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Procedurality of Rationality and Processuality of Being

–

thoughts on Philosophy of Technology following Alfred North Whitehead

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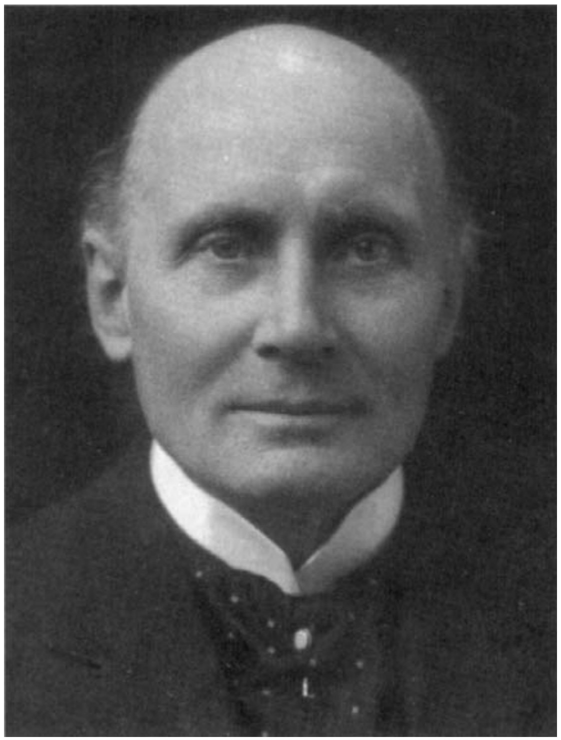
Structure

1. Alfred North Whitehead:
   From the Principia Mathematica to the Reanimation of speculative philosophy
2. Procedural rationality: From the Babylonian mathematics to the process ontology
3. How applied mathematics is possible? On the way to Technomathematics

Alfred North Whitehead (15.2. 1861 – 30.12.1947) – Some life data



1880	Beginning studies of the mathematics at Trinity College, Cambridge
1888	**Lectures on Graßmanns Ausdehnungslehre**
1898	***A Treatise on Universal Algebra***
1900	The beginning of the collaboration with Russell on the Principia Mathematica
1910	***Principia Mathematica***
1911	Lectureship in applied mathematics in London
1918/19	*Enquiry into the Principles of Natural Knowledge und The Concept of Nature*
1924	Professorship in philosophy at Harvard University
1926	*Religion in the Making*
1927/28	***Process and Reality***
1928	***The Function of Reason.***

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The Influence of Hermann Graßmann on Alfred Noth Whitehead

Hermann Günther Graßmann (1809 – 1877)

“My first book, A Treatise on Universal Algebra, was published in February, 1898. It was commenced in January, 1891. The ideas in it were largely founded on Hermann Grassmann's two books, the Ausdehnungslehre of 1844, and the Ausdehnungslehre of 1862. The earlier of the two books is by far the most fundamental. Unfortunately when it was published no one understood it; he was a century ahead of his time.”
(Whitehead, Autobiographical Notes 1941)

“The greatness of my obligations in this volume to Grassmann will be understood by those who have mastered his two *Ausdehnungslehres*. The technical development of the subject is inspired chiefly by his work of 1862, but the underlying ideas follow the work of 1844"
(Whitehead, Introduction to the Treatise on Universal Algebra, S. X)

About the “Principles of Universal algebra"
"The discussions of this chapter are largely based on the 'Uebersicht der allgemeinen Formenlehre' which forms the introductory chapter to Grassmann's Ausdehnungslehre von 1844."
(Whitehead 1898, S. 32)

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Crucial points of Whitehead's conception of philosophy

1. Kants philosophy was made for Newton‘s Universe. The philosophy of Einstein‘s world is still due.
2. Therefore philosophy does not exhaust itself into a language philosophy.
3. Philosophy must be speculative and explain the world.
4. Thanks to modern mathematics speculation of modern philosophy becomes falsifiable.
5. The inner unity of everyday and scientific experience has to defend.
6. The world is not simple but complicated (tricky).
7. The world is not composed of things but of processes.
8. The subject-object structure of language is blocking the way to regard the reality as a process.
9. The world is not split into two separate: a world of spirit and a material world.
10. The reality is not a purposeless process but teleologically ordered.
11. Valuations (perceptions) are intrinsic aspects of all processes.
12. The human reason is nothing else but the refining of the general mental experience of the world. Reason is purposeful.
13. „The function of Reason is to promote the art of life.“ (Whitehead)
14. „To survive" is not enough. Otherwise the undestroyable stones would be the summit of the evolution.
15. The meaning of life is the assertion of the adventure against the fatigue.
16. Visions cannot replace utopias.

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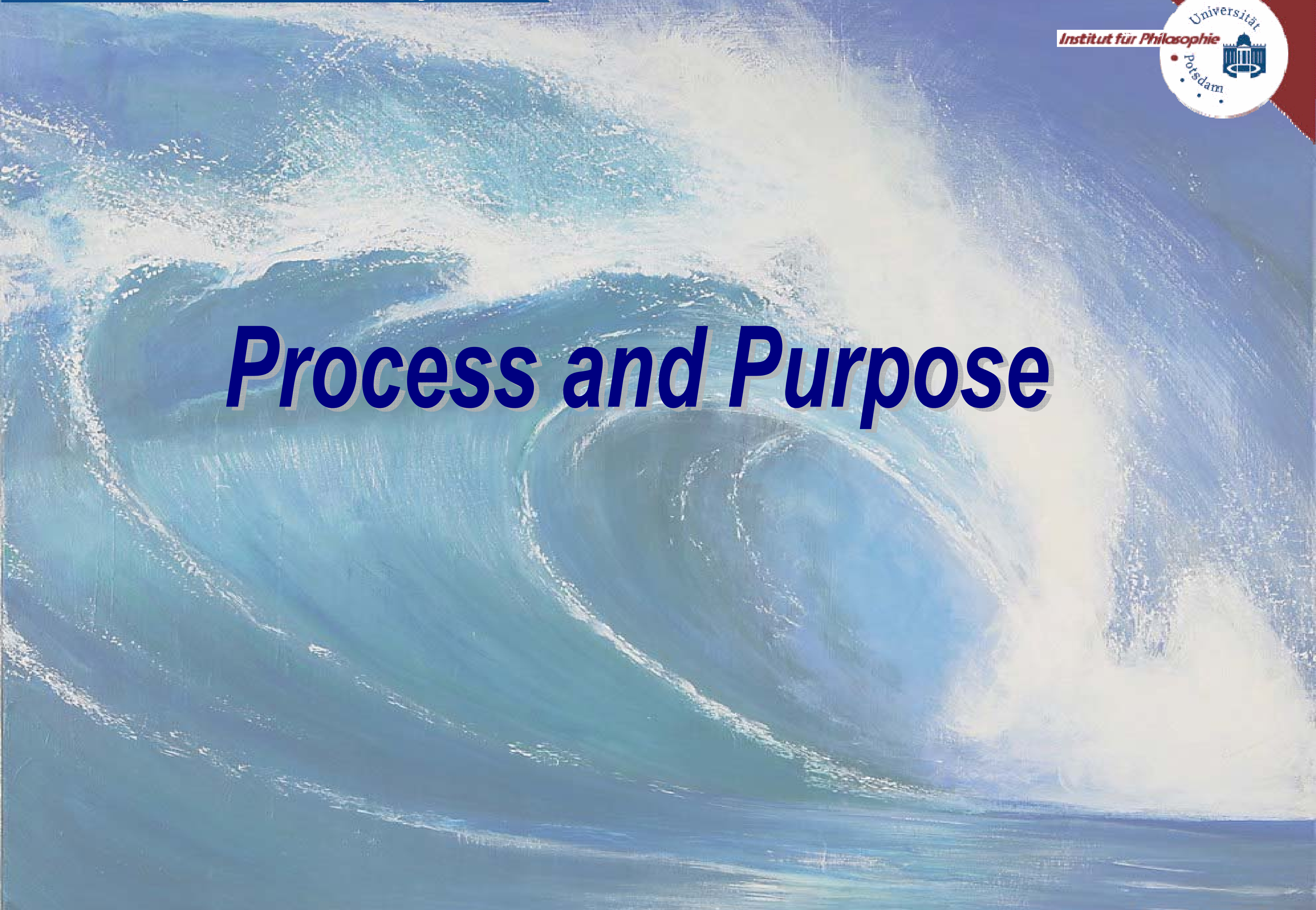

Process and Purpose

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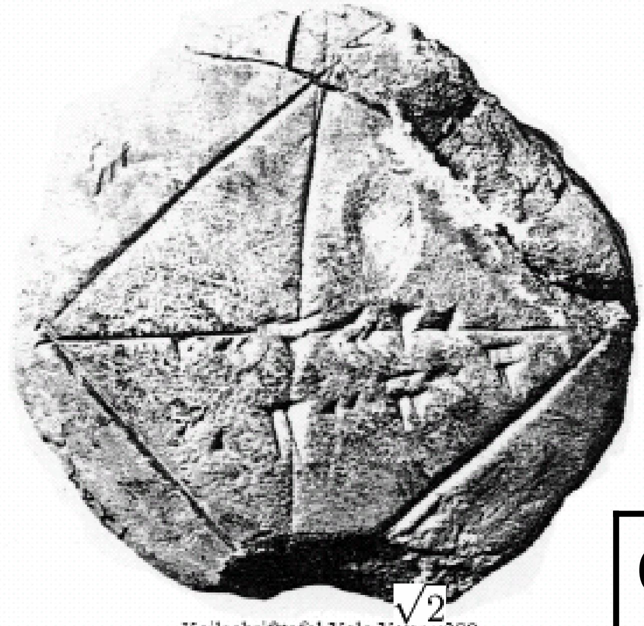
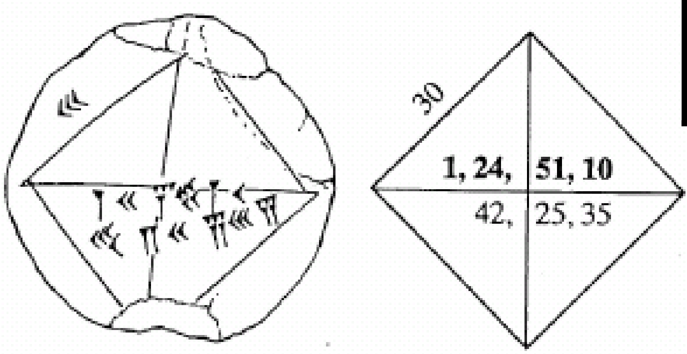
2. Procedural rationality: From the Babylonian mathematics to the process ontology



Keilschrifttafel Yale YBC 7289 –
Darstellung der Approximation von $\sqrt{2}$



Keilschrift für $\sqrt{2}$ (YBC 7289). Man erkennt leicht die Zahl 30 am linken Rand, während die obere Zeile 1; 24, 51, 10 = 1,41421 2963 angibt, darunter der halbe Wert 0; 42, 25, 35 = 0, 70710 981. (1,41421 35623 731 ist korrekt.)

Cuneiform writing for approximate calculation of $\sqrt{2}$

BM 34568, Vs I 6–8a	spB math. Problemtext
The length is 4 and the diagonal is 5. What is the breadth? Because you don't know it: 4 times 4 gives 16. 5 times 5 gives 25. Subtract 16 from 25, will stay 9. **How many times I must how much so that it is 9? 3 times 3 gives 9: The breadth is 3.**	[4 **u**]**š** u_3 5 **bar.nun en sag** **mu nu zu**-u_2 4 GAM 4 / [1]6 5 GAM 5 25 16 **ta** 25 **nim**-*ma re-ḫi* 9 / *mi-nu-*u_2 GAM *mi-ni-i lu*-DU-*ma lu* 9 3 GAM 3 9 / 3 **sag**

A procedural problem solving text of the Babylonian mathematics for the calculation of the length of a rectangle side from the length of the diagonals and the length of the other side (from Ossendrijver 2004)

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Achievements of Babylonian mathematics

- A positional system with floating-point representation;
- Solutions for systems of equations with up to 10 equations with 10 variables;
- Computation of interest and compound computation of interest including the inverse tasks;
- Logarithmic calculation and solving of exponential equations;
- Early forms of steadiness and a concept of function are found;
- Interpolation and approximation methods have to be found;
- *Algorithmic* approaches to the solution of problem classes emerges;
- *“Standard programs"* for classes of practical tasks in almost algebraic notation are to be found.

Therefore Mathematics was developed as an ideational technology that can be regarded as a harbinger of modern computer based technology. In such a way Mathematics was only driven by the need of practical applicability without any other criterion of truth.

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Mathematical problem of a cuneiform script of a The Museum Of The Ancient Near East in Berlin (1800-1600 BC)

The diagonal d of a rectangular gate has to be calculated. Height and width are given with h = 10/60 GAR resp. w = 40/60 GAR (1 GAR corresponds to about 6 meters).

The cuneiform script contains the solution of the problem in the following form (translated):

You: 0;10 width square. 0;1,40 as area you get.
The reciprocal of 0;40 GAR generate. With 0;1,40 of the area multiply it.
0;2,30 you see. One half of 0;2,30 break off. 0;1,15 you see.
0;1,15 to 0;40 height add.
0; 41.15 is his diagonal.

Length of the diagonal according to the Pythagoras‘ Theorem (580-496 BC)

$$d = \sqrt{h^2 + w^2}$$

The exact value is (decimally) 0.6872 GAR

Approximation of the Babylonians (1800-1600 BC)

$$d \approx h + \frac{1}{2}\frac{1}{h}w^2.$$

The approximation results in 0.6875 GAR.

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Procedurality of the stochastic optimization of a machine-tool by tossing a coin

Center lathe Weiler Condor VS; year of construction 1975; GFDL photo (Wikipedia)

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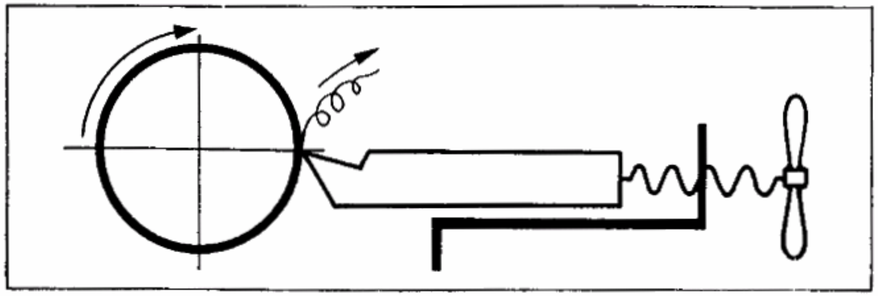
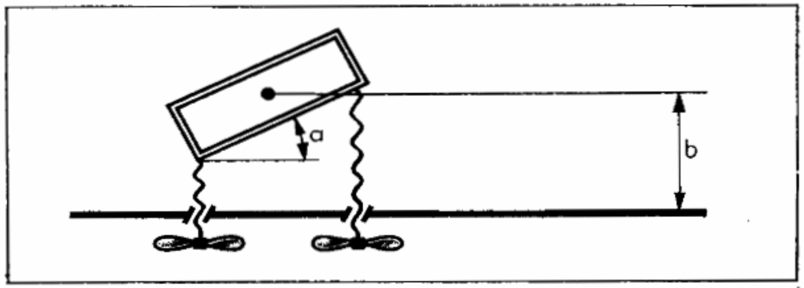
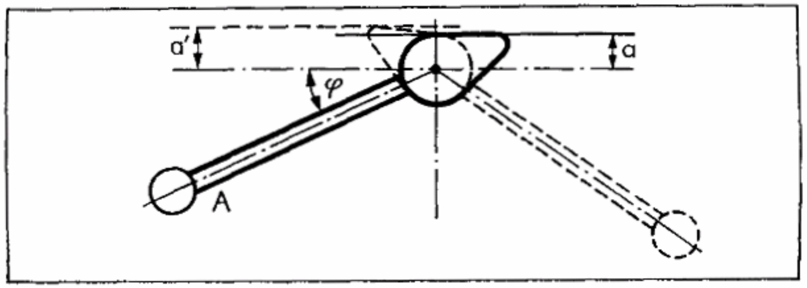


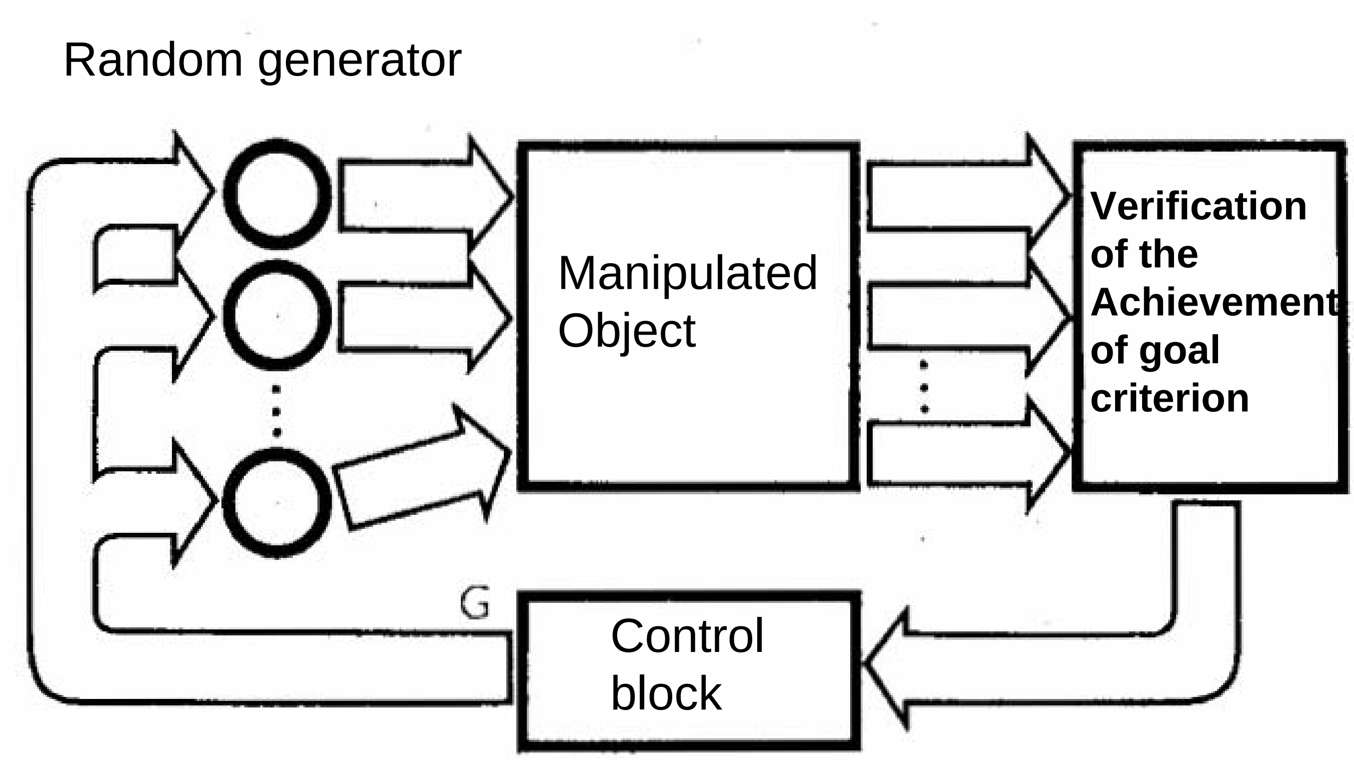
First order position control (following Rastrigin)



Second order position control (following Rastrigin)



Third order position control (following Rastrigin)



Automation of the stochastic optimization (according to Rastrigin 1973)

(**Modern research directions: Randomized algorithms in combinational optimization)**

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Empirical modelling following the radical Empirismus of William James

The modelling process is based on three complementary and not separable from each other principles:

The analysis of a domain or application starts by identifying the fundamental, pre-articulate, structure of the personal experience of the domain. The framework for representing this structure includes identifying:

- the **observables** of a domain (those are choosed as relevant);
- the **dependencies** (indivisible linkages) which are hold between observables;
- the **agents** (instigators of change) with respect to which the observables may be grouped and classified in a systematic way.

Such an analysis leads relatively directly to a computer representation of the domain in which a script of definitions corresponds to a particular state of the model.

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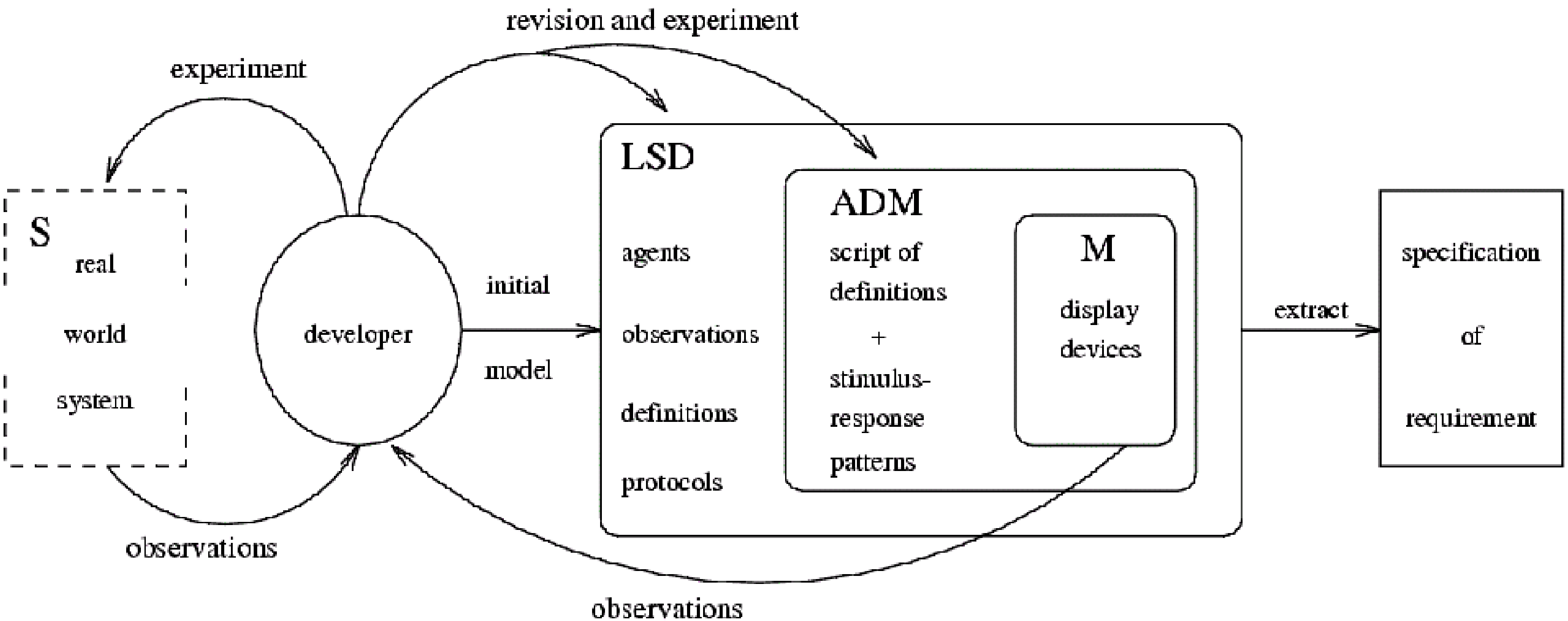
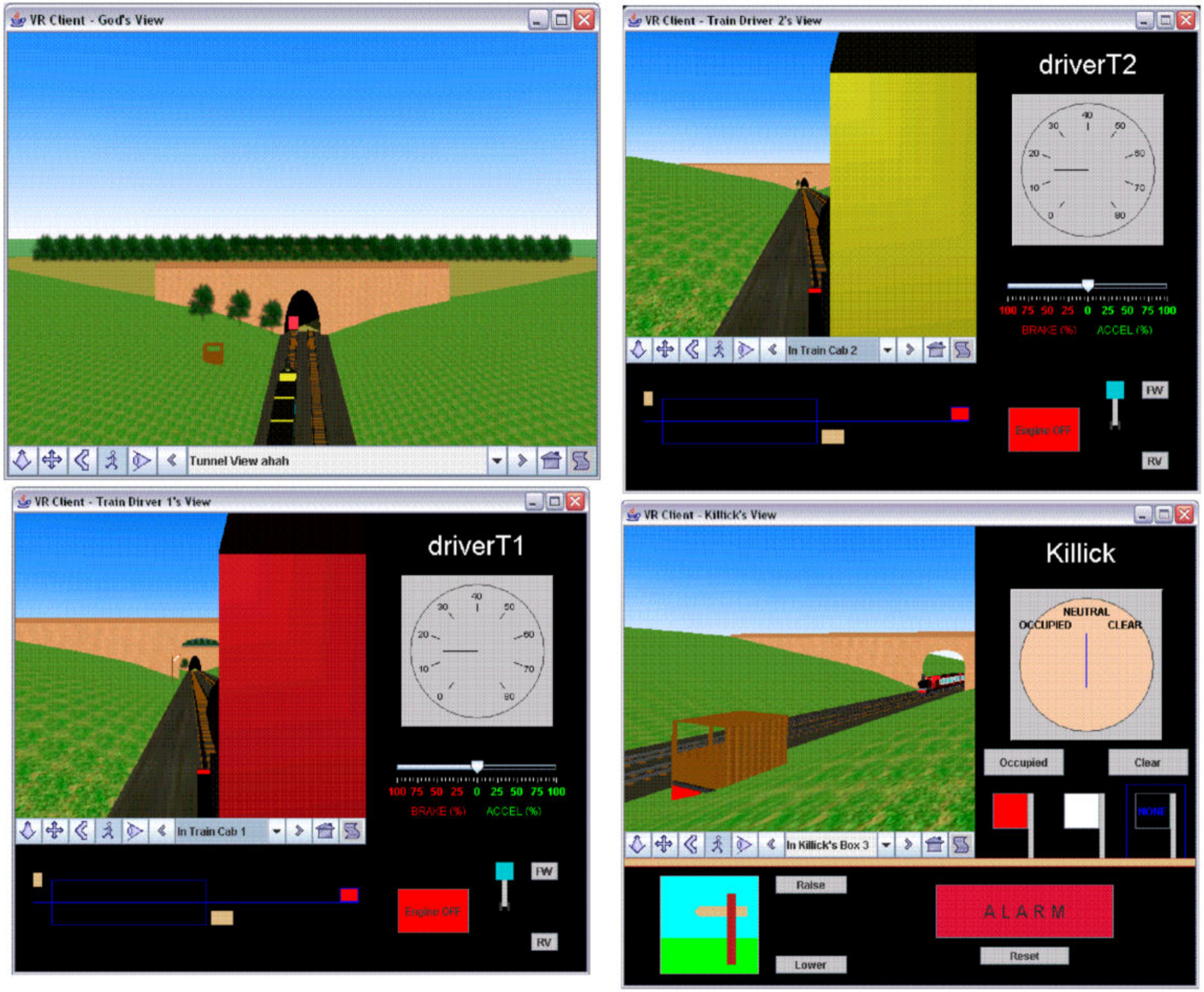


Process of Empirical Modelling (according to Beynon/Russ 1995)



Example of the empirical modelling of the Clayton tunnel problem by Eric Chan, 5-5-2005, (http://empublic.dcs.warwick.ac.uk/projects/claytontunnelChan2005/)

Substance ontology versus Process ontology

Paradox of substance:

Which qualities does the carrier of all qualities, the substance, have?

Paradox of change:

How is a qualitative change of an object possible if the object is determined by self-identity?

Substance paradigm ("*Substance axioms")*	*Process paradigm* ("*Process axioms")*
Principle of independence: Only objects exist independently of other entities: Only objects are individuals.	***Principle of dependence:*** Objects are dependent entities
Principle of singleness: Individuals do not appear repeatedly.	***Principle of multiplicity:*** Individuals can appear repeatedly.
State model of change: Change is the change of qualities.	***State model of change:*** Change is a basic category; states and qualities are defined by changes.
Count nouns: Varieties of things, states and events are described by count nouns (e.g. four chickens).	***Mass terms:*** Varieties off substances, qualities and activities are described by mass terms (e.g. a little chicken).
…	…

3. How applied mathematics is possible?

On the way to Techno-Mathematics

The reply to the question „How applied mathematics is possible?" aims

- at the conditions of the possibility of an applied mathematics,
- at the historically developing conditions of the reality (the establishment) of techno-mathematics,

therefore

- at the development inner- as extra-mathematical needs for a techno- mathematics

as well as

- at the deployment of the inner- and extra-mathematical means of the increase of the potential of techno-mathematics.

Pre-idea of mathematics:

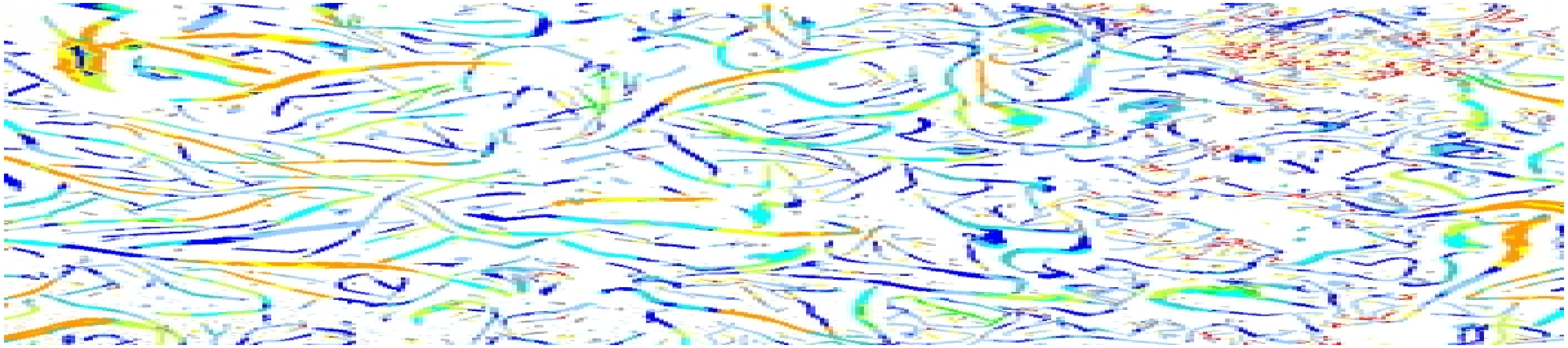
Mathematics is the science of the (think)possible with language means largely formalizable structures of (objectively) possible structures of the reality.

Mathematics is

- language,
- ideational technology,
- sience of ideational technology.

„No doubt: Mathematics has become a technology in its own right, maybe even a key technology. Technology may be defined as the application of science to the problems of commerce and industry."

(Helmut Neunzert 2004, Fraunhofer Institut für Techno- und Wirtschaftsmathematik Kaiserslautern)



Example for the applied mathematics at the ITWM:
Automated colour coded geometric classification of lamella graphite in grey cast iron.

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Rootedness of mathematics in life experience and myth - Mathematics as a *physical technology* and as a *cultural symbolism*

wooden tally stick

Nebra sky disk

“As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality.”(Einstein 1921)

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Poincaré about the Invention of the mathematical continuum

“We are next led to ask if the idea of the mathematical continuum is not simply drawn from experiment. …
But here is an intolerable disagreement with the law of contradiction, and the necessity of banishing this disagreement has compelled us to invent the mathematical continuum. We are therefore forced to conclude that this notion has been created entirely by the mind, but it is experiment that has provided the opportunity.” (1906)

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"Like material technology mathematics creates its basic principles (original concepts) from nature on the way of abstraction, changes them, combines them and creates a means for the theoretical control of the nature. *Mathematics can therefore be defined as 'ideational (non-material) technology'.*" (A.D. Aleksandrov 1972)

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Requirements of the technology studies in mathematics

Specific of the technology studies

Technical systems are bounded in an evolution connection with socio-technical systems.

In the scientific technology description and explanation have a close connection with evaluation and normalisation.

Technology presupposes the increasing usage of nature and humane science for the purpose of the technological synthesis of systems (under given restrictions).

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Mathematical system-synthesis instead of -analysis

Not the axiomatics forms the main emphasis of the cooperation of mathematicians and technicians "… but the solution of the technical system-synthesis with mathematical means. Here mathematics also profits. This particularly applies to the system synthesis, the main task of engineering science.

The synthesis of a system is substantially more difficult than the analysis and leads mathematically to inverse problems" (Lange 1976).

With the production on a scientific basis the need arose for mathematics,

- which permits the technical system-synthesis, -assessment and -optimization under complex consideration of the morphological, functional and scientific characteristics of technical creations.

- which allows to master all functions of technical systems as elements of socio-technical realm.

- whose human production activity helps to modify and to model in a technical way.

Mathematics had to make it possible to build models and calculation procedures, which are able to meet all requirements of the basic concepts of technical knowledge in a practically adequate way.

The problem of the application of mathematics in technology:

The technician "*does not only have to guarantee the technical one but also the commercial success.* He must produce as cheaply as possible. Frightened he notices that the practice does not let the time for a systematic examination."

(A. Stodola, First International Congress of Mathematicians, 1898)

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On the way to the academic institutionalisation of the applied mathematics

Carl David Tolmé Runge
(1856-1927)

Felix Klein
(1849-1925)

Main trends of the development of the mathematics within the last 100 years:

- **Increasing orientation of mathematics towards the control of complex, dynamic and integral connections.**
- **Expansion of the traditional principle- and model-competence of mathematics.**

Catchwords:

- **from the local to the global,**
- **enlargement of dimensions,**
- **from the commutative to the not commutative,**
- **from the linear to the nonlinear,**
- …

(corresponding to Sir Michael Francis Atiyah 2003)

The role of mathematics for technology in terms of recognition

(1) Mathematics as an auxiliary science;
(2) mathematics as an integration science;
(3) mathematics as an initiative science;
(4) mathematics as a restructuring science.

The role of the mathematics for technology in terms of design

The mathematical modelling is the mediator between mathematics and applications.

Primary objectives of mathematical modelling after Kaiser (1977):

1. **Problem of analysis:**
   With mathematical means has to be determined the behaviour of a material system under certain conditions.

2. **Problem of synthesis:**
   By use of mathematics has to be find that system from a set of possible systems which realizes a predefined behaviour as well as possible.

3. **Problem of (re)connaissance:**
   The concrete structure of a material system has to determine as exactly as possible by its signalized behaviour in the context of a reconnaissance hypothesis.

Models in applied mathematics:

A mathematical model is an operational and relational as faithful as possible mapping of an usually only implicit or fuzzy given empirical structure onto an as simple as possible mathematical structure. It pursues the purpose, with regard to certain questions in a limited and not always clearly outlined scope to recognize, analyse, describe, influence and forecast the original structure on the detour via the mapped structure. (after Jaeger/Wenke 1969)

Alogisms arising from the demand for optimality and manageability of the mathematical model

- **conclusion by analogy and transgression of original scopes;**
- **"Proof" of general connections at special cases;**
- **Application of solutions in cases at which the corresponding theorems of existence and uniqueness are not proved yet;**
- **Non-local use of results of local studies;**
- **Use of numeric procedures in the case of unproven convergence;**
- **Use of results of an approximate computation when missing a satisfactory error estimation;**

(cf . Blechman/Myschkis/Panovko 1984).

The applied mathematician is an experimental mathematician in the fields of mathematics and its applications.

"**The mathematician must work as an artist". (Poincaré 1906)**

Modelling is a synthetic process whose combinational power can not be handled with general descriptive knowledge but necessarily includes imagination, intuition and contingency.

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Thanks for Your attention