Thursday, 9:00 am (PST)
Opening Session **zoom #:**

Thursday, 9:15 am (PST)
Keynote 1: Luca Mari **zoom #:**
Title: **Measurement, computation, simulation, etc: is there still a difference in the "big data" age?** Abstract: *Is there a difference between a measurement and a computation? In a context in which more and more processes are digitized and the presence of models is acknowledged as unavoidable (so that the traditional distinction between direct and indirect methods of measurement seems to be lost, under the hypothesis that only indirect measurement is possible), does a difference remain between measurement and computation? And what does the answer imply for the interpretation of the authoritative role of measurement as an epistemic foundation for science? The talk proposes a preliminary analysis, deploying a critical realism approach, to address this issue.*

Welcome to the IOMW 2020 Virtual Conference

Feb 2021

https://www.iomw.org

Measurement, computation, simulation, etc: is there still a difference in the “big data” age?

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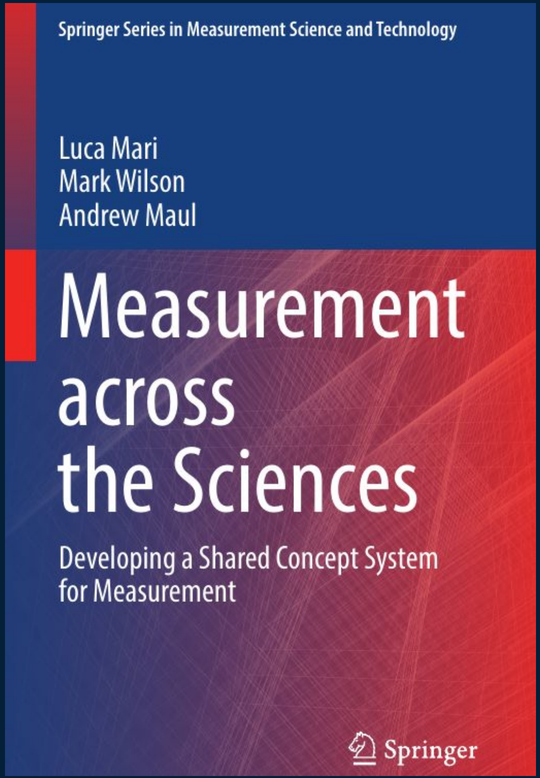
Justification

(why maintaining a distinction between measurement
and other, related processes (computation, simulation, etc)
is important today)

"Measurement is an integral part of modern science
as well as of engineering, commerce, and daily life.
Measurement is often considered a hallmark of the scientific enterprise
and **a privileged source of knowledge**" (Tal, 2020)
Would we say the same for, e.g., computation?

And "**what [is] the source of [this] special efficacy**" of measurement?
(Kuhn, 1961)

Drawing from...



<measur*> in four easy steps

1. At the origin: the Greek concept of measure
2. A critical enabler of the experimental method
3. Exploring measurement as a way of representation
4. … and today?

(proposal: compare your concept of measurement with what follows)

1. At the origin: the Greek concept of measure

“A magnitude is a part of a(nother) magnitude, the less of the greater, when **it measures** the greater” (Euclid, 300 BC)

This seems to justify the claim that the Elements are “the earliest contribution to the philosophy of measurement available in the historical record” (Michell, 2005)

Yes, but...

“A number is part of a(nother) number, the lesser of the greater, when **it measures** the greater” (Euclid, 300 BC)

and indeed, “**a measure** of a number is any number that divides it, without leaving a reminder. So, 2 is a measure of 4, of 8, etc” (Hutton, 1795)

“The term ‘**measure**’ is used [by Euclid] conversely to ‘multiple’; hence [if] A and B have a common measure [they] are said to be commensurable” (De Morgan, 1836)

To settle the issue:

"in the geometrical constructions employed in the Elements [...] **empirical proofs by means of measurement are strictly forbidden**"
(Fitzpatrick, 2008; in his introductory notes to his translation of Euclid's Elements)

The source of the special efficacy of measurement **is not** the Euclidean concept of measure

2. A critical enabler of the experimental method

Before Galileo, “no one had the idea of counting, of weighing and of measuring; or, more exactly, no one ever sought to get beyond the practical uses of number, weight, measure in the imprecision of everyday life” (Koyré, 1948)

The experimental method discovered the importance of empirical processes, and of measurement in particular, but with a radical **physicalist** flavor

And indeed...

> MEASURING, the same as MENSURATION.

> MENSURATION, the act, or art, of measuring figured extension and bodies; or of finding the dimensions and contents of bodies, both superficial and solid.

(Hutton, 1795)

But what about, e.g., temperature?
(Hutton uses the term “observation” for its evaluation...)

A

PHILOSOPHICAL AND MATHEMATICAL DICTIONARY:

CONTAINING

AN EXPLANATION OF THE TERMS, AND AN ACCOUNT OF THE SEVERAL SUBJECTS,

COMPRISED UNDER THE HEADS

MATHEMATICS, ASTRONOMY, AND PHILOSOPHY

BOTH NATURAL AND EXPERIMENTAL;

WITH AN

HISTORICAL ACCOUNT OF THE RISE, PROGRESS, AND PRESENT STATE OF THESE SCIENCES;

ALSO

MEMOIRS OF THE LIVES AND WRITINGS OF THE MOST EMINENT AUTHORS,

BOTH ANCIENT AND MODERN,

WHO BY THEIR DISCOVERIES OR IMPROVEMENTS HAVE CONTRIBUTED TO THE ADVANCEMENT OF THEM.

BY CHARLES HUTTON, LL.D.

FELLOW OF THE ROYAL SOCIETIES OF LONDON AND EDINBURGH, AND OF THE PHILOSOPHICAL SOCIETIES OF HAARLEM AND AMERICA; AND EMERITUS PROFESSOR OF MATHEMATICS IN THE ROYAL MILITARY ACADEMY, WOOLWICH.

This physicalism was plausibly still at the basis of the position of the Ferguson committee (1940):
“to insist on calling these other processes ‘measurement’ adds nothing to their actual significance but merely debases the coinage of verbal intercourse”

“The main point against the measurability of the intensity of a sensation was the impossibility of satisfactorily defining **an addition operation** for it”
(Rossi, 2007)

The source of the special efficacy of measurement
is not physicalism

3. Exploring measurement as a way of representation

From the seminal claim that “measurement is the process of assigning numbers **to represent** qualities” (Campbell, 1920) ...

… to the position that a representation theorem
“makes the theory of finite weak orderings a theory of measurement, because of its numerical representation” (Suppes, 2002)

With the mindset that "the theory of measurement is difficult enough without bringing in the theory of making measurements" (Kyburg, 1984) RTM **is too abstract** for being a theory of an empirical process

The source of the special efficacy of measurement **is not** consistency in representation

4. … and today?

Summary of the open issues deriving from these clashing standpoints

The source of the special efficacy of measurement **is not**

- the Euclidean concept of measure
- physicalism
- consistency in representation

And then?

One option: change paradigm

Renounce to consider measurement as a process with a special efficacy, and characterize it as an **evaluation whose quality is documented**

NIST

PROJECTS/PROGRAMS

Virtual Measurements

Summary

Compared with conventional, physical measurements, the cost of computational modeling continues to drop. This has driven many industries to incorporate computational predictions in their R&D processes. However, to replace a physical measurement, the quantitative reliability of a computational prediction must be known.

NIST Technical Note 1900

Simple Guide for Evaluating and Expressing the Uncertainty of NIST Measurement Results

Antonio Possolo

Measurement is an experimental or computational process that, by comparison with a standard, produces an estimate of the true value of a property of a material or virtual object or collection of objects, or of a process, event, or series of events, together with an evaluation of the uncertainty associated with that estimate, and intended for use in support of decision-making.

According to this position,
computations and simulations of documented quality are measurements

Documenting quality is not only a (possibly) necessary condition
for a property evaluation to be a measurement, but **is also sufficient**

An example:

What acceleration does a force of $1.23(1)\ \mathrm{N}$ produce on a body of mass $2.345(2)\ \mathrm{kg}$?

(let us ask it to the NIST Uncertainty Machine: uncertainty.nist.gov)

We have computed a value of acceleration and a related standard uncertainty:
have we performed a measurement?

Through the requirement that measurement uncertainty be handled, **metrology accepted** (an updated version of) **representationalism?**

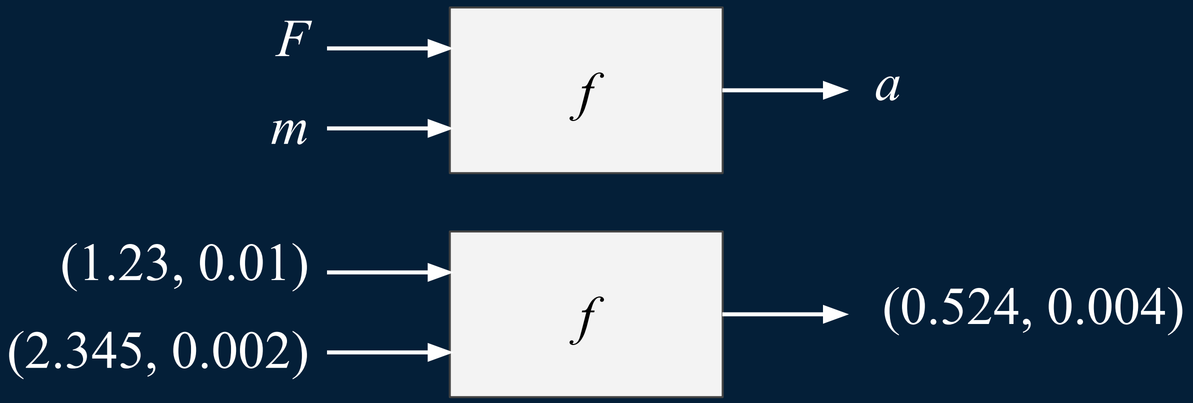
(truth and objectivity have been traded for consistency?)

Toward the conclusion:

why did this happen?

can there be another option?

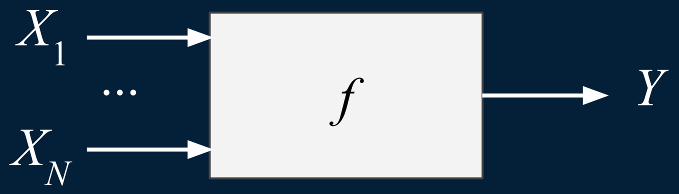
The structure of our example:



Lately f (where then $f(F, m) = F/m$) has been called a **measurement model**

(a "mathematical relation among all quantities known to be involved in a measurement", according to the International Vocabulary of Metrology (VIM))

“Even the simplest, seemingly direct measurements [require a measurement model].
For example, the indication of a bathroom balance ...
is not the measurand Y (which is the mass of the person in kilograms),
but simply one of the input quantities, say, X_1.
The measurand is obtained from the indication X_1, perhaps repeated two or three times, and a series of corrections X_2, X_3, ..., X_N (the zero and the span of the scale, and perhaps its linearity, or the deviation of the local acceleration due to gravity from that of the place in which the balance was manufactured and adjusted).” (Bich, 2008)



Since “even the simplest model will be incomplete if corrections to the indications of the instruments used in direct measurements are not taken into account … **no measurement can strictly be considered to be ‘direct’**.” (Lira, 2002)

The argument is apparently:

P1. any measurement requires corrections
P2. corrections are taken into account through a model
C1. any measurement is based on a model

P3. a measurement that is based on a model is indirect
C2. any measurement is indirect

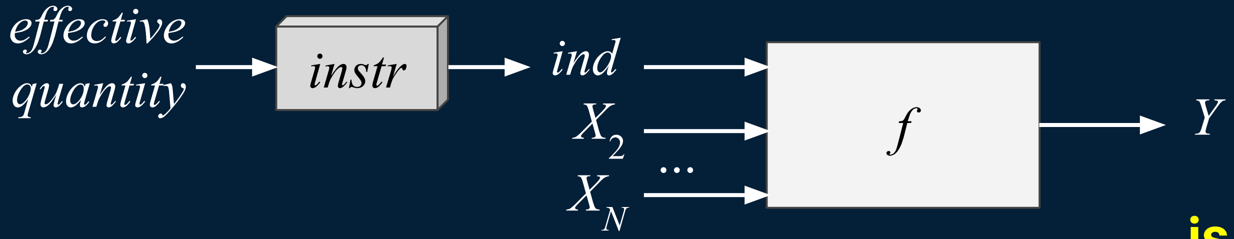
Any measurement is based on a (explicit or implicit) model: **yes, of course!**

A measurement that is based on a model is indirect (and therefore measurement can be a purely computational process): **… really?**

Another option: maintain and strengthen the paradigm

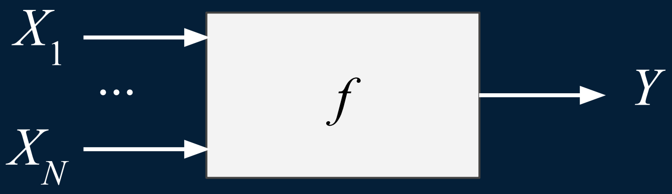
Let us recover the key distinction:

this



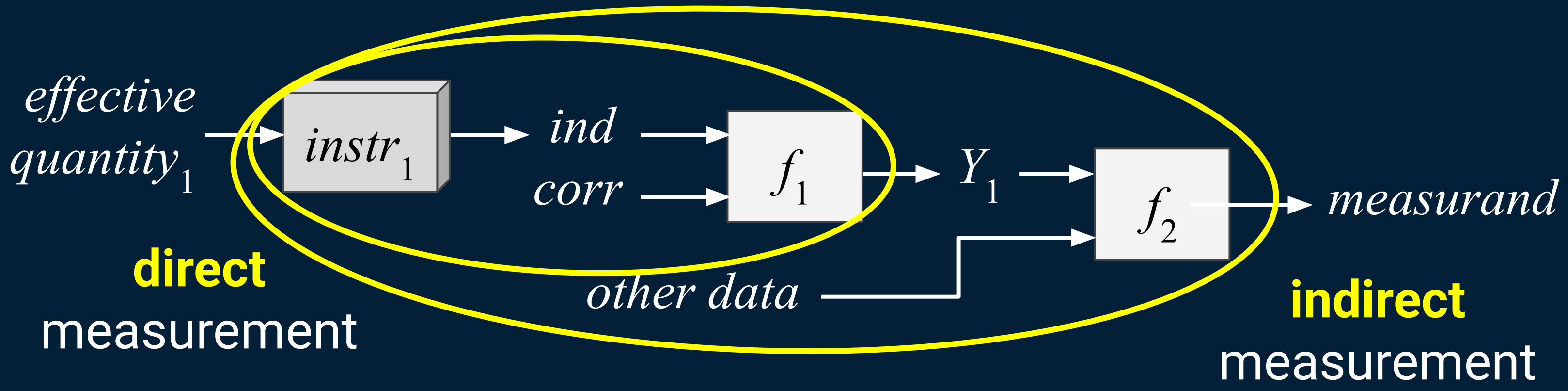
is measurement

this



is not measurement

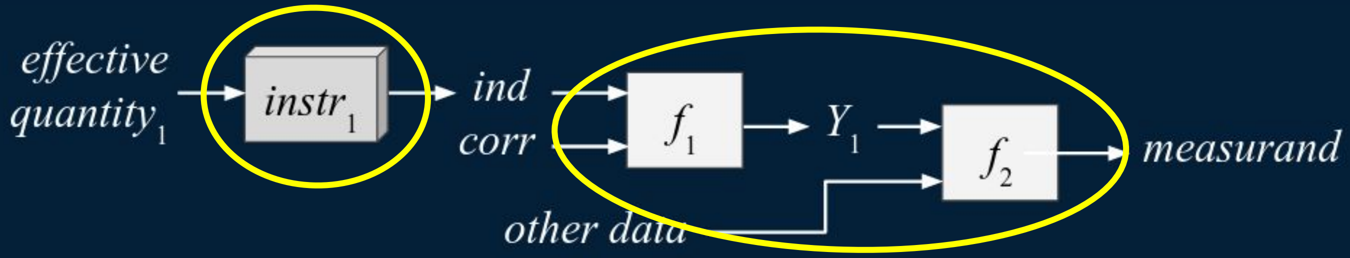
A more complete picture:



Indirect measurements must include at least one direct measurement

(why maintaining a distinction between measurement
and other, related processes (computation, simulation, etc)
is important today)

“Measurement is often considered **a privileged source of knowledge**”
But “**what is the source of this special efficacy?**”



Measurement is effective...
because it is effective...

in **acquiring information from the empirical world**

and in **interpreting it by means of models**

This standpoint promotes a **model-dependent, critical realism**

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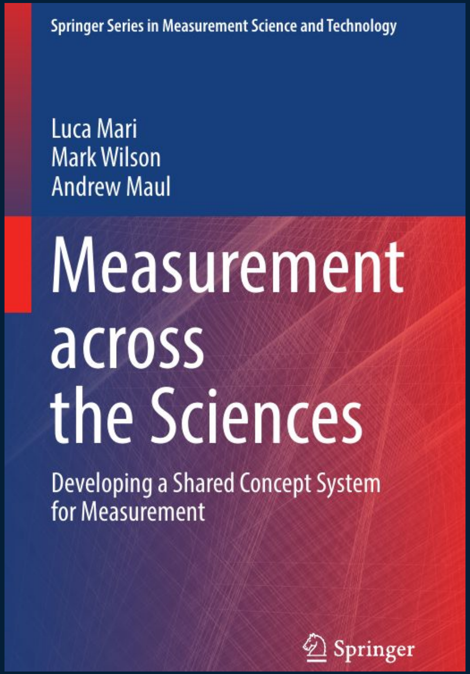
Thank you for your kind attention

(to be possibly continued here



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