Classification of interactive functions as a tool for an electronic atlas developer

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Electronic Atlas (EA)

- **Information organization and navigation**
- **Cartographic representation or visualization block**

  (maps, globes, charts etc.)
- **Functionality**
- **User interface** (layout, flexibility, aesthetics)

The ability and degree to which a map/atlas allows you to solve a specific set of tasks in accordance with its intended use

Functionality in a narrower sense:

- ***System performance***
- ***Set of interactive functions (IFs)***

Interaction operator

Denotes the ***generalized meaning*** of the user's action of manipulating the map

User-centric

Interactive function (IF)

Denotes the ***concrete*** (as detailed as possible) ***change*** of the EA view (map, data, content or atlas as a whole) initiated by the user

System-centric

IF = Meaning of change/action + operand (an operand is a type of object to which the (inter)action is directed)

What are the benefits of the classification of IFs?

Classification *is the ordering of entities into groups or classes on the basis of their similarity* (Bailey, 1994)

- Answers the question “what IFs exist?”
- Organizes the large list of IFs according to a certain principle/goal

1) Accelerates the work of developers

- May be considered the assessment tool in functionality studies of EAs

2) Helps to gain new knowledge about EAs and compare them

3) Ensures the competitiveness of the EA

Requirements for the classification of IFs

- ❑ Relevance
- ❑ Completeness
- ❑ Accuracy and clarity of the names
- ❑ Availability of descriptions (preferably with examples)
- ❑ Logical classification mechanism
- ❑ Ease of use / usability
- ❑ Visibility

Empirical analysis of the set of IFs from as many modern EAs as possible

Expert assessment and verification by practice

The aim of the study

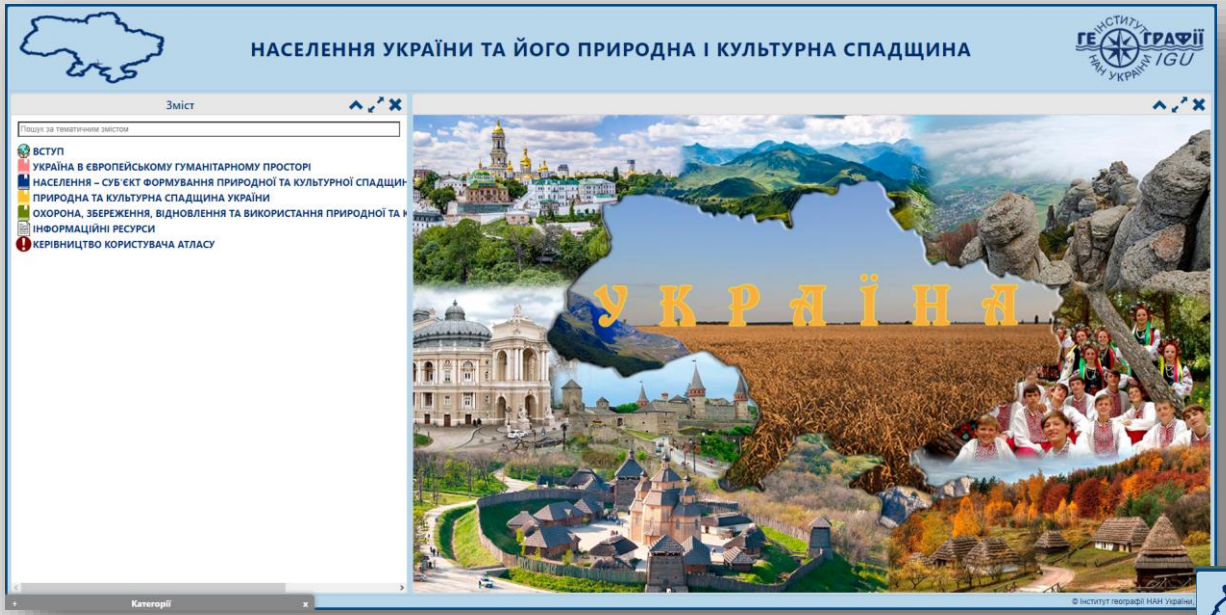
A ***multi-tool approach*** was applied to ***assess the set of IFs*** of the two EAs in order to:

1) to *compare the functionality of EAs* (point out the shortcomings of each according to their purpose and general requirements for EA as a concept)

2) to *compare the scope and character of information* that can be obtained using each classification of IFs

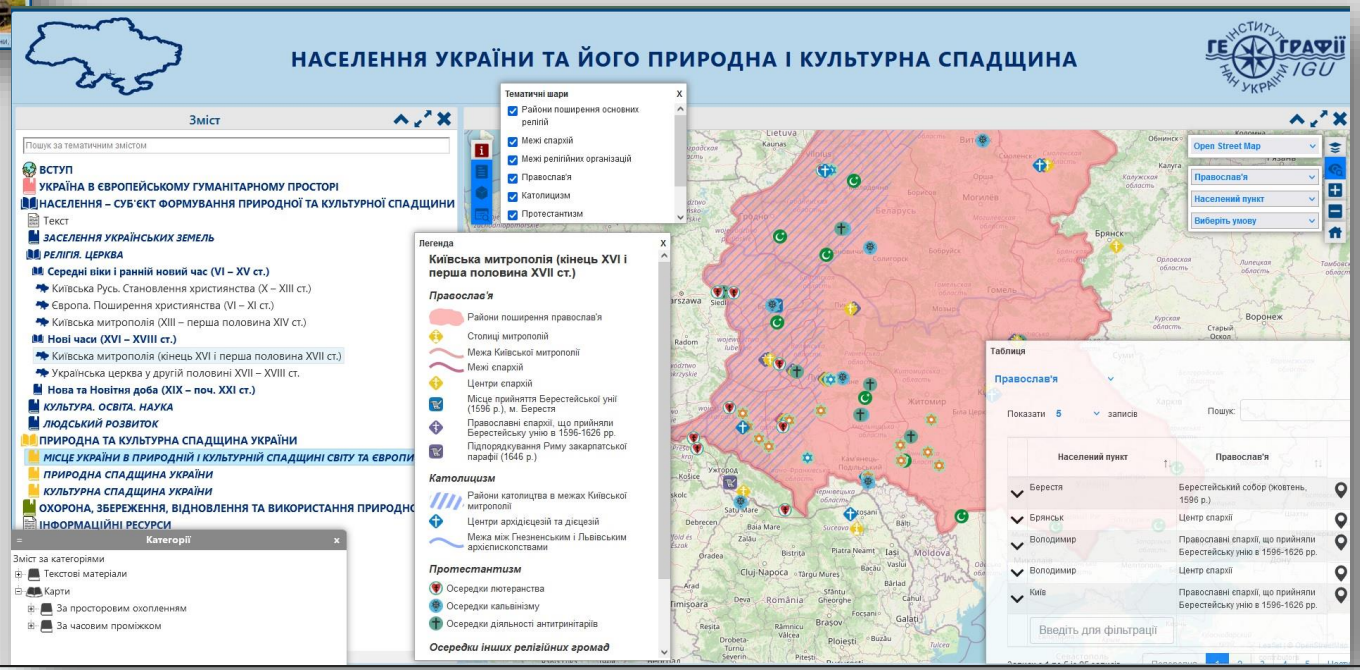
3) to *select* the most appropriate *set of tools for assessing and/or developing the EA*

Materials and Methods



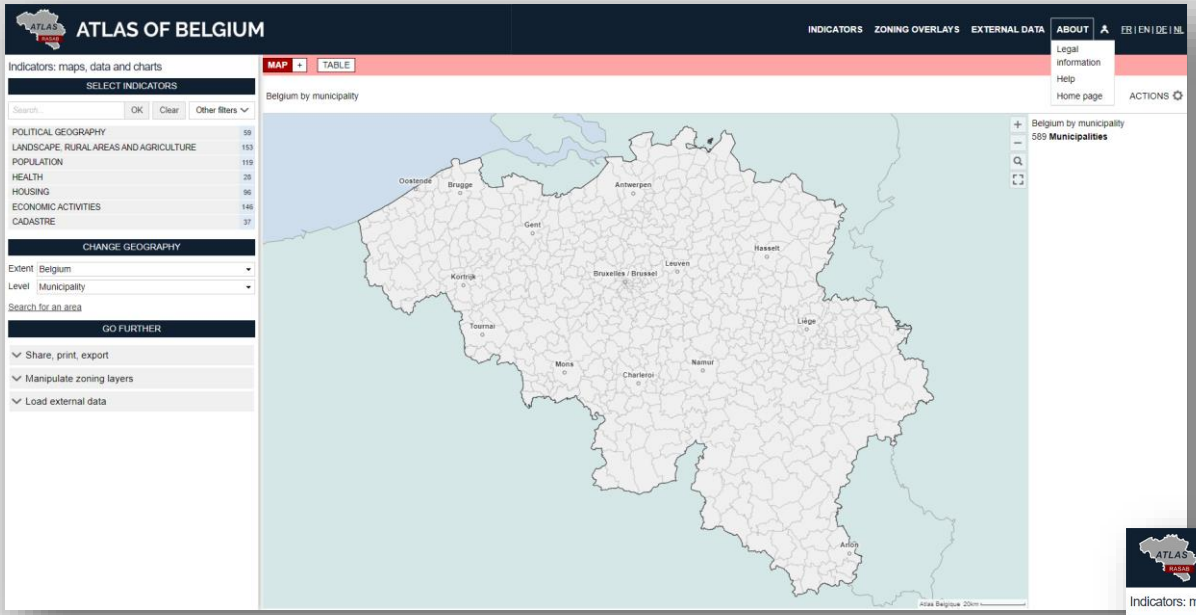
Web atlas "***Population of Ukraine and its natural and cultural heritage***" (PoU) (Rudenko et al., 2020)

Created using the **AtlasSF** framework



Characterized by a ***traditional approach*** to cartographic representation, focusing on the presentation of *complex (multivariate) maps*

Materials and Methods



obtained from Atlas of Belgium (atlas-belgique.be)

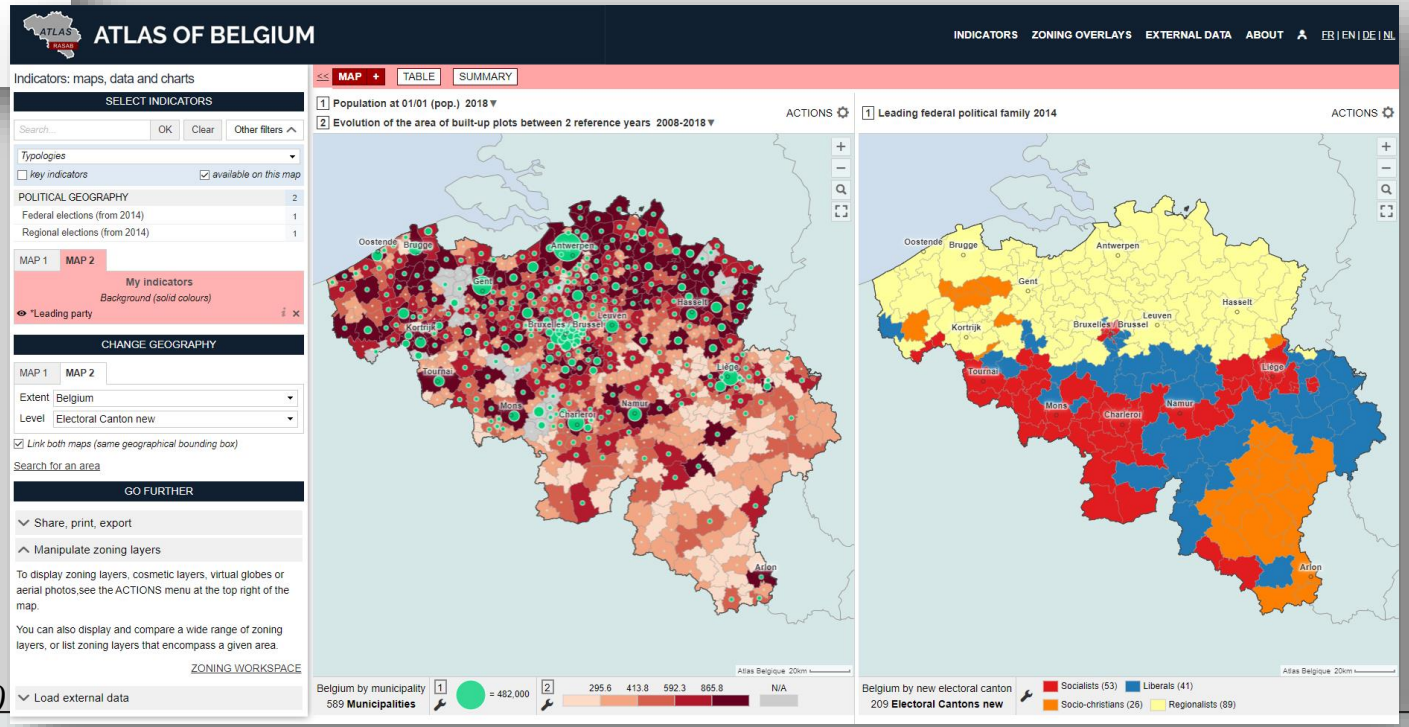
The Atlas of Belgium can be classified as a "***visualization tool***", which aims to provide tools for viewing and analyzing primarily quantitative geodata. This atlas is also closer to statistical atlases than to national atlases

EA with the *largest number of IFs* among about 40 reviewed EAs (Krakovskyi & Kurach, 2022)

obtained from Atlas of Belgium (atlas-belgique.be)

Web atlas "***Atlas of Belgium***" (AoB) (https://www.atlas-belgique.be/geoclipair/web/)

Created using the **Geoclip** framework (https://www.geoclip.fr)



Materials and Methods

The author's **taxonomic classification** (**Krakovskyi & Kurach, 2022**) includes *172 IFs*, divided into the seven groups: ***Settings and Support, Visual Design Adaptation, Navigation, Analysis, Extensibility, Recoverability, and Saving and Tracking***

- ❑ IFs are grouped according to the meaning of the change, i.e., by purpose
- ❑ Bottom up approach
- ❑ Most IFs are formed by composing elements of the "class" (equivalent to the operator), "genus", and "kind" (equivalent to the operand) ranks

TYPE	NAVIGATION							
SUBTYPE	SPACE							
Class	Zooming	Movement						Centering
Genus	...	*Panning*			*Scrolling*		*Rotation*	...
Subgenus								
Kind	...	Information and Navigation Structure	Map	...	Information and Navigation Structure	Text	Map	...

The sequence of taxonomic categories on the example of the *Navigation* group

Materials and Methods

Since the taxonomic categories of the "kind" rank are a sort of "operands" (they prompt where the IF is implemented or what object it is aimed at), the **classification (Krakovskyi & Kurach, 2022)** can be easily modified using the **operand approach**

Atlas (IFs that change/affect the entire system or introductory IFs)

Visualization (among visualizations, **maps** were counted separately)

Content (in particular, IFs with text files)

Data (IFs with tabular data)

Multimedia (in a narrow sense, IFs with images/audio/video)

NAVIGATION														
SPACE														
Zooming							Movement						Centering	
Pointing device / Button				*Bounding box*	*Ratio Scale*		*Scrolling*	*Panning*				*Rotation*		*Coordinates*	*Data Table*
Navigation System	Map	Chart	Image	Map	Map		Atlas	Navigation System	Map	Chart	Image	Map	Image	Map	Map

The operand approach (Krakovskyi & Kurach, 2022) on the example of the *Navigation* group

Materials and Methods

The classification **(Sieber & Cron, 2023)** consists of 77 IFs (72 if we exclude IFs in 3D) placed in the five groups: ***General Atlas Functions, Navigation Functions, Cartographic Visualization Functions, Analytic Functions, Information and Didactic Functions***

- Mixed principle of classifying IFS: by purpose/by origin/by operand. Focused on functional segmentation of the Atlas of Switzerland's GUI
- Top down approach
- Additional division of IFs by the level of sophistication ("Basic Level of Interactivity" and "Advanced Level of Interactivity")

Function Groups	*Function Subgroups*	*Functions* *Basic Level of Interactivity*	*Advanced Level of Interactivity*
General Atlas Functions	System-related Functions	Language Selection; Print; System Status; Help; Imprint; Home; Exit	
	Content-related Functions	Forward/Backward (Map History); Tooltips; Bookmarks	2D/3D Modus Selection; Export/Import: Maps and Data; Hot Spots; Preferences
Navigation Functions	Spatial Navigation	Region Selection; Scale Selection; Zooming; Panning; Reference Map; Location/Georeference; Geographic Index/Gazetteer; Geographic Search	2D Map Rotation; Viewing Direction in a 3D Map; 3D Moving and Flying around; Tracking; Pins, Localizer; Magnifier; Snapping
	Temporal Navigation	Time Point/Period Selection; Temporal Search and Temporal Index	Temporal Animation/Time Change/Time Line
	Thematic Navigation	Theme Selection; Theme Change/Switch; Thematic Index; Thematic Search	
Cartographic Visualization Functions	Map Manipulation	Layer Display/Layer Overlay (on/off); Layer Transparency; Legend Display (on/off)	2D Symbolization/Appearance Modification; 3D Symbolization/Appearance Modification; Projection Change
	Redlining	Labeling: Static	Labeling: Interactive; Additional Map Elements
Analytic Functions	Spatial Queries	Positional Query; Distance and Area Measuring	
	Thematic Queries	Attribute Query	Attribute Selection
	Thematic Analysis	Map Comparison	Classification Modification; Classification (Legend Category) Selection; Map Feature Comparison; Map Feature Selection; Buffering; Intersection; Aggregation
	Terrain Analysis		Hypsography; Slope; Aspect; Visibility; Terrain Profile
Information and Didactic Functions	Commentary Functions	Multimedia: Text, Graphics, Tables, Pictures/Images, Sound, Movies; Preview	Guided Tours; Storytelling
	Self-control Functions		Didactic Tasks; Quizzes; Games

Materials and Methods

Persson et al. (2006) identified *66 IFs* (55 if we exclude IFs in 3D) and distributed them among ***eight types of interaction***

- ❑ Typology without further division of IFs within each type
- ❑ Operand approach
- ❑ Concrete IFs predominate
- ❑ Geovisualization focus

Representation Model	Algorithms for the Creation of a Representation	Primary Model/ Database Query	Multiple Representations		Third and Fourth Dimension		System Interaction
			Arranging Many Simultaneous Views	Dynamic Linking with further Display Types	Temporal Dimension	(Pseudo-) 3D Visualization	

Reproduced by the author from (Persson et al., 2006)

Materials and Methods

The taxonomy of interaction primitives by **Roth (2011)**

This taxonomy was developed from the *user's perspective*, and its purpose is to *highlight the main components of cartographic interaction*

Roth (2011) equates 17 ***interaction operators*** of this taxonomy (18 with the addition of *Underlay*) with both "*generic interactive functionality*" and *IFs*

- ❑ Designed for interactive maps
- ❑ Strong relations primarily with information visualization science

Operator	Card Example
Enabling Operators	
Import	*get started by loading a stock map design of the world*
Export	*export the maps as a .pdf*
Save	*save the map so that you can come back later to make a modification*
Edit	*select a point to change the attribute data*
Annotate	*mark up the map to show where to send resources*
Work Operators	
Reexpress	*switch among multiple map representation strategies*
Arrange	*arrange a large number of maps for simultaneous comparison*
Sequence	*display one time slice after another on the map*
Resymbolize	*change the relative sizing of circular proportional symbols*
Overlay	*click on the layer panel to show layers of different types of crimes*
Reproject	*project the map using the Albers equal area conic projection*
Pan	*pan the map to a different location*
Zoom	*zoom in to see what is around the point source*
Filter	*perform a query that specifies the range of contaminant concentration levels*
Search	*enter search words into Google Maps to find target communities in Pittsburgh*
Retrieve	*brush over the first district of California to see how people voted*
Calculate	*select two cities and calculate the distance between them*

Examples of Each Enabling and Work Operator (Roth, 2013, Table 3)

Materials and Methods

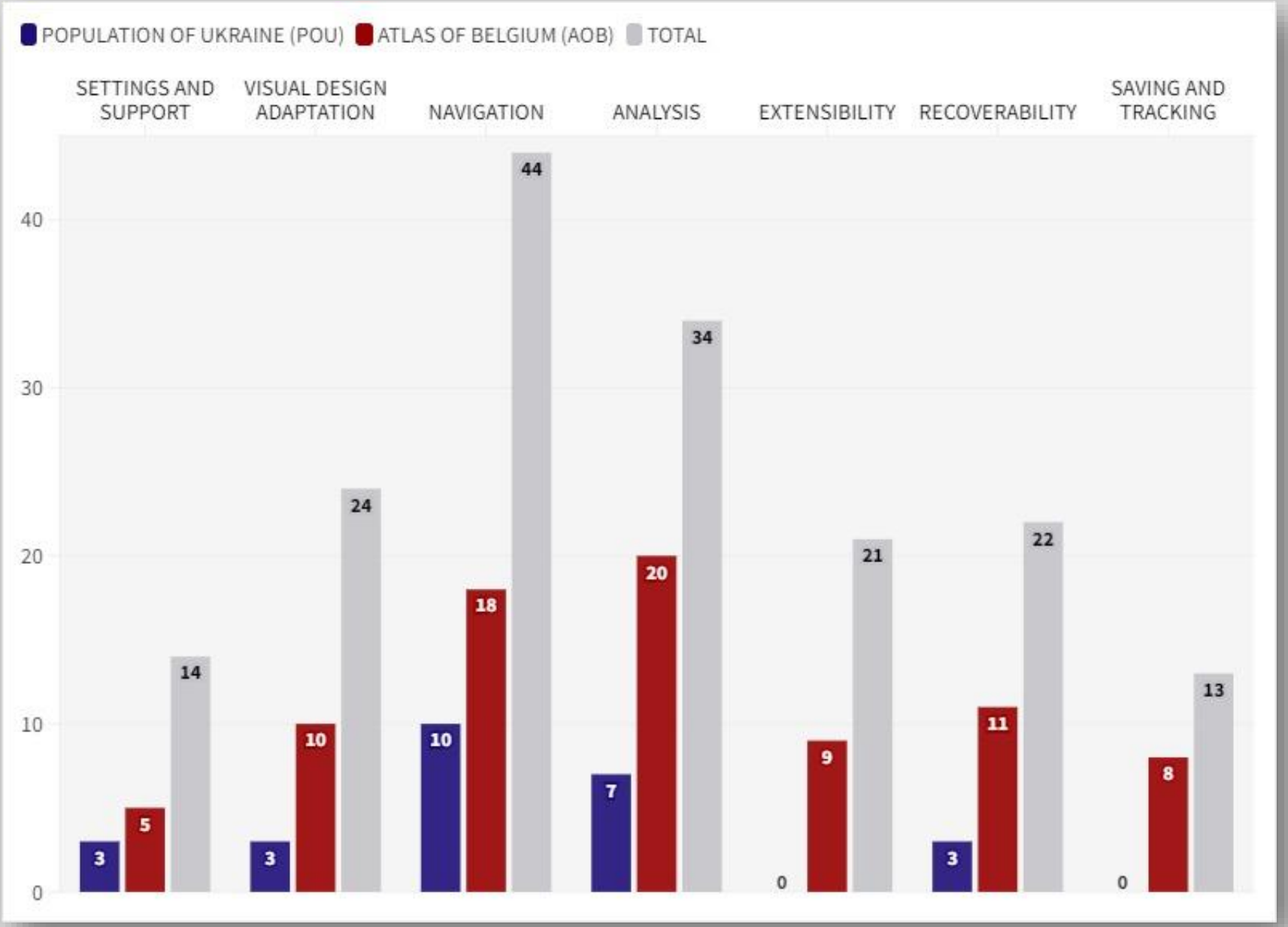
Balciunas' (2014) classification of IFs consists of *30 main web map IFs*, distributed between 8 groups (translated by the author):

1. Image review
2. Data review
3. GUI Management
4. Data Visualization
5. Data Analysis
6. Management of the Mathematical Basis
7. Resource Management
8. Data Management

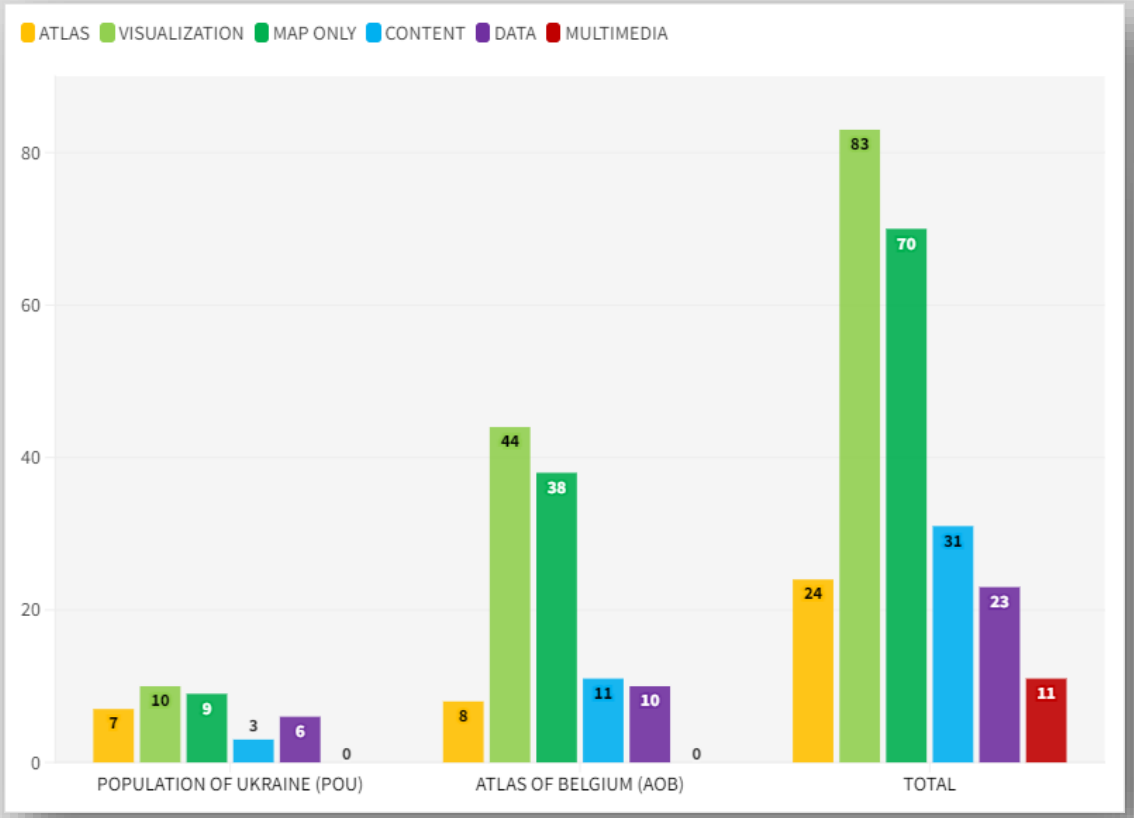
- Designed for interactive web maps
- IFs are grouped according to their purpose
- With the exception of the *Reexpress* and *Sequence* operators, it contains equivalents for all operators, with the granularity of some of them

Results

(Krakovskyi & Kurach, 2022)

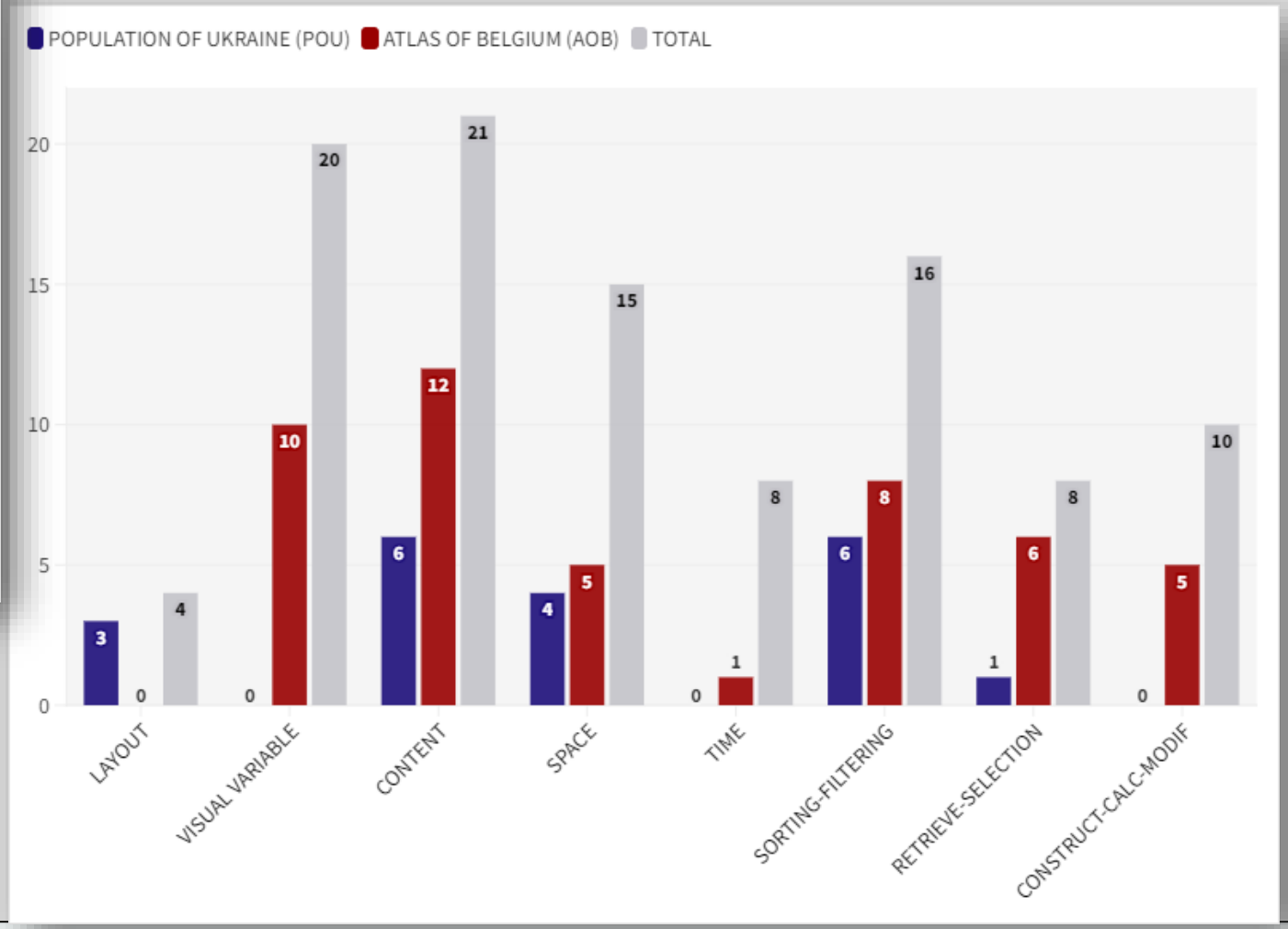


Results: (Krakovskyi & Kurach, 2022)

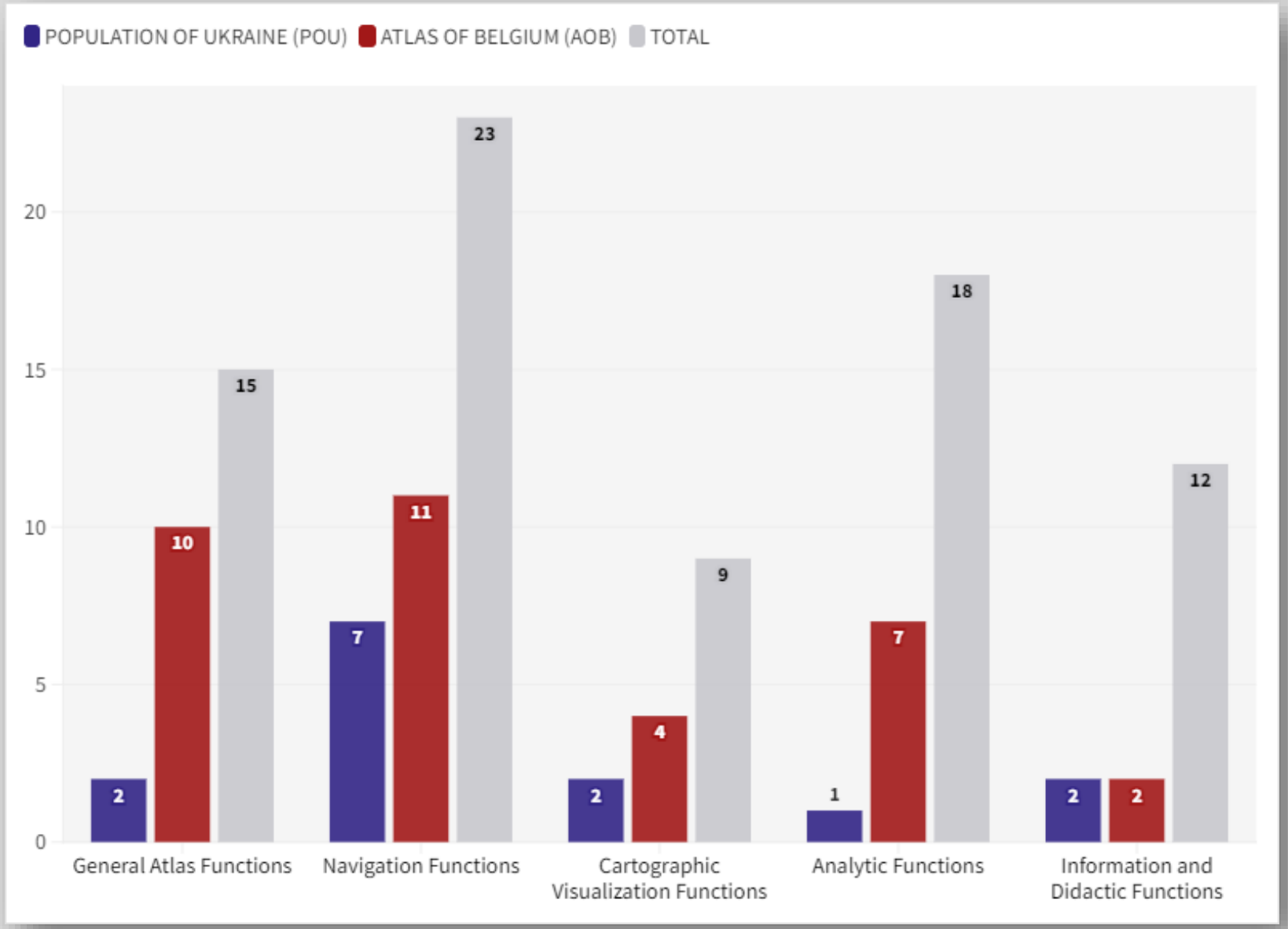


Operand approach

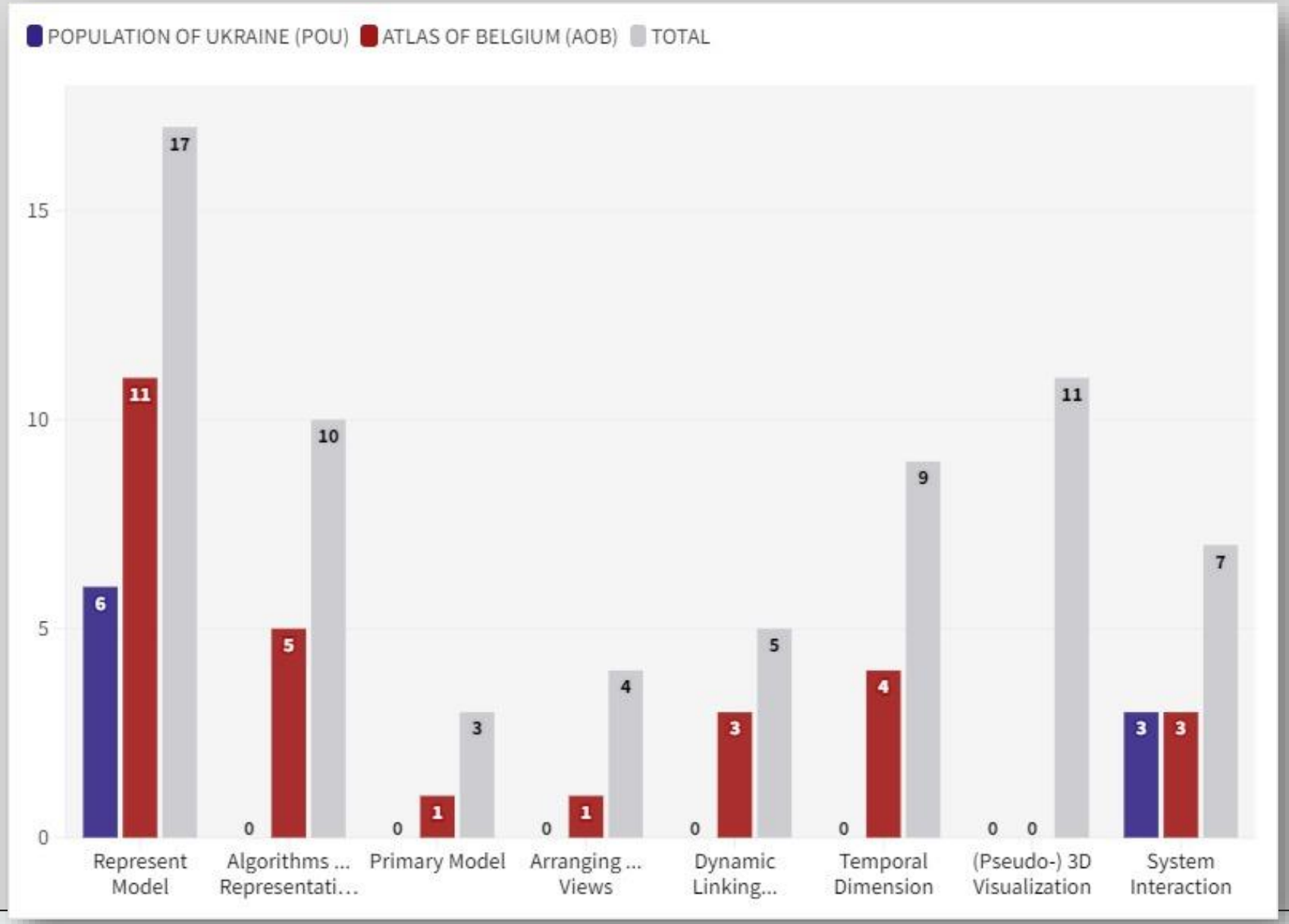
Visual Design Adaptation + Navigation + Analysis



Results: (Sieber & Cron, 2023)



Results: (Persson et al., 2006)



Results: (Roth, 2011)

1
POU
Pan
Zoom
Retrieve
Filter
Search
Calculate
Overlay
Resymbolize
Reproject
Reexpress
Sequence
Arrangement
Import
Export
Save
Edit
Annotate
Underlay

2
AOB
Pan
Zoom
Retrieve
Filter
Search
Calculate
Overlay
Resymbolize
Reproject
Reexpress
Sequence
Arrangement
Import
Export
Save
Edit
Annotate
Underlay

Results: (Balciunas, 2014)

PoU

Map View	Data Identification	Layout Management	Data Visualization	Data Analysis	Management of the Mathematical Basis	Resource Management	Data Management
Zoom	Retrieve Information About Map Objects	Map Layout Modification	Change Visual Classification	Get Data Statistics	Change Projection	Save Map	Edit Data
Panning	Searching Map Objects	Resizing Map Screen	Change Symbols	Query Data	Display Coordinates	Print/Export Map	View and Analysis of Attributive Data
Display Legend	Filtering Map Representation	Management of Map Interface Elements	Change Map Style	Spatial Analysis	Measurement	Embedding Map	Compare Map & Data
Share Place	Change Layers		Change Map Annotation	Analyzing Information Using Visualizations		Import Map/Data/WMS	Change Data Classification
3	4	2	0	0	0	0	1
4	4	3	4	4	3	4	4

AoB

Map View	Data Identification	Layout Management	Data Visualization	Data Analysis	Management of the Mathematical Basis	Resource Management	Data Management
Zoom	Retrieve Information About Map Objects	Map Layout Modification	Change Visual Classification	Get Data Statistics	Change Projection	Save Map	Edit Data
Panning	Searching Map Objects	Resizing Map Screen	Change Symbols	Query Data	Display Coordinates	Print/Export Map	View and Analysis of Attributive Data
Display Legend	Filtering Map Representation	Management of Map Interface Elements	Change Map Style	Spatial Analysis	Measurement	Embedding Map	Compare Map & Data
Share Place	Change Layers		Change Map Annotation	Analyzing Information Using Visualizations		Import Map/Data/WMS	Change Data Classification
4	4	0	3	2	0	4	3
4	4	3	4	4	3	4	4

Conclusions

Drawbacks of the PoU:

- Only basic functionality (according to (Sieber & Cron, 2023)) with no analytical capabilities
- Lack of language selection and map/data export
- The complete absence of IFs for comparing maps and filtering elements in TOC
- Does not contain IFs with image/video/audio

Drawbacks of the AoB:

- Lack of texts and options for manipulating GUI elements
- The complete absence of IFs for retrieving information about the topography (the cartographic representation also pay limited attention to physical geography)
- Does not contain IFs with image/video/audio

Conclusions

Classification for the development of EAs:

(Krakovskyi & Kurach, 2022b)

Due to the greatest detail and scope of IFs for EA (with the exception of IFs in 3D)

Classification for the assessment of EAs:

Both **(Krakovskyi & Kurach, 2022b)** and **(Sieber & Cron, 2023)** are suitable as the ***main tools*** for assessing the set of IFs of EAs

Auxiliary tools:

Operand approach (Krakovskyi & Kurach, 2022)

- ❑ generalized assessment

Typology (Persson et al., 2006)

- ❑ can be combined with any classification
- ❑ appropriate primarily for EAs created using the geovisualization approach

Interaction Operators (Roth, 2011)

- ❑ preliminary and generalized assessment
- ❑ not optimal for assessing EAs

Main web map IFs (Balciunas, 2014)

- ❑ preliminary and generalized assessment
- ❑ illustrative organization scheme
- ❑ not optimal for assessing EAs

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