

Lecture : Visualization Building Blocks

(Marks and Channels)

DATA ANALYSIS AND VISUALIZATION

FALL 2021

Dr. Muhammad Faisal Cheema
FASTNU

GOALS FOR TODAY

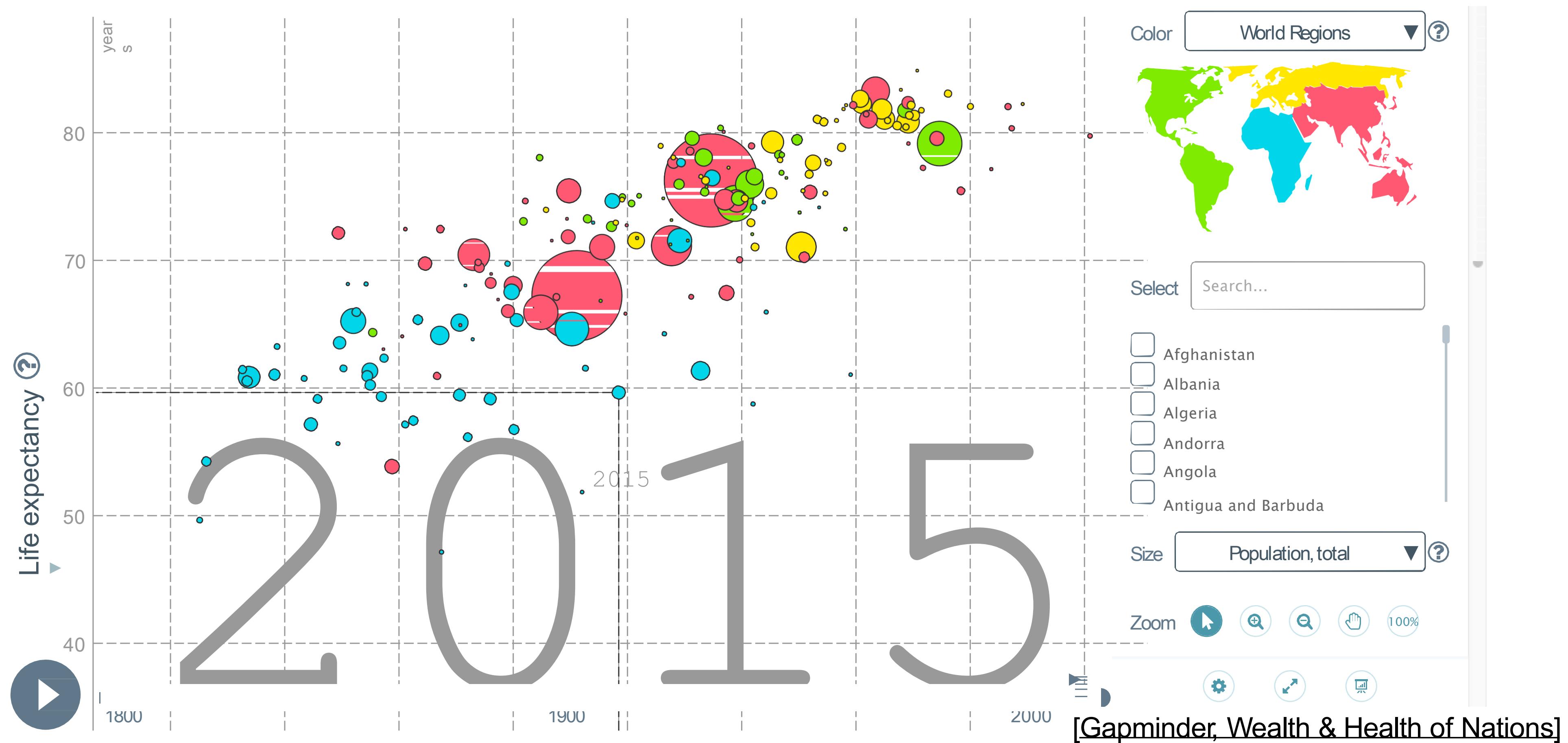
- Learn the basic visual primitives of visualizations (marks and channels)
- Understand how marks and channels are assembled to make visualizations
- Learn which marks and channels are most effective for a given task (“perceptual ordering”)

Visual Encoding

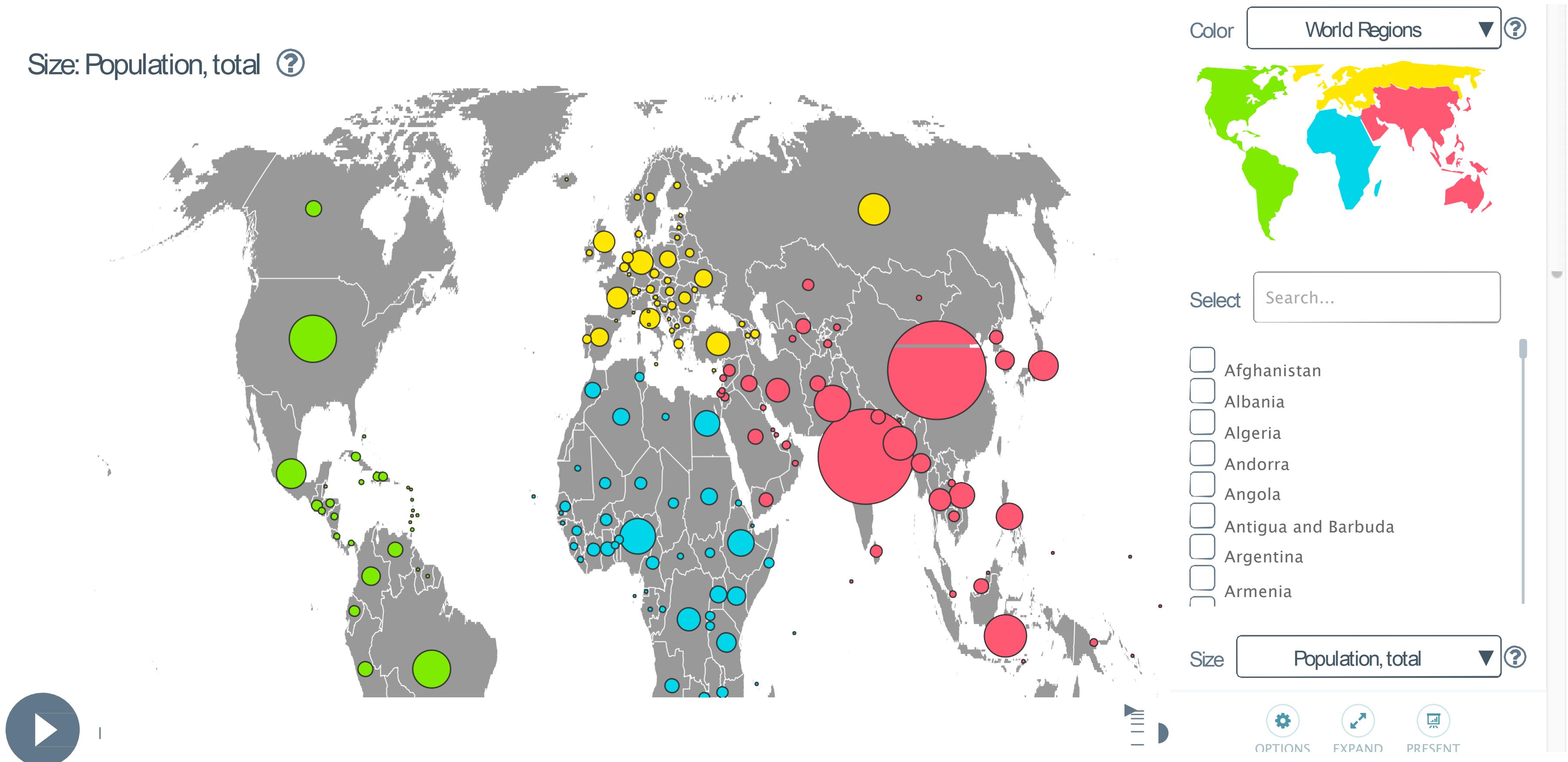
- How should we visualize this data?

Name	Region	Population	Life Expectancy	Income
China	East Asia & Pacific	1335029250	73.28	7226.07
India	South Asia	1140340245	64.01	2731
United States	America	306509345	79.43	41256.08
Indonesia	East Asia & Pacific	228721000	71.17	3818.08
Brazil	America	193806549	72.68	9569.78
Pakistan	South Asia	176191165	66.84	2603
Bangladesh	South Asia	156645463	66.56	1492
Nigeria	Sub-Saharan Africa	141535316	48.17	2158.98
Japan	East Asia & Pacific	127383472	82.98	29680.68
Mexico	America	111209909	76.47	11250.37
Philippines	East Asia & Pacific	94285619	72.1	3203.97
Vietnam	East Asia & Pacific	86970762	74.7	2679.34
Germany	Europe & Central Asia	82338100	80.08	31191.15
Ethiopia	Sub-Saharan Africa	79996293	55.69	812.16
Turkey	Europe & Central Asia	72626967	72.06	8040.78

Potential Solution

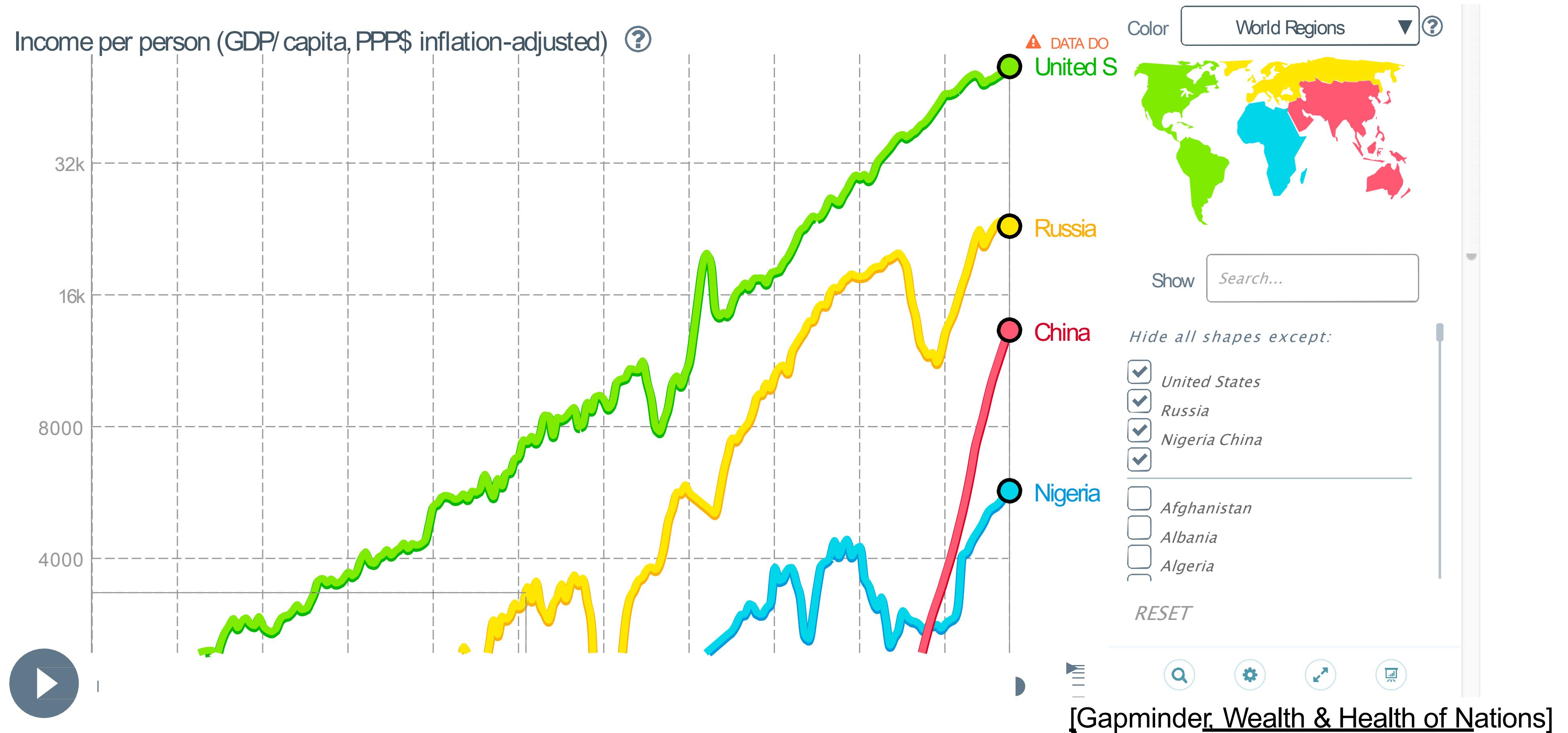


Another Solution



What about change over years?

Another Solution showing trends over time

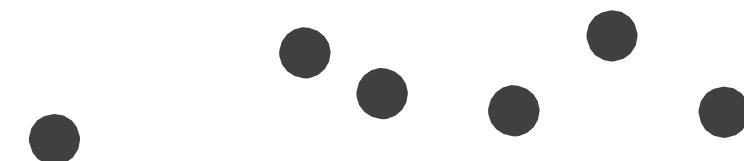


MARKS & CHANNELS

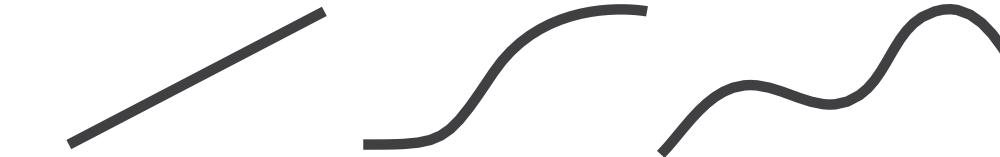
Visual Encoding

- How do we encode data visually?
 - Marks are the basic graphical elements in a visualization
 - Channels are ways to control the appearance of the marks
- Marks classified by dimensionality:

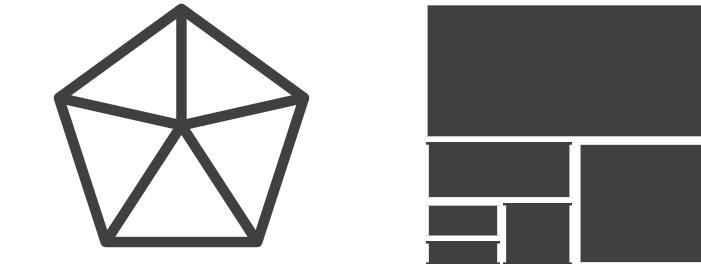
→ Points



→ Lines

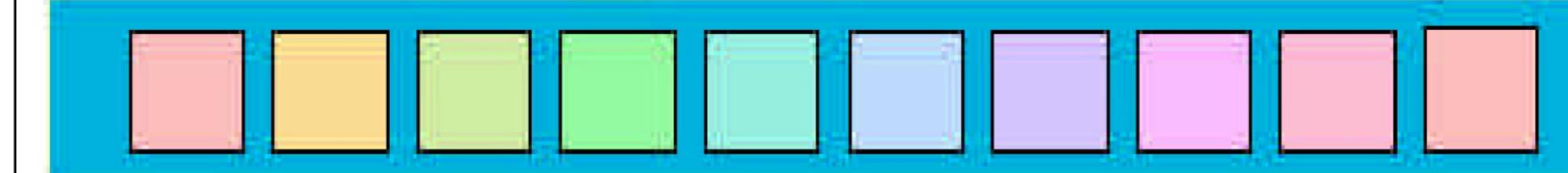
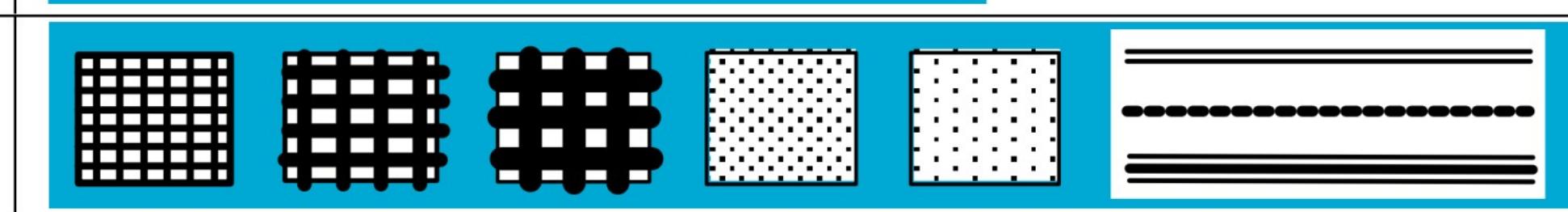


→ Areas



- Also can have surfaces, volumes
- Think of marks as a mathematical definition, or if familiar with tools like Adobe Illustrator or Inkscape, the path & point definitions

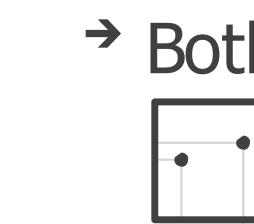
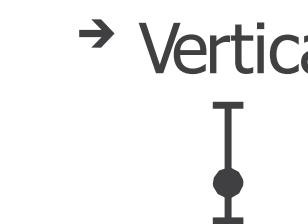
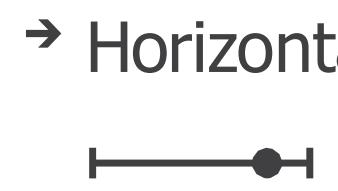
Bertin - Visual Variables

Bertin's Original Visual Variables	
Position changes in the x, y location	
Size change in length, area or repetition	
Shape infinite number of shapes	
Value changes from light to dark	
Colour changes in hue at a given value	
Orientation changes in alignment	
Texture variation in 'grain'	

Visualization Building Blocks

CHANNEL = way to control the appearance of marks,
independent of the dimensionality of the geometric primitive

→ Position



→ Color



→ Shape



→ Tilt



→ Size

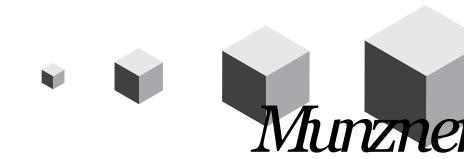
→ Length



→ Area



→ Volume



Visual Attributes Survey

Table of Visual Attributes

Richard Brath
v. Sept 2013

		Information Visualization Researchers										Vision Rsch	Shape Rsch
		Bertin 1967	Cleveland 1985	Mackinlay 1986	MacEachren 1995	Wilkinson 1999	Ware 2000	Mazza 2009	Iliinsky 2012	Chen, Floridi 2013	Preattentive Perception	Brath 2009/2011	
Trans-form	Position	X	X	X	X	X	X	X	X	X			
	Length		X	X			X	X	X	X	X		
	Size (Area)	X	X	X	X	X	X	X	X	X	X		
	Orientation	X		X	X	X	X	X	X	X	X		
	Volume		X	X			X						
Shape	Shape	X		X	X	X	X	X	X	X		X	
	Angle		X	X						X		X	
	Curvature										X	X	
	Mark										X	X	
	Line Ending							X	X	3	X	X	
	Closure								X		X	X	
	Local Warp											X	
	Edge Type									1,2		X	
Colour	Corner Type									3		X	
	Icon, glyph, etc									4			
	Brightness	X		X	X	X	X	X	X	X	X		
	Hue	X	X	X	X	X	X	X	X	X	X		
	Saturation		X	X	X	X	X	X	X	X			

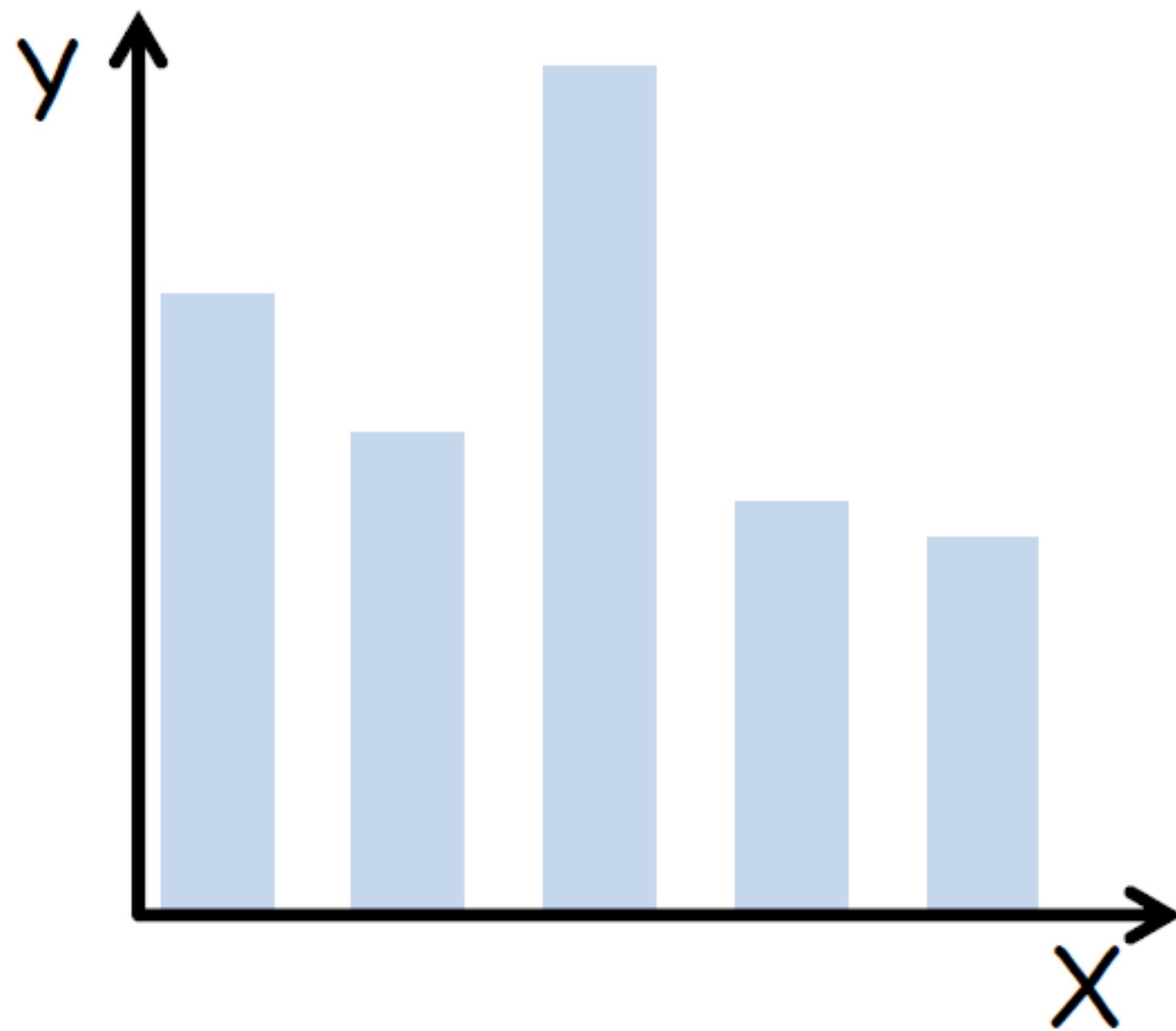
More Visual Attributes

Table of Visual Attributes

Richard Brath
v. Sept 2013

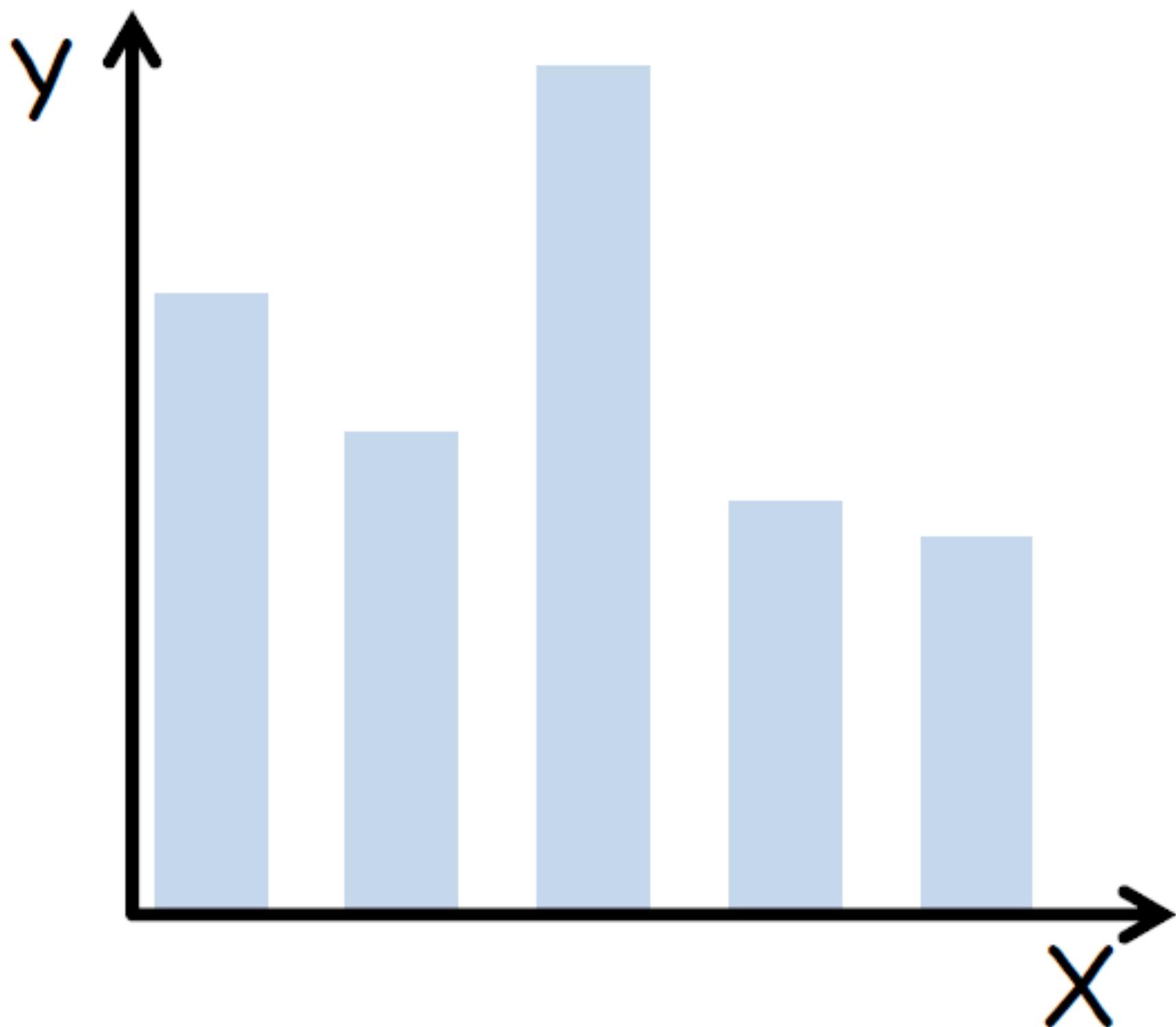
		Information Visualization Researchers								Vision Rsch	Shape Rsch	
		Bertin 1967	Cleveland 1985	MacKinlay 1986	MacEachren 1995	Wilkinson 1999	Ware 2000	Mazza 2009	Iliinsky 2012	Chen, Floridi 2013	Preattentive Perception	Brath 2009/2011
Texture	Granularity	X		X	X	X	X	X	X	X		
	Pattern				X	X	X	X	X			
	Orientation				X	X						
Relation	Connection			X				X	X	X		
	Containment			X				X	X			
Optics	Blur				X	X				X		
	Transparency				X	X				X		
	Stereo Depth										X	
	Concavity									X	X	
	Light Direction									X	X	
	Shadow									X		
	Partial occlusion									X		
Move- ment	Flicker					X			X	X		
	Speed					X			X	X		
	Direction								X	X		
Misc	Numerosity								X	X		
	Spatial Grouping								X	X		
	Arrangement				X							
	Resolution				X							
	Artistic Effects									X		
	Text Labels						X	X	X			

Visualization Building Blocks



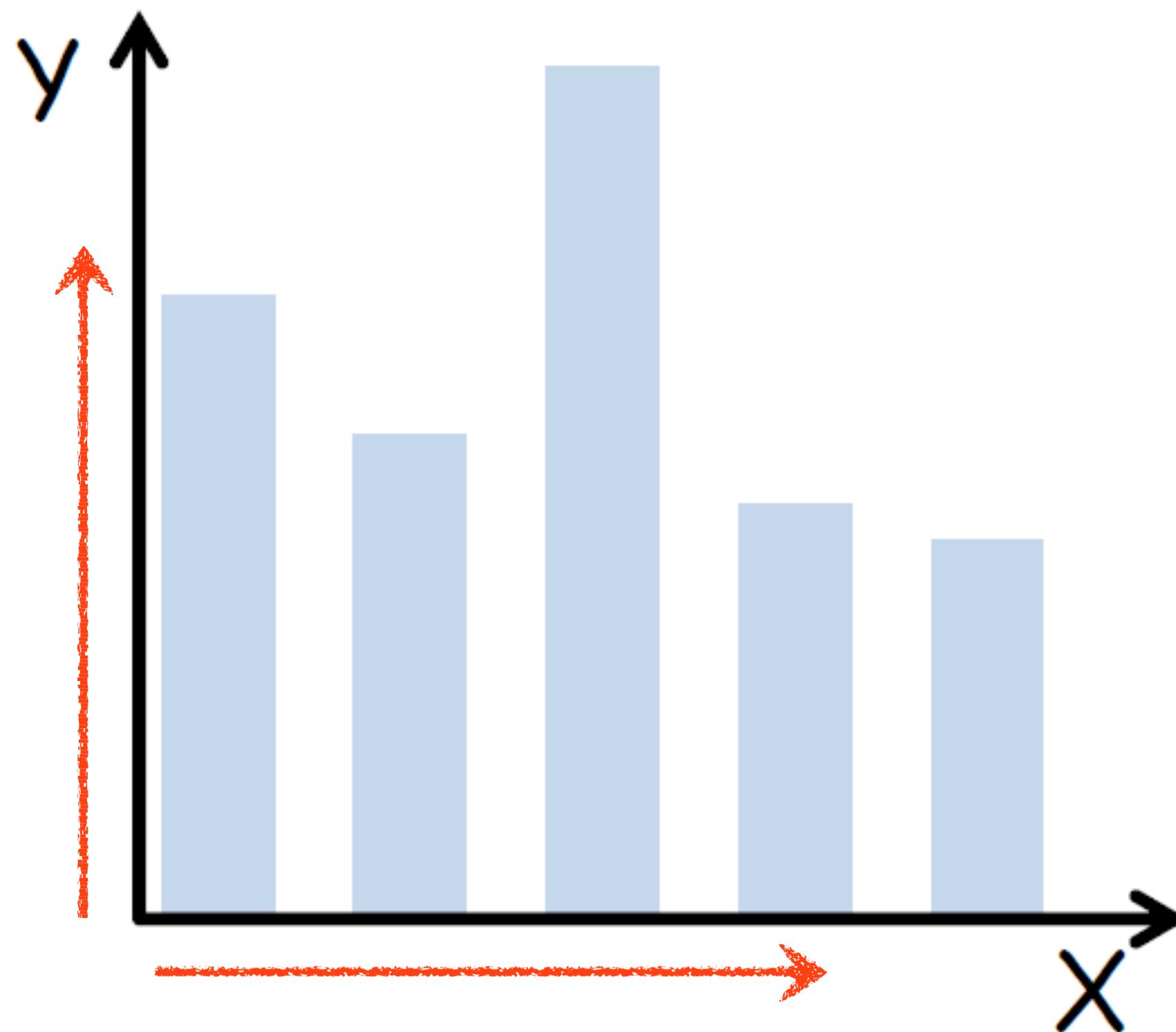
Visualization Building Blocks

of attributes encoded:



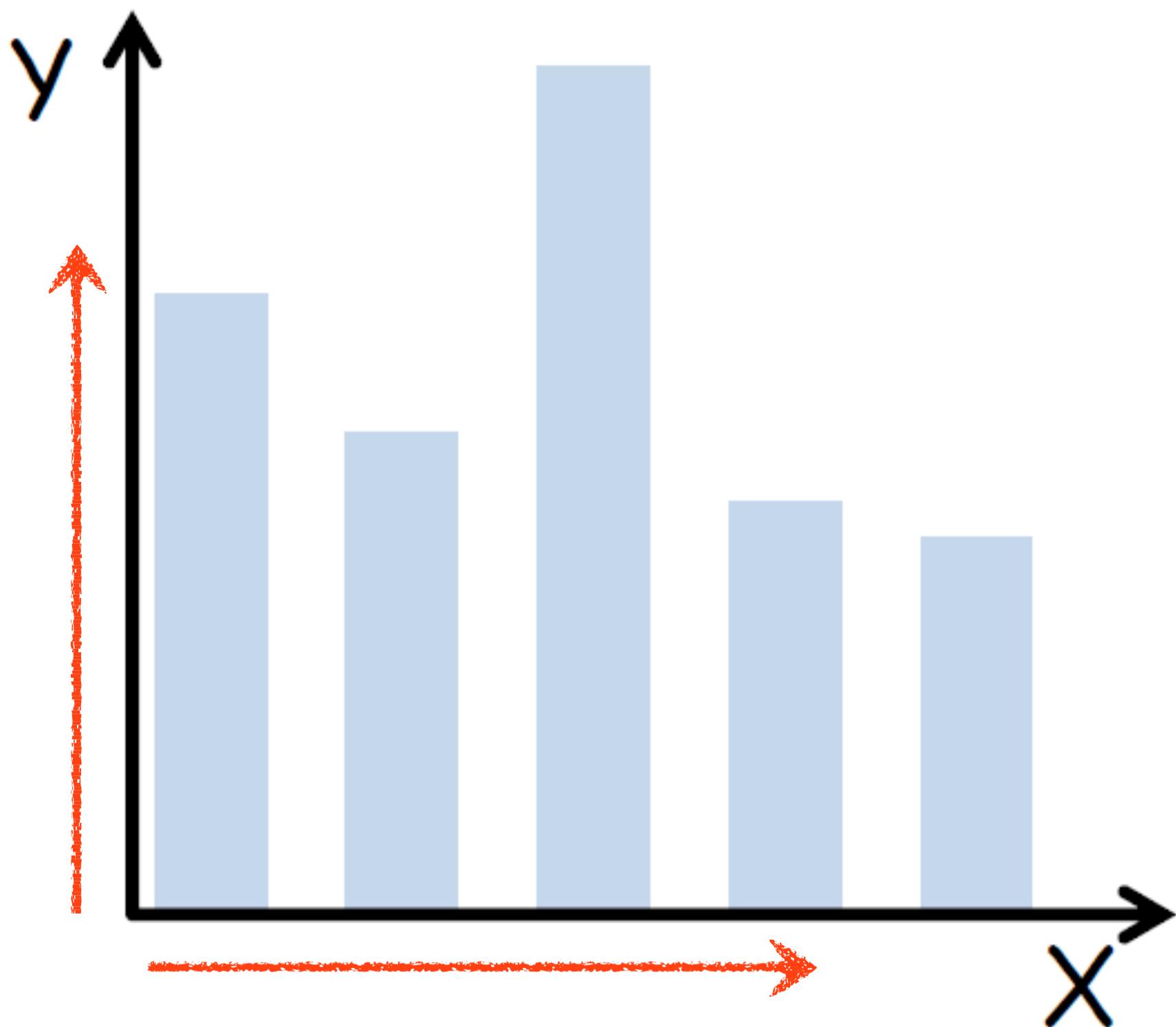
Visualization Building Blocks

of attributes encoded: 2



Visualization Building Blocks

of attributes encoded: 2



MARK:

→ Points



→ Lines

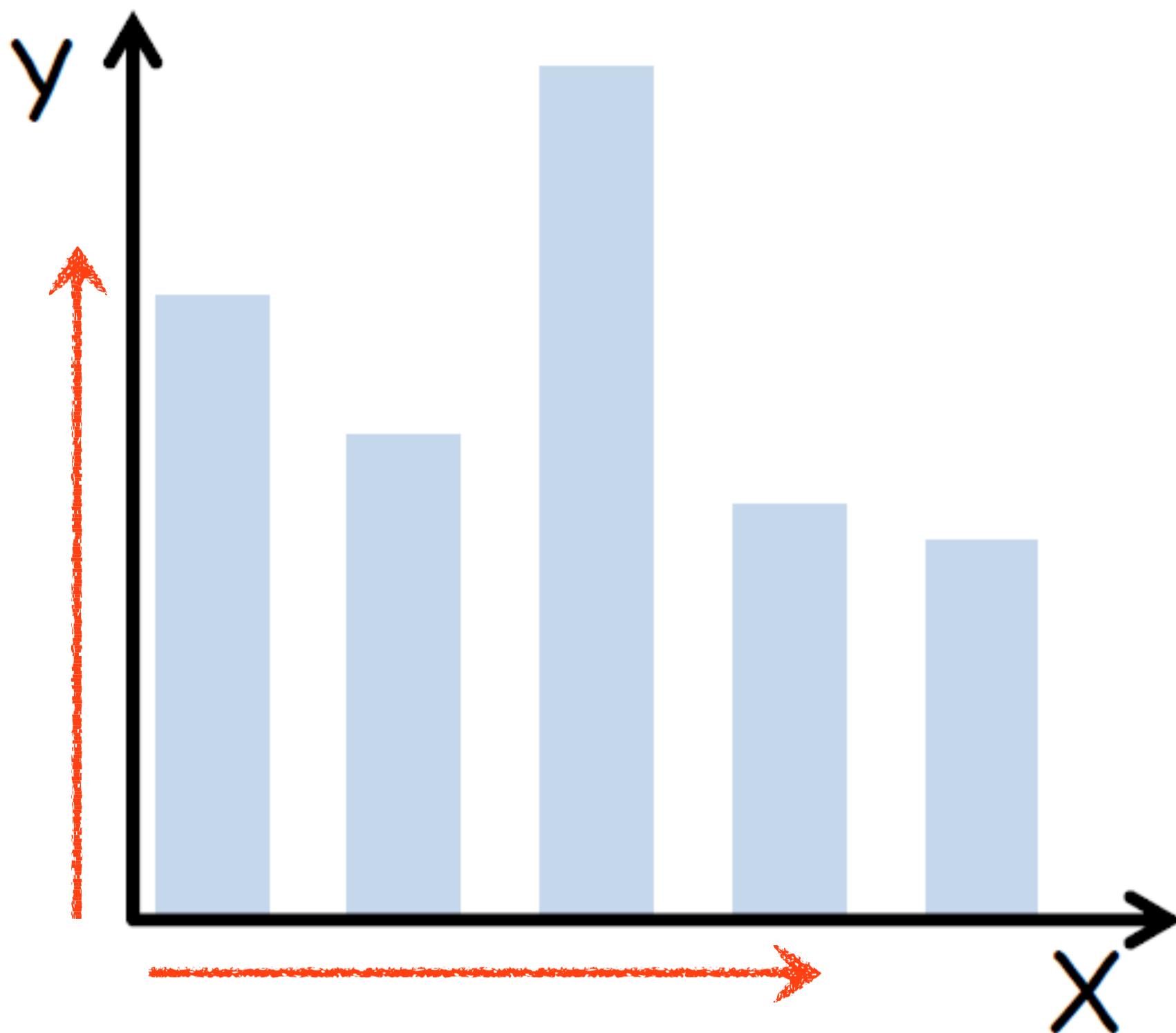


→ Areas



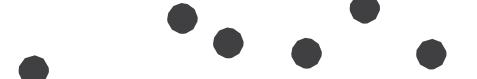
Visualization Building Blocks

of attributes encoded: 2

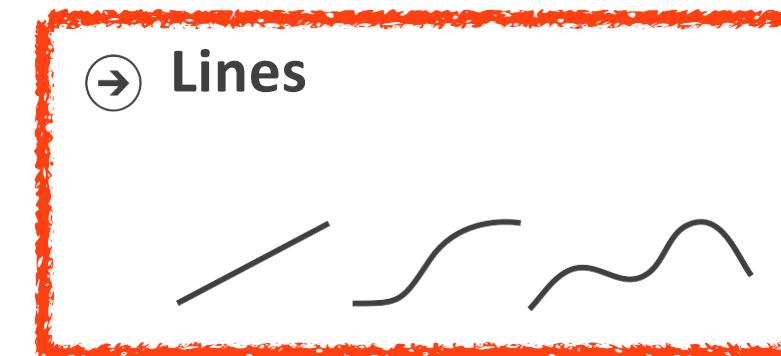


MARK:

→ Points



→ Lines

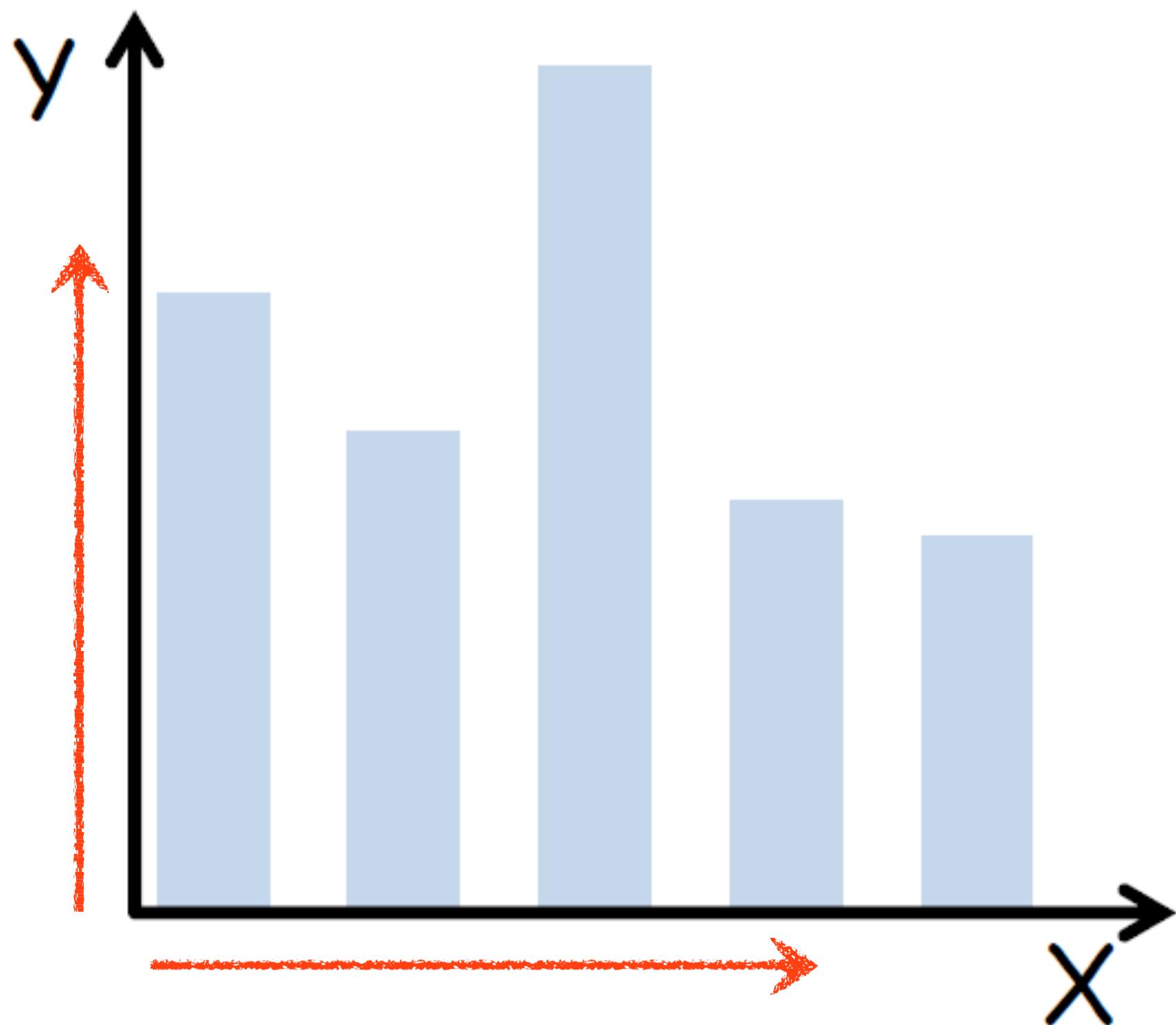


→ Areas



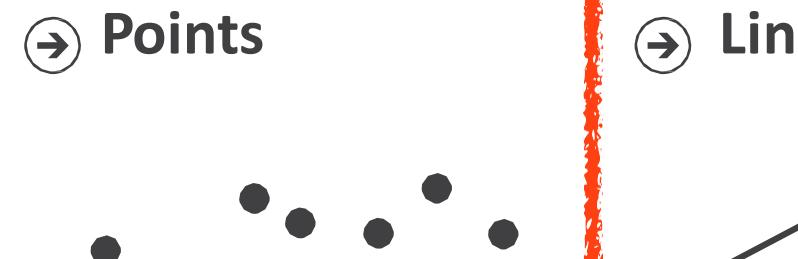
Visualization Building Blocks

of attributes encoded: 2

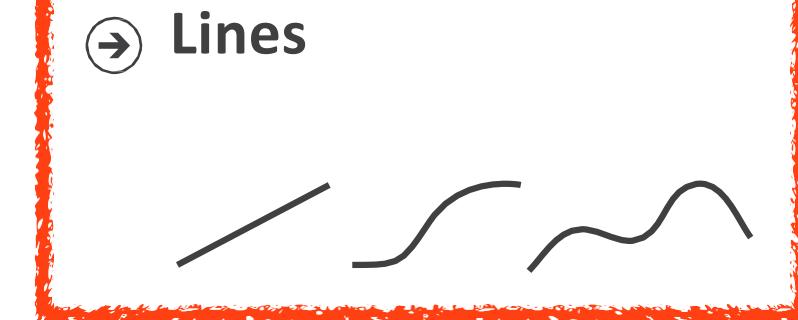


MARK:

→ Points



→ Lines



→ Areas



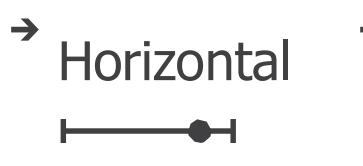
CHANNEL :

→ Position

→ Horizontal



→ Vertical



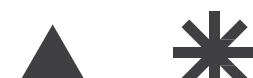
→ Both



→ Color



→ Shape

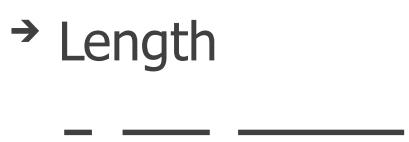


→ Tilt



→ Size

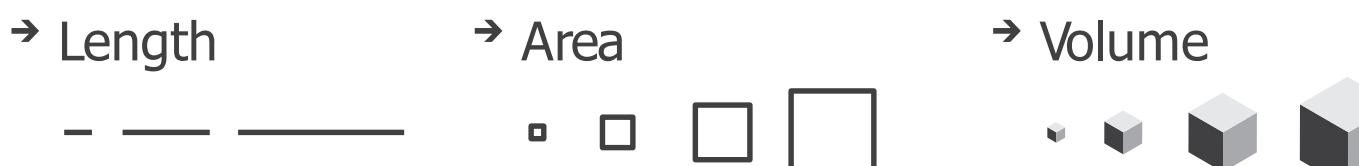
→ Length



→ Area

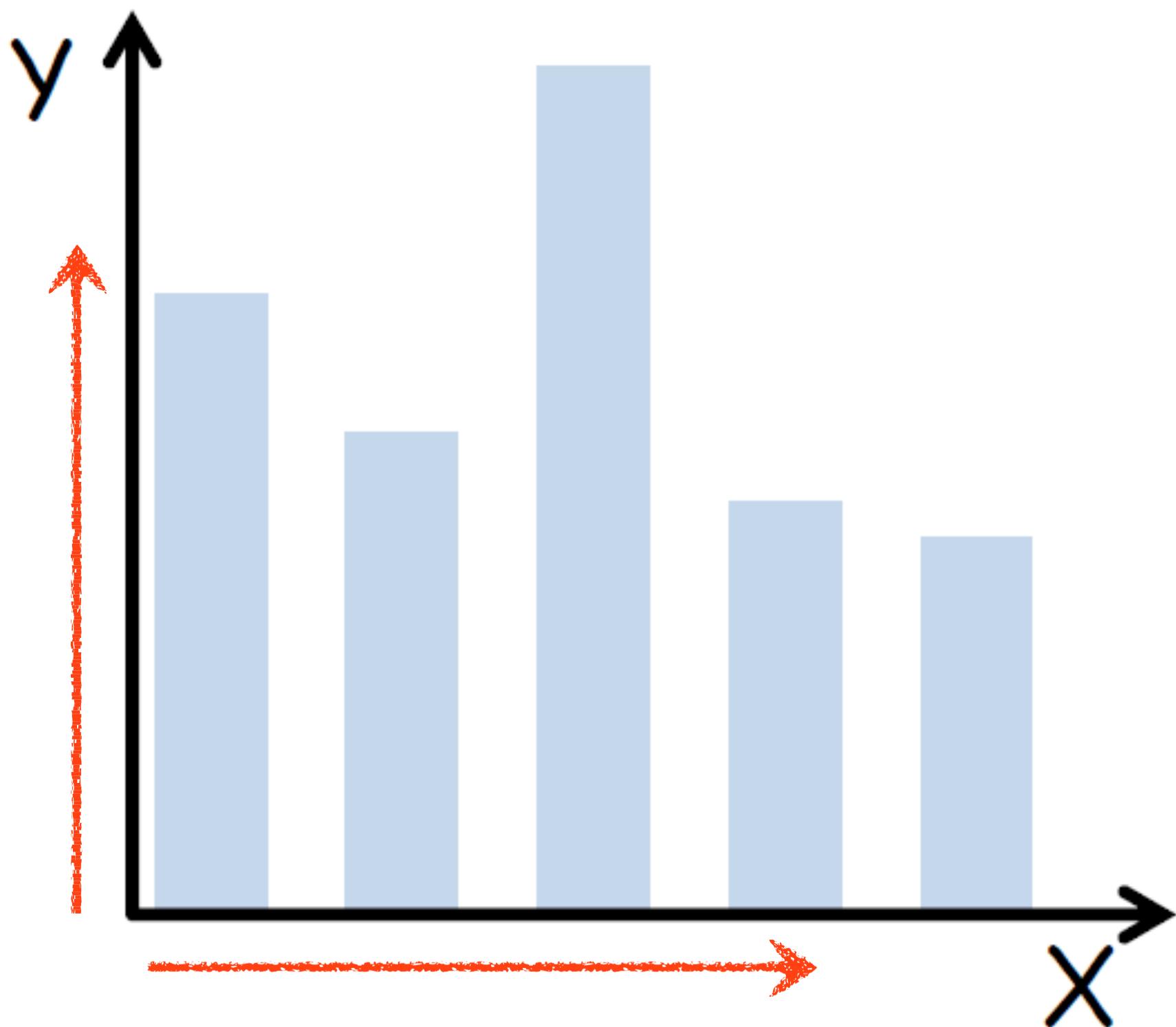


→ Volume



Visualization Building Blocks

of attributes encoded: 2

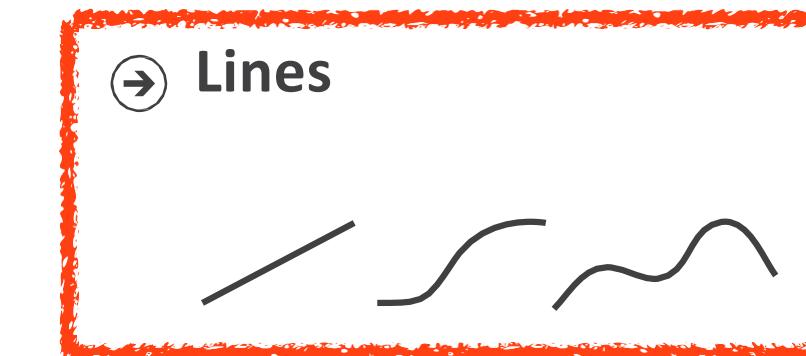


MARK:

→ Points



→ Lines



→ Areas



CHANNEL :

→ Position

→ Horizontal

→ Vertical

→ Both

→ Shape



→ Color



→ Tilt



→ Size

→ Length



→ Area

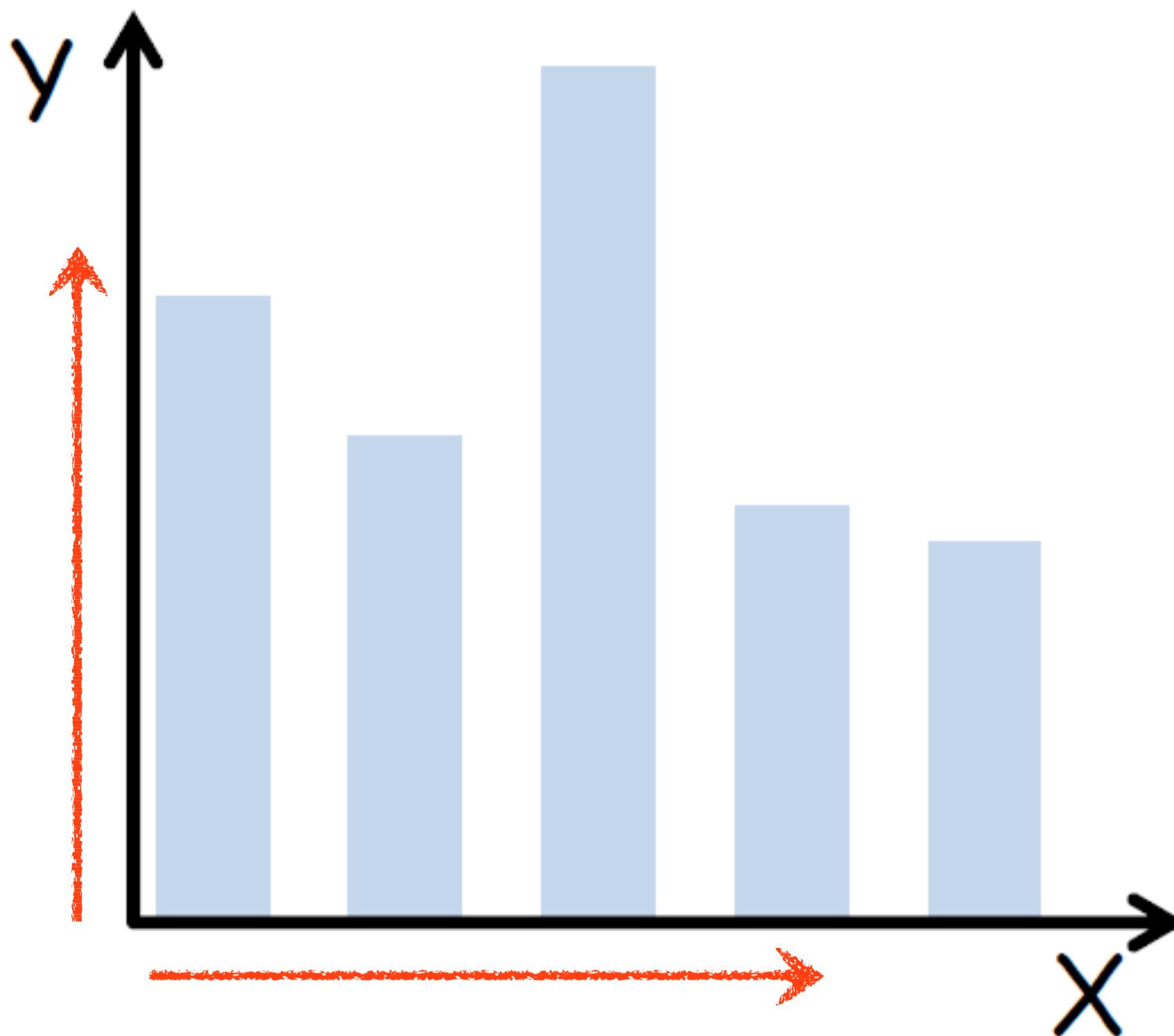


→ Volume



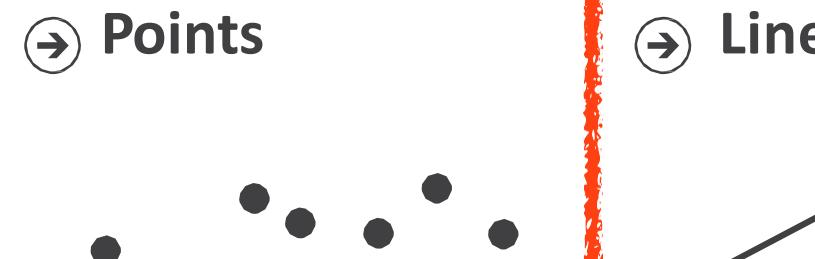
Visualization Building Blocks

of attributes encoded: 2



MARK:

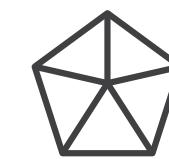
→ Points



→ Lines



→ Areas



CHANNEL :

→ Position

→ Horizontal



→ Vertical



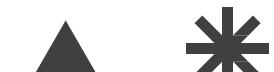
→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length



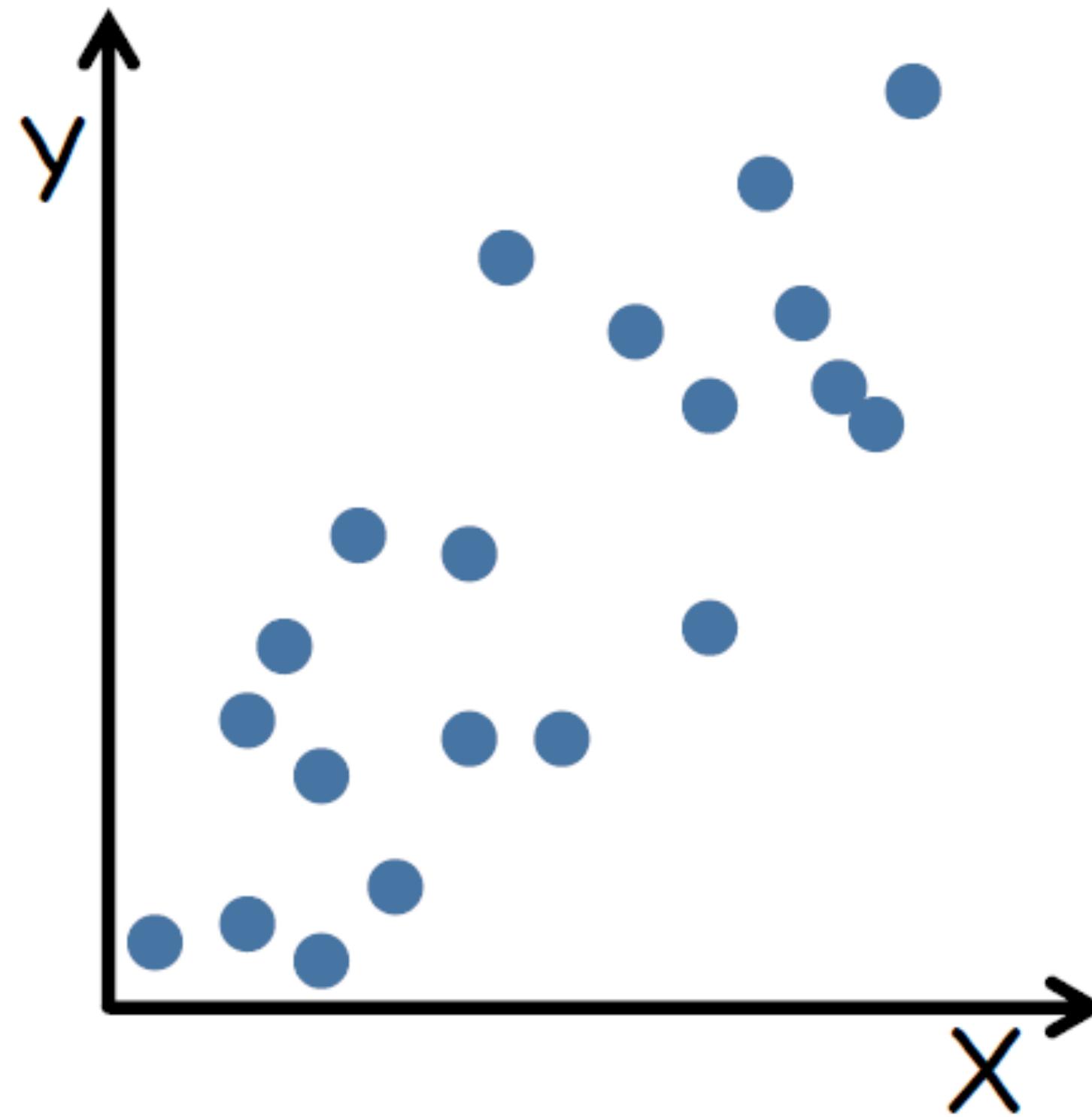
→ Area



→ Volume



Visualization Building Blocks



MARK:

→ Points

→ Lines

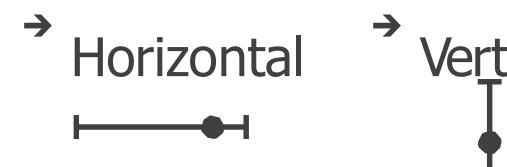
→ Areas



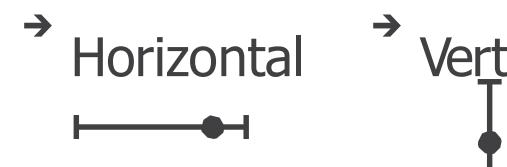
CHANNEL :

→ Position

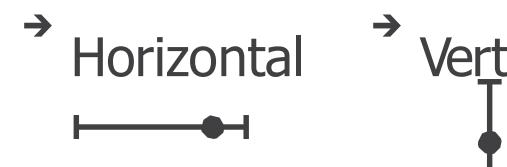
→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area

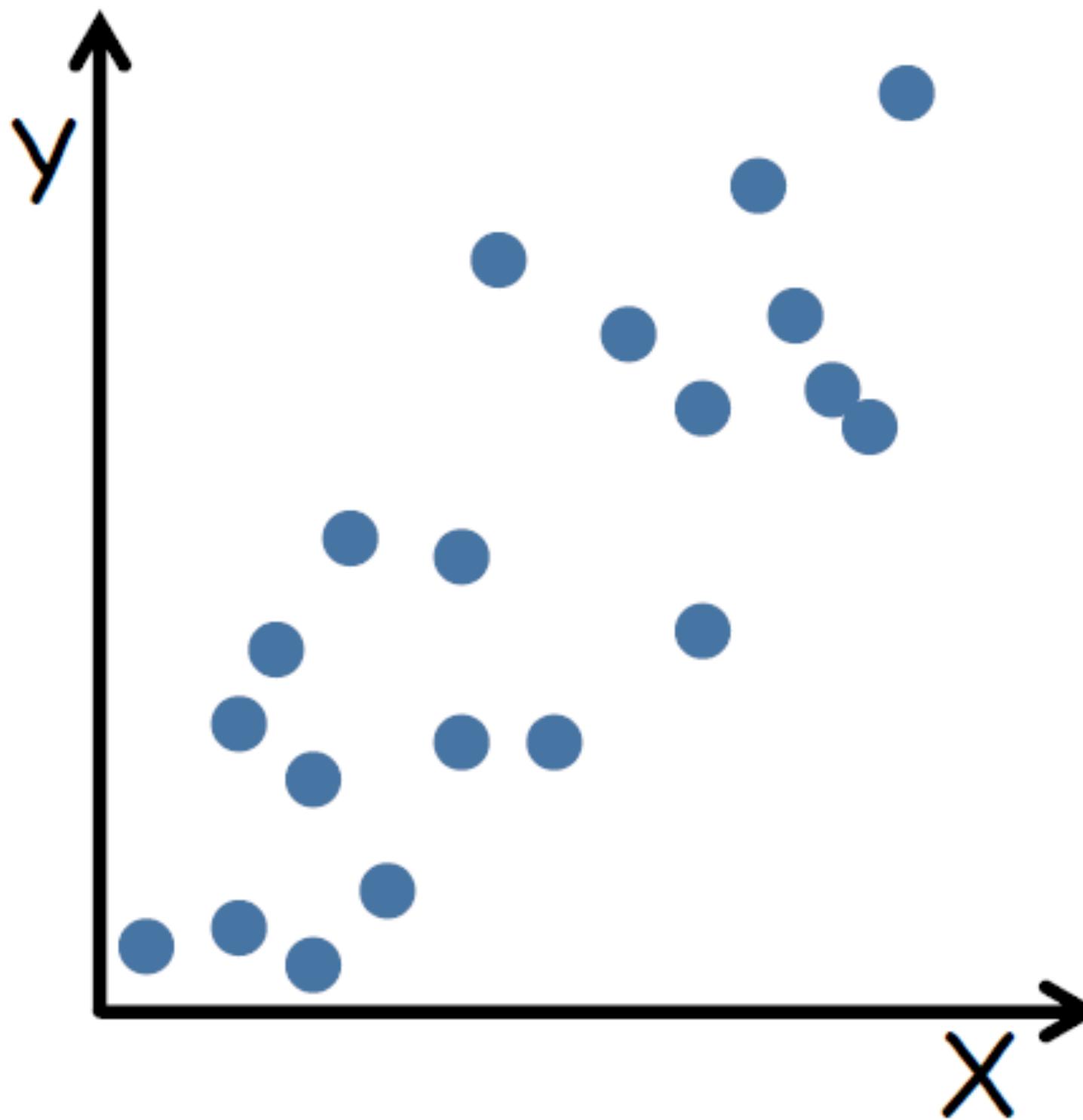


→ Volume



Visualization Building Blocks

of attributes encoded:



MARK:

→ Points

→ Lines

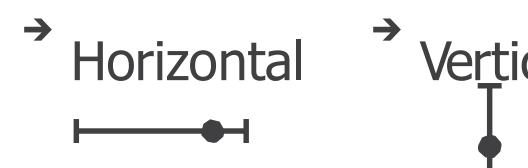
→ Areas



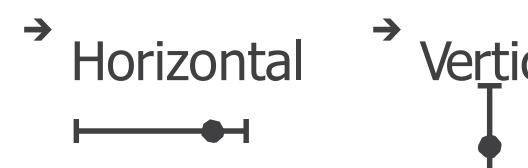
CHANNEL :

→ Position

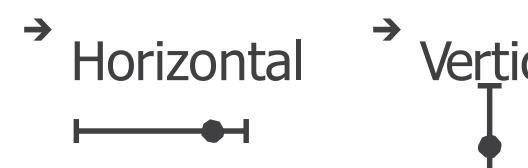
→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area

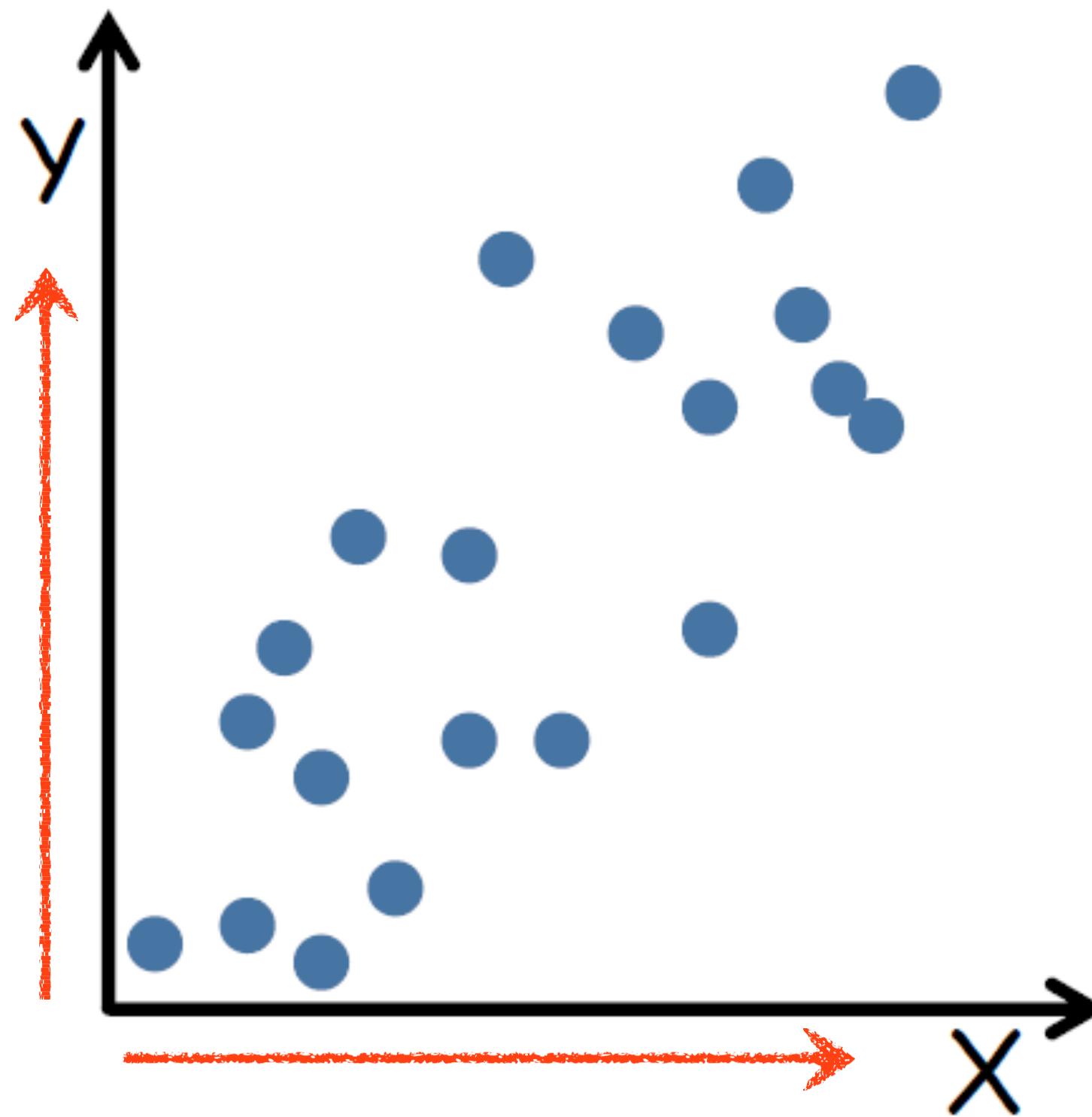


→ Volume



Visualization Building Blocks

of attributes encoded: 2



MARK:

→ Points



→ Lines



→ Areas



CHANNEL :

→ Position

→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



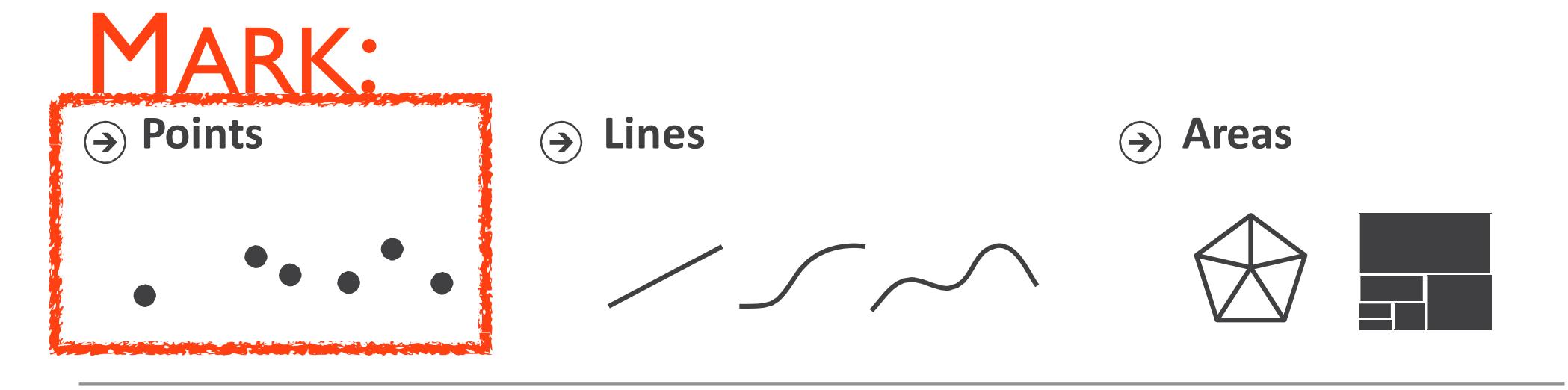
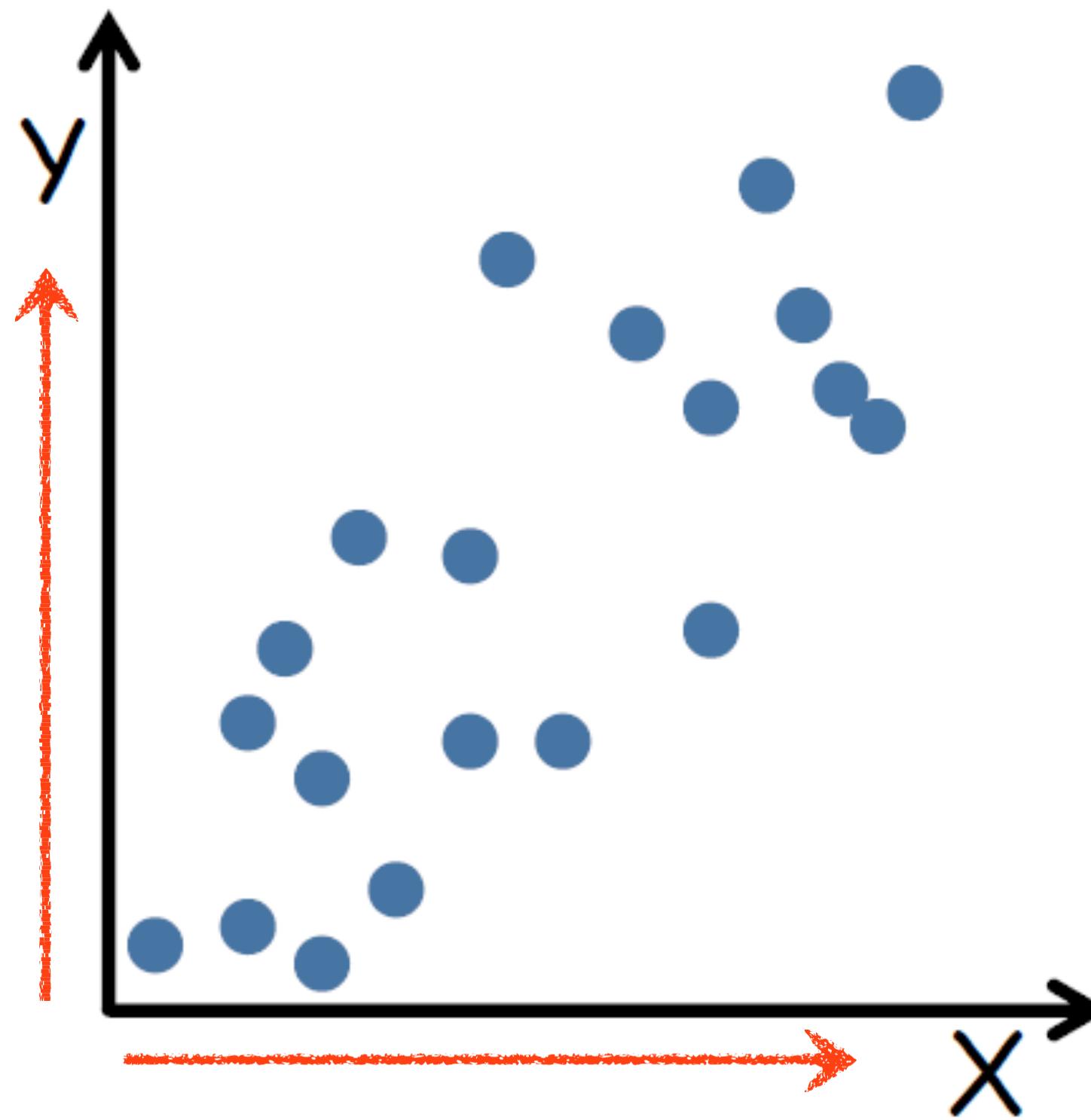
→ Size

→ Length



Visualization Building Blocks

of attributes encoded: 2



CHANNEL :

Position

- Horizontal
- Vertical
- Both

Color



Shape



Tilt



Size

- Length
- Area

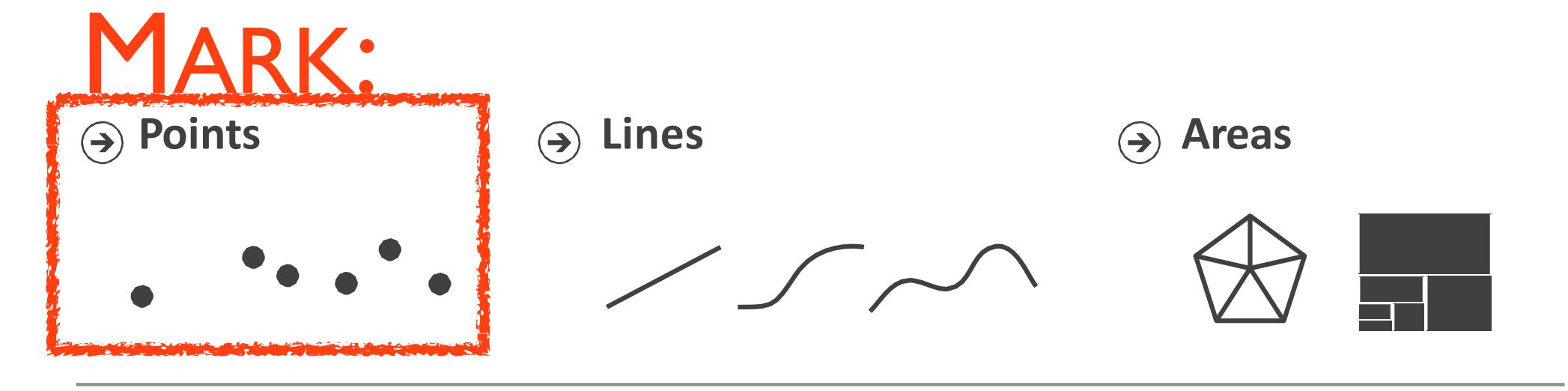
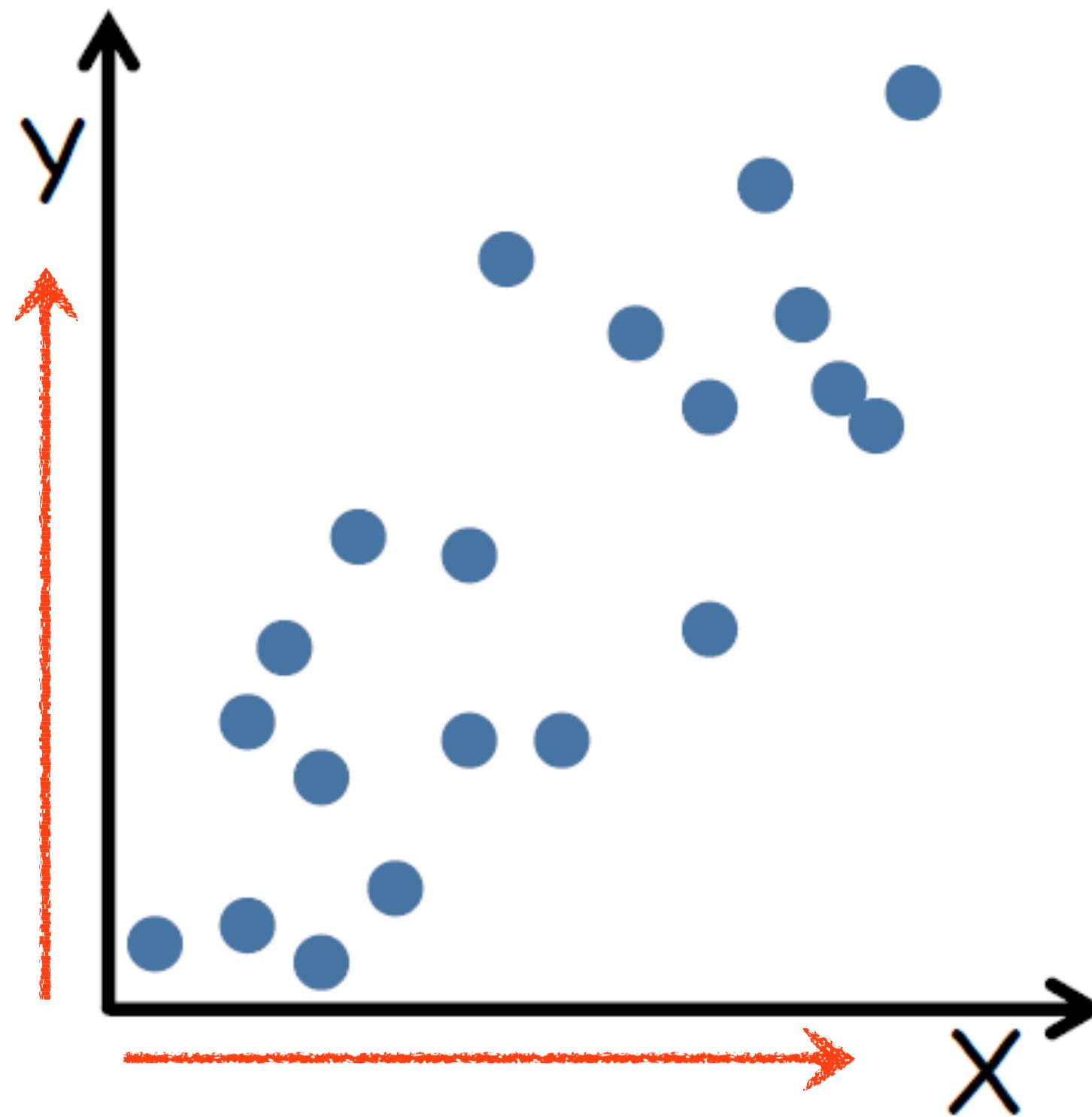


Volume

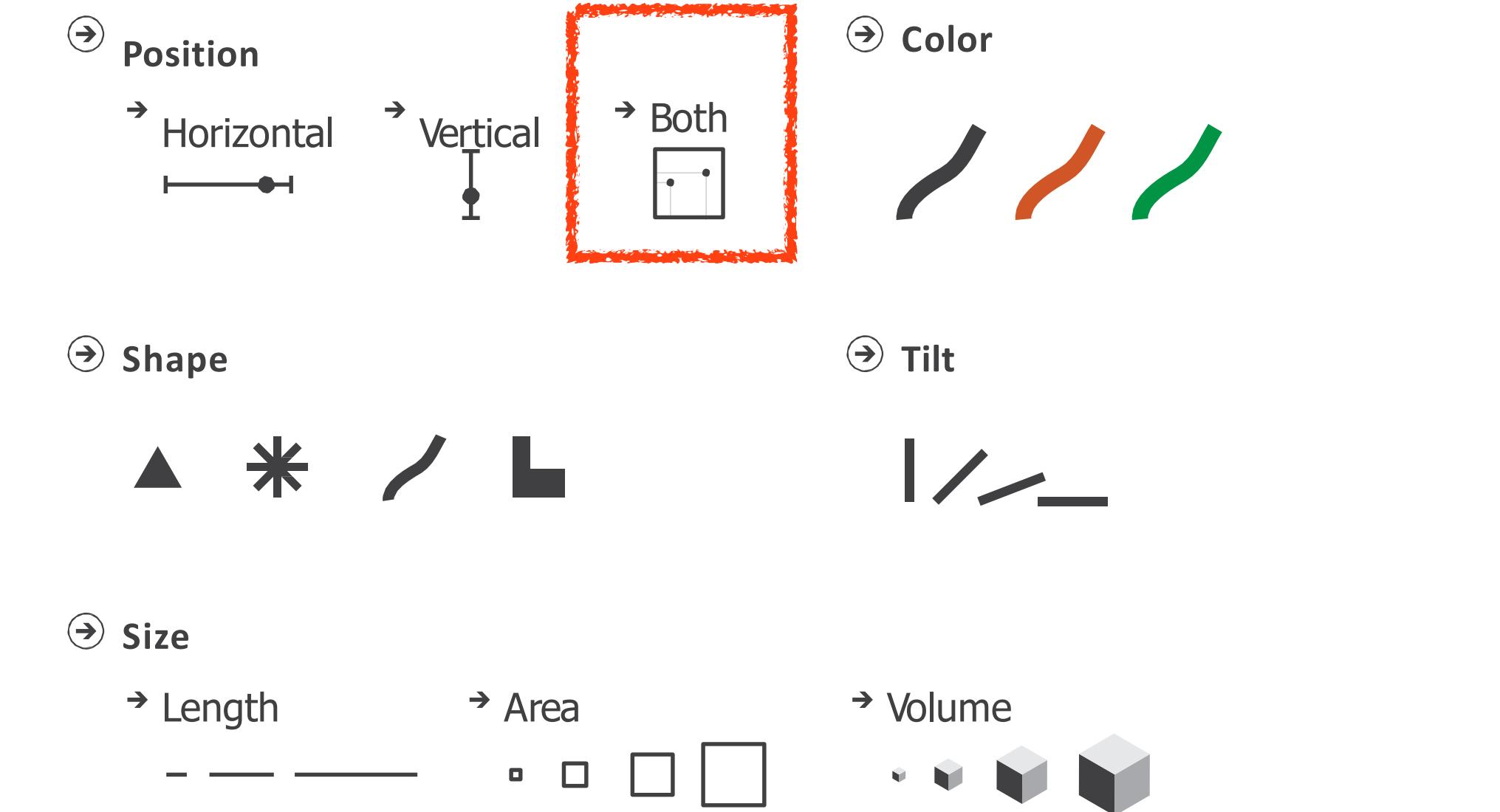


Visualization Building Blocks

of attributes encoded: 2

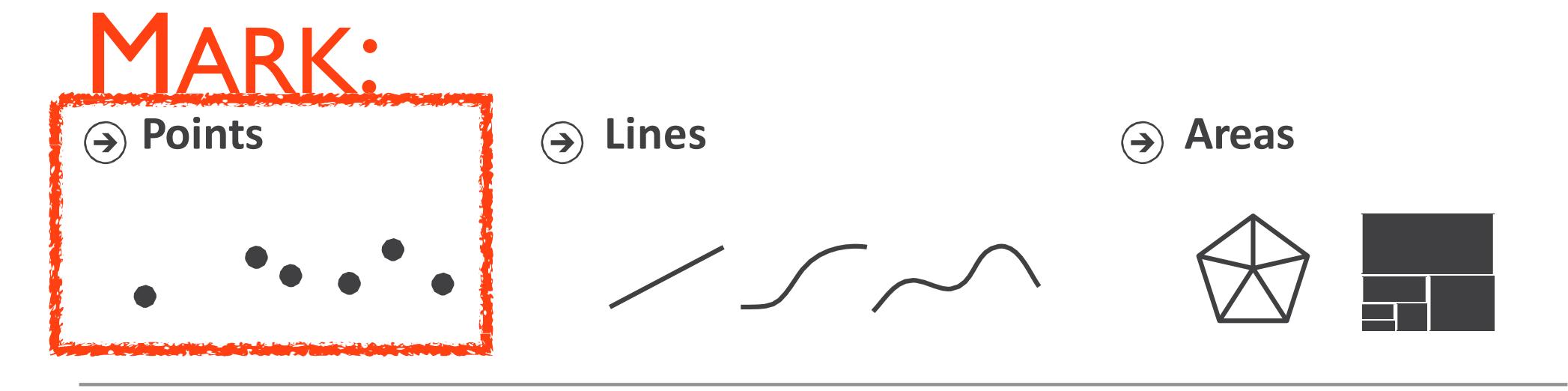
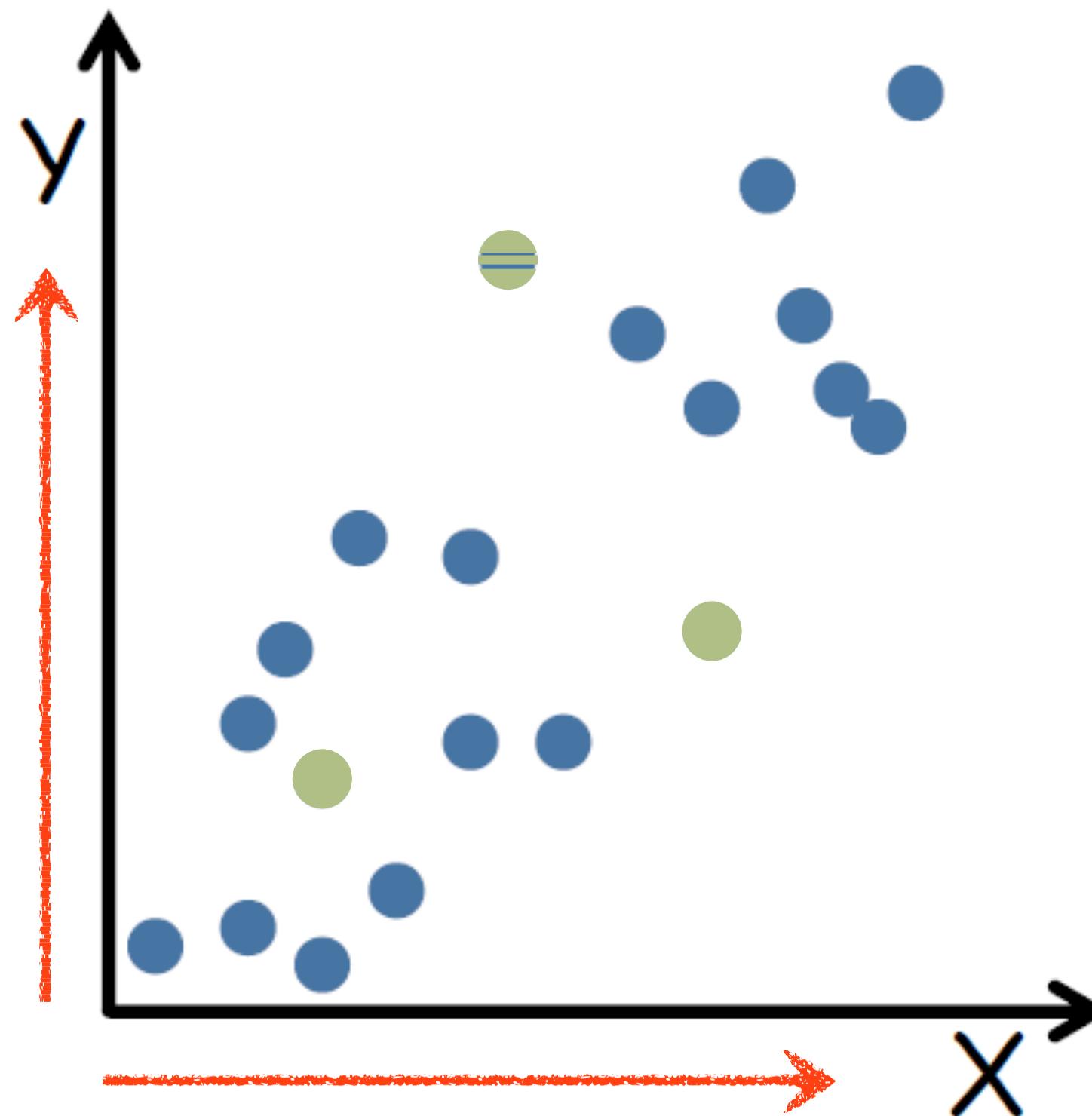


CHANNEL :

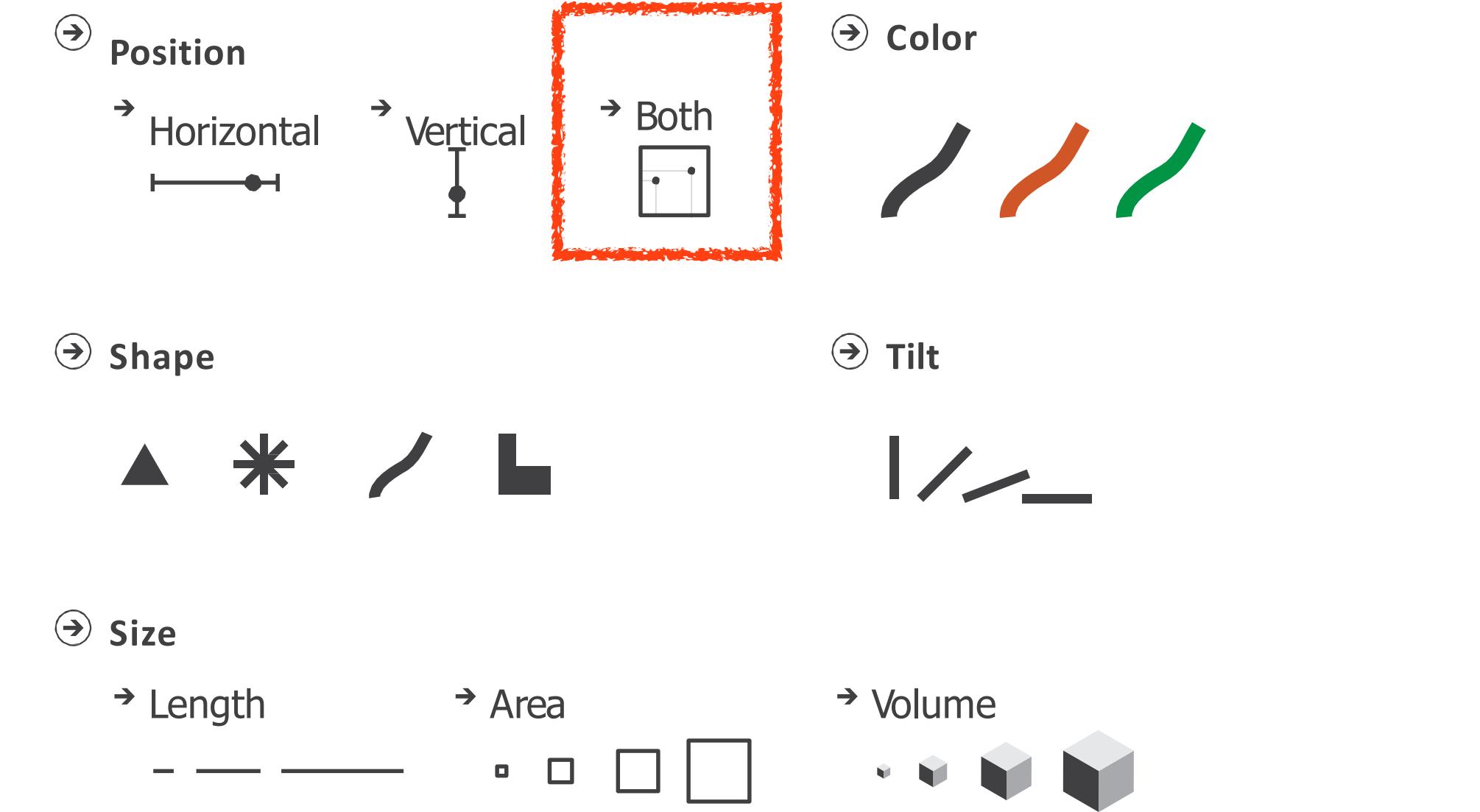


Visualization Building Blocks

of attributes encoded:

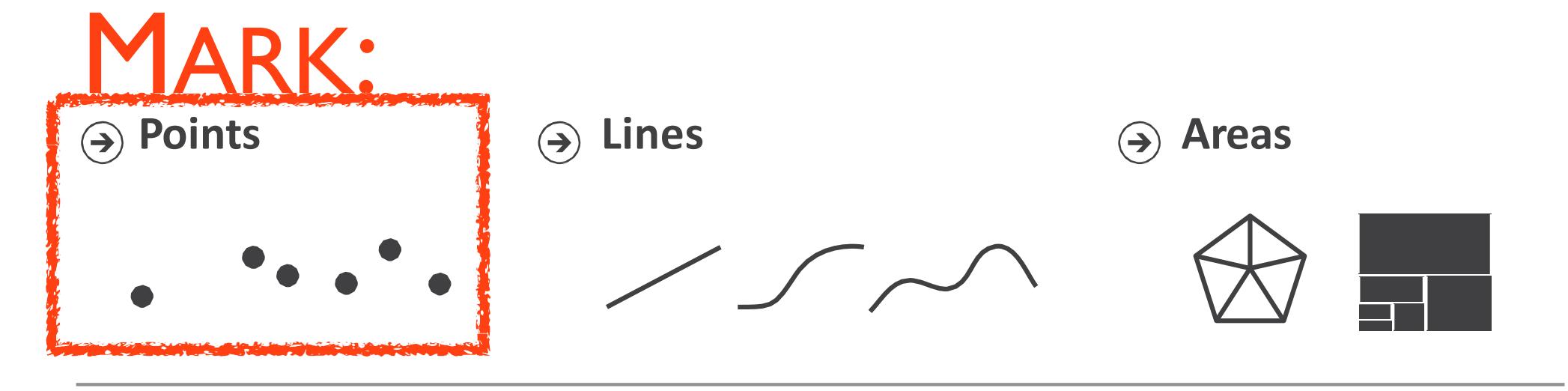
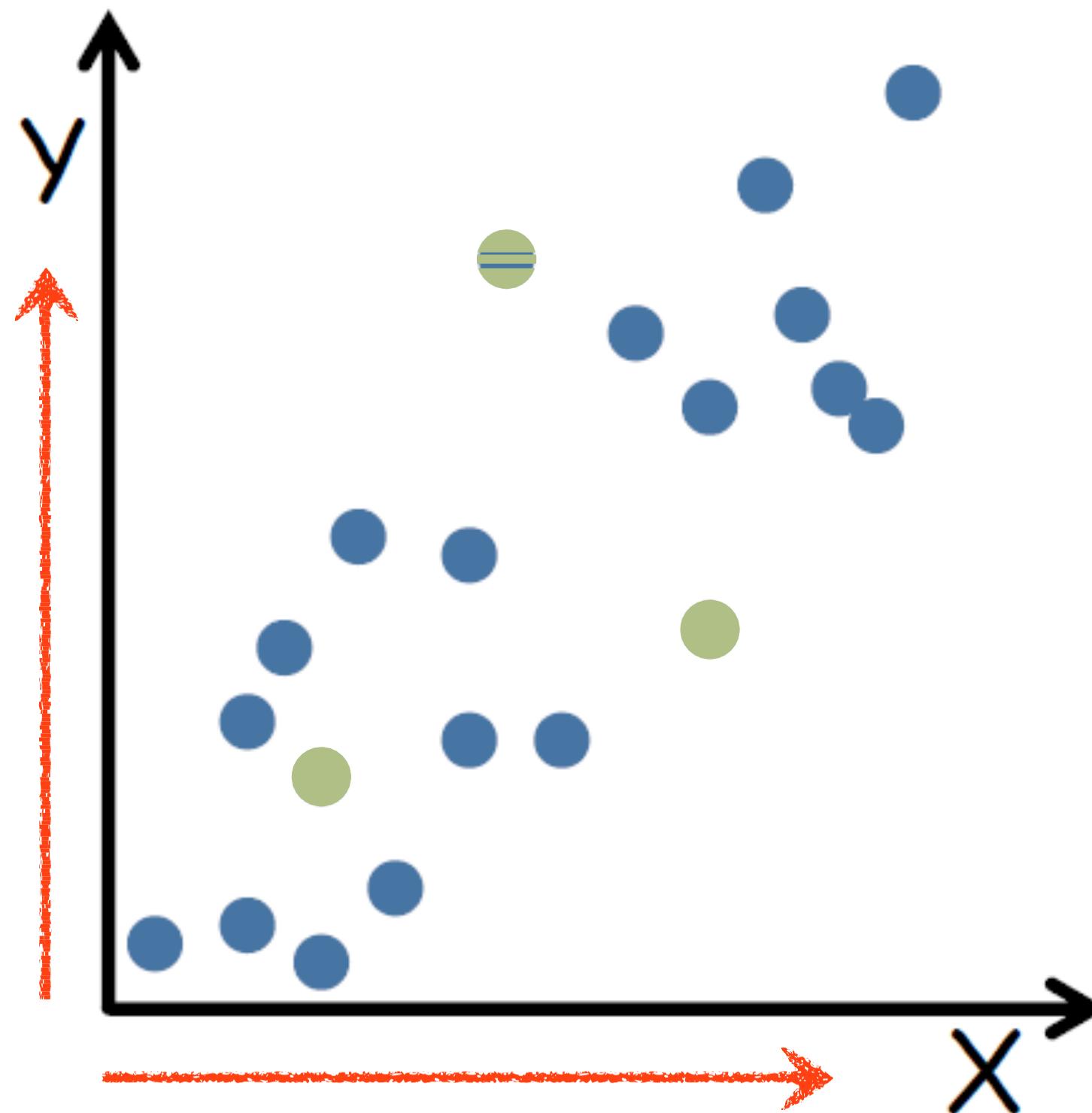


CHANNEL :

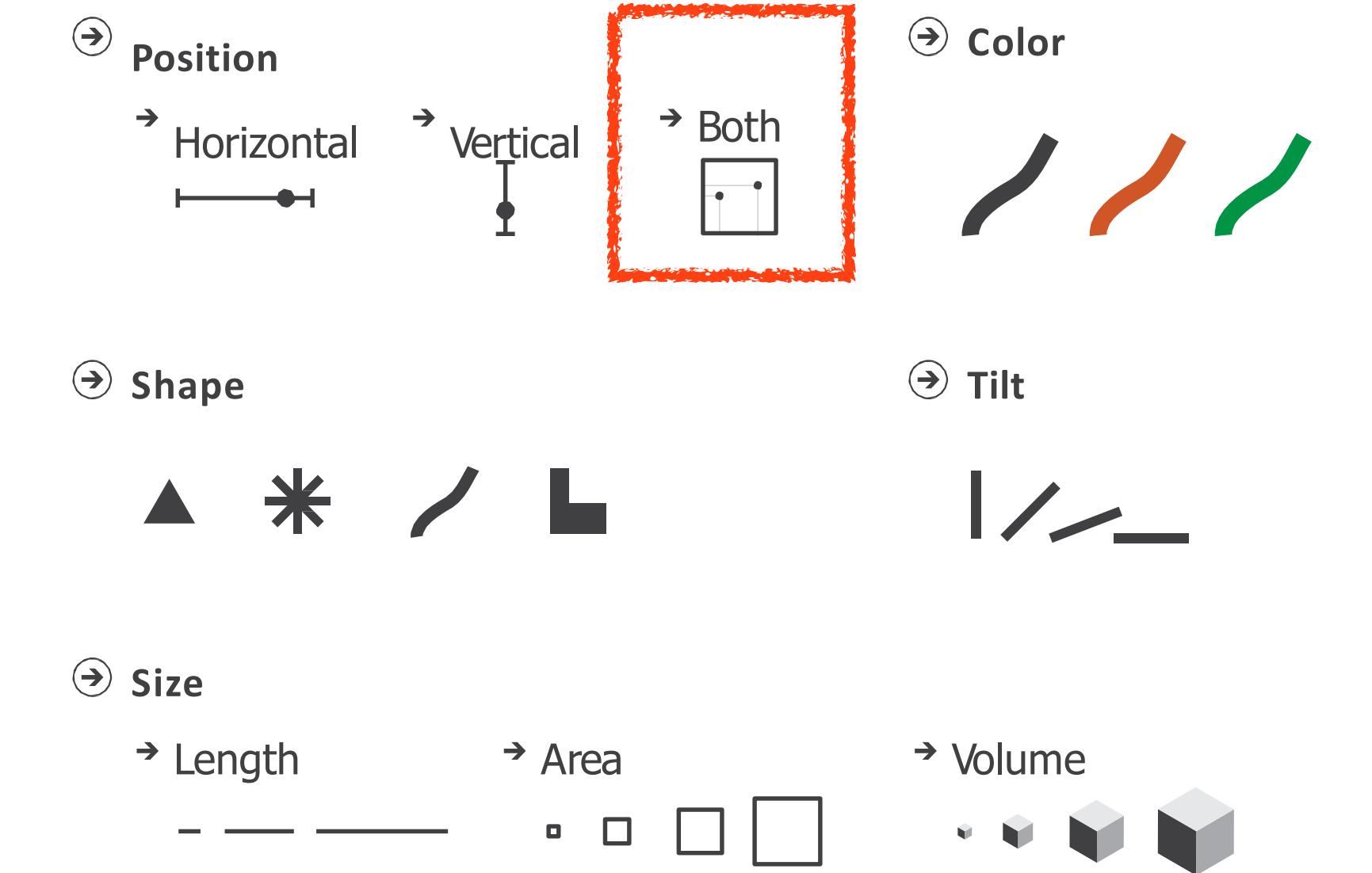


Visualization Building Blocks

of attributes encoded: 3

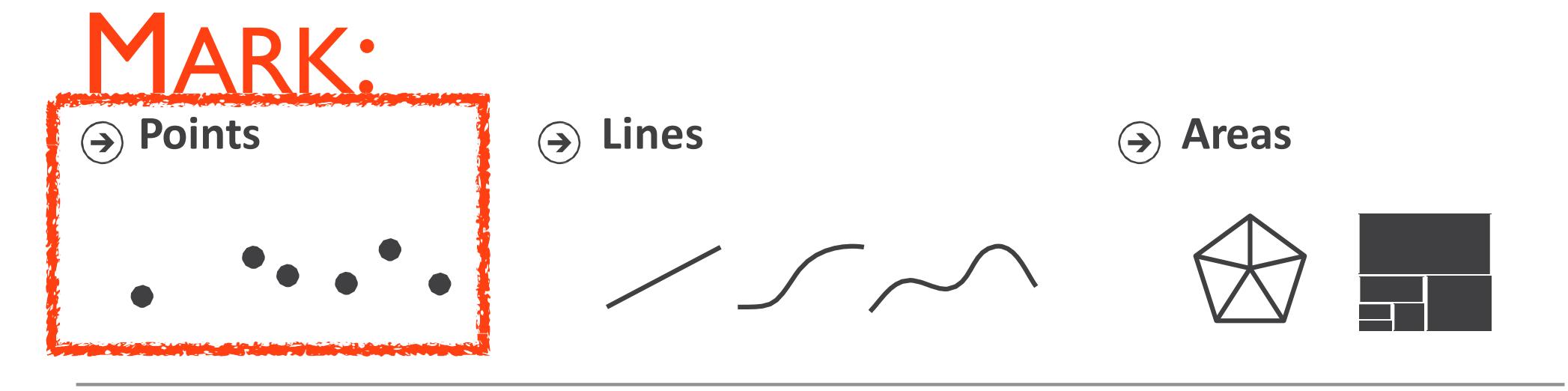
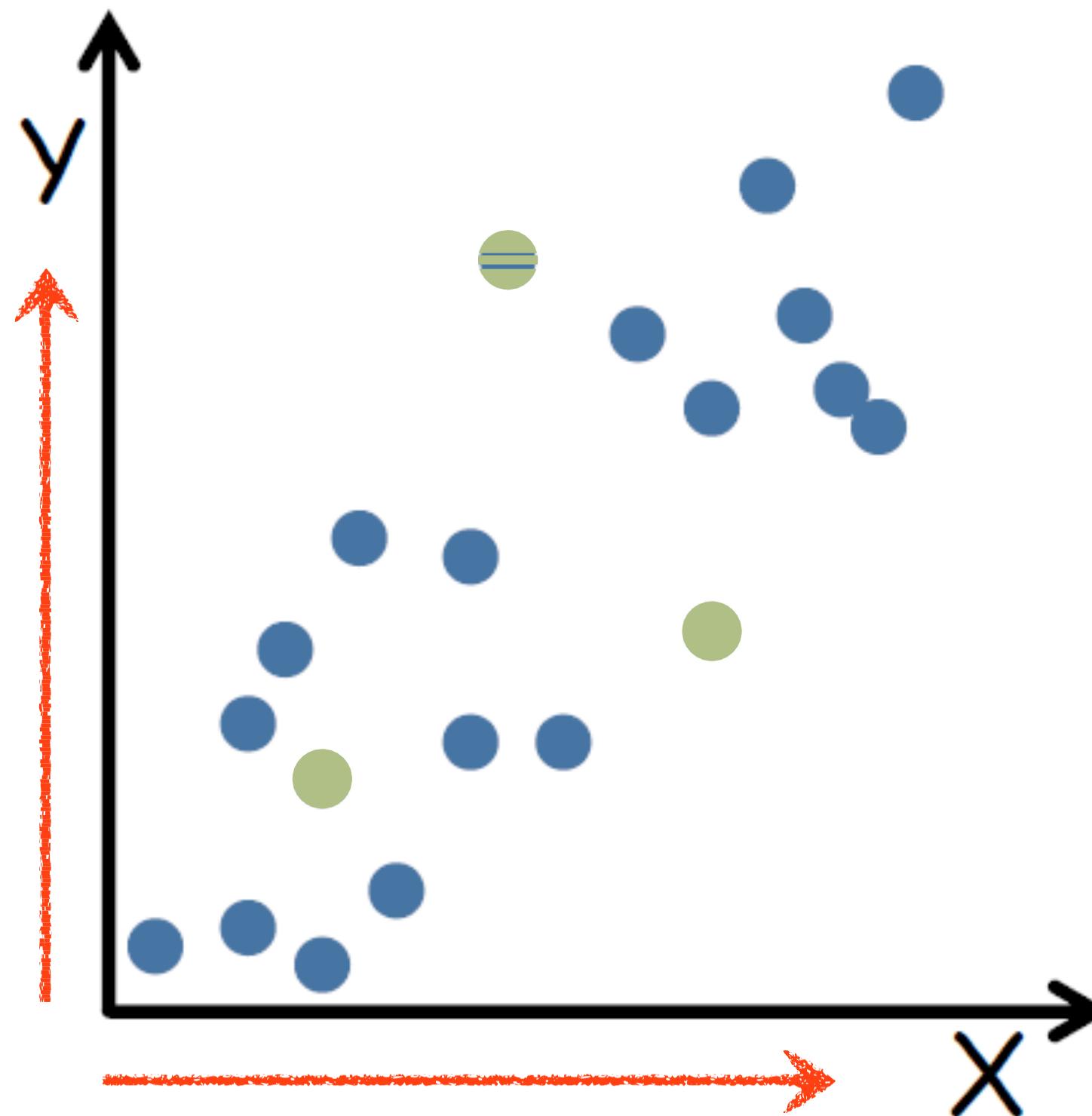


CHANNEL :

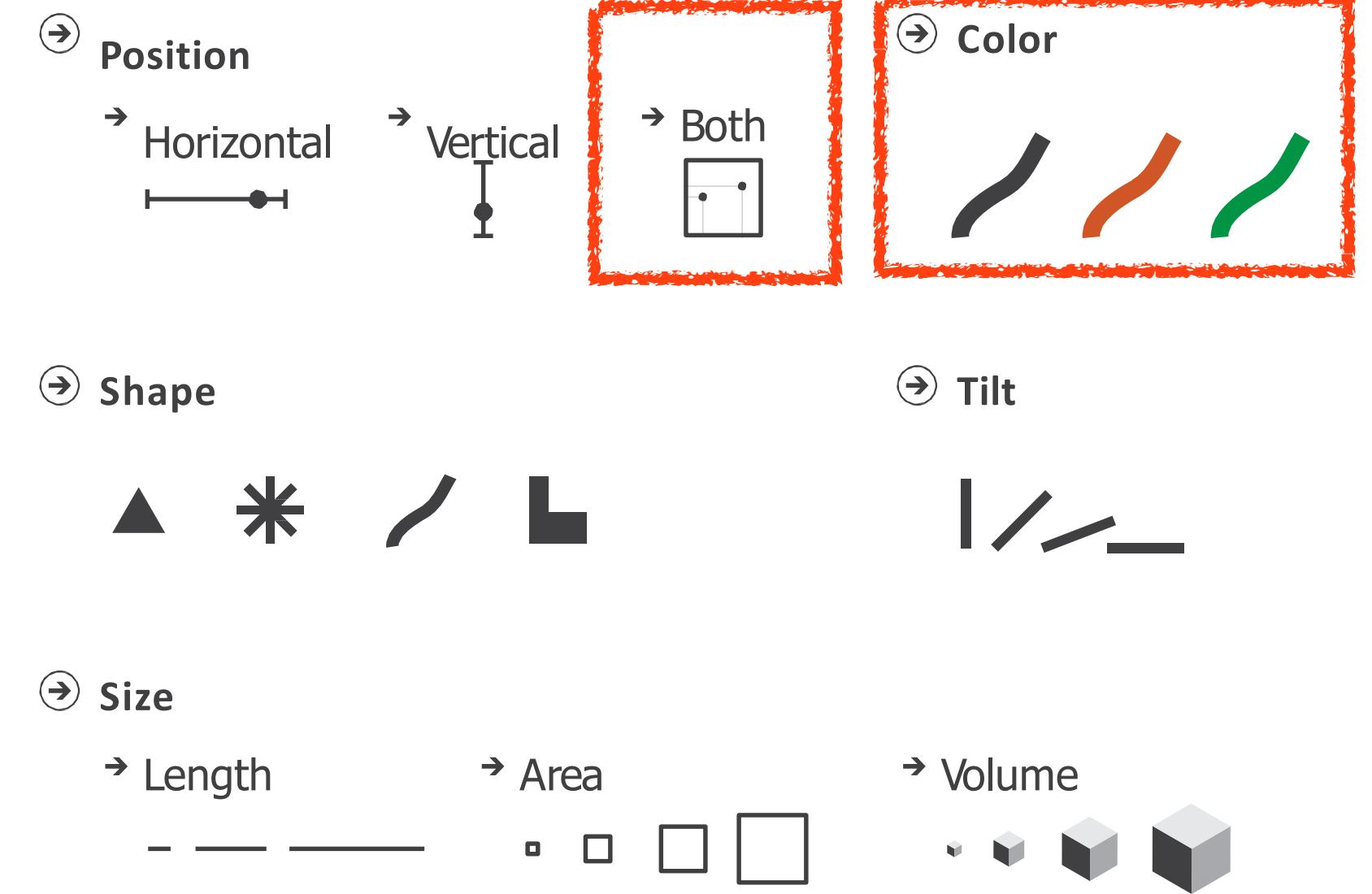


Visualization Building Blocks

of attributes encoded: 3

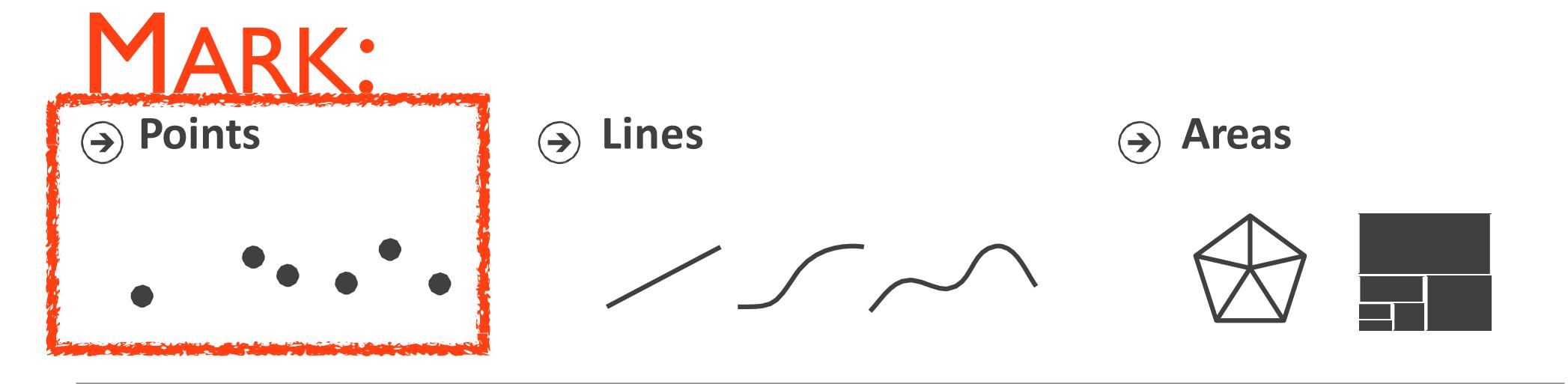
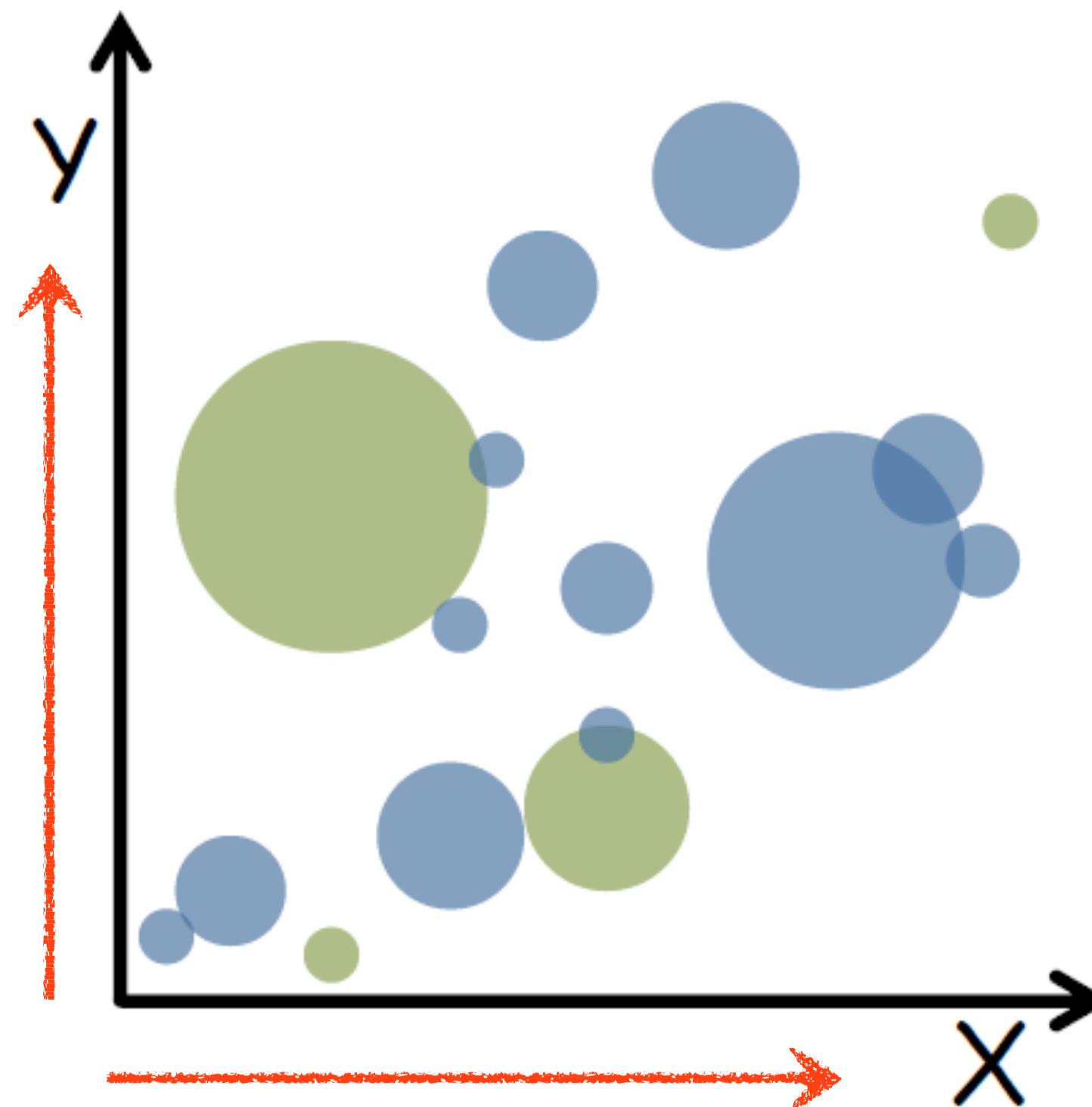


CHANNEL :



Visualization Building Blocks

of attributes encoded:



CHANNEL :

- Position
 - Horizontal
 - Vertical
 - Both

Shape



Tilt



Size

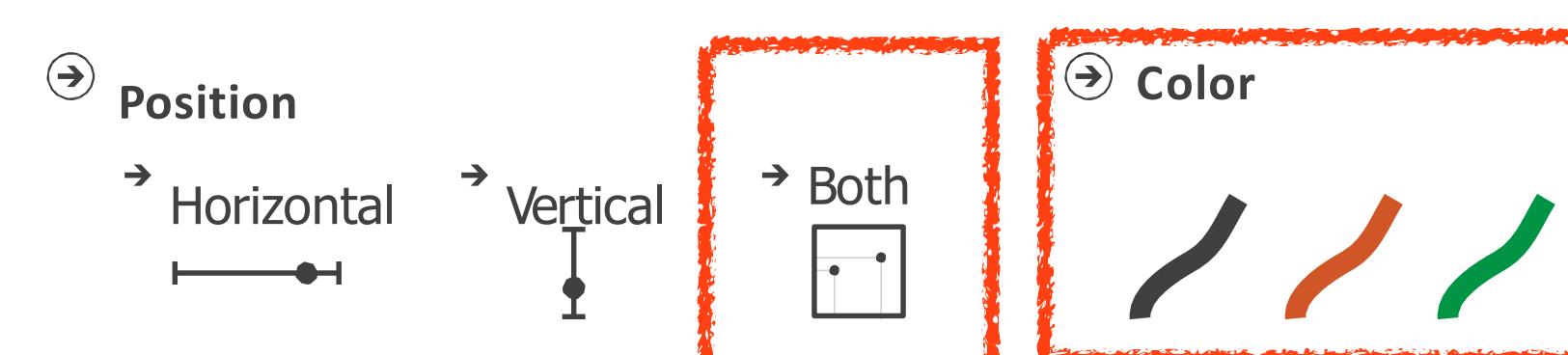
Length



Area

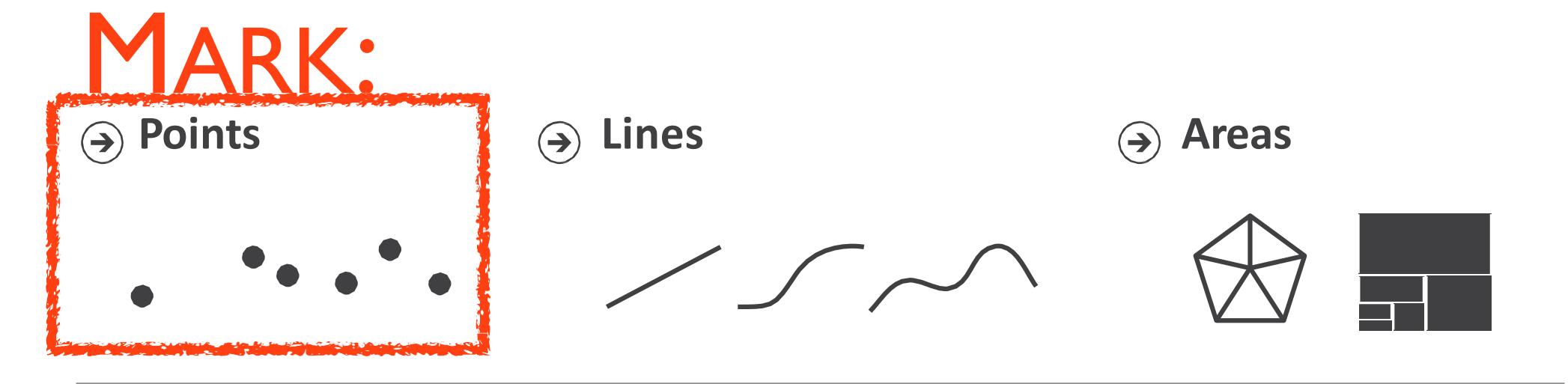
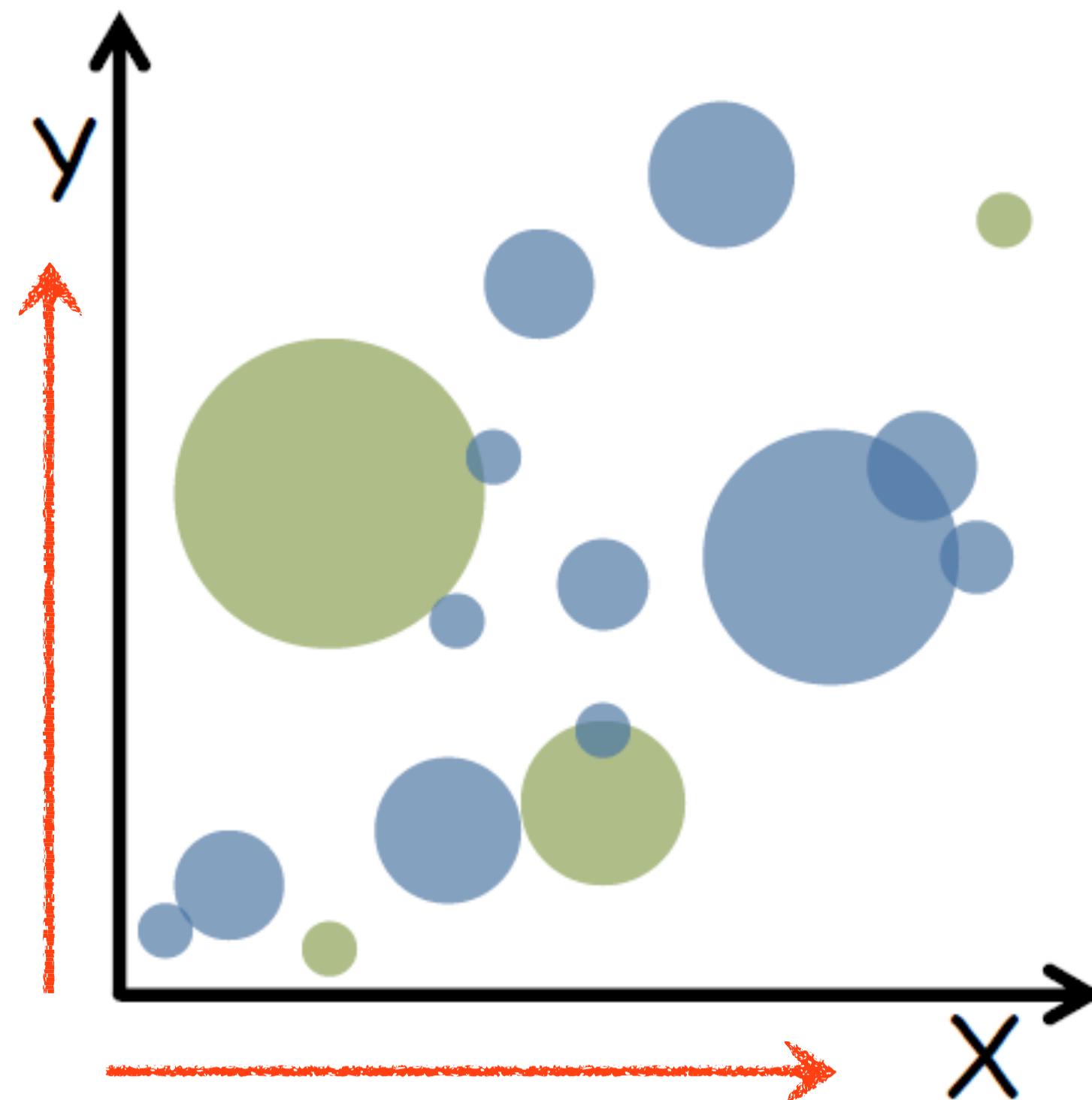


Volume



Visualization Building Blocks

of attributes encoded: 4



CHANNEL :

- Position
 - Horizontal
 - Vertical
 - Both

Shape



Tilt



Size

Length

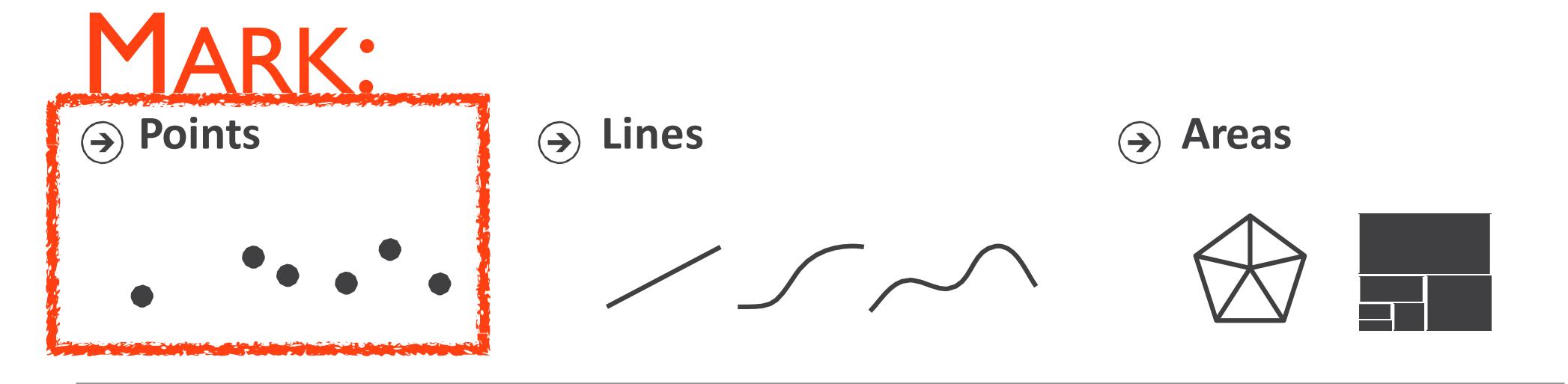
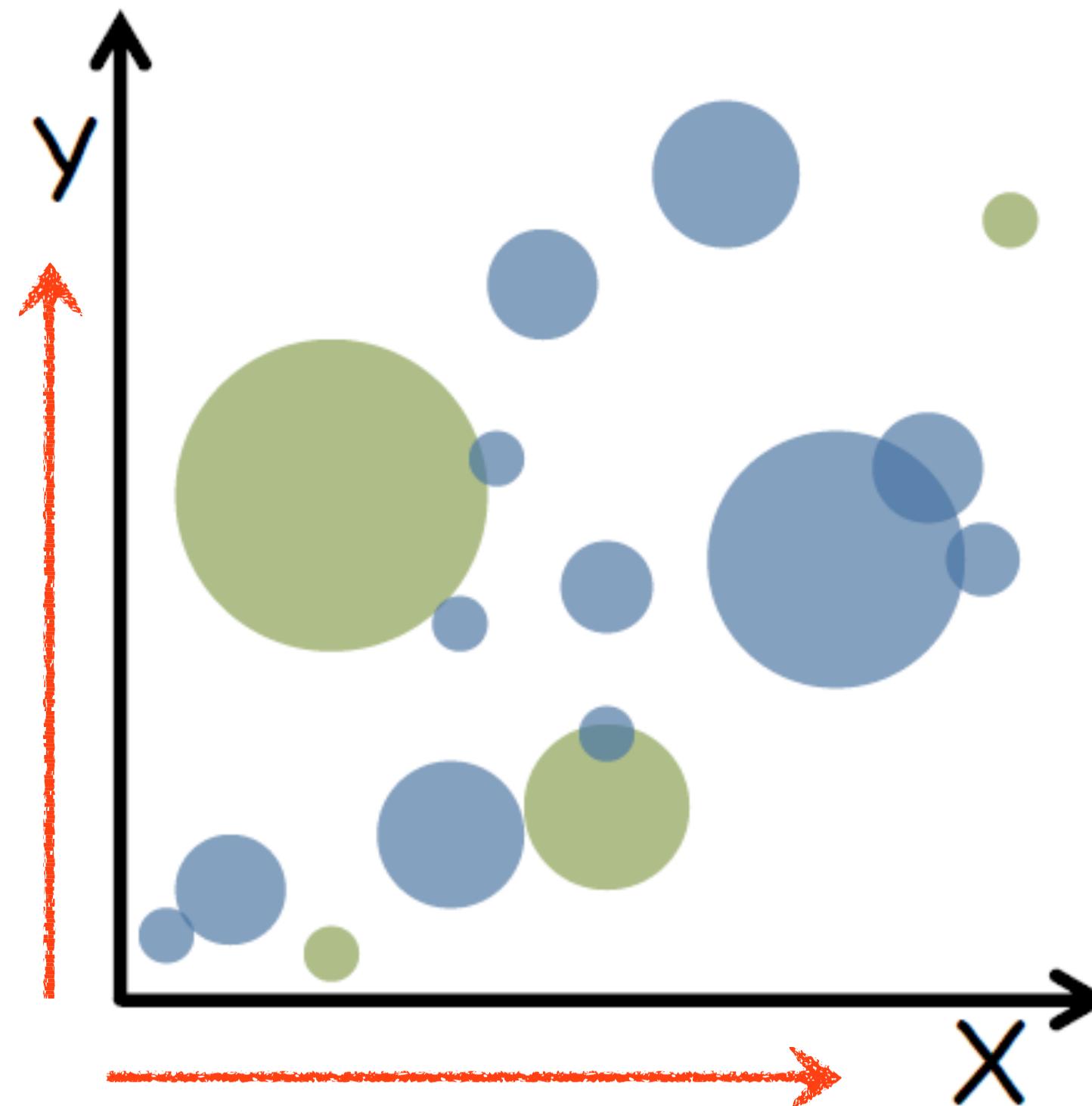
Area

Volume



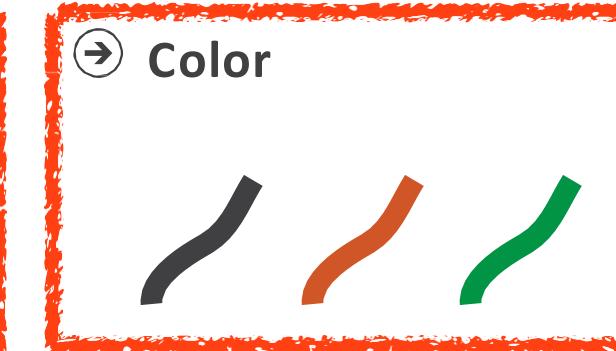
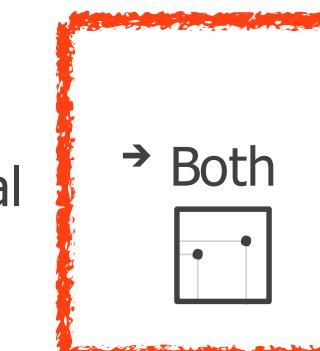
Visualization Building Blocks

of attributes encoded: 4



CHANNEL :

- Position
 - Horizontal
 - Vertical
 - Both



- Shape

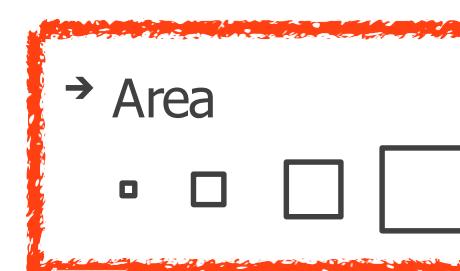


- Tilt

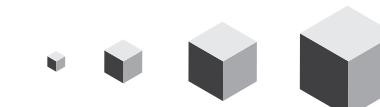


- Size

- Length

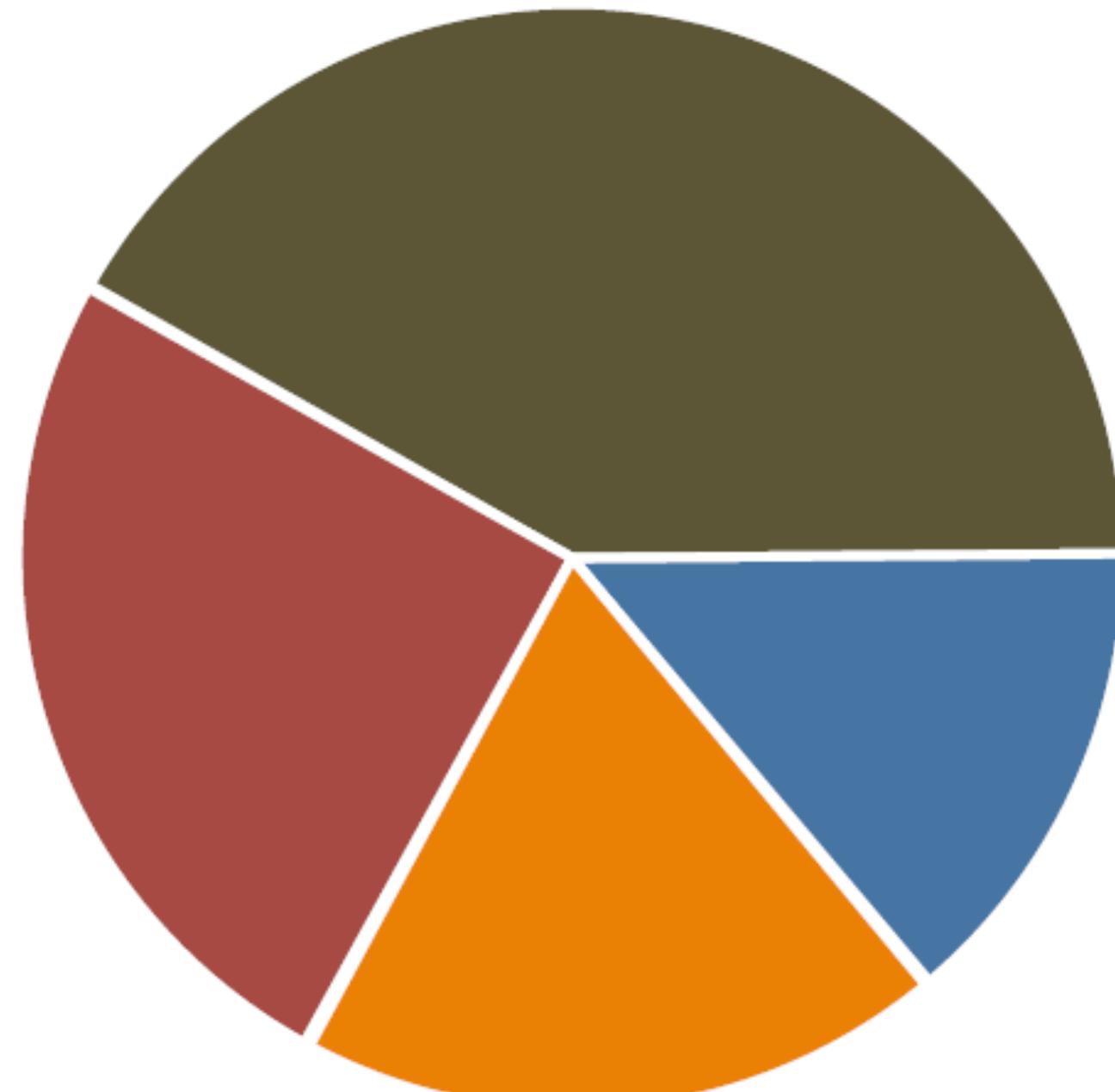


- Volume



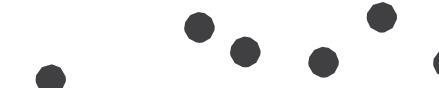
Visualization Building Blocks

of attributes encoded:



MARK:

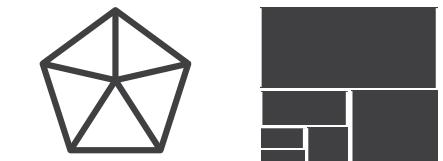
→ Points



→ Lines



→ Areas



CHANNEL :

→ Position

→ Horizontal

→ Vertical

→ Both

→ Color



→ Shape



→ Tilt



→ Size

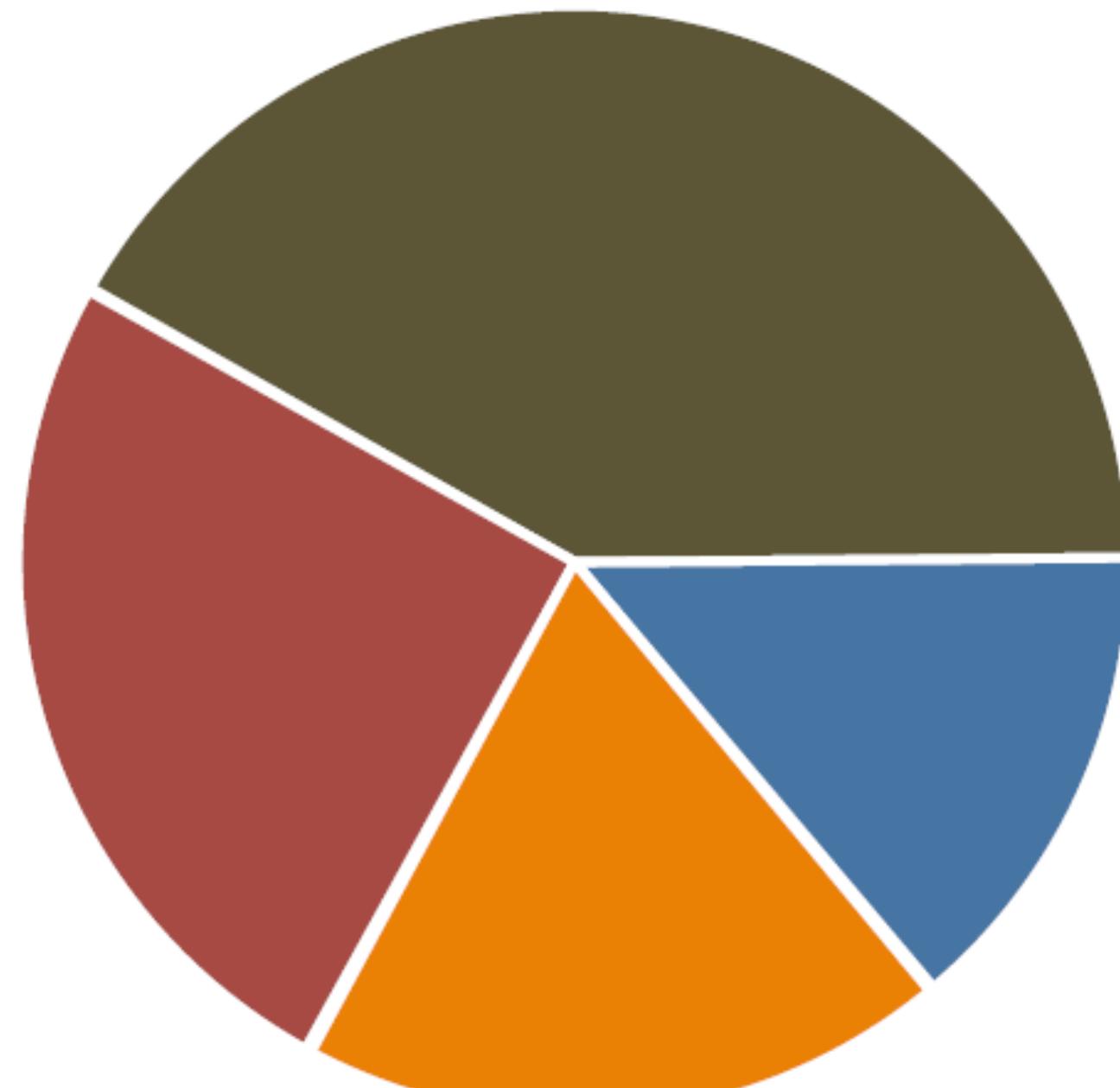
→ Length

→ Area

→ Volume

Visualization Building Blocks

of attributes encoded: 1



MARK:

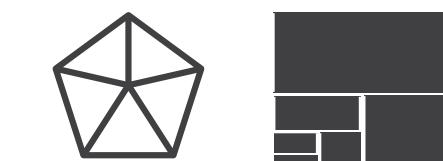
→ Points



→ Lines

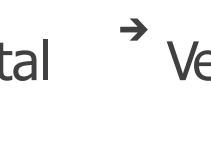


→ Areas



CHANNEL :

→ Position



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area

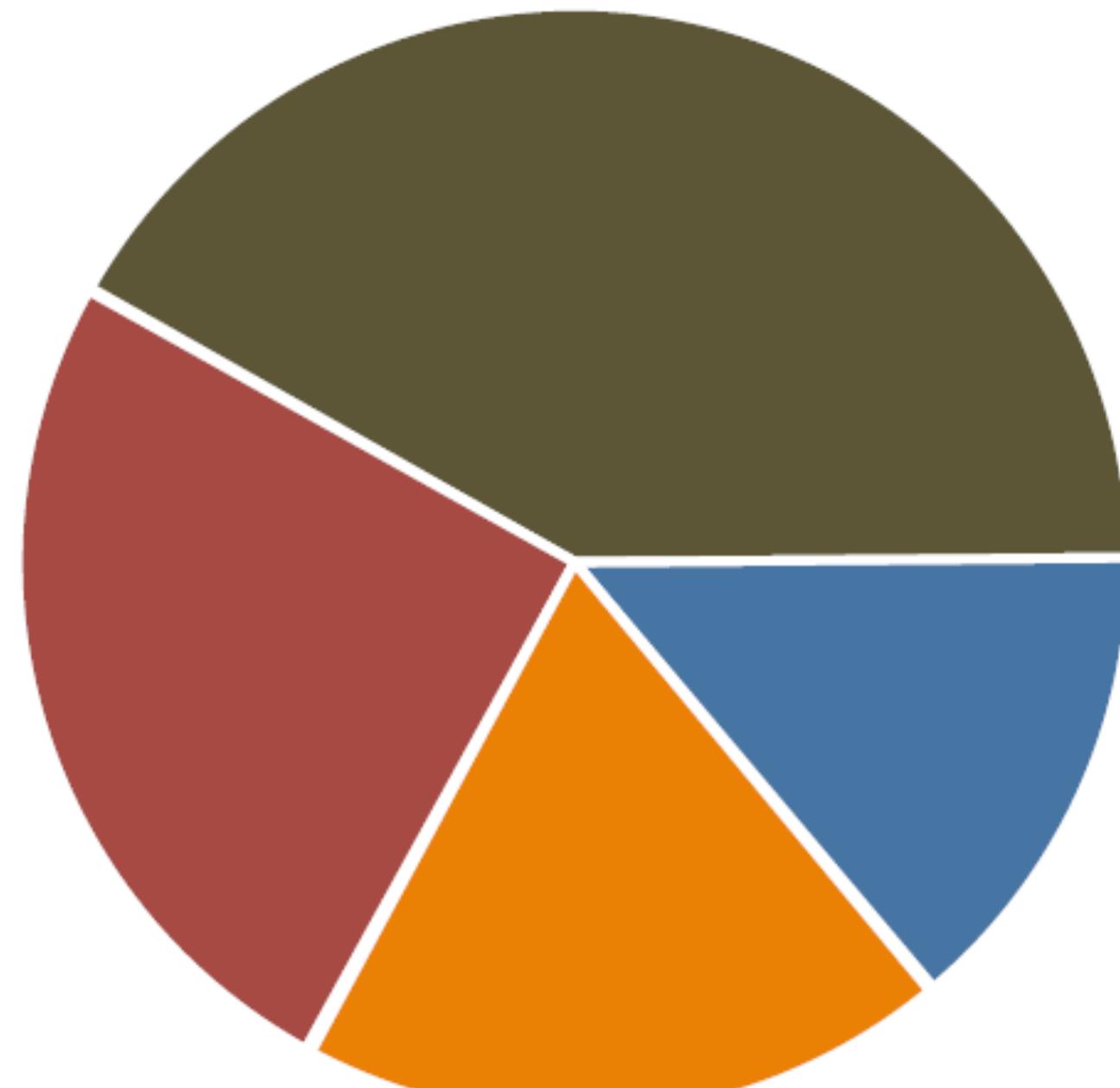


→ Volume



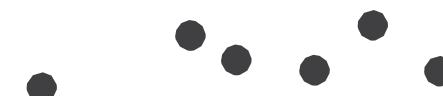
Visualization Building Blocks

of attributes encoded: 1



MARK:

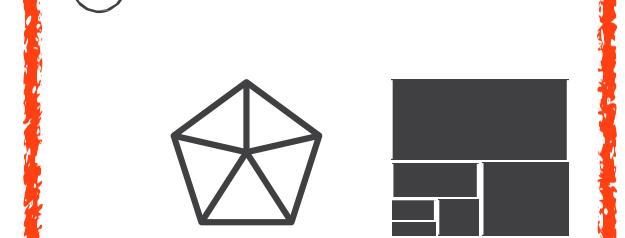
→ Points



→ Lines



→ Areas



CHANNEL :

→ Position



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

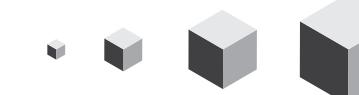
→ Length



→ Area

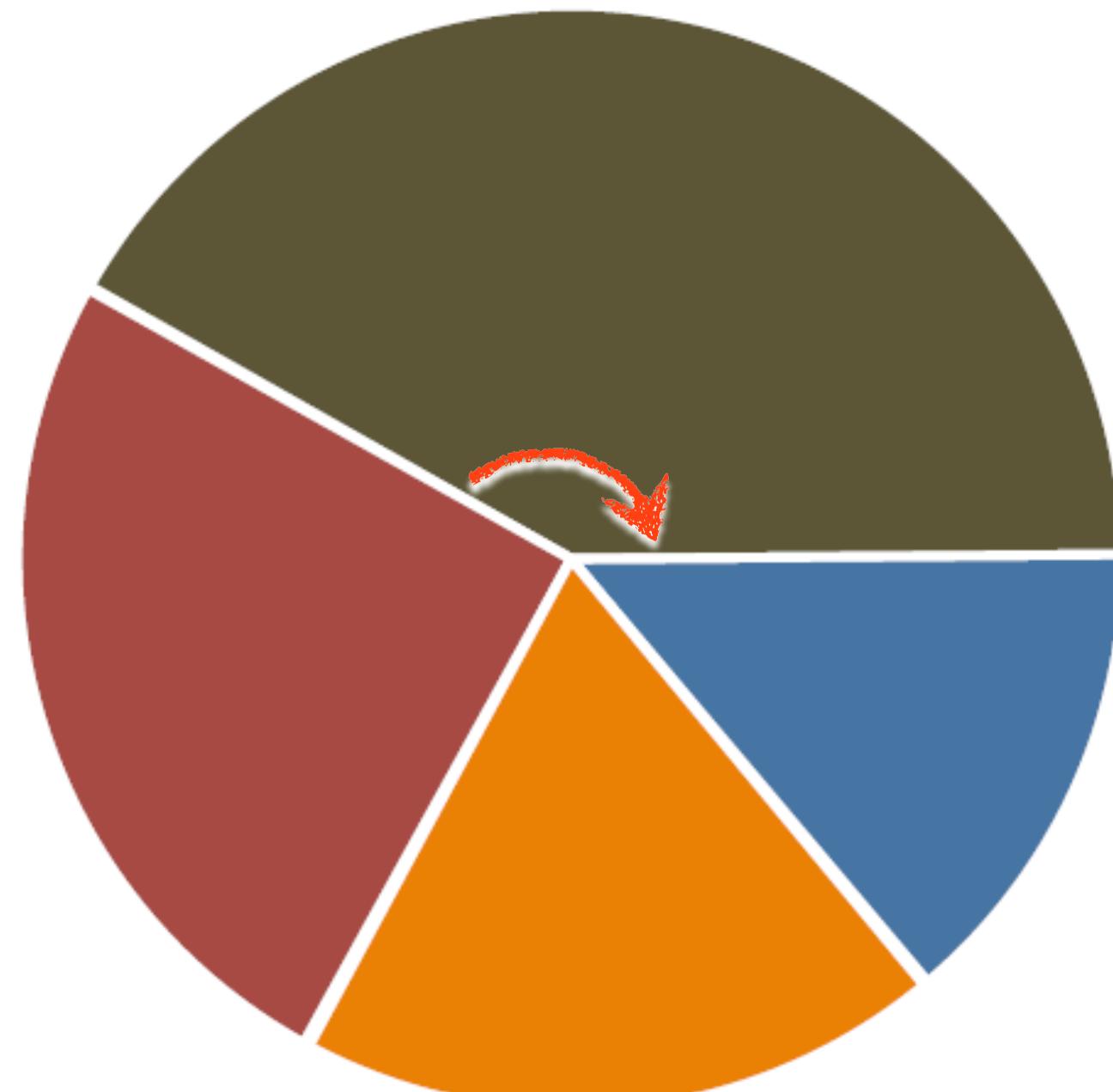


→ Volume



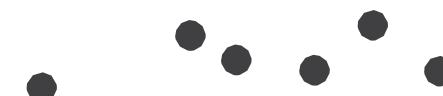
Visualization Building Blocks

of attributes encoded: 1



MARK:

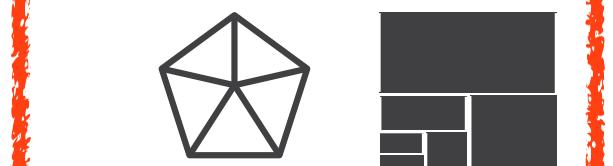
→ Points



→ Lines

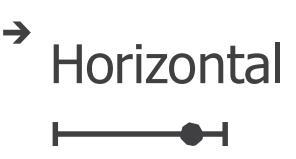


→ Areas



CHANNEL :

→ Position



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area

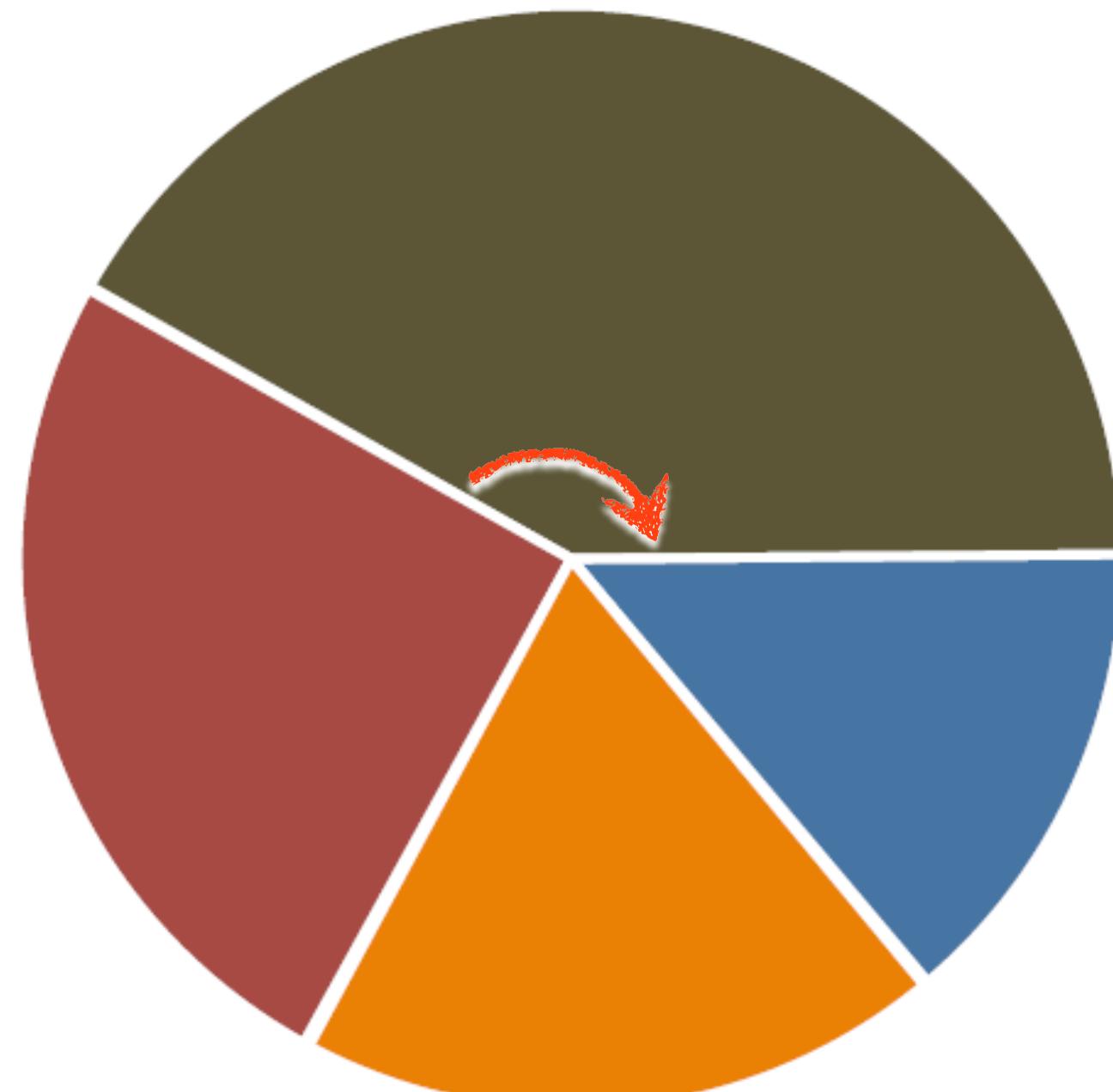


→ Volume



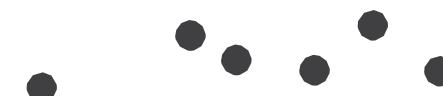
Visualization Building Blocks

of attributes encoded: 1



MARK:

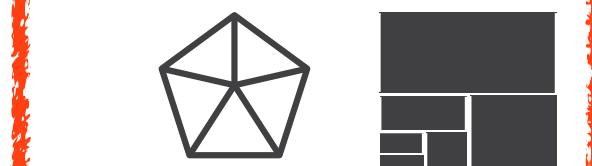
→ Points



→ Lines



→ Areas



CHANNEL :

→ Position

→ Horizontal

→ Vertical

→ Both

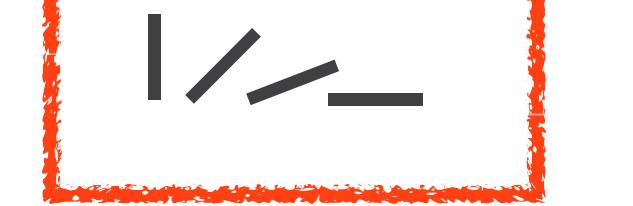
→ Color



→ Shape



→ Tilt



→ Size

→ Length

→ Area

→ Volume

Visualization Building Blocks

of attributes encoded: 1



MARK:

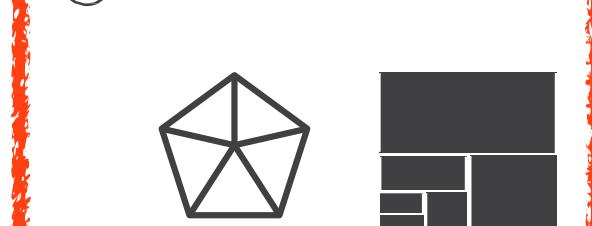
→ Points



→ Lines



→ Areas



CHANNEL :

→ Position



→ Color



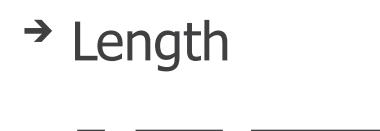
→ Shape



→ Tilt



→ Size



→ Area



→ Volume



Visualization Building Blocks

of attributes encoded: 1



MARK:

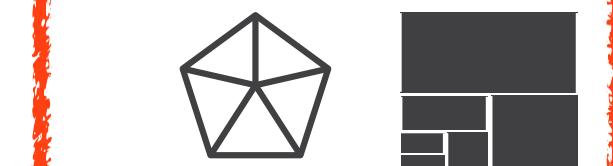
→ Points



→ Lines



→ Areas



CHANNEL :

→ Position

→ Horizontal

→ Vertical

→ Both

→ Color



→ Shape



→ Tilt



→ Size

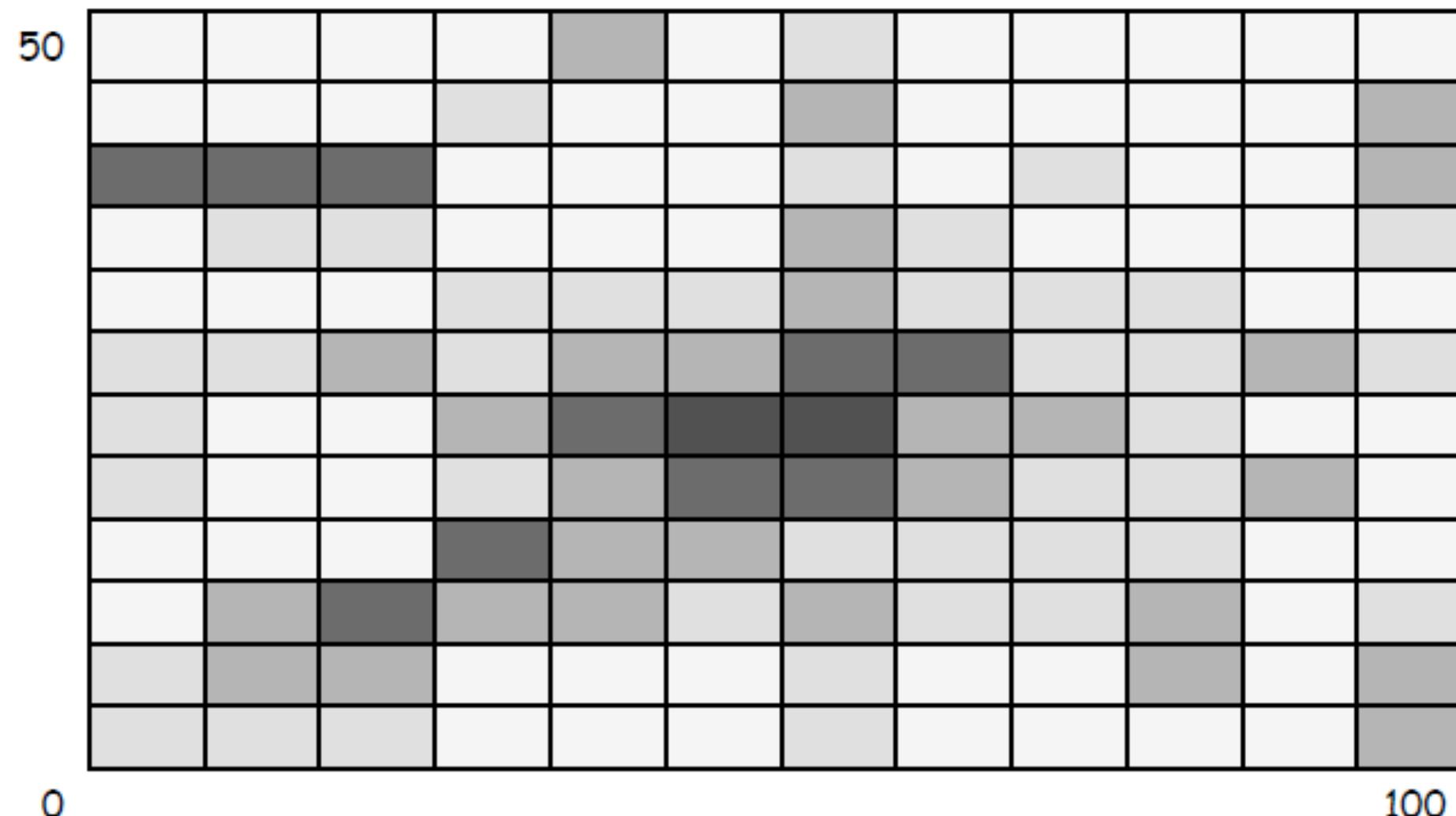
→ Length

→ Area

→ Volume

Visualization Building Blocks

of attributes encoded:



MARK:

→ Points



→ Lines



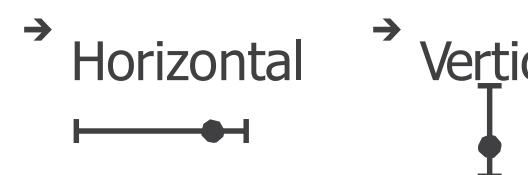
→ Areas



CHANNEL :

→ Position

→ Horizontal



→ Vertical

→ Both



→ Color



→ Tilt



→ Shape



→ Size

→ Length



→ Area

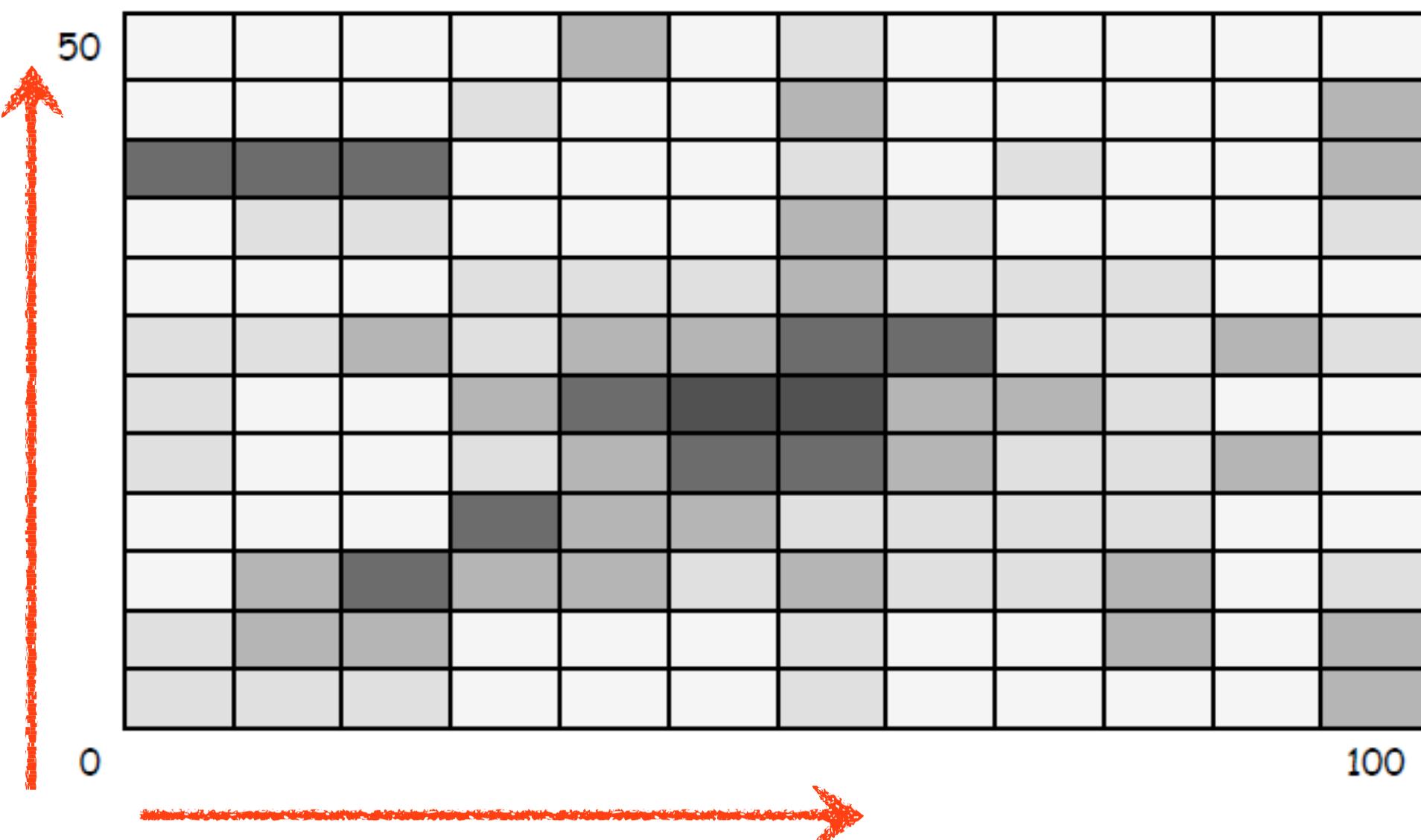


→ Volume



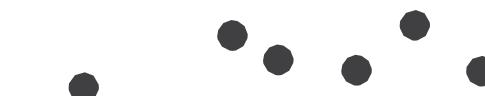
Visualization Building Blocks

of attributes encoded: 3



MARK:

→ Points



→ Lines



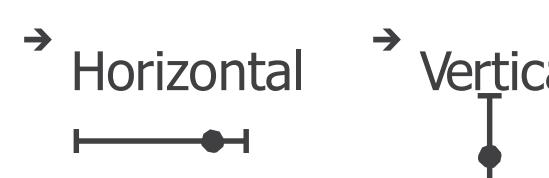
→ Areas



CHANNEL :

→ Position

→ Horizontal



→ Vertical

→ Both



→ Color



→ Tilt



→ Shape



→ Size

→ Length



→ Area

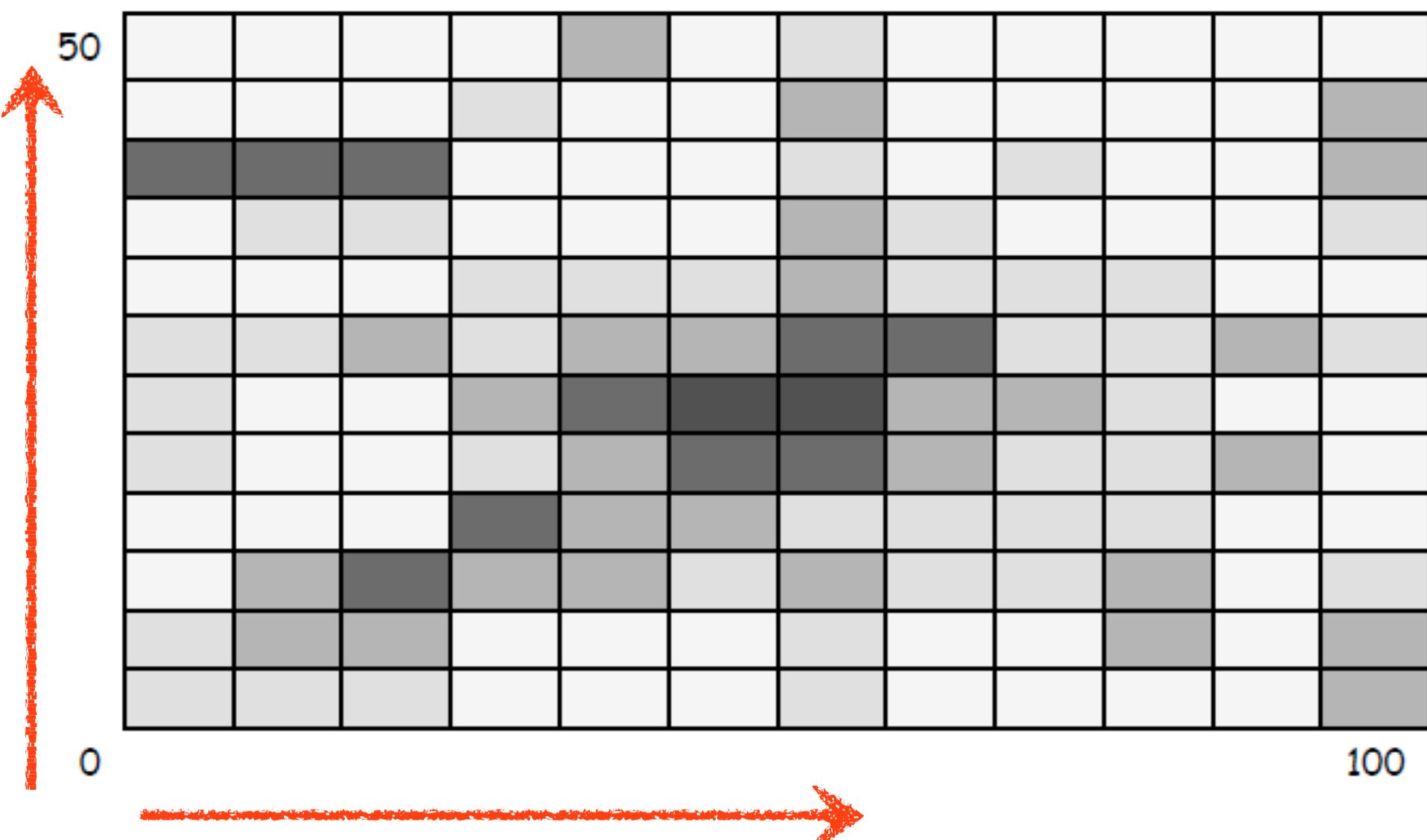


→ Volume



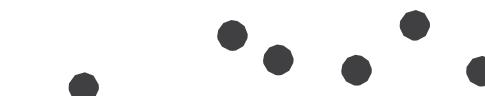
Visualization Building Blocks

of attributes encoded: 3



MARK:

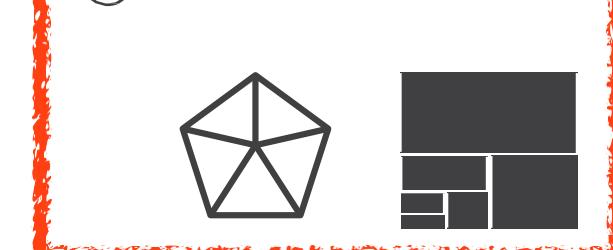
→ Points



→ Lines



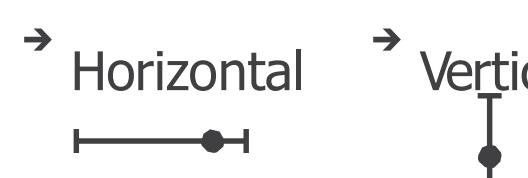
→ Areas



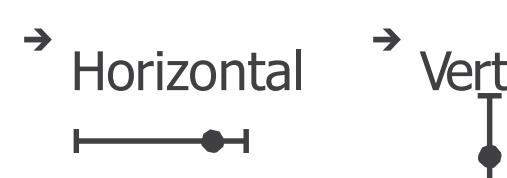
CHANNEL :

→ Position

→ Horizontal



→ Vertical



→ Both



→ Color



→ Tilt



→ Shape



→ Size

→ Length



→ Area

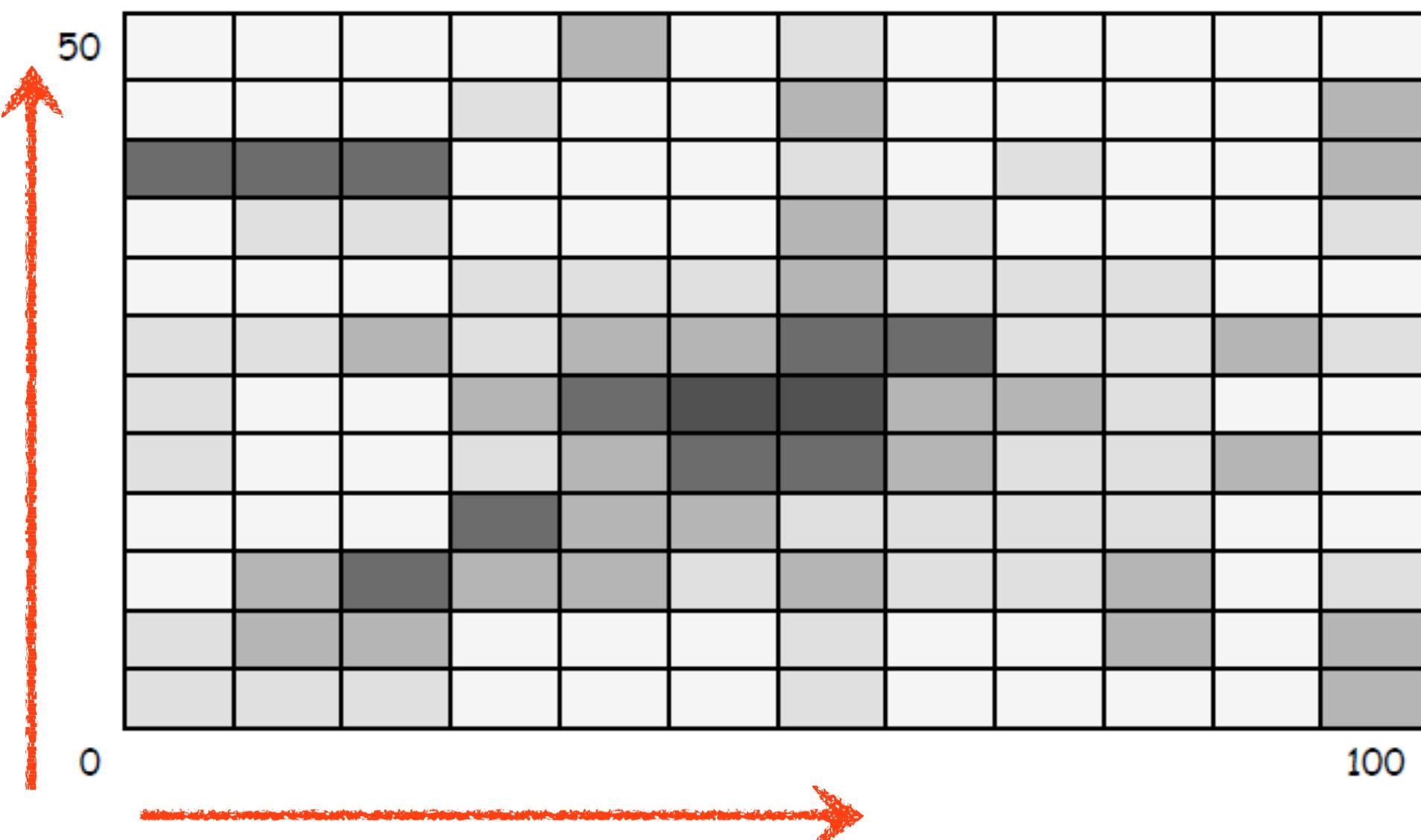


→ Volume



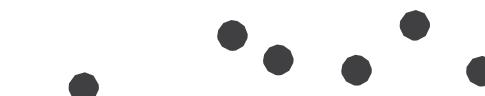
Visualization Building Blocks

of attributes encoded: 3



MARK:

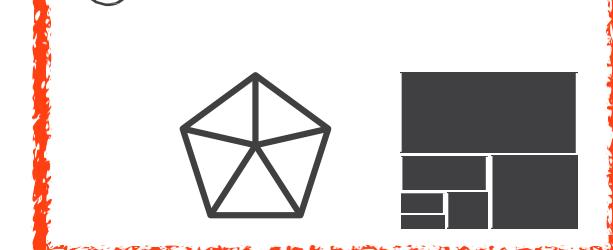
→ Points



→ Lines



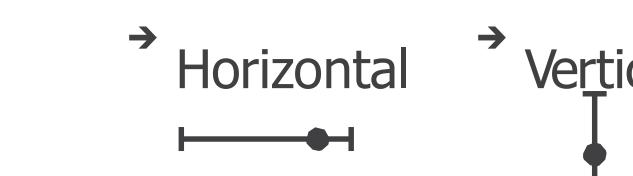
→ Areas



CHANNEL :

→ Position

→ Horizontal



→ Vertical

→ Shape



→ Color



→ Tilt



→ Size

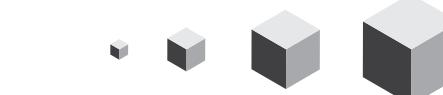
→ Length



→ Area

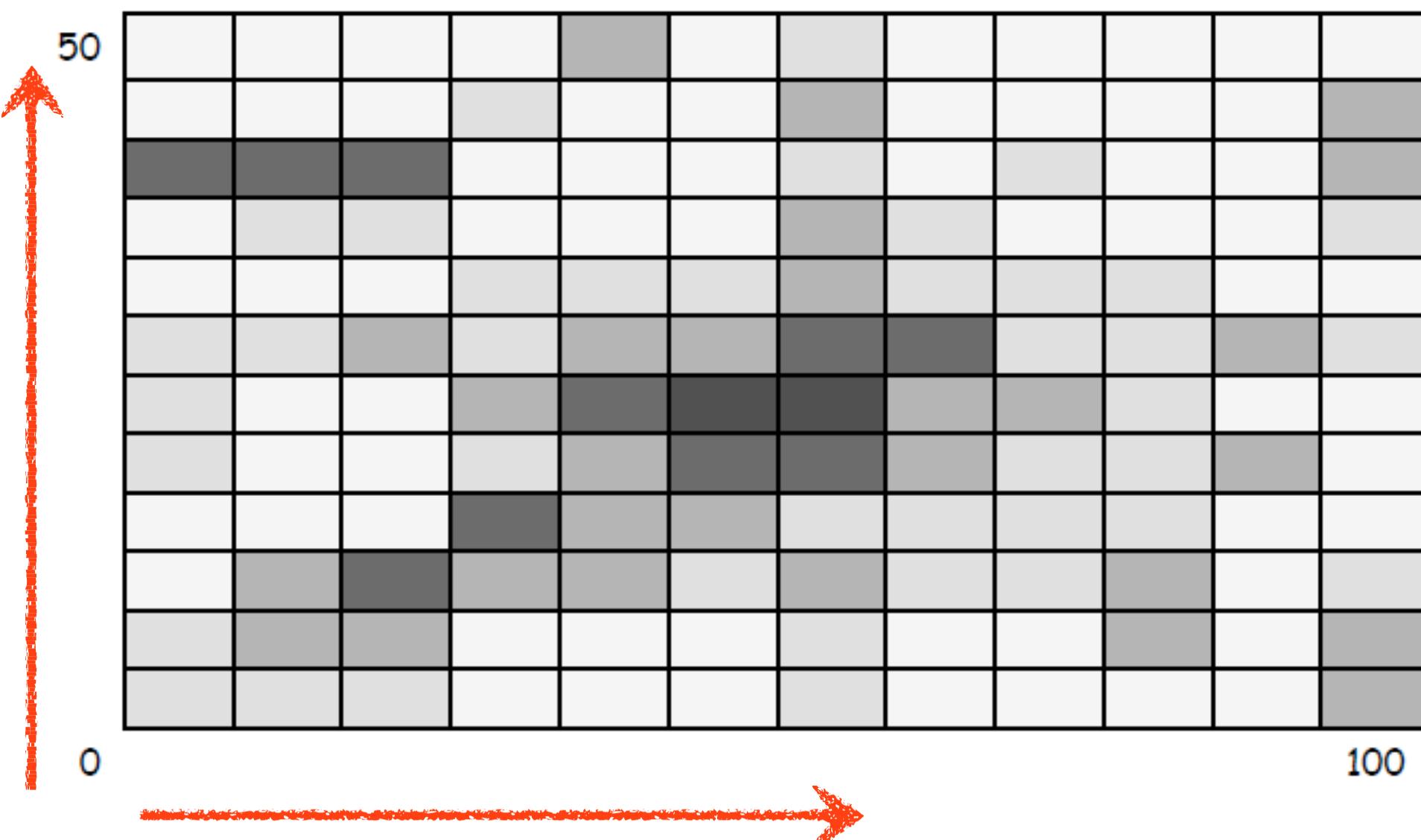


→ Volume



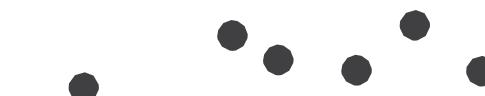
Visualization Building Blocks

of attributes encoded: 3



MARK:

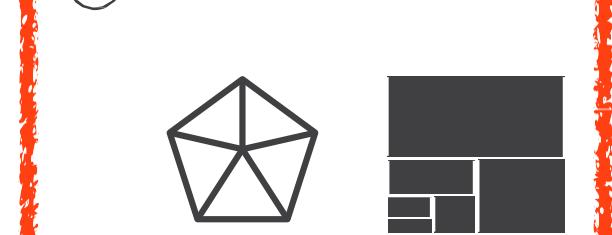
→ Points



→ Lines



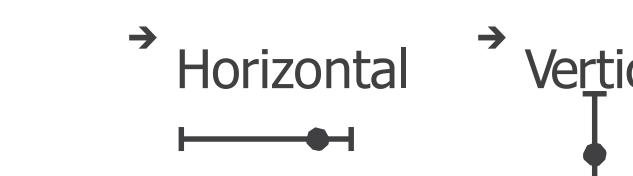
→ Areas



CHANNEL :

→ Position

→ Horizontal



→ Vertical

→ Shape



→ Tilt



→ Size

→ Length



→ Area



→ Volume

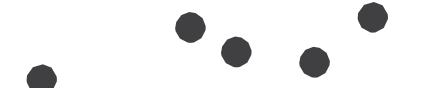


Visualization Building Blocks

of attributes encoded:

MARK:

→ Points



→ Lines

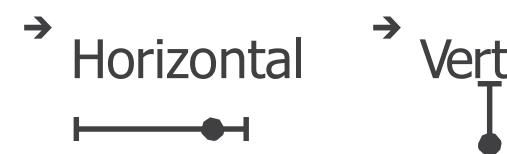
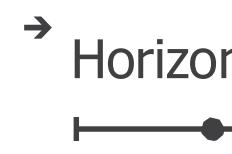


→ Areas



CHANNEL :

→ Position



→ Color



→ Shape



→ Tilt



→ Size

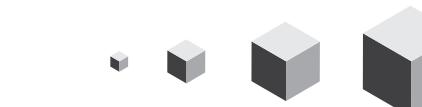
→ Length



→ Area



→ Volume



Visualization Building Blocks

of attributes encoded:

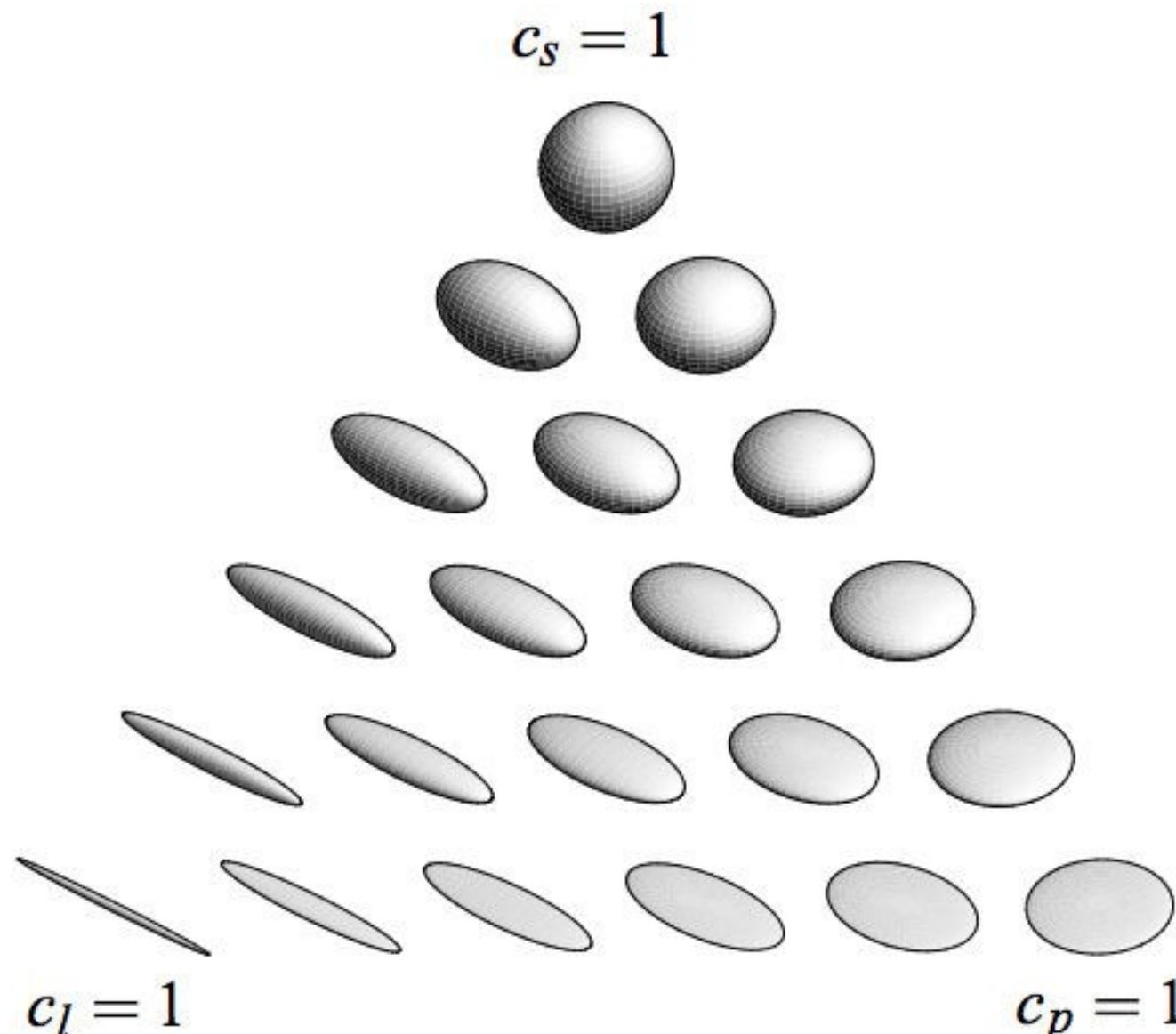
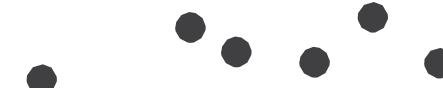


Figure 4: Tensor shapes, with ellipsoids.

MARK:

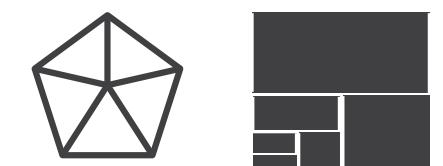
→ Points



→ Lines

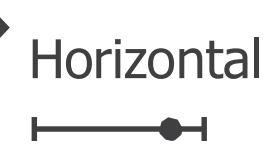


→ Areas



CHANNEL :

→ Position



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area



→ Volume



Visualization Building Blocks

of attributes encoded: 3

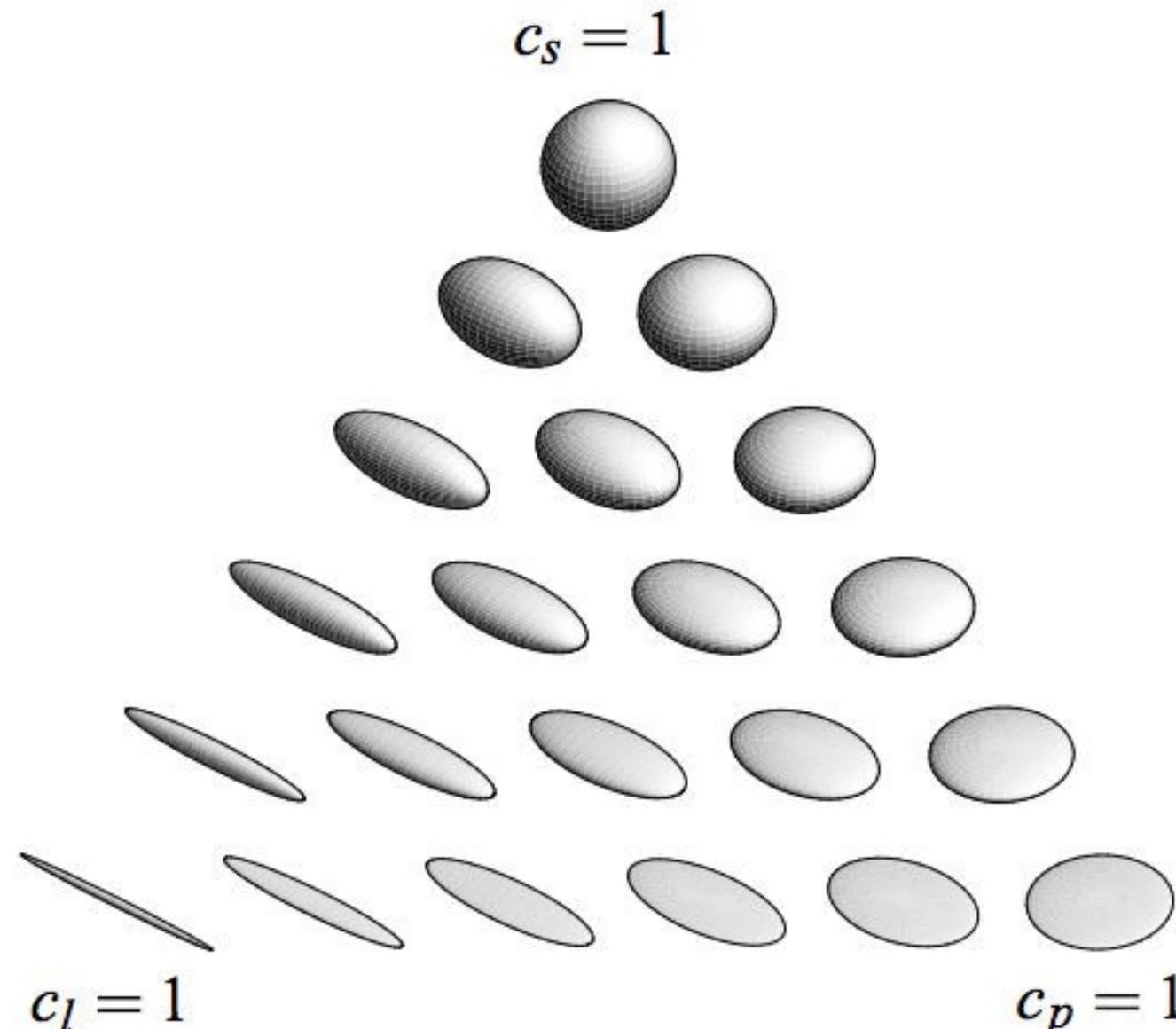


Figure 4: Tensor shapes, with ellipsoids.

MARK:

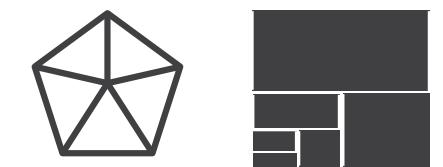
→ Points



→ Lines

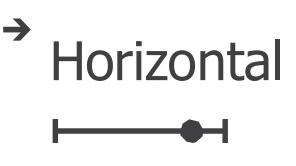


→ Areas



CHANNEL :

→ Position



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area



→ Volume



Visualization Building Blocks

of attributes encoded: 3

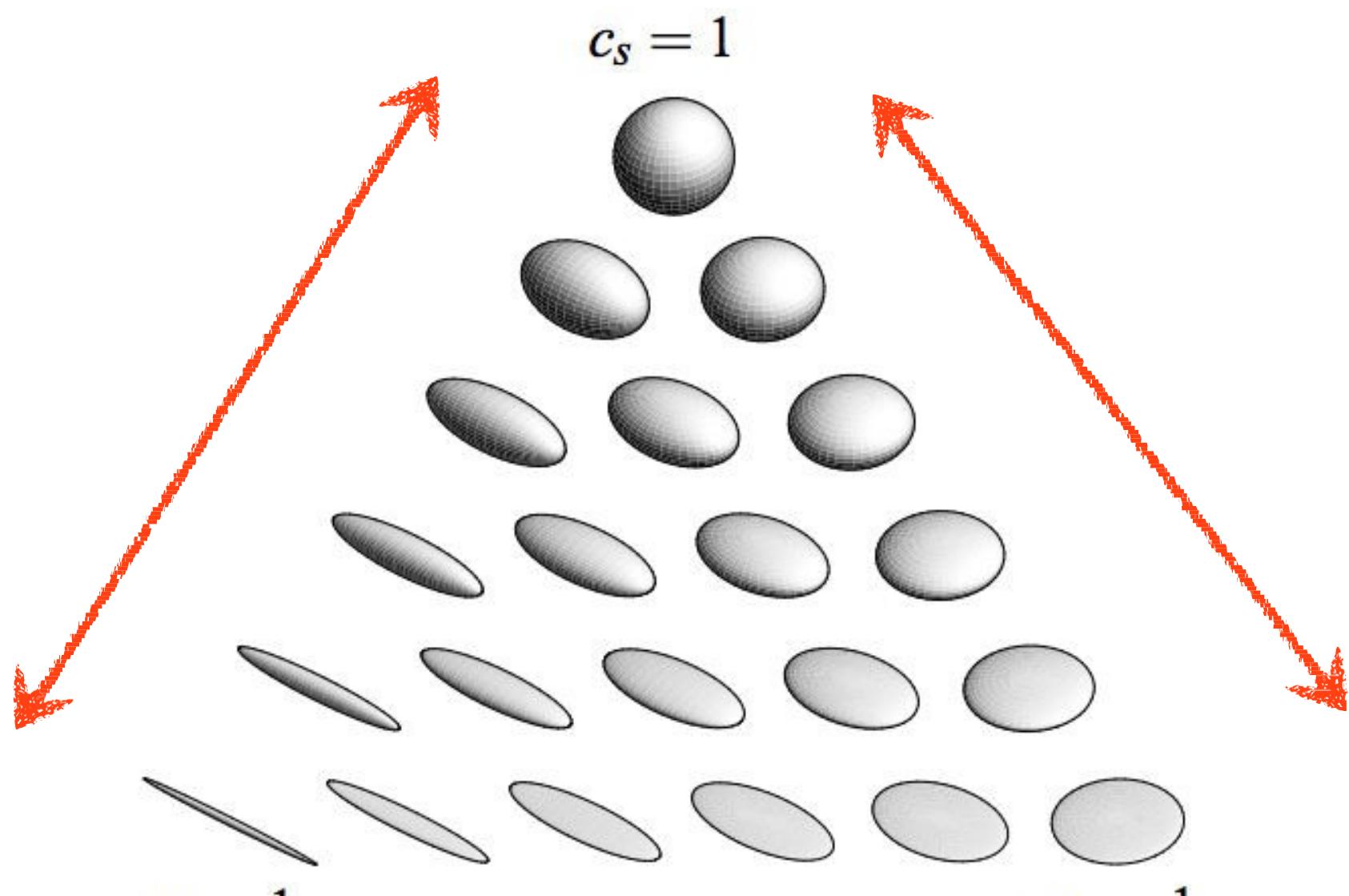


Figure 4: Tensor shapes, with ellipsoids.

+ position in 3D space

MARK:

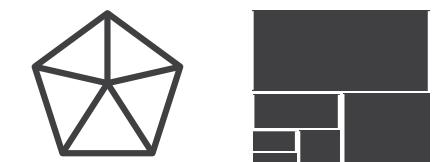
→ Points



→ Lines



→ Areas



CHANNEL :

→ Position

→ Horizontal
— — —
→ Vertical
| | |
→ Both
— | —

→ Color



→ Shape



→ Tilt



→ Size

→ Length
— — —
→ Area
— □ □ □
→ Volume
— ⚡ ⚡ ⚡ ⚡

Visualization Building Blocks

of attributes encoded: 3

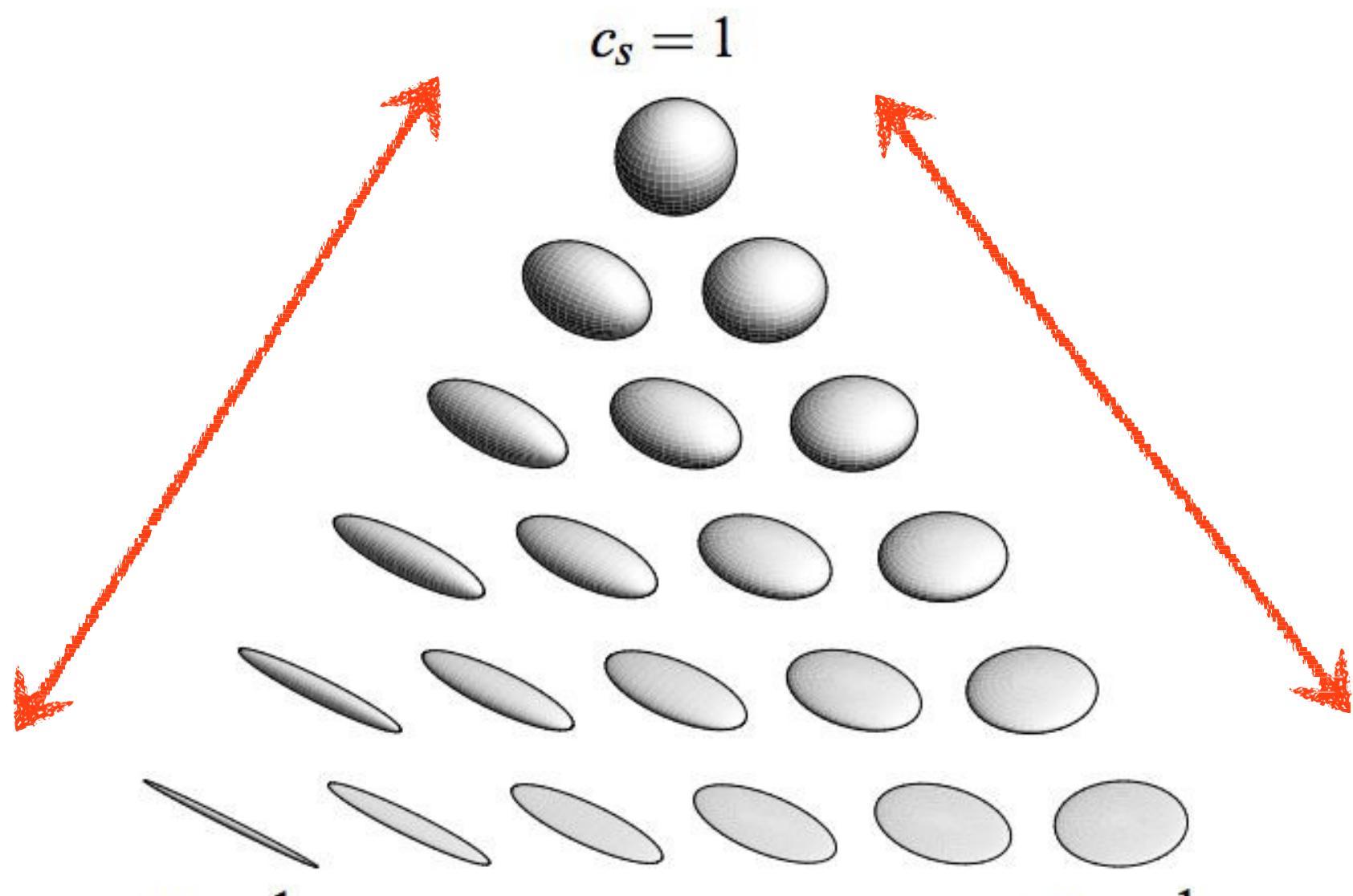
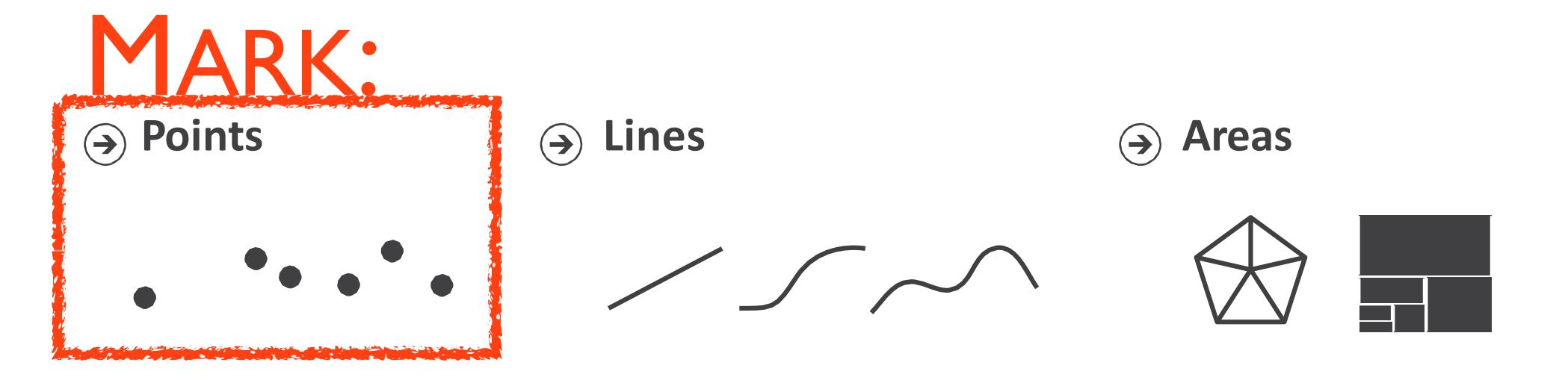
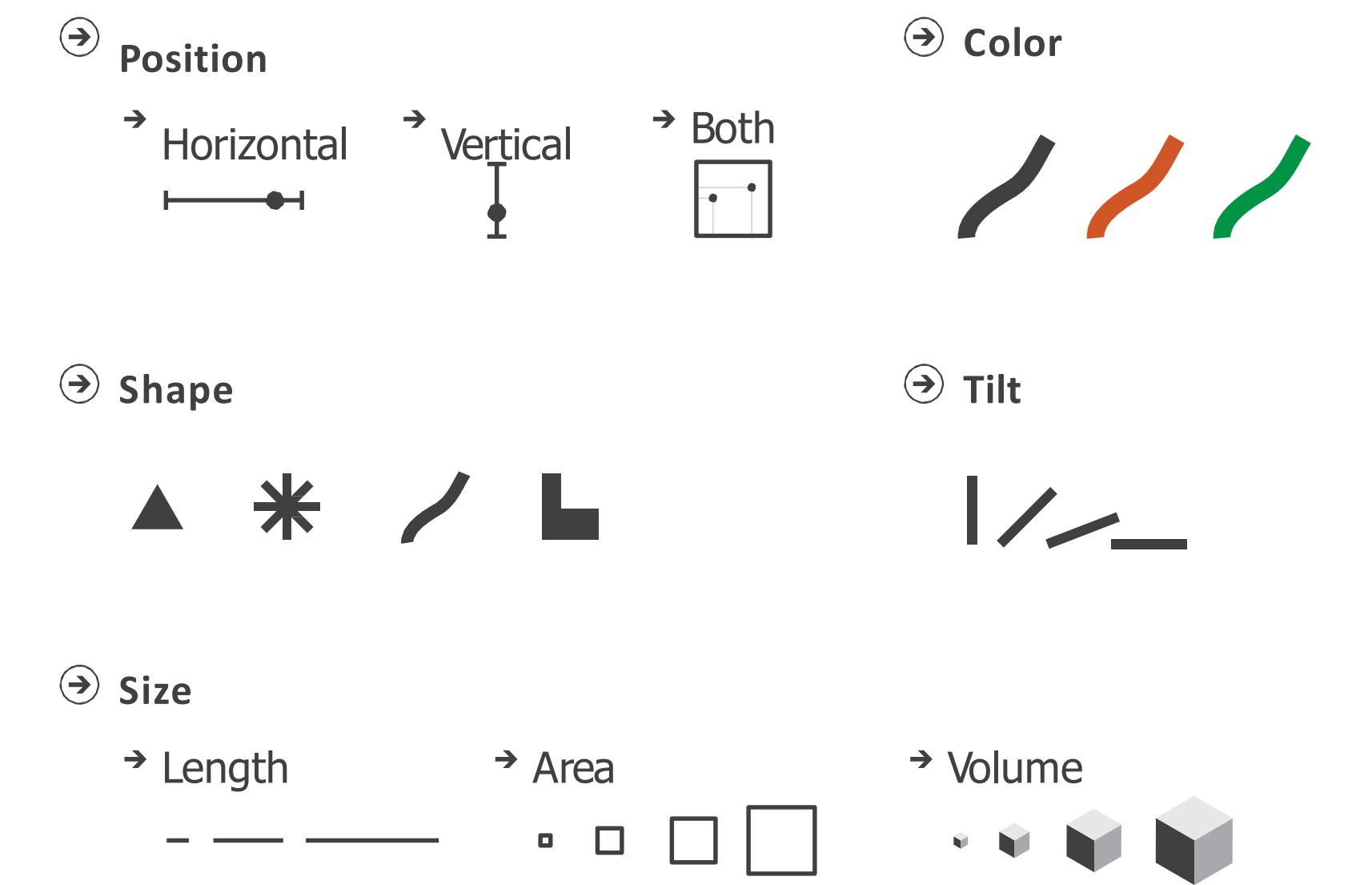


Figure 4: Tensor shapes, with ellipsoids.

← →
+ position in 3D space



CHANNEL :



Visualization Building Blocks

of attributes encoded: 3

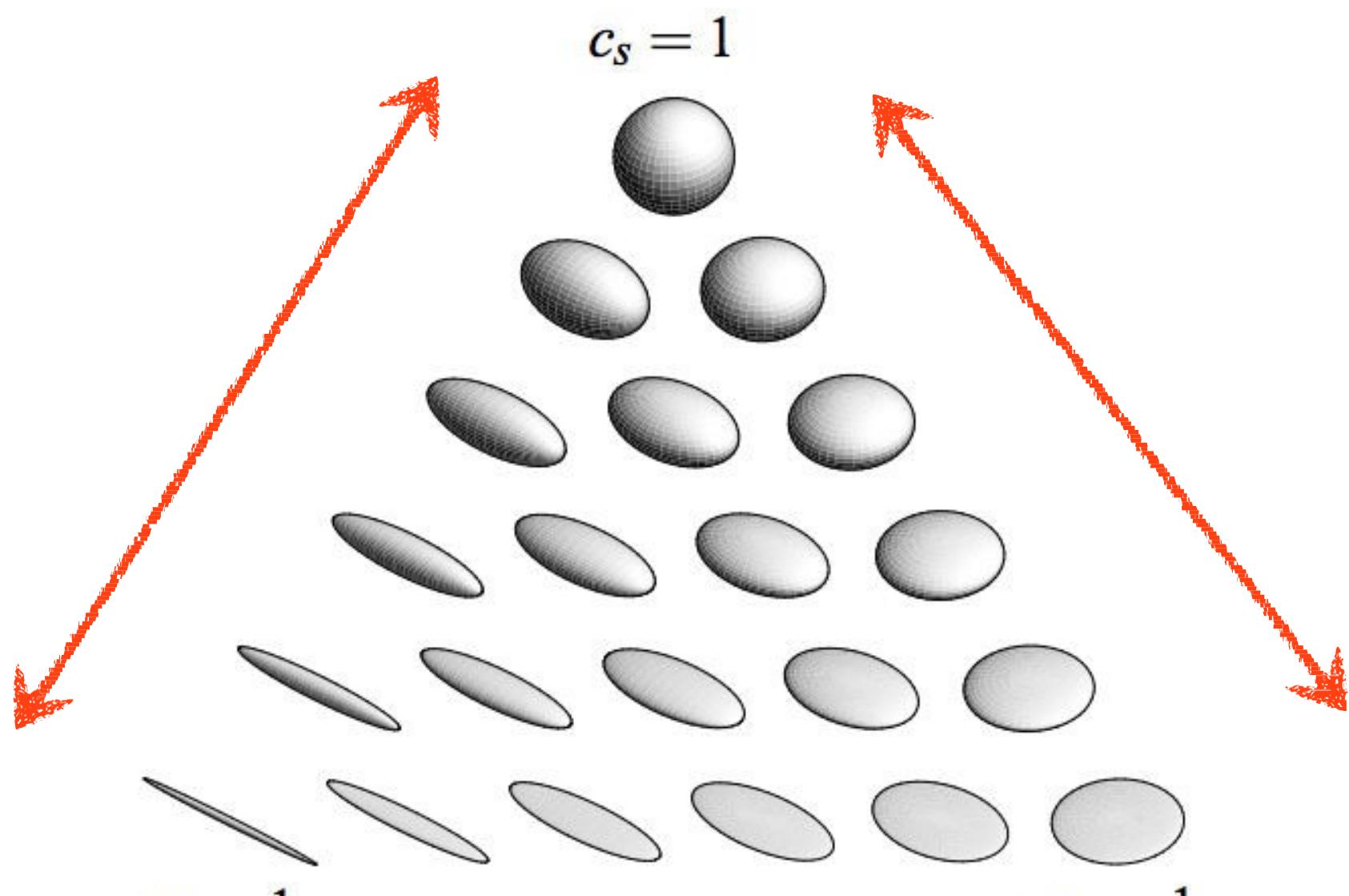
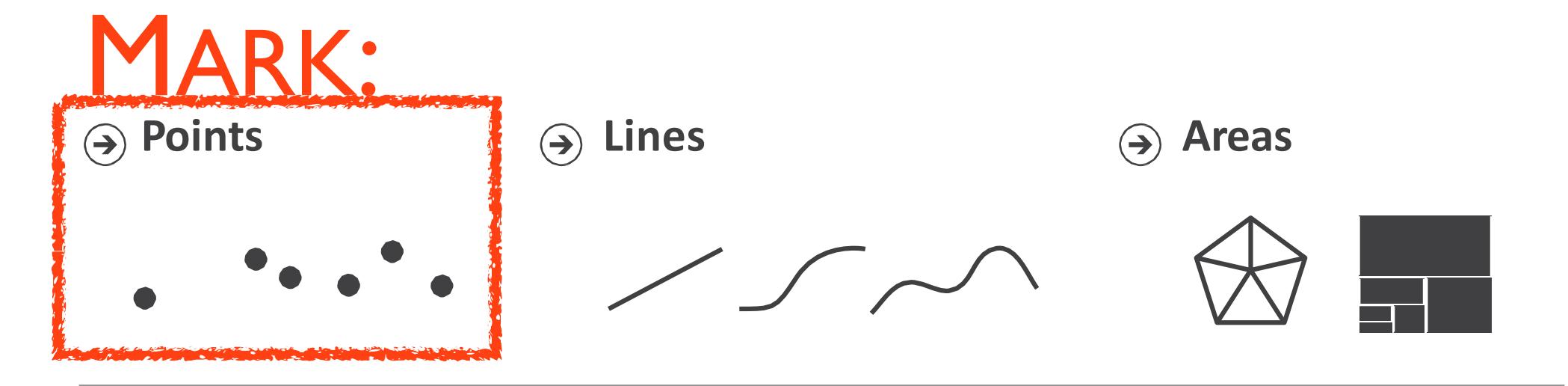
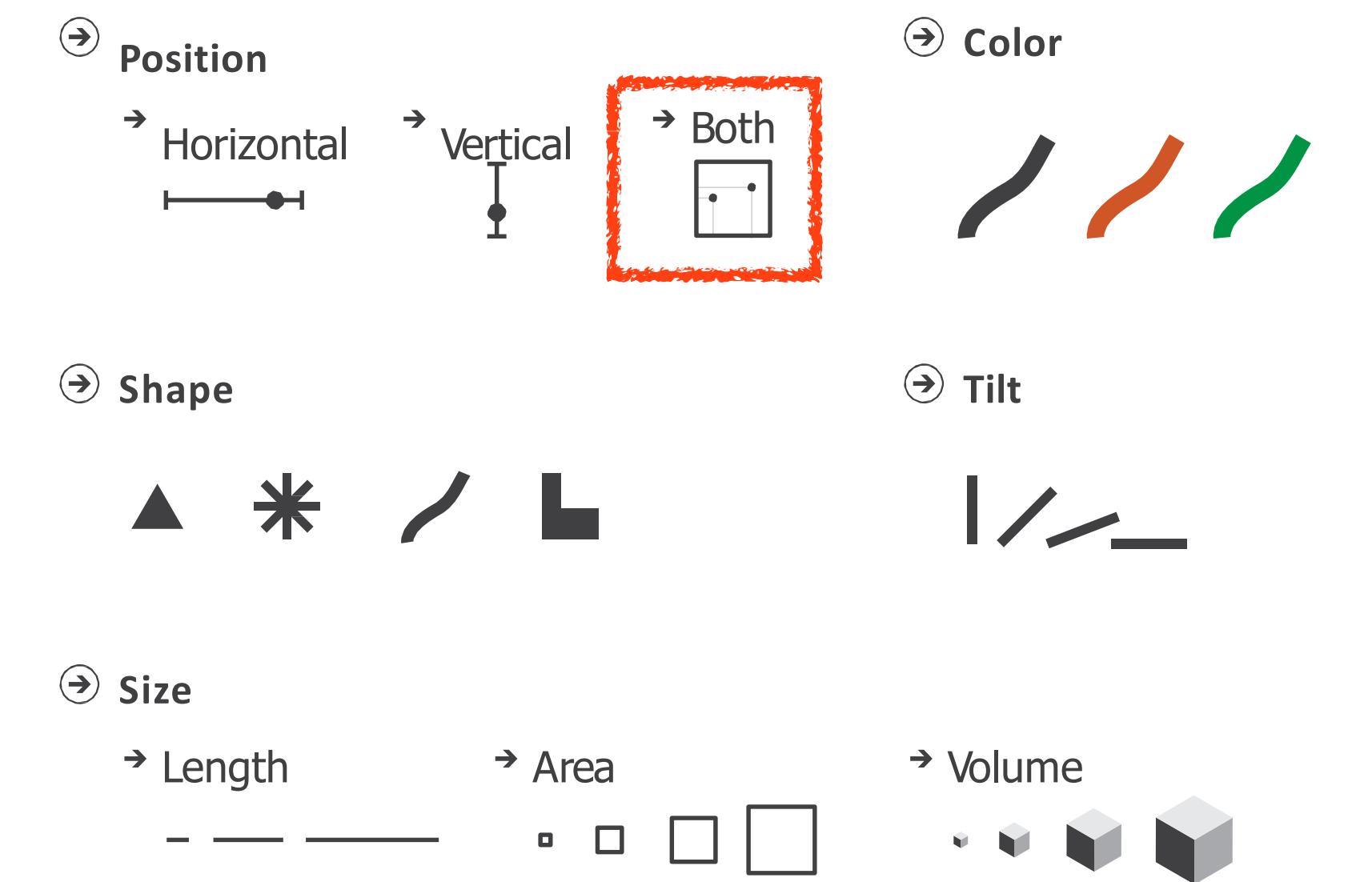


Figure 4: Tensor shapes, with ellipsoids.

+ position in 3D space



CHANNEL :



Visualization Building Blocks

of attributes encoded: 3

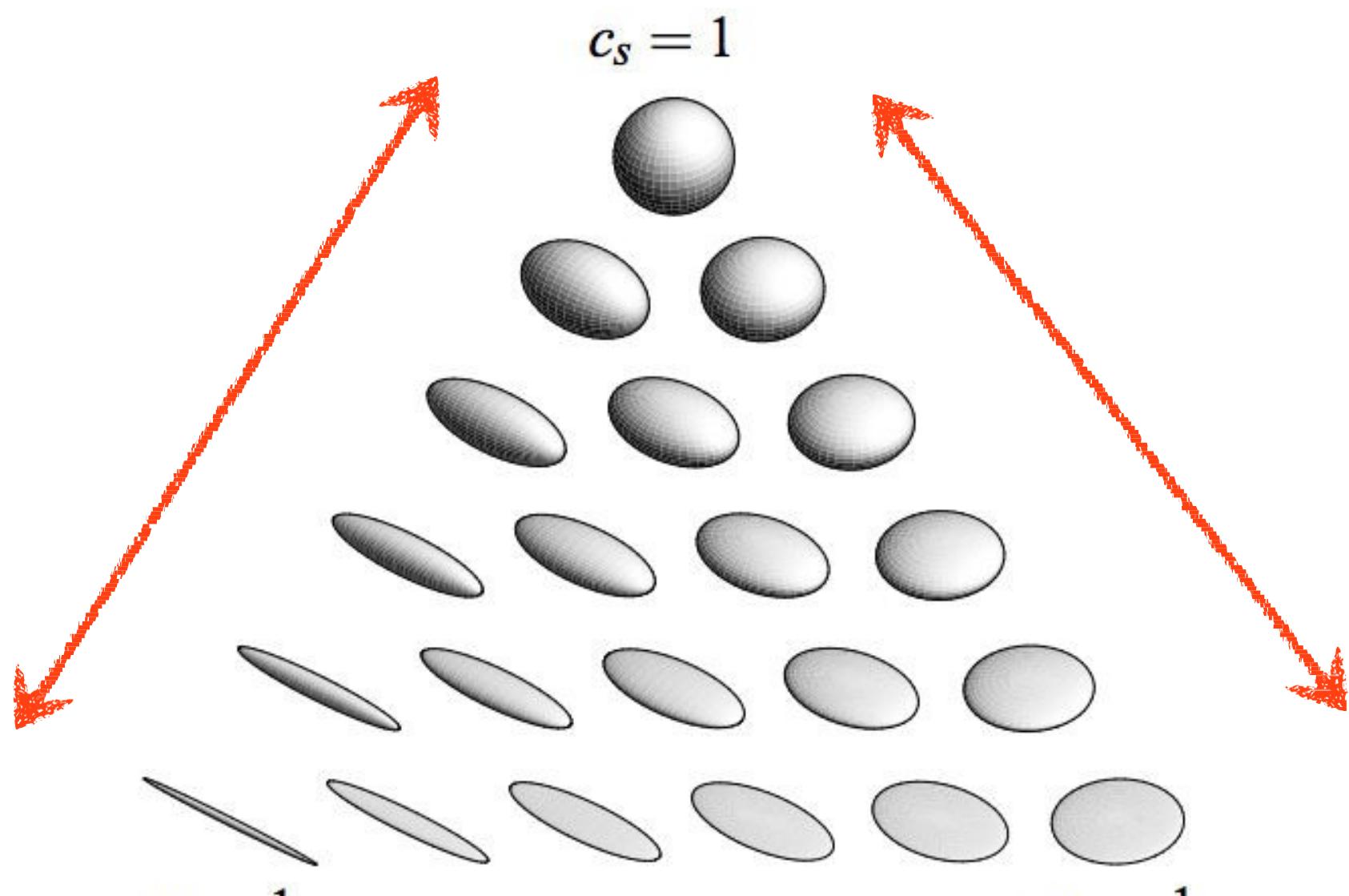
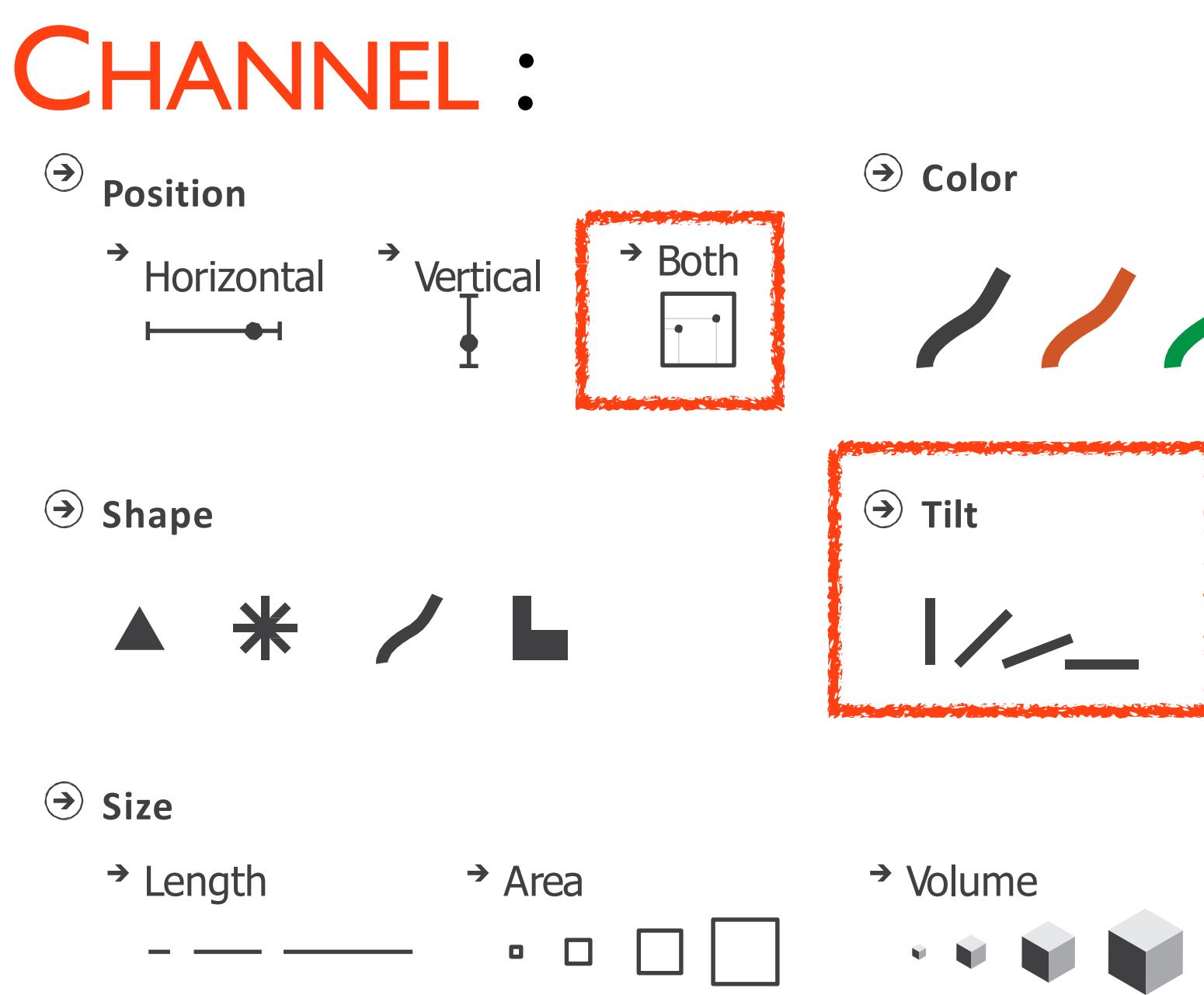
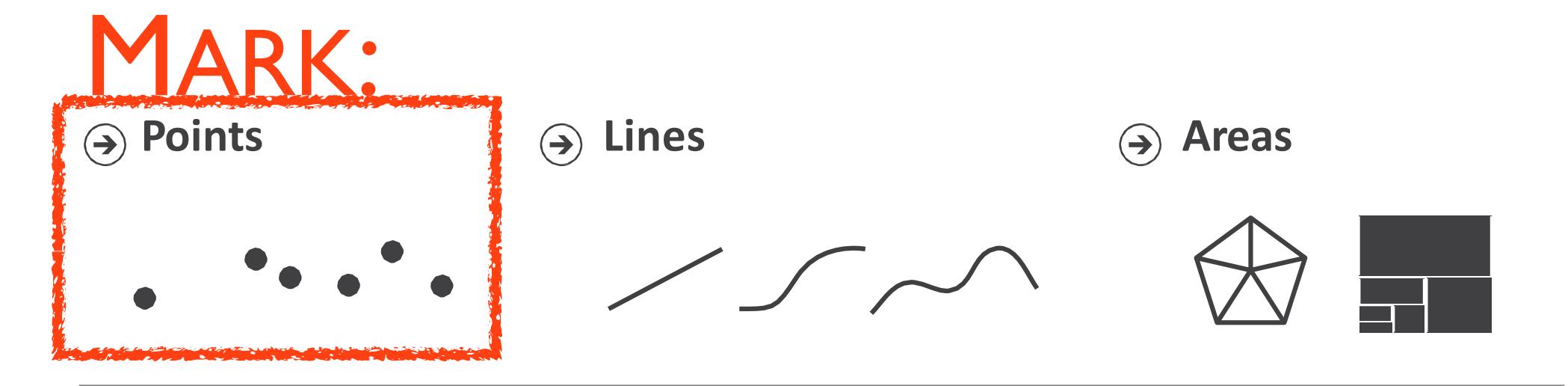


Figure 4: Tensor shapes, with ellipsoids.

← →
+ position in 3D space



Visualization Building Blocks

of attributes encoded: 3

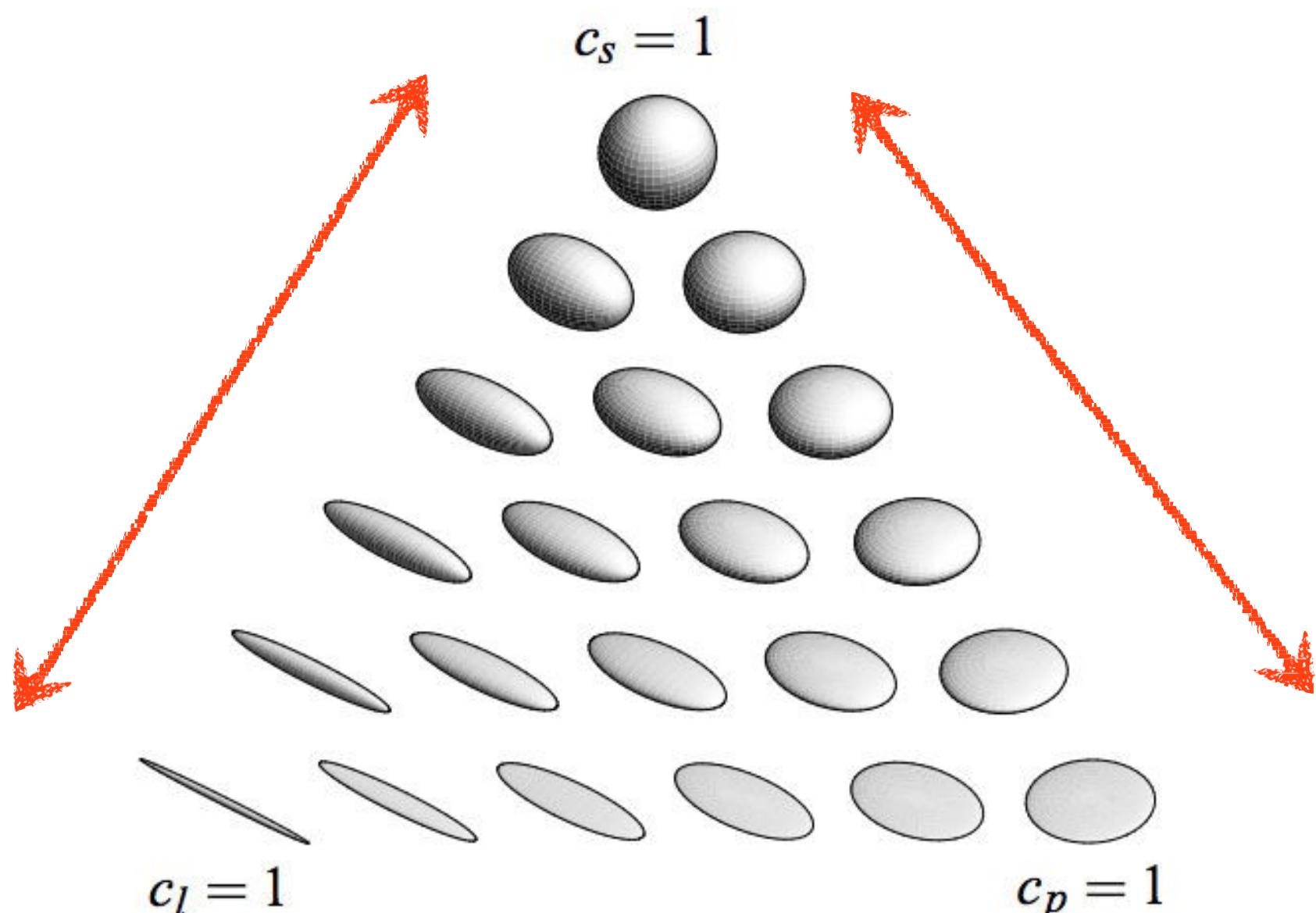
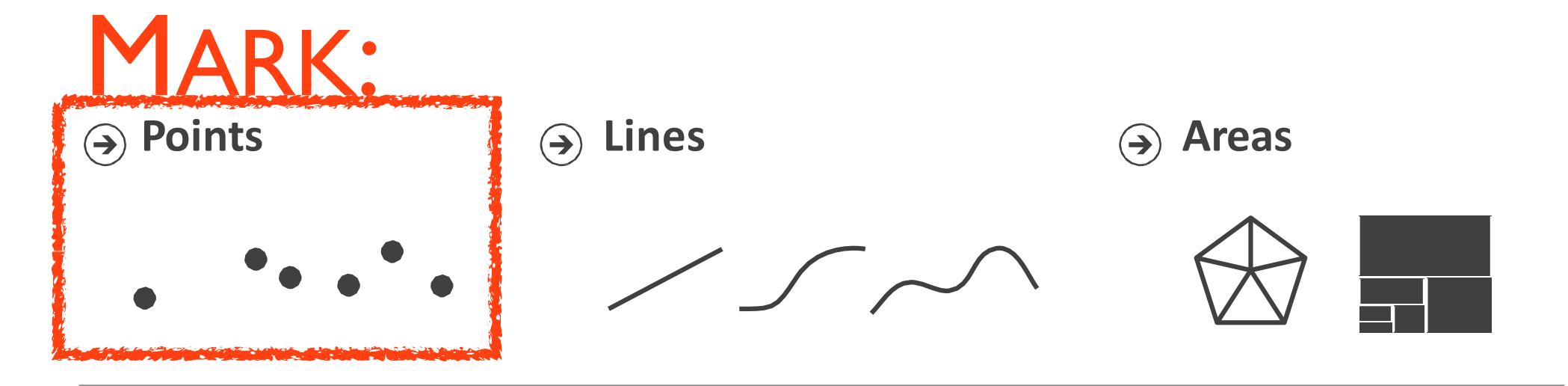
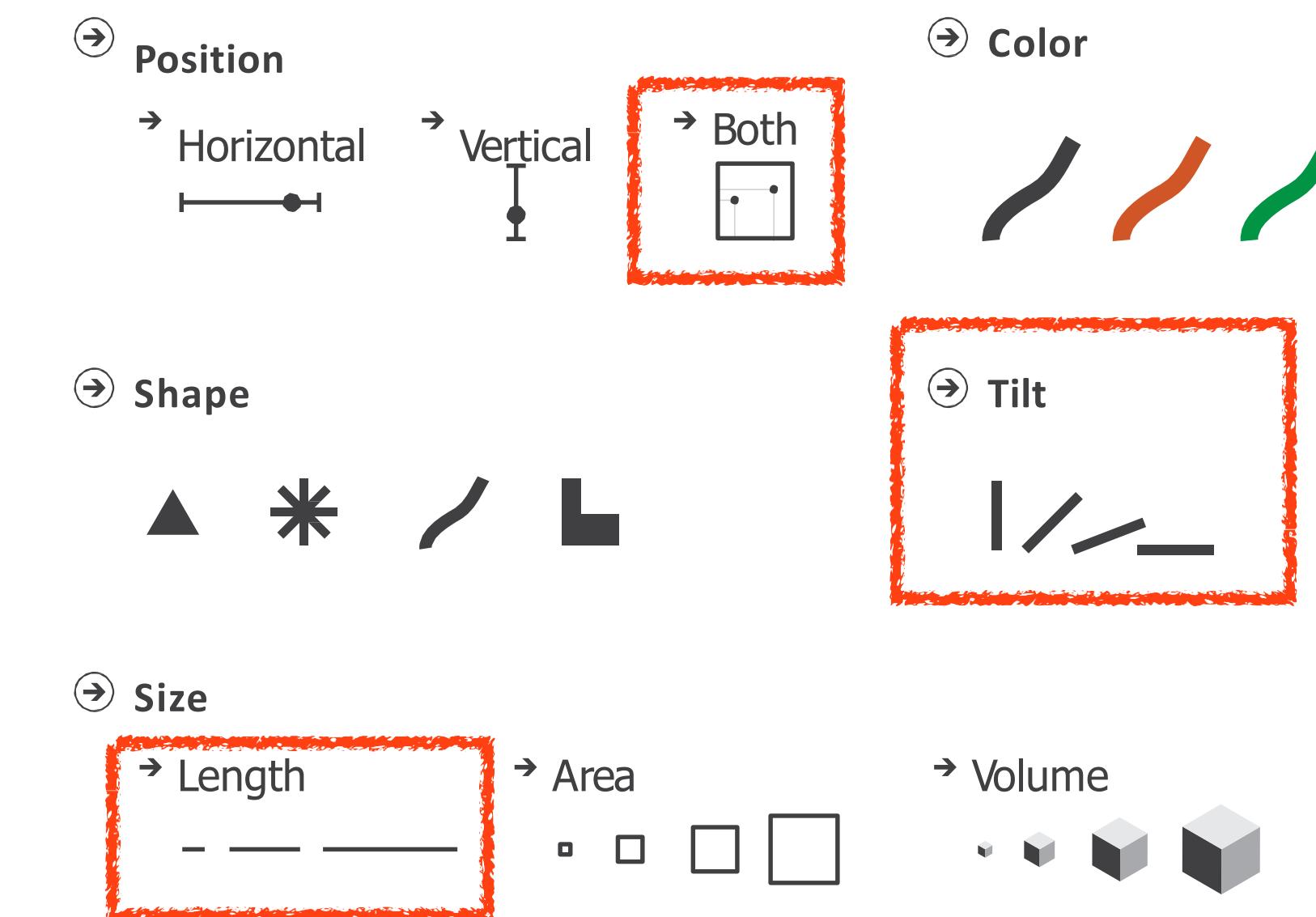


Figure 4: Tensor shapes, with ellipsoids.

← →
+ position in 3D space



CHANNEL :



Visualization Building Blocks

of attributes encoded: 3

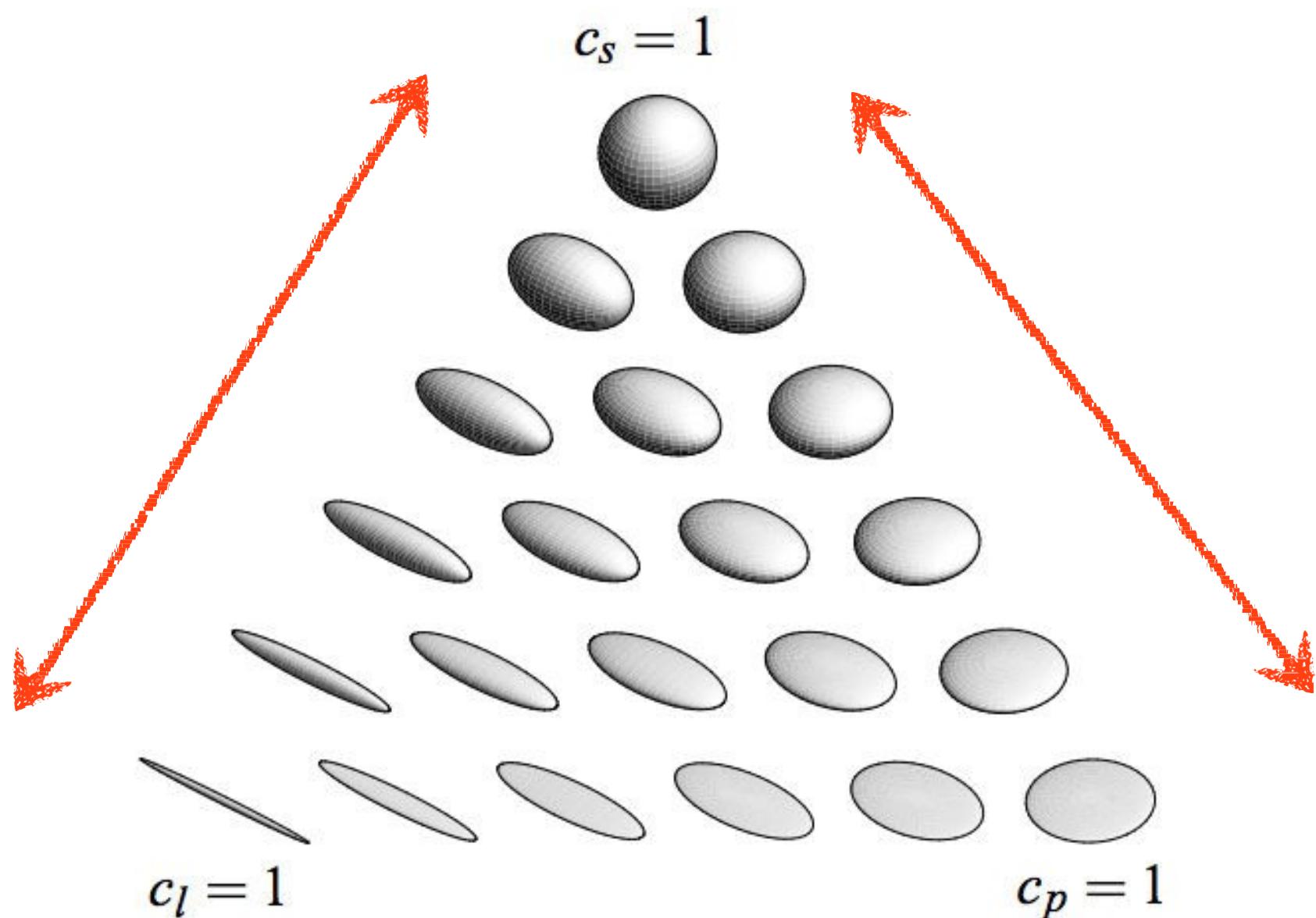
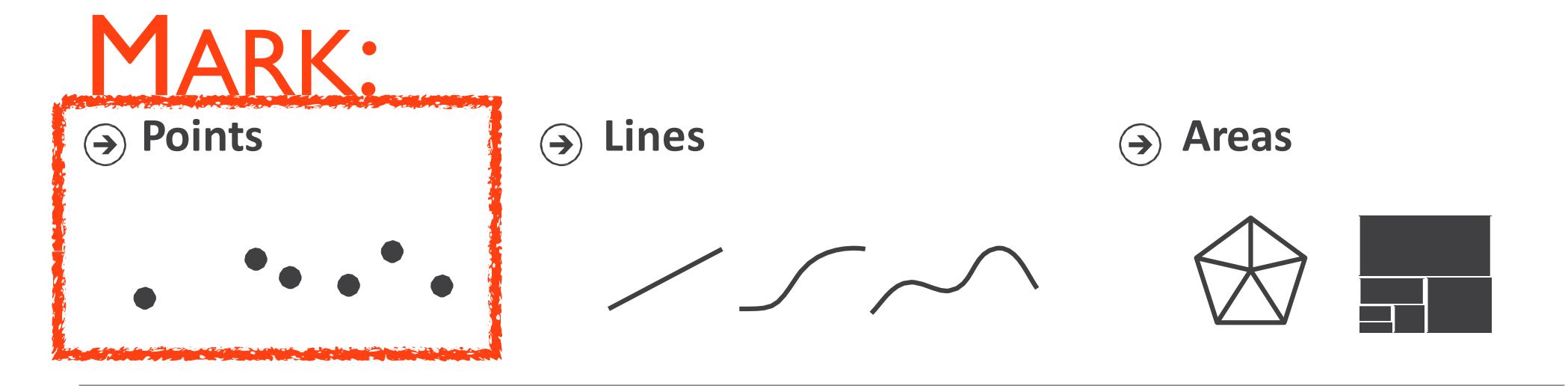
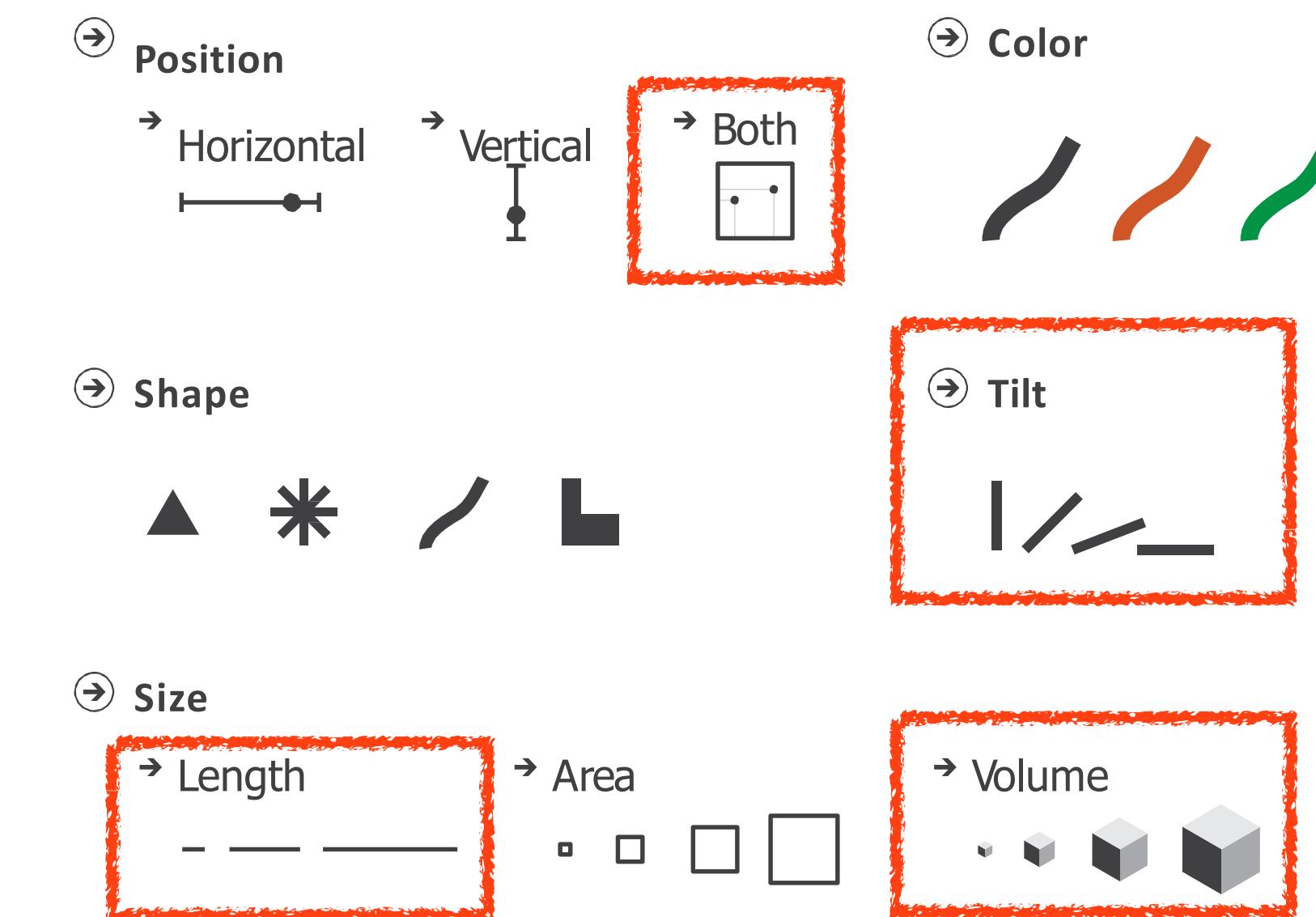


Figure 4: Tensor shapes, with ellipsoids.

← →
+ position in 3D space



CHANNEL :



Visualization Building Blocks

of attributes encoded: 3

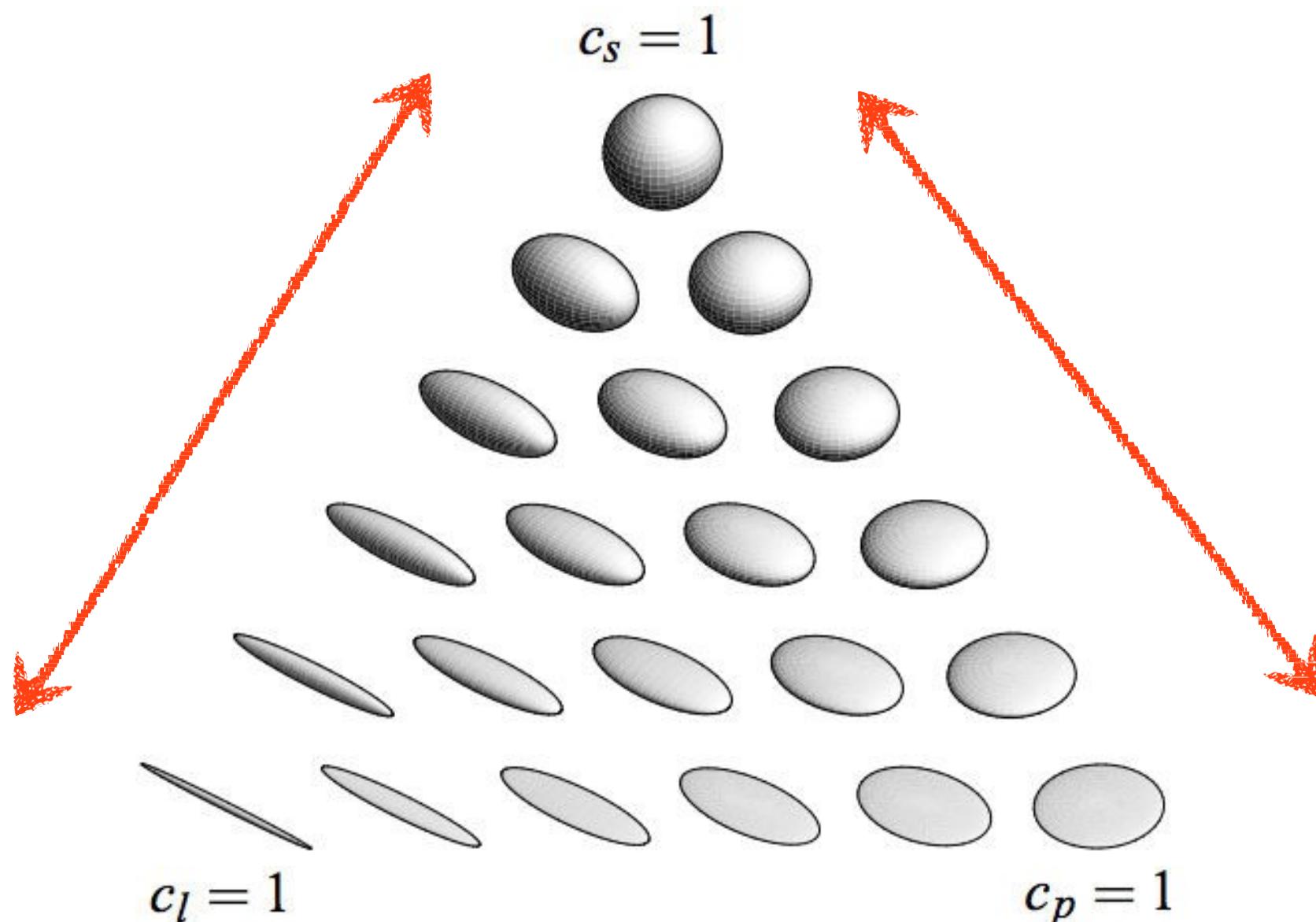
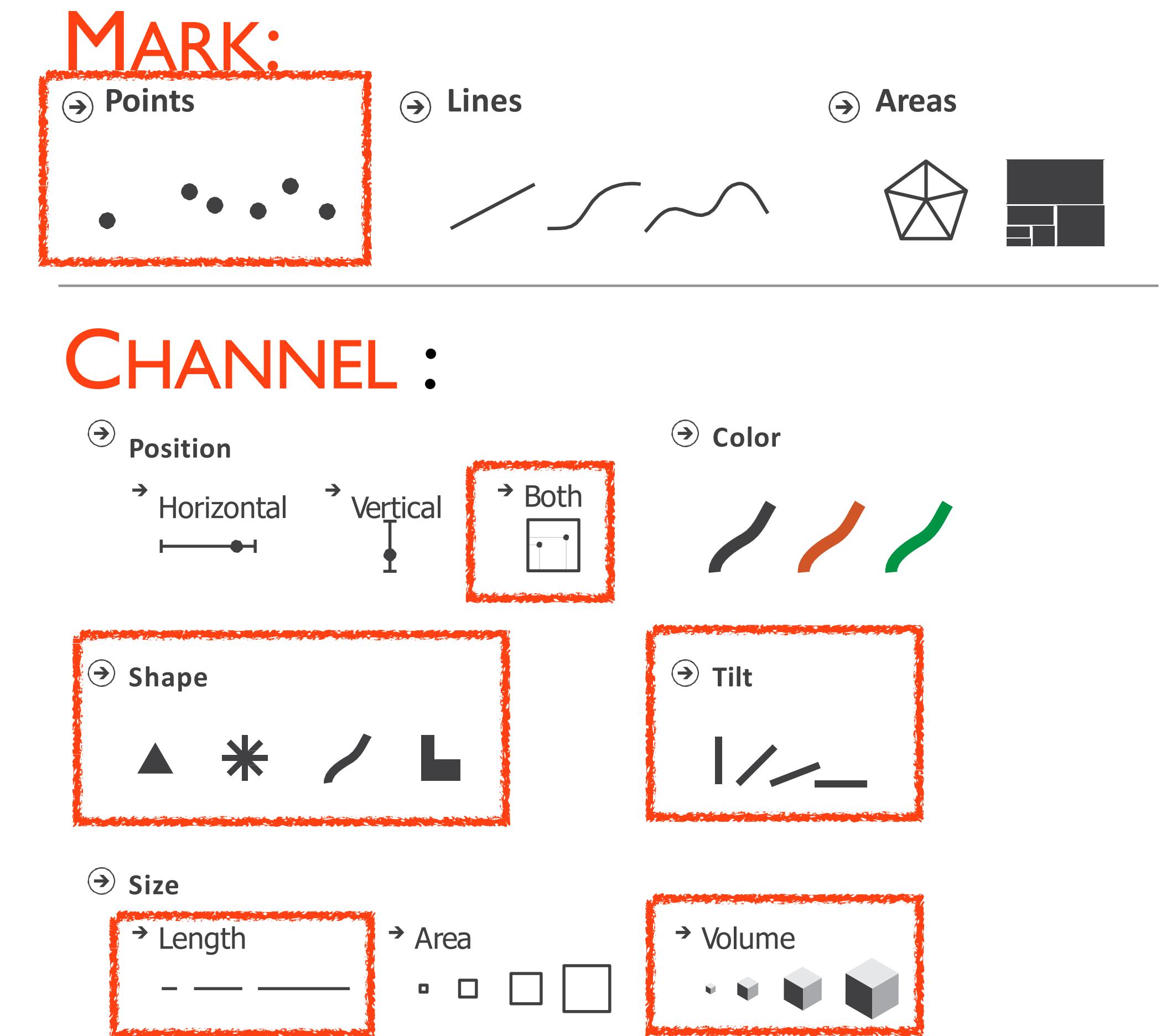


Figure 4: Tensor shapes, with ellipsoids.

← →
+ position in 3D space



Visualization Building Blocks

of attributes encoded: 3

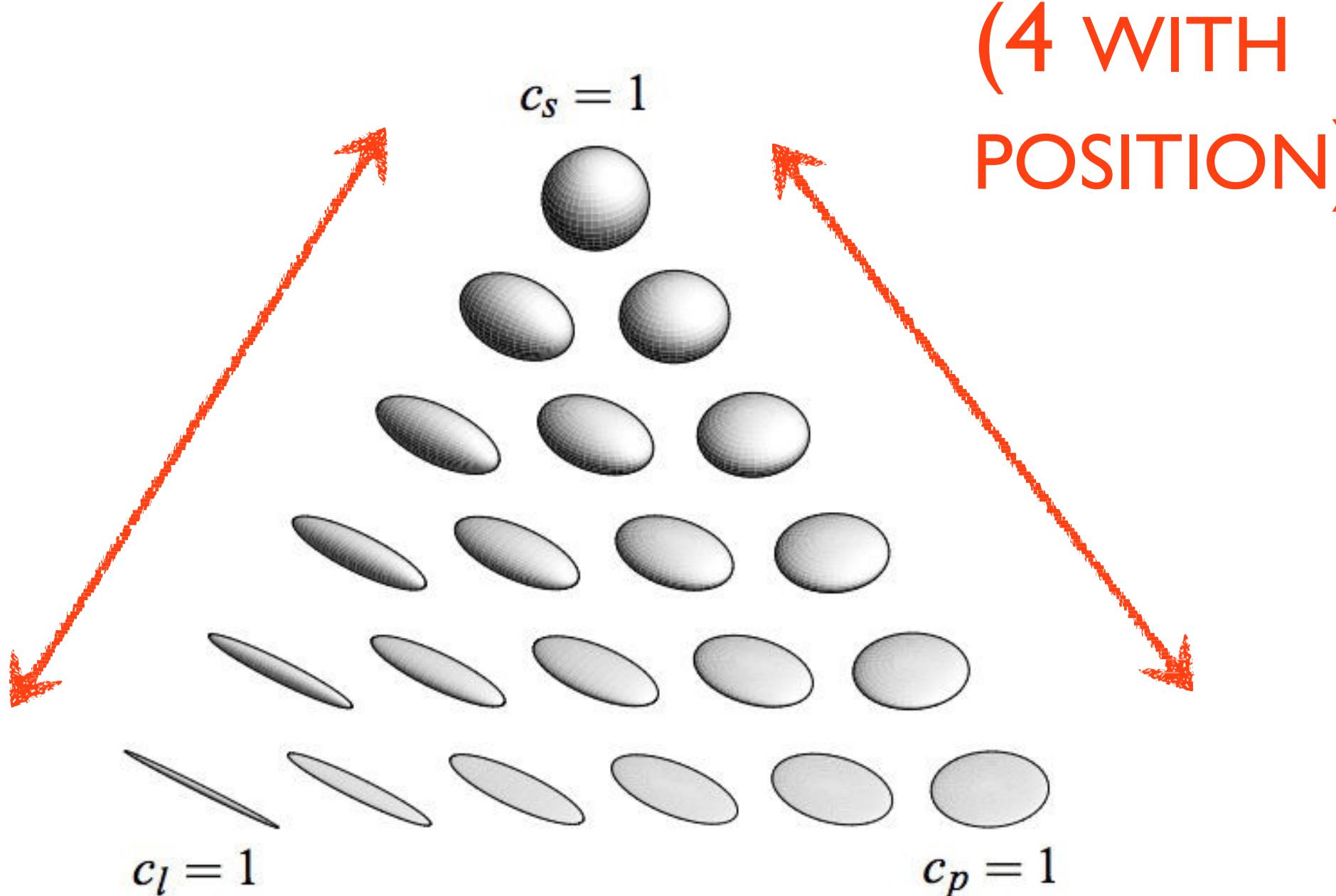
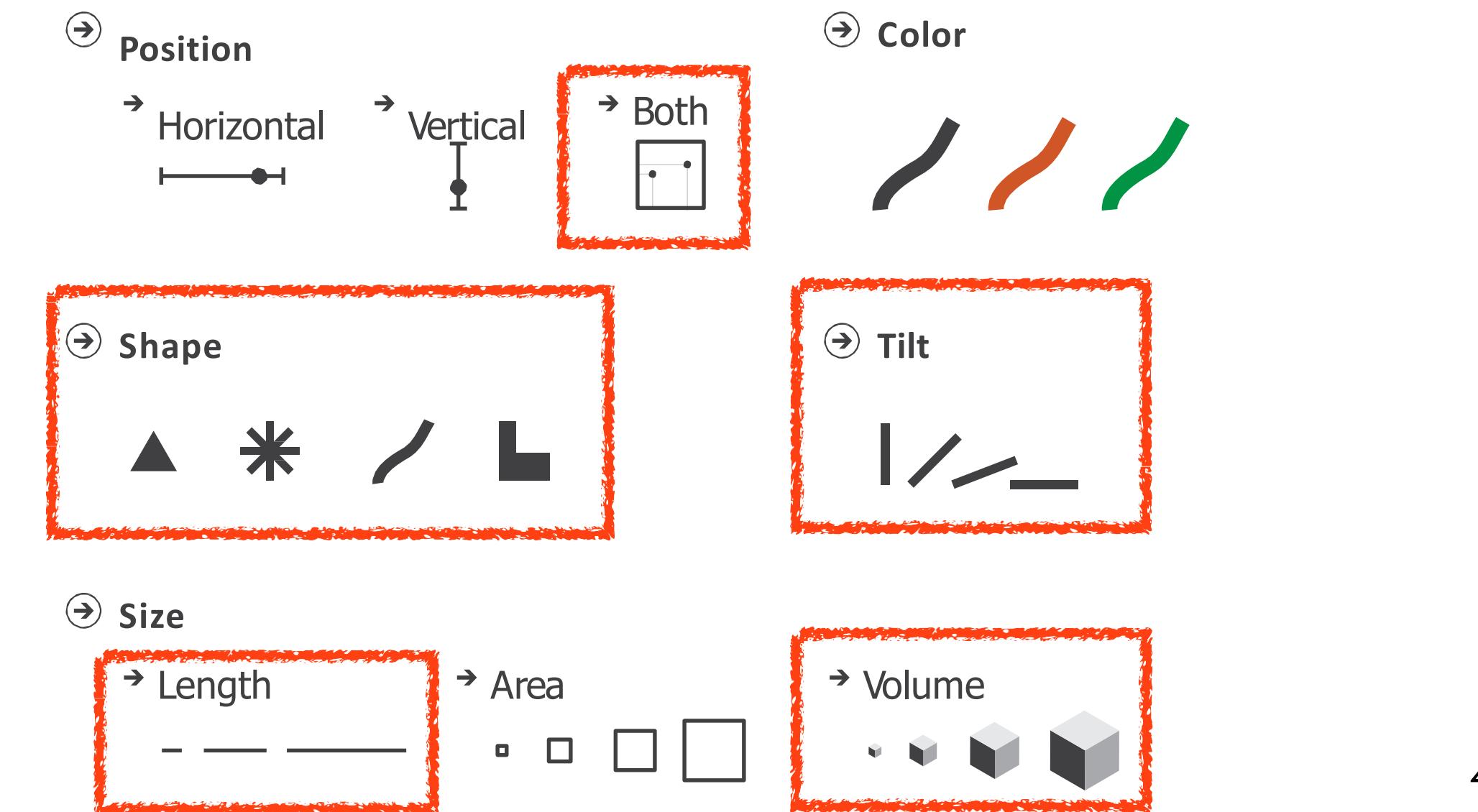


Figure 4: Tensor shapes, with ellipsoids.

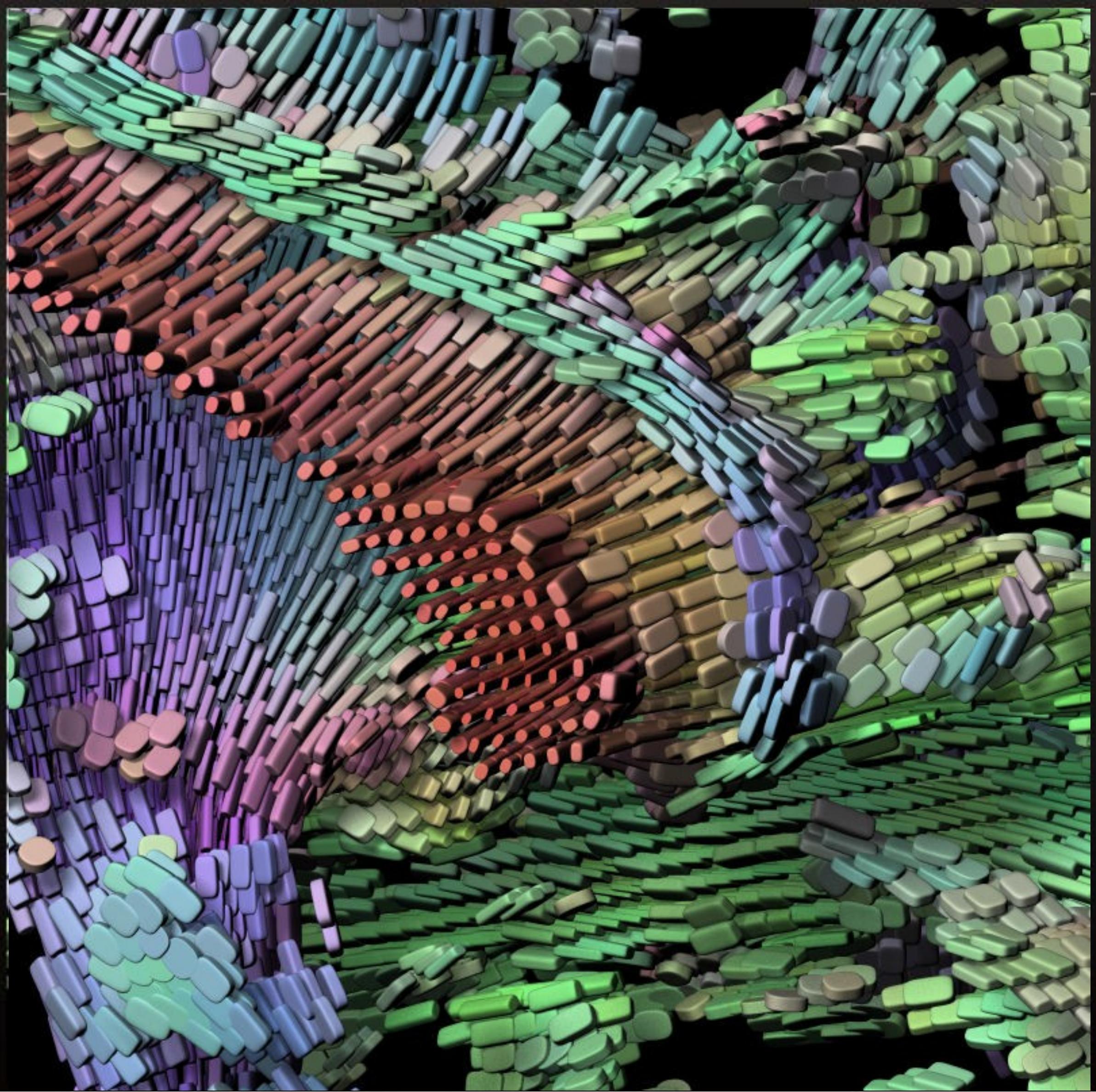
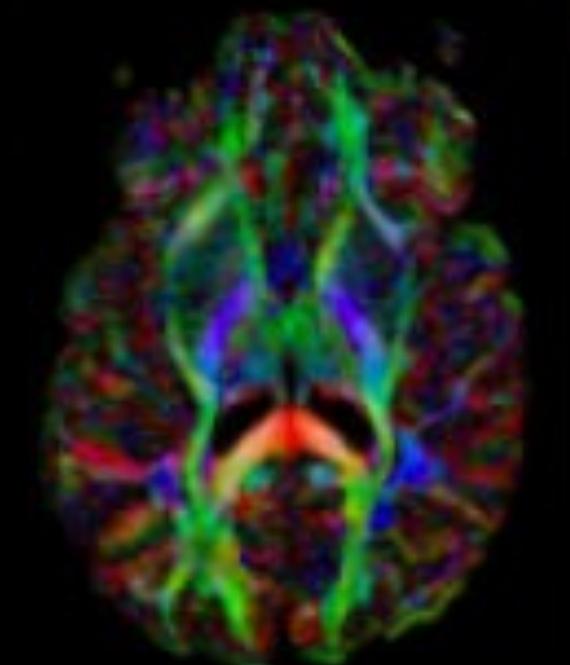
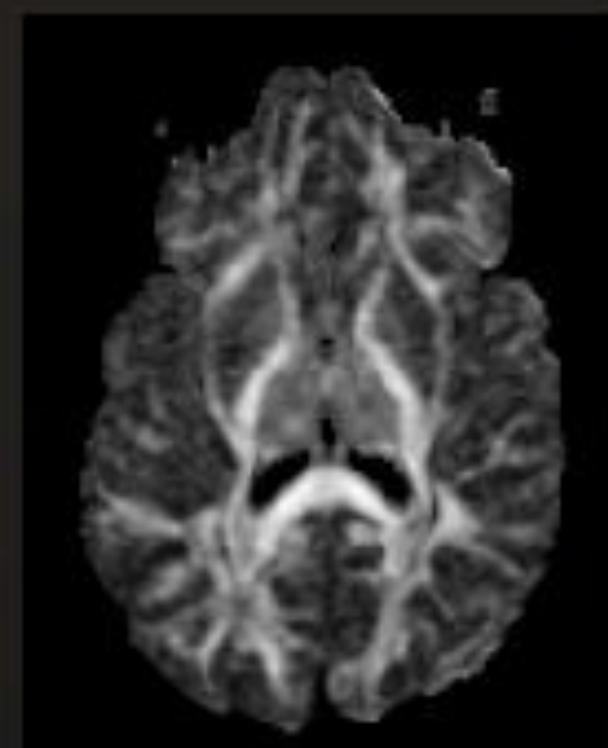
← →
+ position in 3D space



CHANNEL :



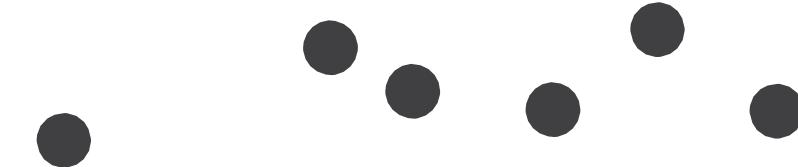
Results



Visualization Building Blocks

Marks as Items/Nodes

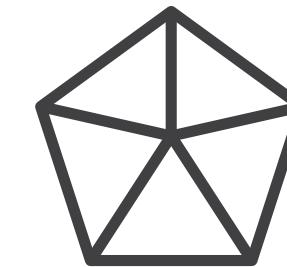
→ Points



→ Lines

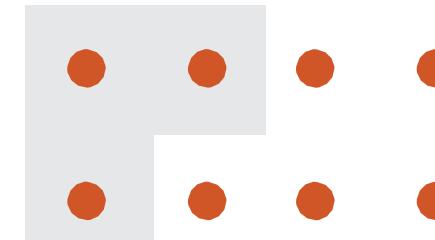


→ Areas

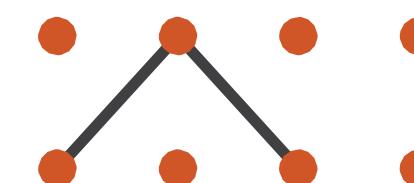


Marks as Links

→ Containment



→ Connection



Visualization Building Blocks

Marks as Items/Nodes

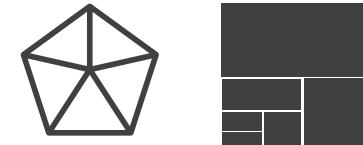
→ Points



→ Lines



→ Areas

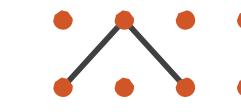


Marks as Links

→ Containment



→ Connection



Channels :

→ Position

→ Horizontal



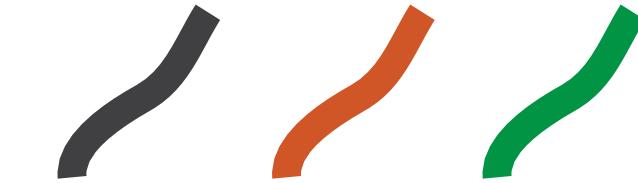
→ Vertical



→ Both



→ Color



→ Shape



→ Tilt

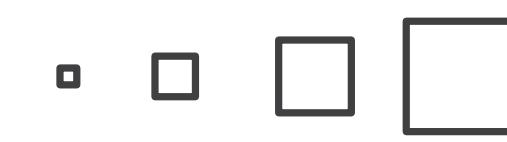


→ Size

→ Length



→ Area



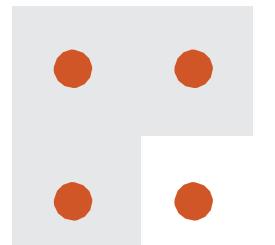
→ Volume



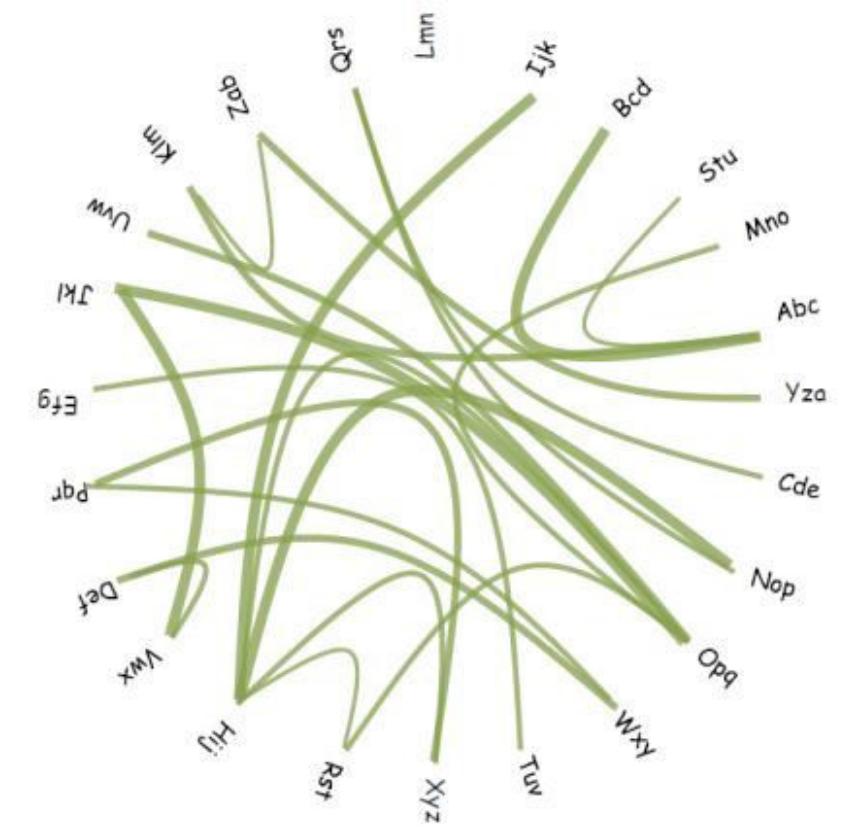
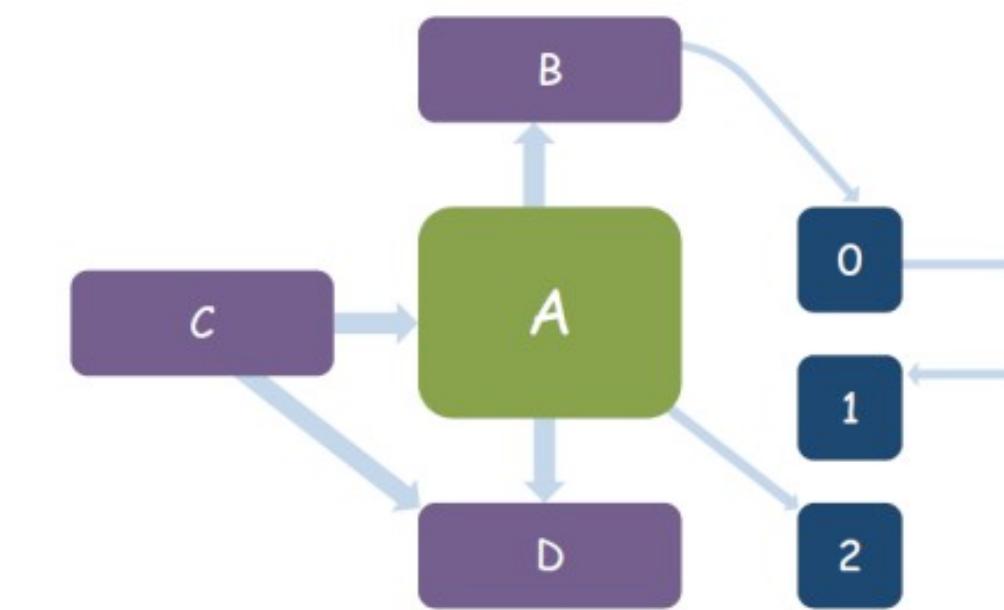
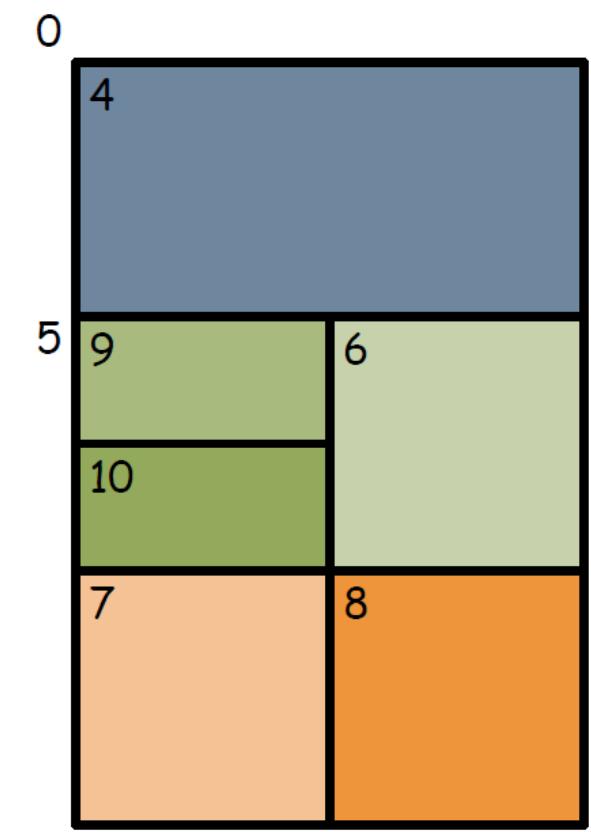
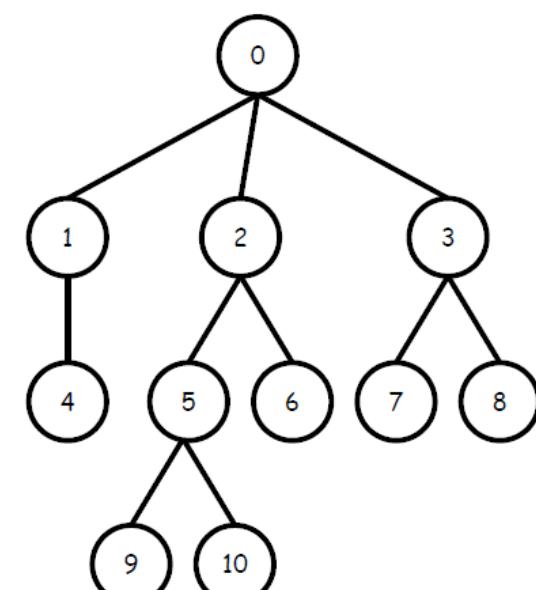
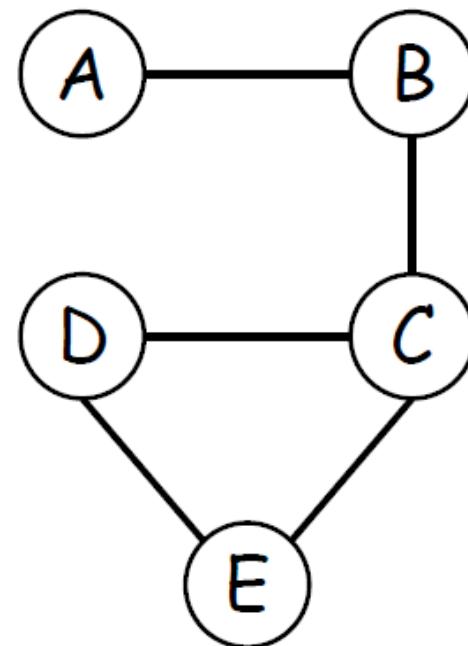
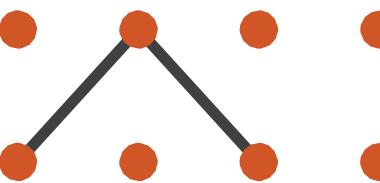
Visualization Building Blocks

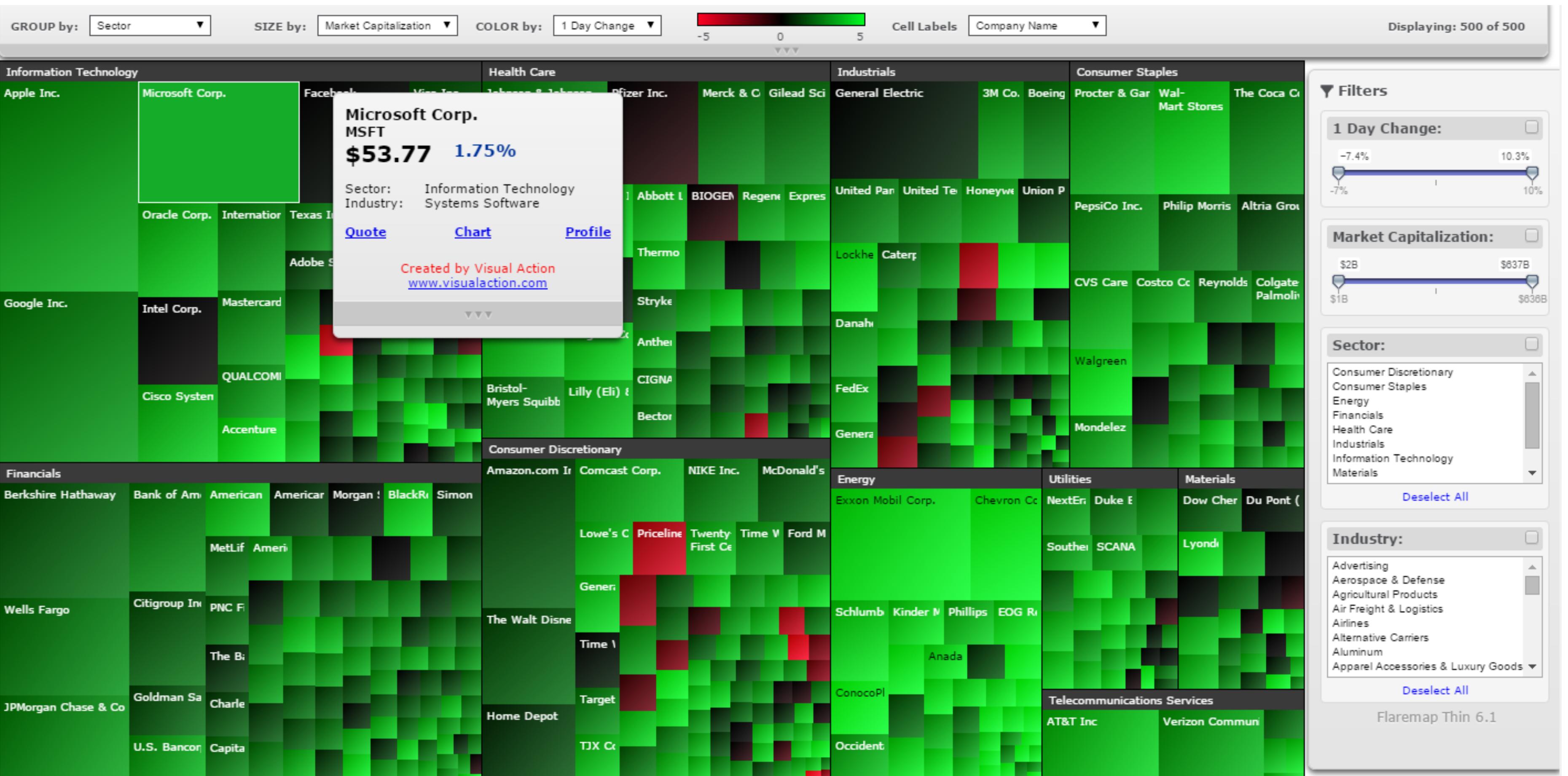
Marks as Links

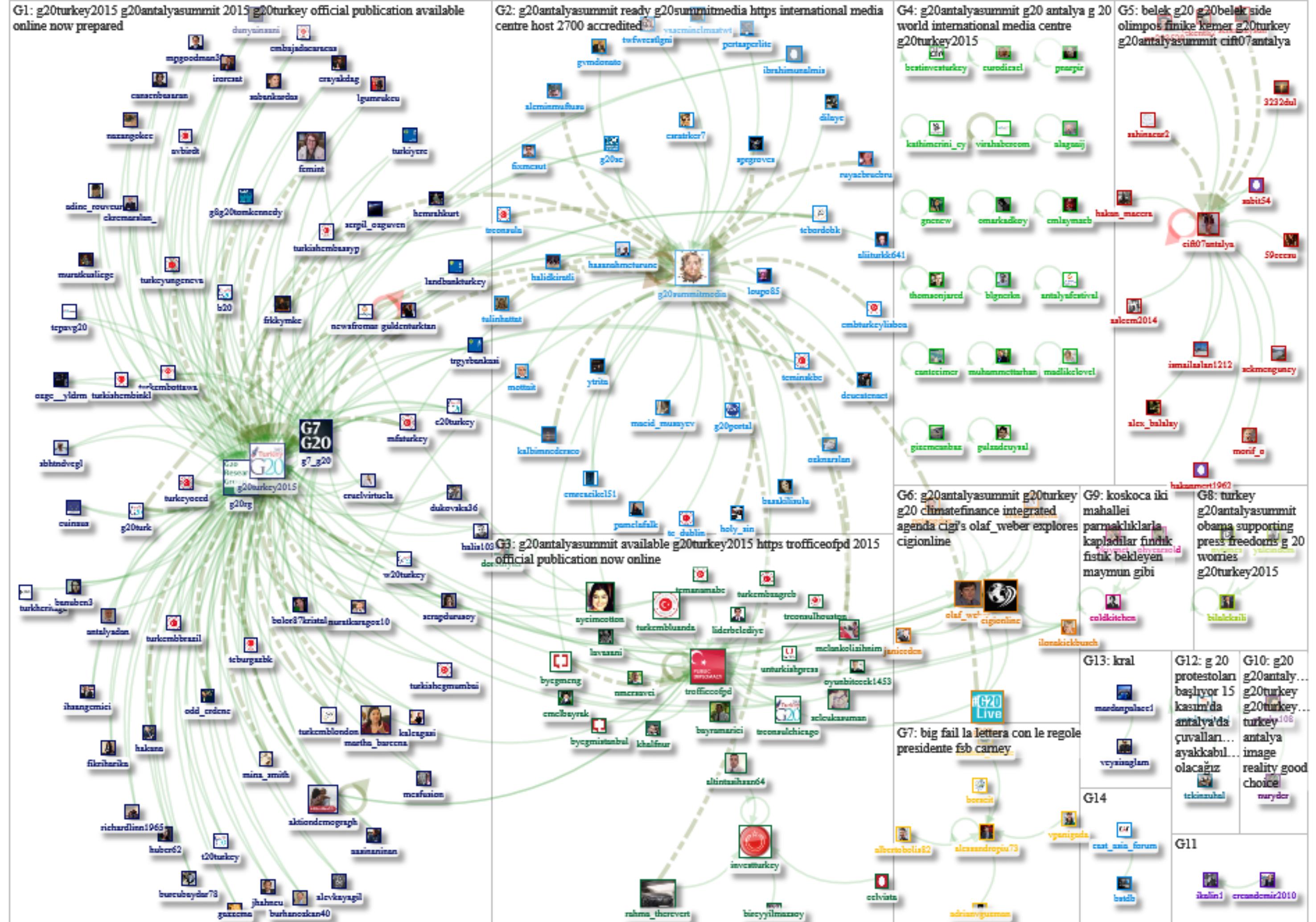
→ Containment



→ Connection



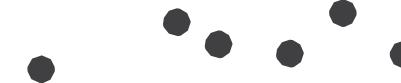




Visualization Building Blocks

Marks as Items/Nodes

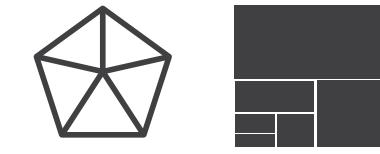
→ Points



→ Lines



→ Areas

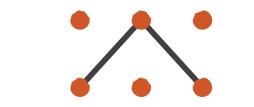


Marks as Links

→ Containment



→ Connection



Note: these are all really important concepts when it comes time to coding your visualizations...!

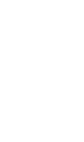
Channels :

→ Position

→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area



→ Volume

