



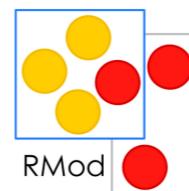
[PolyMath]

version 1.0 → v2.0

Oleksandr Zaitsev, Sebastian Jordan Montaño,
Serge Stinckwich, Hemal Varambhia, etc.

arolla

Inria



Université
de Lille



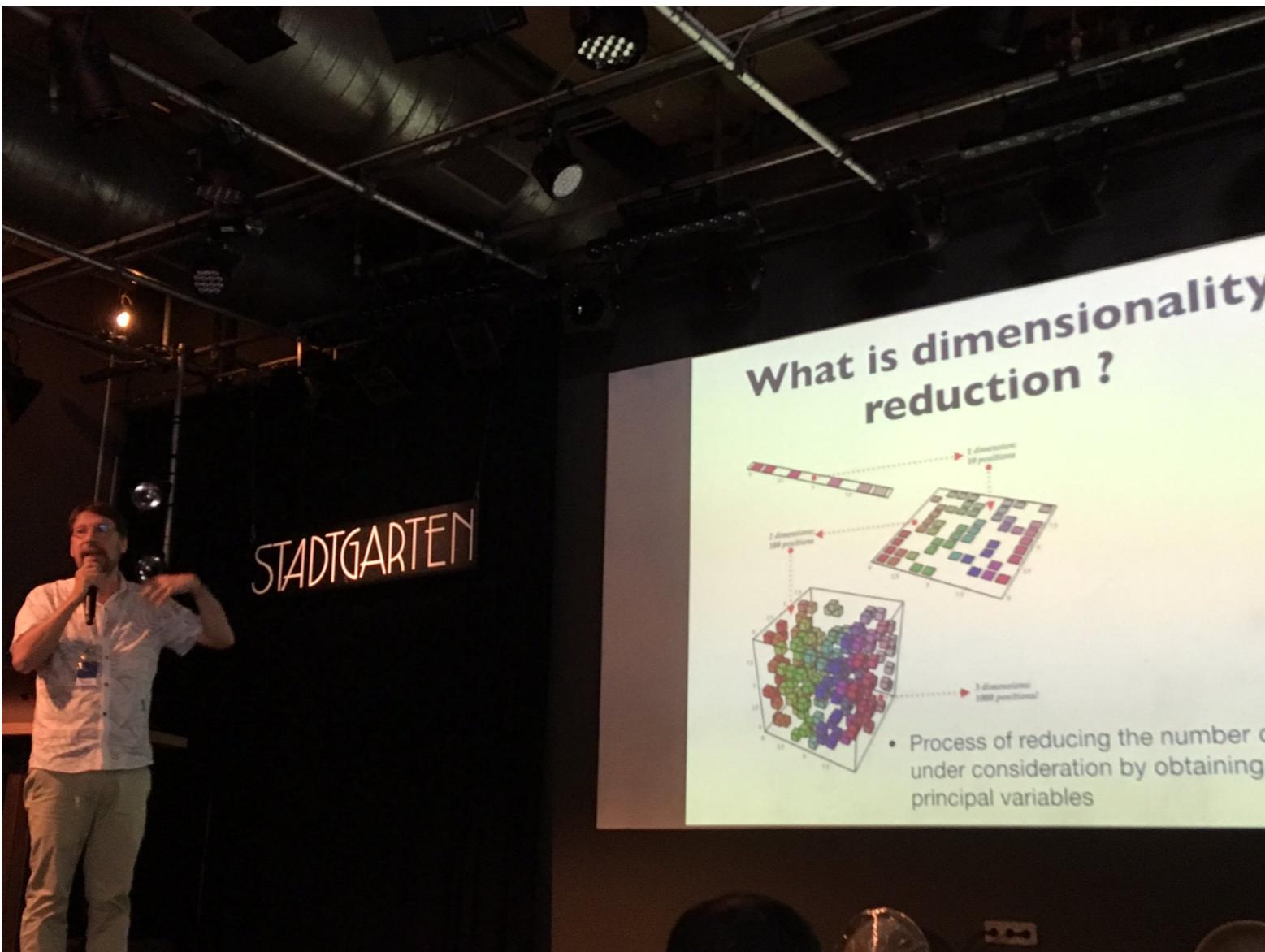
In a nutshell:

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



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



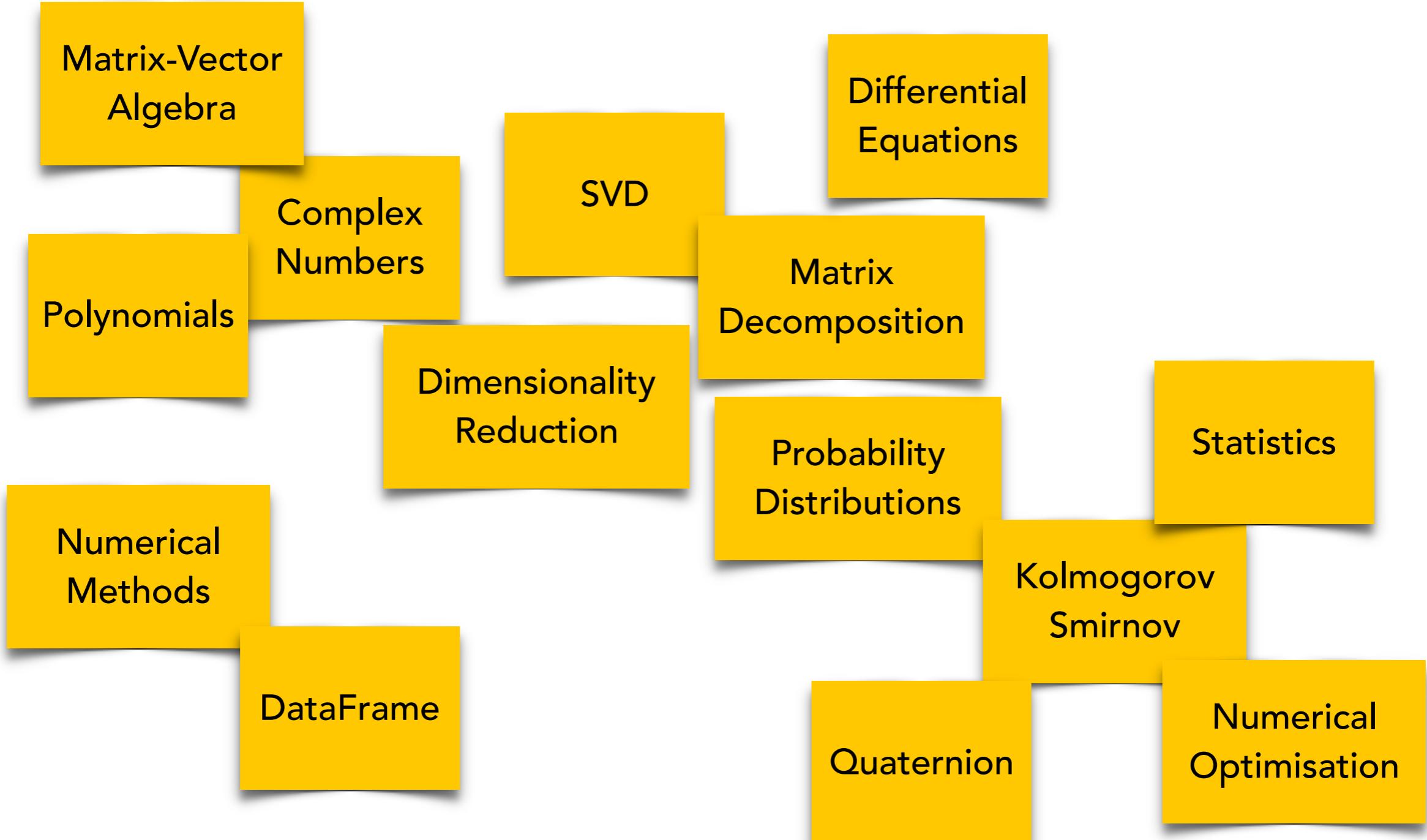
Sebastian
Jordan Montaño



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

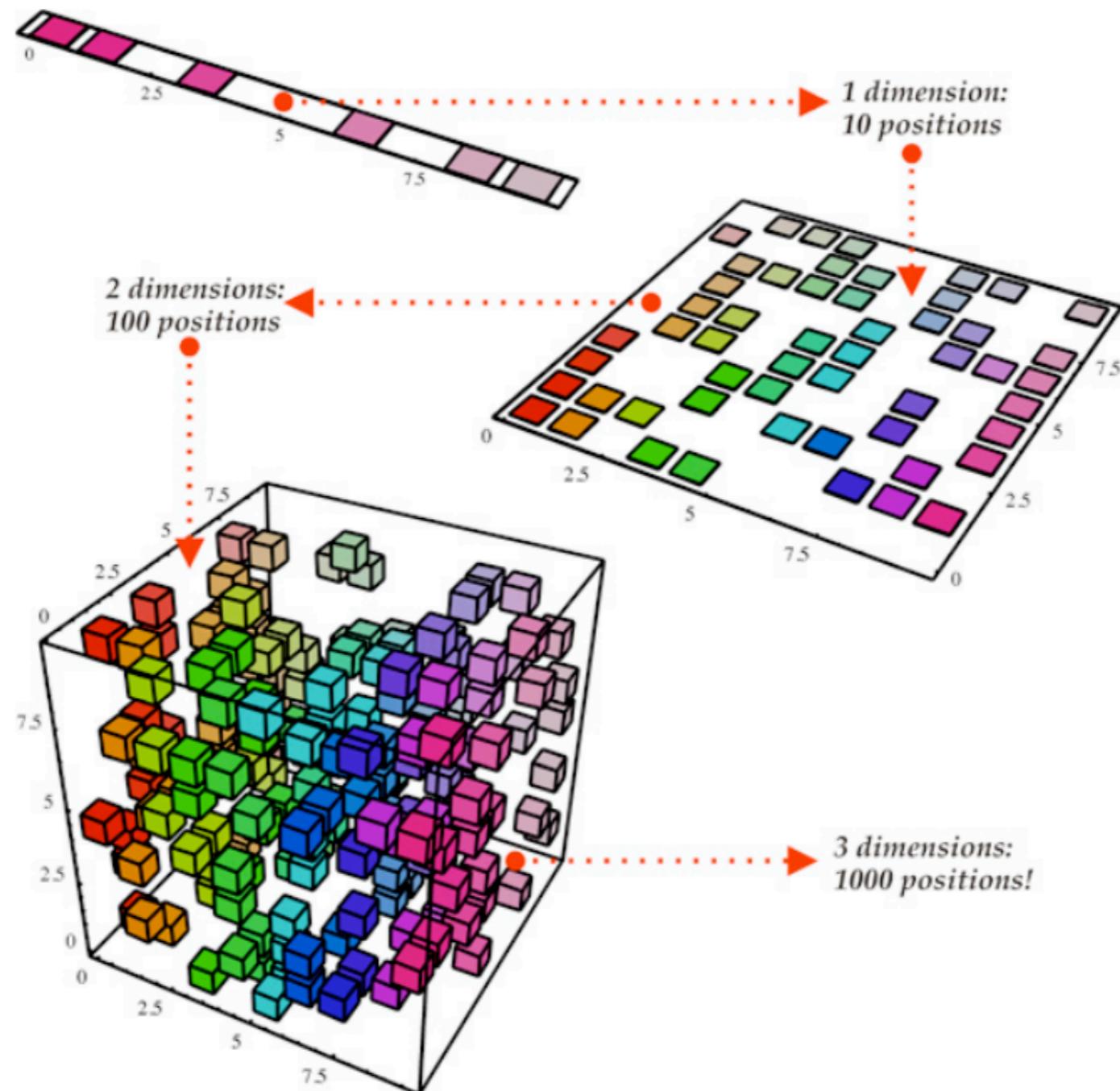
$$\begin{pmatrix} x_{11} & \dots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \dots & x_{mn} \end{pmatrix}$$

Matrix

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

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

Dimensionality Reduction with PCA

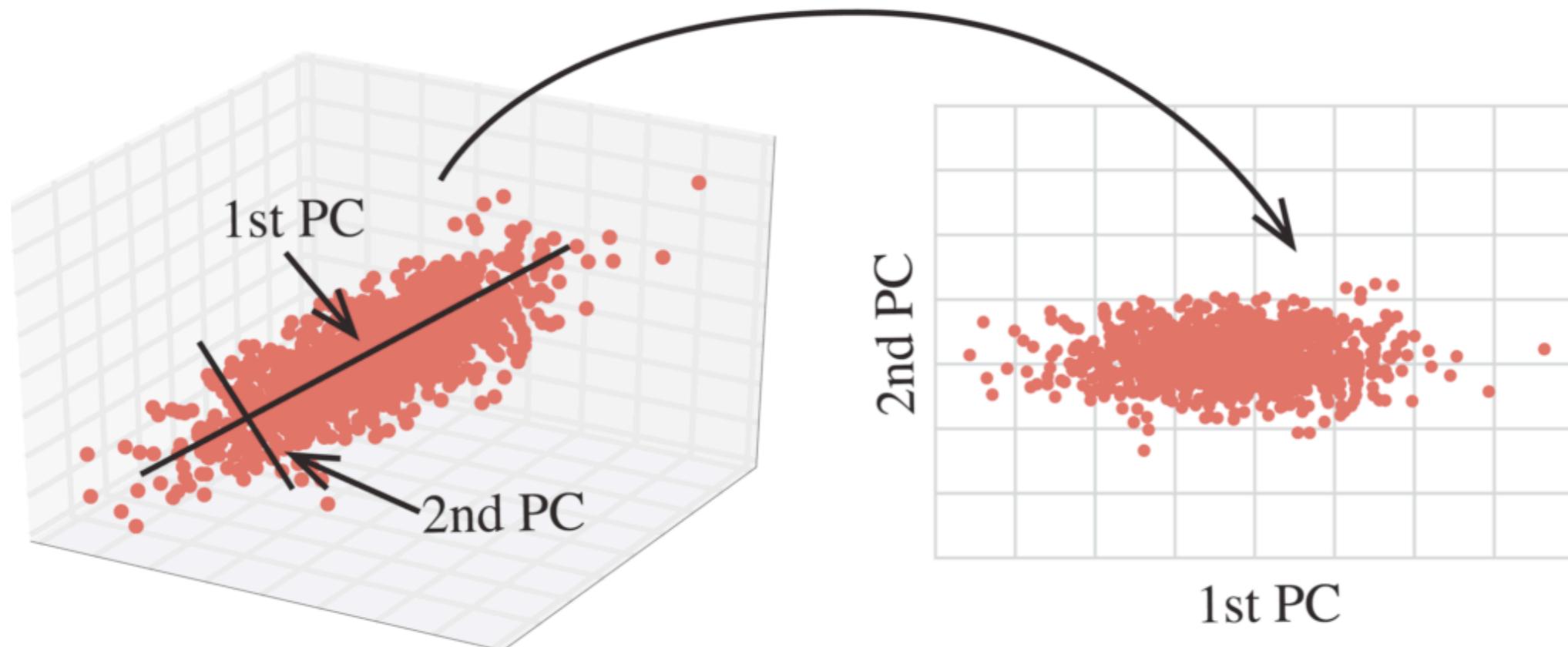


Dimensionality Reduction with PCA



- 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.

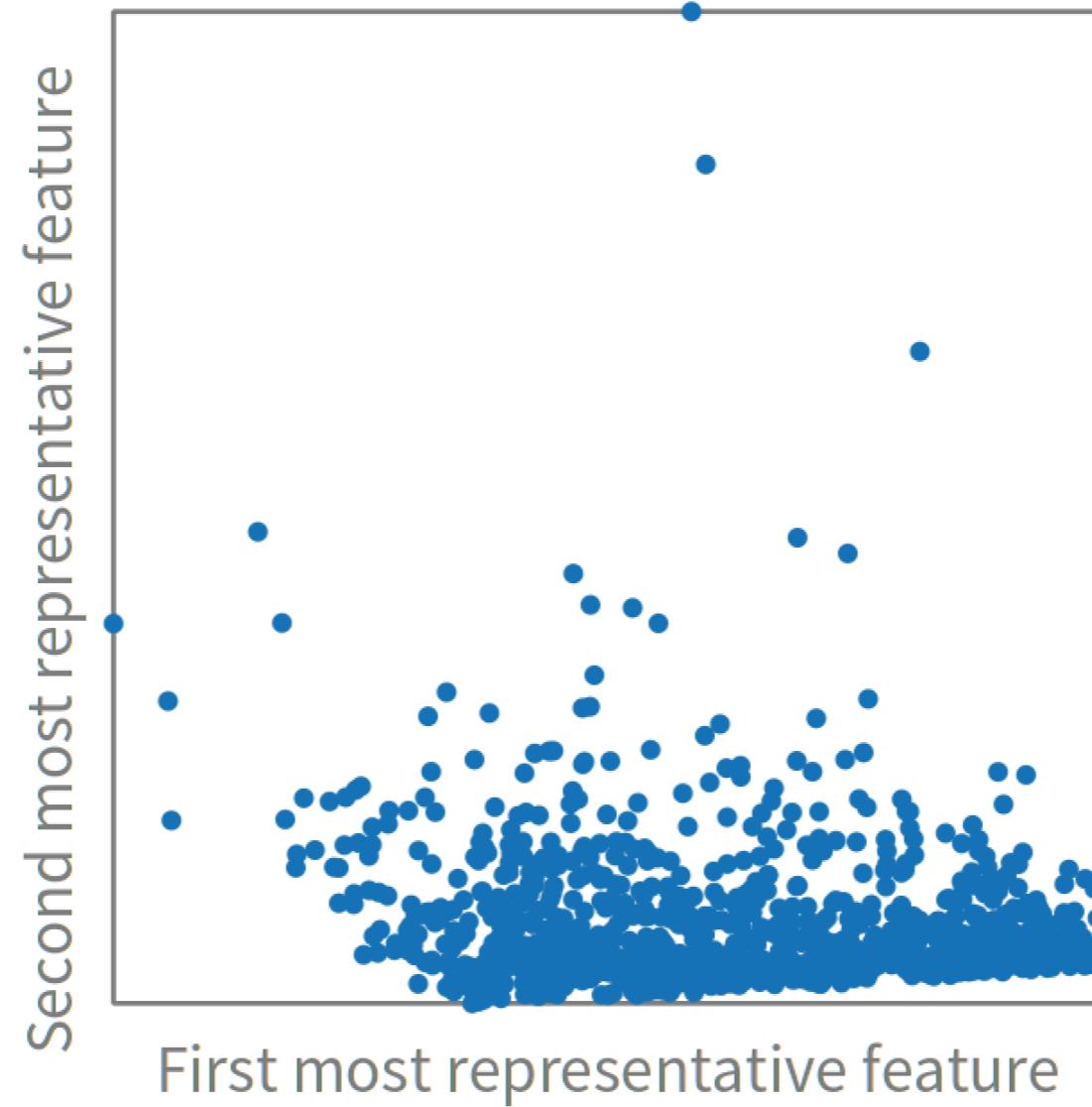
"Transform the matrix"
principalComponents := pca transform: polyMathMatrix.
"Get the principal components"
firstPrincipalComponent := principalComponents rows collect: [ :each | each first].
secondPrincipalComponent := principalComponents rows collect: [ :each | each second].
```

Dimensionality Reduction with PCA



Visualised
with Roassal3


Principal components of the data



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



x - □ 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 DataFrame [150 items] (a ...)

DataFrame Data Description Visualizations Raw Breakpoints Meta

	+ sepal length (cm)	+ sepal width (cm)	+ petal length (cm)	+ petal width (cm)	+ species
1	5.1	3.5	1.4	0.2	setosa
2	4.9	3.0	1.4	0.2	setosa
3	4.7	3.2	1.3	0.2	setosa
4	4.6	3.1	1.5	0.2	setosa
5	5.0	3.6	1.4	0.2	setosa
6	5.4	3.9	1.7000000000000002	0.4	setosa
7	4.6	3.4	1.4	0.3000000000000004	setosa
8	5.0	3.4	1.5	0.2	setosa
9	4.4	2.9	1.4	0.2	setosa
10	4.9	3.1	1.5	0.1	setosa
11	5.4	3.7	1.5	0.2	setosa
12	4.8	3.4	1.6	0.2	setosa
13	4.8	3.0	1.4	0.1	setosa
14	4.3	3.0	1.1	0.1	setosa
15	5.8	4.0	1.2	0.2	setosa
16	5.7	4.4	1.5	0.4	setosa
17	5.4	3.9	1.3	0.4	setosa

Statistic	+ sepal length (cm)	+ sepal width (cm)	+ petal length (cm)	+ petal width (cm)	+ species	Property	+ Value
1st Quartile	5.10	2.80	1.60	0.30	NaN	Dimensions	(150@5)
3rd Quartile	6.40	3.30	5.10	1.80	NaN	Has categorical	true
Median	5.80	3.00	4.35	1.30	NaN	Has nil	false
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		

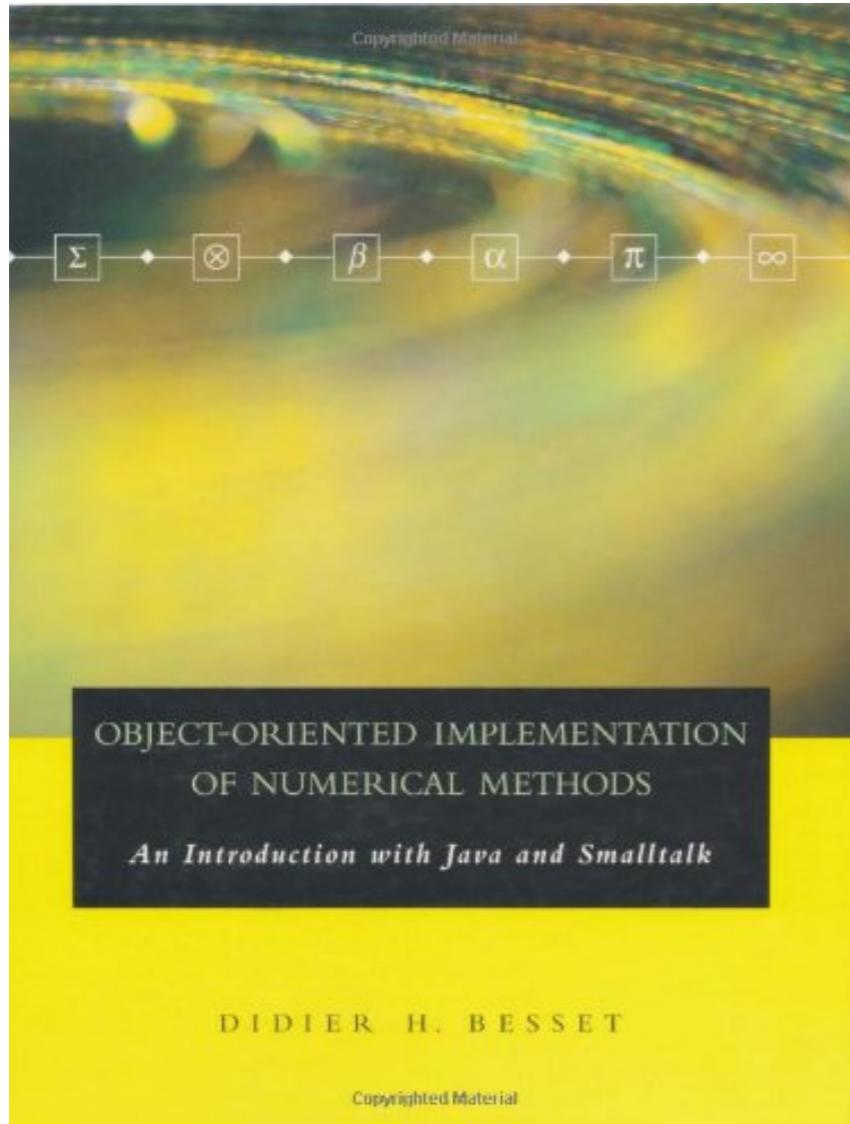
Do it.

```
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



PolyMath Book



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



Part 2:
The future

Goal 1: Decoupling Packages



Moose Panel

Models checkstyle-5.5 output

checkstyle-5.5 (MooseModel)

All model classes (1011) (FAMIXClassGroup)

a RTMondrian (RTMondrian)

RTMondrian visualization showing a complex network of connections between model classes.

Code snippet:

```
b := RTMondrian new.  
b nodes: self.  
b edges connectFrom: #superclass.  
b layout cluster.  
b shape  
bezierLineFollowing: #superclass;  
color: Color blue.  
b edges  
notUseInLayout;  
connectToAll: [ :cls | cls  
queryAllOutgoingInvocations atTypeScope ].  
b
```

Checkstyle-5.5 Model Structure:

- All accesses - All famixaccesses (5921)
- All annotation instances - All famixannotationinstances (73)
- All annotation types - All famixannotationtypes (43)
- All attributes - All famixattributes (1524)
- All caught exceptions - All famixcaughtexceptions (230)
- All classes - All famixclasses (1474)
- All comments - All famixcomments (3172)
- All declared exceptions - All famixdeclaredexceptions (811)
- All enum values - All famixenumvalues (140)
- All enums - All famixenums (59)
- All implicit variables - All famiximplicitvariables (564)
- All inheritances - All famixinheritances (1614)
- All invocations - All famixinvocations (11511)
- All local variables - All famixlocalvariables (2868)
- All methods - All famixmethods (4824)
- All model classes - All model classes (1011)

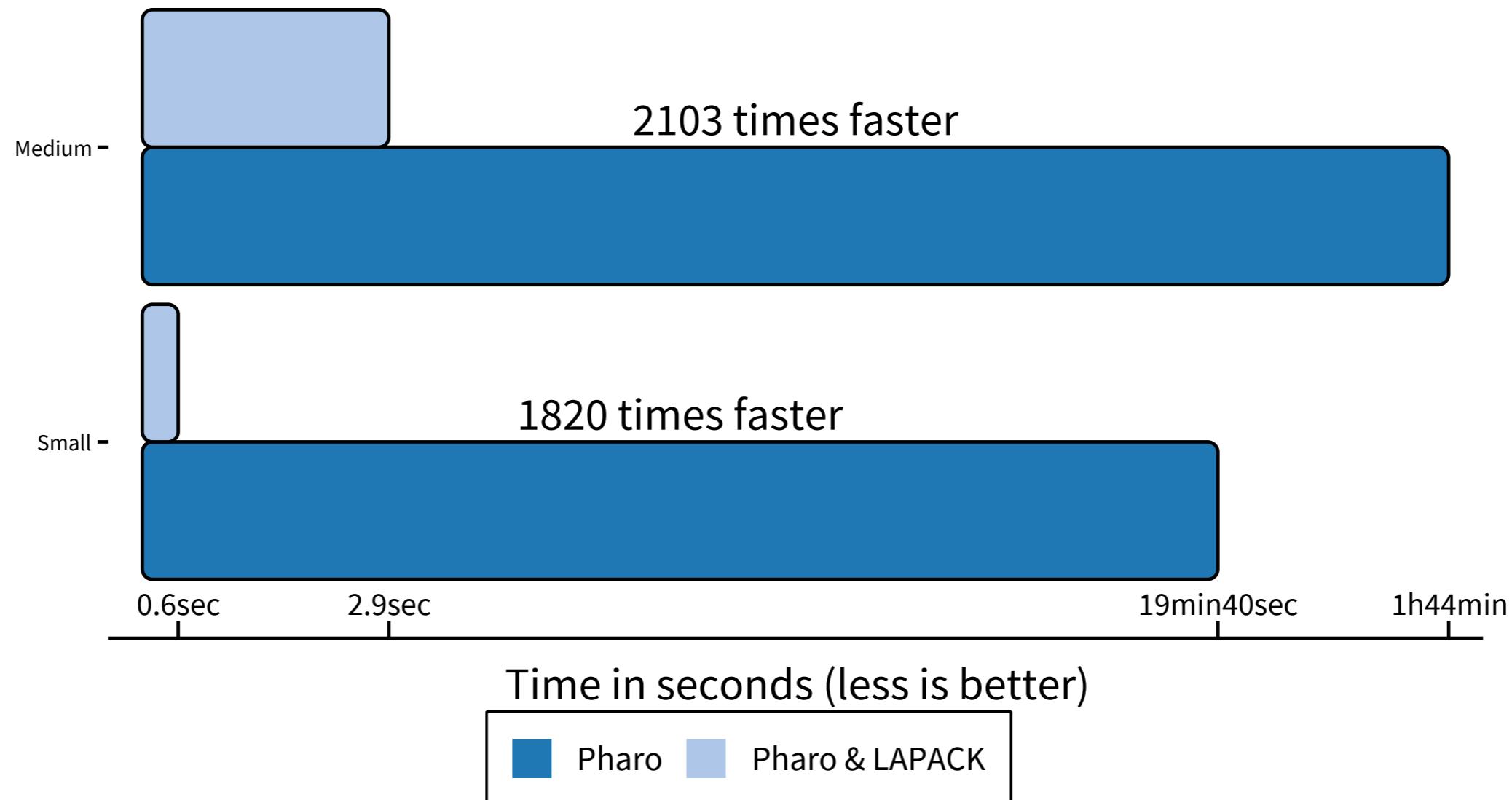


Goal 2: Making PolyMath Faster

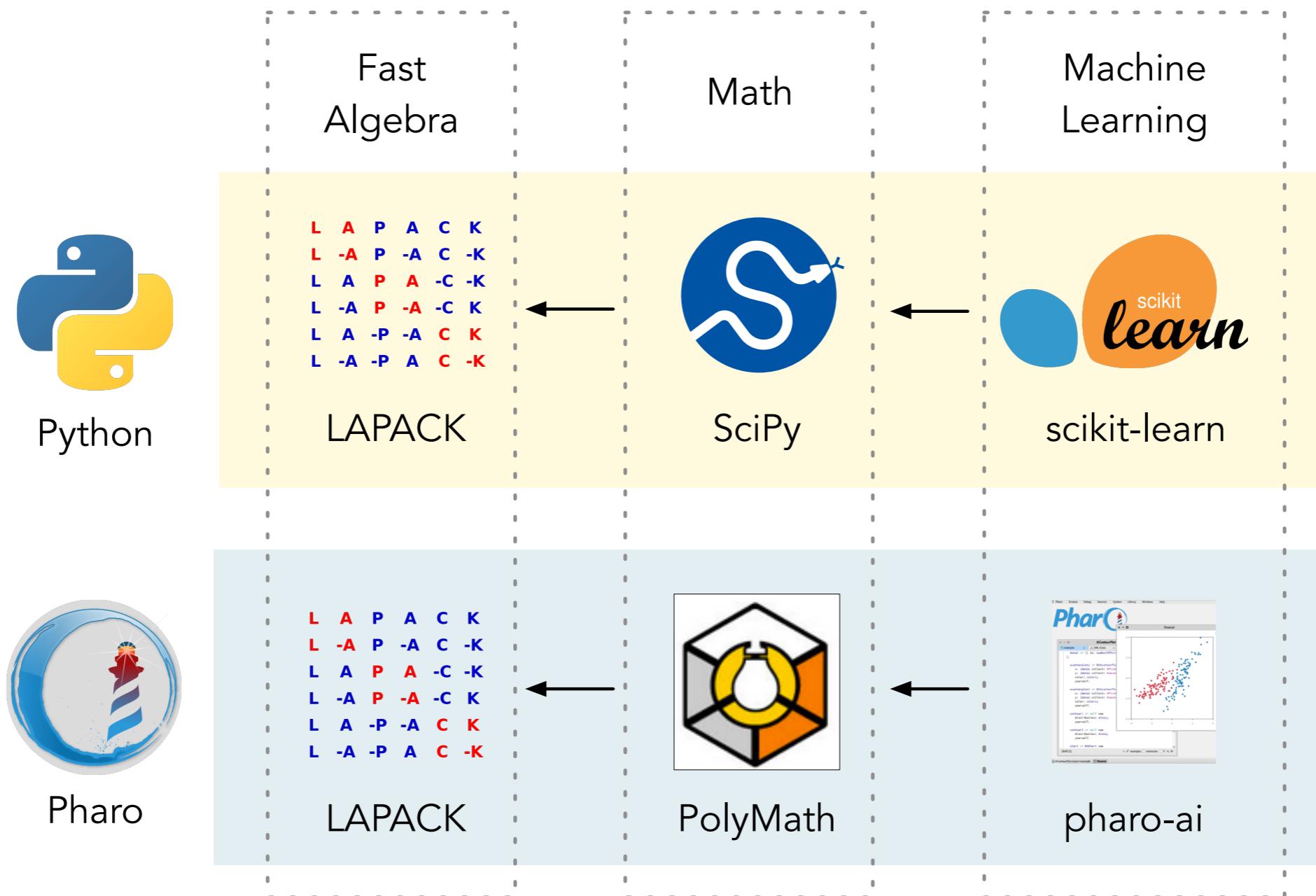


Help

Pure Pharo vs Pharo & LAPACK



Goal 3: More Integration with pharo-ai



Goal 4: Document Using Microdown



Pharo Tools System Debugging Windows Help

MicMathInlineBlock

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

Micro Math

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

? Comment x MicMathInlineB x + Inst. side methc x

$V_i = C_0 - C_3$

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



Pharo Tools System Debugging Windows Help

APriori

APriori

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

Comment APriori Inst. side methc

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 ].
```

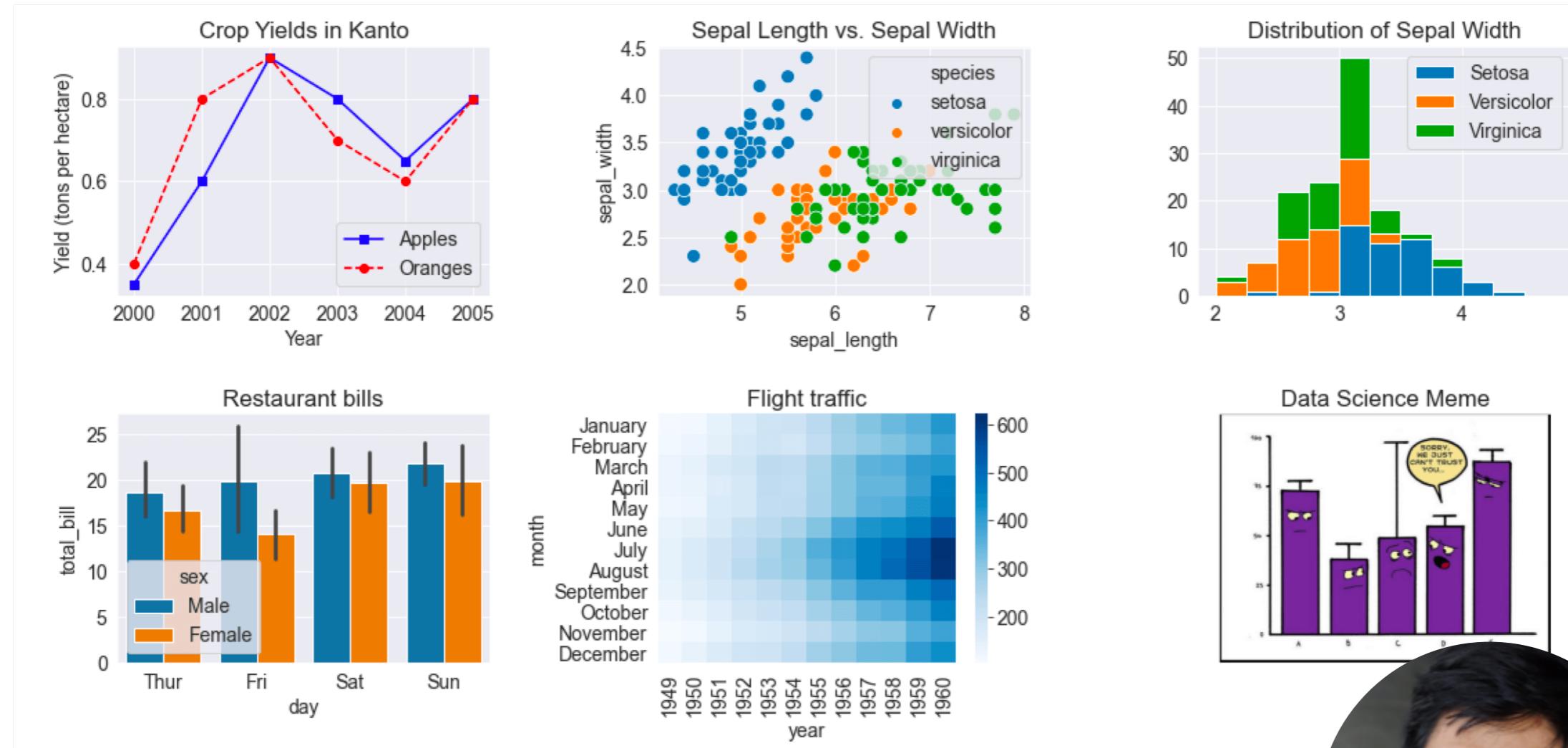
However, the number of possible itemsets grows very quickly as you increase the size of an item base **B**. Note that the collection of all possible subsets of **B** is called powerset and denoted $\mathbb{P}(B)$:

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

Syntax Help Toggle



Goal 5: Roassal Charting



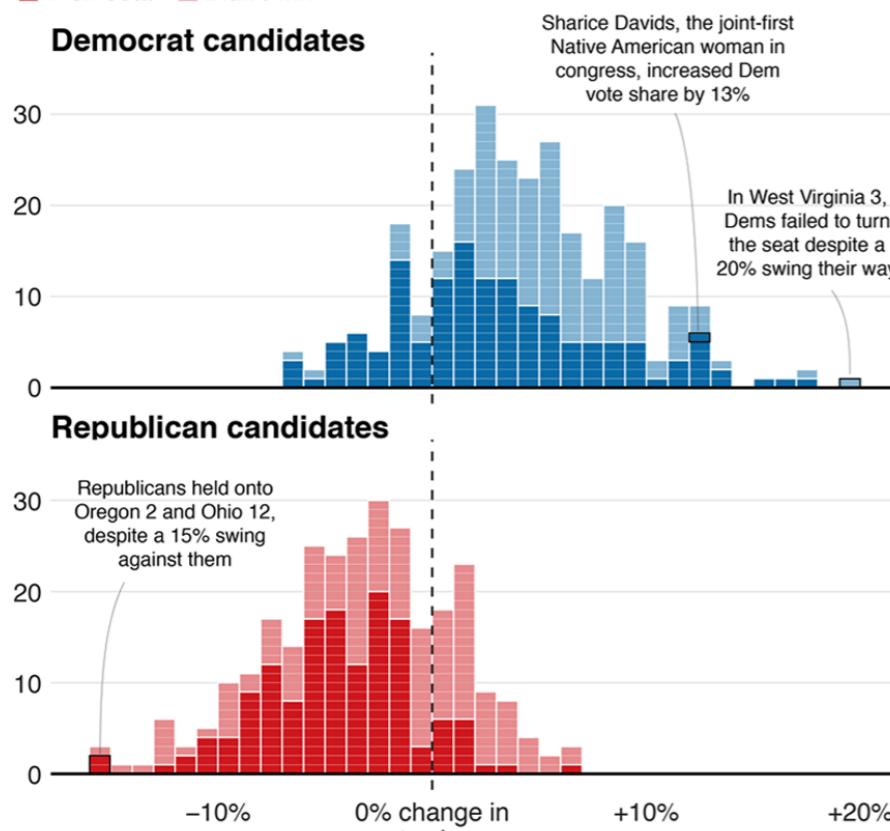
Goal 5: Roassal Charting



Blue wave

■ Won seat ■ Didn't win

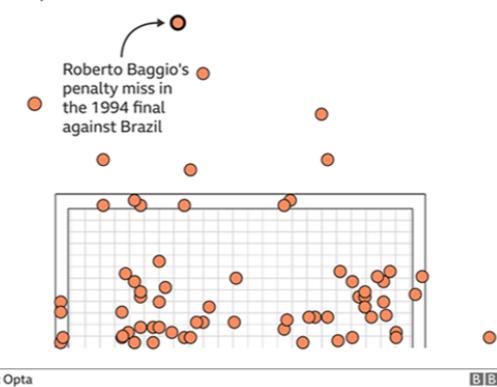
Democrat candidates



Republican candidates

Where penalties are saved

World Cup shootout misses and saves, 1982-2014

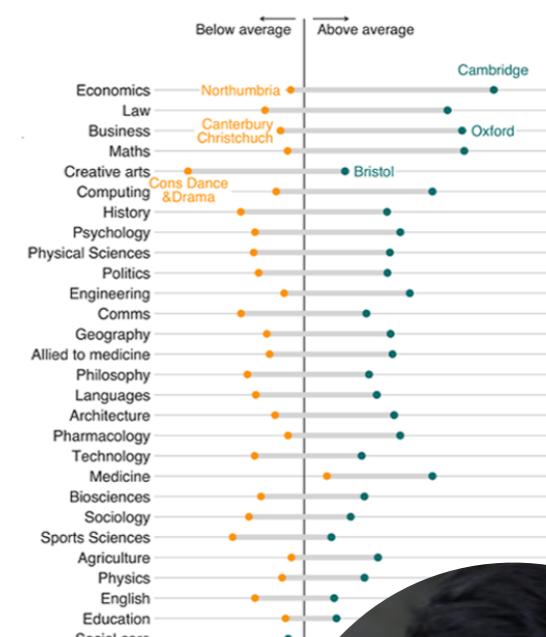


MPs rejected Theresa May's deal by 230 votes



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

Contents ↗

- 1 Optical Coherence Tomography
 - 1.1 Imports, preliminaries, defin
 - 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-
 - 1.3.1.3 Scaling of coherent
 - 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 (FDOCT)
 - 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 δ_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; alternate link: 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]:

30

Goal 6: Notebooks



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

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

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 // 2) ].  
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)) .





Part 3:
How to
support us

Contribute!



Screenshot of the PolyMath GitHub repository issues page.

PolyMathOrg / PolyMath Public

Issues 55

Filters: `is:issue is:open`

55 Open 90 Closed

Issue	Author	Labels	Comments
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



[https://github.com/
sponsors/SergeStinckwich](https://github.com/sponsors/SergeStinckwich)

Become a sponsor to **Serge Stinckwich**

 **Serge Stinckwich**
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
TeX ⭐ 72

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Bronze supporter 

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- You will be listed as a sponsor on one of my GitHub project you want to support