Simulation, données, information, connaissance et prise de décision : configurant la 4ème révolution industrielle

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I’m an engineer

luck or disgrace?

Scientists discover the world
that exists, engineers
create the world that never was

Theodore von Karman

« Pour ce qui est de l'avenir, il ne s'agit pas de le prévoir, mais de le rendre possible. »

- Antoine de Saint-Exupéry

Arguments against new ideas generally pass through distinct stages from:

"It's not true" to
"Well it's true but not important" to
"It's true and it's important, but it's not new – we knew it all along"

From *The Artful Universe*
by John D. Barron

Predicting should precede creating!

But, how predicting the behavior of something that never was?

Many options …

The best way to predict the future is invent it

Alan Curtis Kay

It rarely works …

10/02/2015

20 minutes

Société

Voyance: Dans les boules de cristal se reflètent les inquiétudes des Français

SOCIETE Je vois... La crise économique, le chômage, la peur de l'avenir...

Tarot reading

a particular state of mind is required!

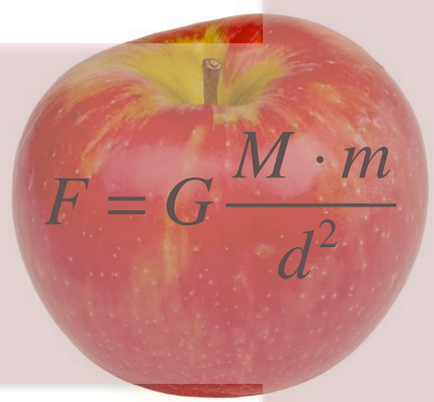
The scientific approach

Example:
Astronomy

First was the data - Babylonian astronomy -

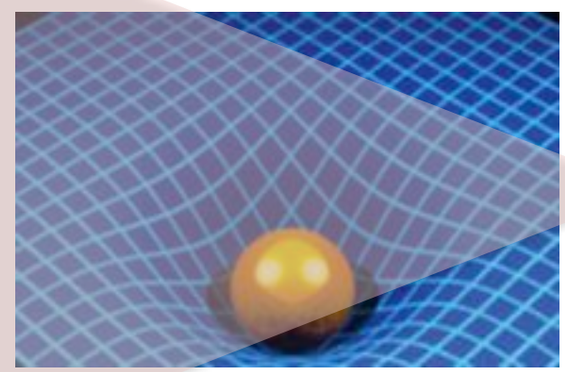
then were the model**s**

Almageste from
Claudius Ptolemy



$$F = G\frac{M \cdot m}{d^2}$$

Newton



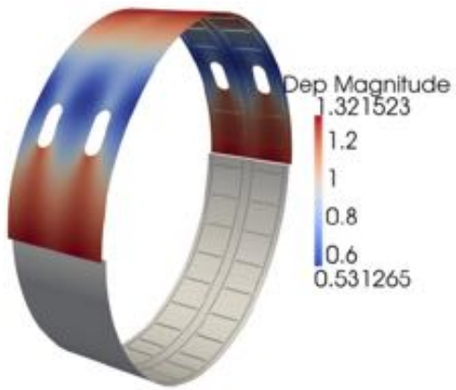
Einstein

All models are wrong but some are useful

George Box

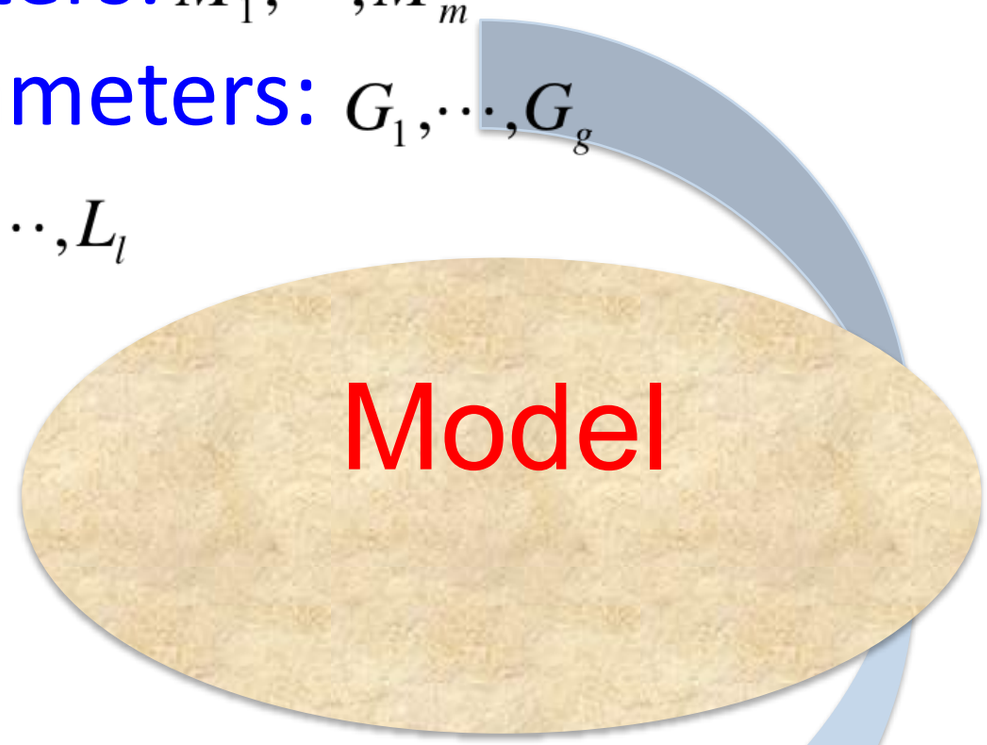
Numerical simulation
based on models

✓ Present



✓ Future

- Material parameters: $M_1, \cdots, M_m$
- Geometrical parameters: $G_1, \cdots, G_g$
- Applied loads: $L_1, \cdots, L_l$



$$U(\mathbf{x}, t; M_1, \cdots, M_m, G_1, \cdots, G_g, L_1, \cdots, L_l)$$

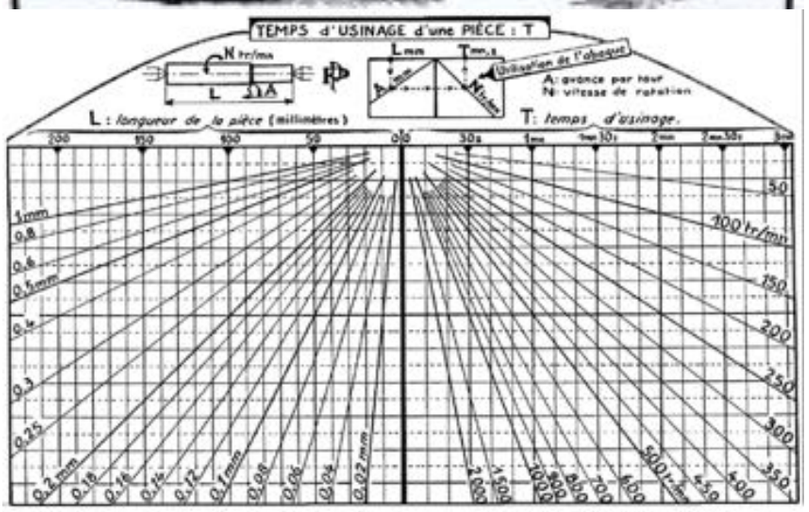
ISSUE

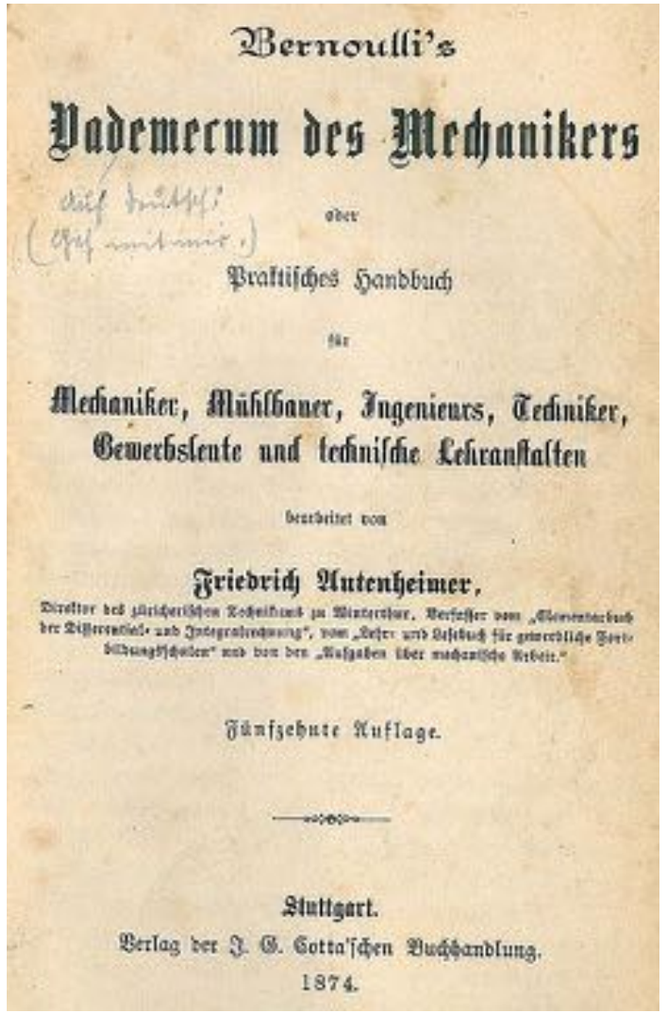
Combinatorial explosion

Solution for each choice of parameters

10 parameters
10 values / parameter =
10^{10} possibilities !!

When all “possible” solutions have been pre-calculated !!





Bernoulli's

Vademecum des Mechanikers

oder

Praktisches Handbuch

für

Mechaniker, Mühlbauer, Ingenieurs, Techniker, Gewerbsleute und technische Lehranstalten

bearbeitet von

Friedrich Autenheimer,

Direktor des zürcherischen Rechenbuch zu Winterthur, Verfasser vom „Elementarbuch der Differential- und Integralrechnung", vom „Lehr- und Lesebuch für gewerbliche Fortbildungsschulen" und von den „Aufgaben über mechanische Arbeit."

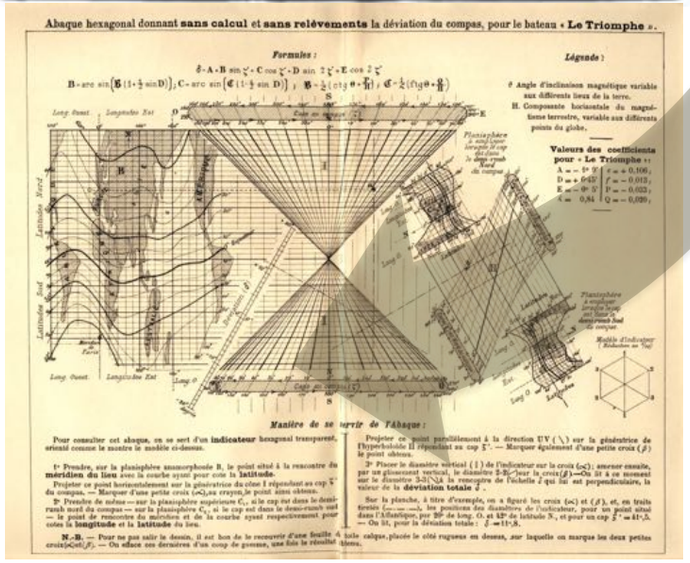
Fünfzehnte Auflage.

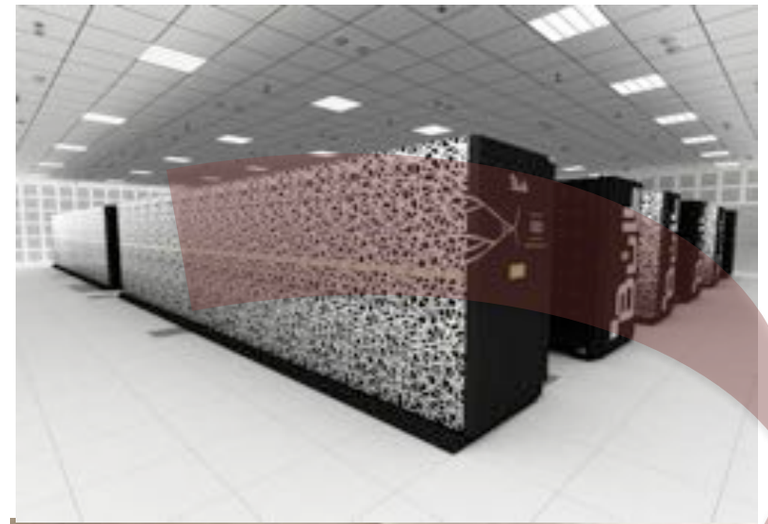
Stuttgart.

Verlag der J. G. Cotta'schen Buchhandlung.

1874.

Towards modern vademecums …





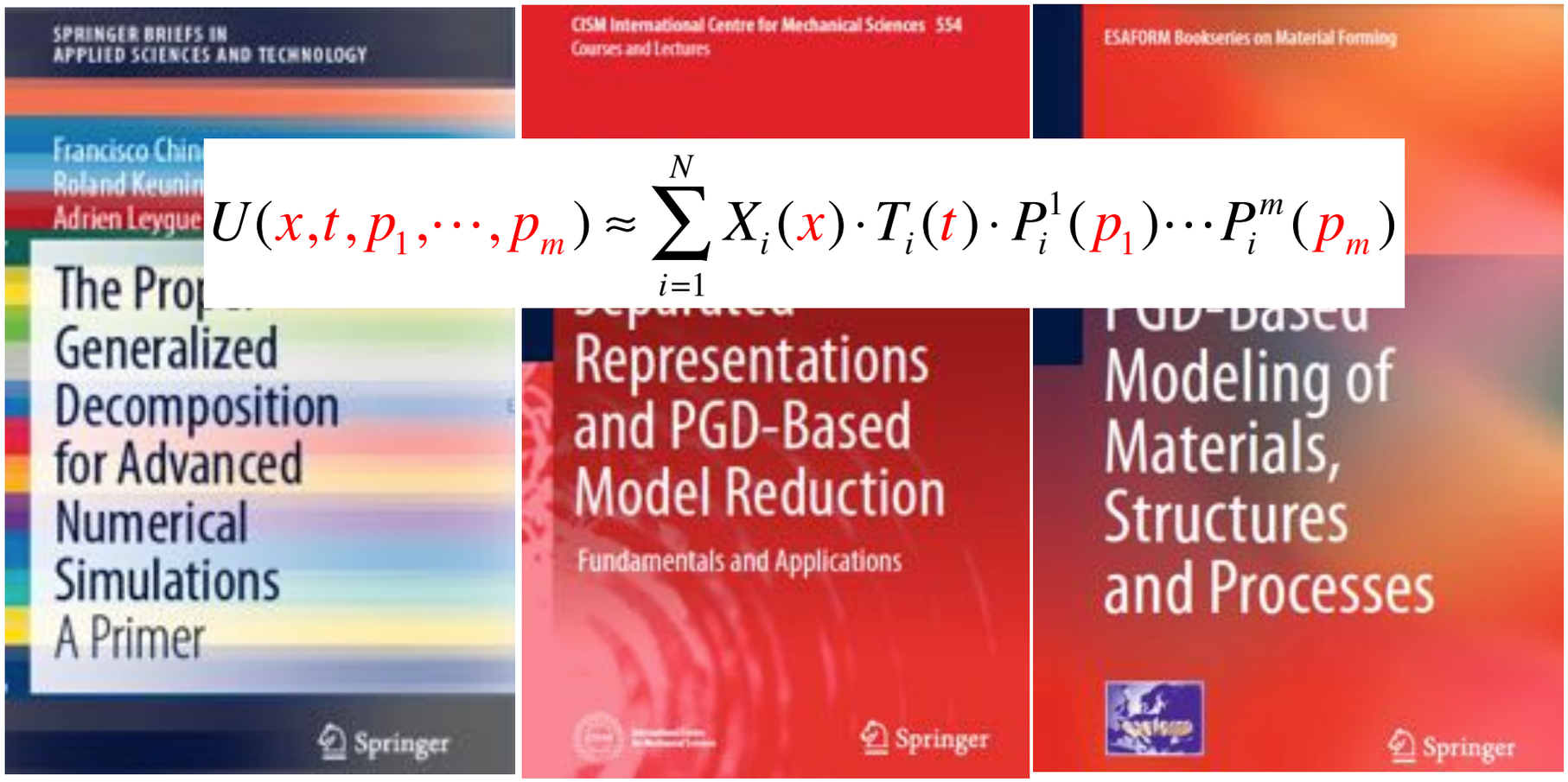
$$U(x,t;p_1,\cdots,p_m)$$

$$U(x,t,p_1,\cdots,p_m)$$

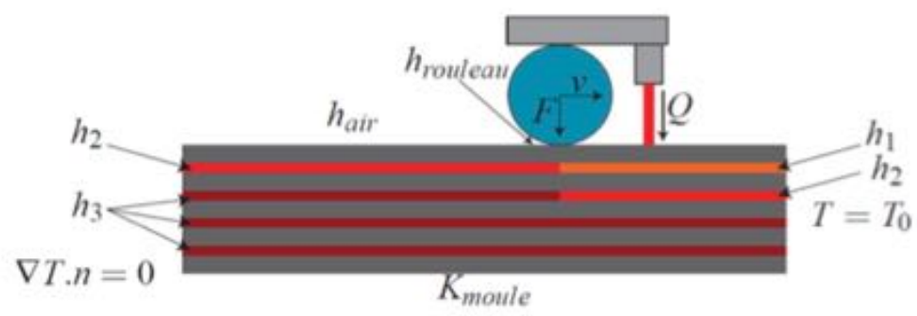
$$(3+1+m)D$$

PGD constructor circumvents curse of dimensionality

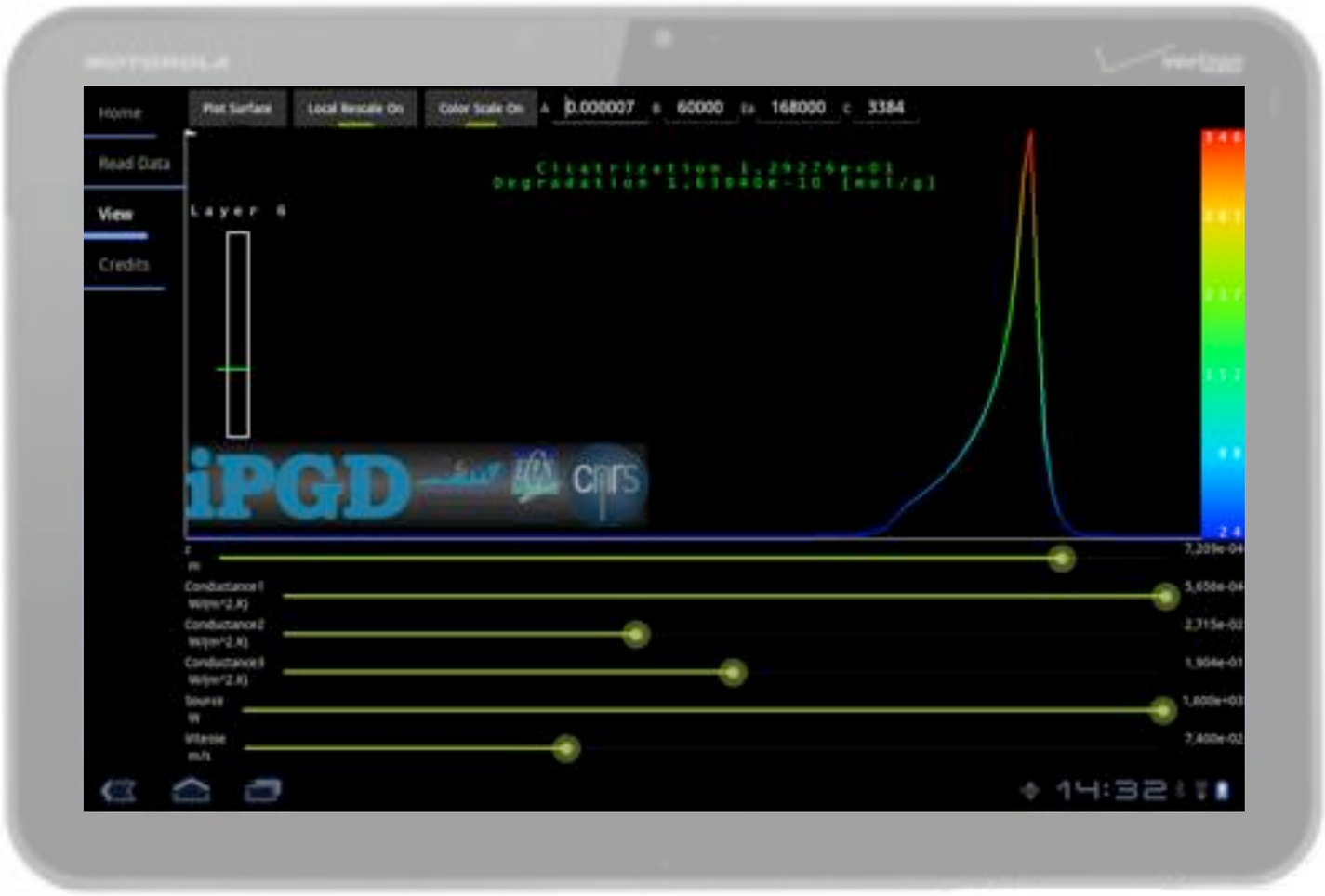
$$U(x,t,p_1,\cdots,p_m) \approx \sum_{i=1}^{N} X_i(x)\cdot T_i(t)\cdot P_i^1(p_1)\cdots P_i^m(p_m)$$



Automated Tape Placement



$$T(x, y, z, t, V, Q, o_1, \cdots, o_n, h_1, h_2, h_3)$$


Home
Read Data
View
Credits
Plot Surface
Local Rescale On
Color Scale On
0.000007
60000
168000
3384
Layer 6
iPGD
cnrs
14:32


iPGD

ISSUES

Sometimes “uncorrelated” parameters are not evident !

Parametric solutions are not always feasible !

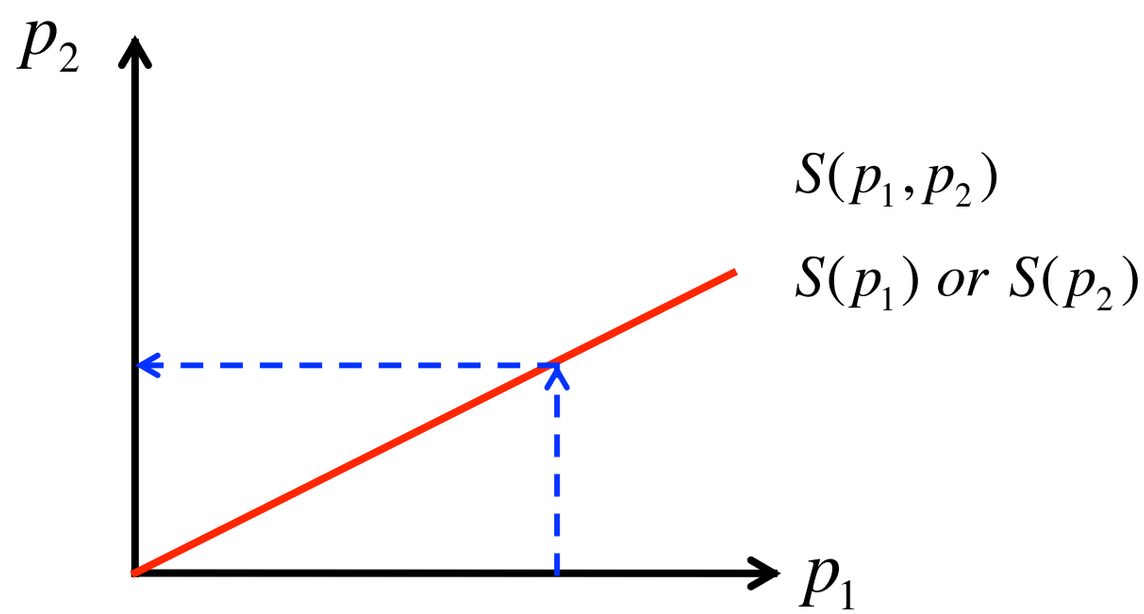
Simulated data – Information – Knowledge – Decision making

First was the data,

then were the models,

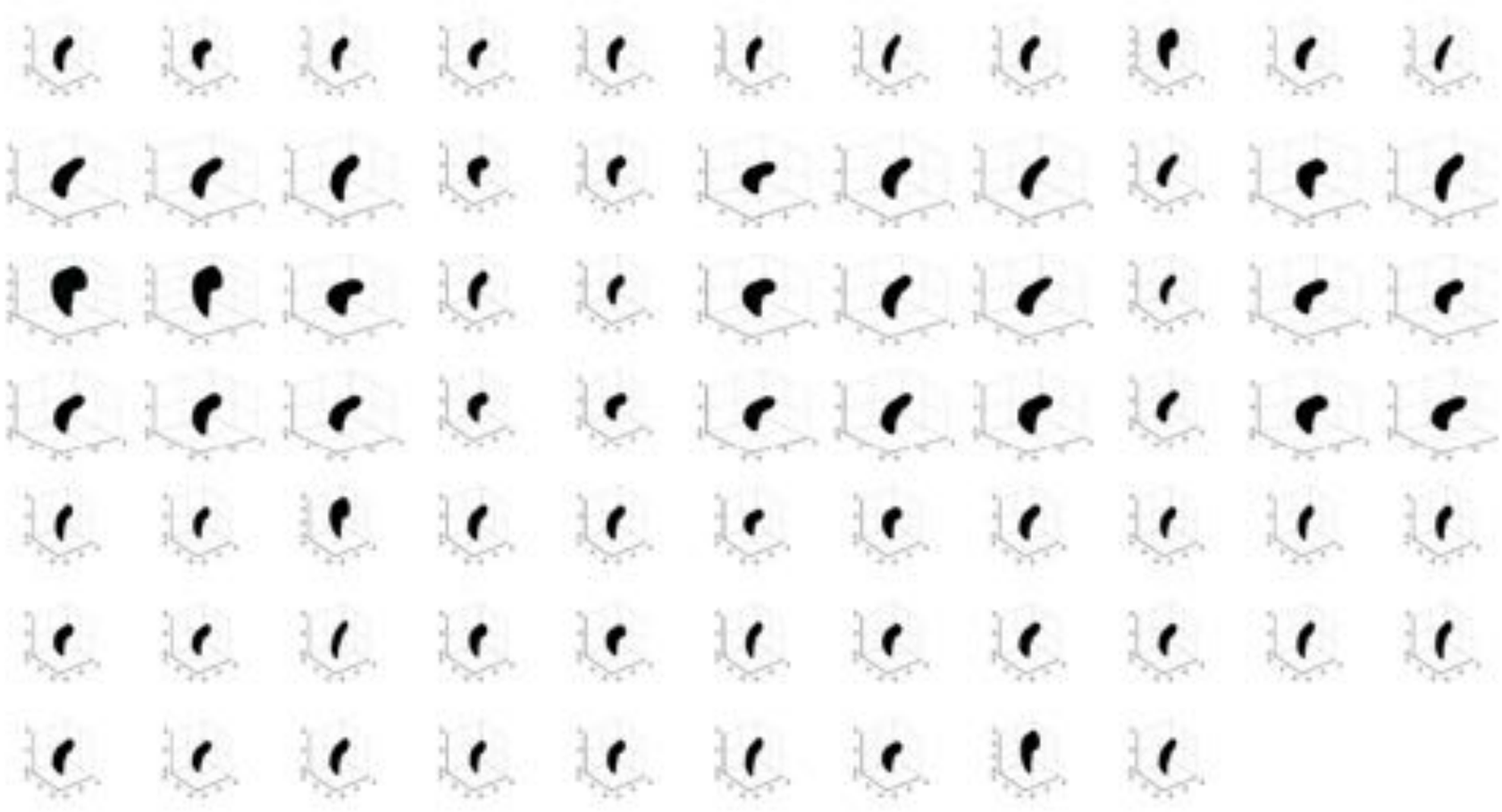
today data-driven applications systems appears as the new paradigm in SBES

From data to information:
removing correlations

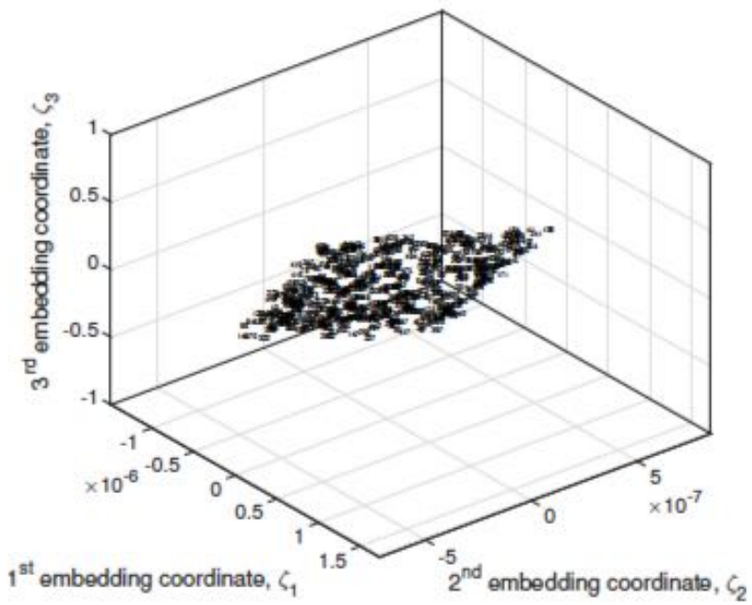


Patient-specific surgical planning

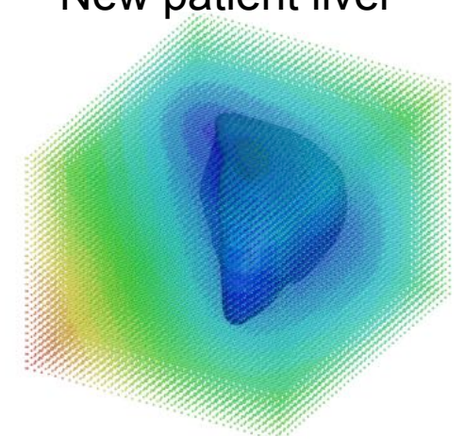
Liver data

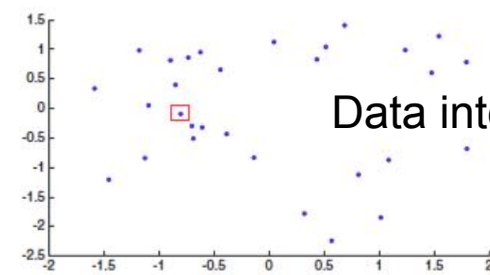


Only two uncorrelated parameters

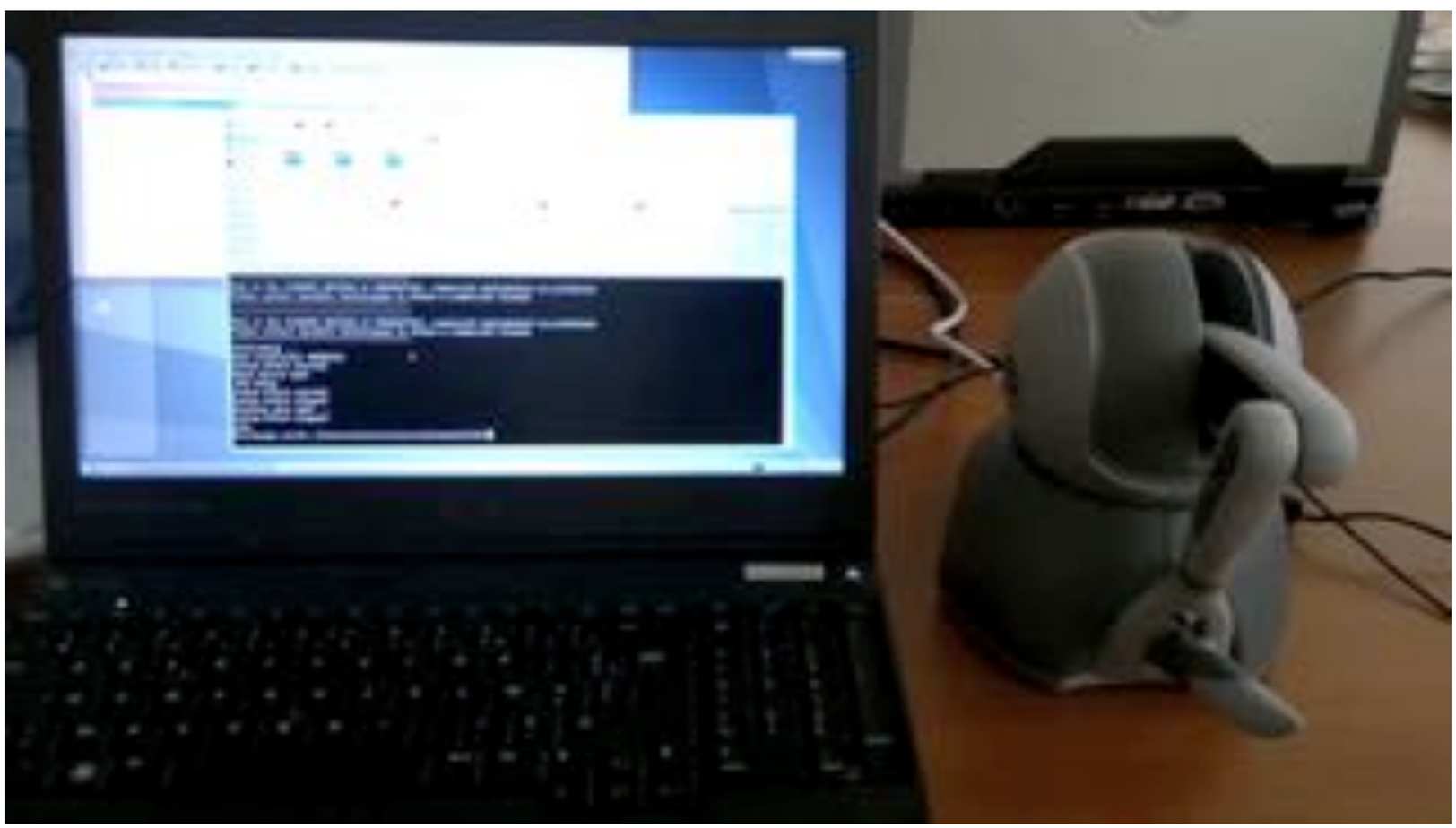


New patient liver





Data interpolation

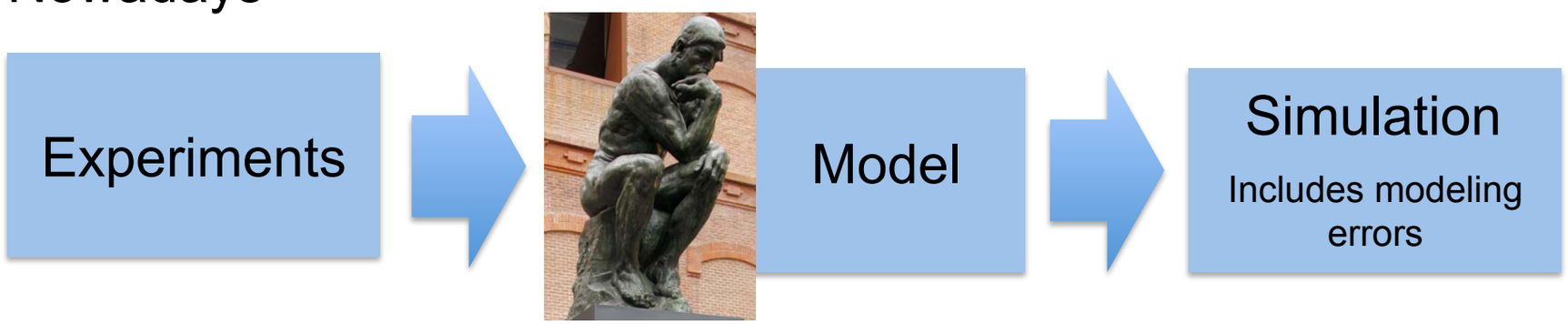


Real-time simulator patient specific

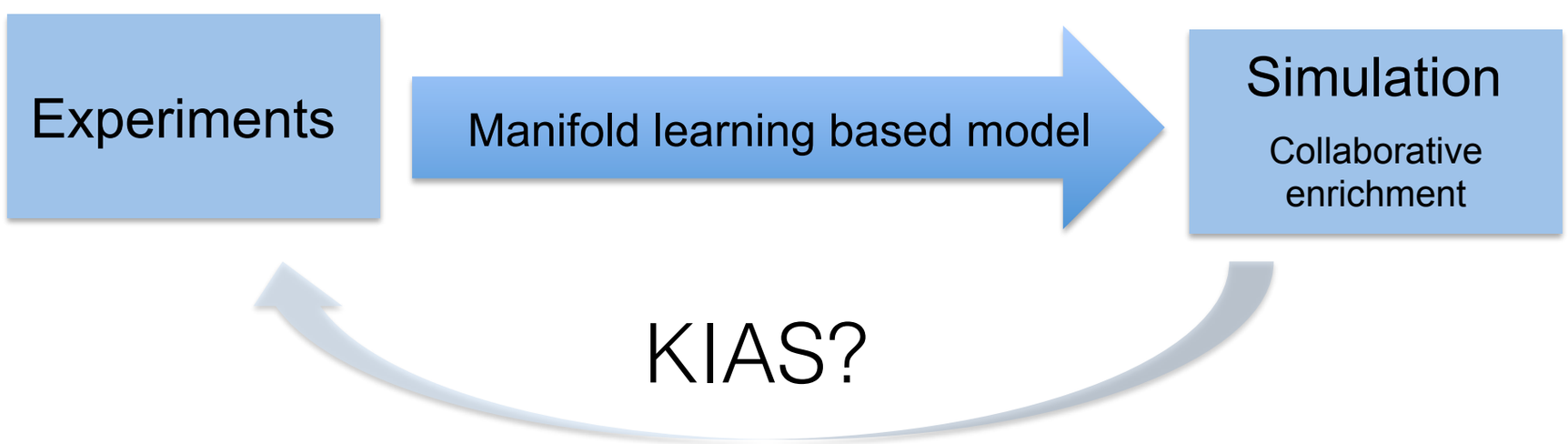
Data-Driven

alleviates modeling

Nowadays



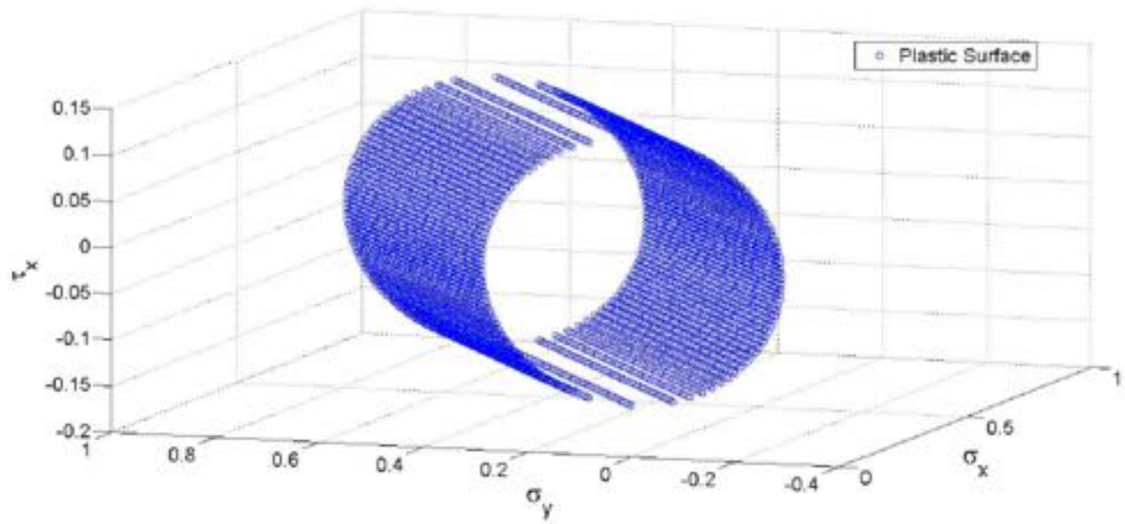
Future

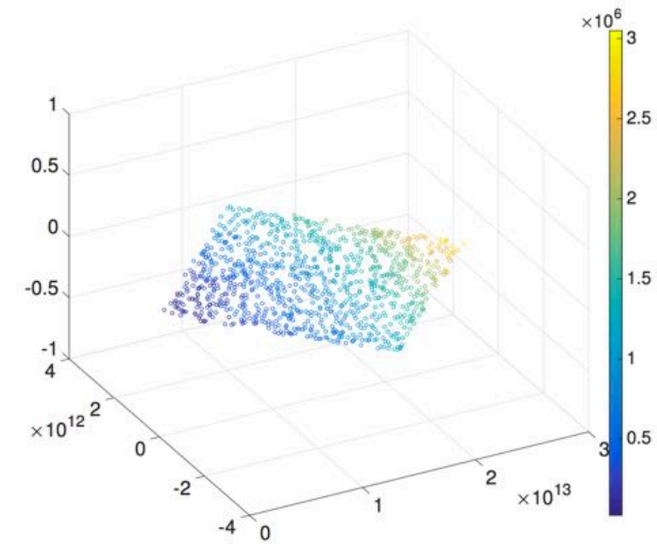


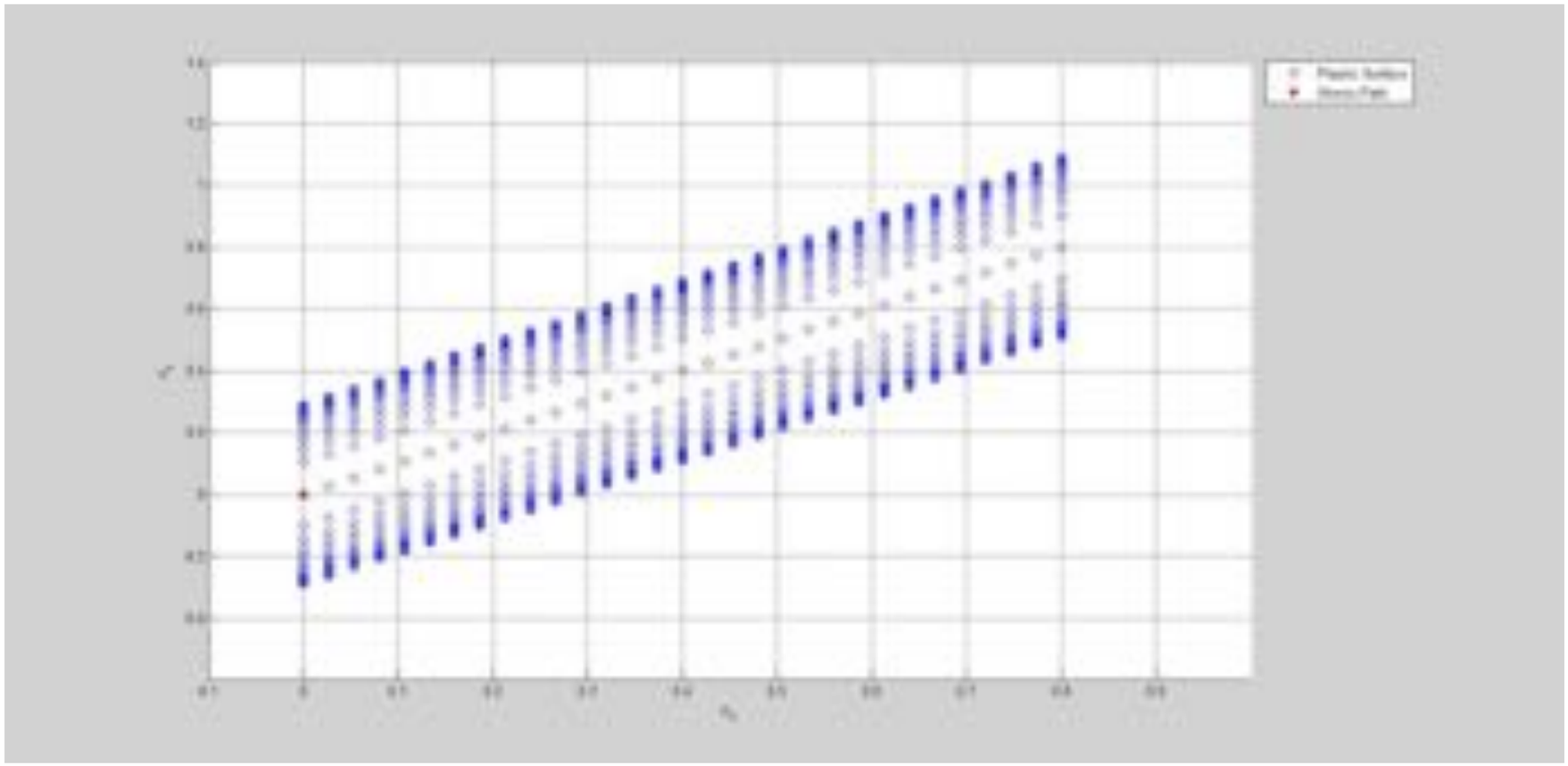
From a methodological viewpoint:

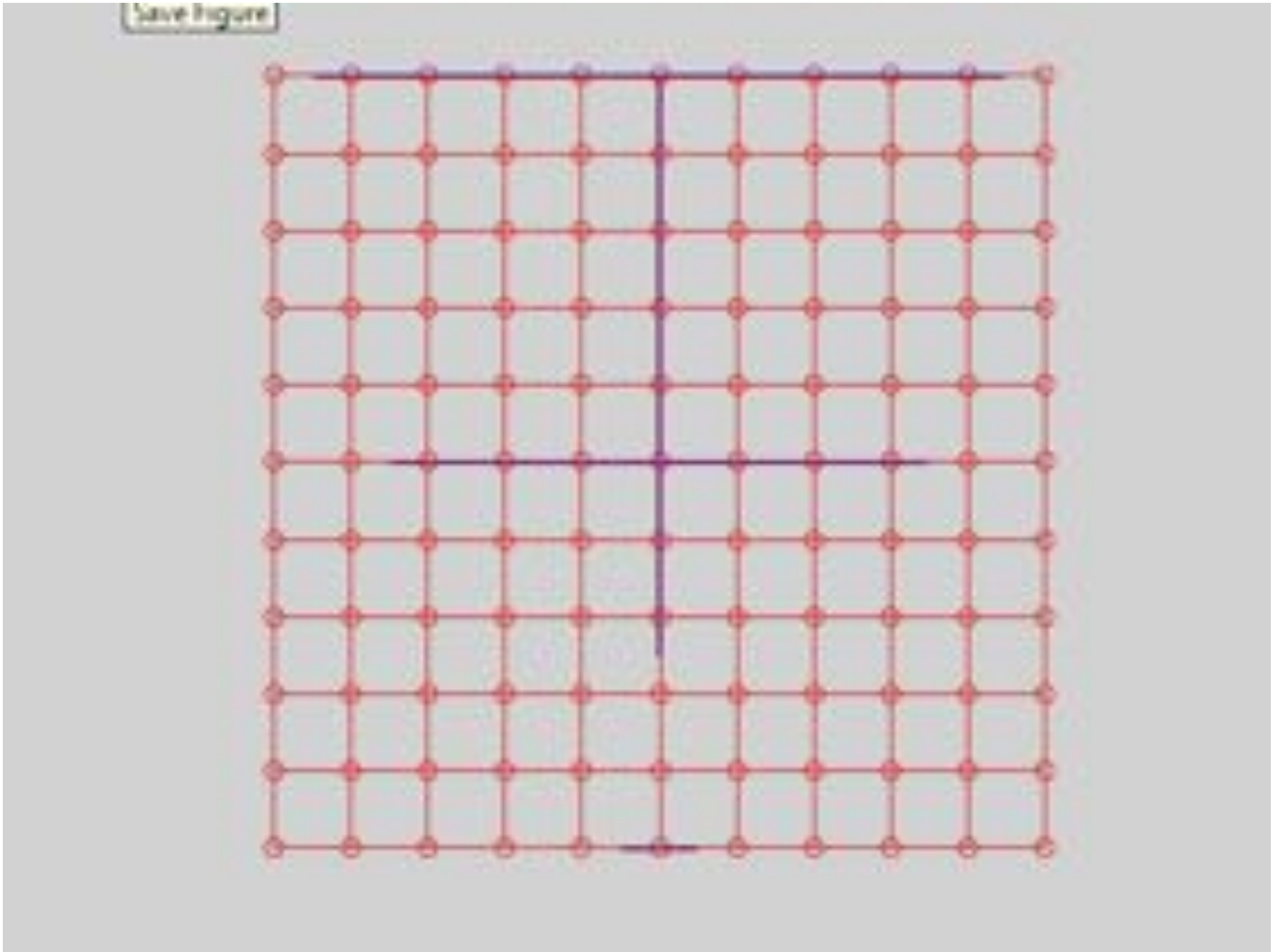
If Hooke had never existed, linear elasticity finite element simulations (based on data) would have existed?

YES, and not only elasticity!

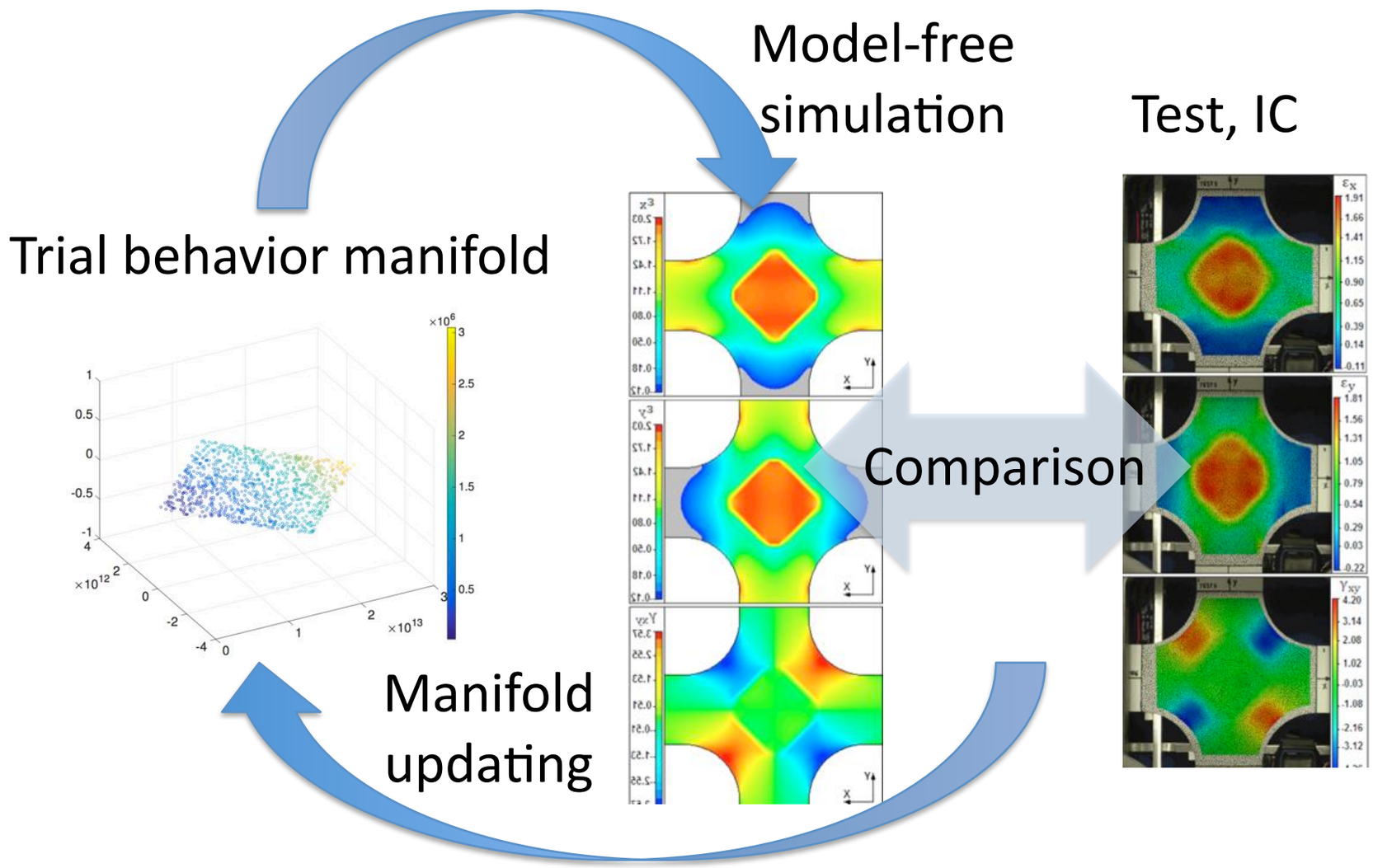

Plastic Surface
τ_x
σ_y
σ_x


$\times 10^{6}$
$\times 10^{12}$
$\times 10^{13}$




Save Figure

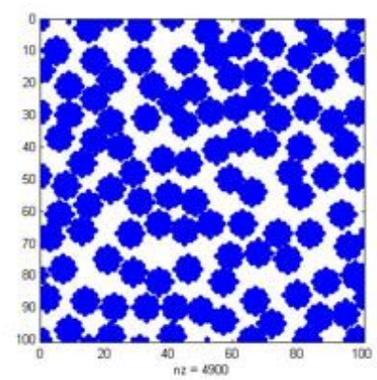
Cheap manifold constructor



Model-Free Upscaling

Phase A : behavior model A

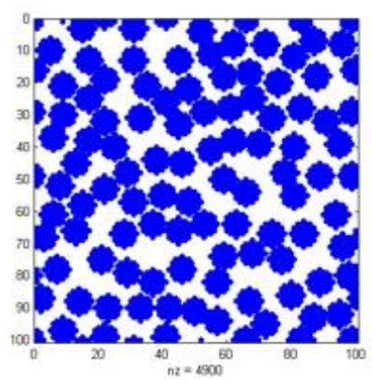
Phase B : behavior model B

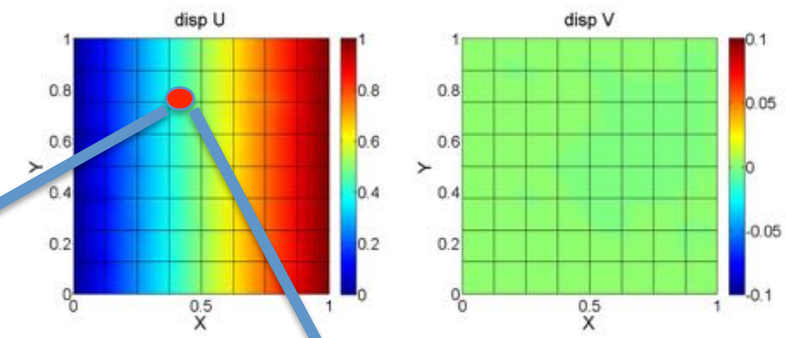


What behavior ?
What model ?

Methodological example

$$\begin{pmatrix} u \\ v \end{pmatrix} = \alpha \begin{pmatrix} x \\ 0 \end{pmatrix} + \beta \begin{pmatrix} 0 \\ y \end{pmatrix} + \gamma \begin{pmatrix} y \\ x \end{pmatrix}$$

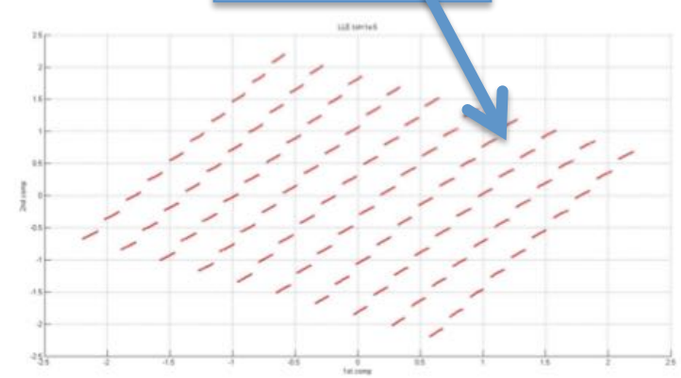




Model free macro simulation

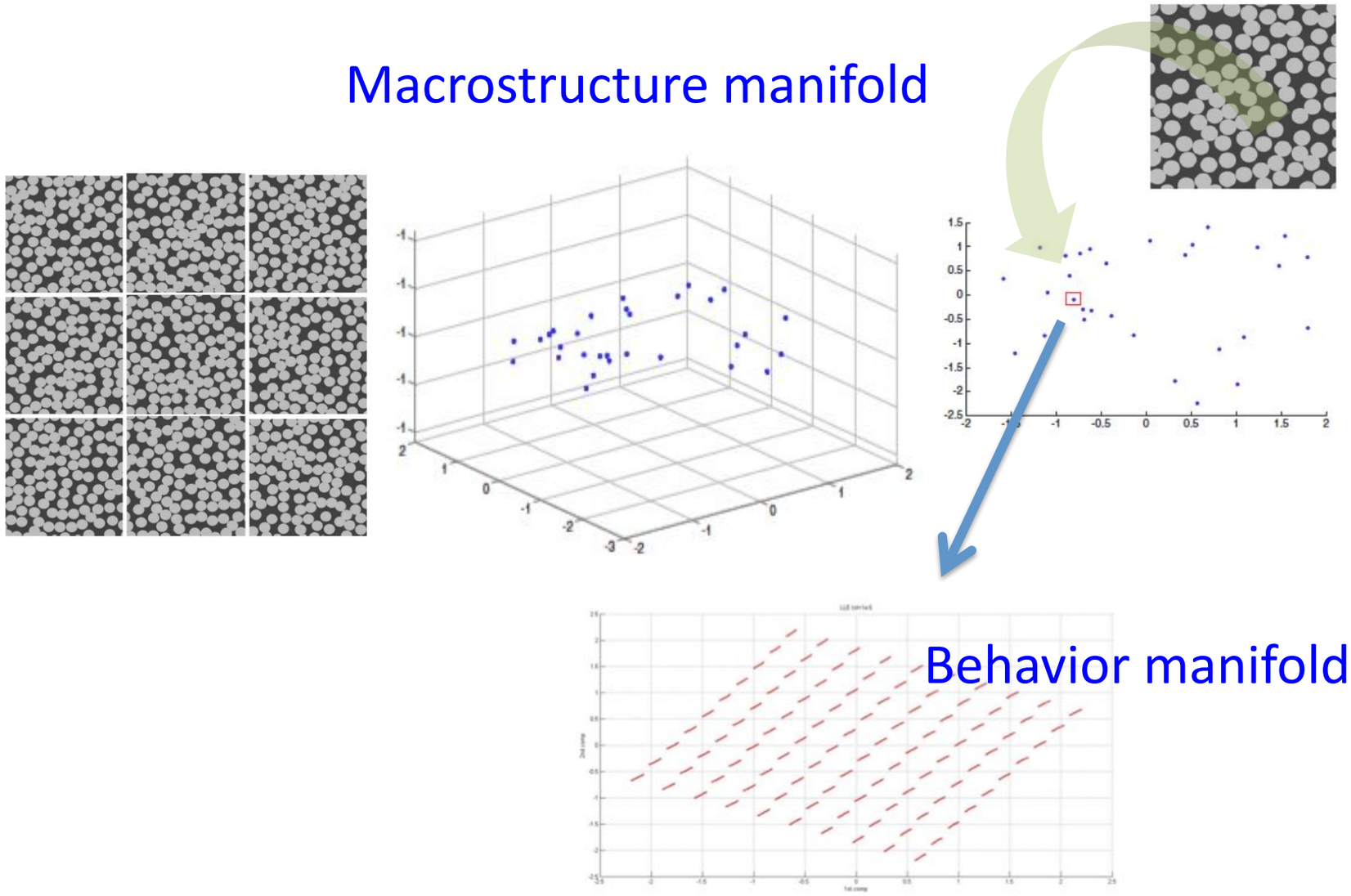
DNS

$$\begin{Bmatrix} \sigma(\mathbf{x}) \\ \varepsilon(\mathbf{x}) \end{Bmatrix} \Rightarrow \begin{Bmatrix} \Sigma \\ \mathrm{E} \end{Bmatrix} \in \mathbb{R}^{12}$$



Manifold learning –> Dim = 2

Macrostructure manifold

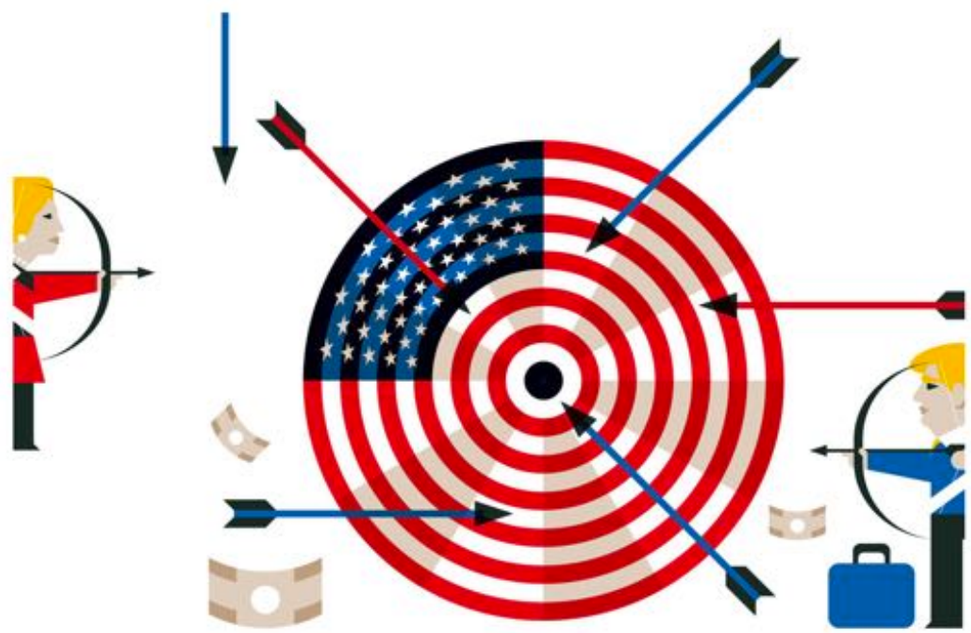


Data-Driven, Data-Mining and Machine Learning, Deep-learning, … open plenty of possibilities.

BUT be careful, surprises are not excluded

Big data en campagne

Comme les publicités commerciales, les messages politiques font l'objet d'un ciblage de plus en plus fin. Dans le numérique, les démocrates ont une longueur d'avance.



L'élection de Trump et les trois échecs du « big data » électoral

La campagne de Hillary Clinton, supposée être à la pointe des technologies de ciblage électoral, a échoué à la faire élire. Du côté des médias, les modèles prévisionnistes, eux aussi basés sur le « big data », n'ont pas su prédire l'issue du scrutin.

LE MONDE | 10.11.2016 à 16h15 • Mis à jour le 11.11.2016 à 06h39 |

Faithless electors: wrong data
Sampling deficiency
Data-mining

In the 4th industrial revolution there is still room for the human being