Matching of an Observed Event and Its Virtual Model in Relation to Smart Theories, Coupled Models and Supervision of Complex Procedures

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Observation-Modeling Duo

OBSERVATION LINK MODELING

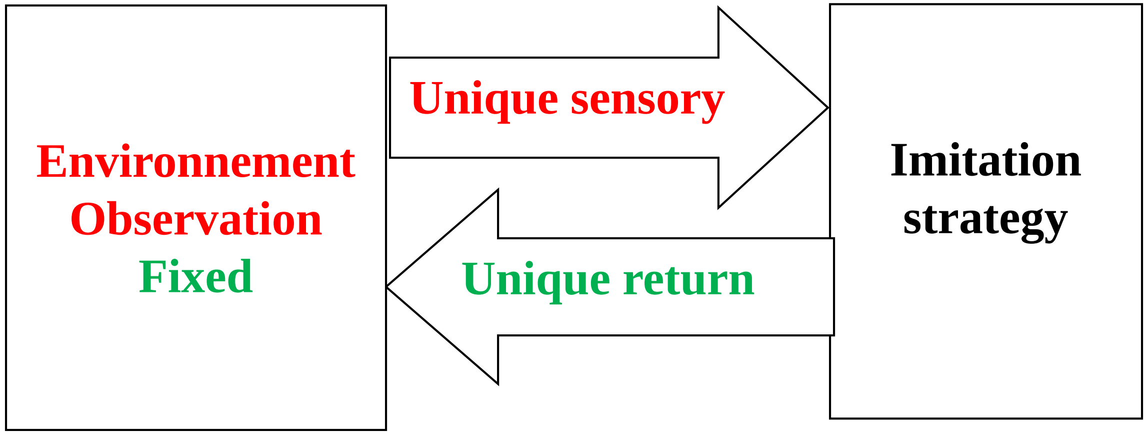
EXPERIENCE, MANIPULATION, OPERATION **THEORY, PREDICTION, IMITATION**

Uncertainty-Link-Capacities

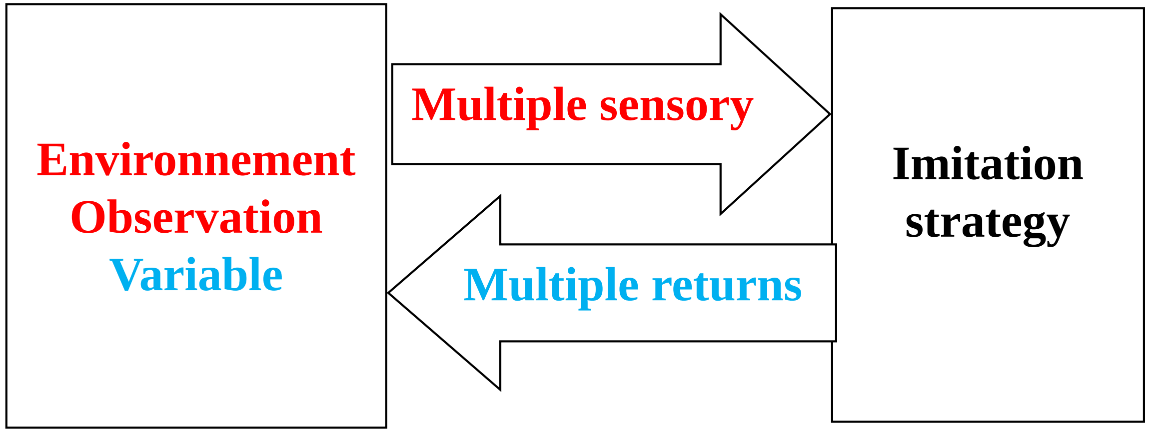
Camouflage (Bates, H. W. 1862)

Camouflaged & Dupe

Predator or Victim



Offline Matching
Static Target
(Unchanged)



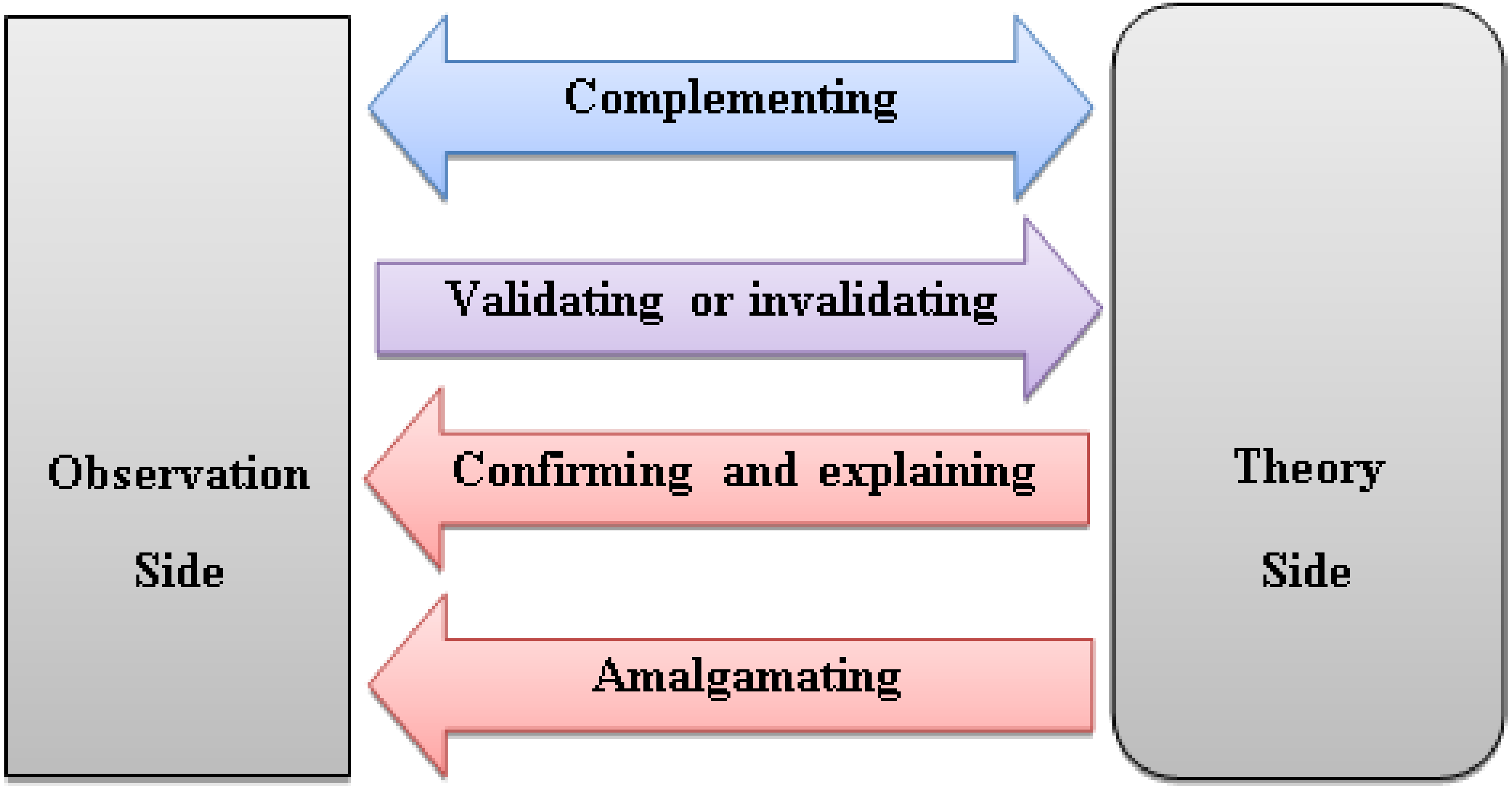
Online Matching
Dynamic Target
(Mutant)

****Observation-Theory Offline Matching**
Managing of Smart Theories

***Idealized Smart Theories**
and Complete Coupled Models

****Observation-Modeling Online Matching**
Supervision of Real Complex Procedures

MANAGING OF SMART THEORIES



Offline Matching

Complementarity of Observation and Theory

***Anthropology (e.g. myths) Observation alone**
(richness of memory- limited field of research)
Claude Lévi-Strauss (1908-2009) ,
Structural Anthropology, Paris 1958
<u>Observation needs modeling for deeper research!</u>

***In general, One can consider a theory only established after validation by observation. Moreover, Such a theory remains valid until disagreement with observation**
<u>Modeling needs observation, simply to be credible!</u>

Theory Generalizing and Amalgamating Observations

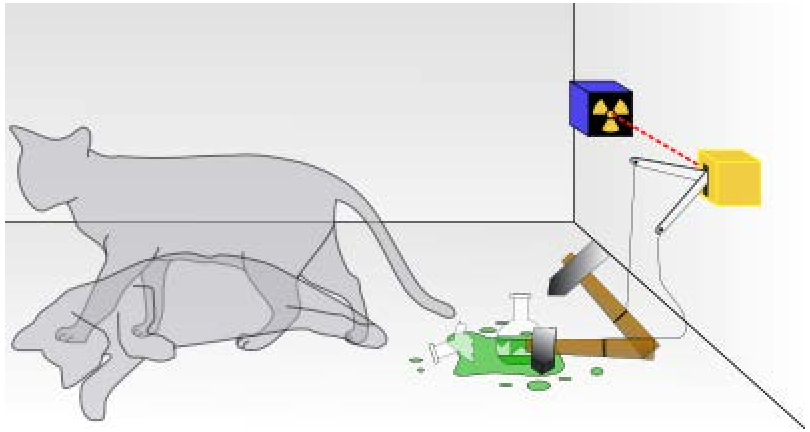
e.g. James Clerk Maxwell (1831-1879)
Unification of three experimental laws:

JCM- Carl Friedrich Gauss (1777-1855), relates ***d*** to ***q***
JCM- André-Marie Ampère (1775-1836), links ***h*** to d*d*/dt and ***j***
JCM- Michael Faraday (1791-1867), relates ***e*** to d*b*/dt

Union was only possible by introducing into an equation a lacking link (displacement current), guarantees the coherence of the integrated organization

Observation Validating or Invalidating a Theory

e.g. Superposition states



S Haroche& D Wineland 1996
(Nobel 2012) validated
E Schrödinger 1930 (Nobel 1933)
& Hall effect
E Hall 1879 invalidated (JC Maxwell 1873)

Observation Confirmed and Explained Later by Theory (Serendipity)

e.g. Superconductivity:
Kamerlingh Onnes (1853-1926) Nobel 1913

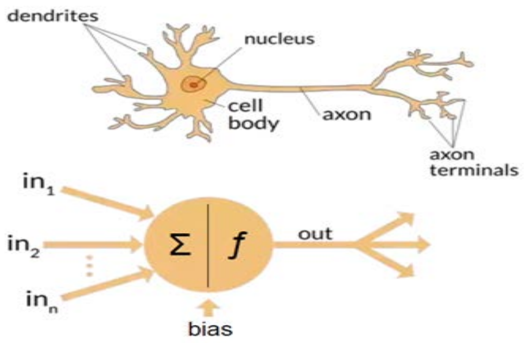
Innovative Computing Tools
Imitating Physical Paradigms

Quantum & Neuromorphic computing

Imitating reality: quantum physics & neurosciences:

Quantum: 2 states (0 &1) switched to 2k, with k energy levels - particle superposition states involving entanglement -
n-bit (one of 2n at time) n-qubit (2n simultaneously) ;
capacity, speed,…

Neuromorphic: ANN or BNN;
optimization, diagnostics, images,
machine learning, AI,…

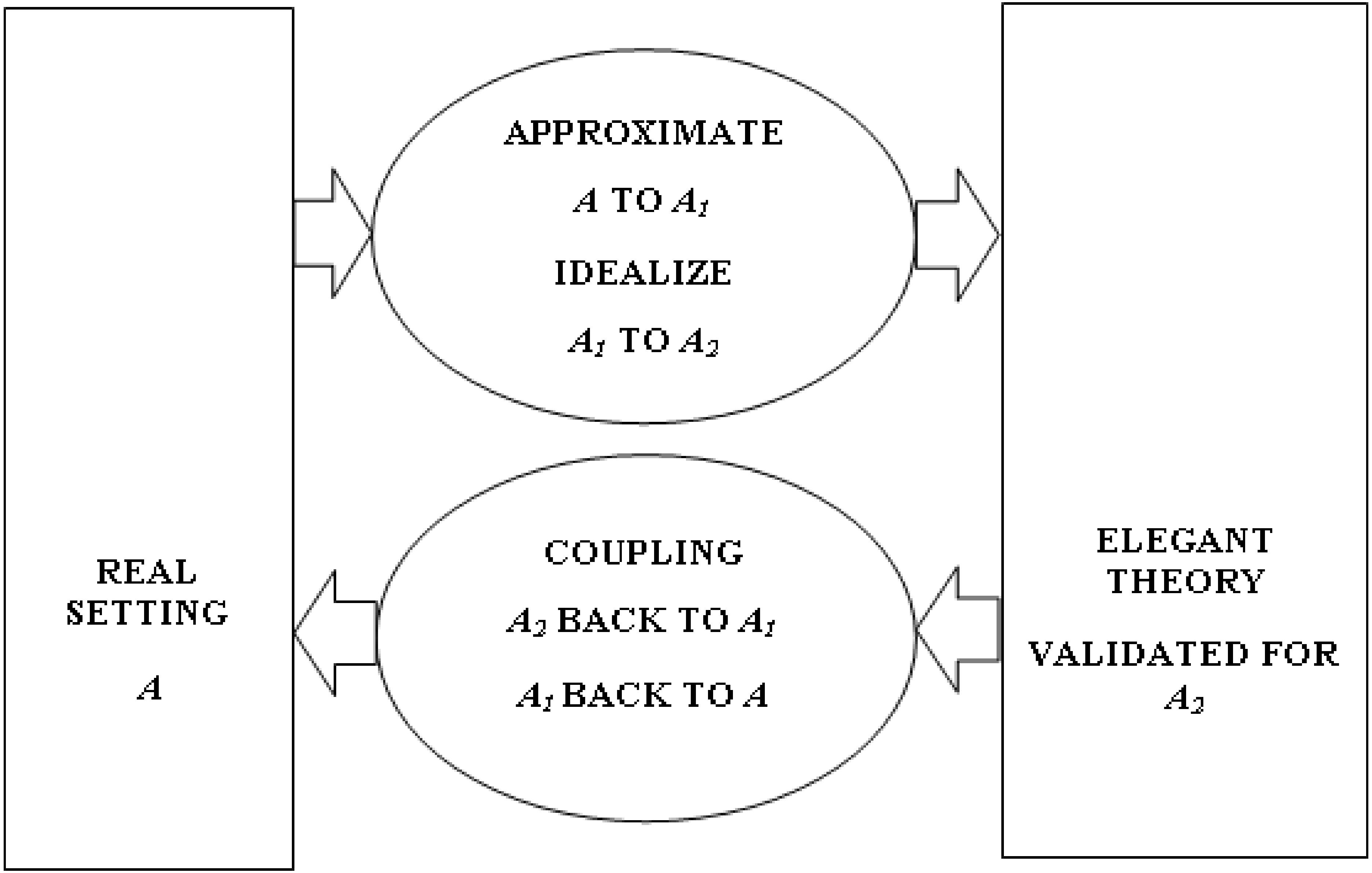


IDEALIZED SMART THEORIES AND COUPLED MODELS

Real A: B(x, y) ∪ C (y) ∪ D (z)….

A_1: B(*x, y*)

Smart A_2: B(x)


APPROXIMATE
A TO A_1
IDEALIZE
A_1 TO A_2
REAL SETTING
A
COUPLING
A_2 BACK TO A_1
A_1 BACK TO A
ELEGANT THEORY
VALIDATED FOR A_2

Coupling Characters

Phenomena P1 & P2

Behaviors B1, B2, B12 Linear / NLinear

Time constants T1, T2 Far/ Close

Limits

L + F ---------------------------- NL+ C

No----------W---------------------S

0 (B12)

Case of Electromagnetic and Energy Conversion Systems

$$\nabla \times \mathbf{H} = \mathbf{J}$$

$$\mathbf{J} = \sigma\, \mathbf{E} + j\, \omega\, \mathbf{D} + \mathbf{J_e}$$

$$\mathbf{E} = -\nabla V - j\, \omega\, \mathbf{A}$$

$$\mathbf{B} = \nabla \times \mathbf{A}$$

Couplings classification

• **Integrated Coupling**	**S**
$v = 1/C. \int i\, dt + r\, i + L.\, di/dt + d\Psi/dt + ȣ$	
• **Causal Couplings**	
EM and Mechanical Coupled Problem	**S**
EM and Thermal Coupled Problem	W
• **Material Intrinsic Couplings**	
Magnetostrictive (magnetic-mechanic),	**S**
Electrostrictive (electric-mechanic),	W
Shape-memory (thermic-mechanic),	W
Thermoelectric (thermic-electric).	W

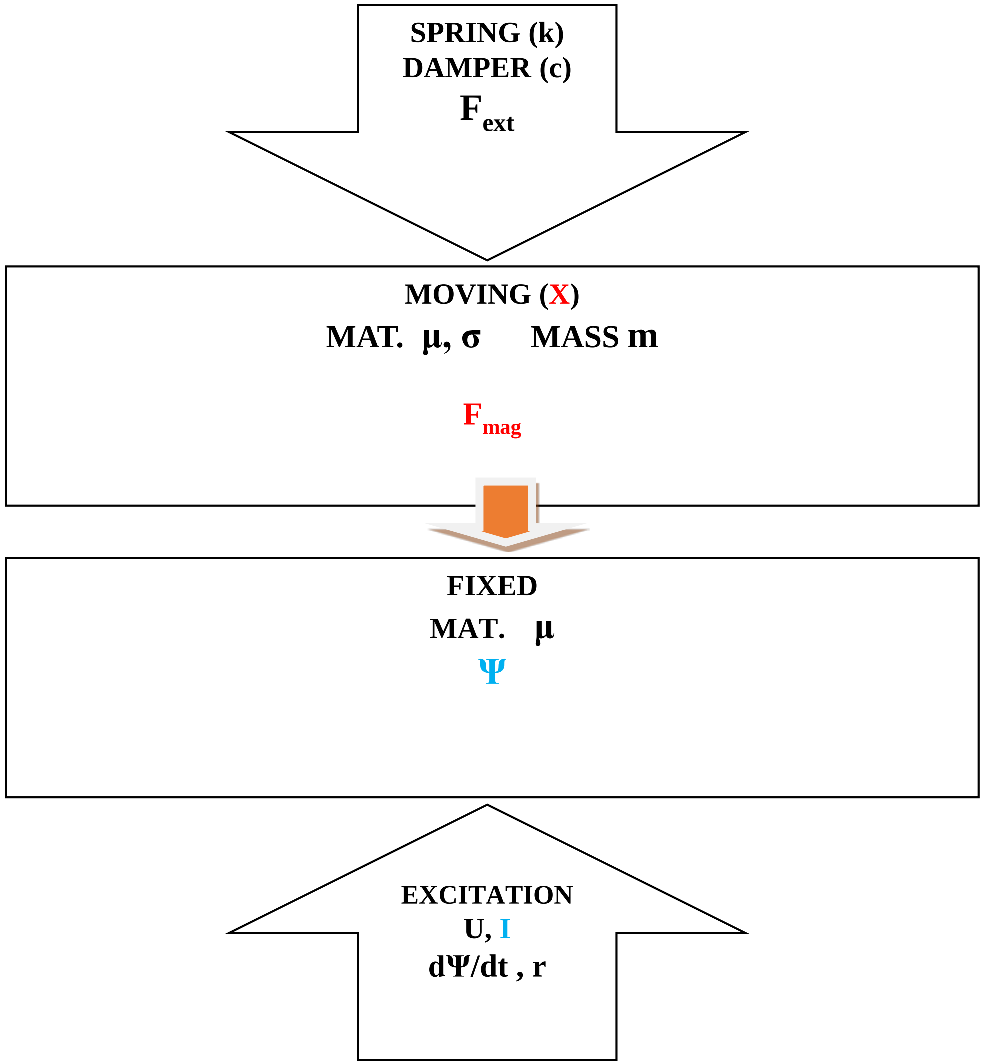
EM and Mechanical Coupled Problem

$$m. \, d^2 X/dt^2 + c. \, dX/dt + k\, X = F_{mag} + F_{ext}$$

$$d\Psi/dt + r\, I = U$$

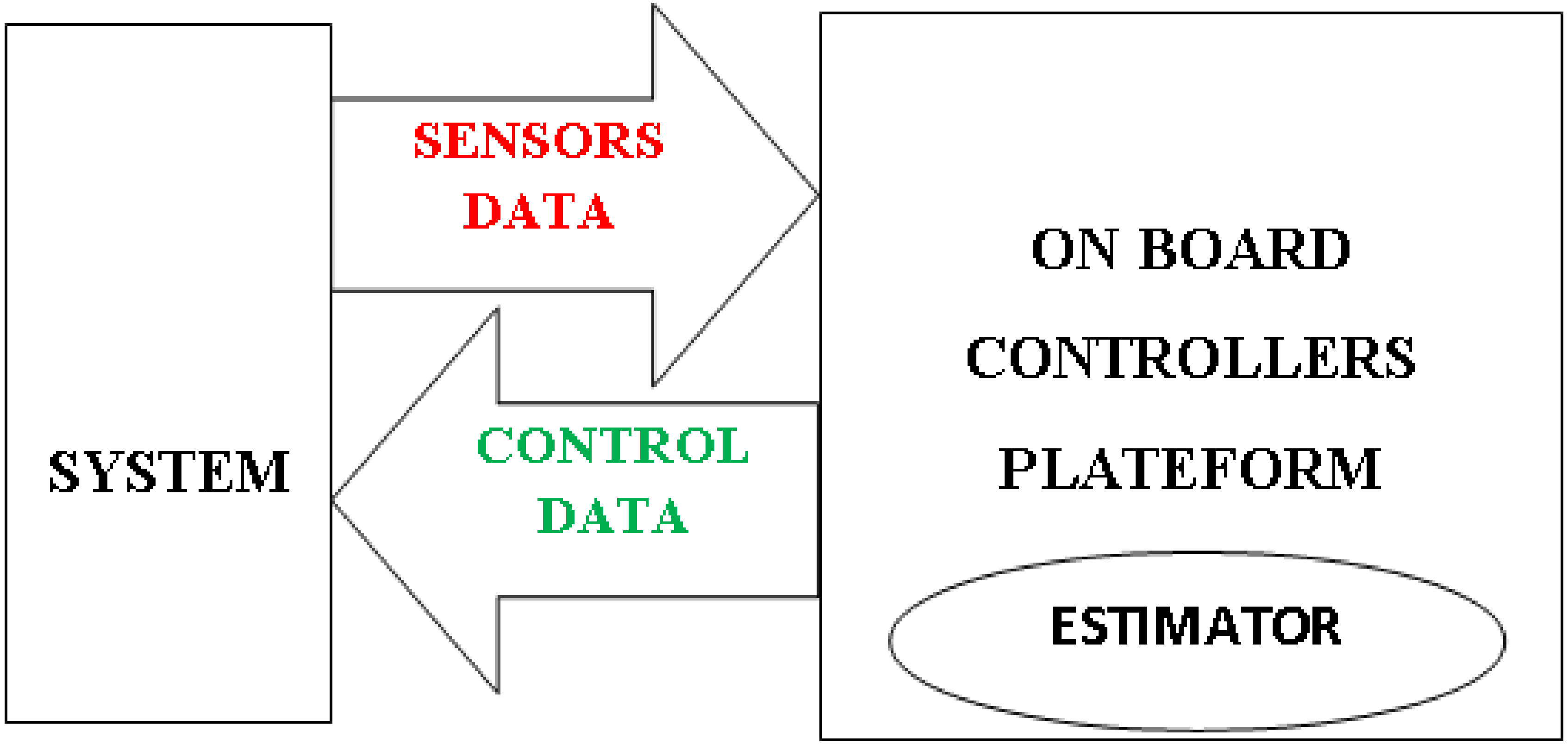
$$F_{mag}(X)$$

$$\Psi\,(I)$$



ONLINE MATCHING OF THE OBSERVATION-MODELING PAIR

Automated Procedures



Matching time- Model accuracy

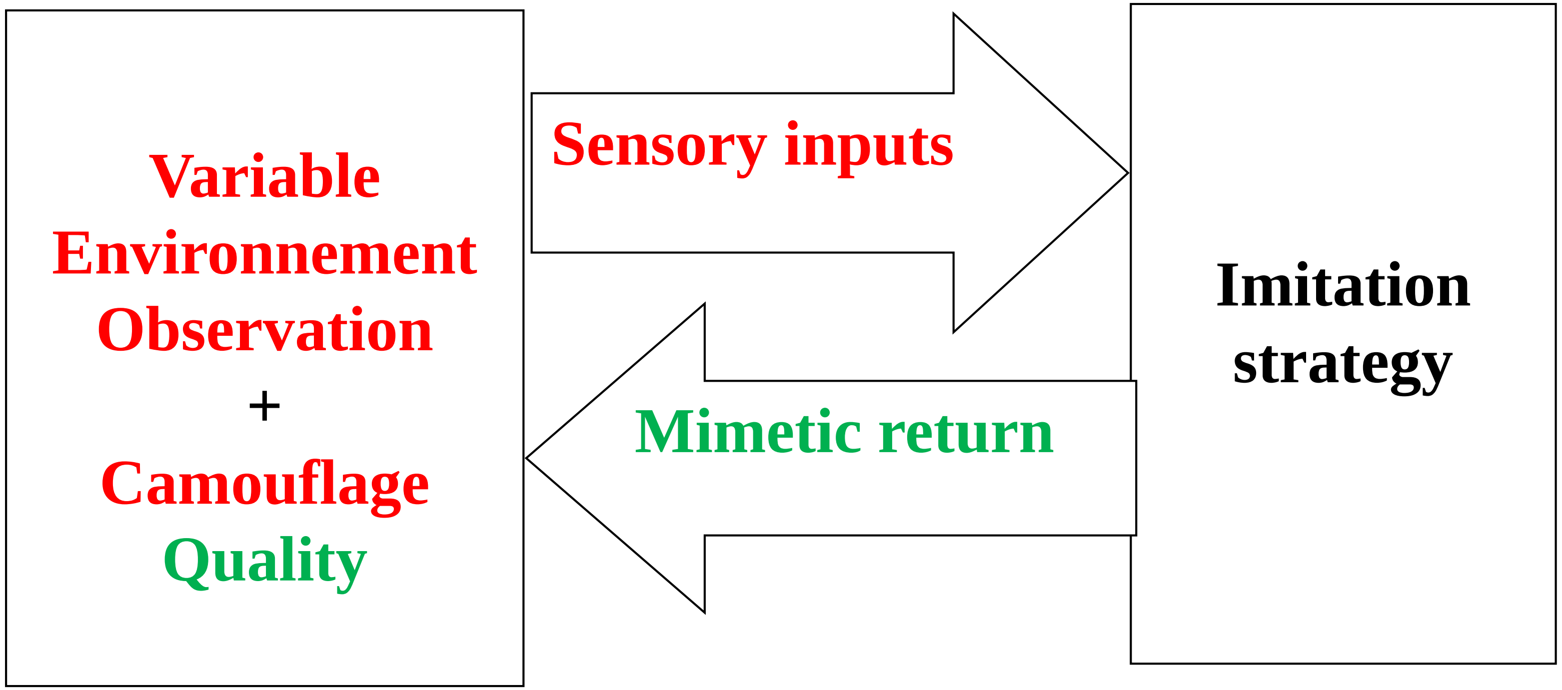
Observation-Modeling Pairing in Complex Procedures

Matching in Natural processes

Matching Twins in Complex Procedures

Matching in Natural Processes

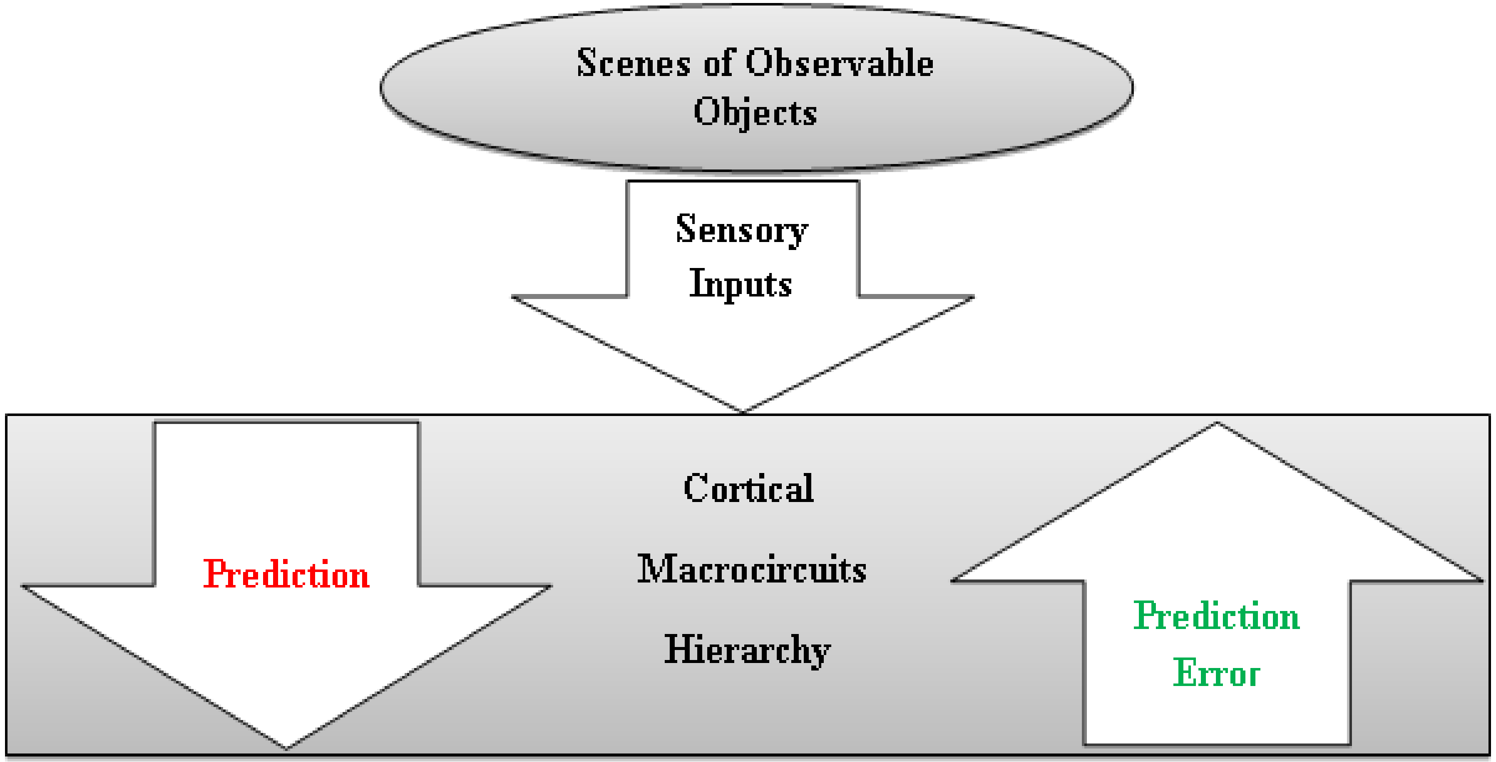
Dynamic camouflage



Camouflaged & Dupe

Bayesian Brain Theory
decision-making under uncertainty

Brain: statistical organ of hierarchical inference
predicts current and future events of past experience



Human brain: 10^{11} neurons, each tied to 10^{4} others

Matching Twins in Complex Procedures

Complex procedures (composite systems)

Multi components and the physical phenomena involved

Classification (composite) by interactions (Perrow, C. 2011) :

Simple, Complicated and Complex interactions

***simply behaves in a direct or linear manner**

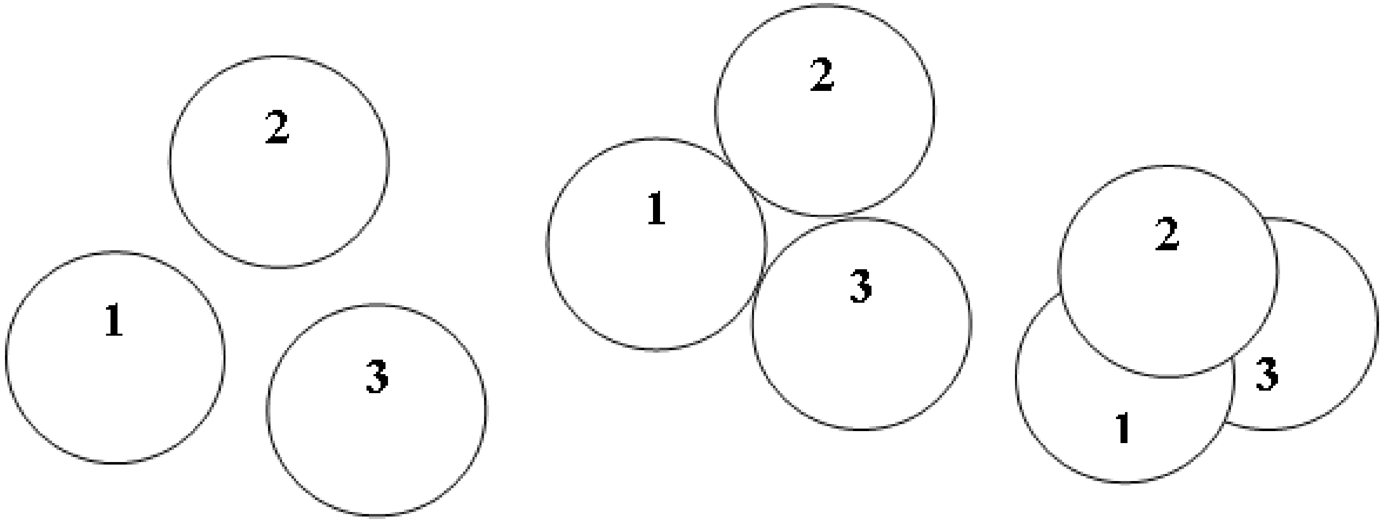
***complicated interactions are linear and loosely coupled**

***complex interactions with tightly coupled links**

Multi components

Classification by interactions (Perrow)

e.g. 3 components

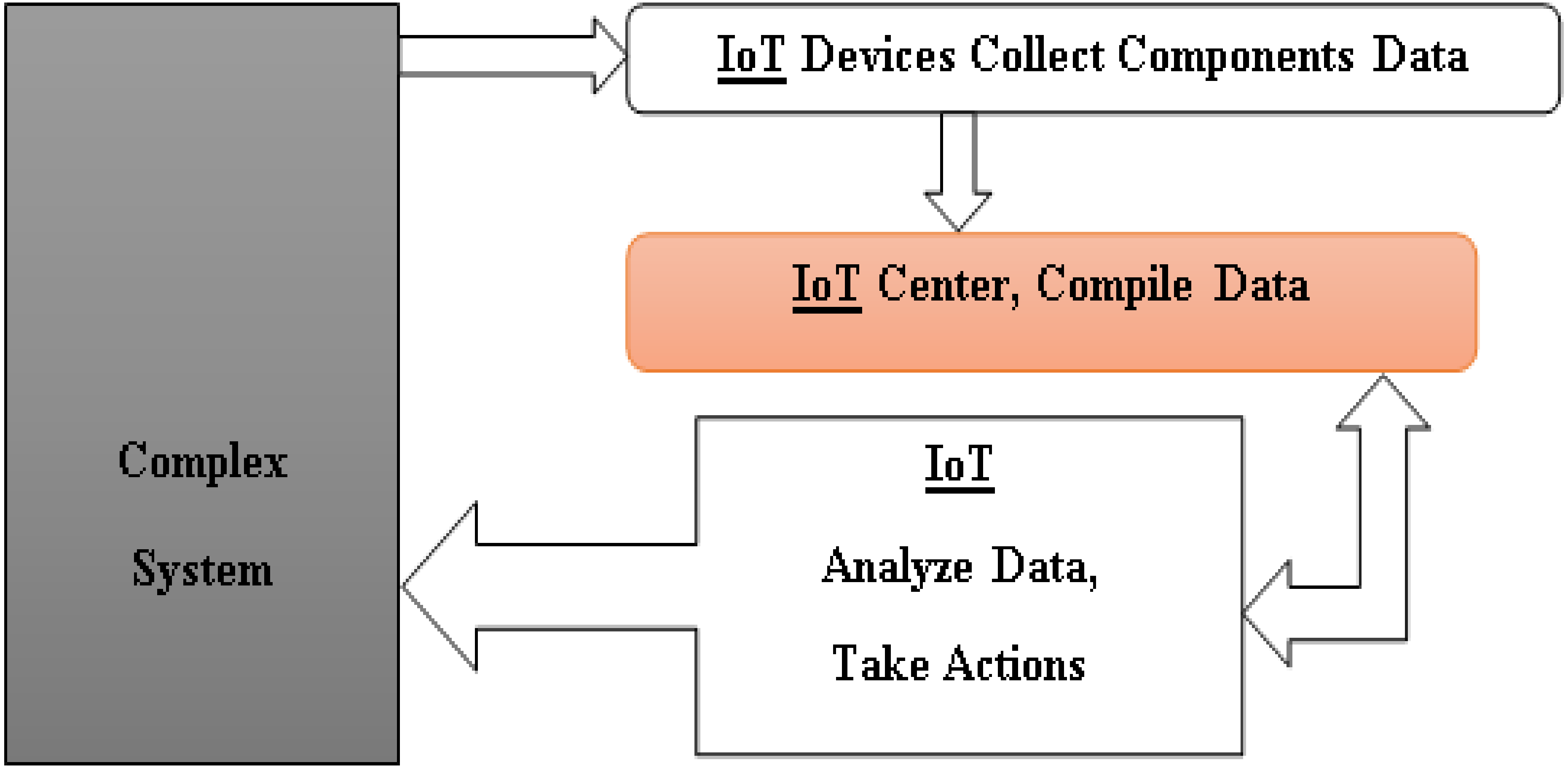


Simple **Complicated** **Complex**

CAE **digital**

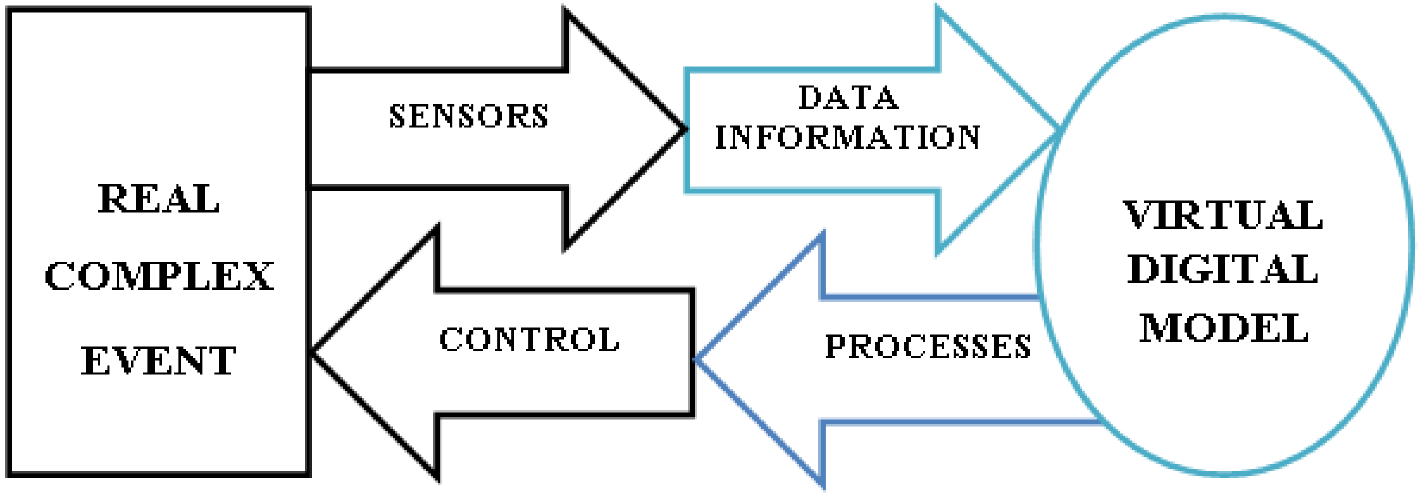
or

IoT **physical**



To temper and control the
irregular and unnecessary behaviors
that occur in these complex procedures

Physical *(multiple)* + Digital *(joined + reduced)*

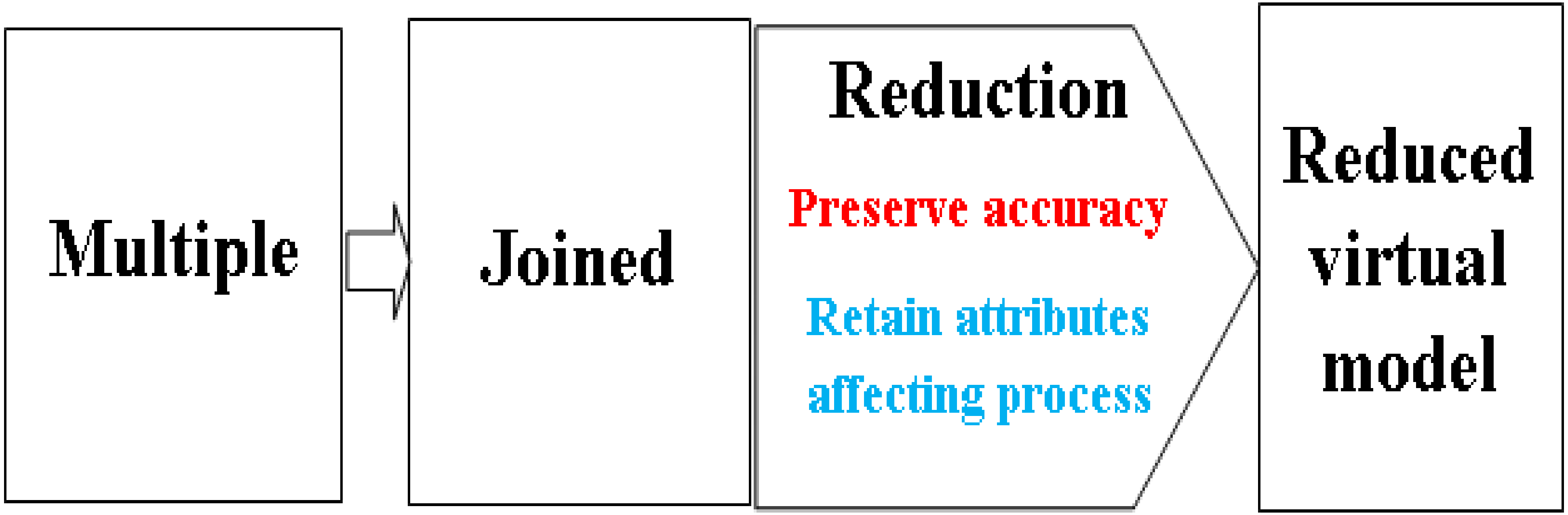


Digital Twin Concept (2002 by M. Grieves)

Consider in

Real: Individual Measurements and Control vectors

Virtual: Joined + Reduction (preserving accuracy)



Reduced + Joined or Joined + Reduced

(depend on system and reduction technique)

Examples of applications of DT

Industrial manufacturing and product design Iterative redesign of an existing product - creation of a new product

Predictive maintenance Optimize the maintenance calendar - predicting the failures of syst. and processes

Healthcare services Medical innovations - enhance clinical health

Security activity Micro grid security- automation syst. security

Control Power syst. control centers and mechatronic syst.

Space, Air, Sea, ground: Intelligent vehicles (EV)
Autonomous navigation control, driver assistance syst., vehicle condition monitoring, battery management syst., electronics and electric drive syst.

Livestock sector Improve precision farming practices, machinery and equipment, health and well-being of a large variety of animals

Smart cities Ensure smart aspects in real property, construction, health system, building, home, transportation and parking

…..HCDT