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# RCAviz: Visualizing and Exploring Relational Conceptual Structures

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# Context

## Objective

- ❖ **Navigate** multi-relational datasets
- ❖ **Searching** alternative or approximate answers, forming hypotheses, finding or acquiring understanding

## Inspiration sources

- ❖ **Exploratory search** (e.g. in Information Retrieval, Marchionini/White)
- ❖ **Conceptual navigation** (e.g. in FCA, Carpineto/Romano, Ducrou/Eklund, Ferré, Wille)

# Directions for exploratory search

## Preliminary data organization

- ❖ **Concepts** for highlighting similar entities
- ❖ Conceptual **classifications** for guiding search along specialisation/generalisation links
- ❖ **Relational** Concept Analysis for highlighting entities sharing similar relationships

## Visualization and interaction

- ❖ Foster human **understanding**
- ❖ Foster human **reasoning**

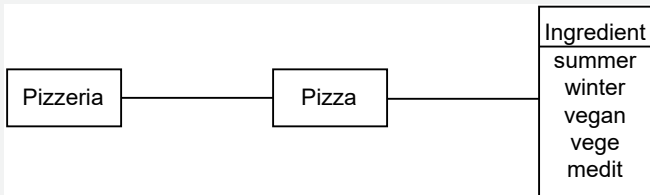
# Relational Concept Analysis

## Principles (Rouane Hacène et al. 2013)

- ❖ Extends the purpose of FCA to take into account **object categories and links** between objects
- ❖ Uses a simplified **entity-relationship model**, with binary relationships
- ❖ Integrates relations in formal contexts as **relational attributes**
- ❖ Uses various **quantifiers** inspired by description logics:  $\exists$ ,  $\exists\forall$ ,  $\exists\forall_{\geq 60}$ , ...  $\exists \supseteq$ ,  $\exists \supseteq_{\geq 60}$ , ...
- ❖ **Iterative** and tunable process
- ❖ RCA provides a **set of interconnected structures** (concept lattices, AOC-posets, etc.)

# Relational Concept Analysis

## Entity Relationship model



## Knowledge Pattern (example)

Pizzerias (offering at least one pizza (with only some ingredients))

$Pizzeria (\exists \text{ offer } Pizza (\exists \forall \text{ contain } Ingredient))$

$Pizzeria (\exists \text{ pizzeria2pizza } Pizza (\exists \forall \text{ pizza2ingredient } Ingredient))$

# Relational Concept Analysis

## Formal contexts

		<b>FC Ingredient</b>	summer	winter	vegan	vege	medit						
<table border="1"> <thead> <tr> <th><b>FC Pizzeria</b></th> </tr> </thead> <tbody> <tr><td>happizzy</td></tr> <tr><td>julipidz</td></tr> <tr><td>smallitaly</td></tr> <tr><td>eataly</td></tr> <tr><td>lafelicita</td></tr> </tbody> </table>	<b>FC Pizzeria</b>	happizzy	julipidz	smallitaly	eataly	lafelicita	<b>FC Pizza</b>	tomato	x		x	x	x
	<b>FC Pizzeria</b>												
	happizzy												
	julipidz												
	smallitaly												
	eataly												
	lafelicita												
	cheeseW	eggplant	x		x	x	x						
	vegeW	zucchini	x		x	x	x						
	veganW	redpepper	x		x	x	x						
indiaW	mushroom		x	x	x	x							
cheeseS	pumkin		x	x	x	x							
vegeS	goatcheese	x			x	x							
indiaS	reblochon	x			x	x							
forest	comte		x		x	x							
justvegan	gruyere		x		x	x							
ocean	mozzarella		x		x	x							
	ham	x	x										
	chicken	x	x										
	salmon	x				x							

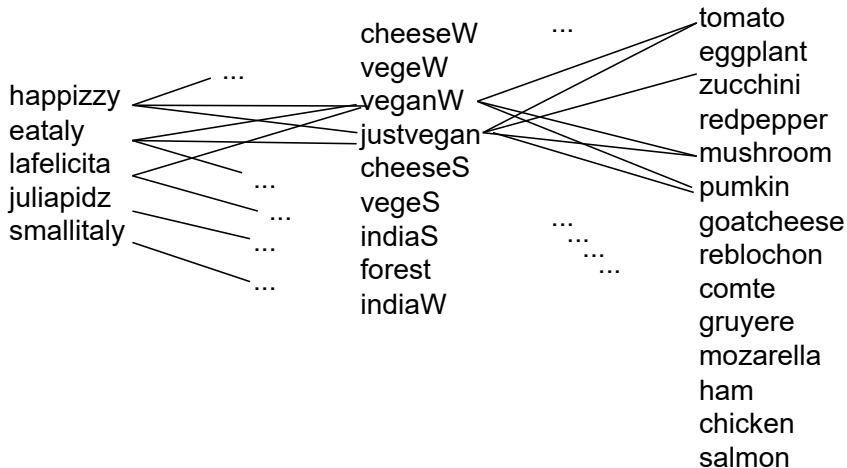
# Relational Concept Analysis

## Relational contexts

RC pizzeria2pizza	cheeseW	vegeW	veganW	indiaW	cheeseS	vegeS	indiaS	forest	justvegan	ocean
happizzy		x	x			x			x	x
juliapidz	x	x		x	x	x	x	x		x
smallitaly					x	x	x			x
eataly	x	x	x	x				x	x	x
lafelicita	x	x	x	x	x	x	x			

RC pizza2ingredient	tomato	eggplant	zucchini	redpepper	mushroom	pumkin	goatcheese	reblochon	comte	gruyere	mozzarella	ham	chicken	salmon
cheeseW	x								x	x	x			
vegeW	x				x	x					x			
veganW	x				x	x								
indiaW	x					x				x			x	
cheeseS	x						x	x			x			
vegeS	x	x	x	x			x							
indiaS	x	x											x	
forest	x			x	x						x	x		
justvegan	x	x			x	x								
ocean	x		x		x						x			x

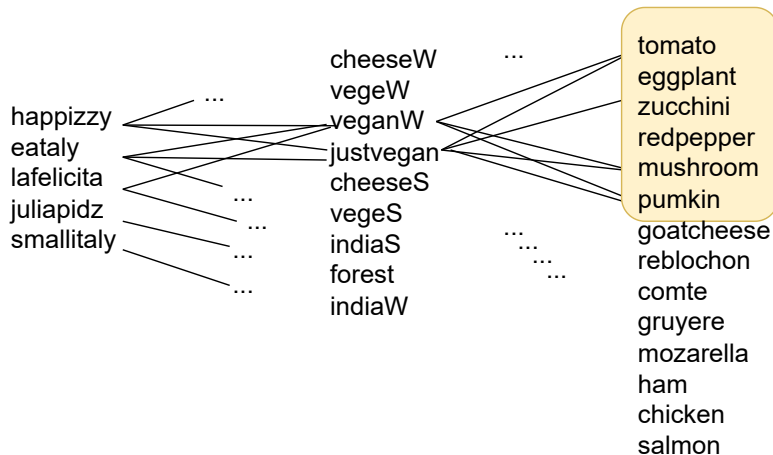
# Concept building





# Concept building

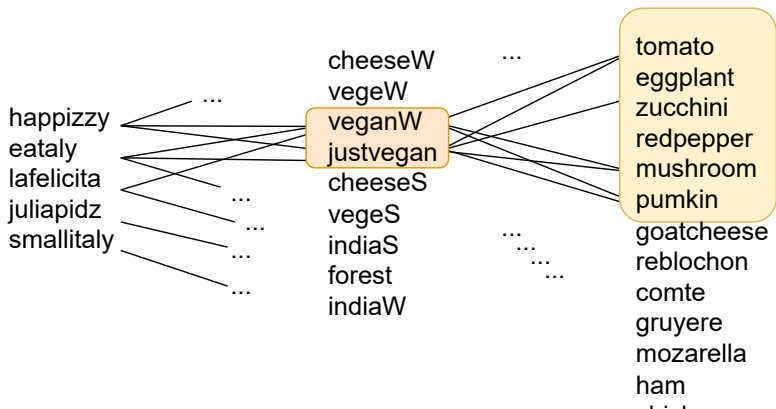
## Concept of **vegan ingredients**



# Concept building

Concept of pizzas that have all their ingredients in the concept of **vegan ingredients**

veganW and justvegan share:  $\exists \text{pizza2ingredient (Vegan)}$

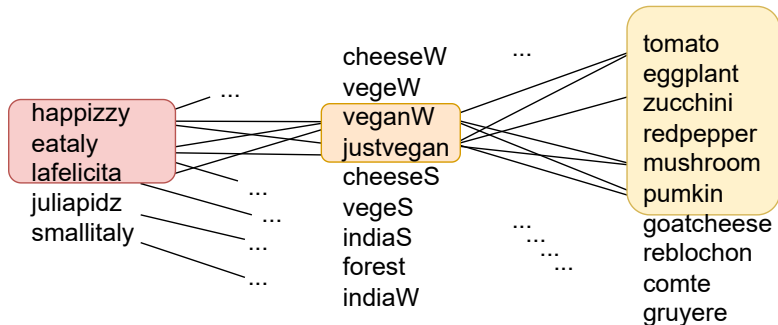


# Concept building

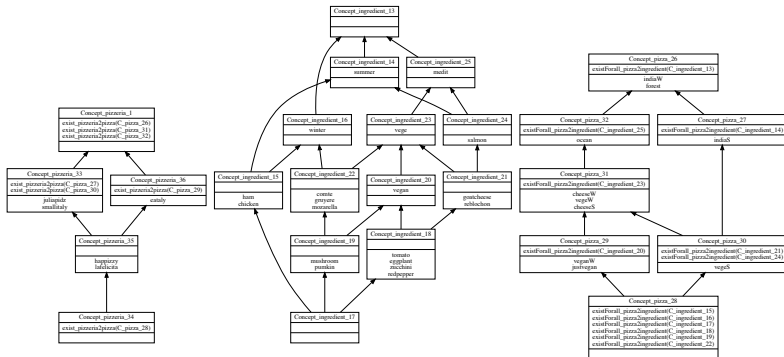
Concept of **pizzerias that have at least one pizza in** the concept of pizzas that have all their ingredients in the concept of **vegan ingredients**

happizzy, eataly and lafelicitita share:

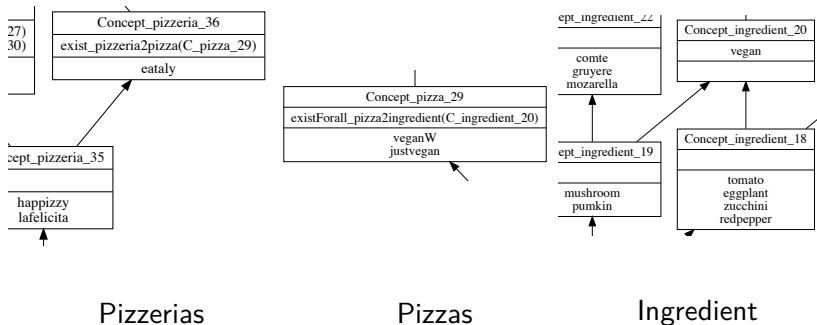
$\exists \text{pizzeria}2\text{pizza} (\exists \forall \text{pizza}2\text{ingredient} (\text{Vegan}))$



# Interconnected concept lattices



# Interconnected concept lattices



# RCA tools



# RCA tools

## RCA tools output

	Output files .dot, .pdf or screen copy	Visualization	Interaction by Navigation in and between structures
Galicia	x	x	
eRCA/Galatea	x	Global/external use of Graphviz	
FCA4J	x	Global/external use of Graphviz	
COGUI/RCA	x	Global/internal use of Graphviz	
RCAexplore	x	Local/In textual concept-browser	In concept-browser and along relational attr. in global visualization

## Tracks for improvement

- ❖ Local and graphical visualization
- ❖ Interaction: selection, navigation in structures and between structures via the relational attributes

# Requirements

## Requirements

- R1 Having a **starting** point: Selection of a concept via objects or attributes, or both
- R2 **Local** and **graphical** visualization: Observing a concept and its neighbors
- R3 Navigation **step-by-step**: From concept to concept along super/sub-concept links and along relational attributes
- R4 **Step back**: Keep and interact with an History



# Requirements

## RCA tools

	R1 Initial concept selection by O/A	R2 Local visu with only neighbors	R3 Step-by-step nav. among concepts	R4 History
Galicia				
eRCA/Galatea				
FCA4J				
COGUI/RCA				
RCAexplore		Textual descr. only (concept browser)	In concept browser or along relational attr. in global visu.	

# Principles

## Web application

- ❖ HTML, CSS, Javascript, D3.js
- ❖ Concept Selector
- ❖ Concept Explorer
  - ❖ History
  - ❖ Explorer

**#Digit Ag** Visualization and Exploration of Conceptual Structures through RCA

**What is RCA?**  
Learn more about it: [RCA-LEMM](#)

Start by uploading a JSON or RCAV file (with the correct RCA format).  
Check in folder: [smpg/ka2021.json](#)

**Need help?**  
Documentation  
Examples

Then select a context. Once you have selected a context, pick which attributes and/or objects you want, and then select a concept to start your navigation.

**Context: Country**

**Objects:**

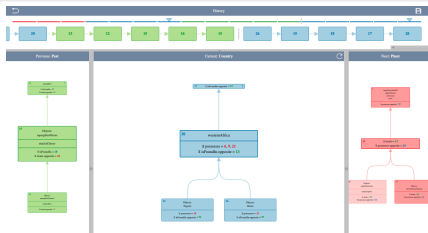
- Africa
- Asia
- Europe
- North America
- Oceania
- South America

**Attributes:**

- continent
- population
- area
- population\_10
- population\_15
- population\_20
- population\_25
- population\_30
- population\_35
- population\_40
- population\_45
- population\_50
- population\_55
- population\_60
- population\_65
- population\_70
- population\_75
- population\_80
- population\_85
- population\_90
- population\_95
- population\_100

**Concepts:**

- Africa
- Asia
- Europe
- North America
- Oceania
- South America



# Concept selector

## Concept selector

- ❖ Select attributes / objects ; search field for long list
- ❖ Logical operators AND / OR
- ❖ Corresponding concepts and introducer concept (if 1 selected element)

What is RCA?  
Learn more about it:  
**HAL-LIRMM**

Start by uploading a JSON or RCAV file (with the correct RCA-format):  
Choisir le fichier **aspergillus2021.json**

Need help?  
**Documentation**  
**Examples**

Then select a context. Once you have selected a context, pick which attributes and/or objects you want, and then select a concept to start your navigation.

Context: **Country**

**Objects**

Select all

Unselect all Selected

Benin  Nigeria  
 Namibia  SouthernAfrica

**Attributes**

Select all

Unselect all Selected

australAfrica  ∃ possesses: 10  
 ∃ possesses: 11  ∃ possesses: 21  
 ∃ possesses: 22  ∃ possesses: 25  
 ∃ possesses: 6  ∃ possesses: 7

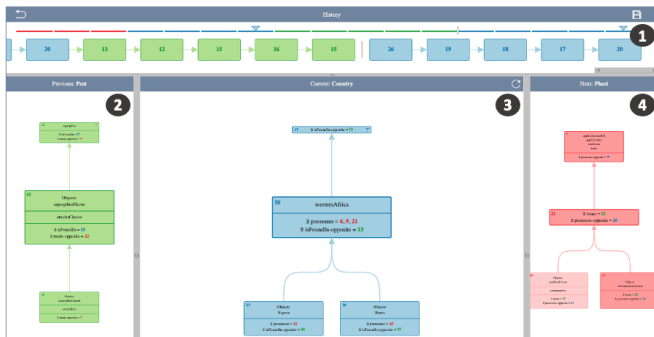
**Concepts**

19  20  23  26

# Concept explorer

## Concept explorer

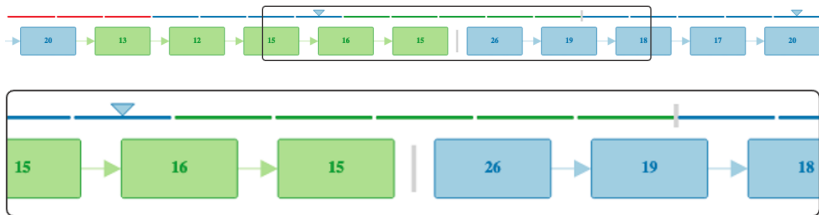
- ❖ One color per context
- ❖ History (1)
- ❖ Conceptual structures (2), (3) and (4) connected via relational attributes (e.g. from blue to red structure)



# History

## History

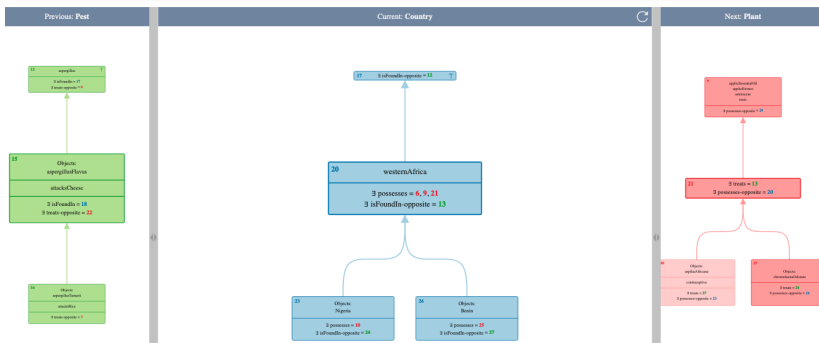
- ❖ Colored line: all explored concepts; the triangles show the current concept, highlighting if it has already been explored
- ❖ List of concepts: ids; slider; arrow for step-by-step; bar when step back; red cross to remove the concept



# Explorer

## Explorer

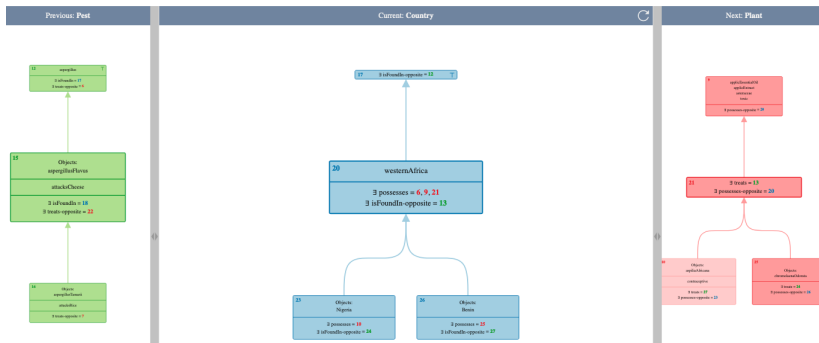
- ❖ 3 panels centered on a concept and its neighbors: Previous (left panel), Current (center panel), Next (right panel)
- ❖ Possible moves towards: super-concept, sub-concept, relational attribute range



# Explorer

## Explorer

- ❖ Relational attributes grouped by relation
- ❖ Opposite links



# Conclusion

## Work summary

- ❖ A web application
- ❖ Local visualization (a concept and its neighbors)
- ❖ Panels for previous, current and next conceptual structure
- ❖ Interactive navigation on conceptual structures interconnected by relational attributes (RCA)
- ❖ Interactive history



# Future Work

## Web application improvement

- ❖ Show larger parts of the conceptual structures
- ❖ Complete information in several views:
  - ❖ Selector: to choose the initial concept
  - ❖ History: to choose the relevant concept to step back
  - ❖ Explorer: to know the full intents and extents and choose the next step
- ❖ Visualizing the ER model
- ❖ Initiate the navigation with more complex queries
- ❖ Intensive testing and bug fixing

# Future Work

## RCA

- ❖ Integrate local, on-the-fly, conceptual structure computation (concept lattice, AOC-poset)
- ❖ Connection with a tool under development to visualize implication rules

## Practicing on...

- ❖ Knomana dataset: to assist experts in their navigation to search pesticidal plants for controlling pests on crops
- ❖ Software Product Lines: to guide users in product configuration

# Thank you!



<https://rcaviz.lirmm.fr/>

Youtube demo: <https://youtu.be/asXPtI9Th1M>

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ANR

French National Research Agency  
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The anonymous  
reviewers