The case for normware

21 February 2025, *Uppsala Vienna AI Colloquium*

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Socially Intelligent Artificial Systems (SIAS),
Informatics Institute, University of Amsterdam

Prologue:
on the continuity between institutions and computations

Sileno, G., Of duels, trials, and simplifying systems, European Journal of Risk Regulation (2020).

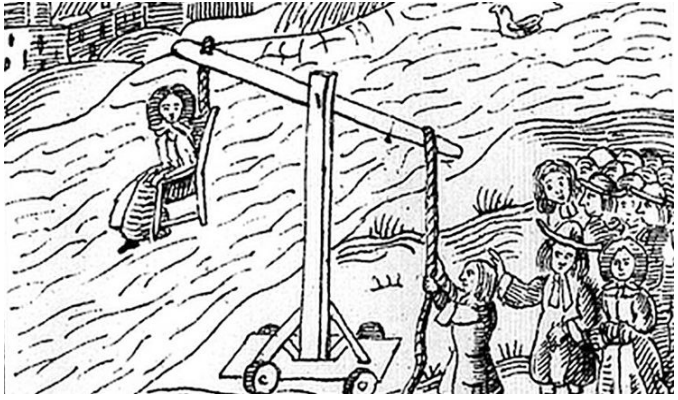
Ordalia or the “judgment of God”

In medieval times, juridical disputes that could not be or were willingly not regulated by human means were solved by calling for the “the judgment of God”.

Two main types:

- **unilateral**, e.g. proof of water, of fire, of bread
- **bilateral**, or judicial duel

Ordalia or the "judgment of God"



water ordeal

fire ordeal

"If you are innocent,
God will save you"

boiling water ordeal

Ordalia or the "judgment of God"

host *or* **altar bread** ordeal

an interesting variation:

"If you are guilty,
God will chock you"

Ordalia or the "judgment of God"

"If you are innocent,
God will make you win"

Ordalia or the "judgment of God"

"If you are innocent,
God will make you win"

Detailed process (*arbiters, choice of weapons, rules of attack*). Once set, the duel it is just a matter of **execution**.

Ordalia or the "judgment of God"

"If you are innocent,

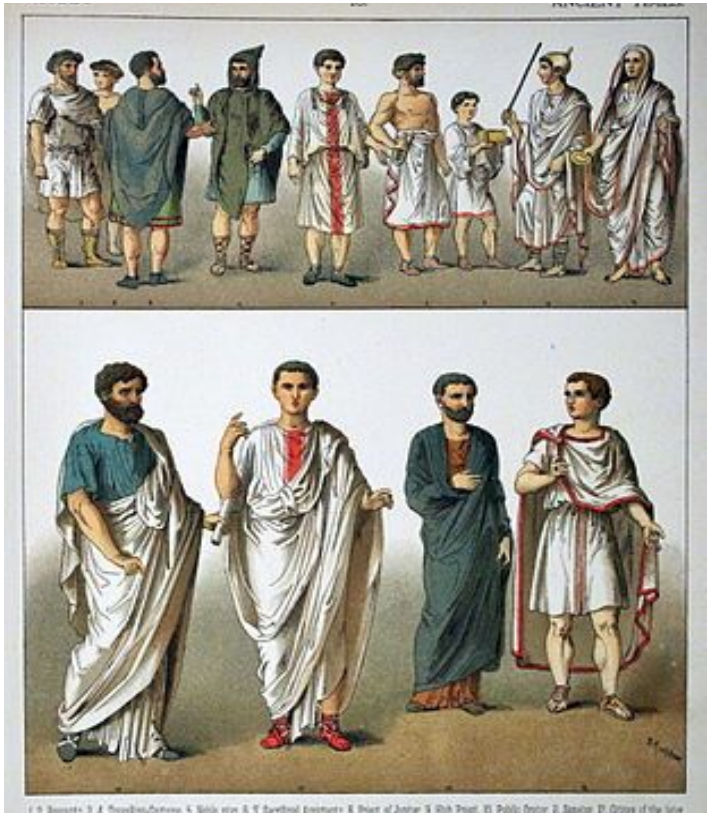
Detailed process (*arbiters, choice of weapons, rules of attack*). Once set, the

fast to set, prompt response, clear (and definitive) result

Trials, eg. *per formulas*

In Roman times:

- parties were required to be in front of a *magistratus*
- the *magistratus* led the parties to write a *formula*, representing adequately the dispute and providing a “judgment template”
- a private judge gave judgment following the formula



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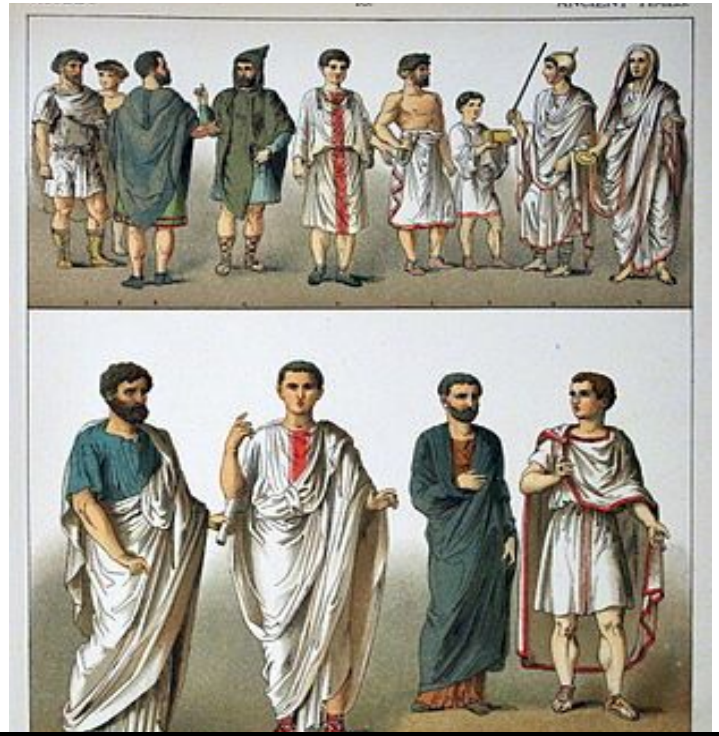
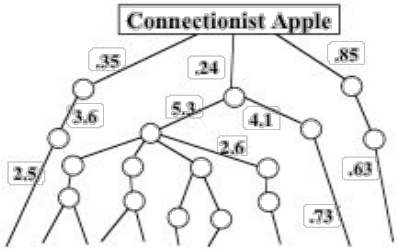


slow to set, but verbalized and written, might be not definitive

AI?

AI?

sub-symbolic AI



APPLE

AI?

associationistic methods:
neural networks, deep learning, gen AI

sub-symbolic AI

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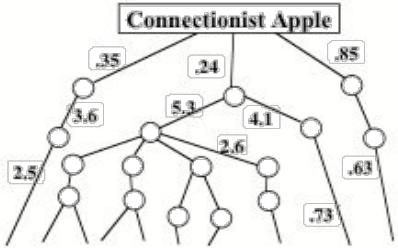

AI?

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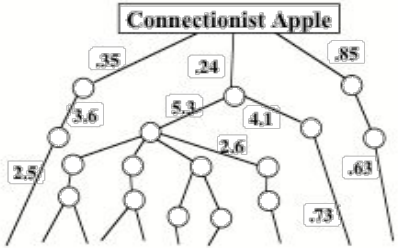

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Tacit
Graded, Fast
Automatic

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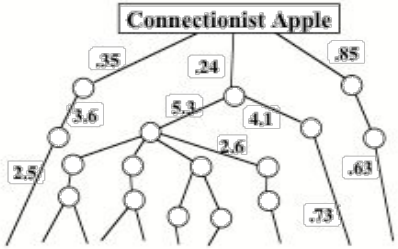

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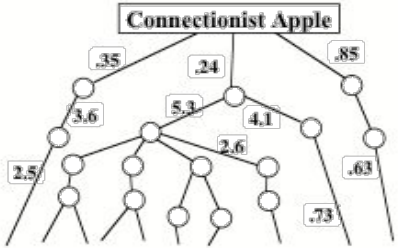

unintelligible

If the model has been already trained

fast to set, prompt response, clear (and definitive) result

AI?

. . .

. . . ROUND

. . . RED SWEET

. . . FRUIT

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symbolic AI

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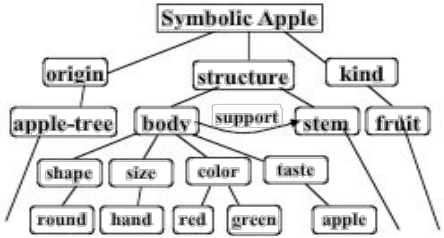

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logic-based methods,
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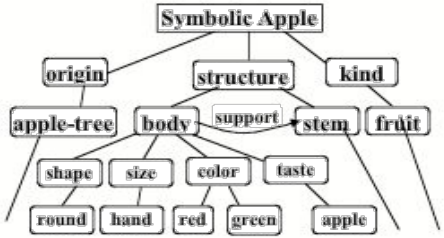

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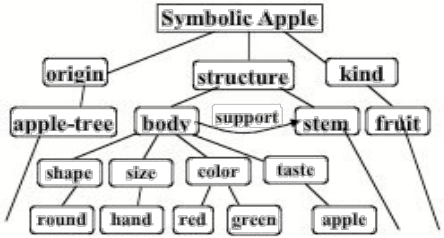

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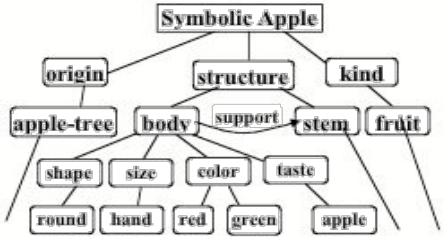

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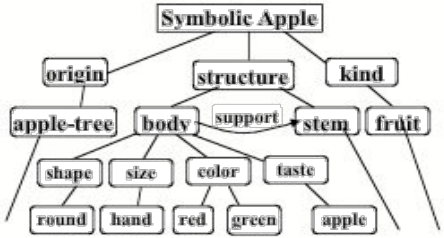

Explicit, Crisp
Less-Fast
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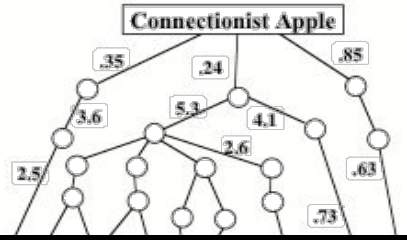
intelligible

If you bring new evidence/rules

You have to write down all evidence/rules

slow to set, but verbalized and written, might be not definitive

Computational vs Institutional systems?



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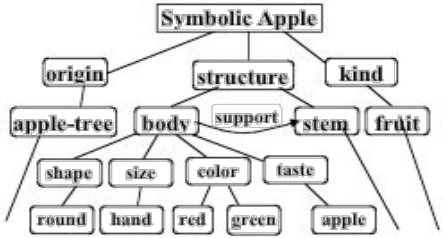

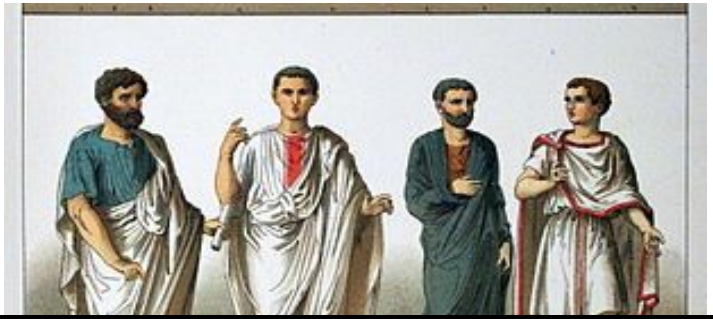

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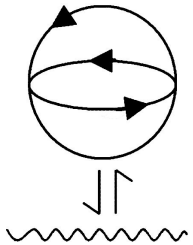

One way to understand this correspondence is by remounting to the concept of systems…

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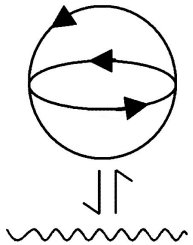

In open settings, any system experiences at some point increases of complexity

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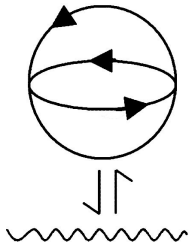

In open settings, any system experiences at some point increases of complexity

roughly: proportional to number of system failures

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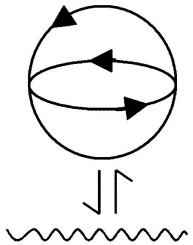

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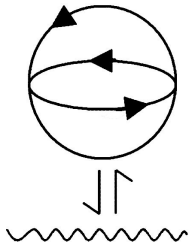
roughly: proportional to number of system failures

The system either:

- simplifies the environment, or, more in general,
- finds a simplified informational niche, or
- increases its internal complexity, or
- eventually collapses.

Heiner, Ronald A. "The origin of predictable behavior." *The American economic review* 73.4 (1983): 560-595.

Simplifying systems



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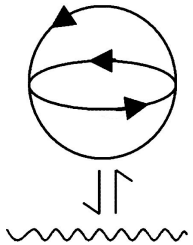

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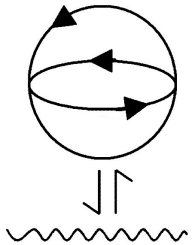

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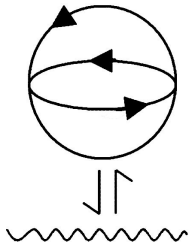
to facilitate interactions (reducing failures, or enabling prompt response to them)

Simplifying systems



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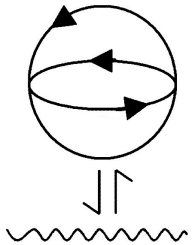
The system either:

- finds a simplified informational niche ← **Ordeals**
  ← **Institutional procedures**
- increases its internal complexity ← **Humans in the loop (judges, legislative bodies, ..)**

Simplifying systems



In open settings, any system experiences at some point increases of complexity
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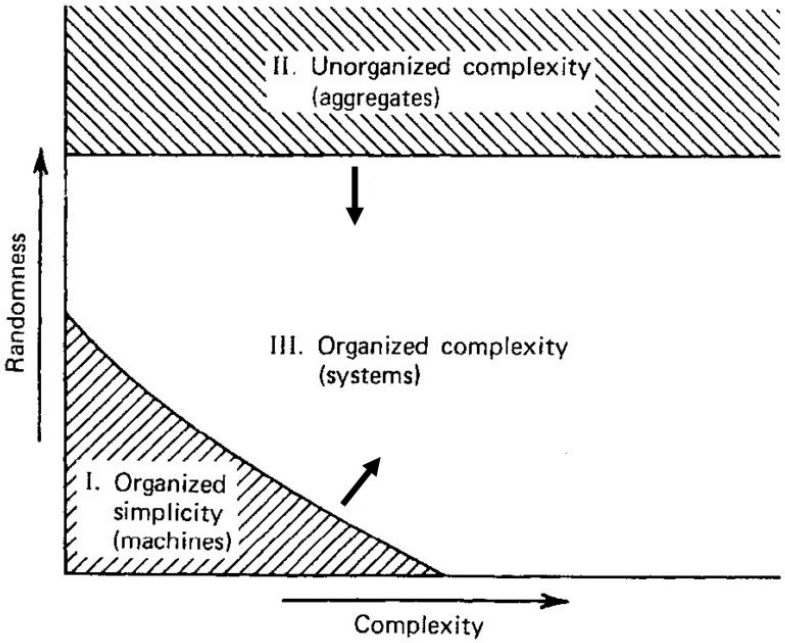
The system either:

- finds a simplified informational niche ← **Machine-learning AI**
  ← **Rule-based AI**
- increases its internal complexity ← **Humans in the loop (users, designers, ..)**

Computational and institutional systems are both information-processing systems promoting some form of "order" in the world!



VanRoy 2009,
Weinberg 1977

Part I:
types of “law”,
and a more nuanced distinction

text-driven law **data-driven law** **code-driven law**

Hildebrandt, M., Code Driven Law. Scaling the Past and Freezing the Future, In: Is Law Computable? Critical Perspectives on Law and Artificial Intelligence, eds. Markou, Deakin, Hart Publishers (2020)

text-driven law **data-driven law** **code-driven law**

legal activity performed by humans by means of sources of norms such as statute and case law

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open-textured concepts
multi-interpretability
→ **it can be contested**

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legal certainty +
justice (proportionality, distribution, …) **?**
instrumentality (contextual policy goals) **?**

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COMPUTATIONAL LEGALISM

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in so far humans are involved

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decision support systems

derived from statistical/inductive methods

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TRAINING DATASET

instance + label
instance + label
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is the rationality behind labeling still the same?

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is the training method producing adequate, reproducible, robust results?

TRAINING METHOD

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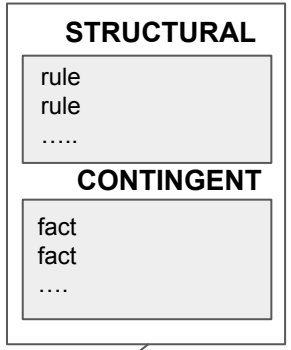

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were all the relevant rules considered?
were all the relevant facts given?
is the formalization correct?
is the reasoning tool robust?

STRUCTURAL

rule
rule
.....

CONTINGENT

fact
fact
....

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automatic decision-making

data-guided law

decision support systems

derived from statistical/inductive methods

code-driven law

legal norms or policies that have been articulated in computer code

were all the relevant rules considered?
were all the relevant facts given?
is the formalization correct?
is the reasoning tool robust?

STRUCTURAL

rule
rule
.....

CONTINGENT

fact
fact
....

legal certainty +
justice (proportionality, distribution, …) **?**
instrumentality (contextual policy goals) **?**

statistical closure

logical closure
→ **it can be contested**

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is this all?

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(cf. discussions on universal human rights, ethical frameworks)

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(explicit articulation of policy-maker purposes)

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including computational actors
possibility of **continuous, automated testing/verification**

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monolithical systems

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ecological system including interfaces with humans

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a serious technological gap exists today...

Part II:
what is normware?

A tentative ontology

HARDWARE

- **physical device**
- when running
  ⇒ **physical process**
- situated in a
  physical environment

SOFTWARE

- **symbolic device**
- when running
  ⇒ **symbolic process**
- relies on
  physical processes

A tentative ontology

HARDWARE

- **physical device**
- when running
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- situated in a
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SOFTWARE

- **symbolic device**
- when running
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- relies on
  physical processes

NORMWARE

- **?**
- when running
  ⇒ ?
- relies on **?**

A tentative ontology

?

HARDWARE	SOFTWARE	NORMWARE	
• **physical device**	• **symbolic device**	• **?**	**ARTIFACT dimension**
• when running **⇒ physical process**	• when running **⇒ symbolic process**	• when running **⇒ ?**	**PROCESS dimension**
• situated in a **physical environment**	• relies on **physical processes**	• relies on **?**	

Normware as artifacts…

Normware as artifacts:
1. directives concerning regulation

the cookie jar
must be full

you are prohibited
to eat cookies

you can not eat
cookies

Normware as artifacts:
1. directives concerning regulation

aiming to regulate situations in the world

the cookie jar must be full

aiming to regulate behaviour

you are prohibited to eat cookies

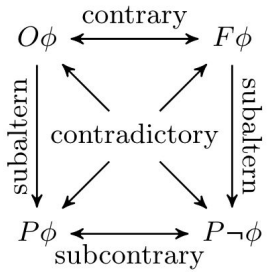
you can not eat cookies

Normware as artifacts:
1. directives concerning regulation

we can have explicit normative specifications…

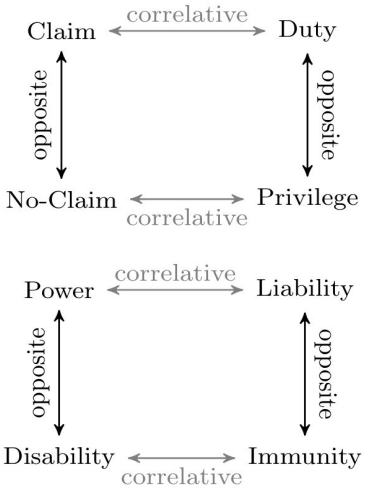
```
Order Deny,Allow
Deny from all
Allow from example.org
```

access-control policies



languages based on deontic logic

languages based on Hohfeld's primitives



Normware as artifacts:
1. directives concerning regulation

but programs in themselves
are already mandatory in nature!

`a := 2 + 2`	computer ***has*** to perform 2 + 2…
`?mother(maggie, bart)`	computer ***has*** to prove that…
`animal :- dog.`	computer ***has*** to make animal true if dog is true

Normware as artifacts:
2. directives concerning terminology/meaning

what is a cookie?

what is a jar?

the cookie jar must be full

what does it mean to be full?

who is you?

what is eating?

you are prohibited to eat cookies

you can not eat cookies

Normware as artifacts:
3. directives concerning expectations

eating cookies → cookies are destroyed → the jar is not full

the cookie jar must be full

practical **normative reasoning always require some world knowledge**

you are prohibited to eat cookies

you can not eat cookies

Normware as artifacts:
4. devices intended to regulate

behaviour can be regulated even if we do not have access to the inner decision-making mechanism!

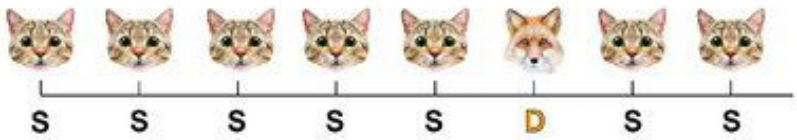
doors regulate entrances

semaphores regulate traffic

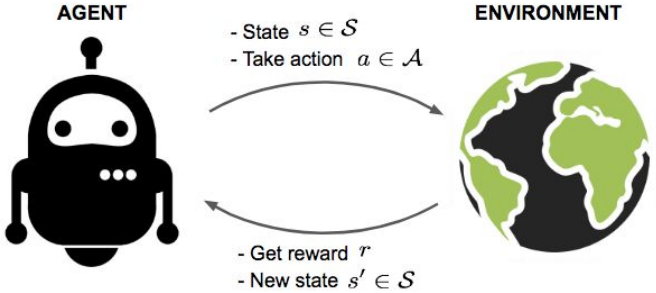
Normware as artifacts:
4. devices intended to regulate

black-boxes (eg. ML models) are also artifacts expressing some form of normativity/normality

"is this a cat?"



"how to (best) behave in certain conditions?"



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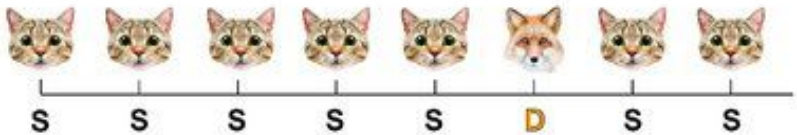

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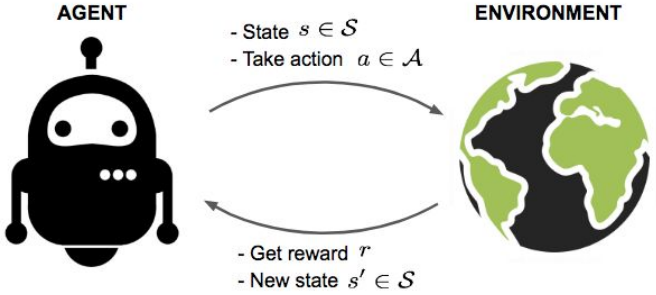


from a functional point of view, they also count as normware!

Normware as processes

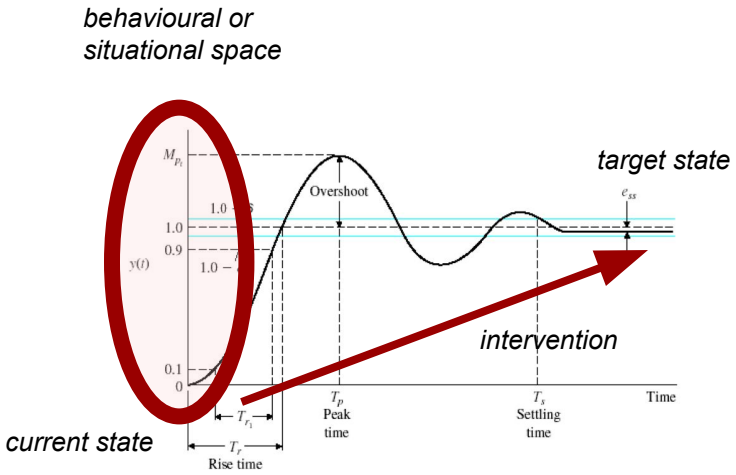
Normware as processes:
1. regulation as control

Whether artificial or natural, designed or emergent,

what counts in control is

- the existence of some ***reference*** (the **target** of control),
- which the entity is set to either *approach* or *avoid* (the **direction** of control).

Normware as processes:
1. regulation as control



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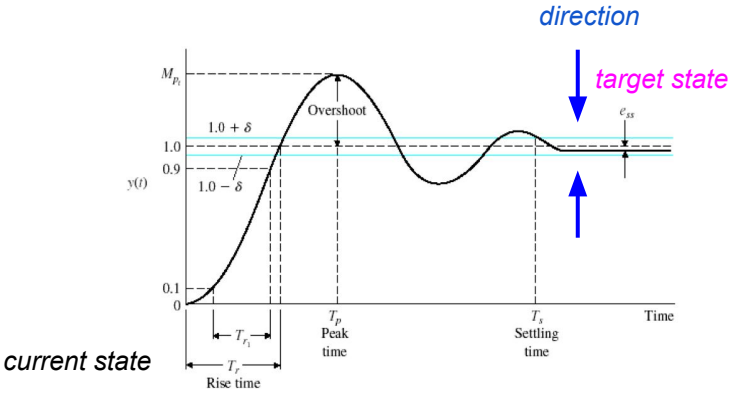

Whether artificial or natural, designed or emergent,

what counts in control is

- the existence of some ***reference*** (the **target** of control),
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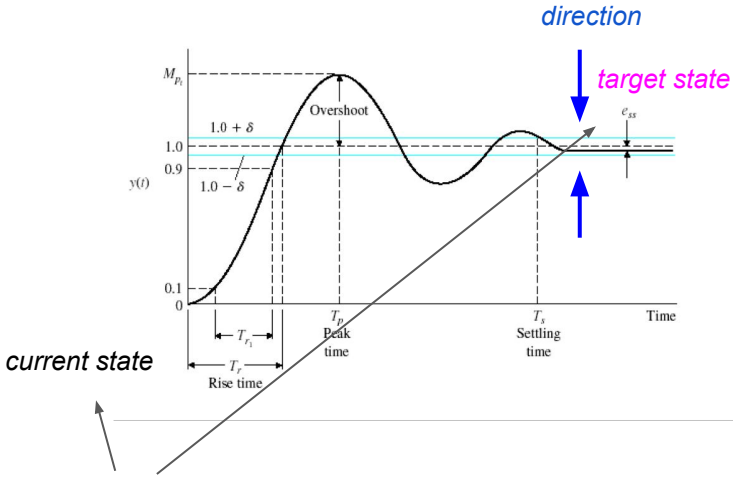
by defining directives by this control signature (target, direction), any regulative mechanisms can be abstracted from its implementation.

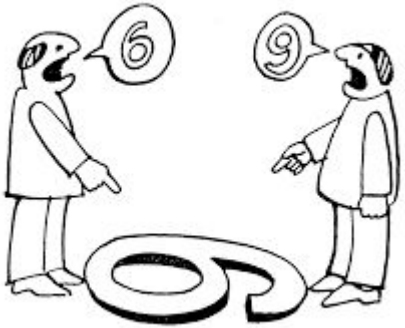
Normware as processes:
1. regulation as control



what defines the references though?

Normware as processes:
2. higher-order indetermination

indeterminacy of references



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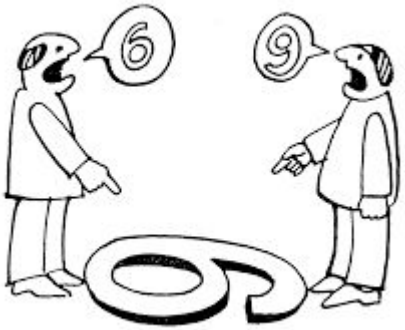
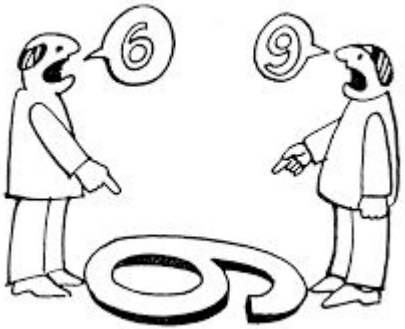


indeterminacy of directives

Normware as processes:
2. higher-order indetermination

indeterminacy of references

antinomies



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Normware as processes:
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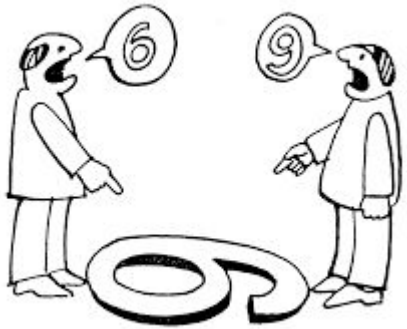
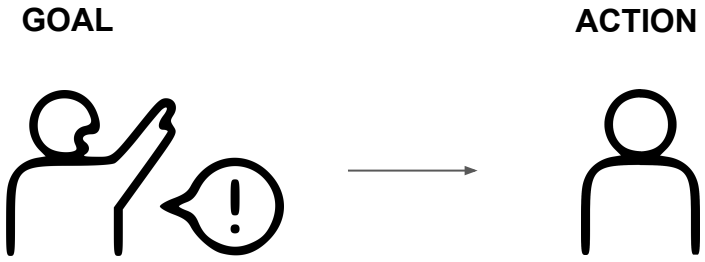


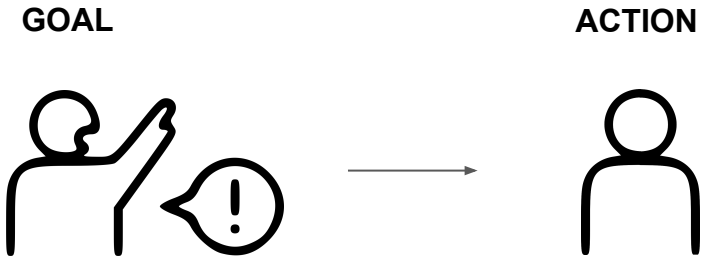
indeterminacy of directives

mechanisms of conflict resolution
are needed at systematic level!

Normware: first-order control



Normware: first-order control



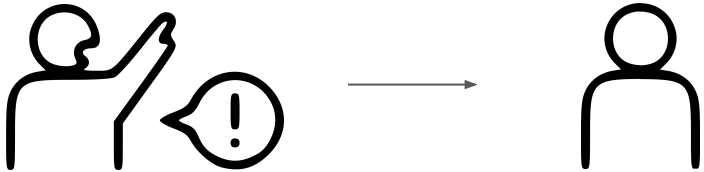
code-driven	instruction	operation
data-driven	labelled dataset	ML black box

Normware: first-order control

In both cases, some method has been used to select the action from a pool of actions based on the goal…

pool of actions

GOAL **ACTION**



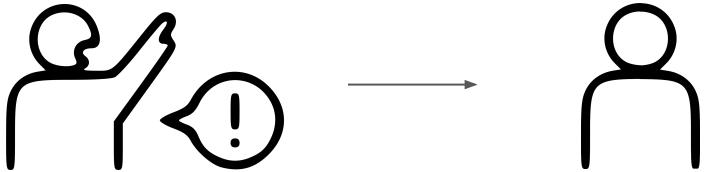
code-driven	instruction	operation
data-driven	labelled dataset	ML black box

Normware: first-order control

But then, where the goal comes from?

pool of actions

GOAL **ACTION**



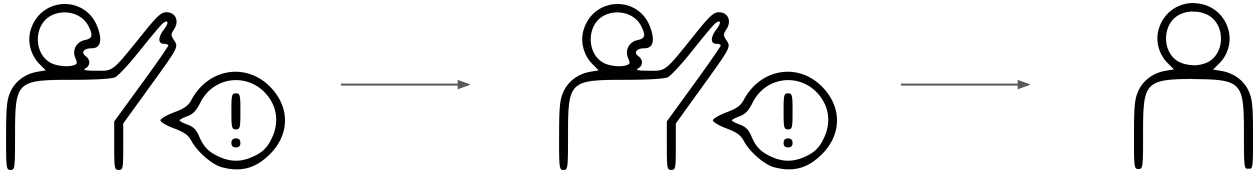
code-driven	instruction	operation
data-driven	labelled dataset	ML black box

Normware: second-order control

But then, where the goal comes from?
We add depth!

pool of actions

STRATEGIC GOAL → **TACTICAL GOAL** → **ACTION**



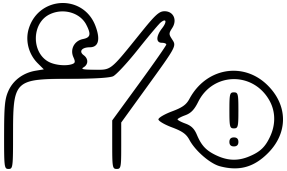
Normware: second-order control

But then, where the goal comes from?
We add depth!

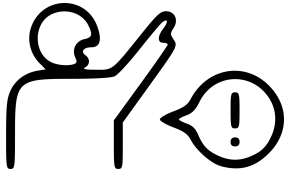
pool of goals

pool of actions

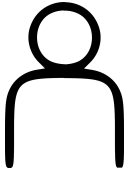
STRATEGIC GOAL



TACTICAL GOAL



ACTION



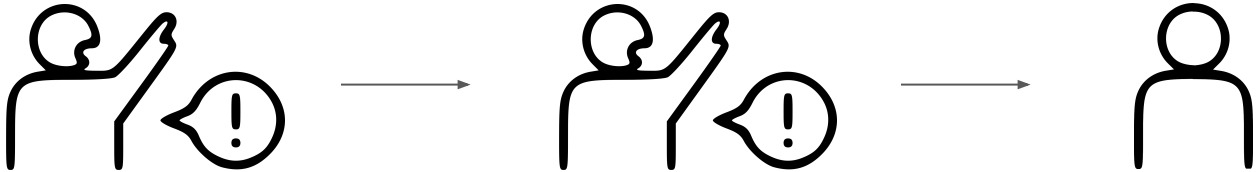
Normware: second-order control

But then, where the goal comes from?
We add depth!

pool of goals

pool of actions

STRATEGIC GOAL → **TACTICAL GOAL** → **ACTION**



trustworthy AI *and* ***explainable AI*** *issues in ML due to lack of the strategic component*

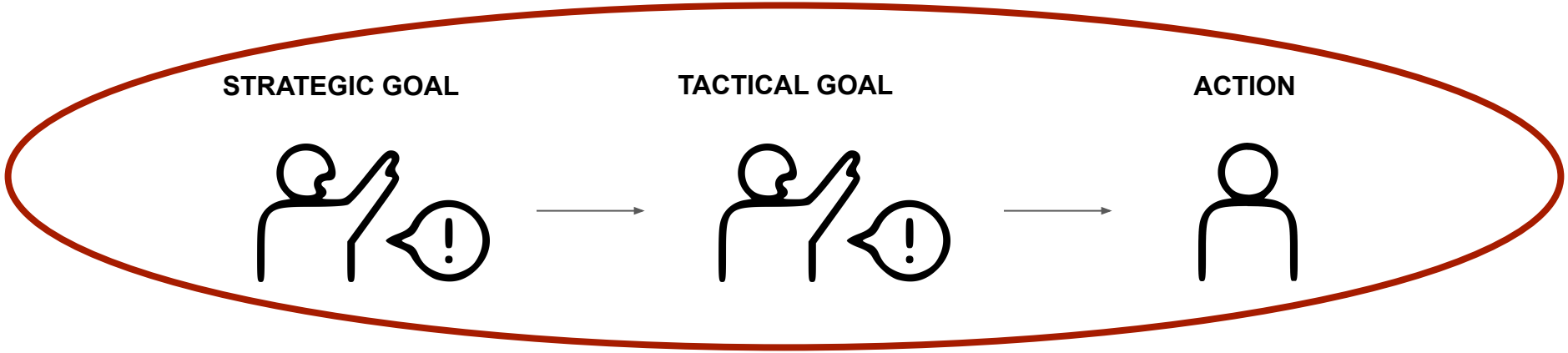
Sileno, G., Boer, A. and van Engers, T., The Role of Normware in Trustworthy and Explainable AI, Proceedings of XAILA workshop: Explainable AI and Law, in conjunction with JURIX 2018

Normware: second-order control

cybernetic view on systems: ***policy***, ***intelligence***, ***operations***

Normware: second-order control

cybernetic view on systems: ***policy***, ***intelligence***, ***operations***

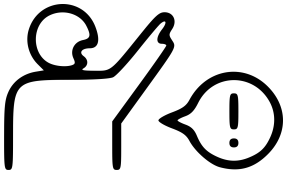


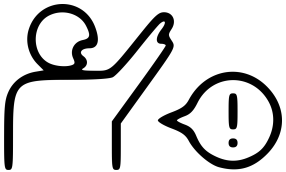
…yet it is about a single “organism”, not an “ecology”

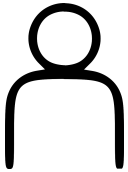
“TOTALITARIAN” architecture

Normware: plural second-order control

we need to acknowledge the presence of several ***autonomous entities****,*







Normware: plural second-order control

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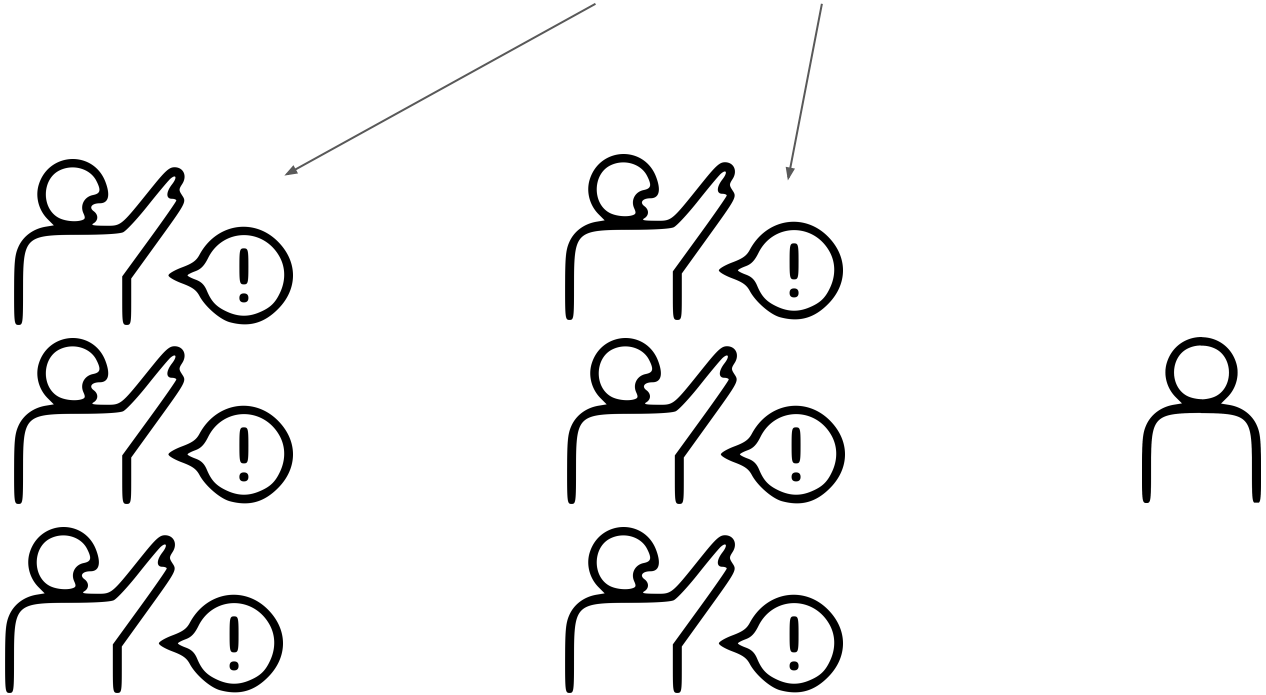
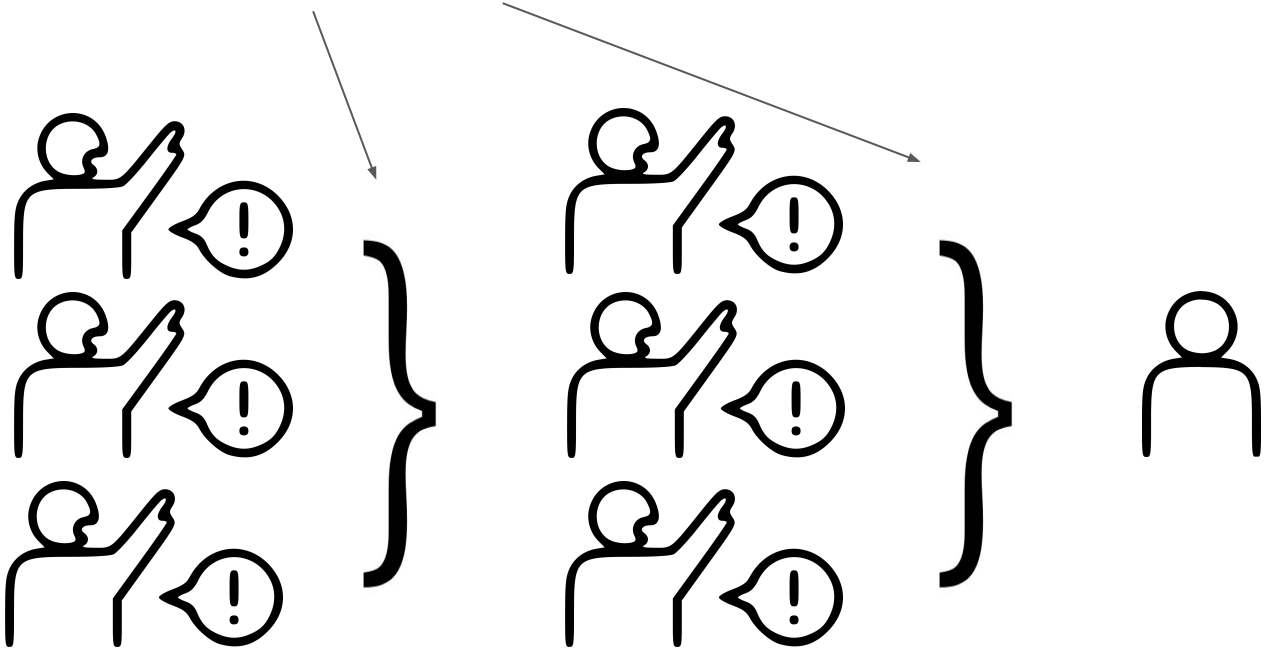


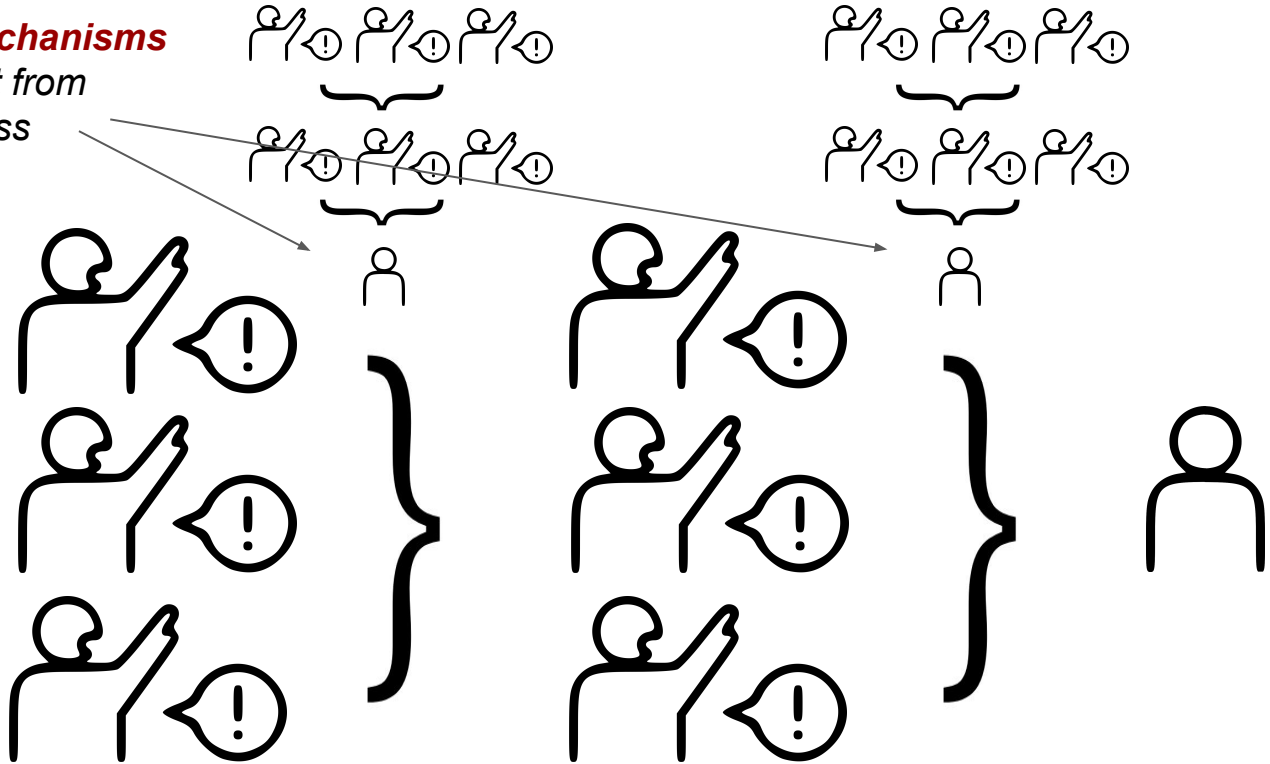
Normware: plural second-order control

we need to acknowledge the presence of several ***autonomous entities****,*
and adequate conflict ***resolution mechanisms***



Normware: plural second-order control

resolution mechanisms
may also result from
a similar process



Normware: plural second-order control

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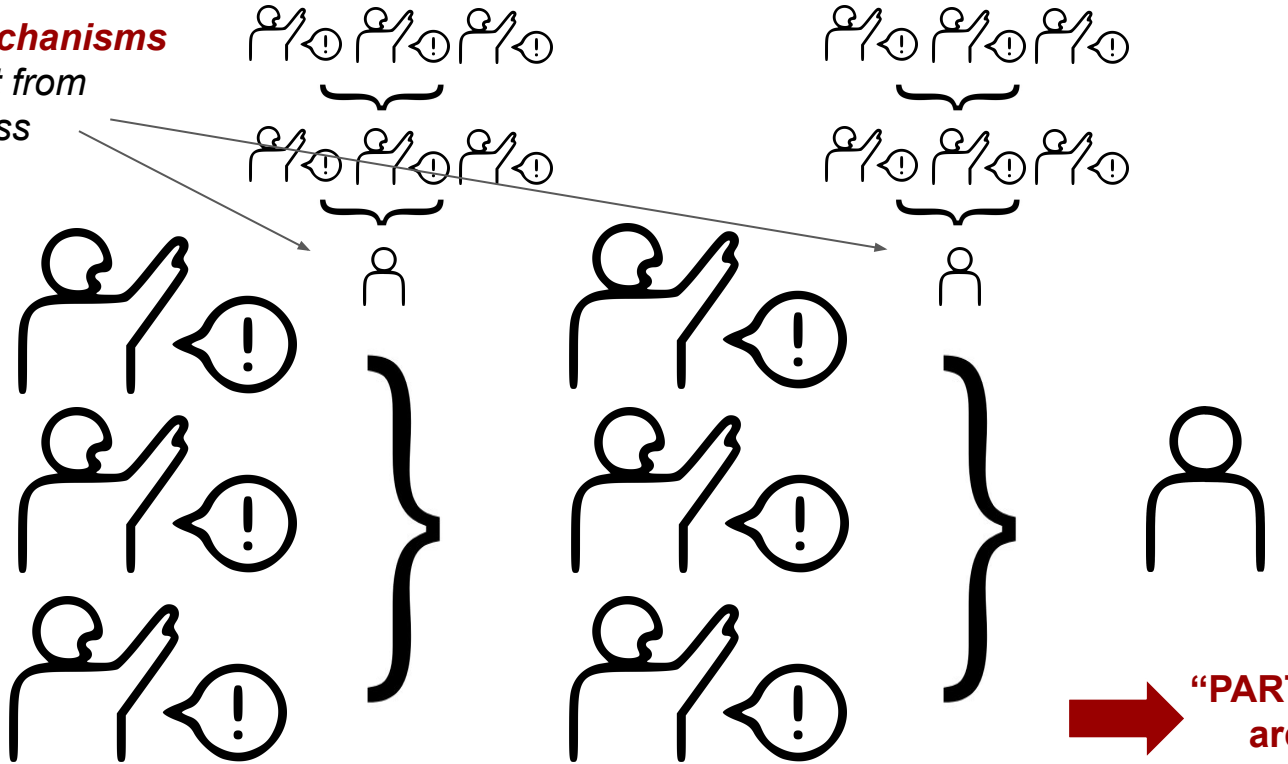

“PARTICIPATORY” architecture

Normware: plural second-order control

resolution mechanisms
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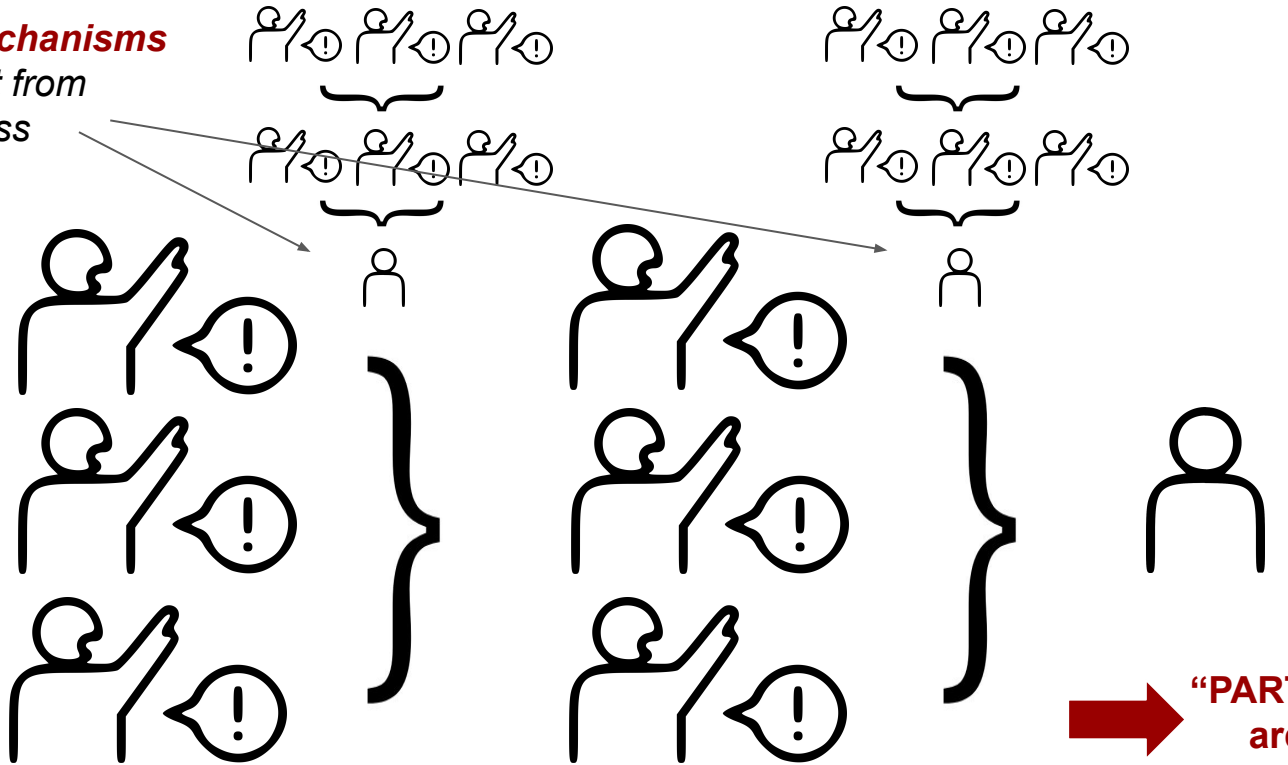
a similar process



“PARTICIPATORY” architecture

Sileno, G., Grosso, P., Accounting Value Effects for Responsible Networking. Proceedings of ACM SIGCOMM 2021 Workshop on Technologies, Applications, and Uses of a Responsible Internet (TAURIN2021).

A less tentative ontology

?

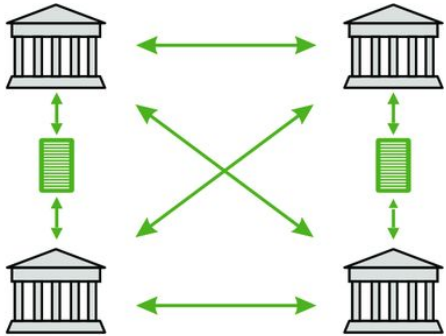
HARDWARE	SOFTWARE	NORMWARE
physical device	**symbolic device**	**coordination device**
when running ⇒ **physical process**	when running ⇒ **symbolic process**	when running ⇒ **coordination process**
situated in a **physical environment**	relies on **physical processes**	relies on **symbolic** (possibly hard-coded) **processes**

from individual devices...

from individual devices to digital social systems...

Social networks

Distributed Ledgers



Digital Markets

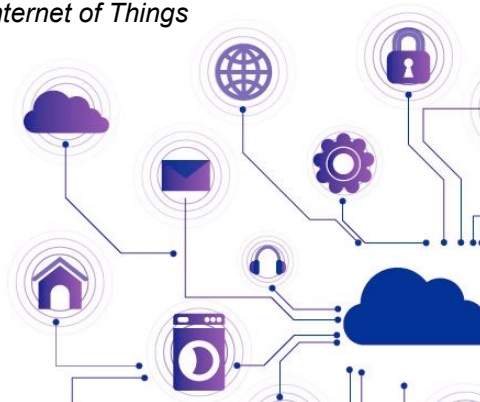
Internet of Things

from “mechanical” to “institutional” approaches to computation...

not *instructions,* but ***contracts***, ***regulations***, ***laws***...

Digital Markets

Internet of Things



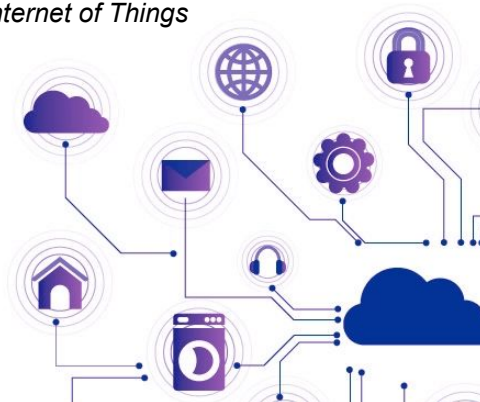
from “mechanical” to “institutional” approaches to computation...

not *instructions,* but ***contracts***, ***regulations***, ***laws***…

focus on PERFOMANCE → **focus on COORDINATING EXPECTATIONS**

Digital Markets

Internet of Things



overarching question

- Instead of relying on infrastructures ruled by single actors, we engage with challenges concerning:
  - how to design and deploy ***computational infrastructures***
  - in which **users may decide** and **enact their own policies**

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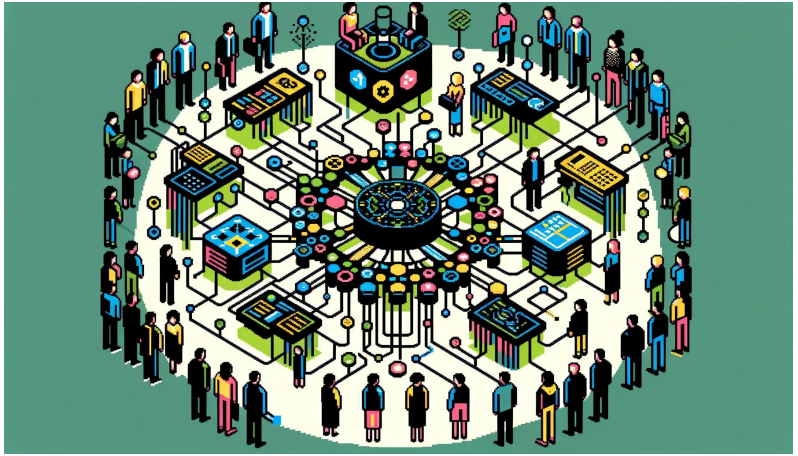
  - how to design and deploy ***computational infrastructures***
  - in which **users may decide** and **enact their own policies**

reusable components and mechanisms!

overarching motivation

- By enabling a pluralism of interactional mechanisms via “private” regulations, we make explicit the continuity holding between computational distributed systems and social systems.



This is relevant to ***responsible computing*** initiatives, concerning eg. responsible/participatory AI or responsible Internet.

Key points

- There is continuity between institutional and computational activities.
- We don’t need institutions to become more mechanical, institutional constructs need to be brought into the computational realm.
- As we have a plurality of normative sources & mechanisms, we need a plurality of computational normative sources & mechanisms.

→ **normware**

Contemporary socio-technical challenge:

NO mechanizing law

SI! introducing legitimate normative processes within the computational realm

Contemporary socio-technical challenge:

code-driven law

data-driven law

NO **mechanizing law**

law-makers, policy-makers, citizens, …

SI! **introducing legitimate normative processes within the computational realm**

normware

The case for normware

21 February 2025, *Uppsala Vienna AI Colloquium*

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