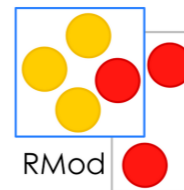




[ PolyMath ]

**version 1.0 → v2.0**

**Oleksandr Zaitsev, Sebastian Jordan Montaña,**  
Serge Stinckwich, Hemal Varambhia, etc.



In a nutshell:

PolyMath is a library for scientific computing in Pharo.

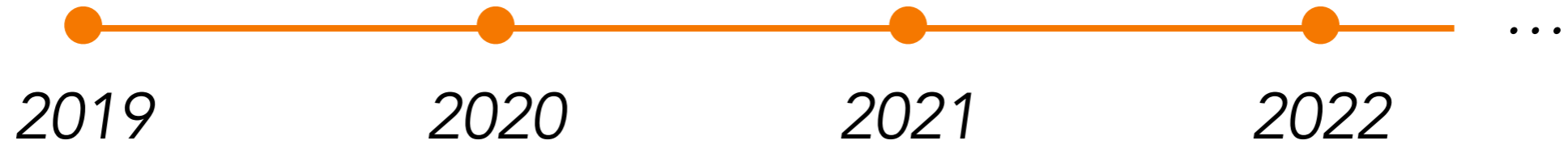


*(it's a math library)*

# On ESUG 2019 in Cologne, Serge Stinckwich presented PolyMath v1.0



Time flies :)





 Now we are here

So today we will:

1. Remind you what is PolyMath
2. Discuss what lies ahead
3. Tell you how to support us



[ PolyMath ]

Part 1:  
PolyMath -  
Who are we?



We are not mathematicians



# Contributors (between v1.0 and now)



Serge  
Stinckwich



Hemal  
Varambhia



Oleksandr  
Zaitsev



Yvan  
Guifo



Rakshit



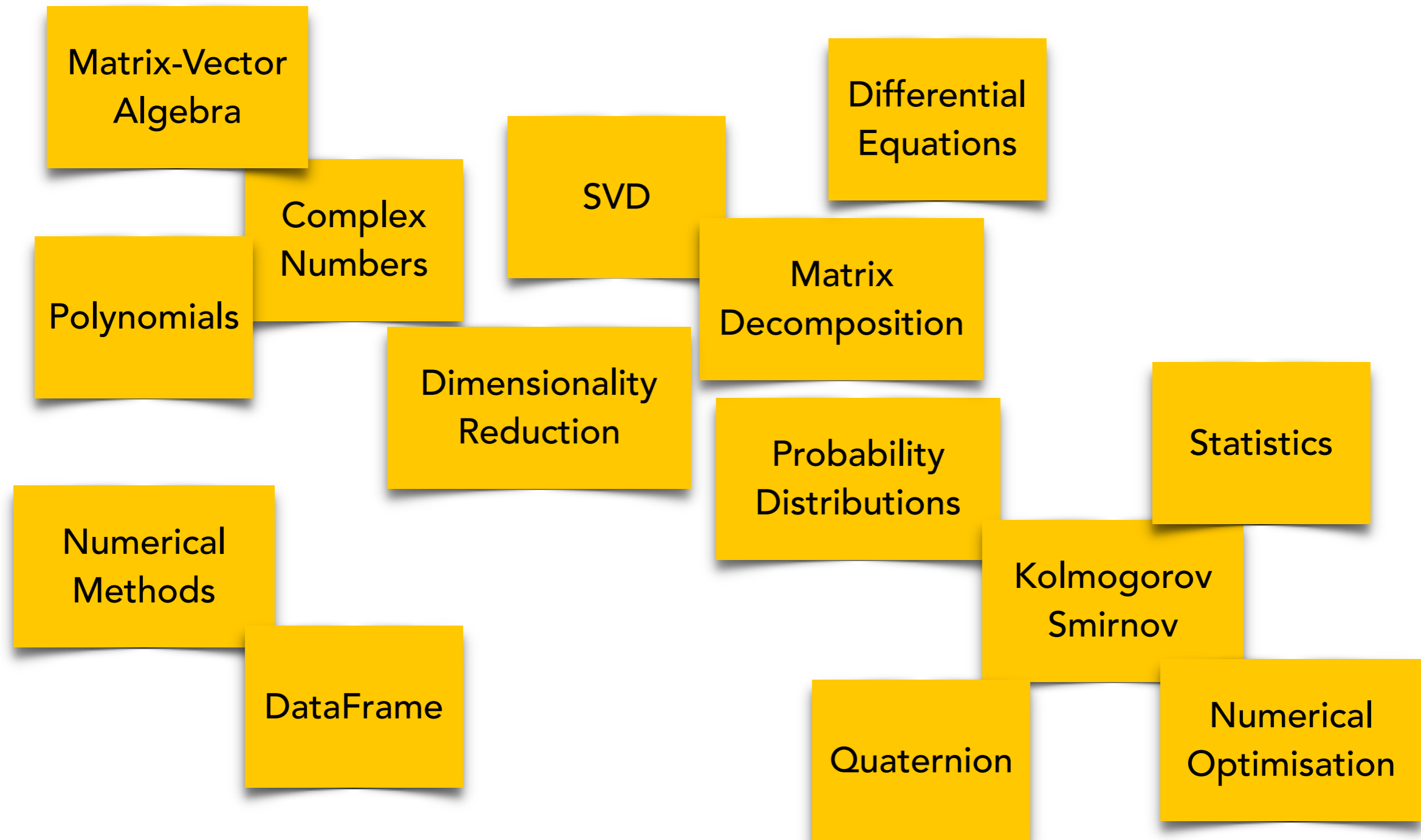
Sebastian  
Jordan Montaña



Hernan  
Moralez Durand



# Some Packages & Algorithms



# Getting Started with PolyMath

---



```
Metacello new
```

```
  repository: 'github://PolyMathOrg/PolyMath';
```

```
  baseline: 'PolyMath';
```

```
  load.
```

# Two Data Structures



$$\begin{pmatrix} y_1 \\ \vdots \\ y_m \end{pmatrix}$$

Vector

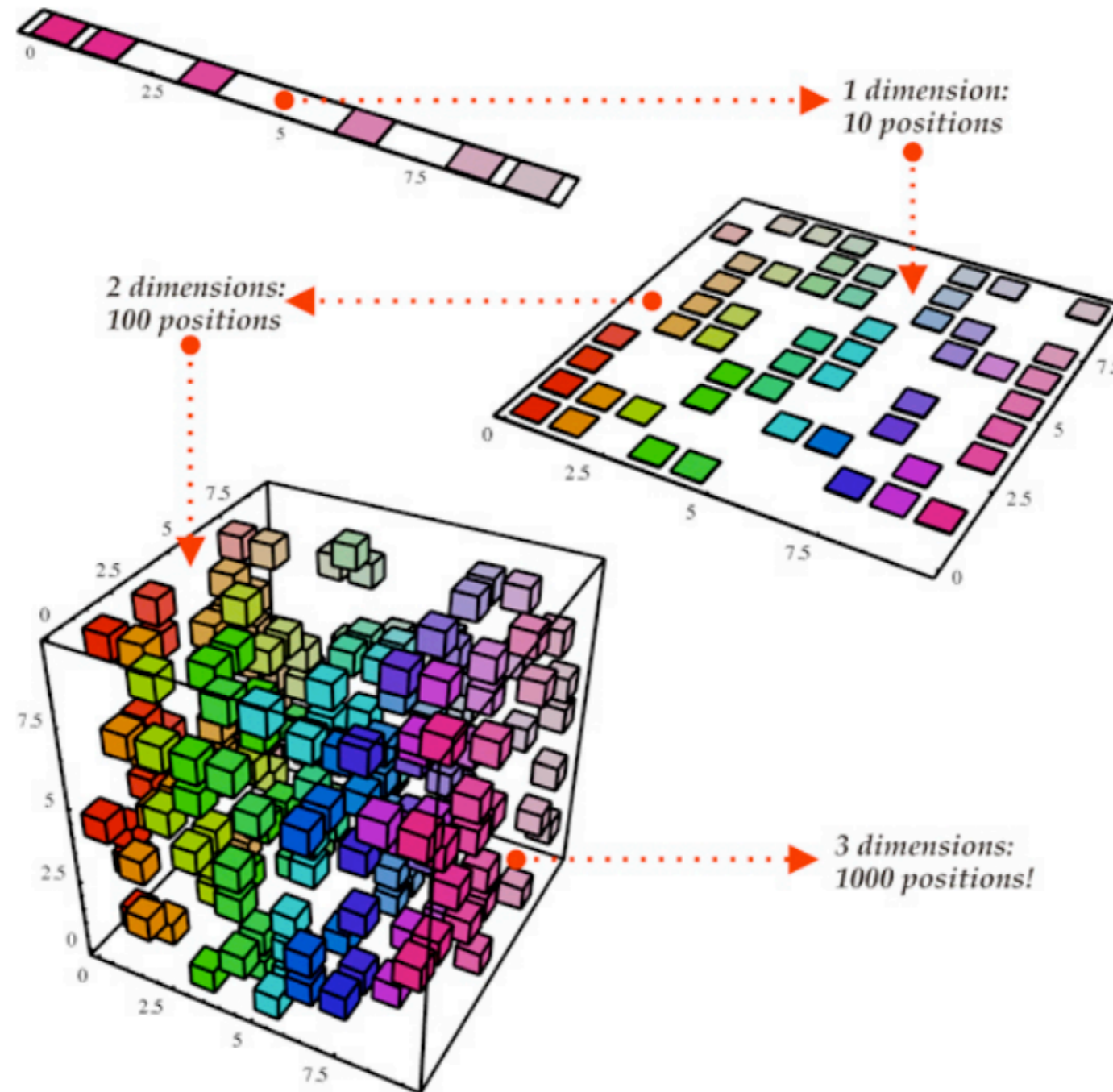
$$\begin{pmatrix} x_{11} & \dots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \dots & x_{mn} \end{pmatrix}$$

Matrix

```
vector := PMVector withAll:  
  #(1 4 3 -1).
```

```
matrix := PMMatrix rows: #(  
  (1 0 0)  
  (0 1 0)  
  (0 0 1)).
```

# Dimensionality Reduction with PCA



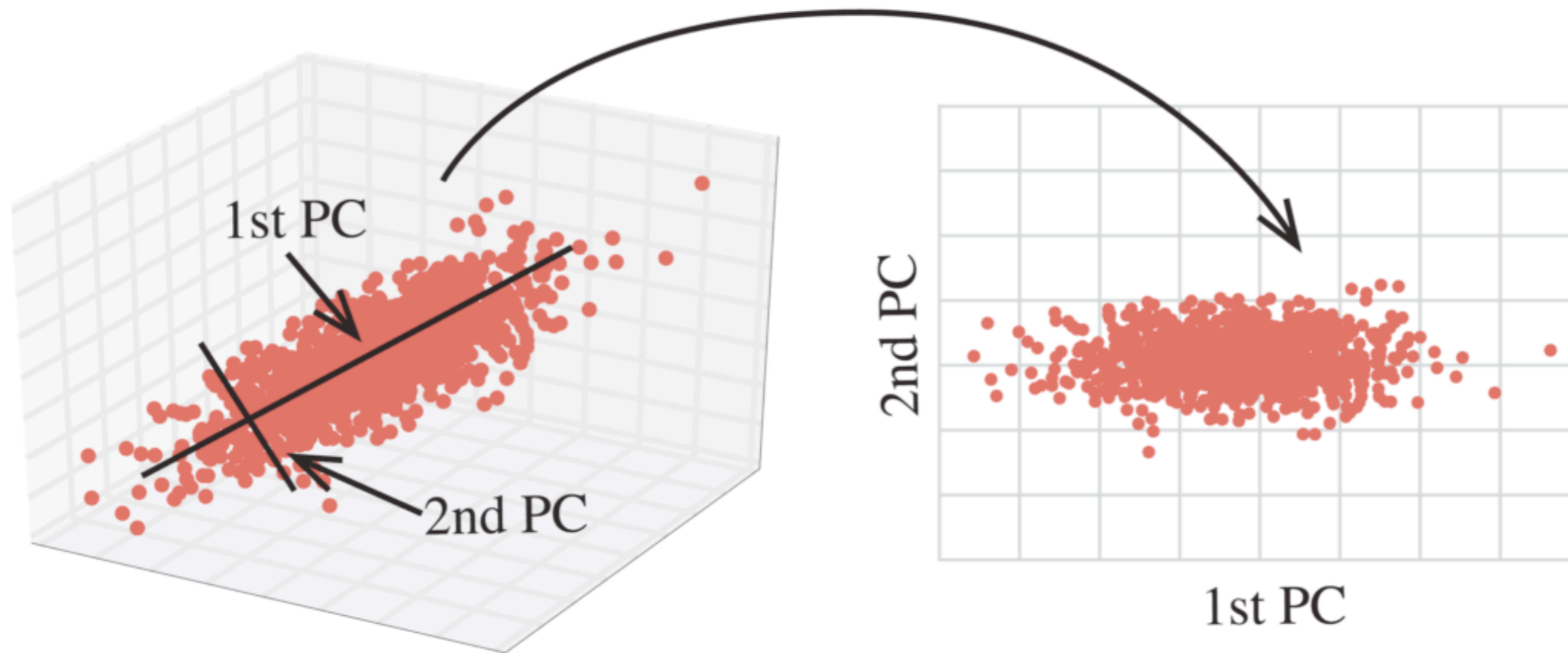
# Dimensionality Reduction with PCA

---



- Used in machine learning, statistics to solve the dimensionality curse.
- Dimensionality reduction approach that perform a linear mapping of the data to a lower-dimensional space, in such a way that the variance of the data in low-dimensional representation is maximised.

# Dimensionality Reduction with PCA



# Dimensionality Reduction with PCA



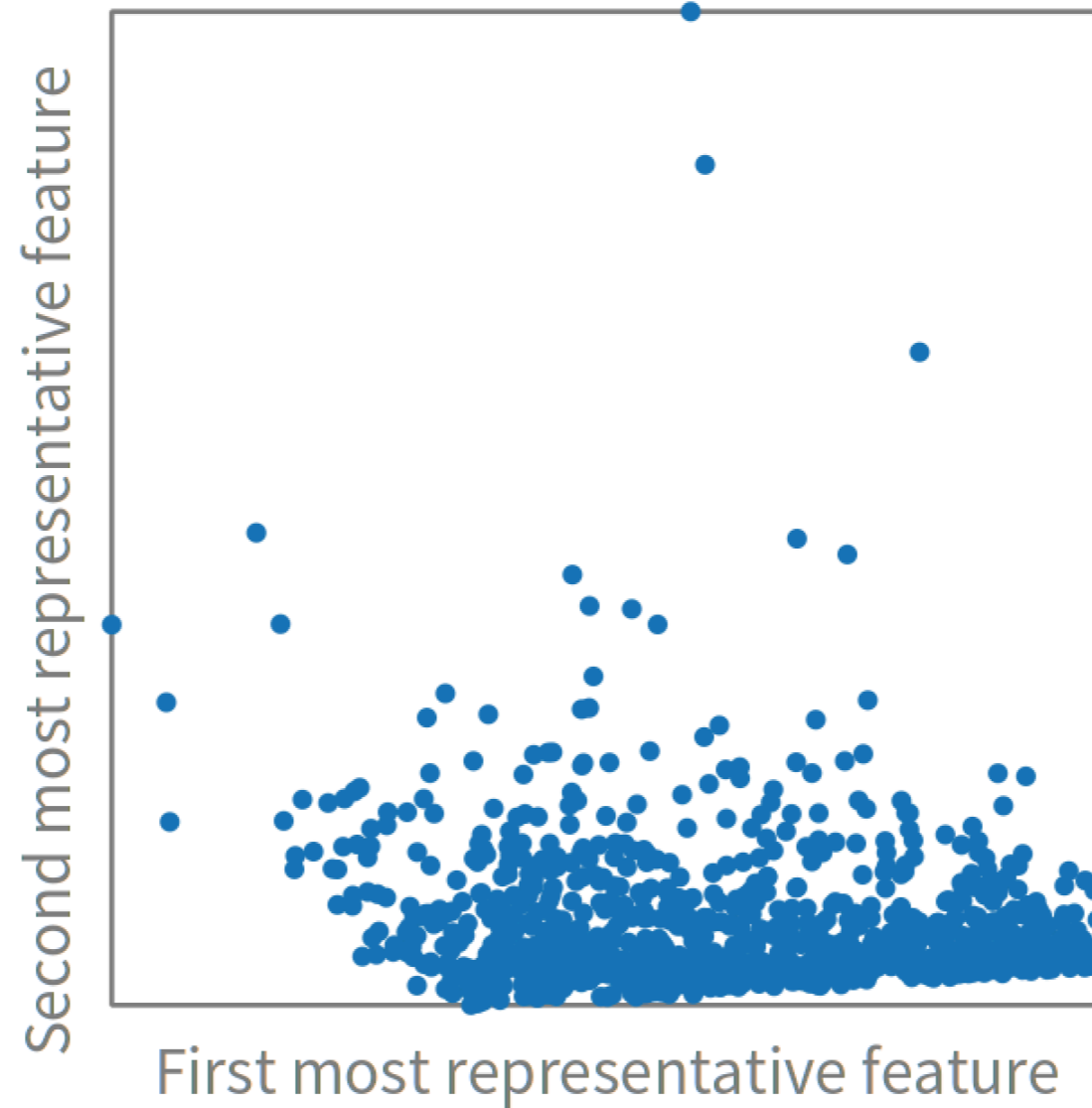
```
"Principal Component Analysis"  
"Initializing PolyMath Matrix"  
polyMathMatrix := PMMatrix rows: data.  
pca := PMPrincipalComponentAnalyserSVD new.  
  
"Reduce to 2 dimensions"  
pca componentsNumber: 2.  
"Fit the algorithm"  
pca fit: polyMathMatrix.  
  
"Transform the matrix"  
principalComponents := pca transform: polyMathMatrix.  
"Get the principal components"  
firstPrincipalComponent := principalComponents rows collect: [ :each | each first].  
secondPrincipalComponent := principalComponents rows collect: [ :each | each second].
```



# Dimensionality Reduction with PCA



## Principal components of the data



Visualised  
with Roassal3  
♥

# DataFrame



Attributes

sepal_length	sepal_width	petal_length	petal_width	Iris_class
5	2	3.5	1	versicolor
6	2.2	4	1	versicolor
6.2	2.2	4.5	1.5	versicolor
6	2.2	5	1.5	virginica
4.5	2.3	1.3	0.3	setosa
5.5	2.3	4	1.3	versicolor
6.3	2.3	4.4	1.3	versicolor
5	2.3	3.3	1	versicolor
4.9	2.4	3.3	1	versicolor
5.5	2.4	3.8	1.1	versicolor
5.5	2.4	3.7	1	versicolor
5.6	2.5	3.9	1.1	versicolor
6.3	2.5	4.9	1.5	versicolor
5.5	2.5	4	1.3	versicolor
5.1	2.5	3	1.1	versicolor
4.9	2.5	4.5	1.7	virginica
6.7	2.5	5.8	1.8	virginica
5.7	2.5	5	2	virginica
6.3	2.5	5	1.9	virginica
5.7	2.6	3.5	1	versicolor
5.5	2.6	4.4	1.2	versicolor
5.8	2.6	4	1.2	versicolor

Data point /example

Numerical value

Categorical value

```
irisDataFrame := DataFrame readFromCsv: 'iris.csv'.  
irisDataFrame inspect
```

# DataFrame



Inspector on a DataFrame [150 items] (a DataSeries('sepal length (cm)')->5.1 'sepal width (cm)')->3.5 'petal length (cm)')->1.4 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->4.9 'sepal width (cm)')->3.0 'petal length (cm)')->1.4 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->4.7 'sepal width (cm)')->3.2 'petal length (cm)')->1.3 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->4.6 'sepal width (cm)')->3.1 'petal length (cm)')->1.5 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->5.0 'sepal width (cm)')->3.6 'petal length (cm)')->1.4 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->5.4 'sepal width (cm)')->3.9 'petal length (cm)')->1.7000000000000002 'petal width (cm)')->0.4 'species')->'setosa') a DataSeries('sepal length (cm)')->4.6 'sepal width (cm)')->3.4 'petal length (cm)')->1.4 'petal width (cm)')->0.30000000000000004 'species')->'setosa') a DataSeries('sepal length (cm)')->5.0 'sepal width (cm)')->3.4 'petal length (cm)')->1.5 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->4.4 'sepal width (cm)')->2.9 'petal length (cm)')->1.4 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->4.9 'sepal width (cm)')->3.1 'petal length (cm)')->1.5 'petal width (cm)')->0.1 'species')->'setosa') a DataSeries('sepal length (cm)')->5.4 'sepal width (cm)')->3.7 'petal length (cm)')->1.5 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->4.8 'sepal width (cm)')->3.4 'petal length (cm)')->1.6 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->4.8 'sepal width (cm)')->3.0 'petal length (cm)')->1.4 'petal width (cm)')->0.1 'species')->'setosa') a DataSeries('sepal length (cm)')->4.3 'sepal width (cm)')->3.0 'petal length (cm)')->1.1 'petal width (cm)')->0.1 'species')->'setosa') a DataSeries('sepal length (cm)')->5.8 'sepal width (cm)')->4.0 'petal length (cm)')->1.2 'petal width (cm)')->0.2 'species')->'setosa') a DataSeries('sepal length (cm)')->5.7 'sepal width (cm)')->4.4 'petal length (cm)')->1.5 'petal width (cm)')->0.4 'species')->'setosa') a DataSeries('sepal length (cm)')->5.4 'sepal width (cm)')->3.9 'petal length (cm)')->1.3 'petal width (cm)')->0.4 'species')->'setosa')

DataFrame | Data Description | Visualizations | Raw | Breakpoints | Meta

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	species
5.1	3.5	1.4	0.2	setosa	
4.9	3.0	1.4	0.2	setosa	
4.7	3.2	1.3	0.2	setosa	
4.6	3.1	1.5	0.2	setosa	
5.0	3.6	1.4	0.2	setosa	
5.4	3.9	1.7000000000000002	0.4	setosa	
4.6	3.4	1.4	0.30000000000000004	setosa	
5.0	3.4	1.5	0.2	setosa	
4.4	2.9	1.4	0.2	setosa	
4.9	3.1	1.5	0.1	setosa	
5.4	3.7	1.5	0.2	setosa	
4.8	3.4	1.6	0.2	setosa	
4.8	3.0	1.4	0.1	setosa	
4.3	3.0	1.1	0.1	setosa	
5.8	4.0	1.2	0.2	setosa	
5.7	4.4	1.5	0.4	setosa	
5.4	3.9	1.3	0.4	setosa	

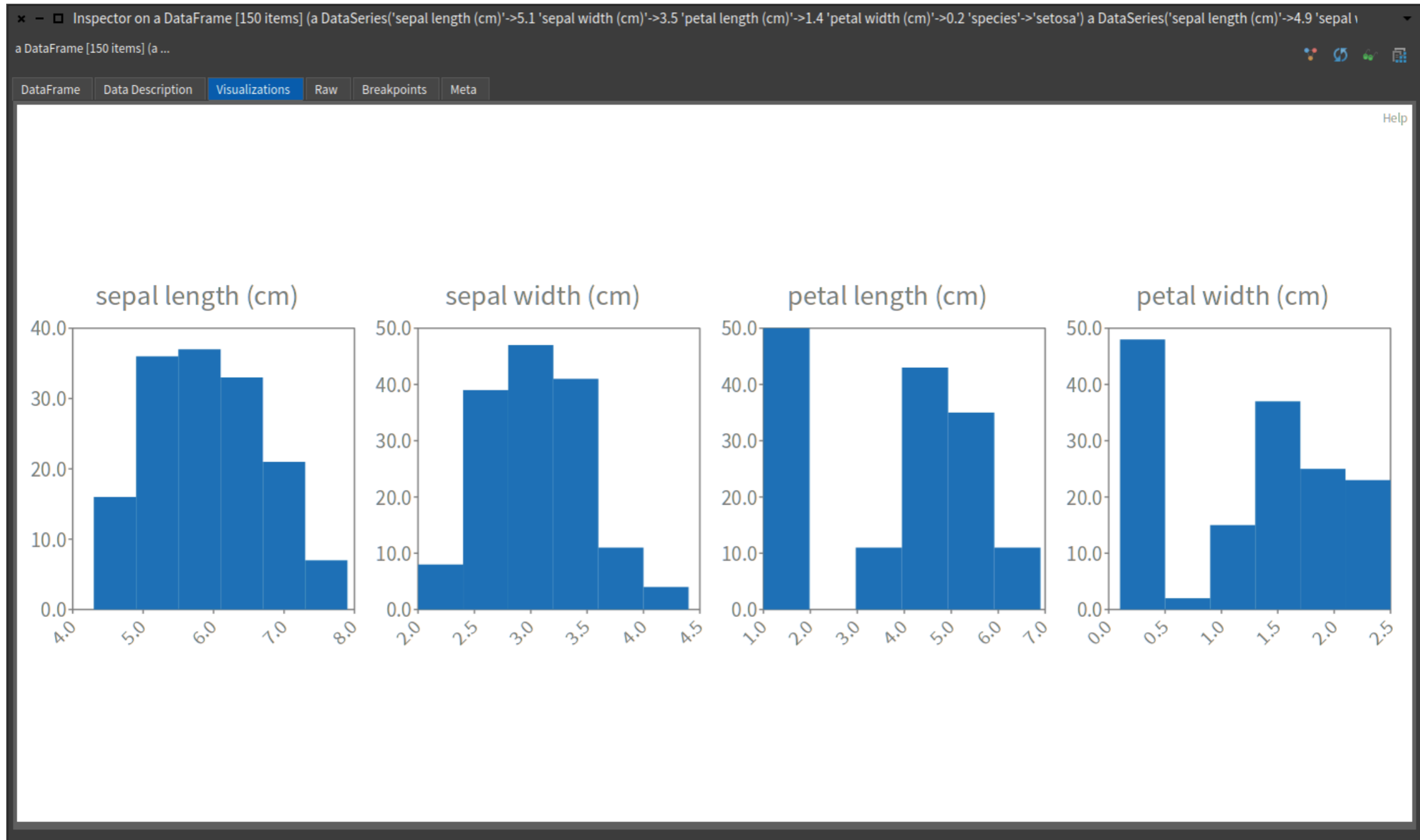
Statistic	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	species
1st Quartile	5.10	2.80	1.60	0.30	NaN
3rd Quartile	6.40	3.30	5.10	1.80	NaN
Median	5.80	3.00	4.35	1.30	NaN
Minimum	4.30	2.00	1.00	0.10	NaN
Maximum	7.90	4.40	6.90	2.50	NaN
Variance	0.69	0.19	3.12	0.58	NaN
Standard deviation	0.83	0.44	1.77	0.76	NaN
Mode	5.00	3.00	1.40	0.20	NaN
Average	5.84	3.06	3.76	1.20	NaN

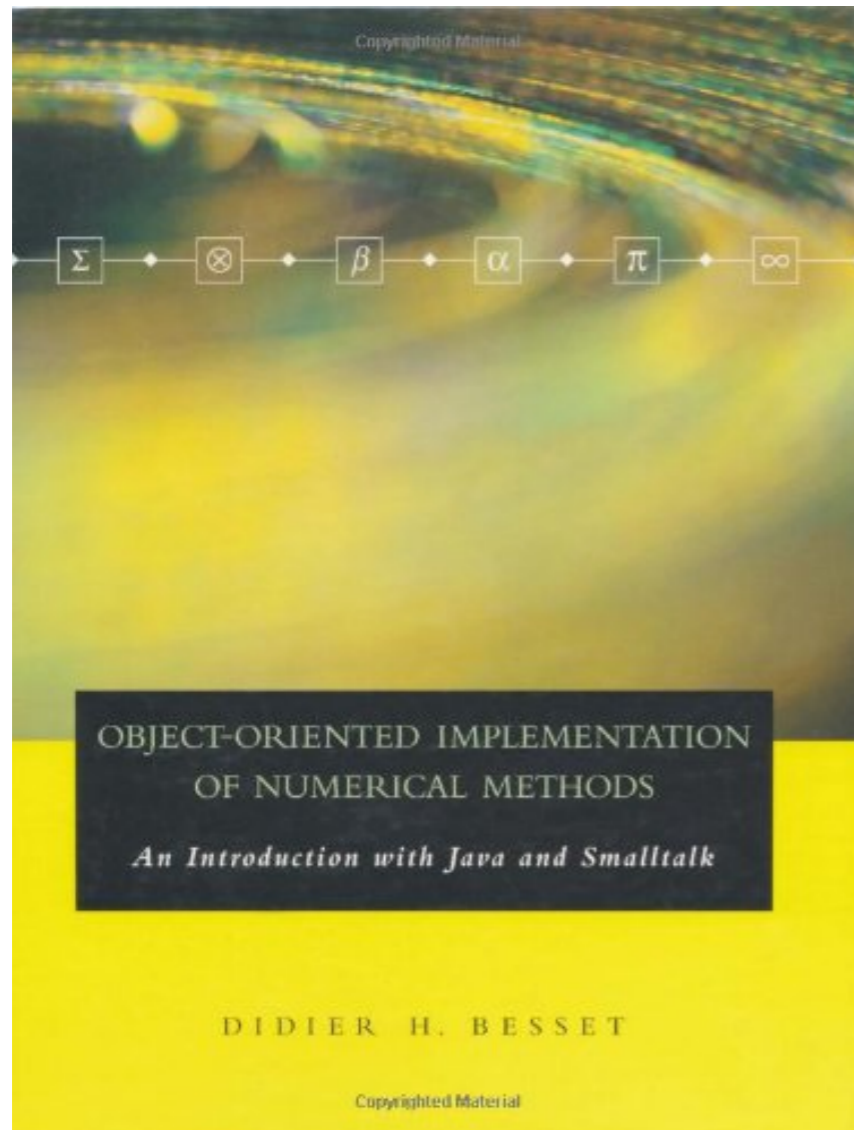
Property	Value
Dimensions	(150@5)
Has categorical	true
Has nil	false

Do it

```
1 self.columnNames "an OrderedCollection('sepal length (cm)' 'sepal width (cm)' 'petal length (cm)' 'petal width (cm)' 'species')".
2 (self.column: 'species') values asSet size "3"
```

# DataFrame





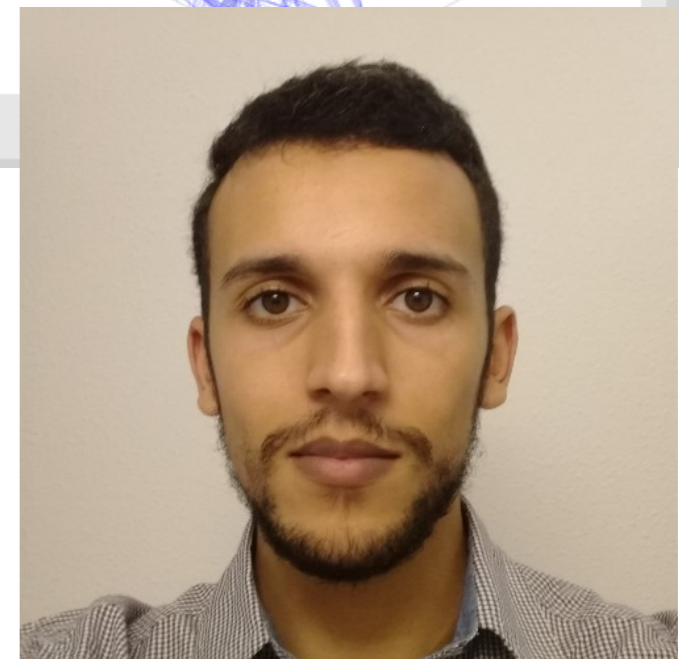
*“Object-Oriented  
Implementation of Numerical  
Methods. An Introduction with  
Java and Smalltalk”*  
by Didier B. Besset



[ PolyMath ]

Part 2:  
The future

# Goal 1: Decoupling Packages

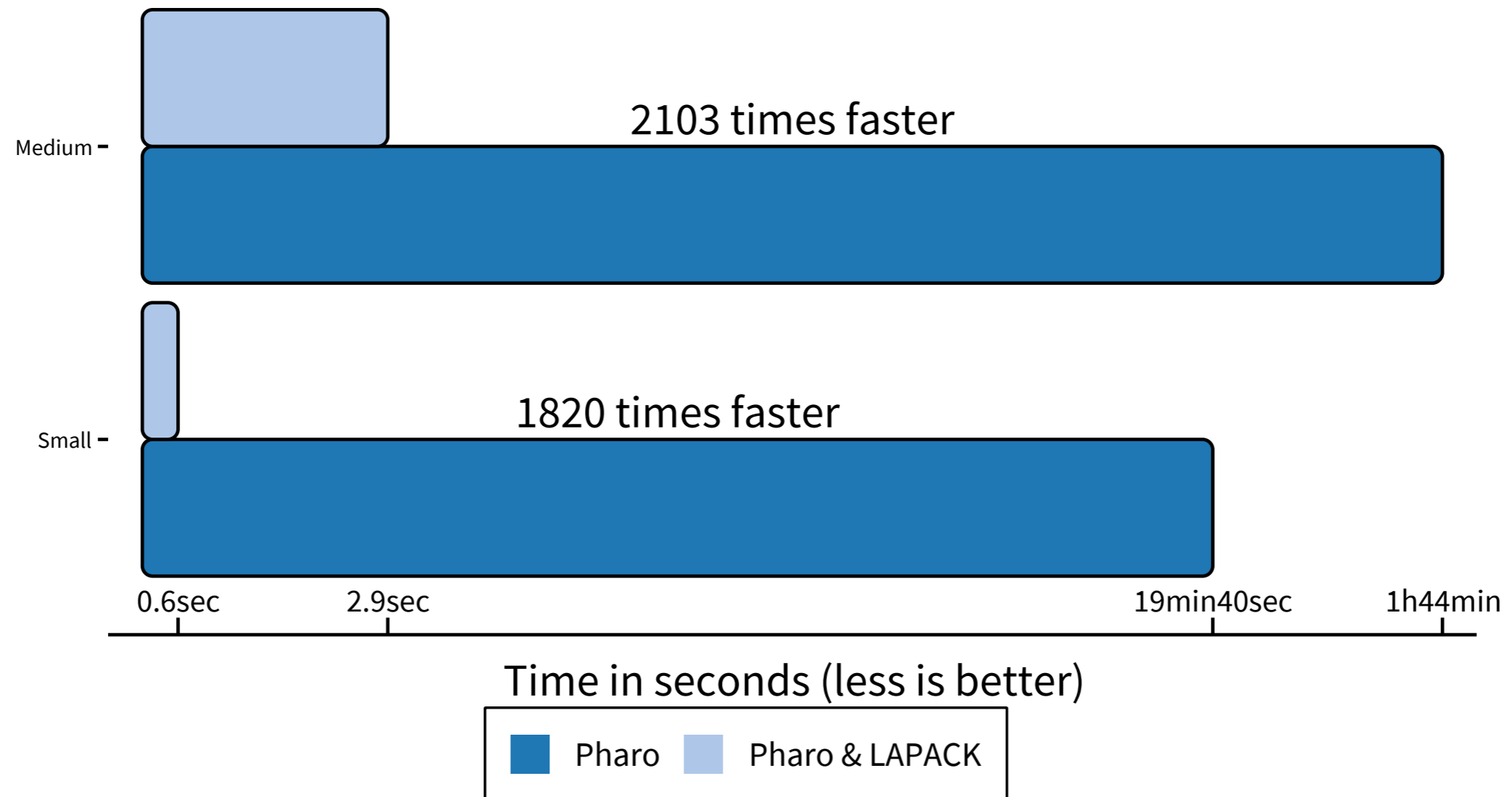


# Goal 2: Making PolyMath Faster



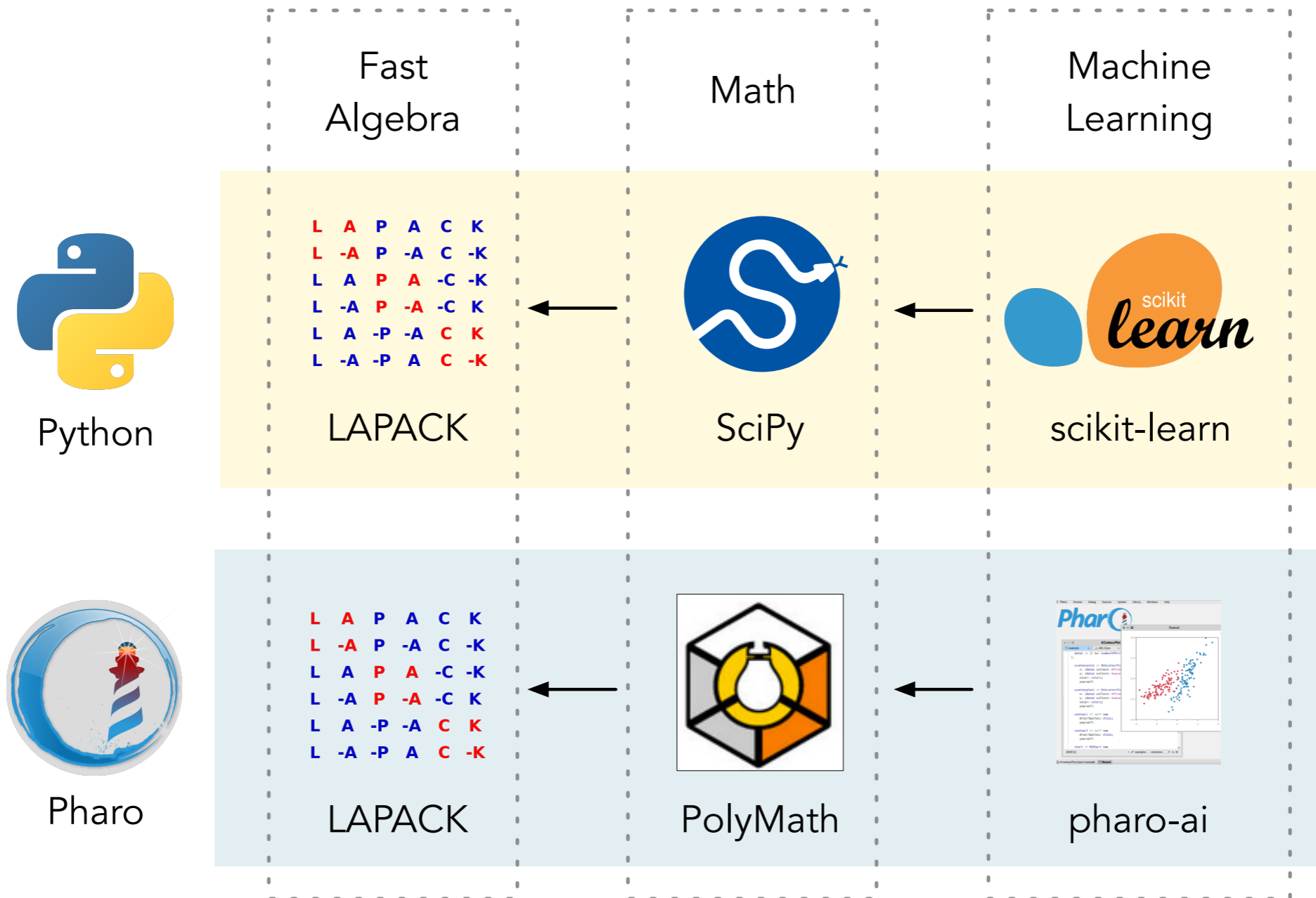
Help

## Pure Pharo vs Pharo & LAPACK





# Goal 3: More Integration with pharo-ai



# Goal 4: Document Using Microdown



Pharo Tools System Debugging Windows Help

BaselineOfMicrodown  
Microdown  
Microdown-Calypso  
Microdown-Pillar  
Microdown-Pillar-Tests  
Microdown-RichTextComposer  
Microdown-Tests

MicMathBlock  
MicMathDelimiter  
MicMathInlineBlock

instance side

All Packages Scoped View Flat Hier. Inst. side Class side Methods Vars Class refs.

Comment MicMathInlineB Inst. side methc

$V_i = C_0 - C_3$

Example 2

Code: `$a^2 + b^2 = c^2$`

$a^2 + b^2 = c^2$

Example 3

Code: `$$\sin(x) = \sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)!}$$`

$\sin(x) = \sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)!}$

Example 4

Code: `$f(a) = \frac{1}{2\pi i} \oint_{\gamma} \frac{f(z)}{z - a} dz$`

$f(a) = \frac{1}{2\pi i} \oint_{\gamma} \frac{f(z)}{z - a} dz$

Syntax Help  Toggle Edit

MicMathInlineBlock



# Goal 4: Document Using Microdown



The screenshot shows the Pharo IDE interface. The top menu bar includes Pharo, Tools, System, Debugging, Windows, and Help. The Pharo logo is visible in the top left. The main window is titled 'APriori' and displays a class browser on the left with a tree view containing folders like 'APriori-Tests' and 'BaselineOfAPriori', and classes like 'APrioriAssociationRule', 'APrioriBrowser', 'APrioriCandidateGenerator', 'APrioriFrequentItemsetsSele...', 'APrioriItemset', 'APrioriItemsetCounter', 'APrioriMetric', and 'APrioriConfidenceMetric'. The right pane shows the 'instance side' of the 'as yet unclassified' method, listing methods such as 'allAssociationRulesFromItemset:', 'associationRuleMetrics', 'associationRules', 'buildAssociationRules', 'calculateAssociationRuleMetrics:', 'calculateItemsetMetrics:', 'findFrequentItemsets', 'frequentItemsets', 'frequentItemsets:', and 'initializeTransactions:'. Below the browser, there are view options: 'All Packages', 'Scoped View', 'Flat', 'Hier.', 'Inst. side', 'Class side', 'Methods', 'Vars', and 'Class refs.'. The bottom pane shows a documentation window for the 'as yet unclassified' method, containing the following text:

algorithm, and then decode the results before presenting them to the user. But encoding is optional and in this example, we process items as strings to make it more clear what is going on.

Turns out, this is not an easy thing to do.

### Why This is a Complicated Problem?

So far, the problem does not seem complicated: you can find all frequent itemsets in a database of transactions simply by iterating over all possible sets of items and selecting the ones that pass the minimum support threshold:

```
itembase combinations select: [ :itemset |
    itemset support >= minsup ].
```

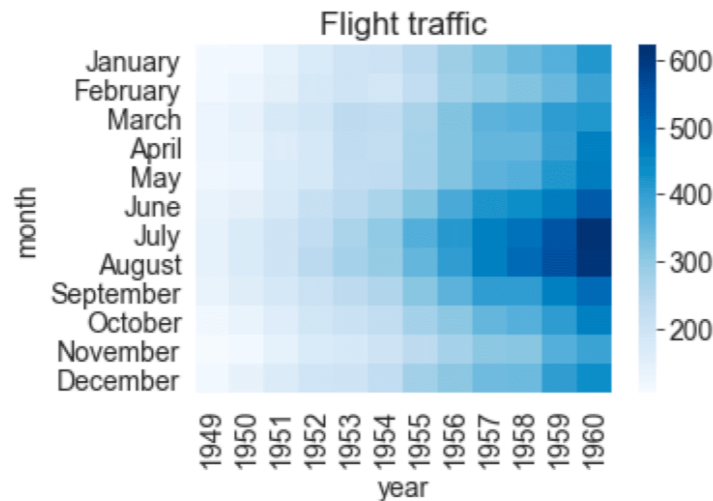
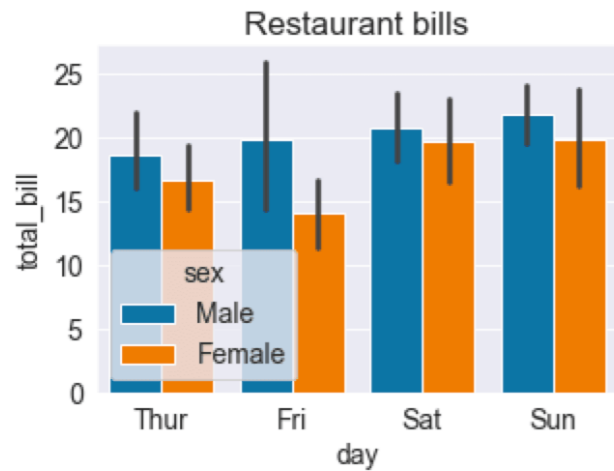
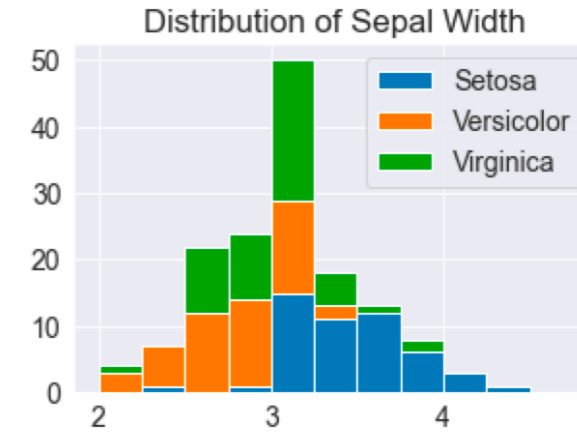
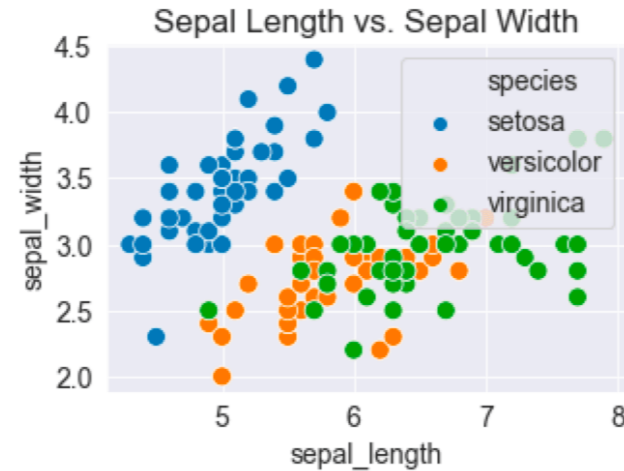
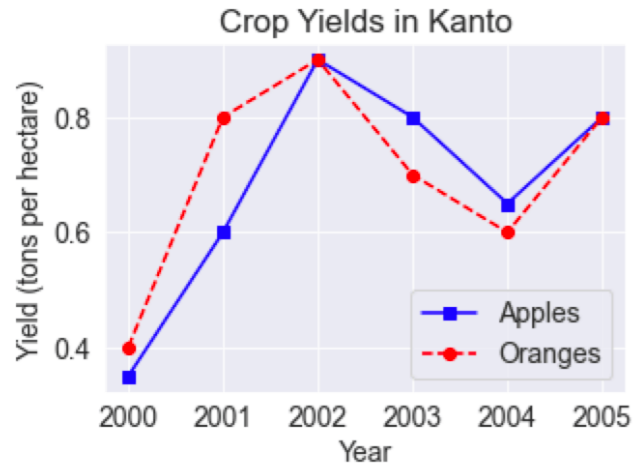
However, the number of possible itemsets grows very quickly as you increase the size of an item base **B**. Note that the collection of all possible subsets of **B** is called *powerset* and denoted  $\mathbb{P}(B)$ :

$$|\mathbb{P}(B)| = \sum_{k=0}^{|B|} C_k^{|B|} = 2^{|B|}$$

Syntax Help  Toggle



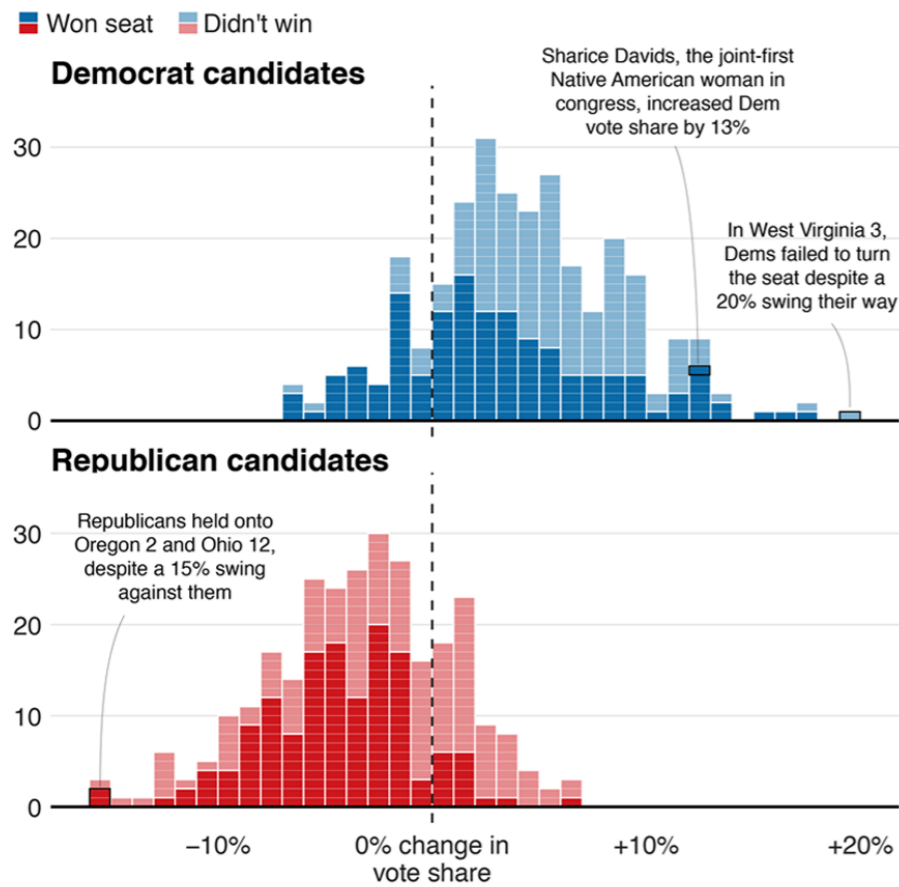
# Goal 5: Roassal Charting



# Goal 5: Roassal Charting



## Blue wave

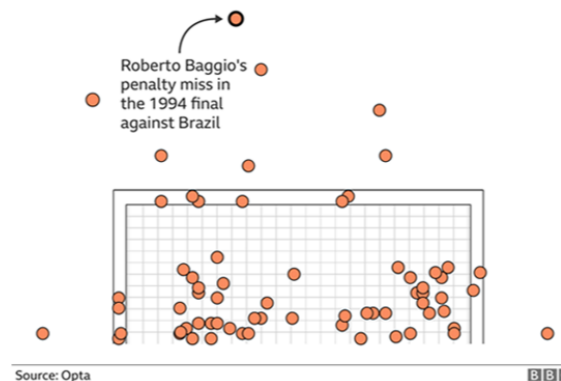


Source: AP, 19:01 ET



## Where penalties are saved

World Cup shootout misses and saves, 1982-2014

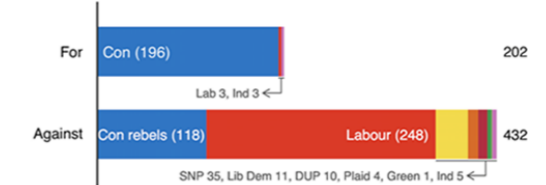


## Fast-growing cities face worse climate risks

Population growth 2018-2035 over climate change vulnerability



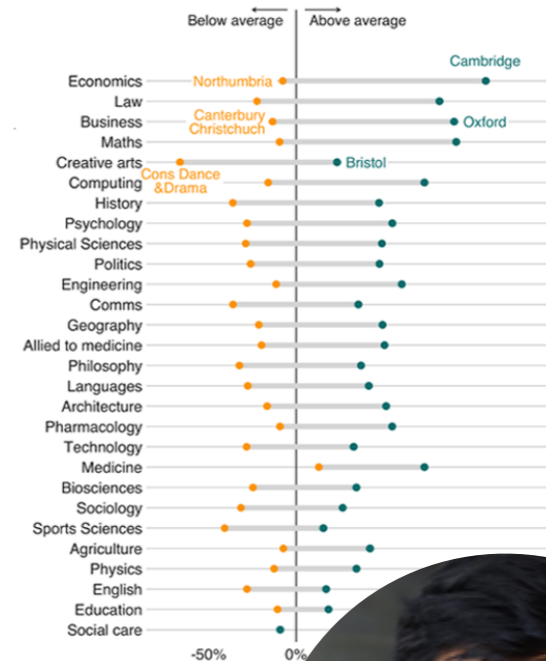
## MPs rejected Theresa May's deal by 230 votes



Source: Commons Votes Services. Excludes 'tellers', the Speaker and deputies

## Earnings vary across unis even within subjects

Impact on men's earnings relative to the average degree



# Goal 6: Notebooks



Jupyter Optical Coherence Tomography-Copy1 Last Checkpoint: Last Sunday at 6:14 PM (autosaved)

File Edit View Insert Cell Kernel Navigate Widgets LaTeX\_envs Help

Code

## Contents

- 1 Optical Coherence Tomography
  - 1.1 Imports, preliminaries, defir
  - 1.2 Imaging system - overview
  - 1.3 OCT Theory - overview
    - 1.3.1 Comments and calcula
      - 1.3.1.1 Resolution "back-of
      - 1.3.1.2 Scan depth "back-of
      - 1.3.1.3 Scaling of coheren
    - 1.3.2 Time Domain OCT (TD
      - 1.3.2.1 Detection-bandwid
      - 1.3.2.2 TDOCT: SNR and
      - 1.3.3 Fourier Domain OCT
        - 1.3.3.1 Impact of finite spe
        - 1.3.3.2 Interlude: Finite sa
        - 1.3.3.3 Impact of finite nur
        - 1.3.3.4 FDOCT: SNR and
      - 1.3.4 Spectral domain/swept
        - 1.3.4.1 SSOCT: SNR and I
    - 1.4 Simulation
    - 1.5 Potential laser sources

### 1.3.3 Fourier Domain OCT (FDOCT)

In FDOCT, the different wavelengths are collected on a spectrometer, with  $N_{pix}$  pixels, and spectral resolution  $\delta_r$ .

Returning again to Eq. (8) (see, e.g., Izatt and Choma (Izatt J.A., Choma M.A. (2008) Theory of Optical Coherence Tomography. In: Drexler W., Fujimoto J.G. (eds) Optical Coherence Tomography. Biological and Medical Physics, Biomedical Engineering. Springer, Berlin, Heidelberg; doi: [https://doi.org/10.1007/978-3-540-77550-8\\_2](https://doi.org/10.1007/978-3-540-77550-8_2); alternate link: [https://www.researchgate.net/publication/226178102\\_Theory\\_of\\_Optical\\_Coherence\\_Tomography/download](https://www.researchgate.net/publication/226178102_Theory_of_Optical_Coherence_Tomography/download));

$$I_D(k) = \frac{Q}{4} S(k) \left[ R_R + \sum_{n=1}^N R_n \right] \quad \text{" DC terms "}$$

$$+ \frac{Q}{2} S(k) \left[ \sum_{n=1}^N \sqrt{R_R R_n} \cos [2k(z_R - z_n)] \right] \quad \text{" Cross - correlation terms "}$$

$$+ \frac{Q}{2} S(k) \left[ \sum_{n \neq m=1}^N \sqrt{R_n R_m} \cos [2k(z_n - z_m)] \right] \quad \text{" Autocorrelation terms "}$$

In the FDOCT configuration,  $z_R$  is held fixed.

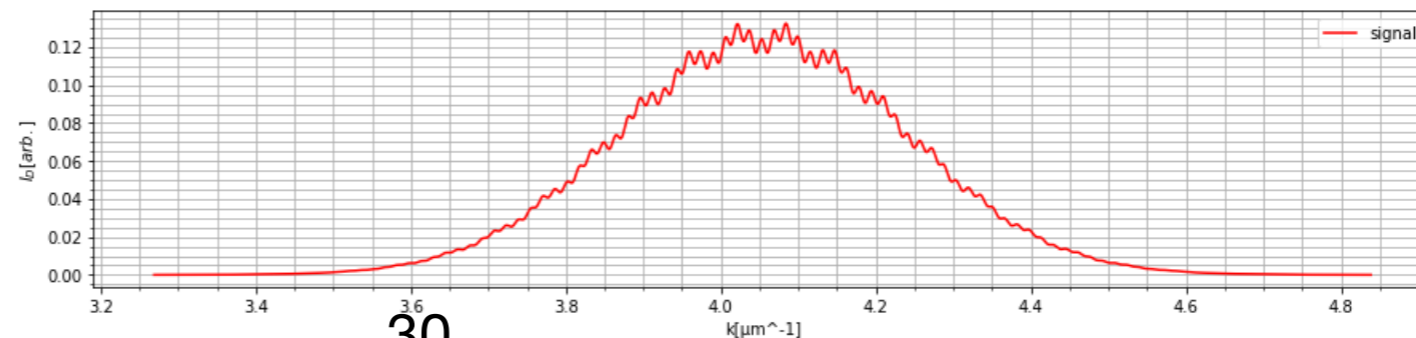
```
In [23]: lambda_0 = 1.5500
k_0 = 2.0*np.pi/lambda_0
Dlambda_0 = 0.100
Dk = 2.0*np.pi*Dlambda_0/lambda_0**2.0

k_range = np.linspace(-3.0*Dk+k_0, +3.0*Dk+k_0, 10000)

TD_OCT_signal = 0.25*0.5*(np.exp(-((k_range - k_0)/Dk)**2.0)) \
+ 0.5*np.sqrt(0.5*2.0E-4)*(np.exp(-((k_range - k_0)/Dk)**2.0)) \
*np.cos(2.0*k_range*(50.0)) \
+ 0.5*np.sqrt(0.5*1.5E-4)*(np.exp(-((k_range - k_0)/Dk)**2.0)) \
*np.cos(2.0*k_range*(200.0))
```

```
In [26]: fig_disp
```

Out[26]:



# Goal 6: Notebooks



jupyter mondrian Last Checkpoint: 04/06/2018 (autosaved)

File Edit View Insert Cell Kernel Widgets Help Trusted | Pharo Smalltalk

### Example 1. Mondrian interactive drawing

This first example creates a new RTMondrian diagram. Note that the variables are:

```
In [1]: self loadScript: IPRoassal js
```

```
Out[1]:
```

```
In [2]: b := RTMondrian new.
b nodes: (1 to: 300).
b edges connectFrom: [ :value | value // 2 ].
b shape
  —bezierLineFollowing: [ :value | value // 2 ];
  —color: Color blue trans.
b edges
  —notUseInLayout;
  —connectTo: [ :value | (value / 10) asInteger + (value // 10) ];
b layout cluster.
```

```
Out[2]:
```

```
In [3]: self display
         interactionOn;
         openInJupyter: b extent: 640@640
```

```
Out[3]:
```

jupyter polymath Last Checkpoint: a minute ago (unsaved changes)

File Edit View Insert Cell Kernel Widgets Help Trusted

### Installing PolyMath

PolyMath is the new name of SciSmalltalk. All the code and documentation will be moved here soon.

```
In [1]: Metacello new
        repository: 'http://smalltalkhub.com/mc/PolyMath/PolyMath/main';
        configuration: 'PolyMath';
        version: '0.98';
        silently;
        load
```

Install DataFrame

```
In [2]: Metacello new
        baseline: 'DataFrame';
        repository: 'github://PolyMathOrg/DataFrame';
        load.
```

Save the sessions to keep the changes

```
In [ ]: Smalltalk saveSession
```

Let's restart the kernel pushing "stop" button

```
In [1]: df := DataFrame fromRows: #(
        ('city' 'coll' 'col2')
        ('Barcelona' 1.609 true)
        ('Dubai' 2.789 true)
        ('London' 8.788 false)).
```





[ PolyMath ]

Part 3:  
How to  
support us



# Contribute!



PolyMathOrg / PolyMath Public

Sponsor Edit Pins Unwatch 19 Fork 39 Starred 16

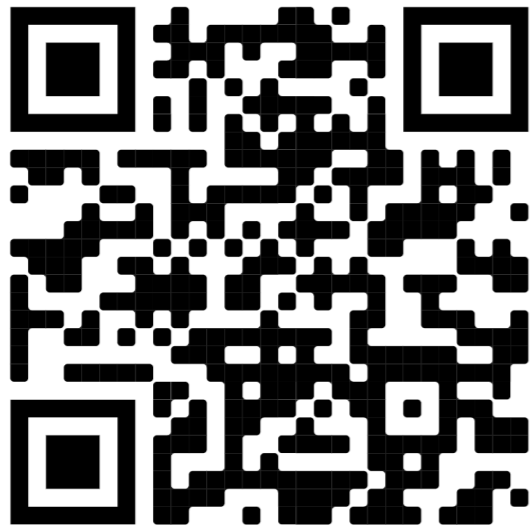
<> Code Issues 55 Pull requests 1 Discussions Actions Projects Wiki Security Insights

Filters is:issue is:open Labels 19 Milestones 2 New issue

55 Open ✓ 90 Closed Author Label Projects Milestones Assignee Sort


- Some tests are failing randomly from time to time** Priority: Medium Type: Bug #279 opened on 5 May by olekscode 6
- Move all methods and tests related to complex numbers from PMMatrix and PMVector into Math-Complex package** Priority: Low Refactoring Type: Maintenance #275 opened on 4 May by olekscode 1
- Implement Moore-Penrose pseudoinverse for PMMatrix** Priority: Medium Type: Enhancement #260 opened on 26 Apr by olekscode 2
- Some SVD tests are failing** Priority: Medium Type: Bug #259 opened on 26 Apr by olekscode
- More robust implementation of PMComplex >> sqrt** Priority: Low Type: Enhancement #257 opened on 24 Apr by olekscode 3
- Deprecated method in PMGeneralFunctionFit>>#evaluate** #234 opened on 7 Apr by SergeStinckwich
- PMImplicitSystem>>jacobianAtX:t: should be implemented** #230 opened on 18 Feb by SergeStinckwich
- Use the data-inspector to browse data frames?** Type: Enhancement #225 opened on 29 Nov 2021 by hernanmd 1

# Sponsor our work



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SergeStinckwich  
Macau


Hi there! I'm Serge, I'm a computer scientist and a Smalltalk developer.


Your sponsorship will support my development of [PolyMath](#), a computational science library for Pharo and the [PolyMath book](#), I'm currently writing.

If you would like to support my Open Source work, consider joining me as a sponsor! Anything helps. The more I get from sponsorships the more I can actively contribute in the community.  
Thank you

Featured work

-  **PolyMathOrg/PolyMath**  
Scientific Computing with Pharo  
Smalltalk ☆ 160
-  **PolyMathOrg/libtensorflow-pharo-bindings**  
TensorFlow library bindings for Pharo  
Smalltalk ☆ 31
-  **SquareBracketAssociates/PolyMath-book**  
PolyMath - An Introduction to numerical computing with Pharo  
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