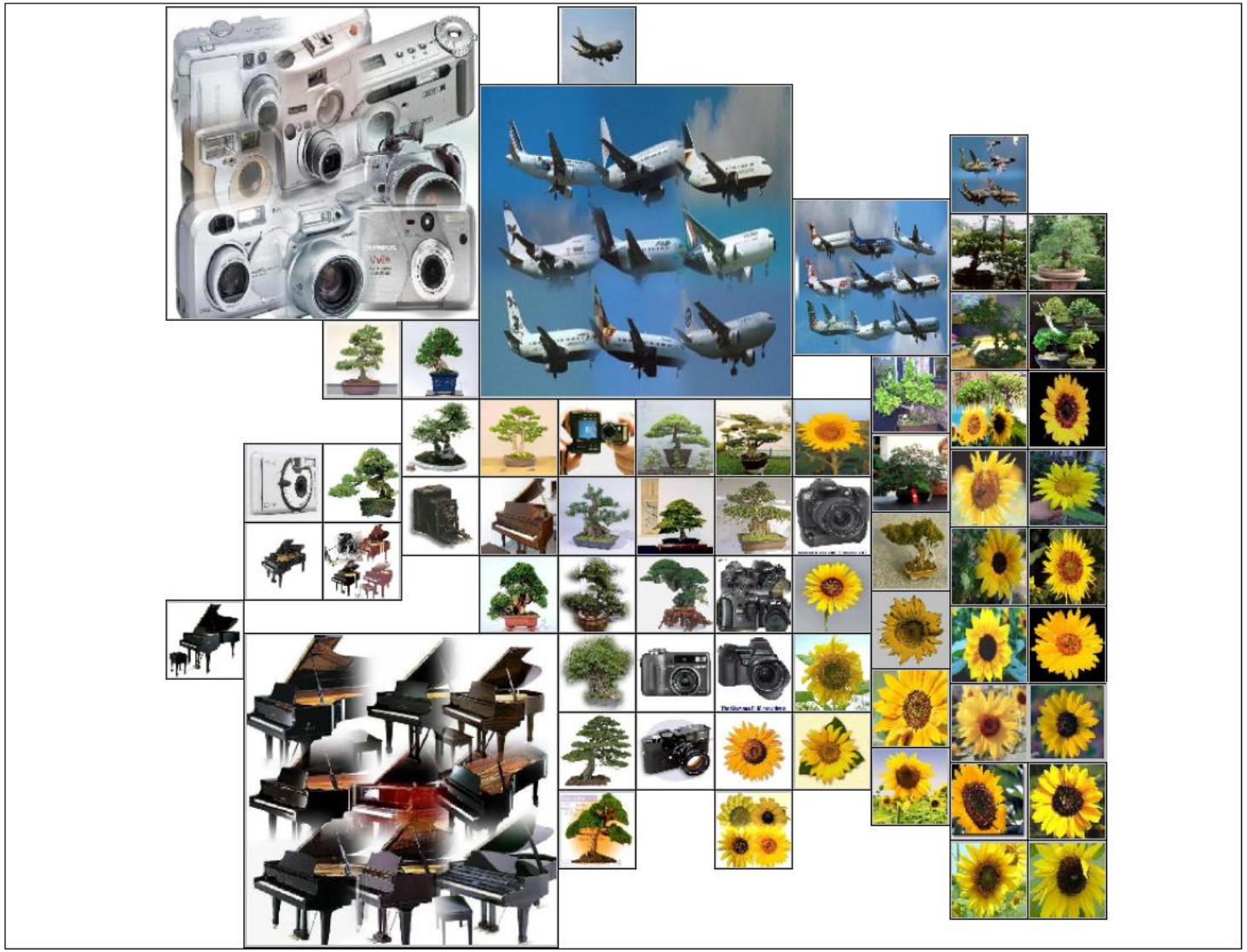
Image Gallery



(a)

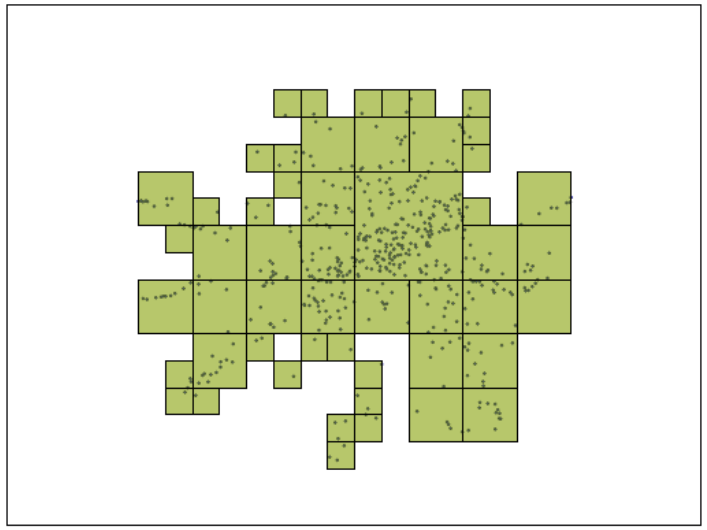


(b)

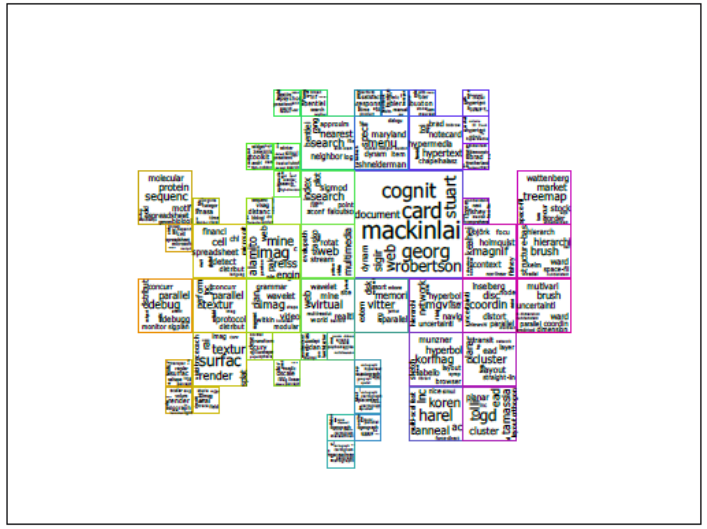


(c)

Wordcloud-based Document Summarization



(a)



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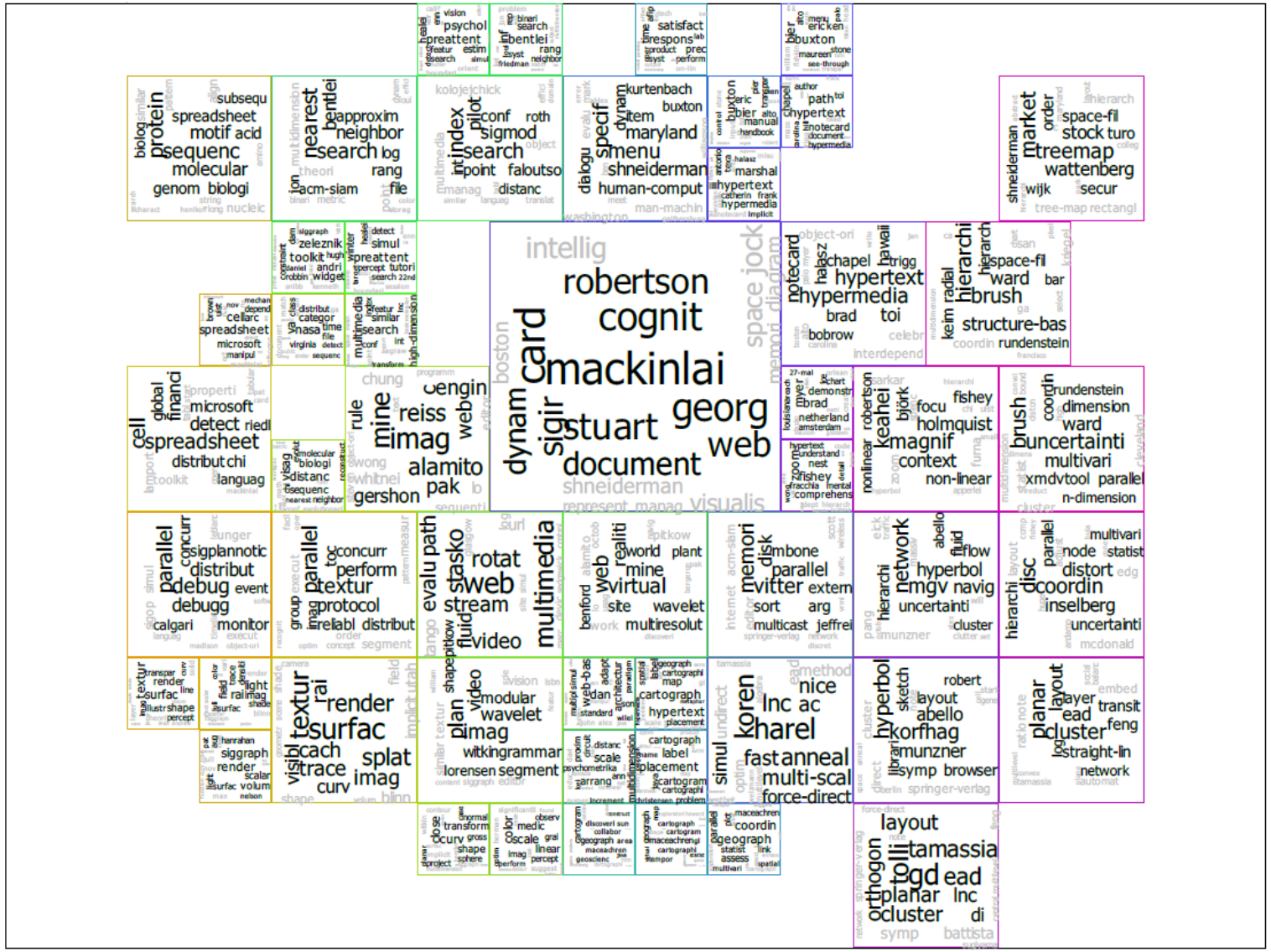

(c)

Video Gallery

Discussion and Conclusions

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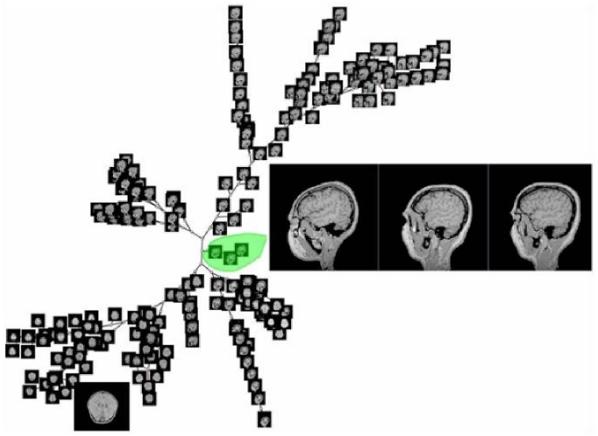
- Although more general, the proposed method performed quite well when quantitatively compared against existing techniques.
- The only parameter involved is the refinement level for the adaptive grid, which is application dependent.
- The adaptive refinement can split a cluster. Data sensitive refinement would be more effective.

Semantically Aware Dynamic Layouts

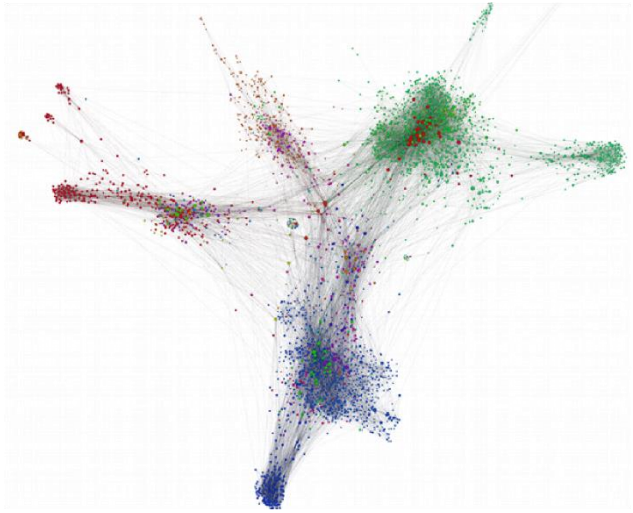
- Conference on Graphics, Patterns and Images (SIBGRAPI 2014)

Most techniques devoted to build layouts from geometrical primitives rely on overlap removal schemes that avoid visual clutter and produce pleasant visualizations.

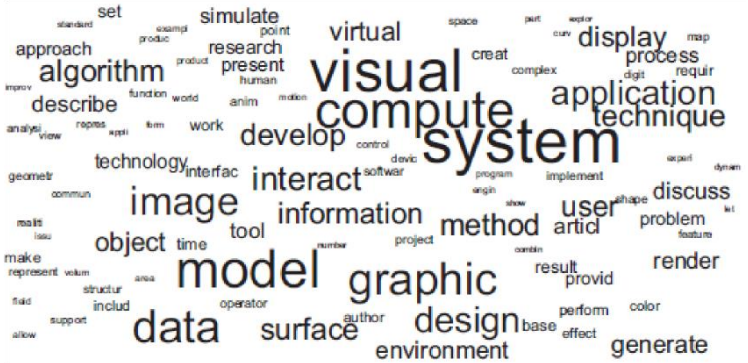
(a) Video visualization



(b) Image Datasets



(c) Large graph visualization



(d) Wordclouds

Most of the existing techniques do not enable users with interactive resources to dynamically modify the layout while preserving semantic relations. **The few ones that allow dynamical arrangements demand quite intricate implementation**.

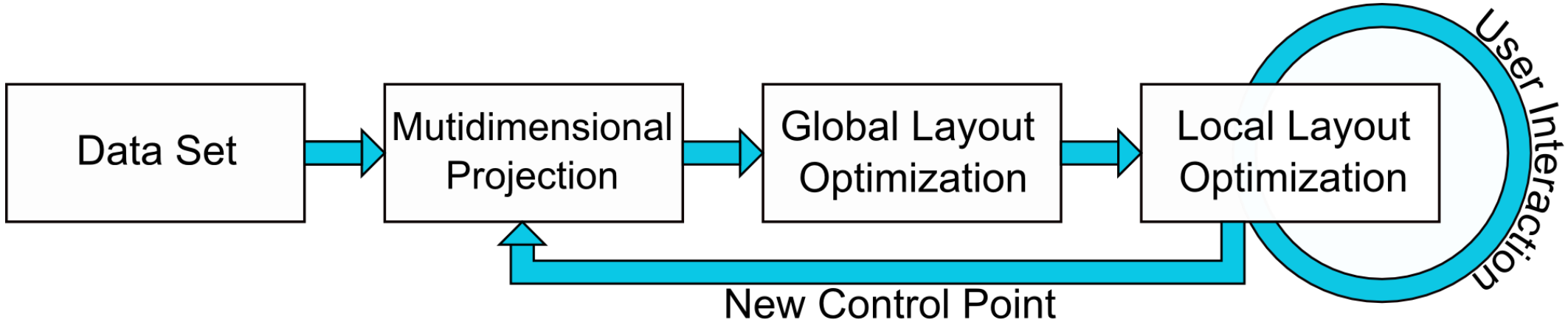
Bernhard Reinert, Tobias Ritschel, Hans-Peter Seidel
Interactive By-example Design of Artistic Packing Layouts
ACM Transactions on Graphics (TOG) - Proceedings of ACM SIGGRAPH Asia 2013.



In this work, we propose a novel semantic aware layout construction technique that allows users to freely tailor 2D arrangements according to their interest.

Contributions

- A fully interactive technique to arrange geometric primitives in two-dimensional layouts.
- A mechanism to enforce semantic relationship among entities of the layout.
- A combination of interpolation and optimization mechanism to enable a pleasant and dynamic layout update during and after user intervention.


Data Set
Mutidimensional Projection
Global Layout Optimization
Local Layout Optimization
User Interactio
New Control Point

Semantic Preserving Dynamic Layouts

Enabling User Interaction

- There are two main issues that must be addressed to enable friendly interactive resources, namely, dynamic update of the layout during user interaction and preservation of semantic relations in the modified layout.

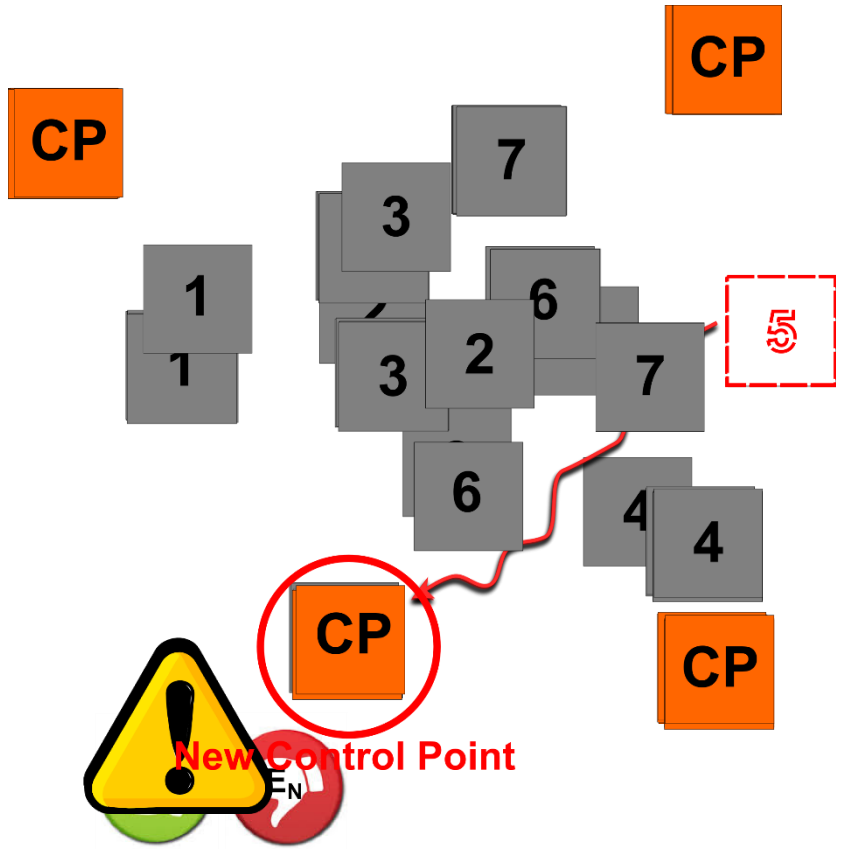
- Dynamically updating the layout during interaction is important to improve user experience and to ensure pleasant interaction resources.

- Preserving semantic relations is mandatory to facilitate layout readability and interpretation.

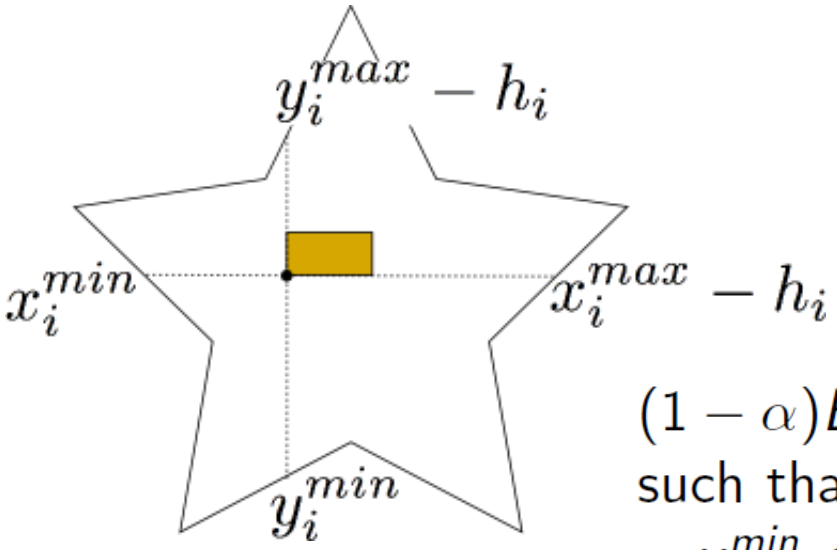
Semantic Preserving Dynamic Layouts

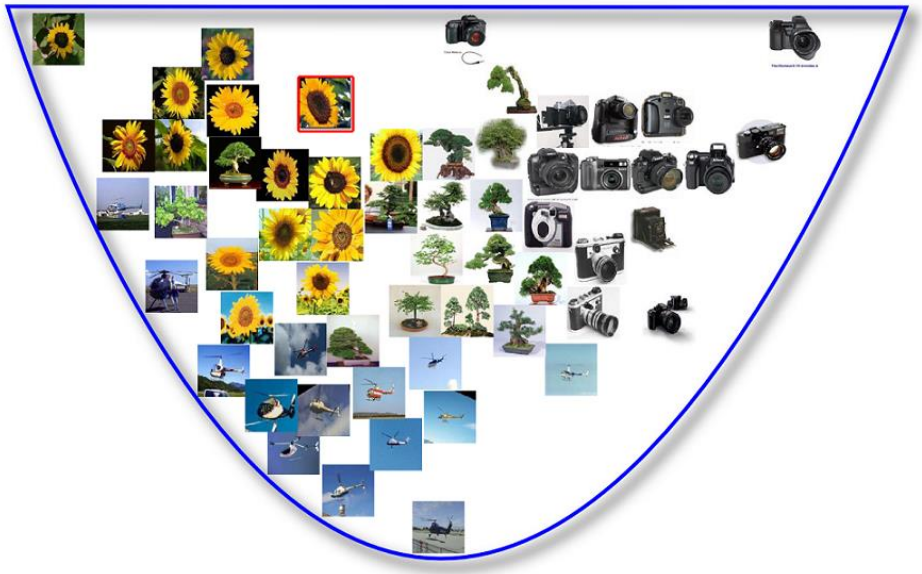
Enabling User Interaction

- When the user drags a primitive, the layout is dynamically optimized, but using only the overlap energy EO.
- During interaction the user keeps attention on the object s/he is interacting with, neglecting semantic relations temporarily.
- After interaction, we recover the semantic relation between neighbor instances by control points used in the MP step.
- Make each user selected instance a new control point for the multidimensional projection.
- Since the original control points are fixed, most parts of the layout remain unchanged, preserving the visualization context as much as possible.



In order to confine each geometric primitives within a given visual domain we impose constraints to the minimization problem.





$$(1-\alpha)E_O + \alpha E_N$$

such that:

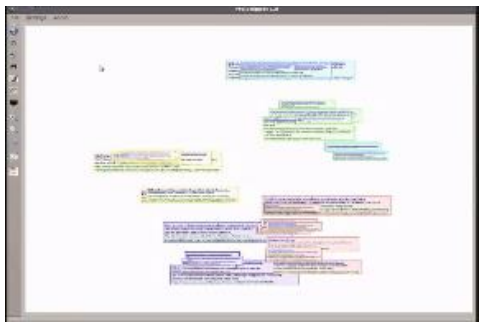
$$x_i^{min} \leq x_i \leq x_i^{max} - h_i, \quad i = 1, \ldots, n$$
$$y_i^{min} \leq y_i \leq y_i^{max} - v_i, \quad i = 1, \ldots, n.$$

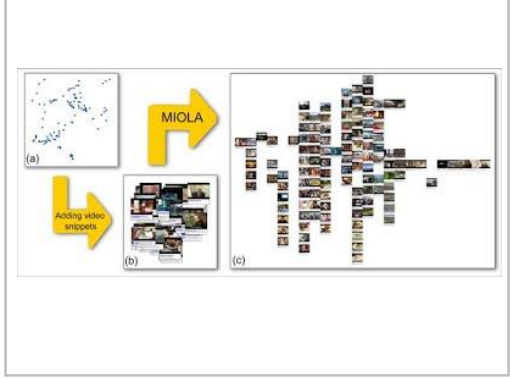
Conclusion

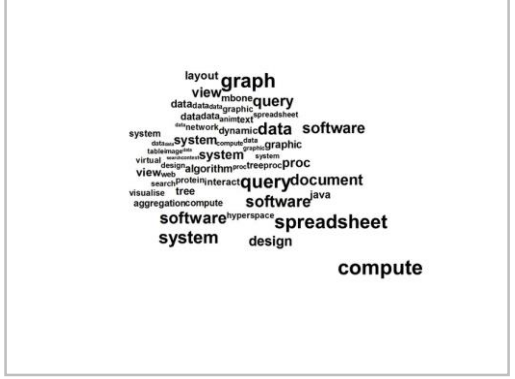
- In this work we introduced a novel methodology to build layouts made up geometric primitives.
- Our approach is very flexible, allows free user intervention, and can deal with arbitrary visual domains, thus bearing traits not present in most existing methods.
- The proposed technique is useful in diferent visualization scenarios and quit effective in terms of semantic preservation during layout construction.
- The simple computational and mathematical formulation render our methodology a good alternative for tailoring semantic layouts.

Conclusion (1/5)

- We presented four different formulations to address the generation of semantic layouts from multidimensional data. As can be noticed, all of these approaches deal simultaneously with multiple requirements for empowering exploration and analysis capabilities of similarity based 2D representations.







Conclusion (2/5)

- One of the **positive aspects** in managing multiple requirements during layout construction is that we can **play with properties** such as object size and neighborhood to **highlight relevant portions** of the layout without losing the semantic relation among objects. By handling additional requisites such as overlap-free and optimal usage of display area we can reduce visual clutter while improving readability. As far as we known, no other techniques devoted to build layouts from geometric primitives is able to deal with so many concurrent requirements to generate meaningful layouts.

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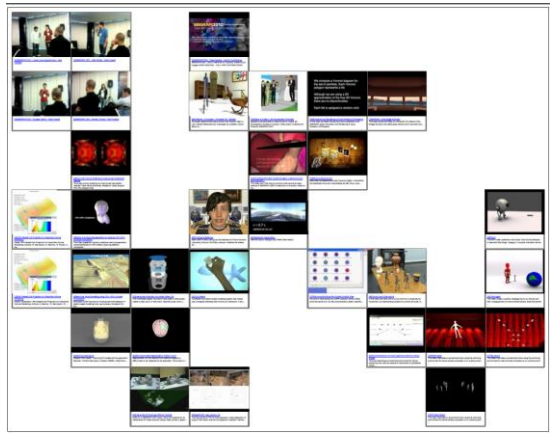
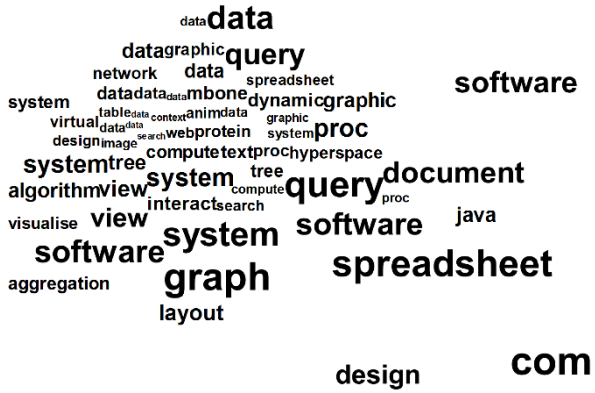
Conclusion (3/5)

- The **practical usefulness** of our methods is demonstrated in different multimedia data visualization applications. Within these we can mention textual snippets from web search engines, worclouds from document collections, image galleries and videos from video streaming sites. An important benefit of our methods is that **are highly applicable to any dataset** as long as it can be described as multidimensional data and a distance measure can be used to establish similarity relations between instances.



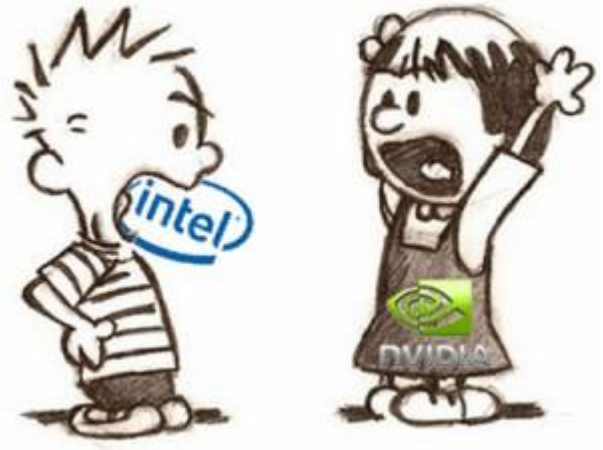


Conclusion (4/5)

- Identifying **new requirements** is a mandatory task to evolve in this research topic. All of requirements addressed in this study were result of experimentation on **multidimensional data** associated to geometric primitives.
- In this way we believe that introducing semantic layouts into different contexts that to the focused in this work will **widely enrich** the development of this topic.

Conclusion (5/5)

- We are currently investigating **new interactive mechanisms to enable a free navigation** throughout the layout as well as dynamic user-driven layout updates. A major drawback is concerns to the **number of instances** to optimize during semantic interactions since solving an optimization problem with a **high number of variables fast enough** as to provide a real time interaction is computationally costly.



“Generation of semantic layouts for interactive multidimensional data visualization”

Erick Gomez Nieto, PhD

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