

Renewing Charts with Better Understanding of Visual Perception

Min Lu, Assistant Professor, Shenzhen University

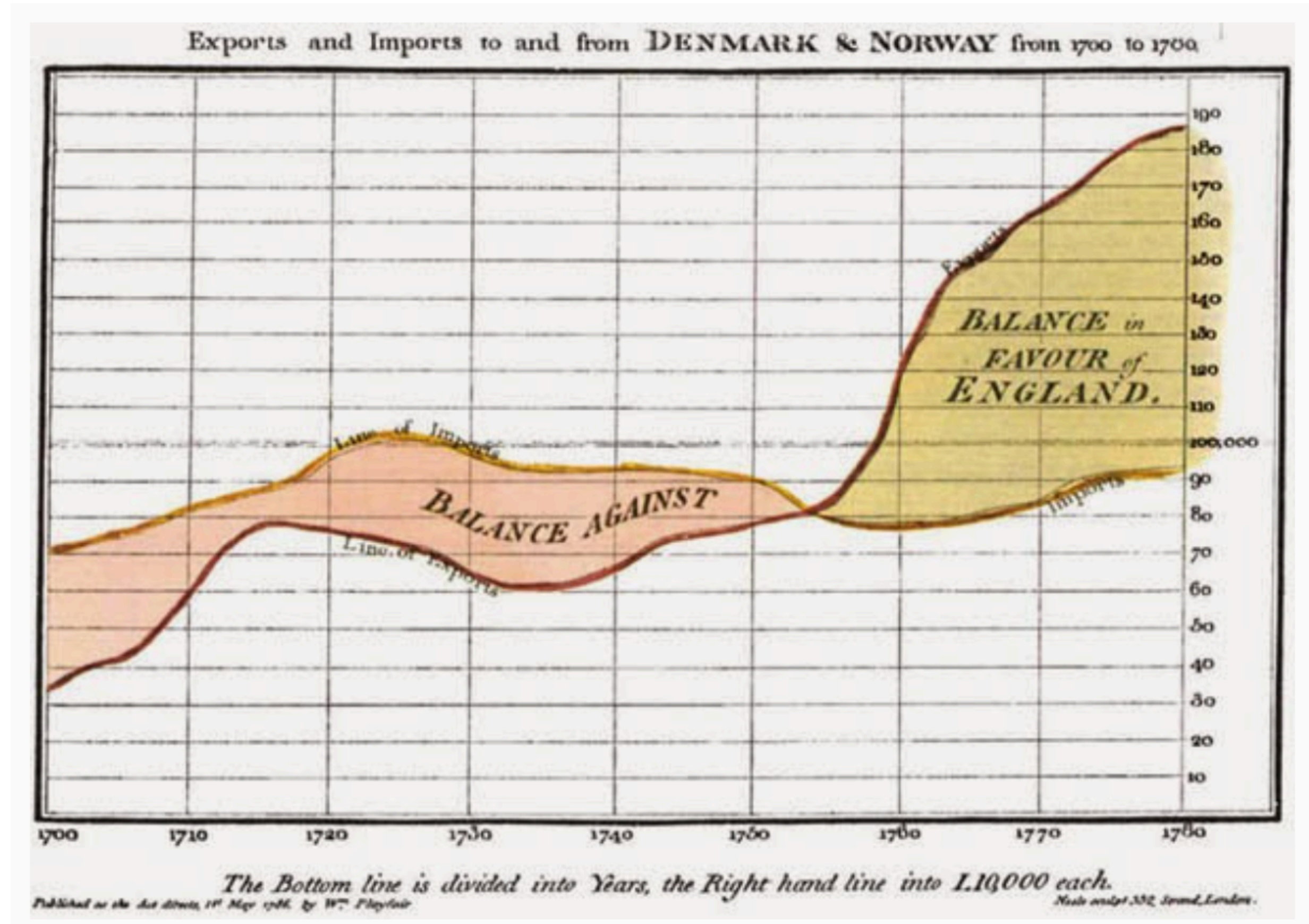
Email: lumin.vis@gmail.com

Homepage: <http://deardeer.github.io>



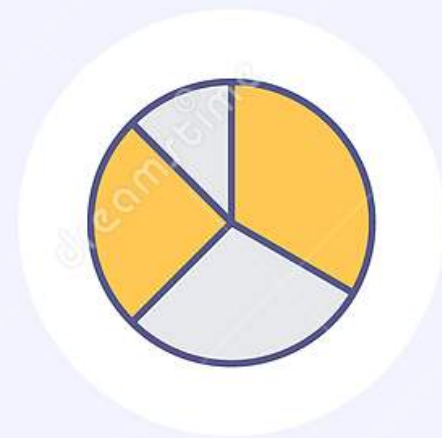


William Playfair
(1759 – 1823)



Playfair's trade-balance time-series chart, 1786

Charts: a collection of widely accepted visualisations



PIE CHART



COLUMN CHART



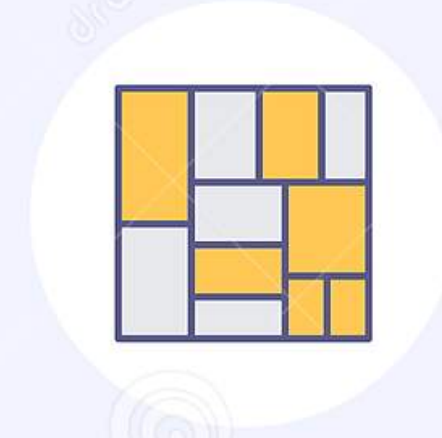
HISTOGRAM



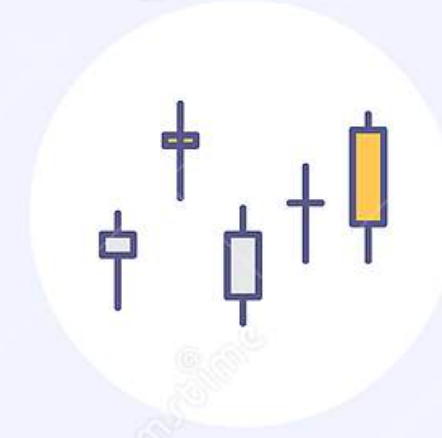
GRAPH



AREA CHART



TREEMAP



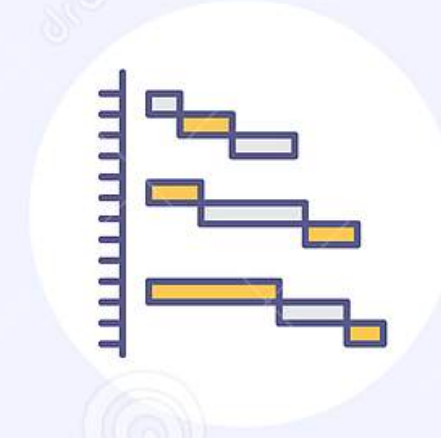
STOCK ANALYSIS



POLAR DIAGRAM



TABLE



GANTT CHART



BAR CHART



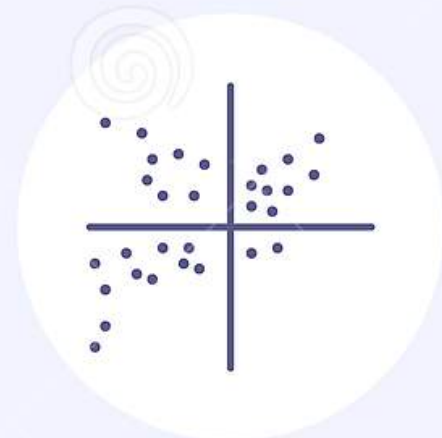
GAUGE CHART



BUBBLE CHART



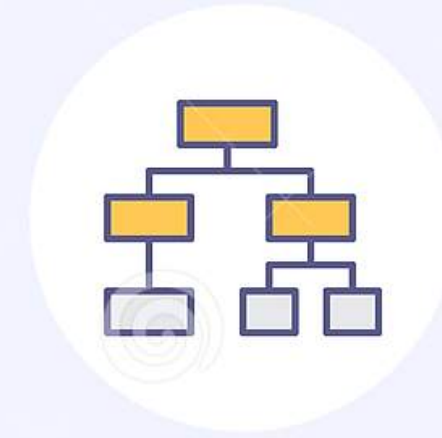
DONUT CHART



SCATTER CHART



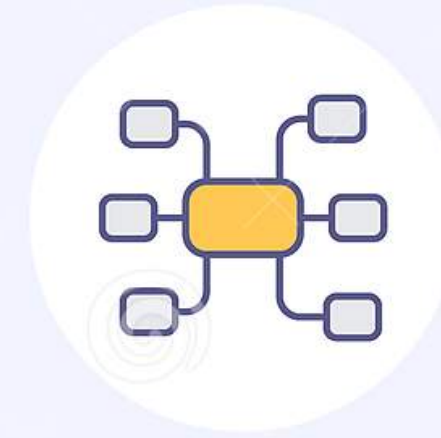
FINANCIAL ANALYSIS



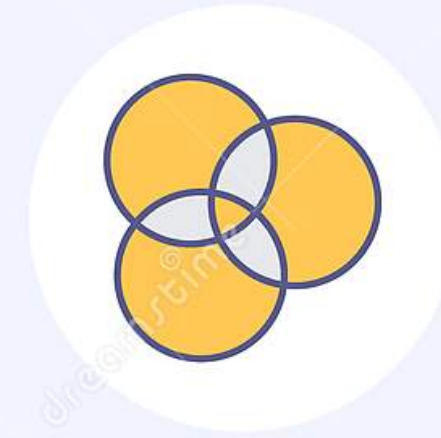
ORG CHART



COMBO CHART



MIND MAP



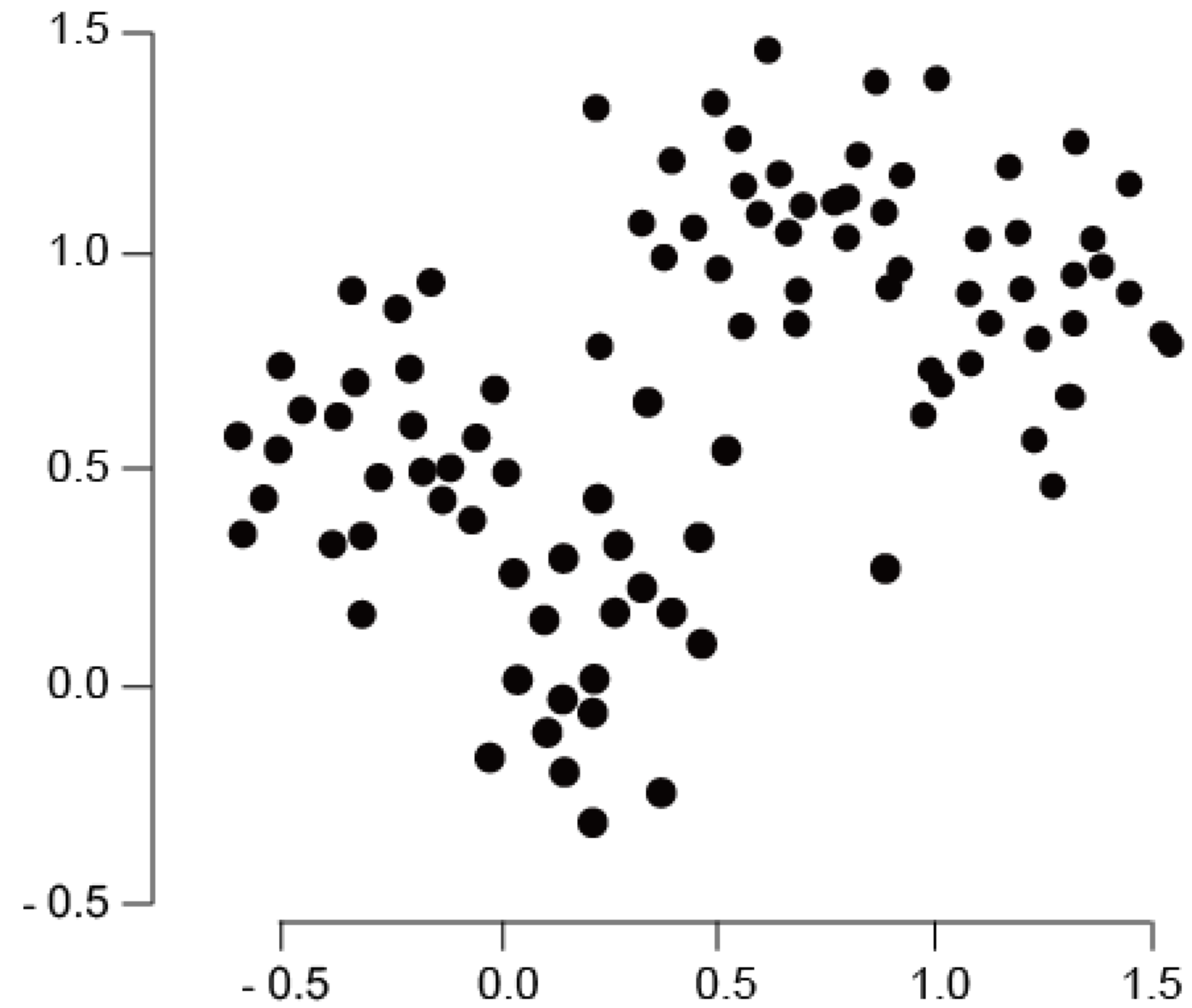
VENN DIAGRAM

Better Understanding of Visual Perception

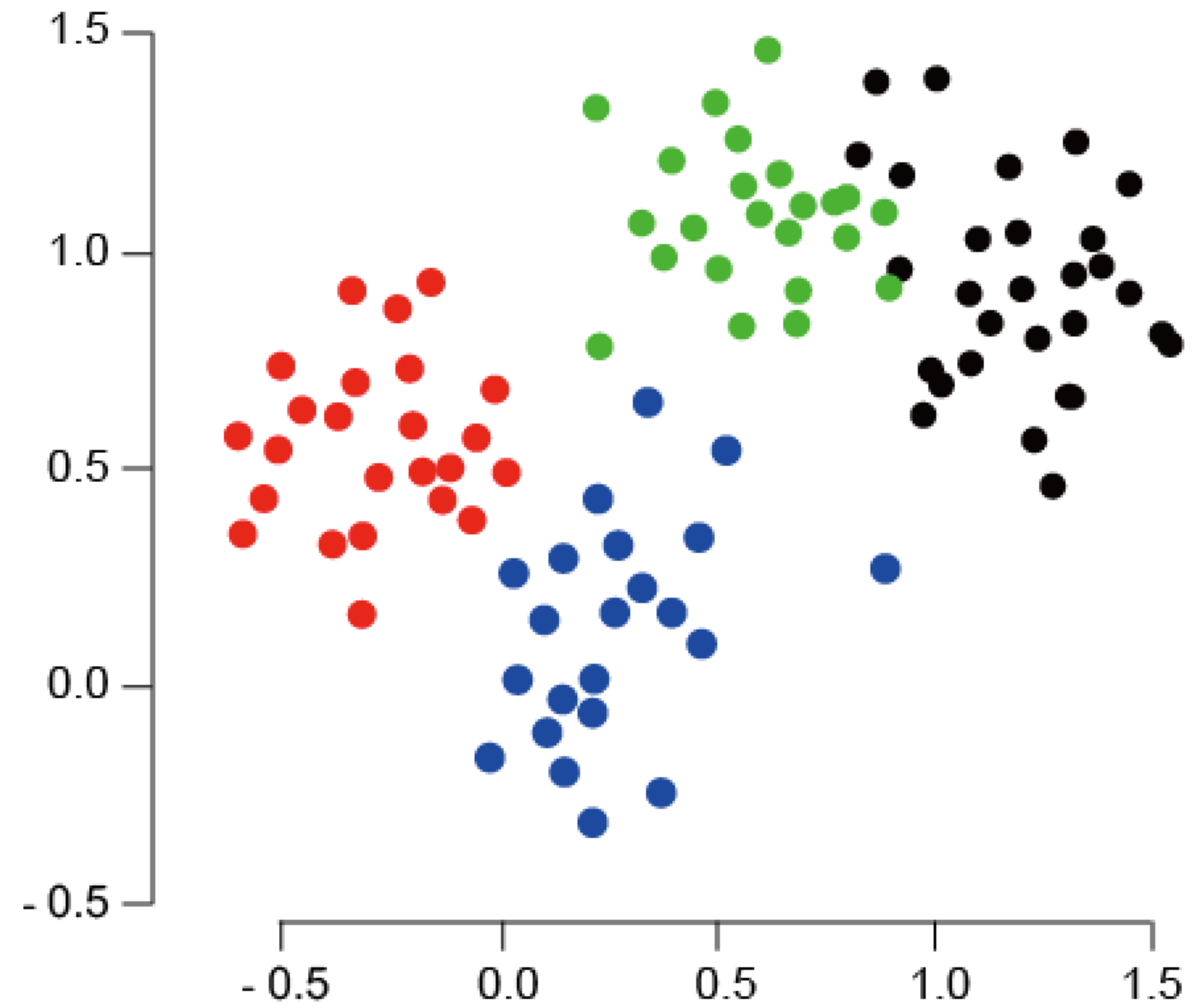


Renewing Charts

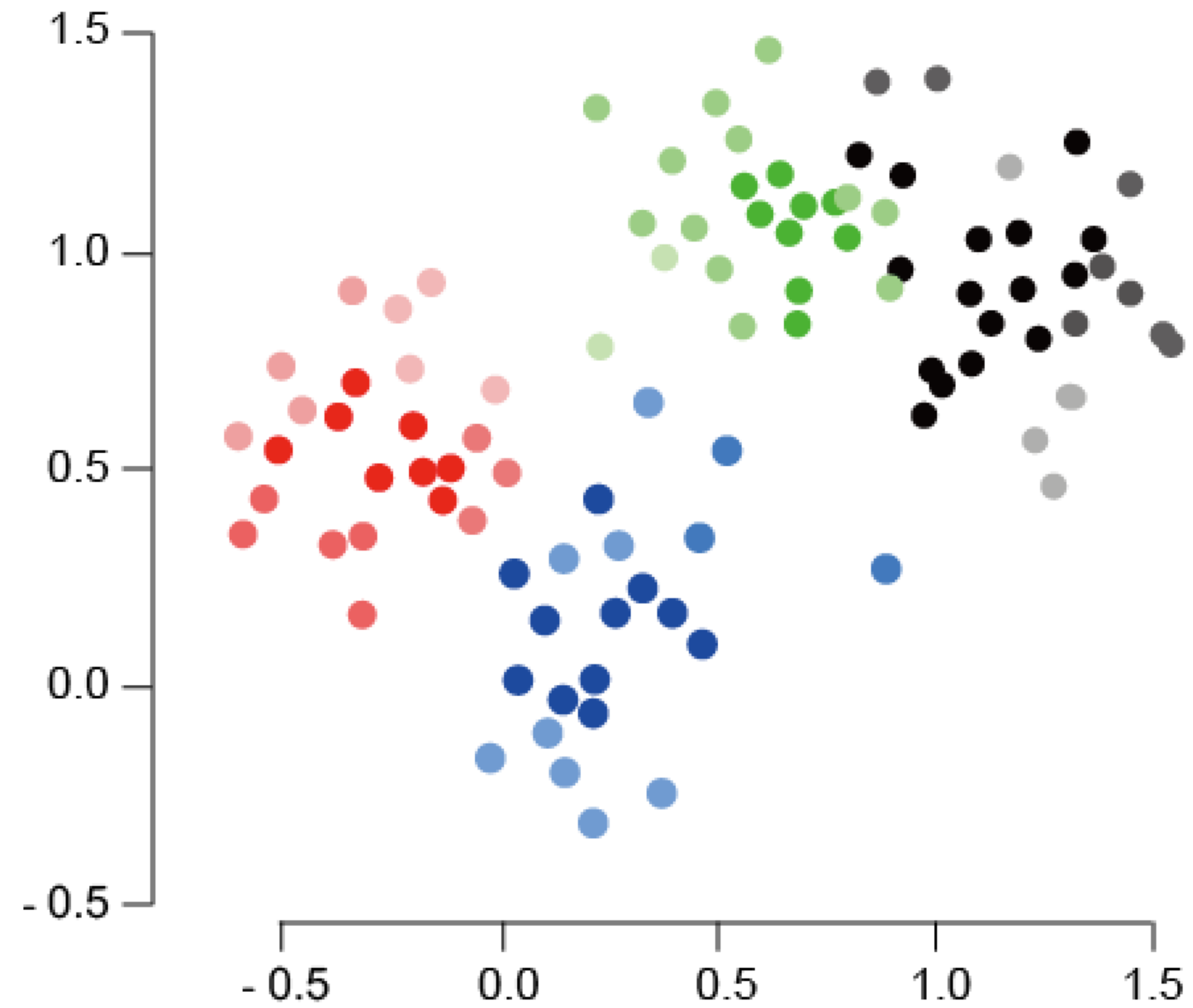
Scatterplot



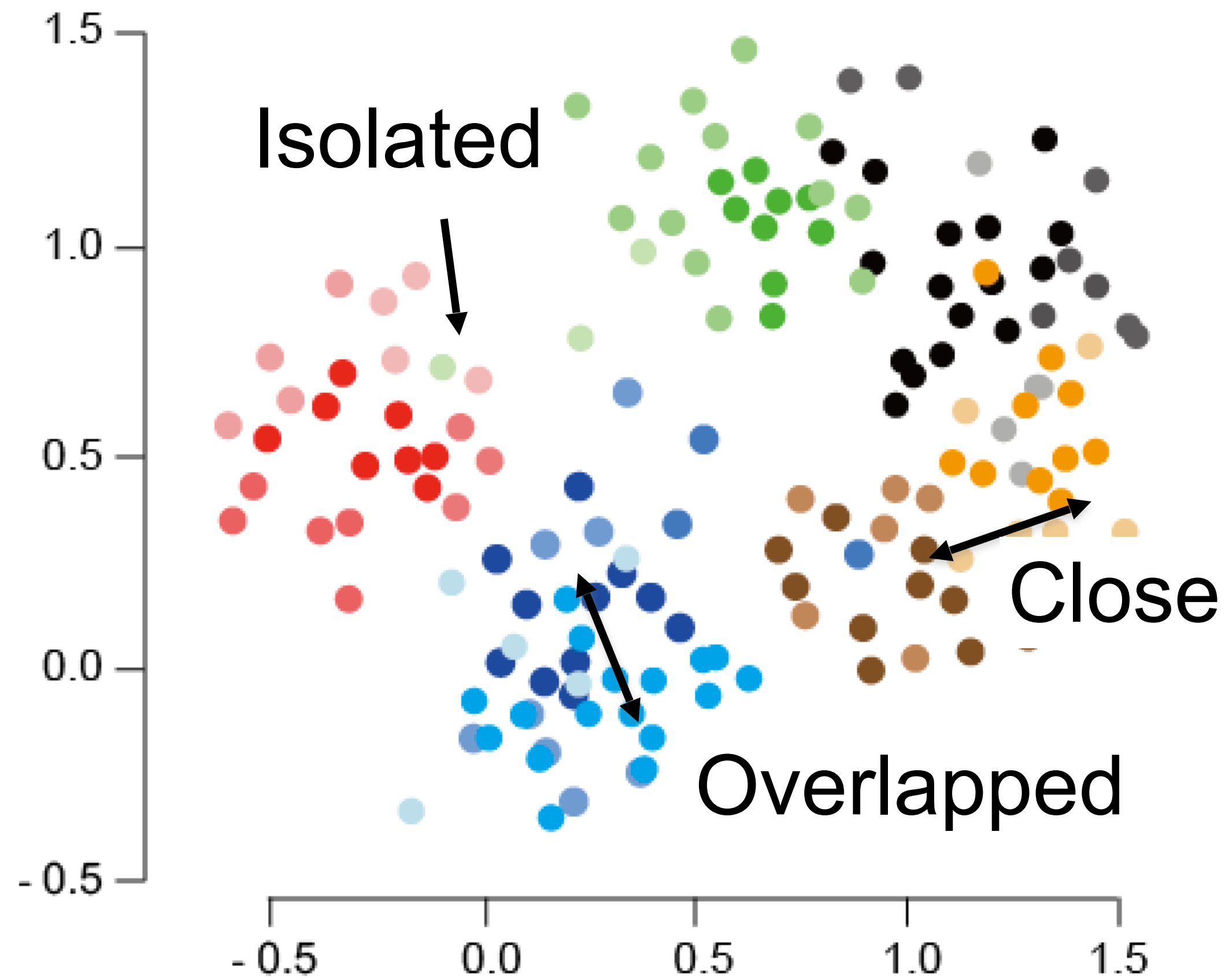
Multi-Class Scatterplot



Multi-Class Scatterplot with Associating Uncertainty



Visualize Multiclass in Scatterplot



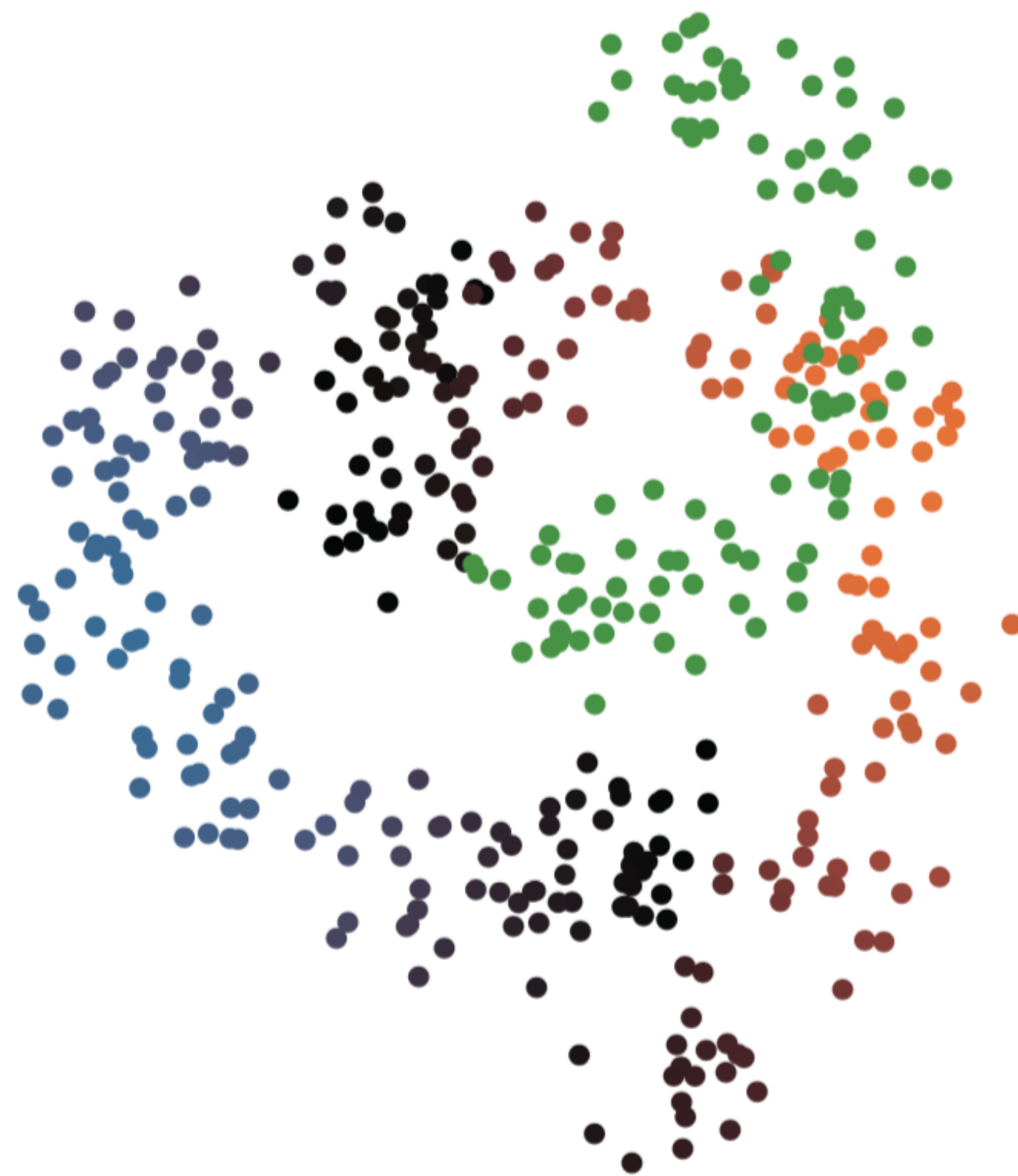
- To provide better perception of groups
- To convey associating uncertainty

Winglets: Visualizing Association with Uncertainty in Multi-class Scatterplots

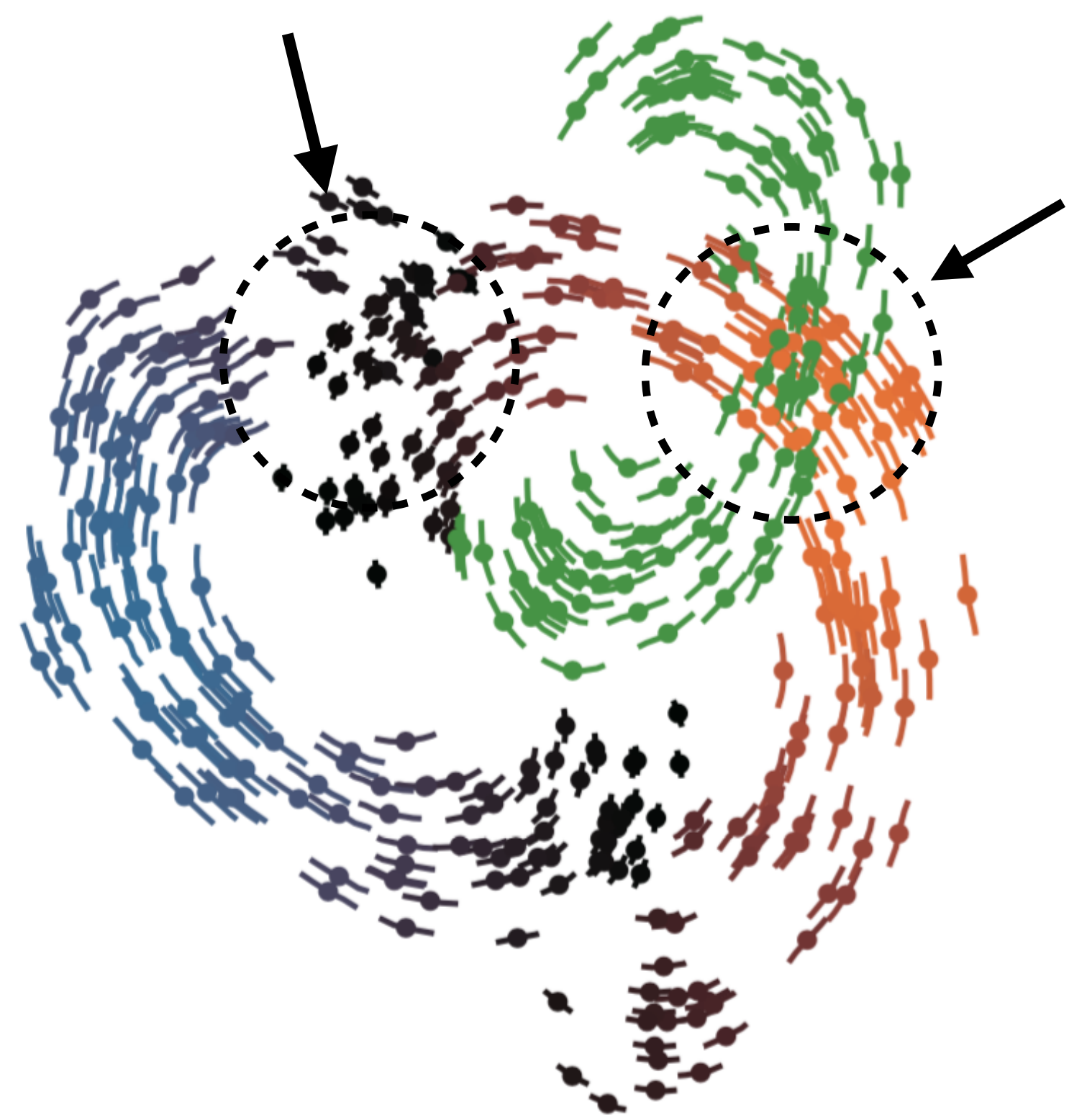
Min Lu¹, Shuaiqi Wang¹, Joel Lanir², Noa Fish³, Yang Yue¹
Daniel Cohen-Or³ and Hui Huang¹

¹ Shenzhen University, China ² University of Haifa, Israel ³ Tel Aviv University, Israel





Winglets



Perceptual Grouping

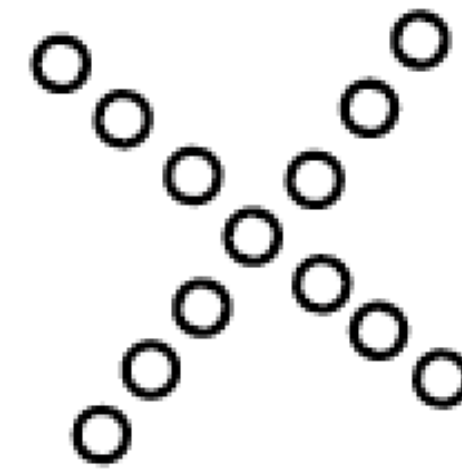
- **Gestalt Principles** [Wertheimer, 1923]
 - a set of principles in psychology
 - about how objects are visually perceived as groups by human



Proximity Principle



Similarity Principle



Continuity Principle



Closure Principle

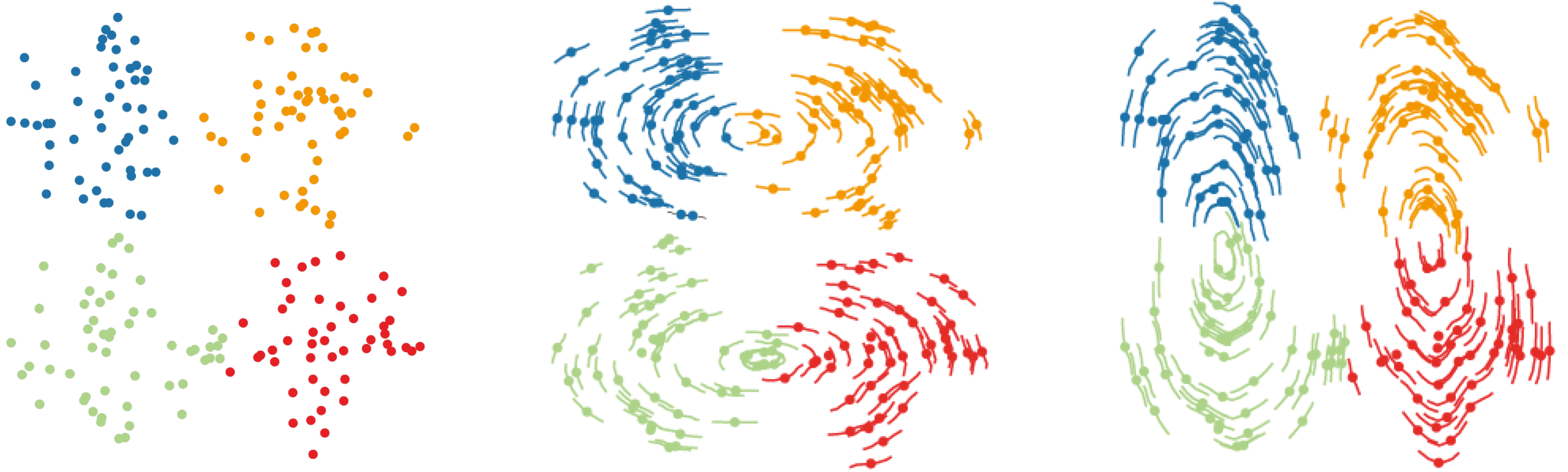
[1] M. Wertheimer. Untersuchungen zur lehre von der gestalt. ii. *Psychological Research*, 4(1):301–350, 1923.

Closure Principle

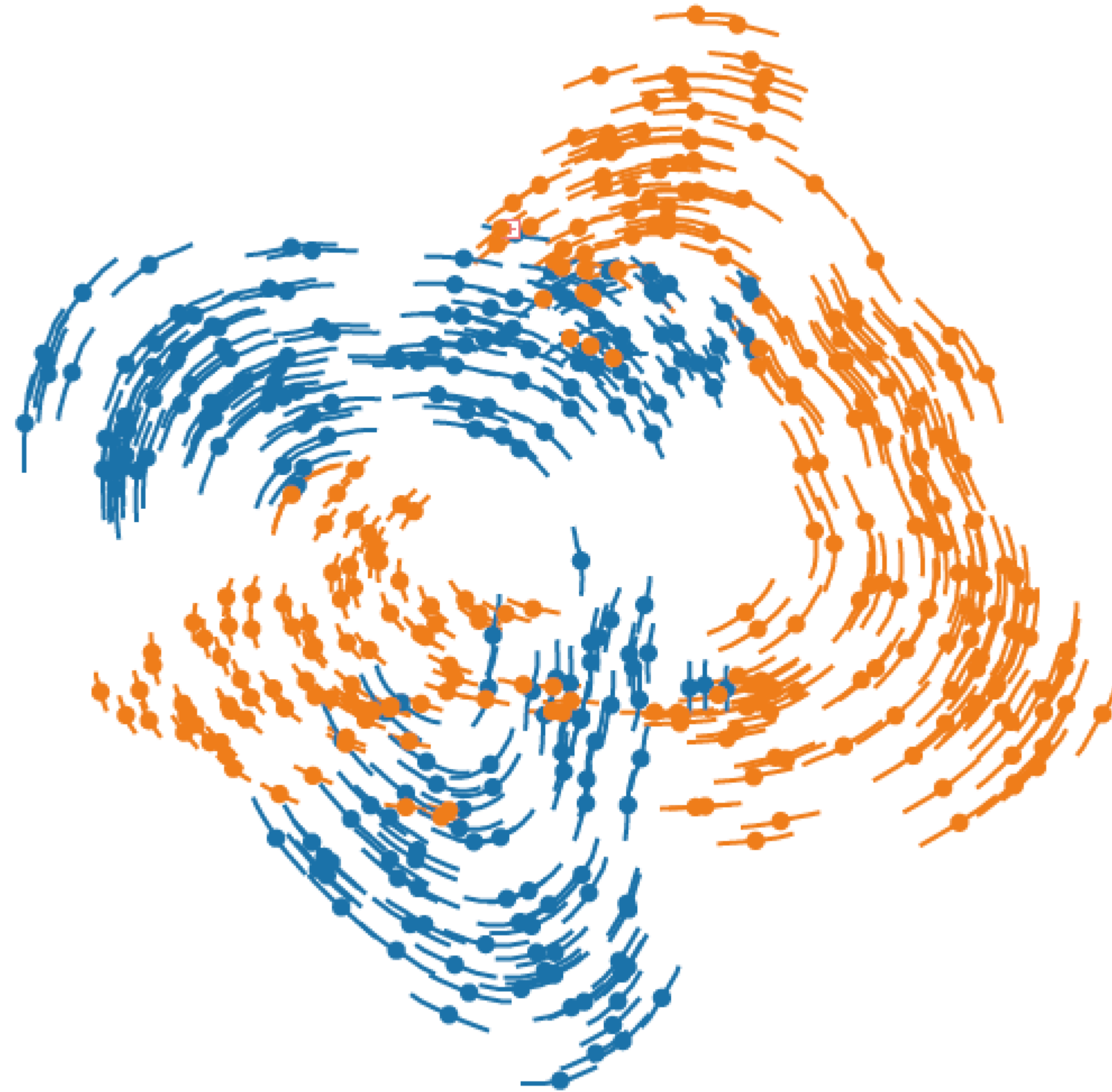
- We complete figures even when part of the information is missing



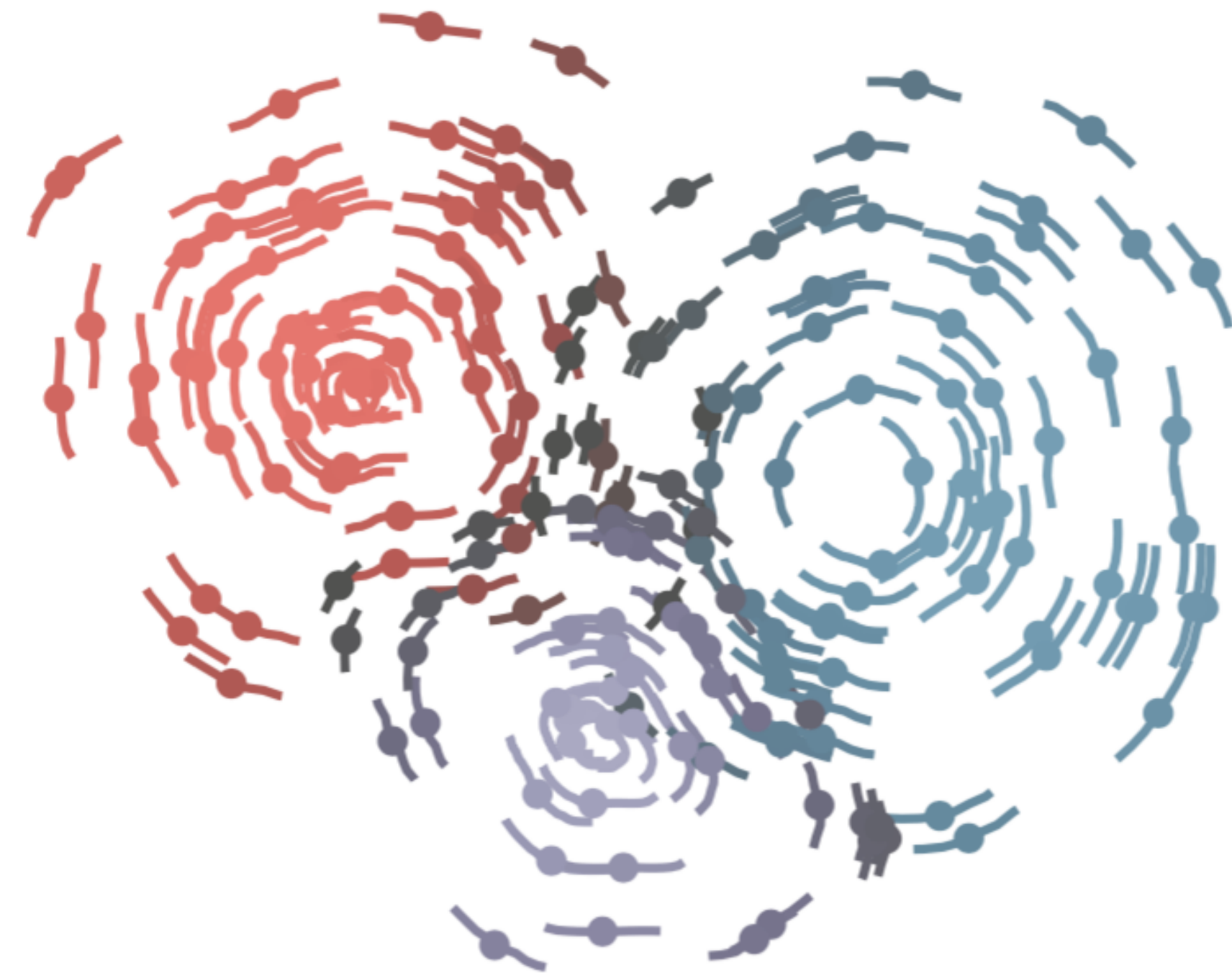
Winged Scatterplot



Winged Scatterplot (cont.)

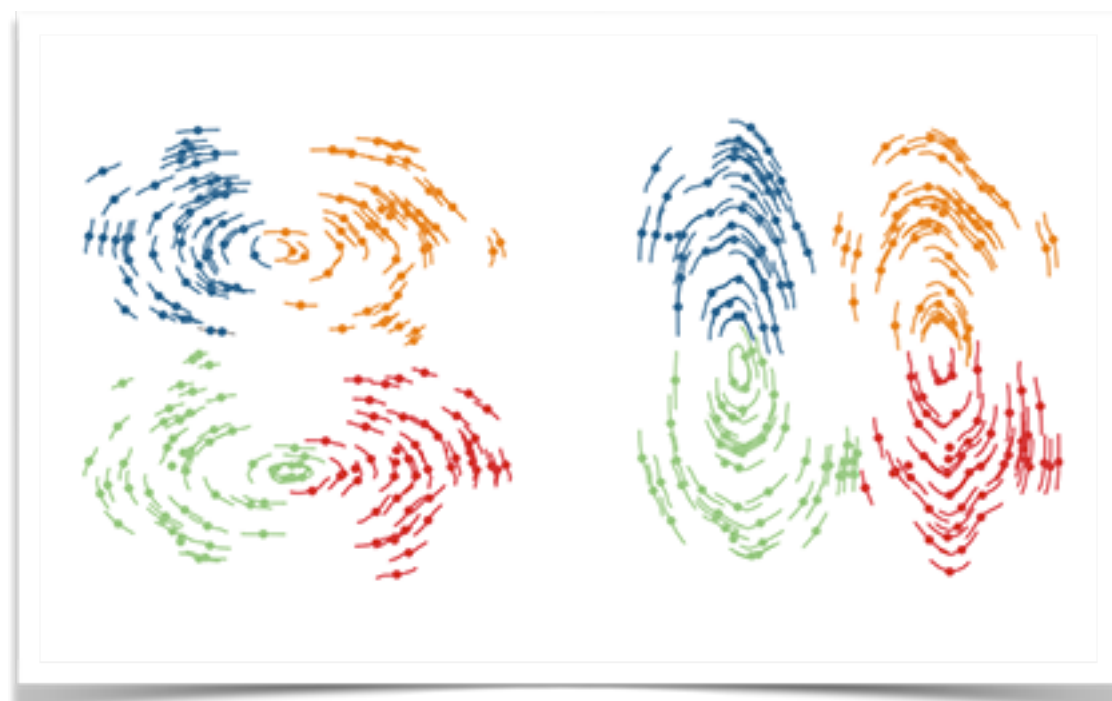


Winged Scatterplot (cont.)



Renewing Multiclass Scatterplot

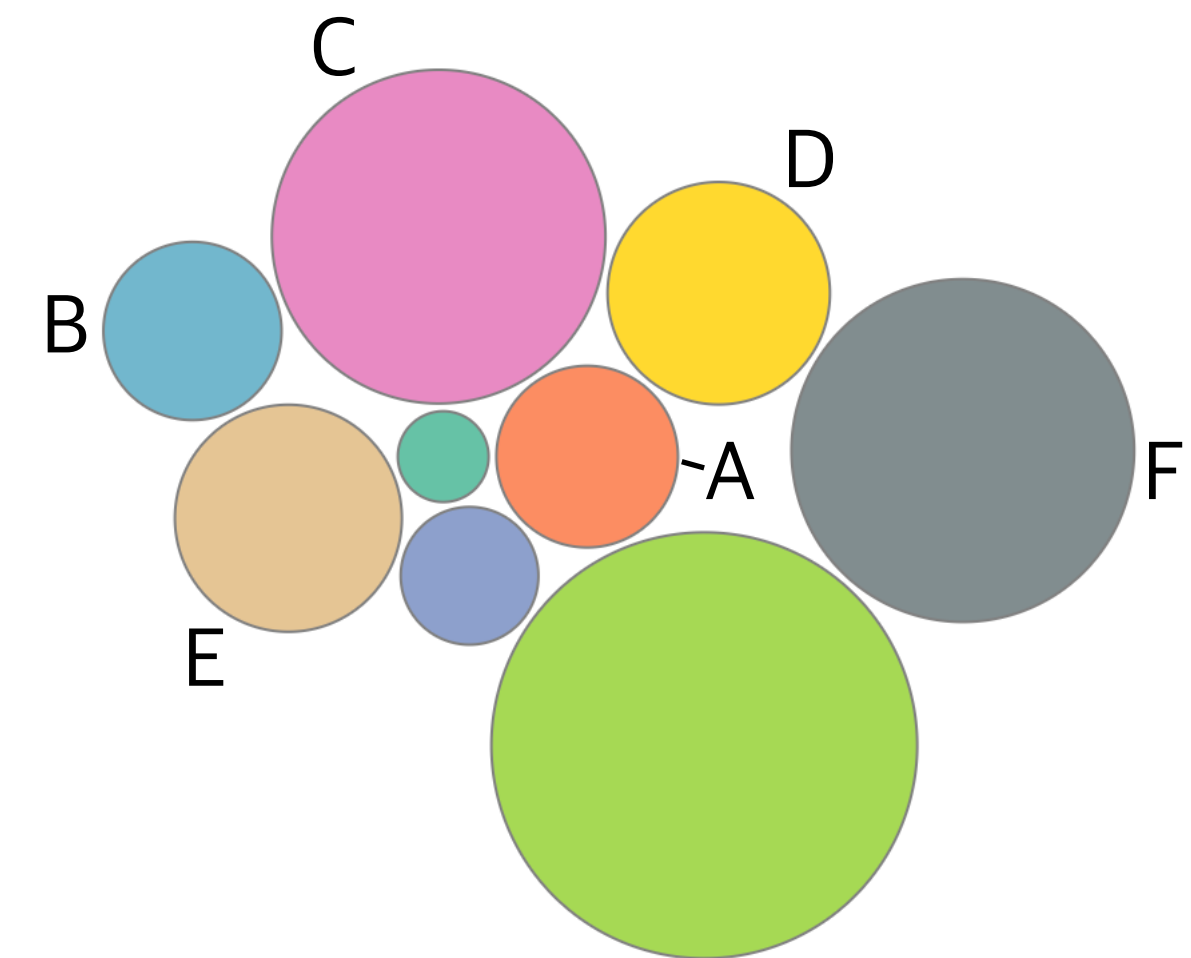
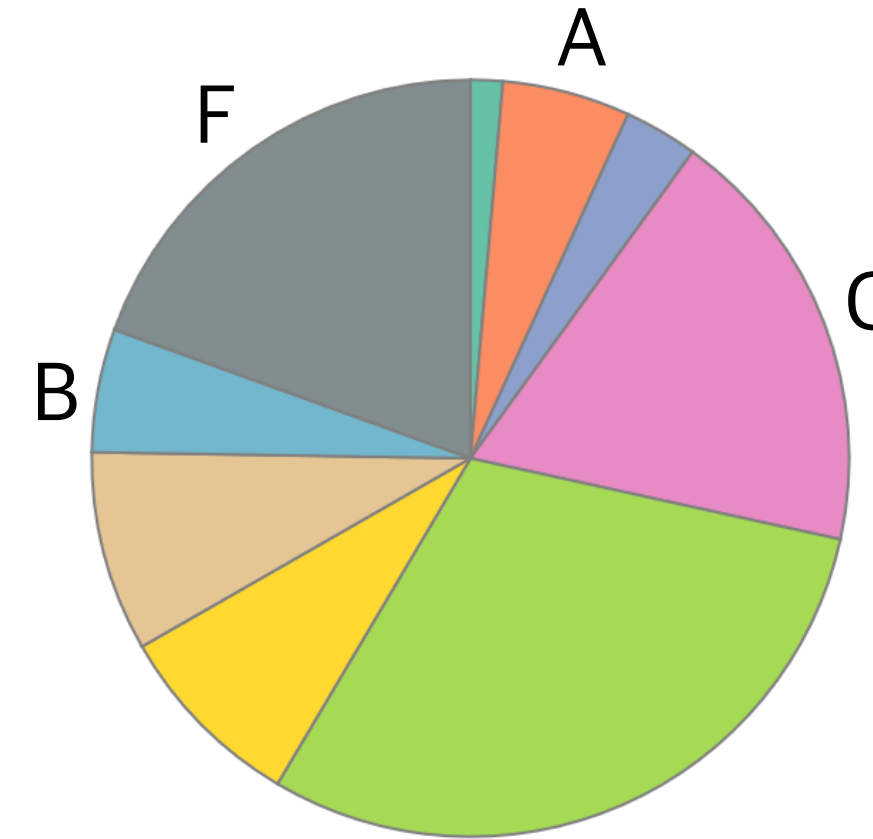
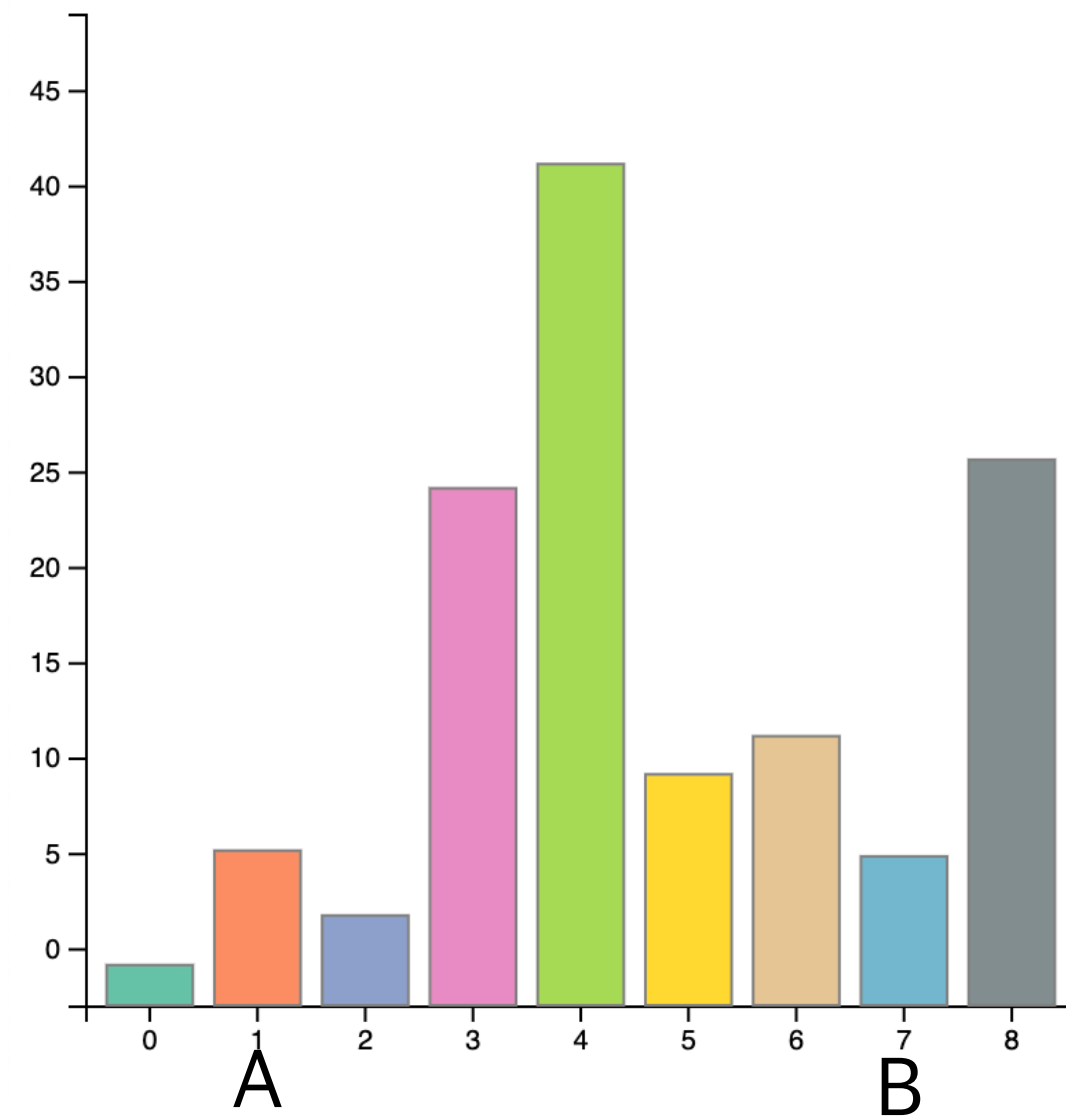
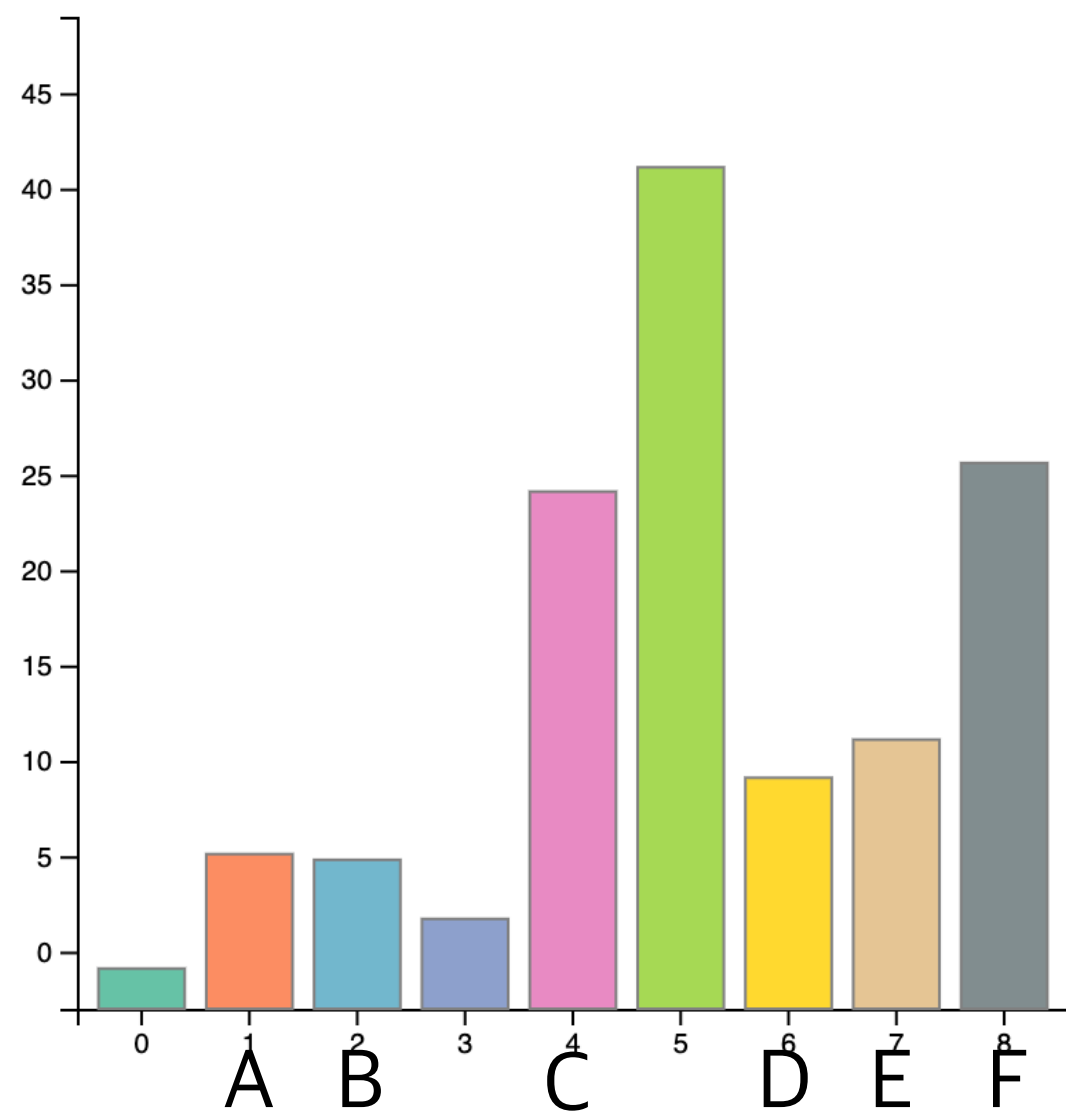
with Closure Gestalt Principle



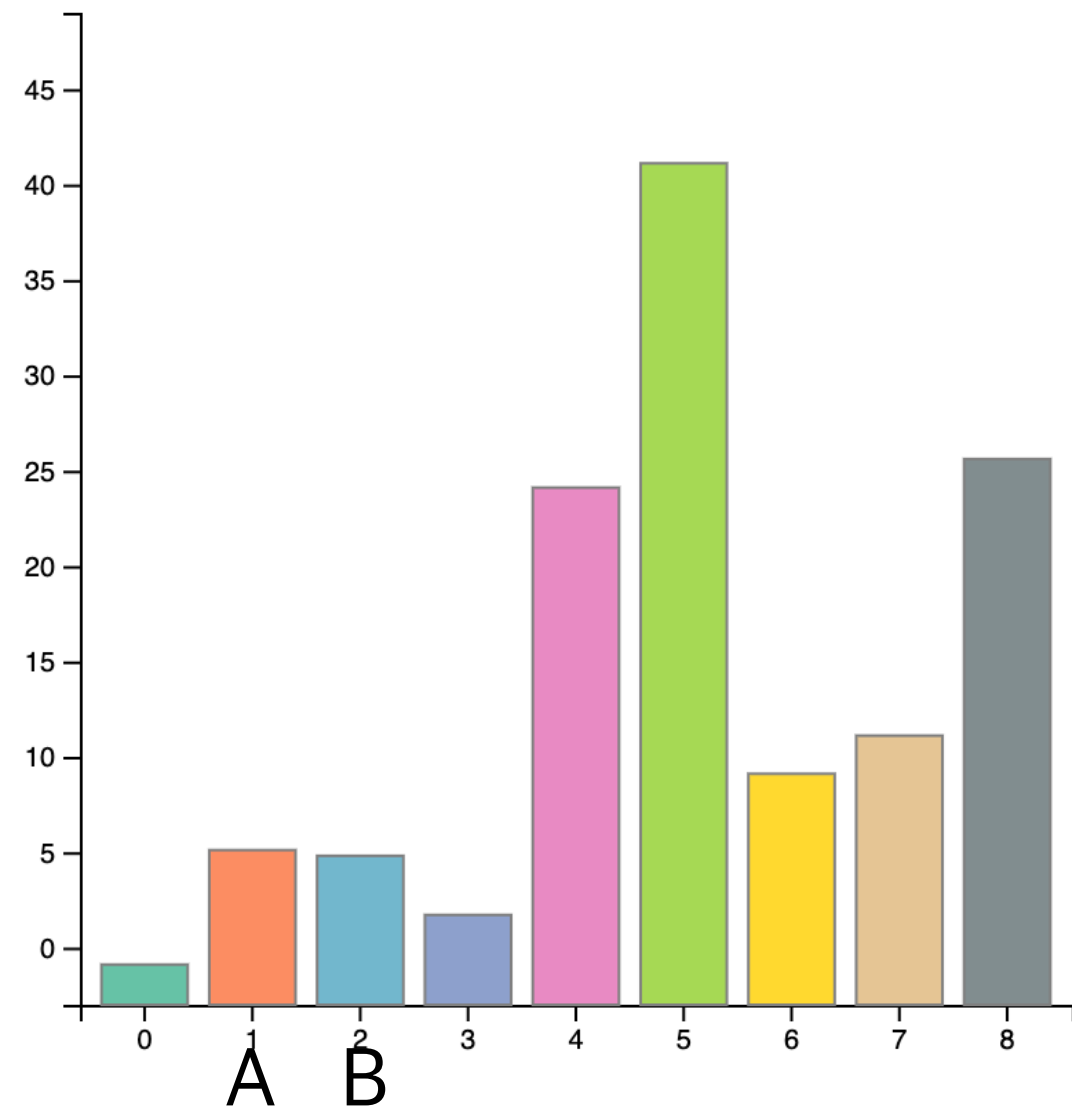
Winglets [InfoVis'19]

Lu, M., Wang, S., Lanir, J., Fish, N., Yue, Y., Cohen-Or, D., & Huang, H. (2019). Winglets: Visualizing association with uncertainty in multi-class scatterplots. IEEE transactions on visualization and computer graphics, 26(1), 770-779.

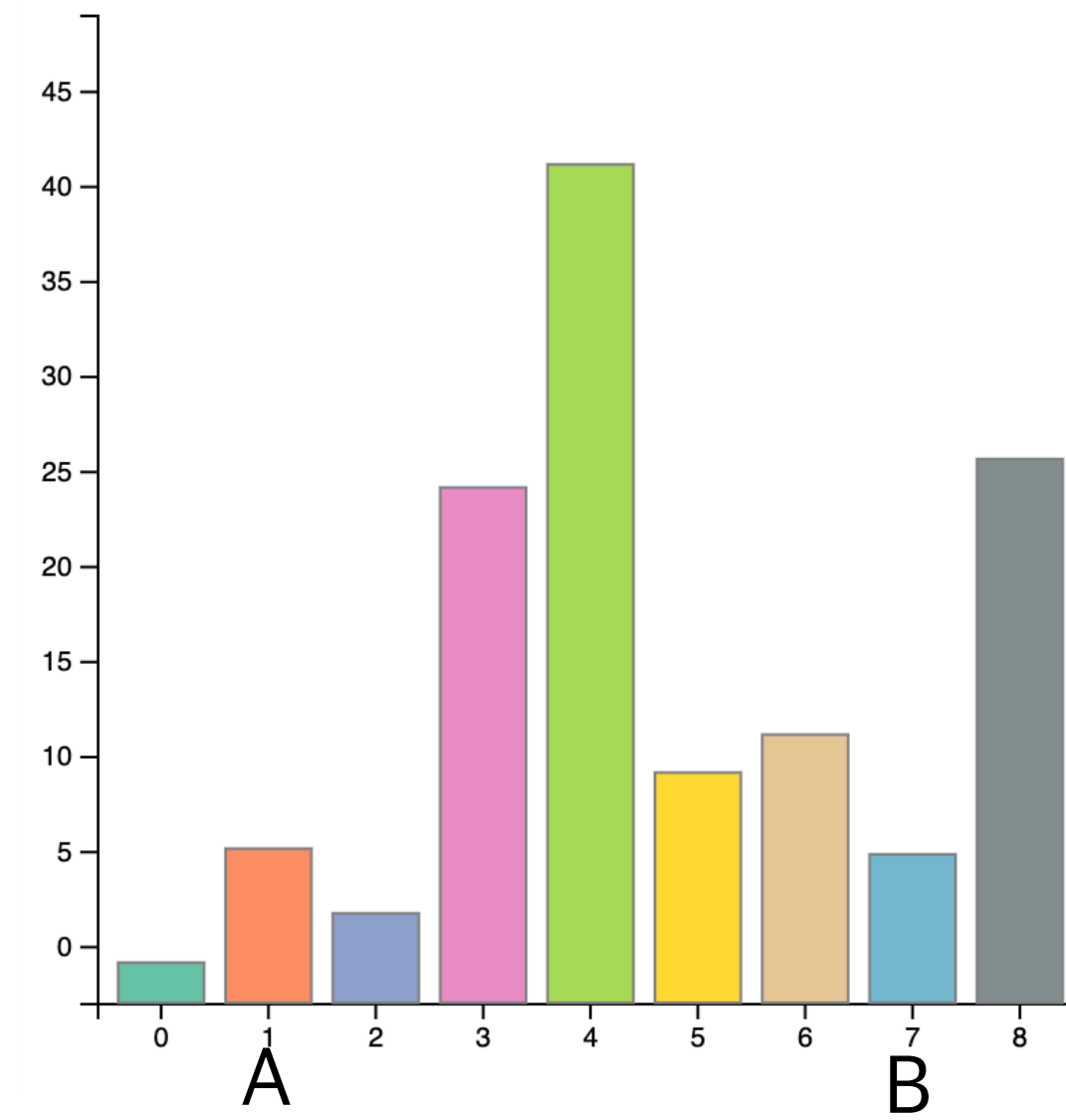
Open source code: <https://github.com/DarkDisasters/Winglets/>




 Visual Precision Decreases



Height Difference: noticeable



Height Difference: not noticeable

Just Noticeable Difference (JND)

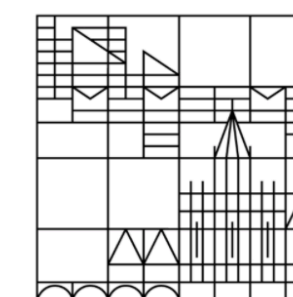
Modeling Just Noticeable Differences in Charts

Min Lu¹, Joel Lanir², Chufeng Wang¹, Yucong Yao¹, Wen Zhang¹,
Oliver Deussen³ and Hui Huang¹

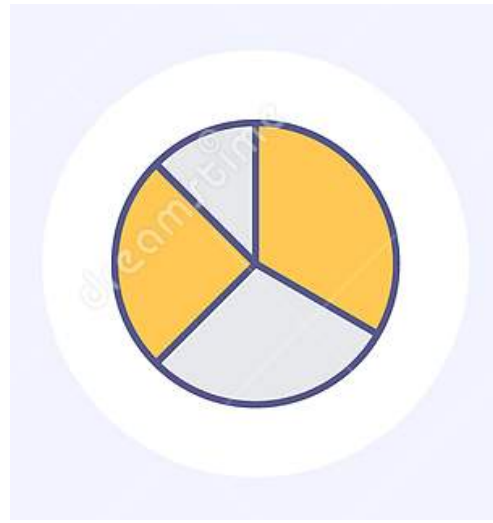
¹ Shenzhen University, China ² University of Haifa, Israel ³ University of Konstanz, German



Universität
Konstanz



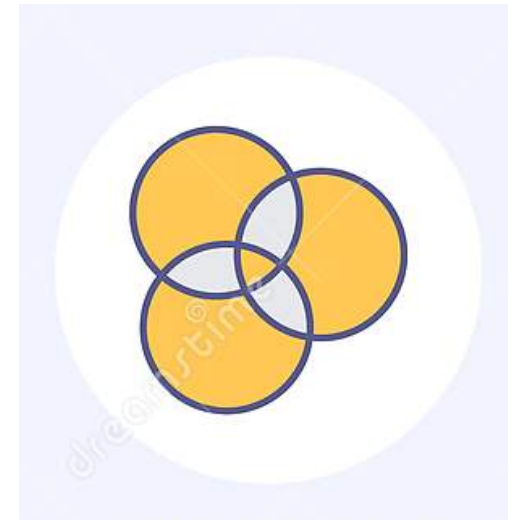
Three Types of Charts



Pie chart



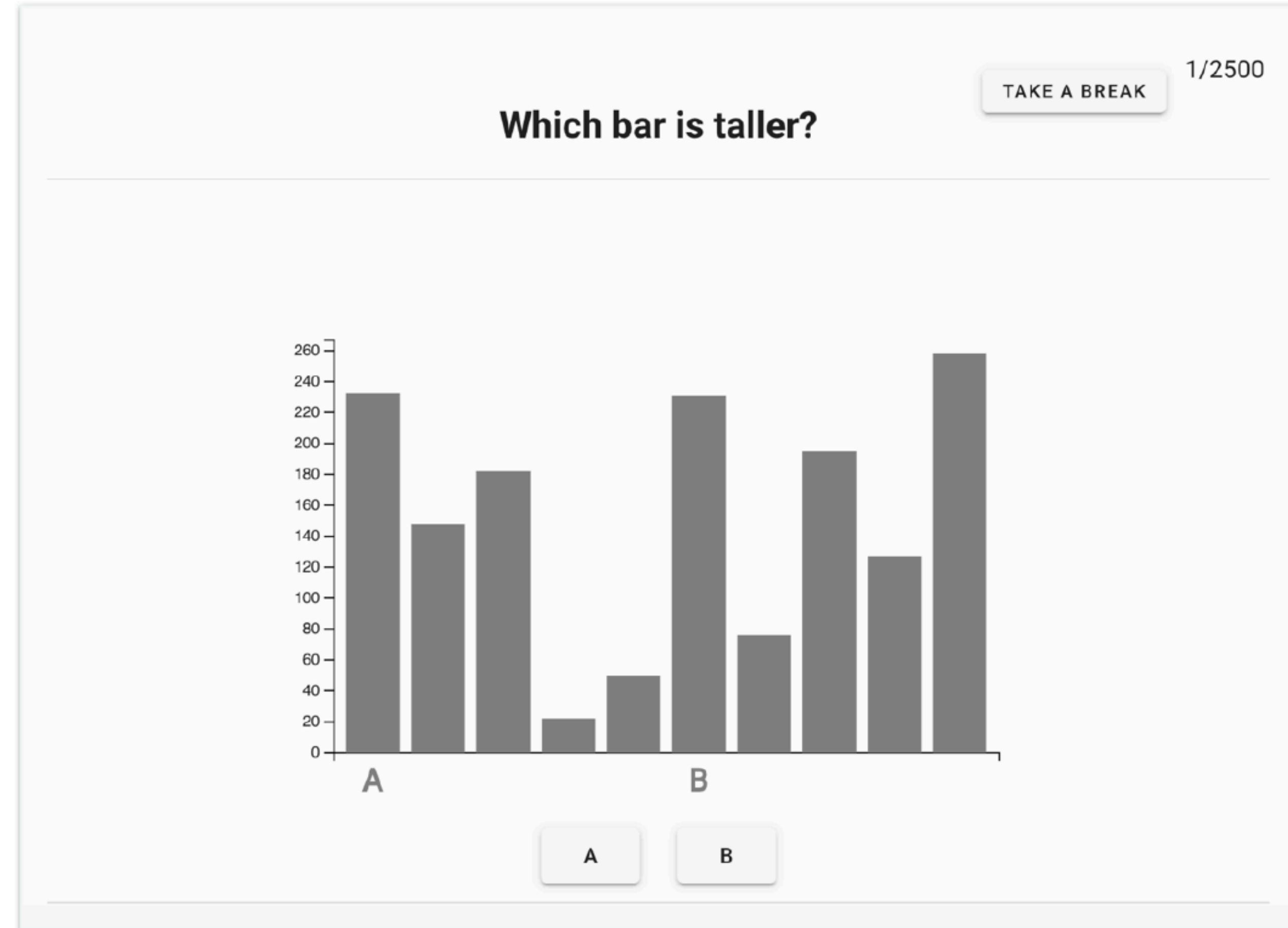
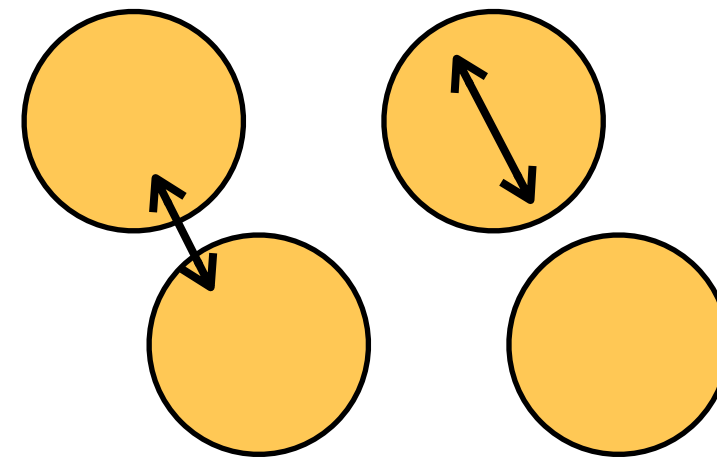
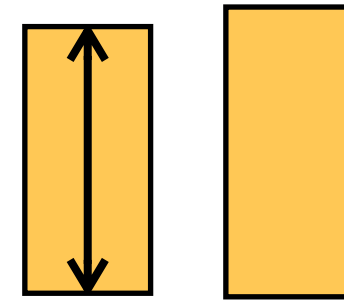
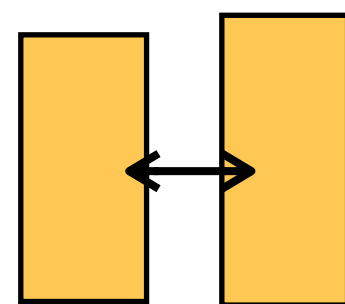
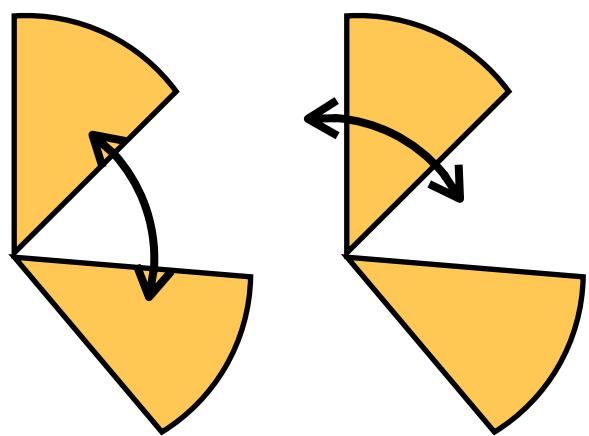
Bar chart



Bubble chart

Two Variables

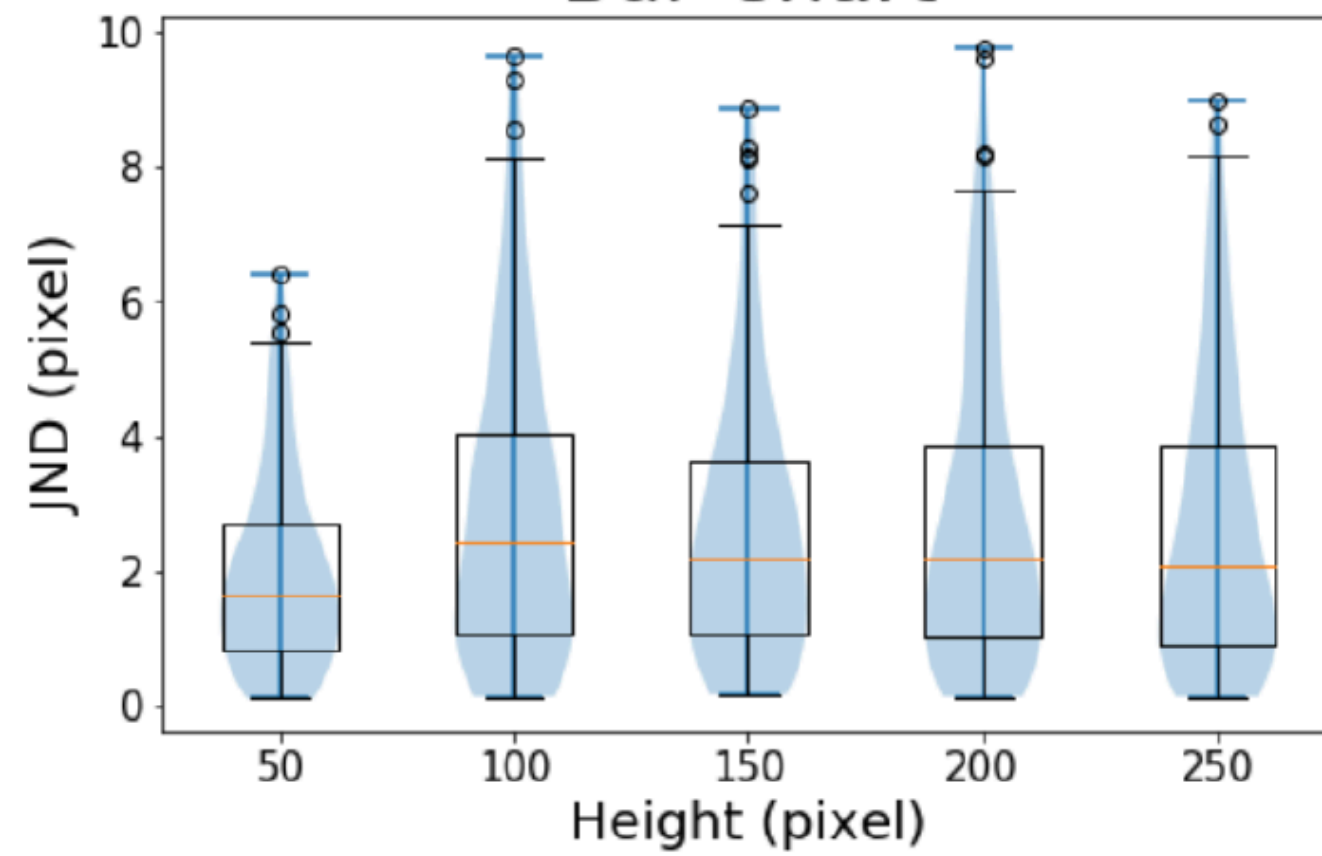
- Distance between objects
- Intensity of objects



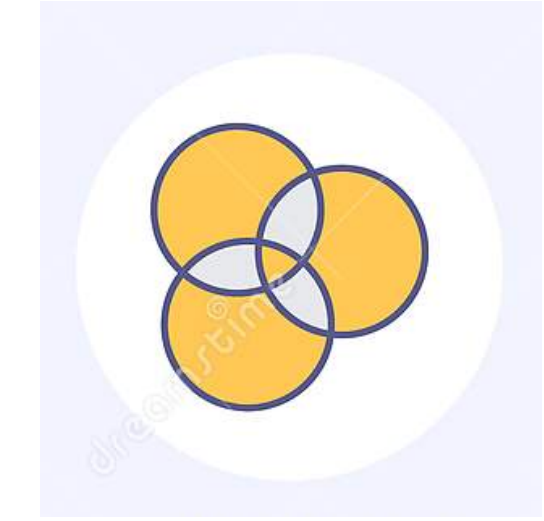
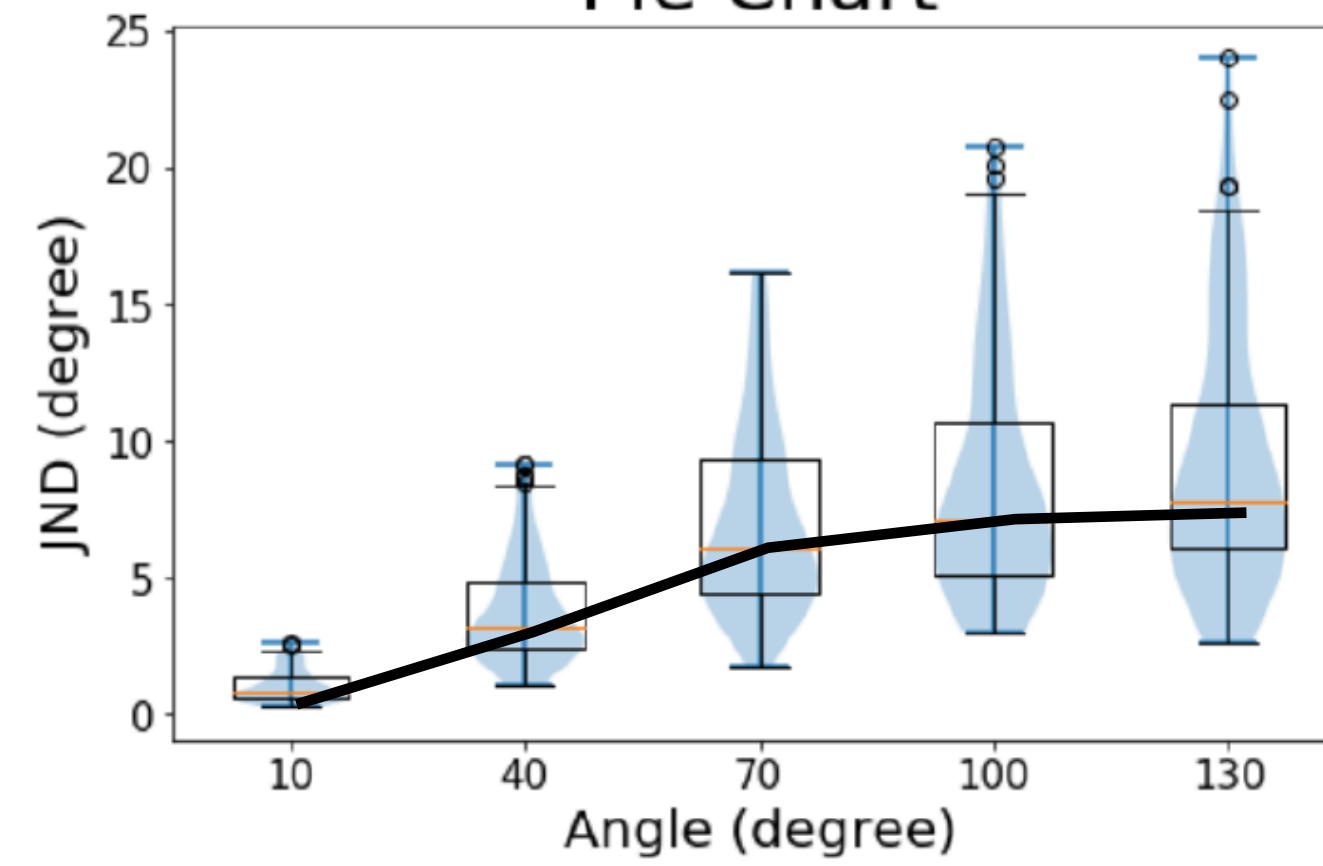
<http://47.96.162.114:8080/>



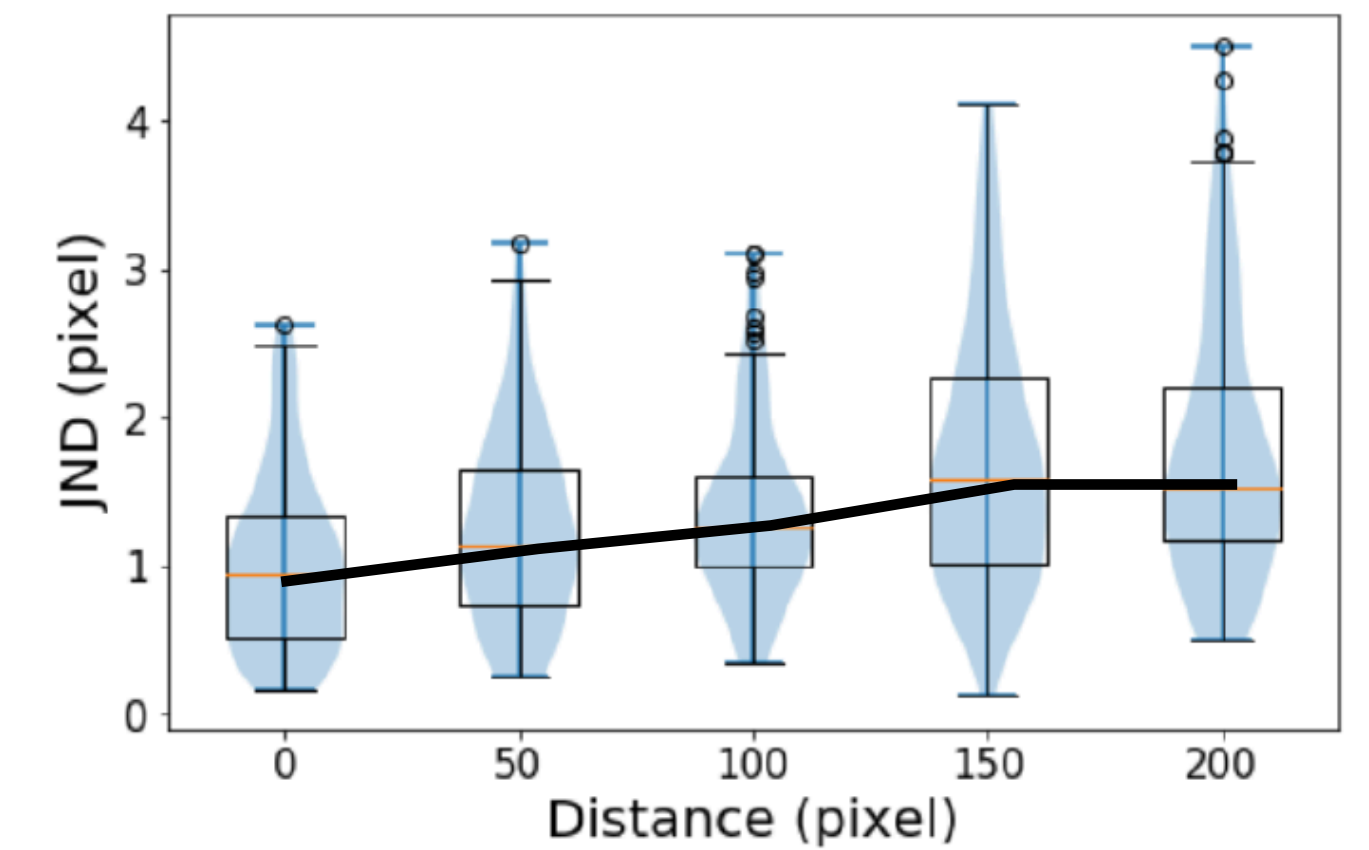
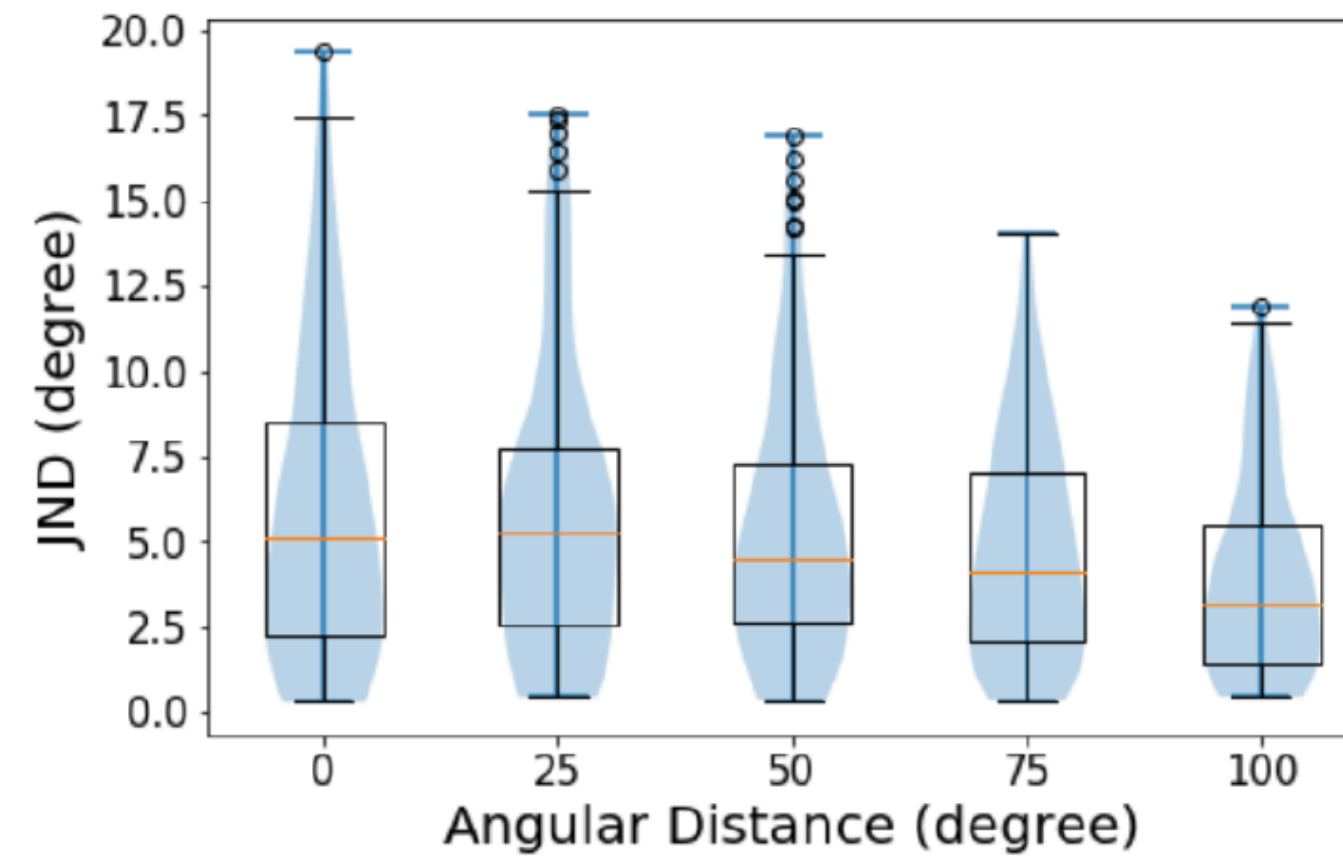
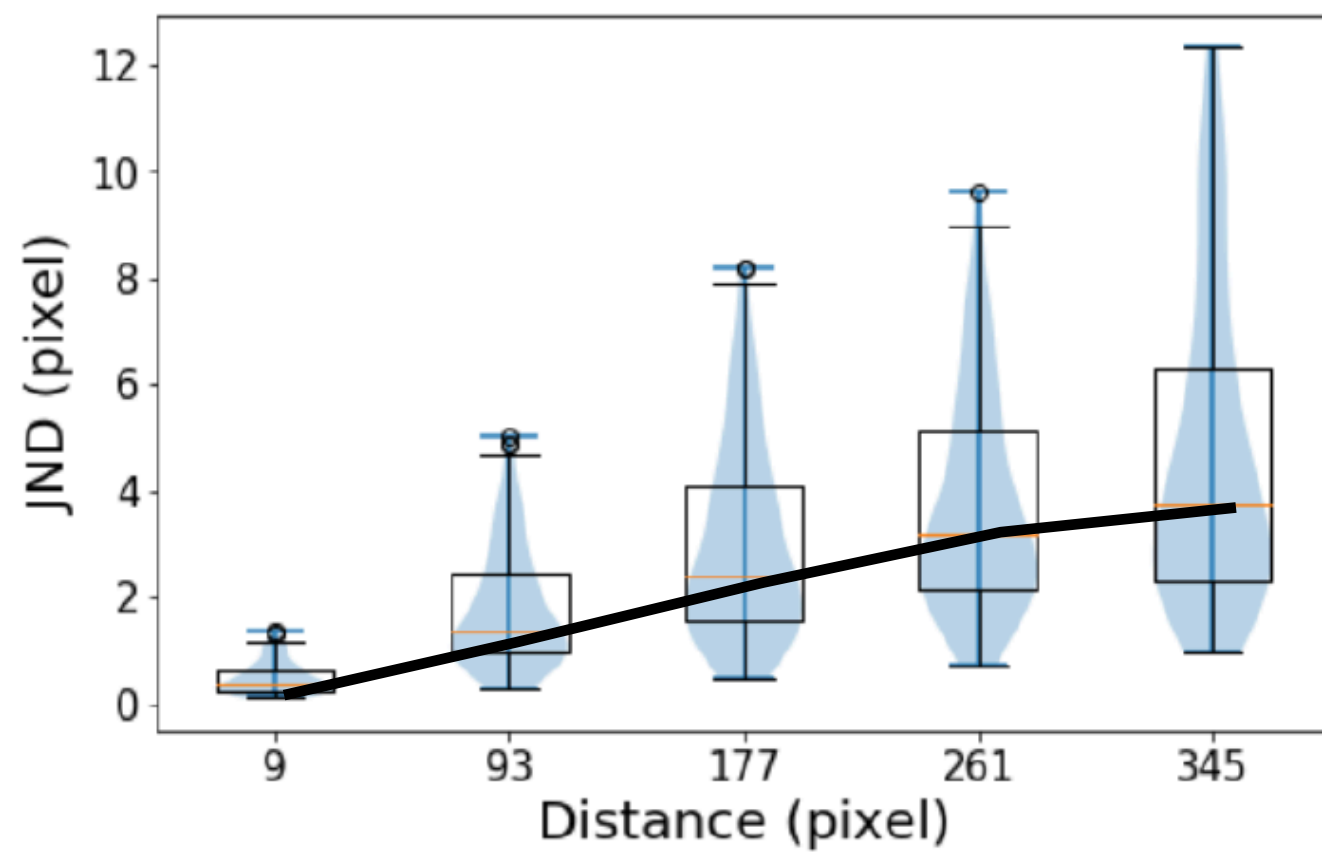
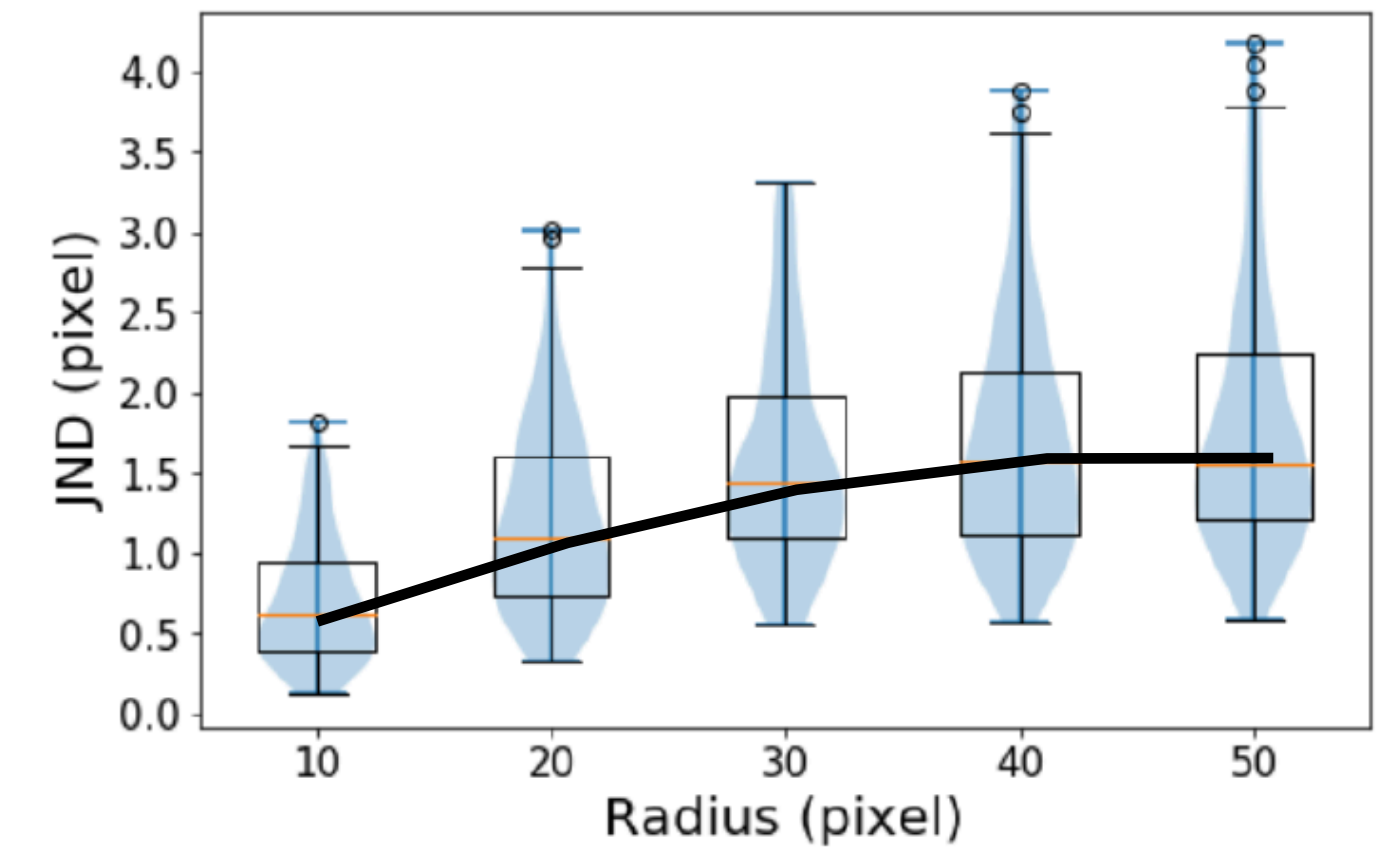
Bar Chart



Pie Chart



Bubble Chart



$$\log(JND_{i,c}) = \beta_{c,0} + \beta_{c,1}Distance_i + \beta_{c,2}Intensity_i + u_k + \varepsilon_i$$

Linear model	Coefficients						Normality of residuals	Skewness	Excess kurtosis	Homosce-dasticity
	β_0	p	β_1	p	β_2	p				
Bar	0.6211	p=0.2189	0.0156	p<.0001	--	--	p<.0001	6.6566	66.8330	p=0.0068
Pie	1.0621	p=0.2175	--	--	0.0860	p<.0001	p<.0001	3.7003	30.3479	p=0.0005
Bubble	0.2820	p= 0.0609	0.0041	p<.0001	0.0290	p<.0001	p<.0001	1.4643	7.6624	p=0.0024
Log-linear Model										
Bar	-0.4653	p=0.0006	0.0065	p<.0001	--	--	p=0.0012	0.0124	0.2919	p=0.3942
Pie	0.2405	p=0.0247	--	--	0.0187	p<.0001	p=0.0019	-0.1634	-0.3535	p=0.1030
Bubble	-0.7697	p<.0001	0.0031	p<.0001	0.0235	p<.0001	p<.0001	-0.4606	0.9276	p=0.1405

Chart Enhancement

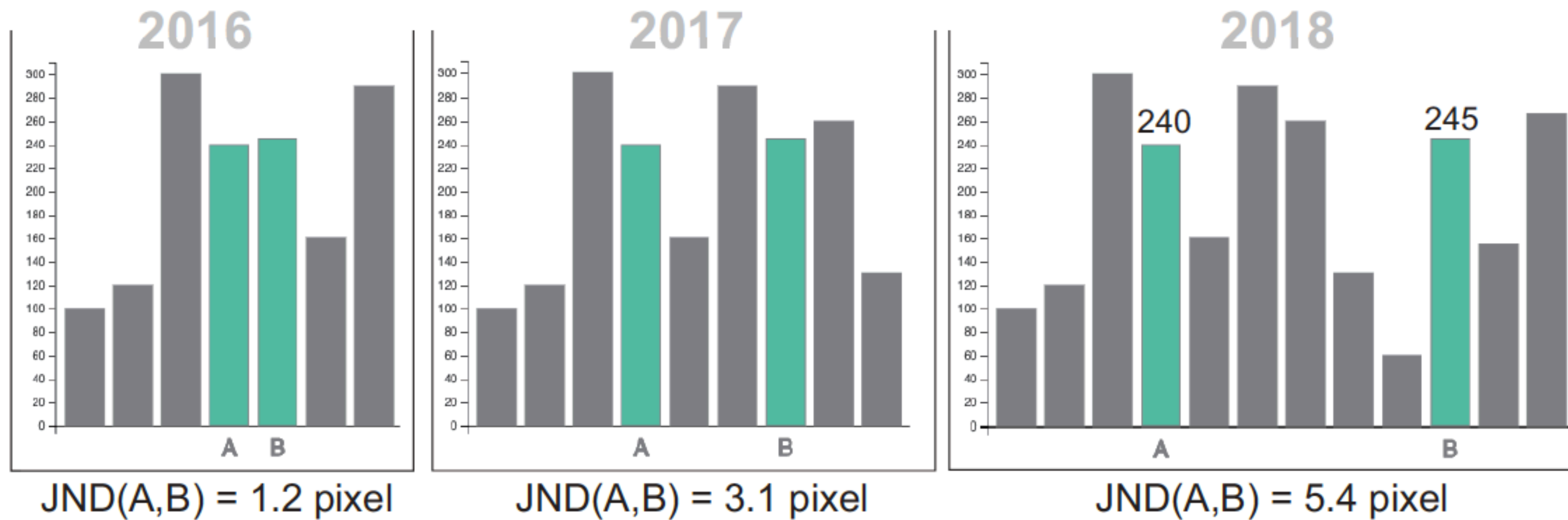
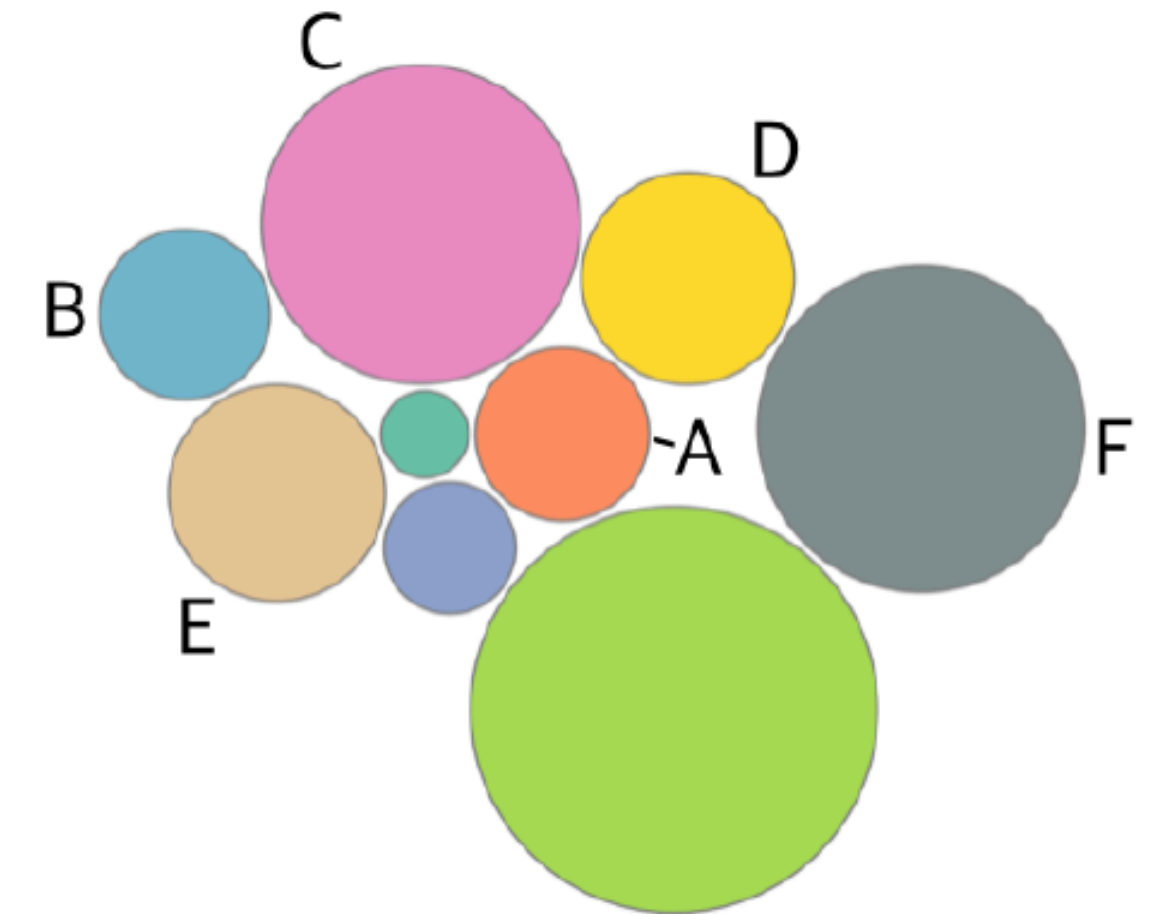
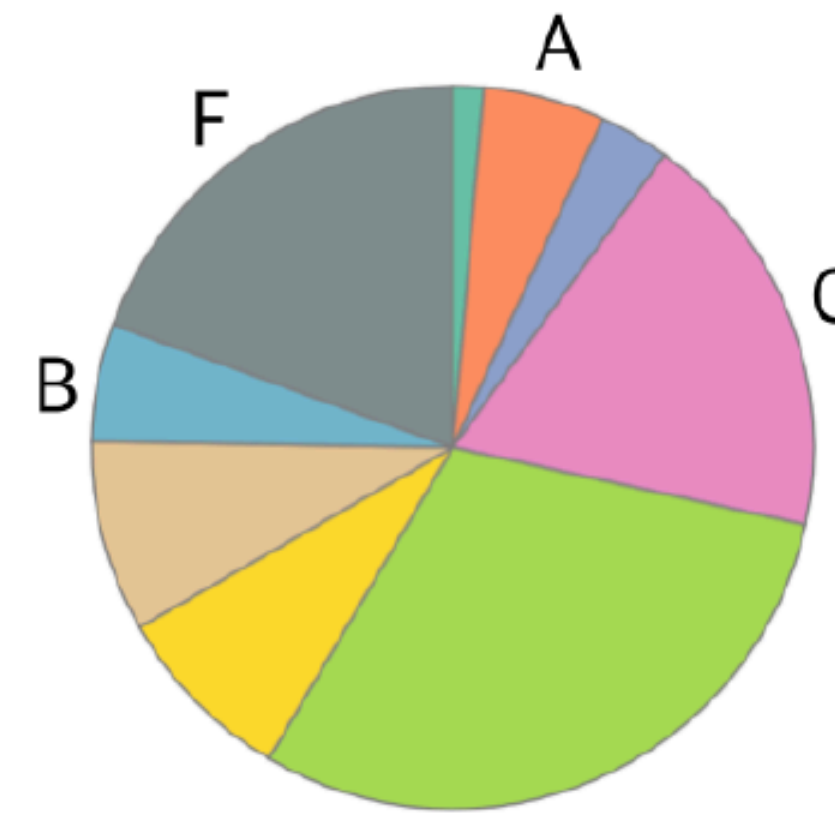
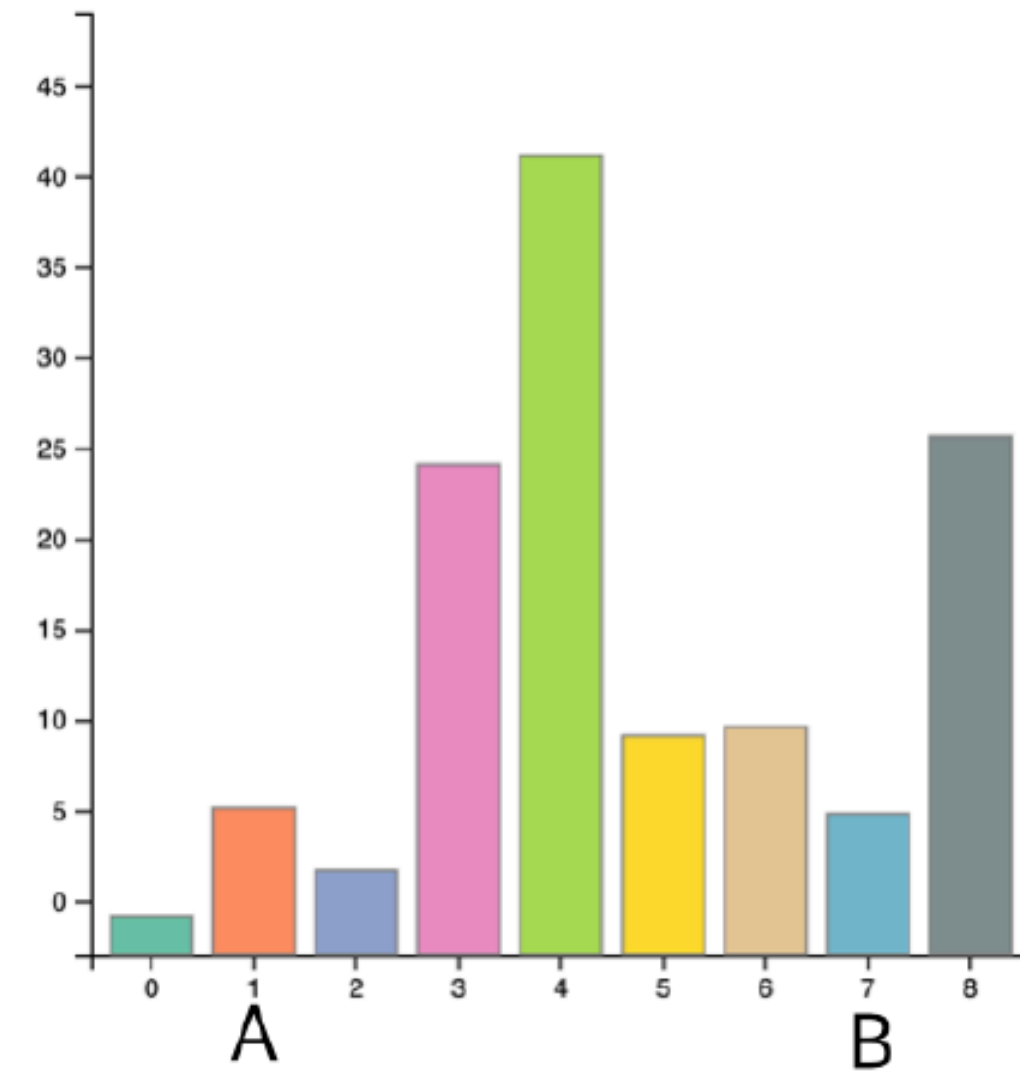
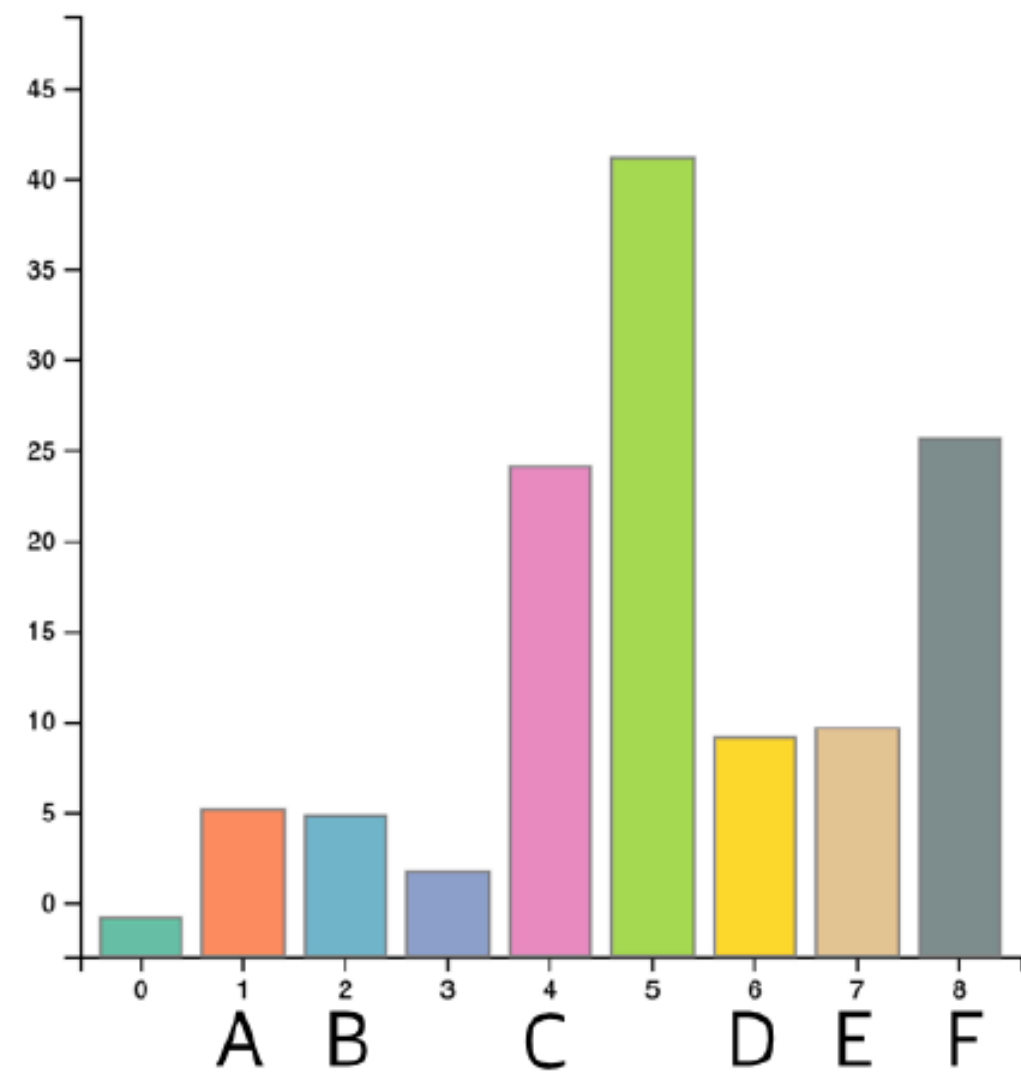


Chart Quality Measurement

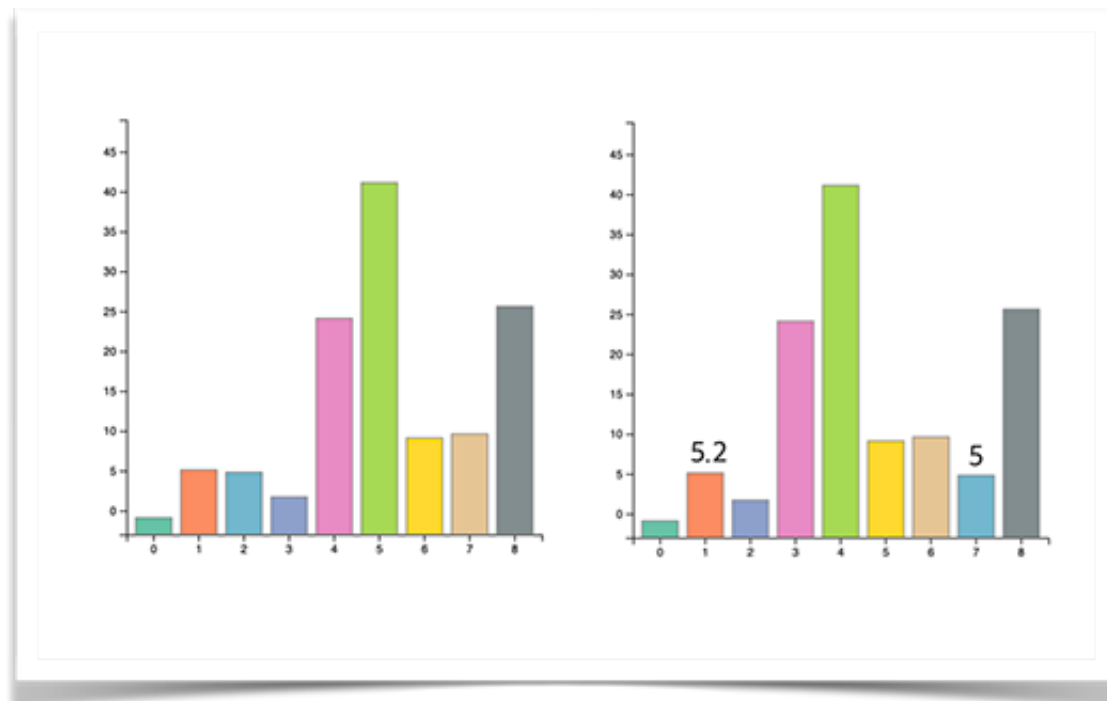


Renewing

Bar/Bubble/Pie Charts

with

JND Modeling



JND Modeling [Vis'21, Conditionally Accepted]

Lu, M., Lanir, J., Wang, C., Cong, Y., Zhang, W., Duessen, O., & Huang, H. (2021). Modeling Just Noticeable Differences in Charts, IEEE VIS, 2021 (conditionally accepted)

Online JND Experiment: <http://47.96.162.114:8080/>

Visual Encoding



Position



Length



Angle/Slope



Area



Volume



Difference



Color hue



Color Saturation

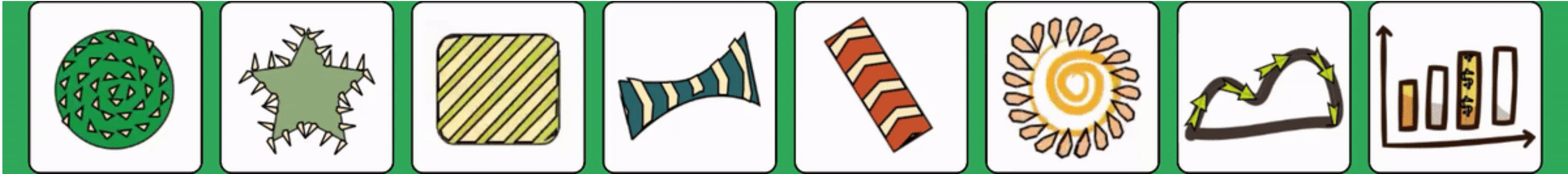


Contrast



Texture

Dynamic Visual Encoding ?



Enhancing Static Charts with Data-driven Animation

Min Lu¹, Noa Fish³, Joel Lanir², Shuaiqi Wang¹, Yang Yue¹
Daniel Cohen-Or³ and Hui Huang¹

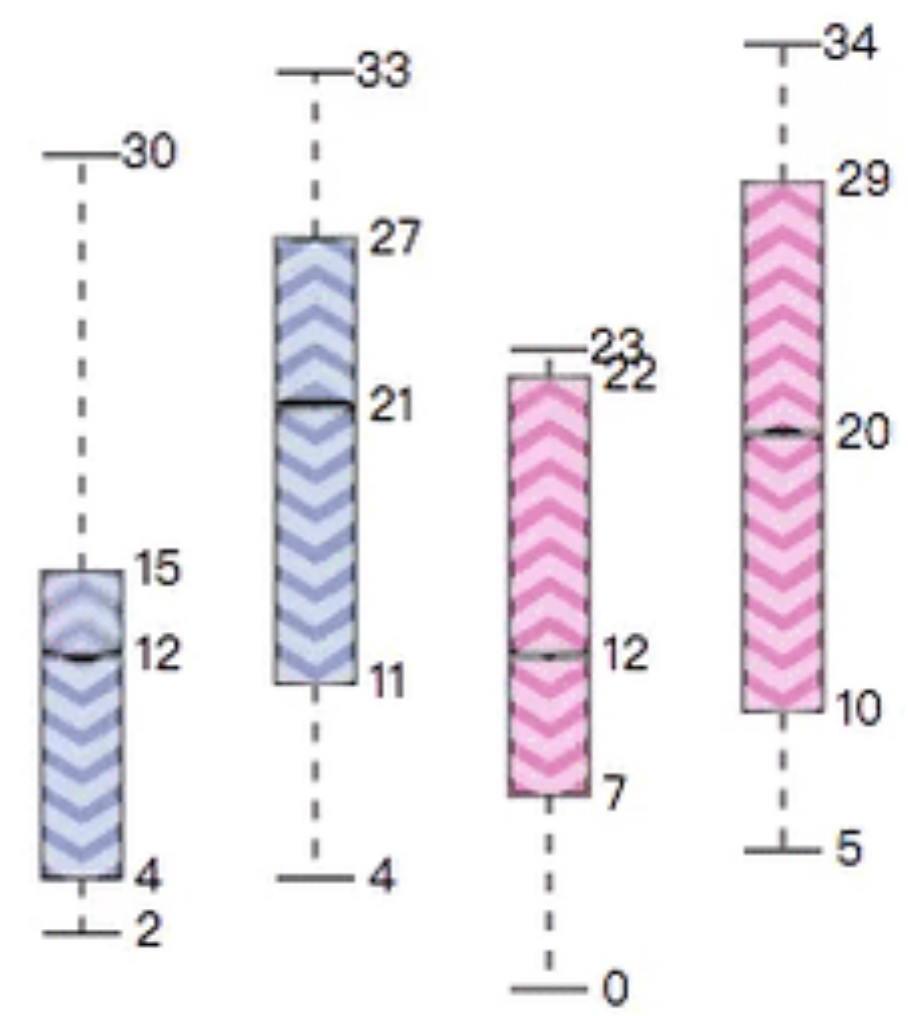
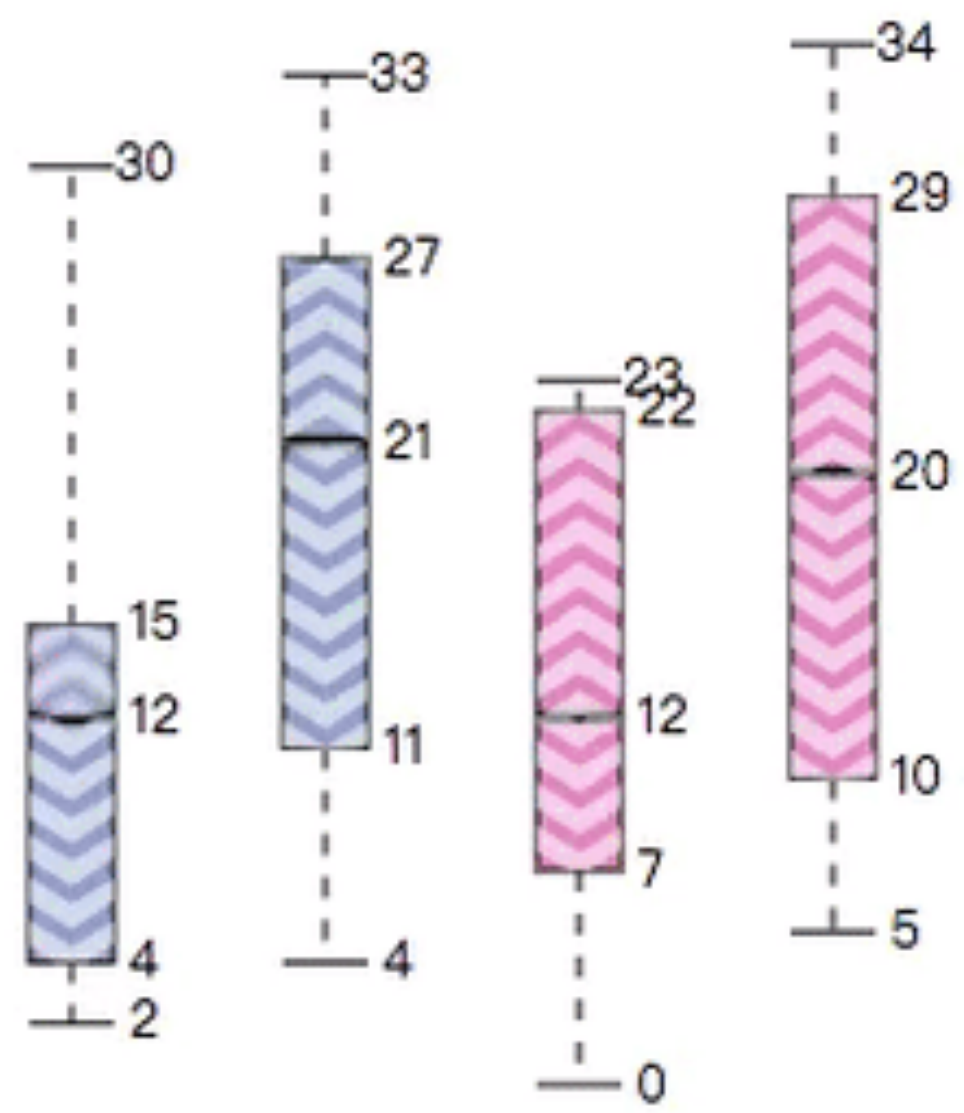
¹ Shenzhen University, China ² University of Haifa, Israel ³ Tel Aviv University, Israel



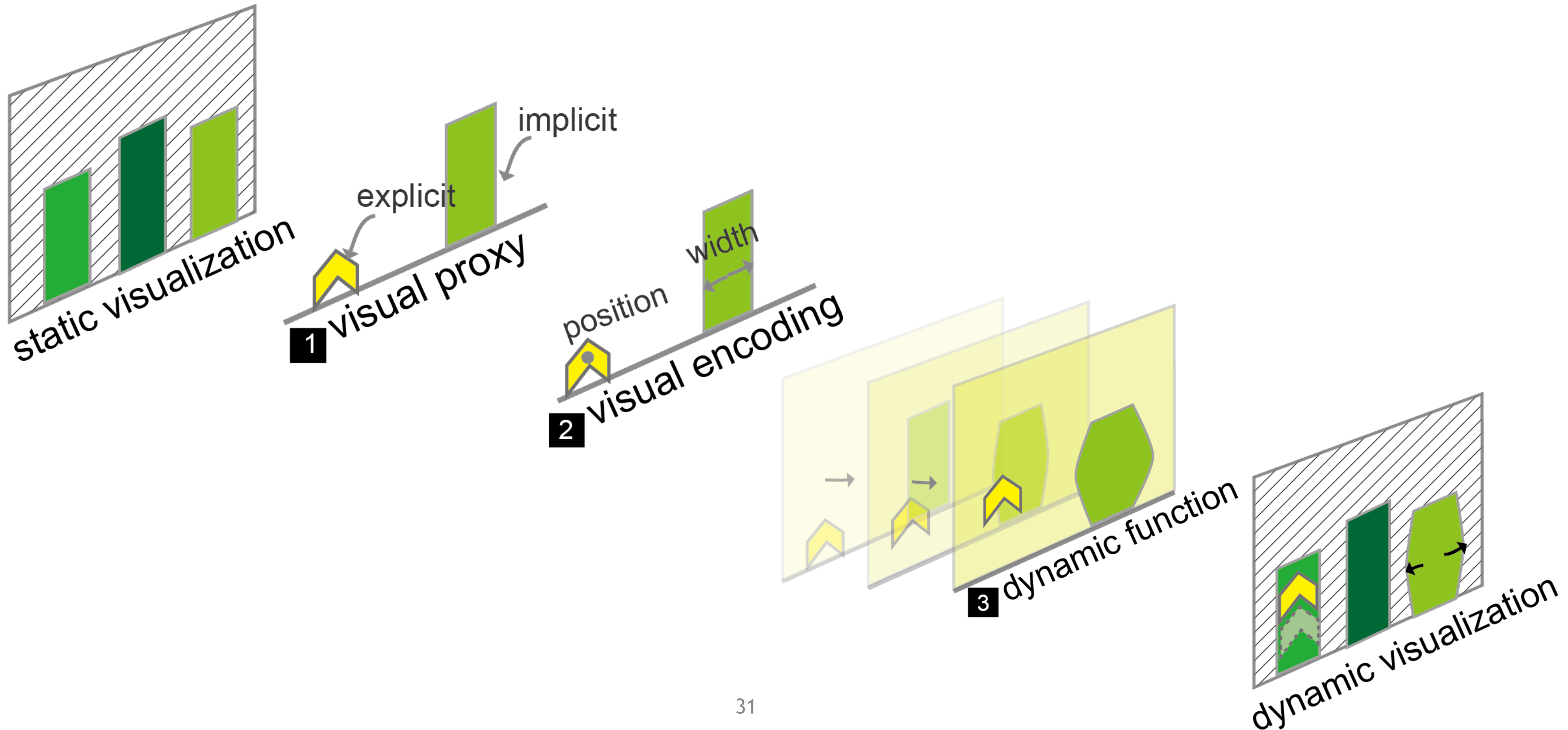


Data-driven Animation

dynamic visual cues to encode **non-temporal** data



Data-driven Dynamic Effect



Three Dynamic Effects



Marching Ants

Dynamics of Position



Geometry Deformation

Dynamics of Geometry
(e.g., shape, size)



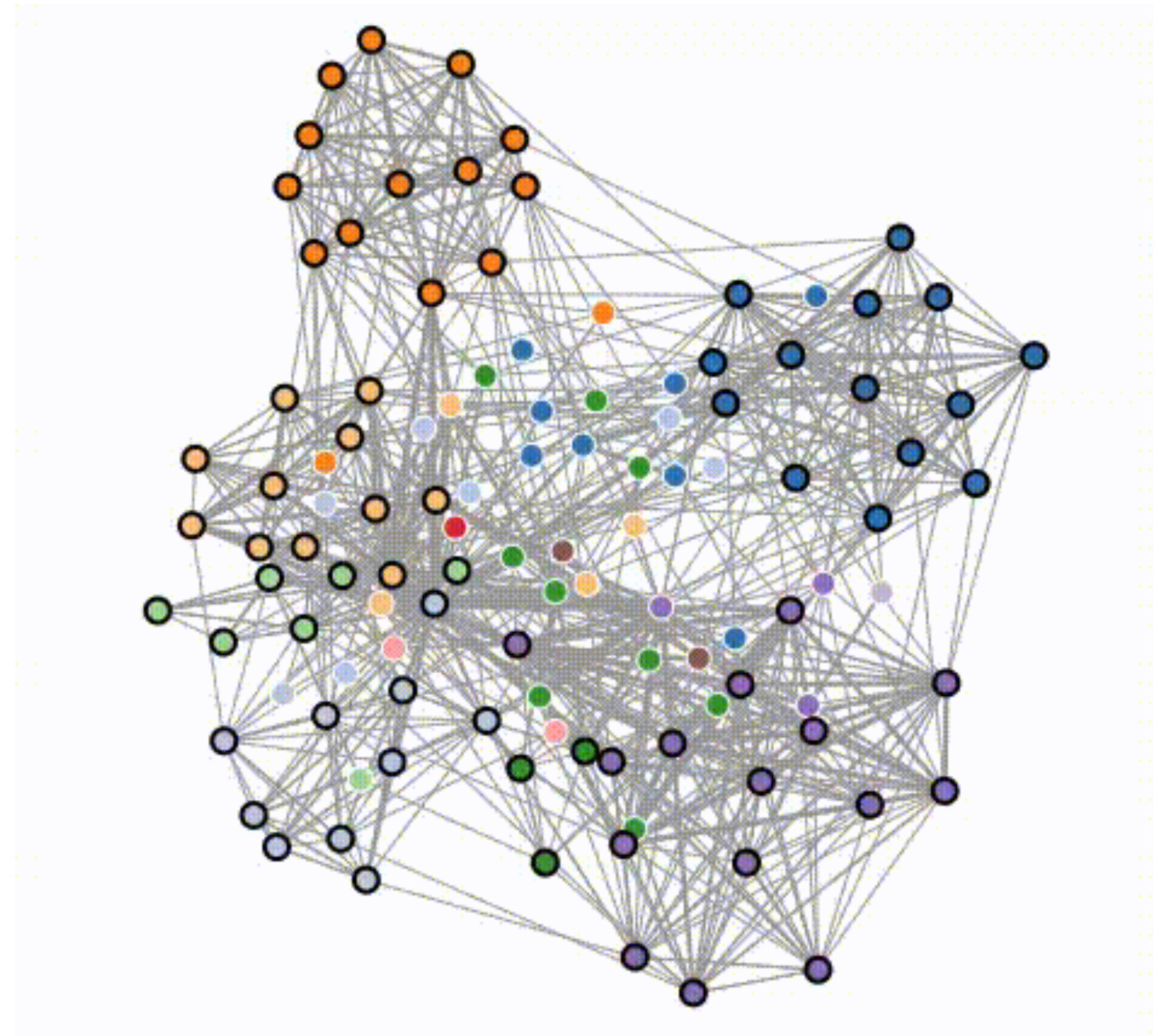
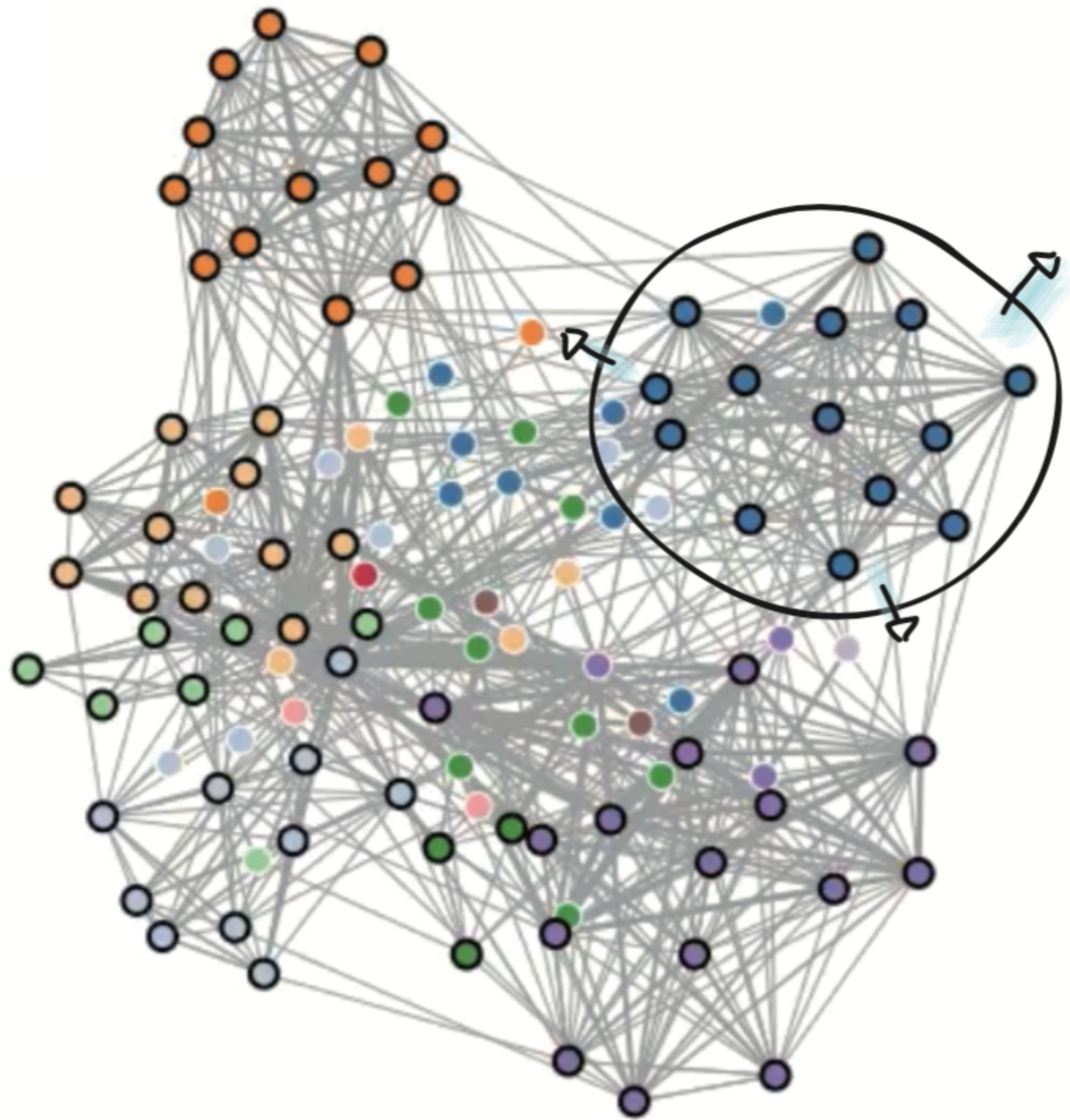
Gradual Appearance

Dynamics of Appearance
(e.g., color, texture)

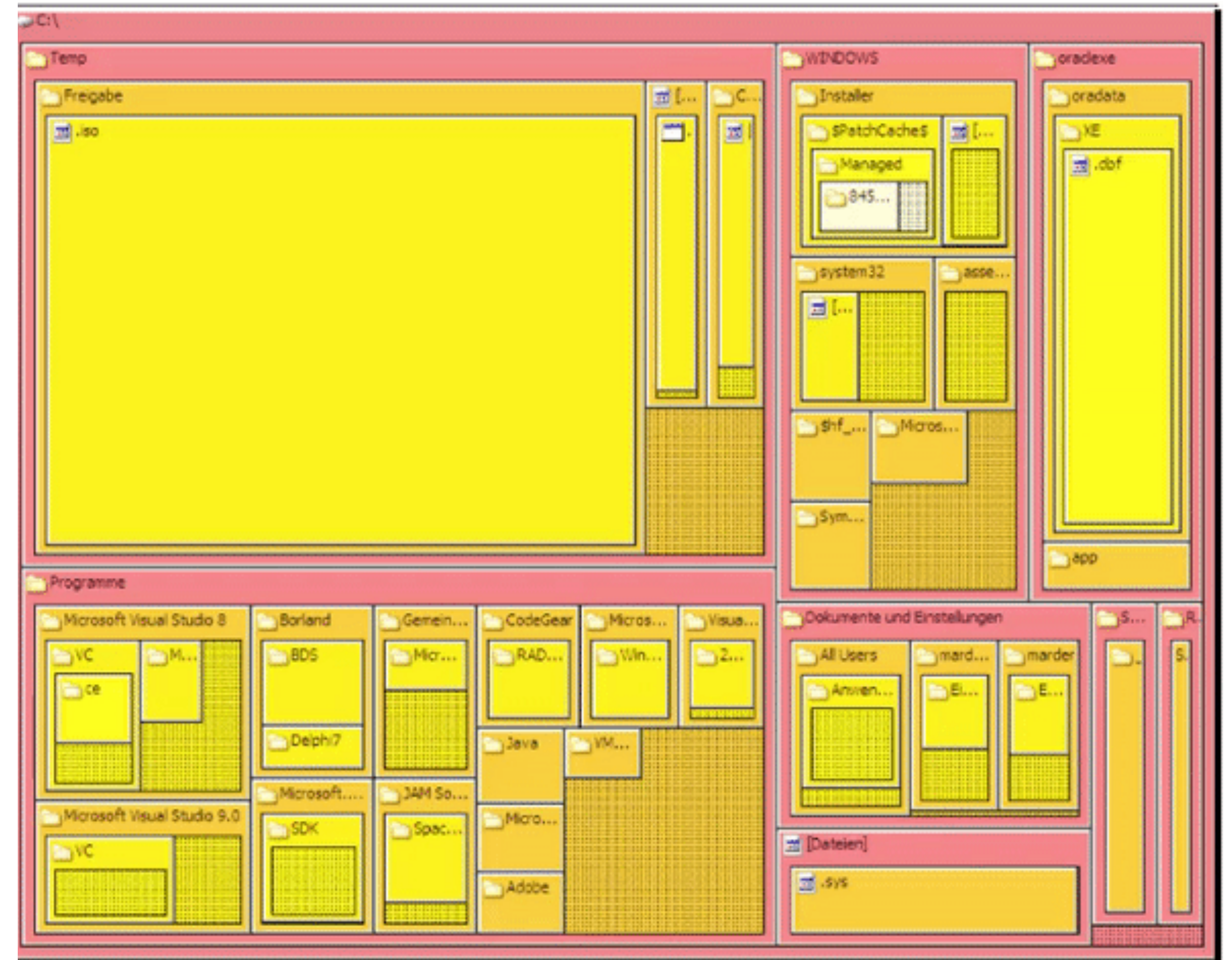
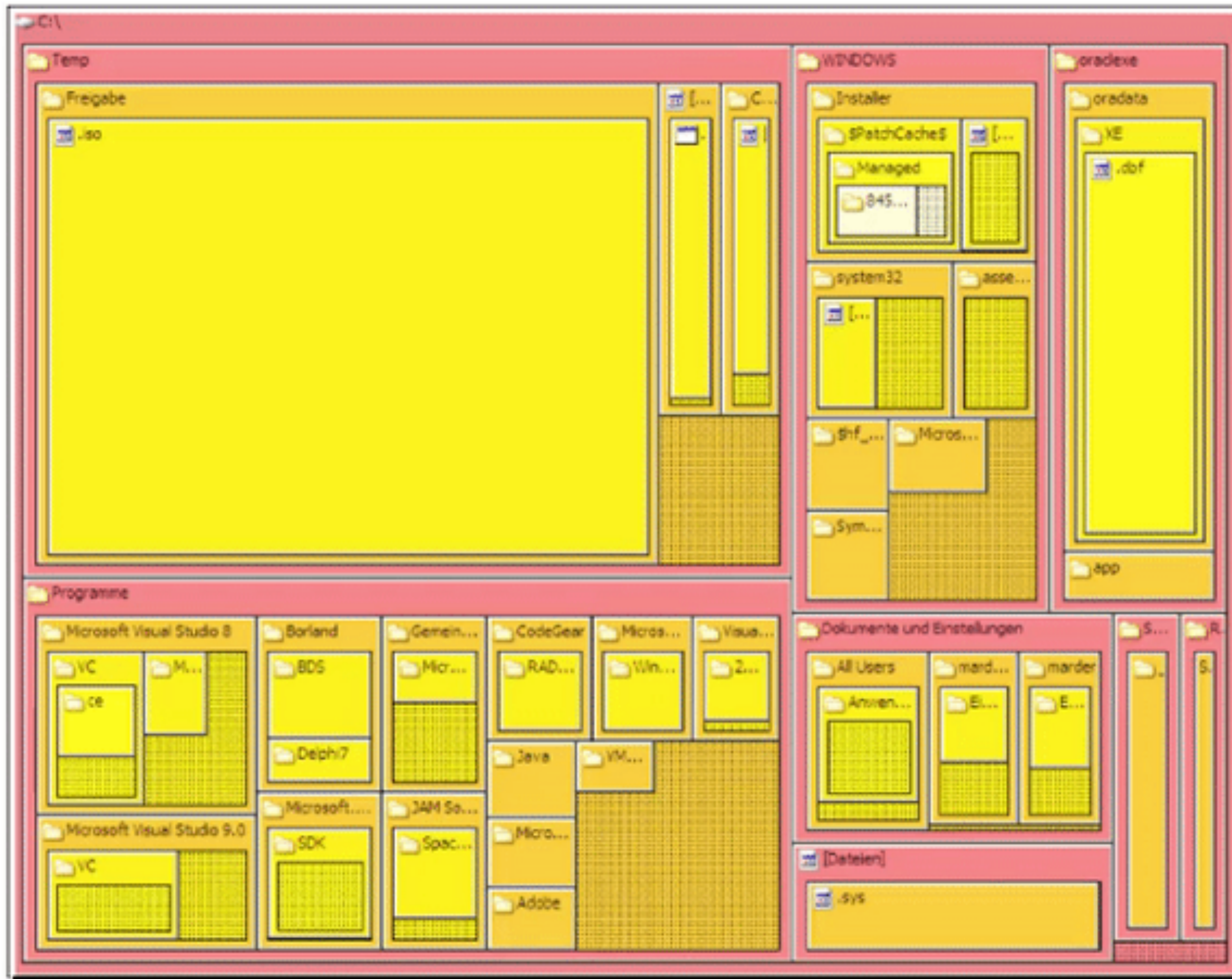
Examples – Marching Ants



Examples – Geometry Deformation

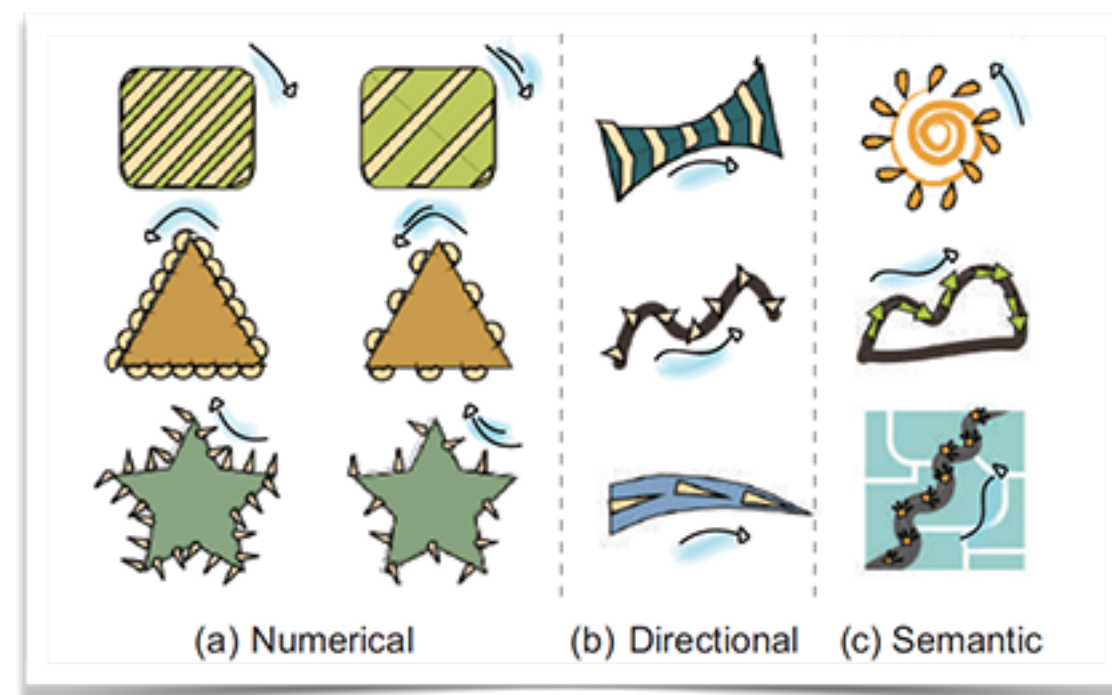


Examples – Gradual Appearance



Renewing Charts

with Data-driven Animations



Data-driven Animation [TVCG]

Lu, M., Fish, N., Wang, S., Lanir, J., Cohen-Or, D., & Huang, H. (2020).
Enhancing Static Charts with Data-driven Animations.
IEEE Transactions on Visualization and Computer Graphics.

Open Source Codes: <https://github.com/vizgroup/DynamicEffect>



Visual Information Flow

- Trace graphical data elements
- Get the story!

INFOGRAPHIC ELEMENTS

PLACE YOUR TEXT HERE

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam ipsum ipsum, auctor sit amet semper in, vestibulum a ante. Sed dictum eget leo quis sagittis.

PLACE YOUR TEXT HERE

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam ipsum ipsum, auctor sit amet semper in, vestibulum a ante. Sed dictum eget leo quis sagittis.

PLACE YOUR TEXT HERE

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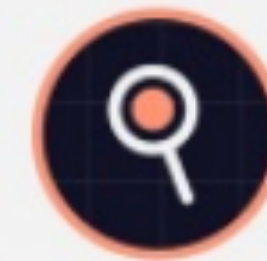
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PLACE YOUR TEXT HERE

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam ipsum ipsum, auctor sit amet semper in, vestibulum a ante. Sed dictum eget leo quis sagittis.

NEW

ELECTRIC CAR INFOGRAPHIC



01

LOREM IPSUM DOLOR SIT AMET,
CONSECTETUR ADIPISCING ELIT.

02

LOREM IPSUM DOLOR SIT AMET,
CONSECTETUR ADIPISCING ELIT.



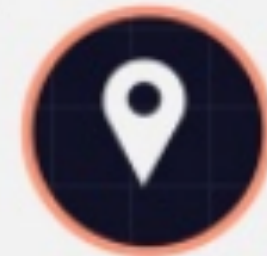
03

LOREM IPSUM DOLOR SIT AMET,
CONSECTETUR ADIPISCING ELIT.



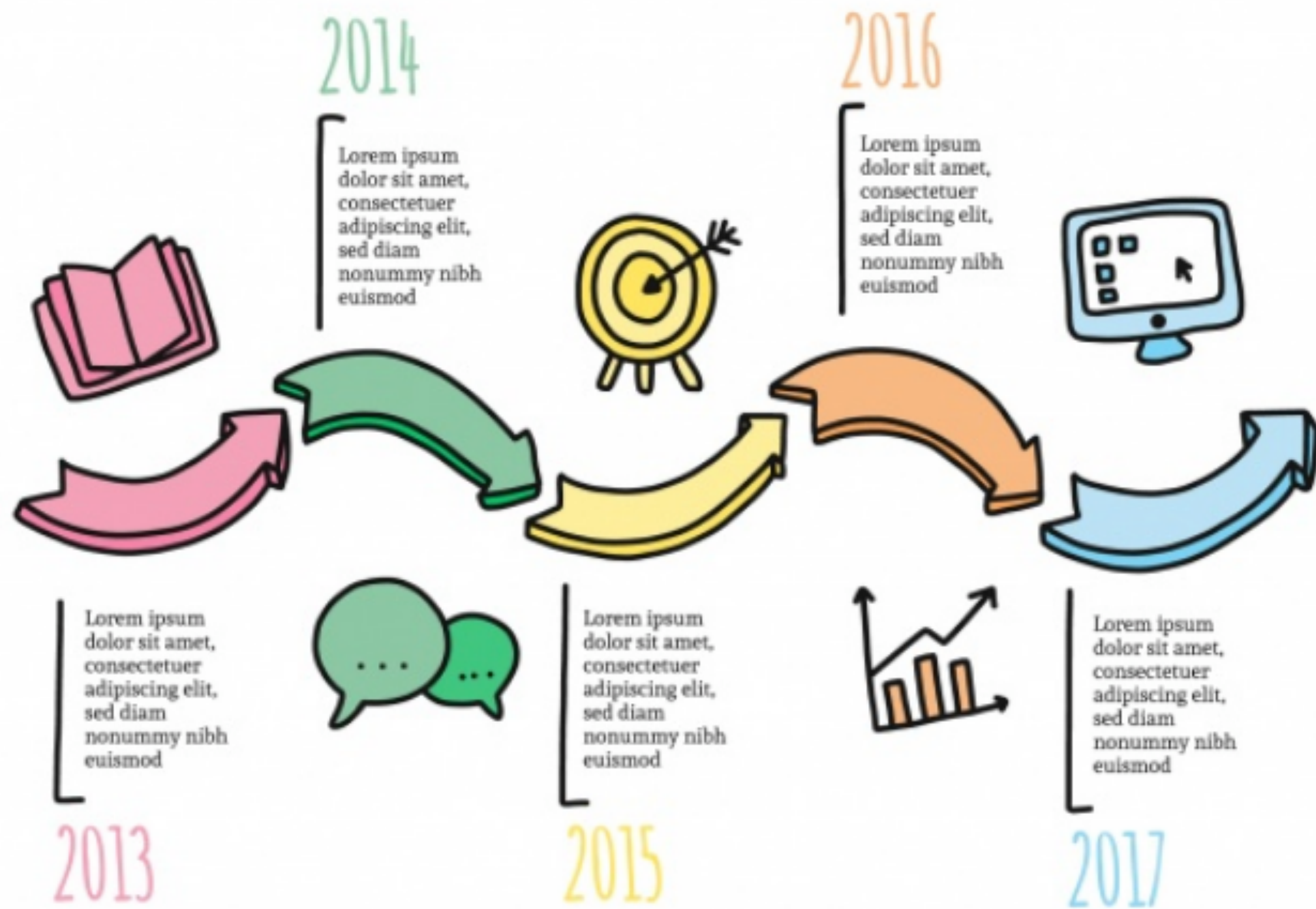
04

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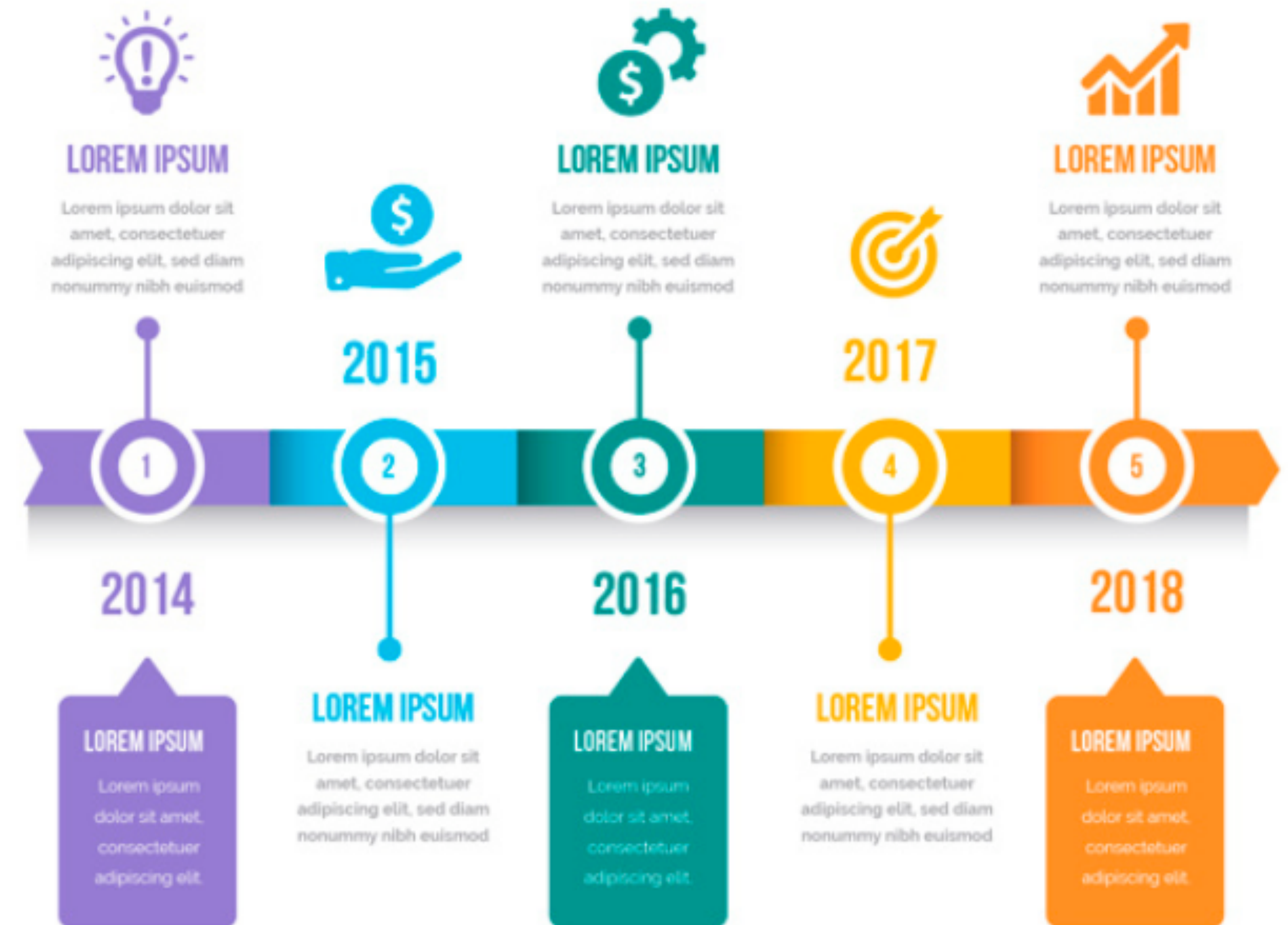


05

LOREM IPSUM DOLOR SIT AMET,
CONSECTETUR ADIPISCING ELIT.



BUSINESS TIMELINE



Exploring Visual Information Flows in Infographics

Min Lu¹, Chufeng Wang¹, Joel Lanir², Nanxuan Zhao³, Hanspeter Pfister⁴
Daniel Cohen-Or⁵ and Hui Huang¹

¹ Shenzhen University, China ² University of Haifa, Israel ³ City uniiversity of Hong Kong, China ⁴
Harvard University, US ⁵ Tel Aviv University, Israel



INFOGRAPHIC DESIGN

01 DATA 01
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed

02 DATA 02
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed

03 DATA 03
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04 DATA 04
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed

05 DATA 05
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed

designed by freepik

INFOGRAPHIC

01 LOREM IPSUM
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02 LOREM IPSUM
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03 LOREM IPSUM
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04 LOREM IPSUM
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designed by freepik

BUSINESS INFOGRAPHIC

01 Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat.

02 Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat.

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04 Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat.

MARKETING STRATEGY
YOUR SLOGAN TEXT GOES HERE

CORPORATE PLAN
YOUR SLOGAN TEXT GOES HERE

SEO DEVELOPMENT
YOUR SLOGAN TEXT GOES HERE

VECTOR DESIGN
YOUR SLOGAN TEXT GOES HERE

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designed by freepik

INFOGRAPHIC STEPS

STEP N° 1
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STEP N° 2
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STEP N° 3
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STEP N° 4
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designed by freepik

INFOGRAPHIC TIMELINE

1. Lorem Ipsum
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ELECTRIC CAR INFOGRAPHIC

01 LOREM IPSUM DOLOR SIT AMET, CONSECTETUER ADIPISCING ELIT, SED

02 LOREM IPSUM DOLOR SIT AMET, CONSECTETUER ADIPISCING ELIT, SED

03 LOREM IPSUM DOLOR SIT AMET, CONSECTETUER ADIPISCING ELIT, SED

04 LOREM IPSUM DOLOR SIT AMET, CONSECTETUER ADIPISCING ELIT, SED

05 LOREM IPSUM DOLOR SIT AMET, CONSECTETUER ADIPISCING ELIT, SED

NEW

LIGHT BULB INFOGRAPHIC

YOUR TITLE
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InfoVIF Dataset

- Crawled ~14K infographics
 - [Freepik](#)
 - [Shutterstock](#)
- Design templates of infographics
 - Well designed elements
 - Diverse in designs



<https://contributor.freepik.com>

All images

Photos

Vectors

Illustrations

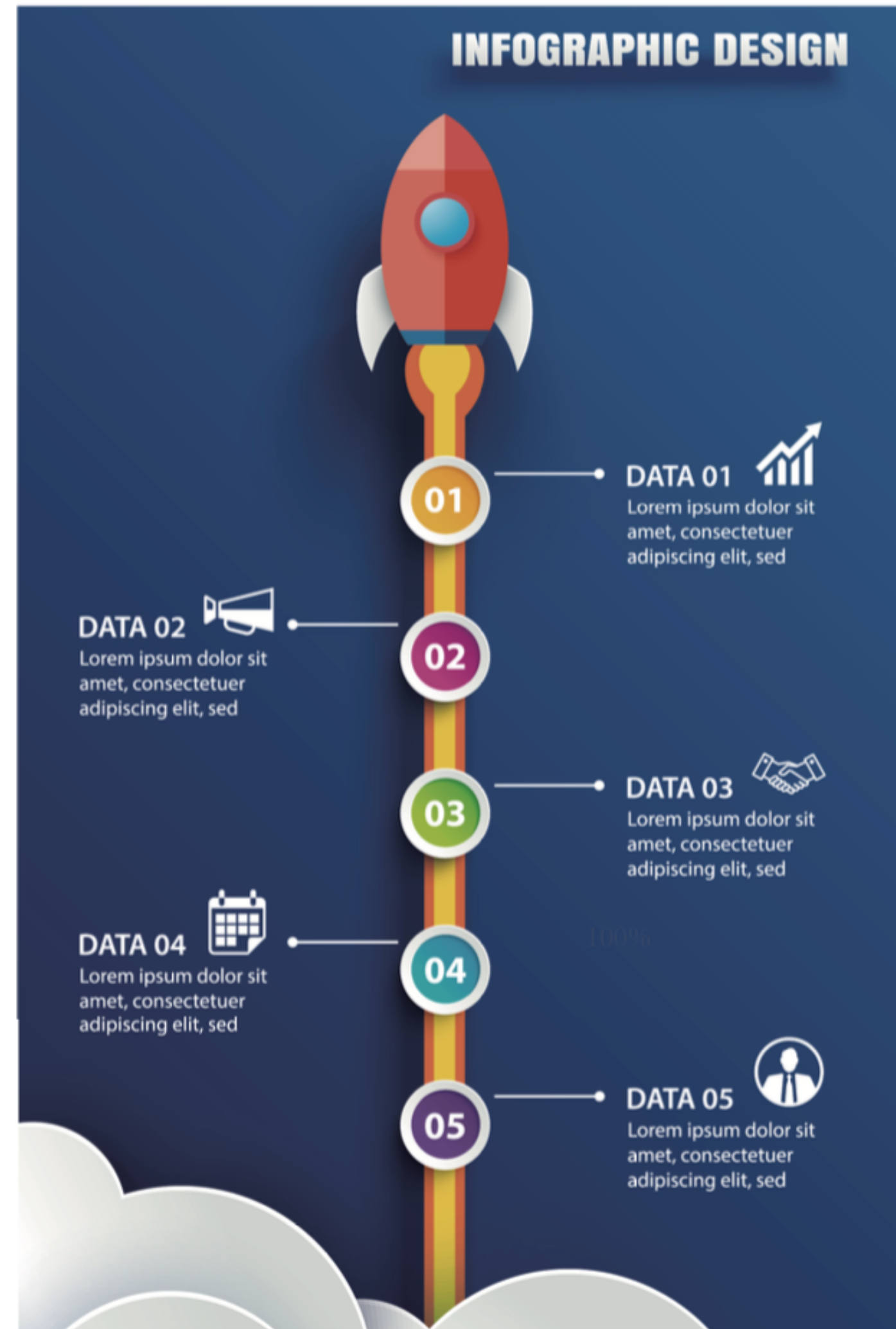
Orientation

All orientations

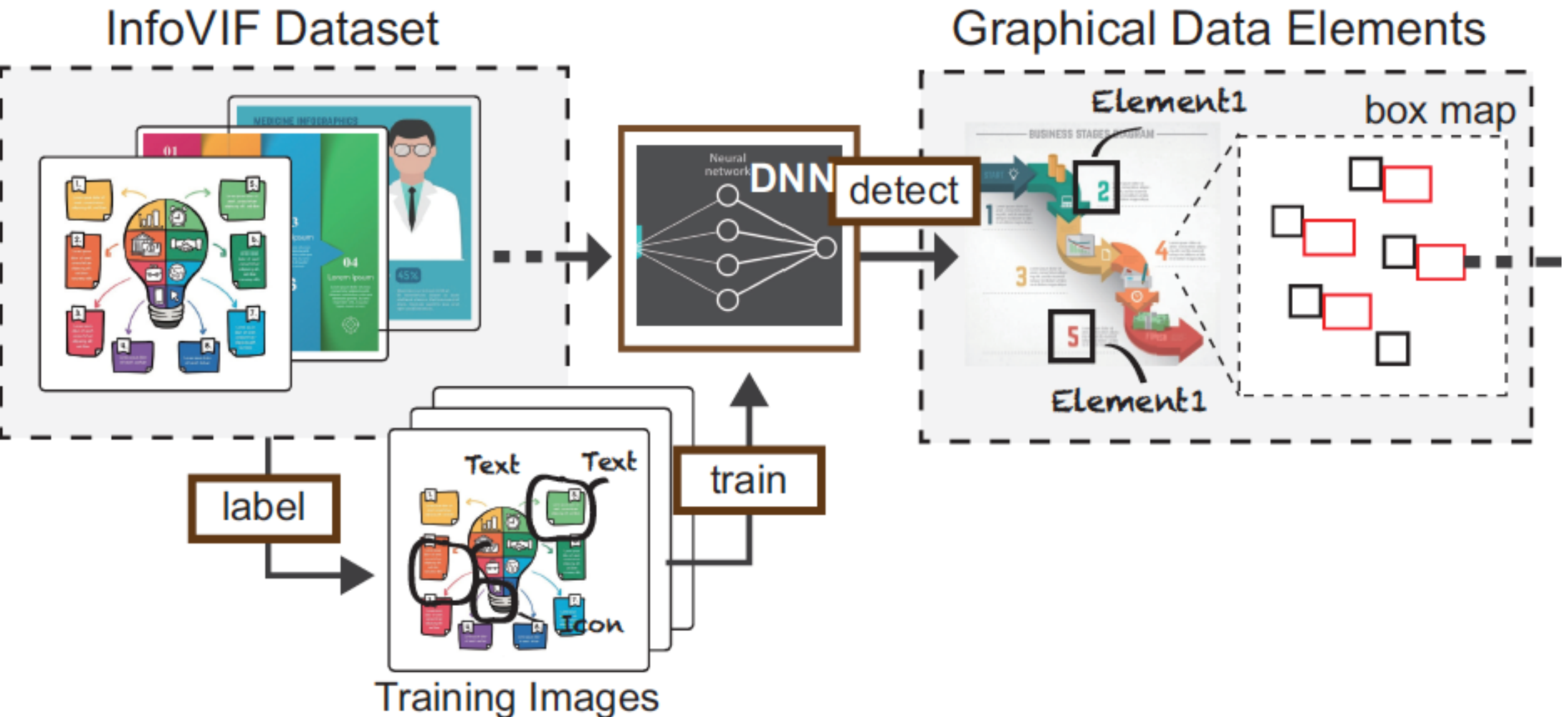
Horizontal



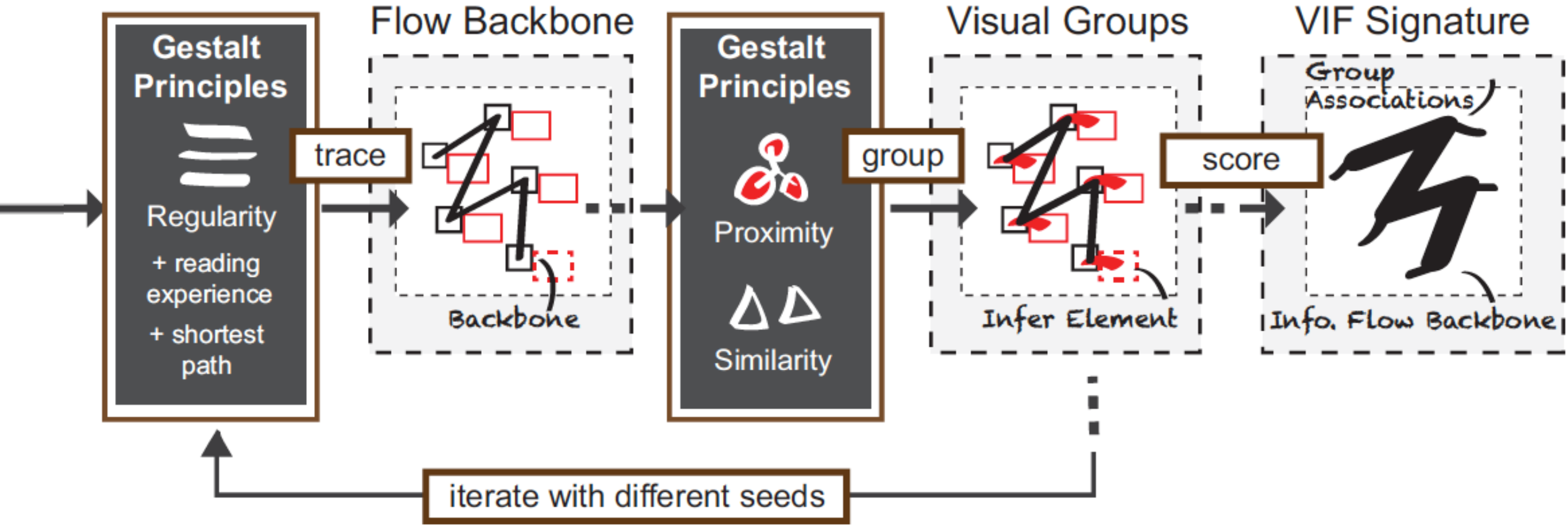
Infographic Model



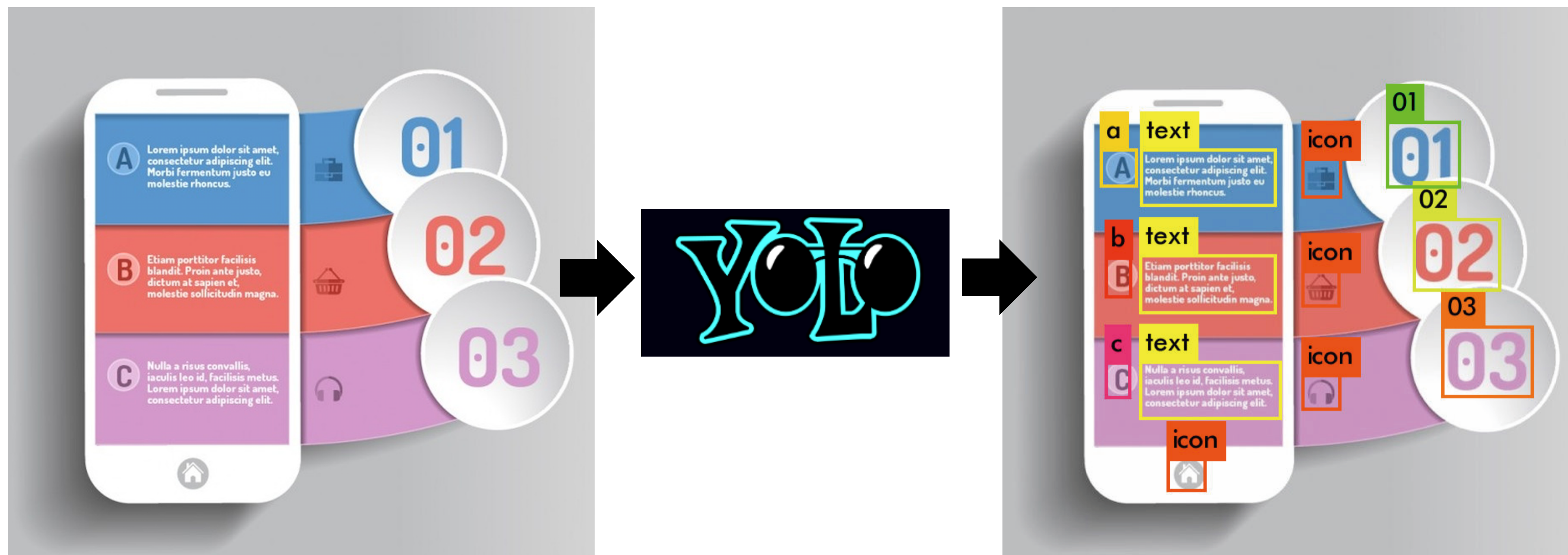
Data Element Detection



VIF Construction



Data Element Detection



Input

Output

Training Dataset

- 4.3K manually labeled data



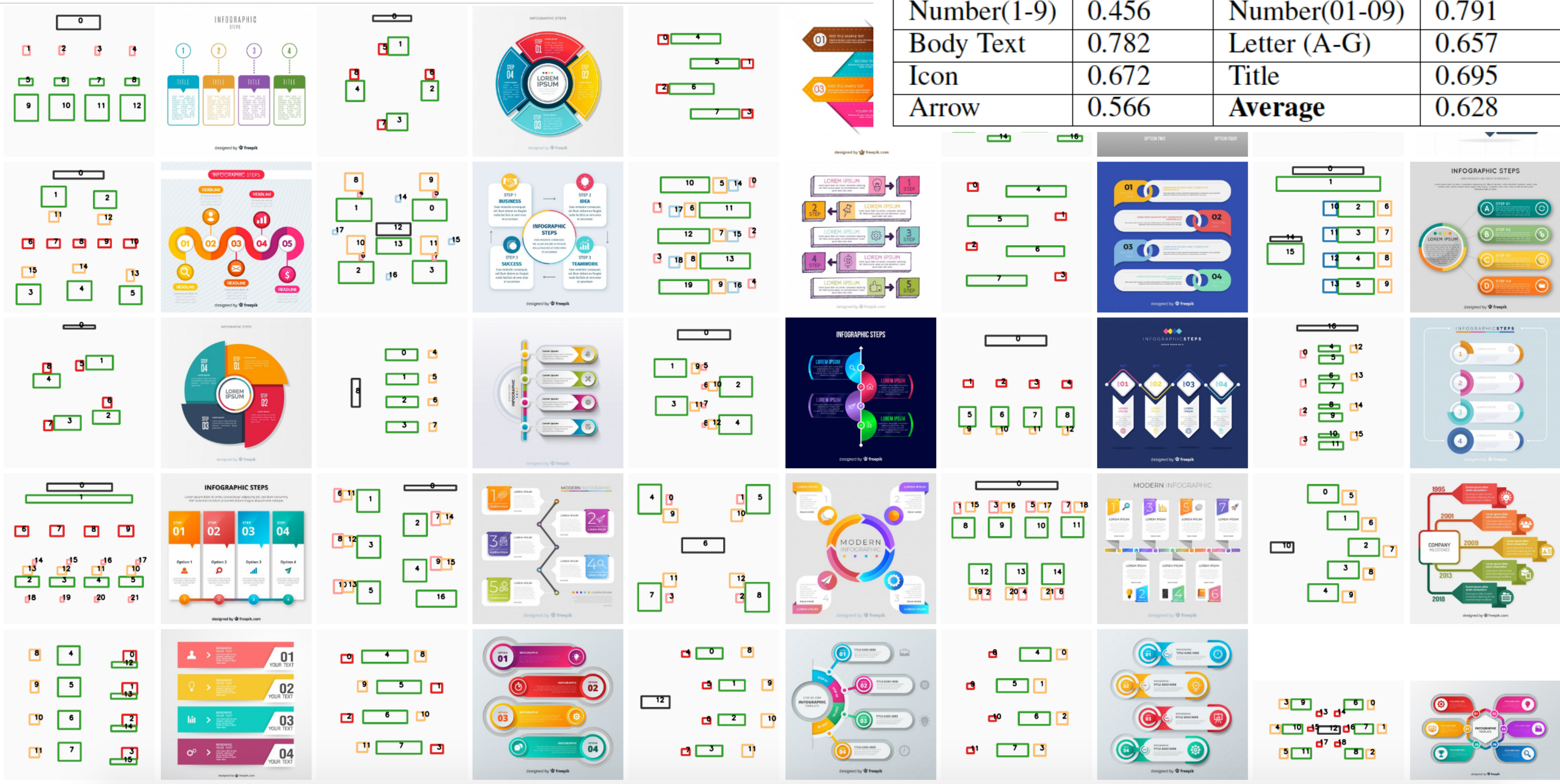
- Number 0 1 2 3 4 5 6 7 8 9
- z_Number 00 01 02 03 04 05 06 07 08 09 10
- Letter a b c d e f g
- Arrow up left down right up-right up-left down-left down-right
- Textbox [black box]
- Icon icon
- Title title

Next Img Update Box
#img=100 #label=100 #unlabel=0
Return to Label Next Labeled Img
#labeled img=100 Now: 6027.jpg

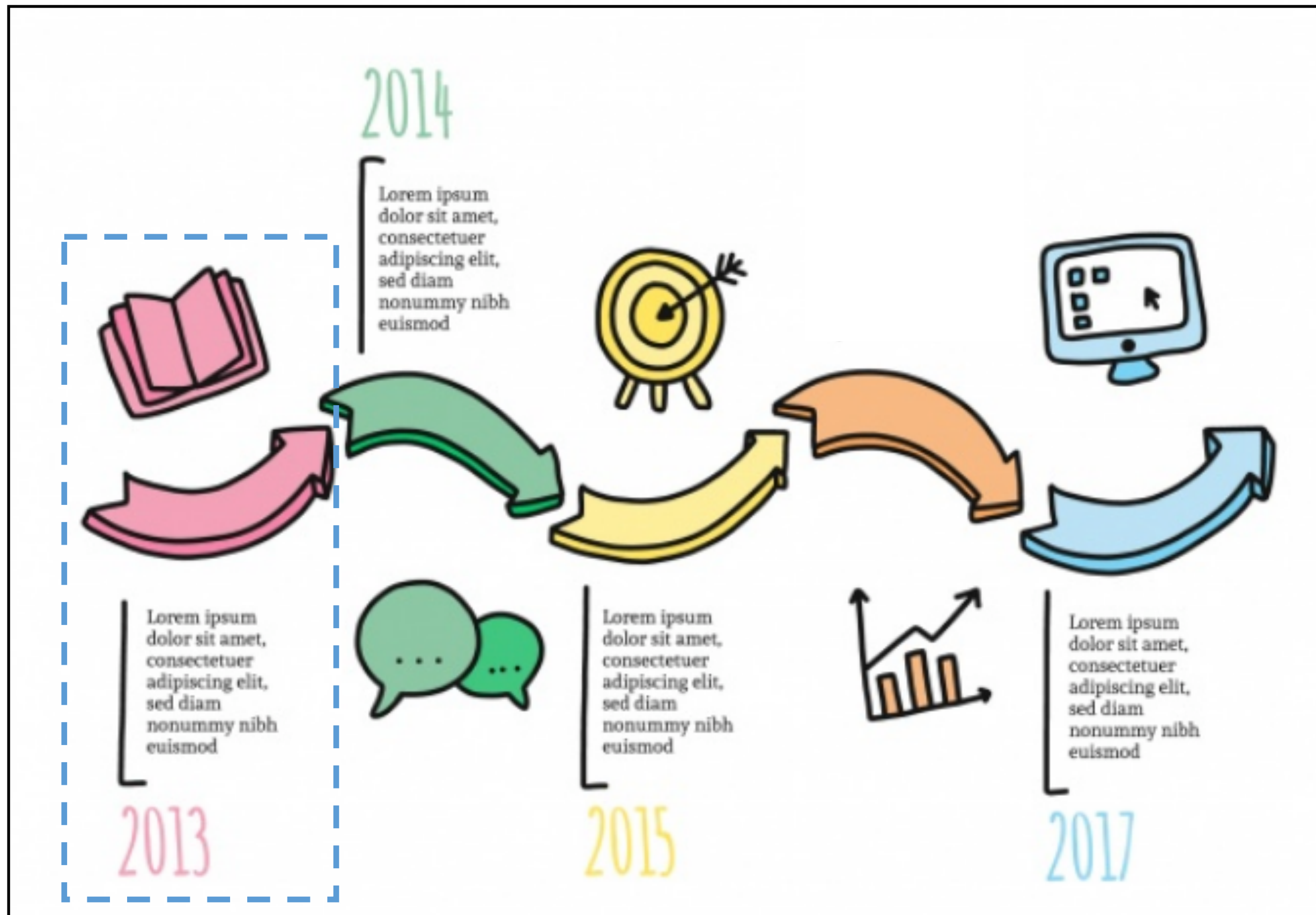
Training Dataset (cont.)

- Image Augmentation
 - Gray scale, Cropping
- 4.3K manually labeled data -> 23K training data

Class	Precision	Class	Precision
Number(1-9)	0.456	Number(01-09)	0.791
Body Text	0.782	Letter (A-G)	0.657
Icon	0.672	Title	0.695
Arrow	0.566	Average	0.628



Gestalt Rules in Infographics Design

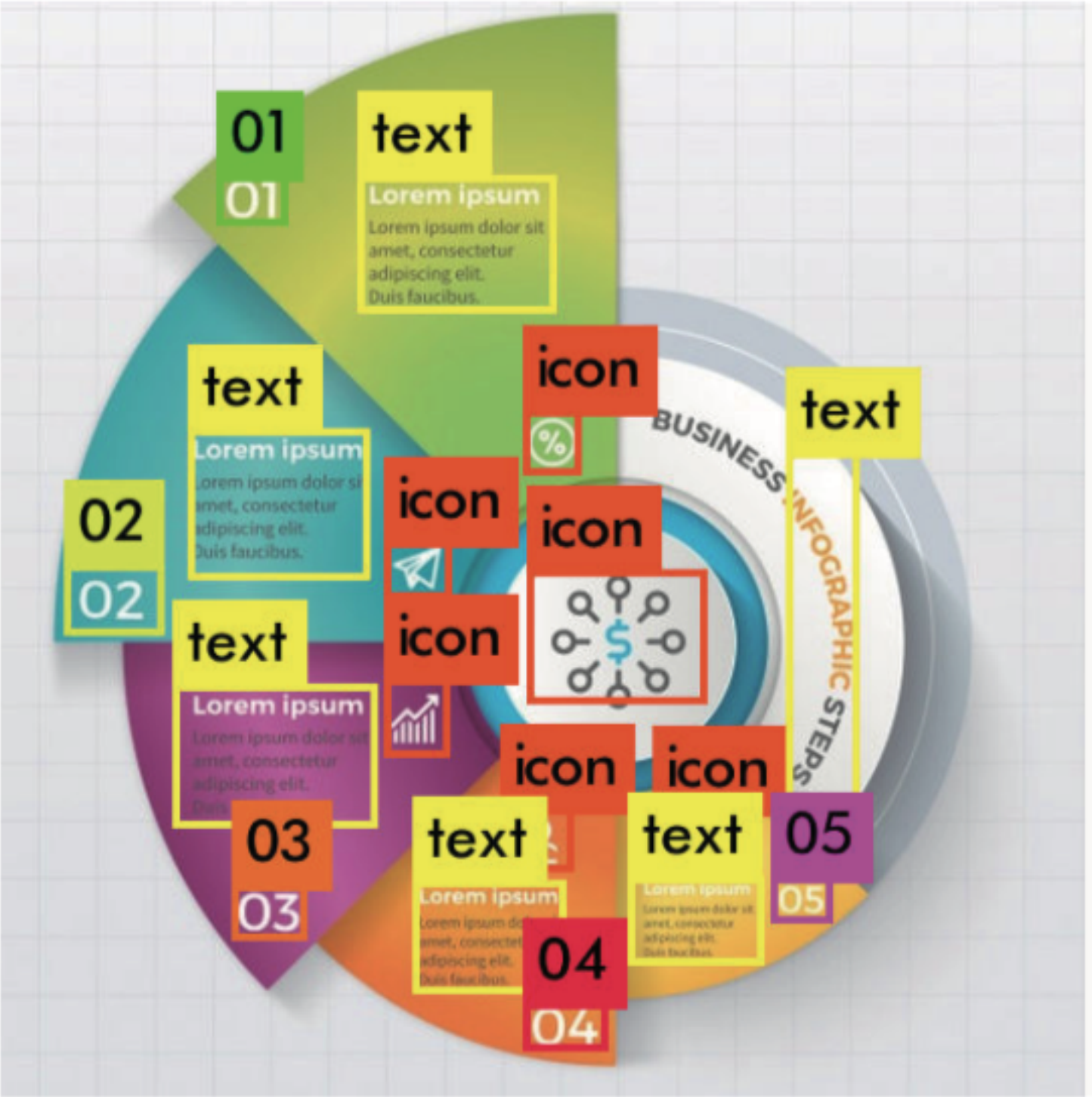


- **Proximity Principle** in a group
 - Elements are placed close to each other
- **Similarity Principle** among groups
 - Groups are with similar visual configuration
- **Regularity Principle** across groups
 - Groups are placed in harmonious patterns (e.g., symmetrical, avoid long jump, etc.)

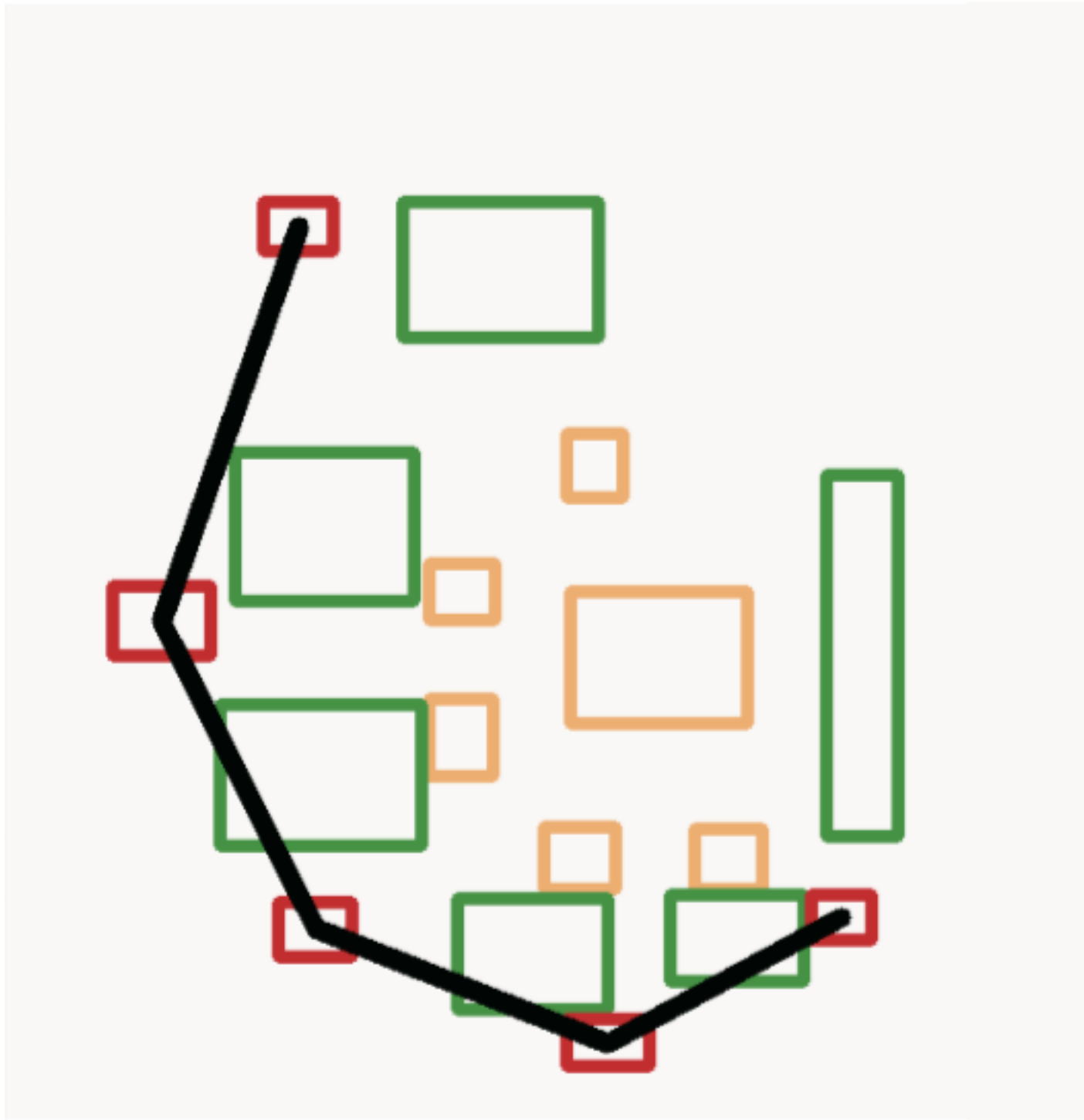
Visual Group:

Elements depict a piece of information together

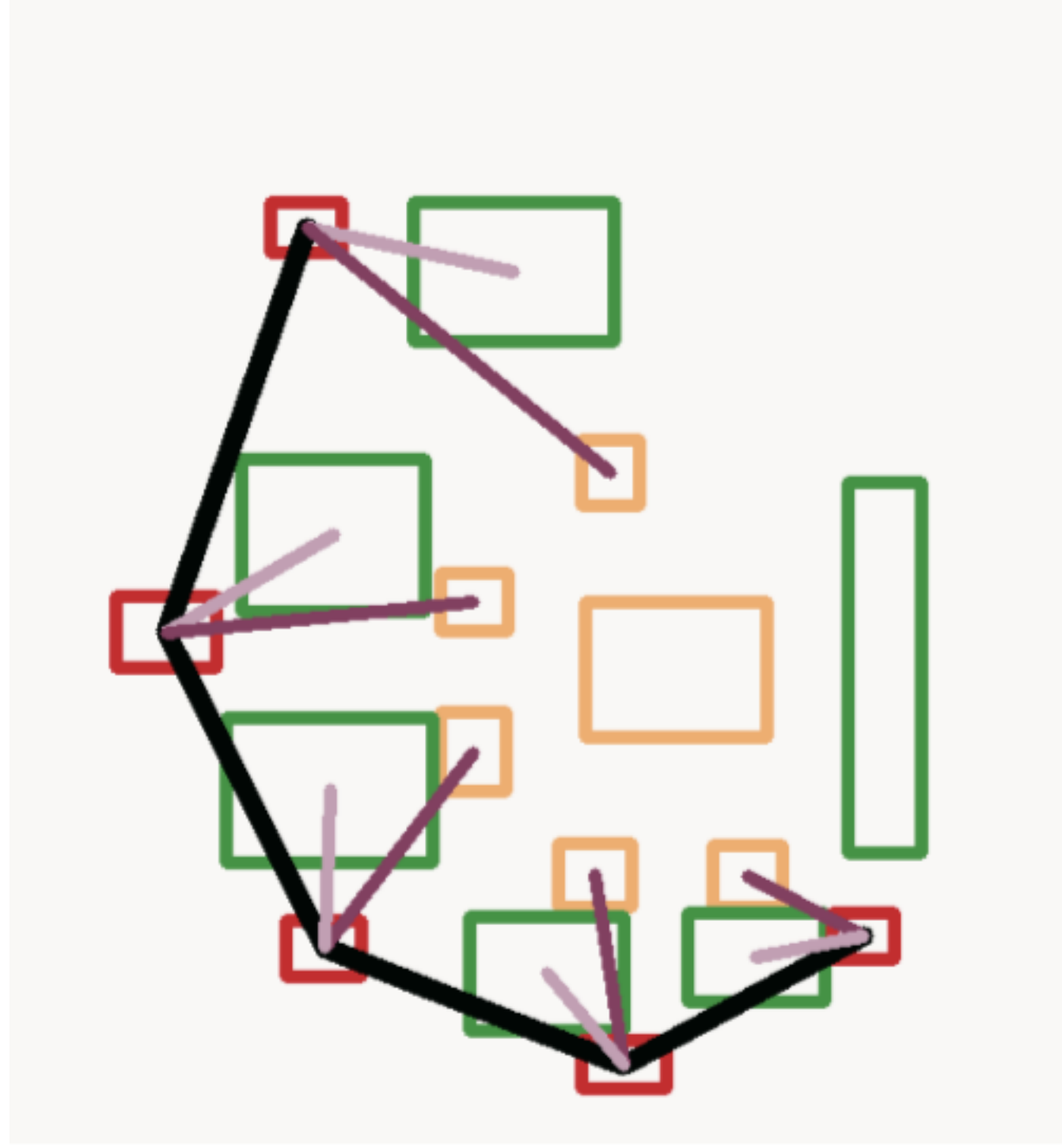
Information Flow Construction



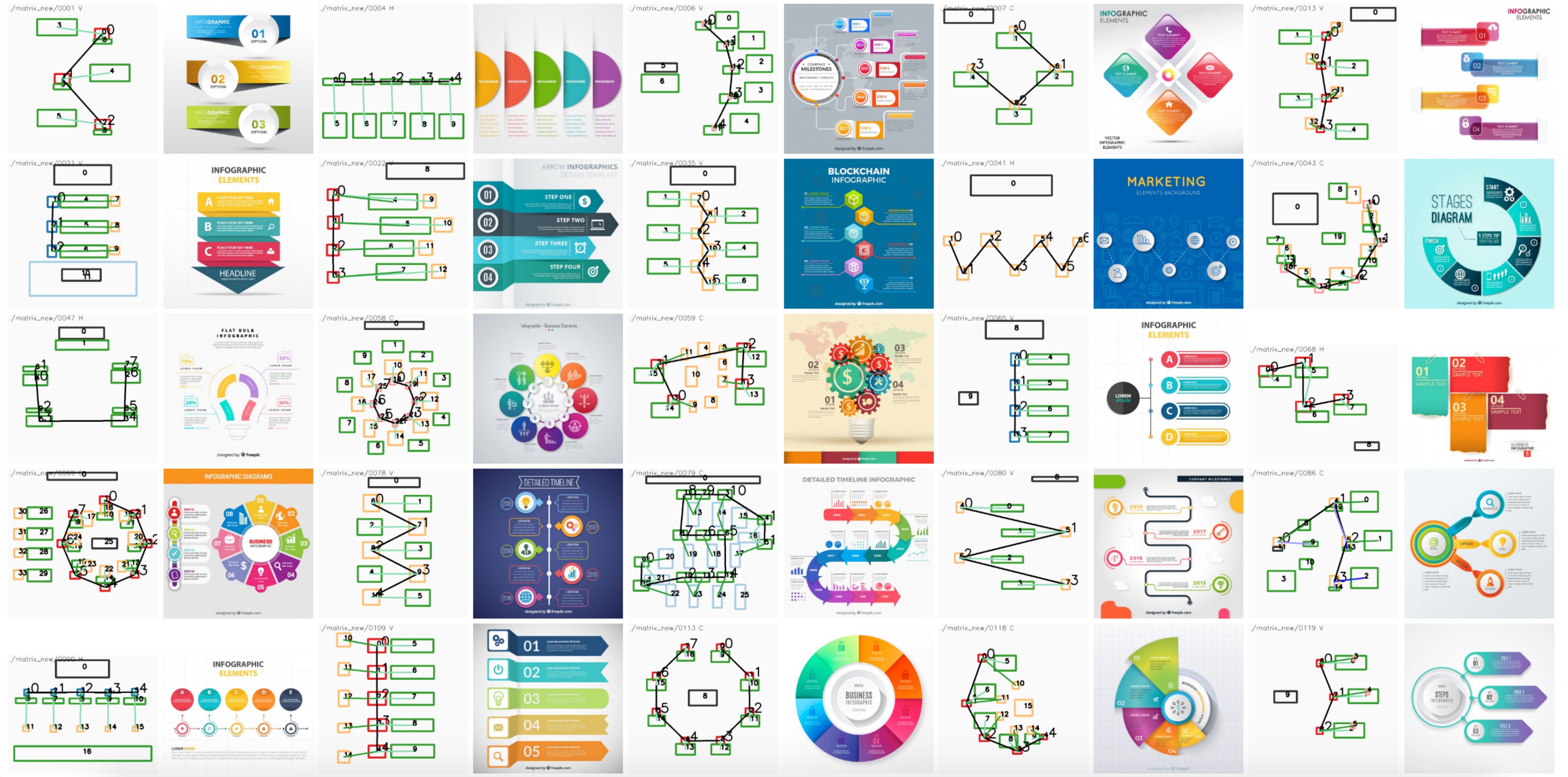
Input



(b) Traced Backbone



(c) Associated Groups



VIF Signature

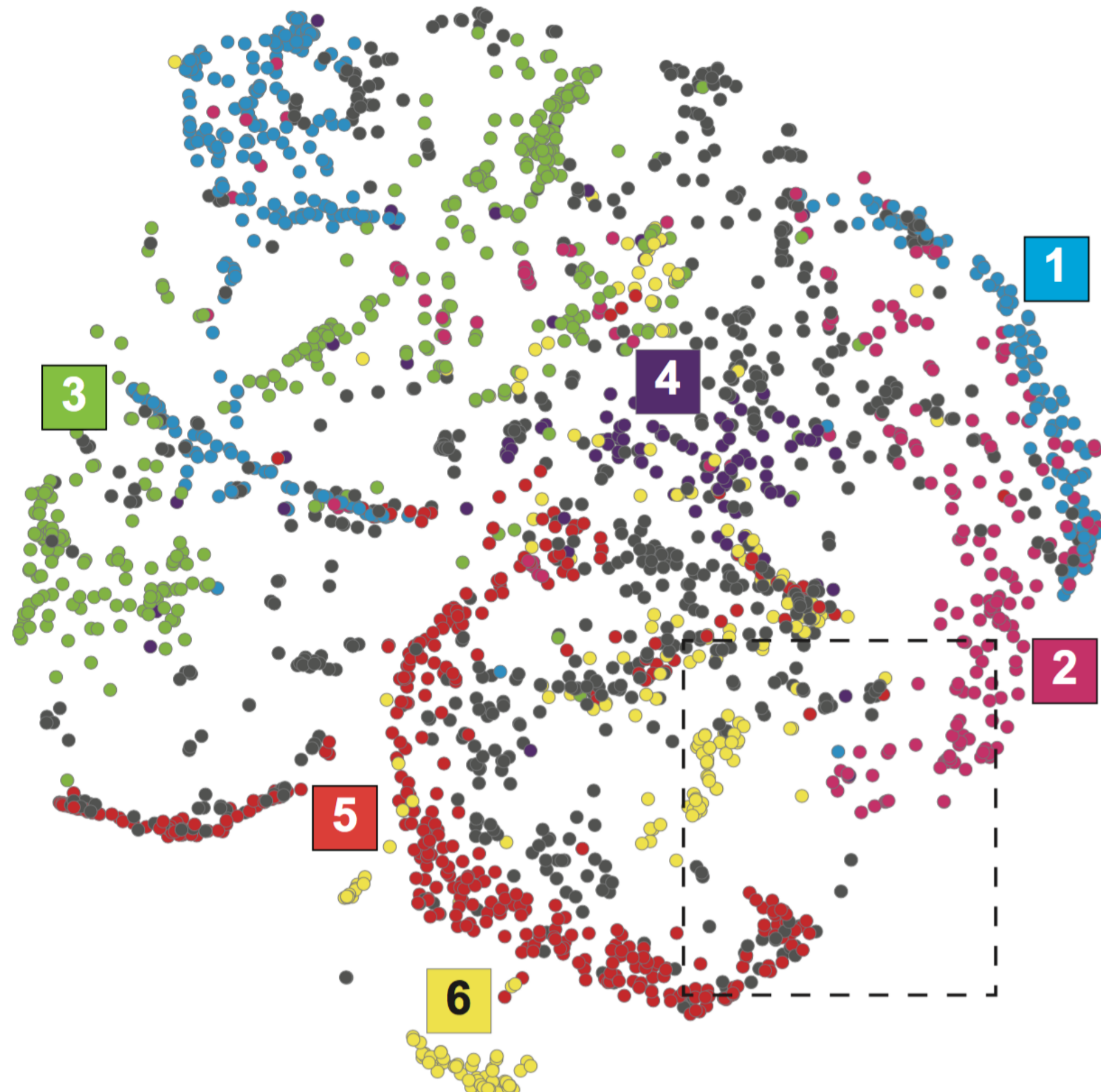


100 pixel

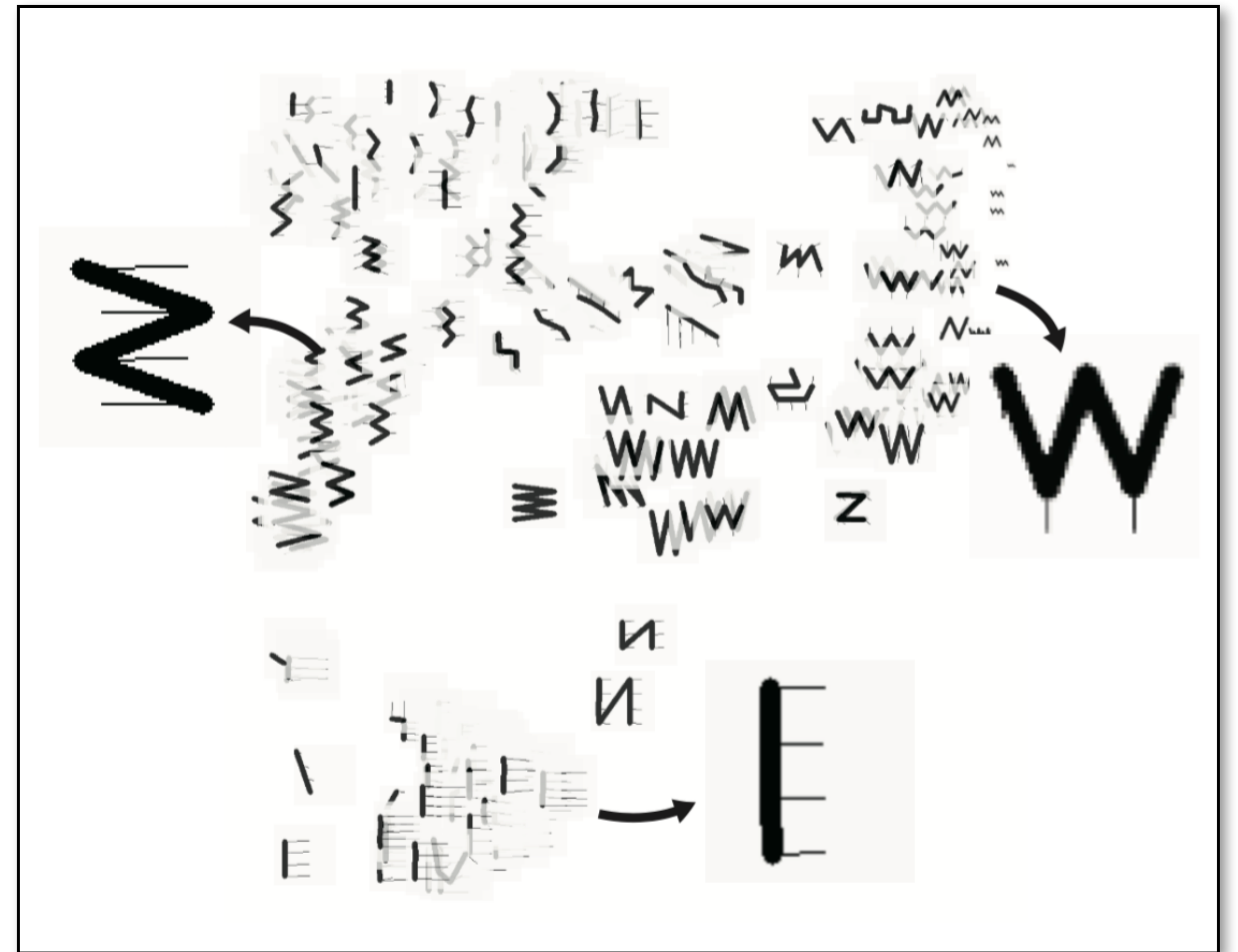
100 pixel



Space of VIF Signatures



T-SNE Projection of 2500 Samples

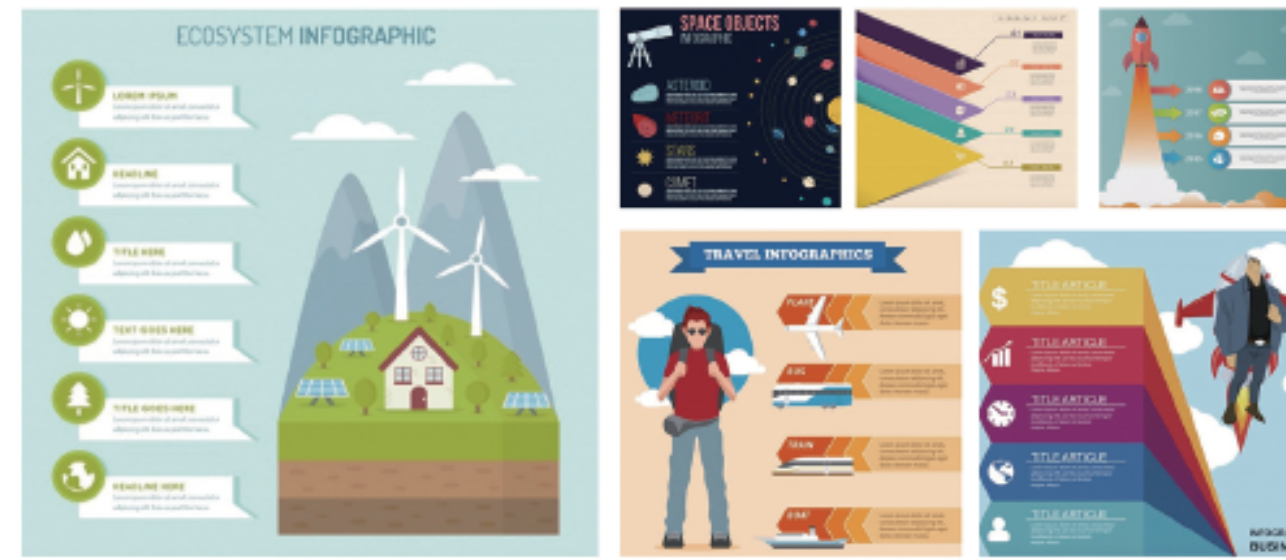


Close-up of VNF Signatures

1 Landscape



3 Portrait



5 Clock



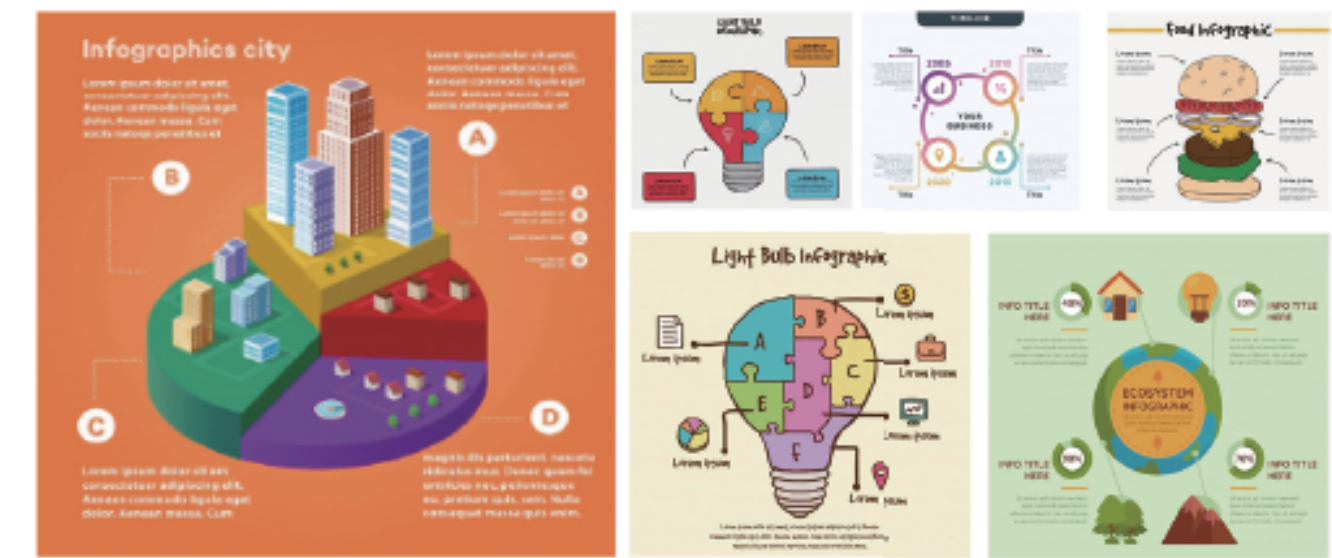
2 W Pulse



4 Spiral



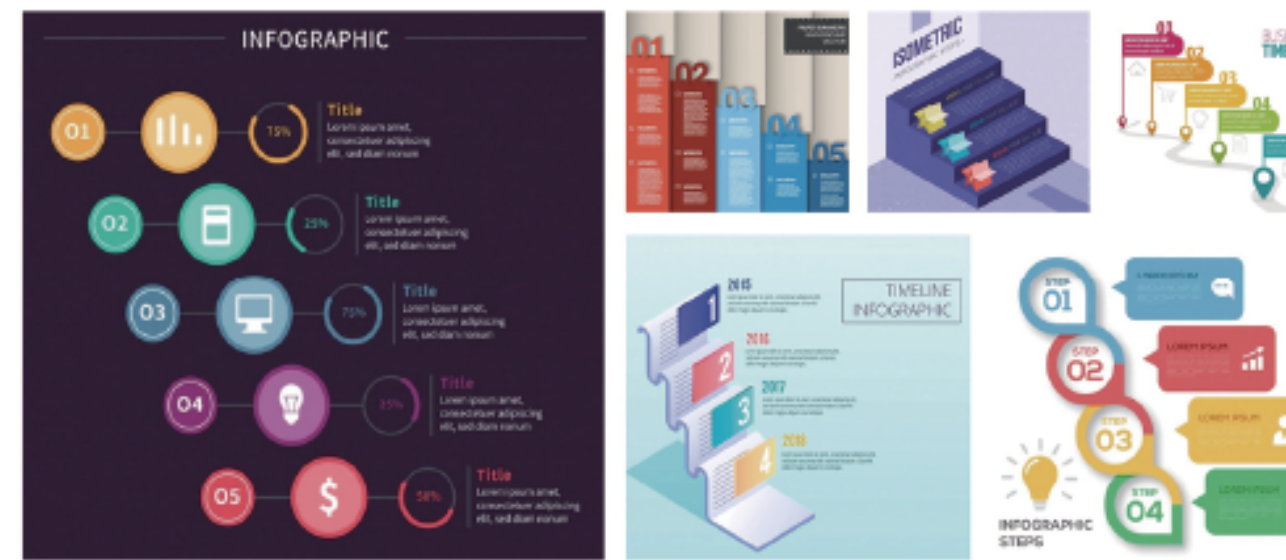
6 Star



Bowl



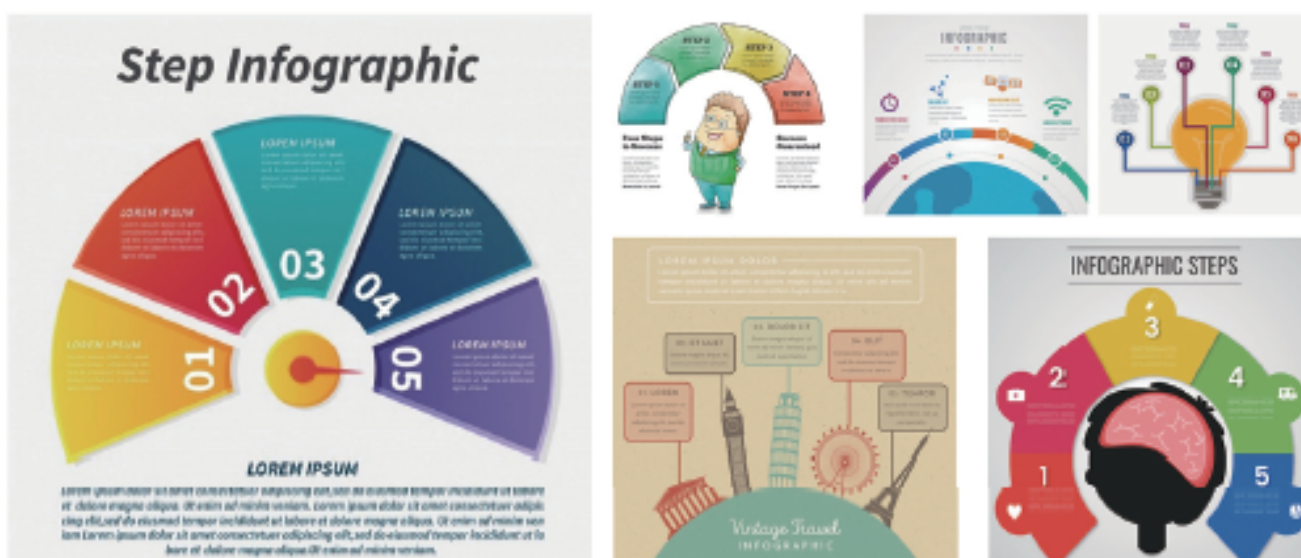
Down-ladder



Left-wing



Dome



Up-ladder



Right-wing



Exploring Visual Information Flows in Infographics

Min Lu¹, Chufeng Wang¹, Joel Lanir², Nanxuan Zhao^{3,4}, Hanspeter Pfister³,
Daniel Cohen-Or^{1,5} and Hui Huang¹

¹Shenzhen University ²University of Haifa ³Harvard University ⁴City University of Hong Kong ⁵Tel Aviv University



Renewing **Charts**

with **Constructed Visual Information Flow**



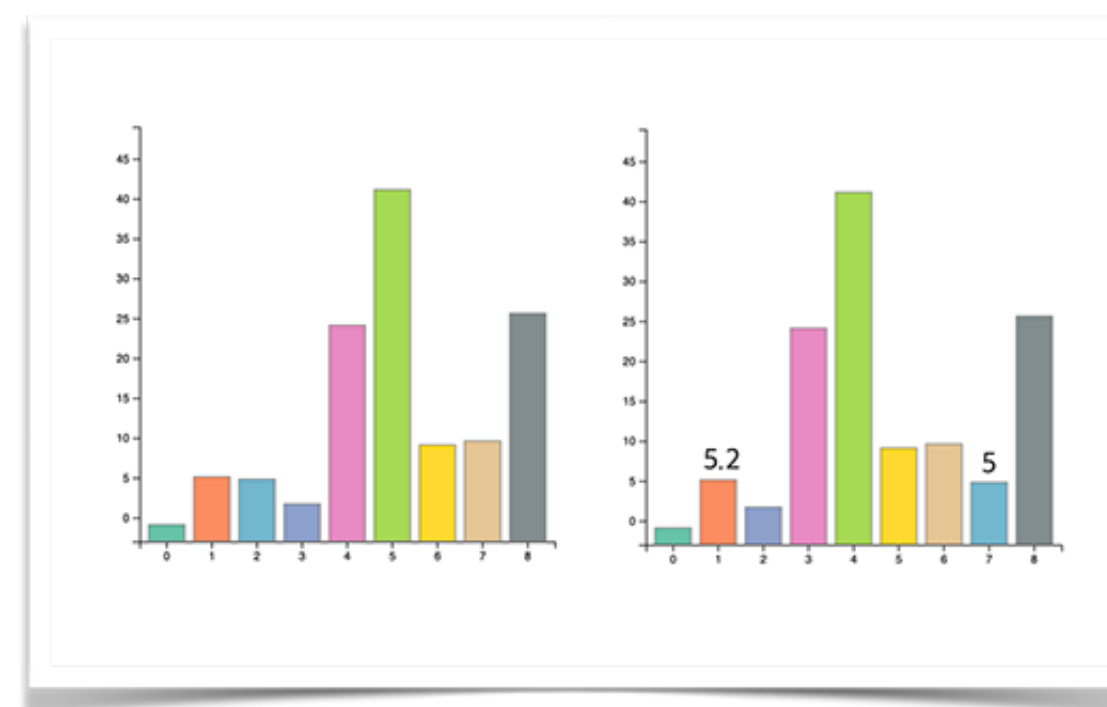
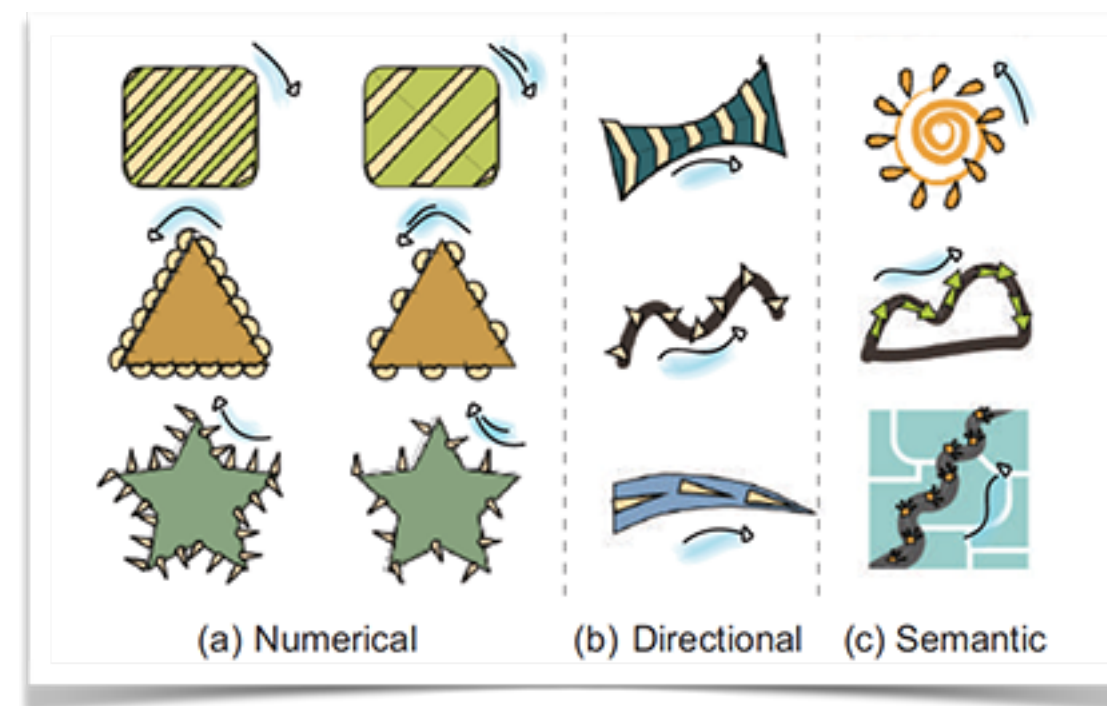
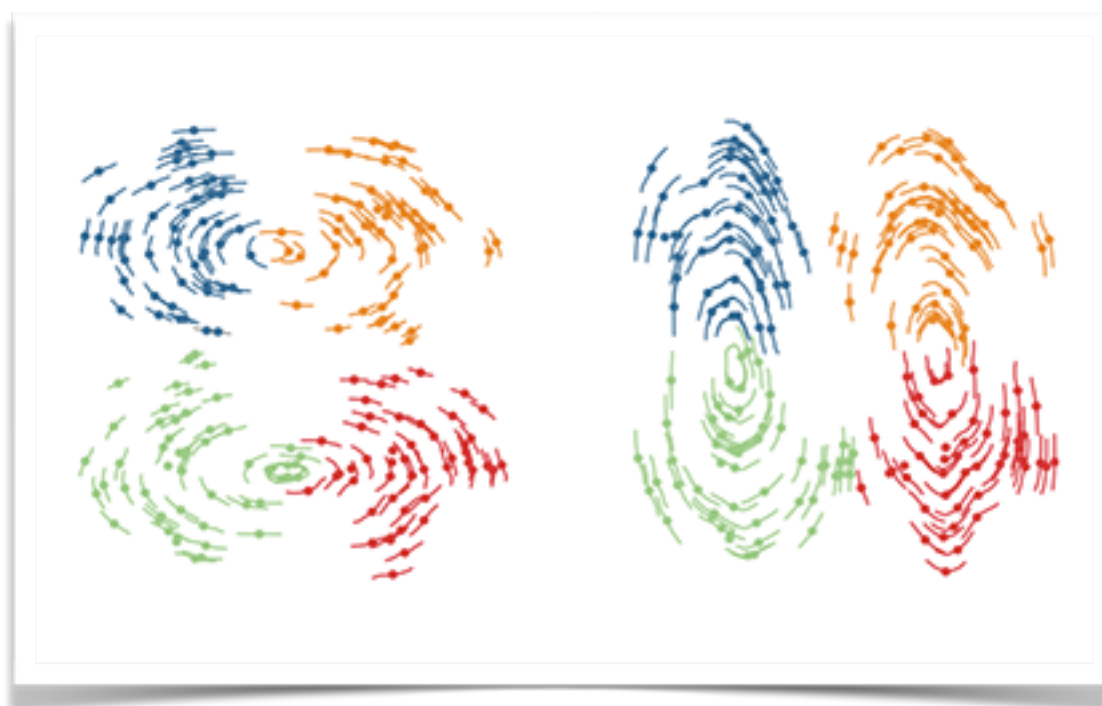
Visual Information Flow [CHI'21]

Lu, M., Wang, C., Lanir, J., Zhao, N., Pfister, H., Cohen-Or, D., & Huang, H. (2020).

Exploring visual information flows in infographics.

In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (pp. 1-12).

InfoVIF Dataset: <http://47.103.22.185:8089/>



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