BIOSTEC 2023

16TH INTERNATIONAL JOINT CONFERENCE ON BIOMEDICAL ENGINEERING SYSTEMS AND TECHNOLOGIES

16 - 18 FEBRUARY, 2023

LISBON, PORTUGAL

BIODEVICES

BIOIMAGING

BIOINFORMATICS

BIOSIGNALS

HEALTHINF

Towards the Virtual Human Simulator

and beyond to the digi-real duality

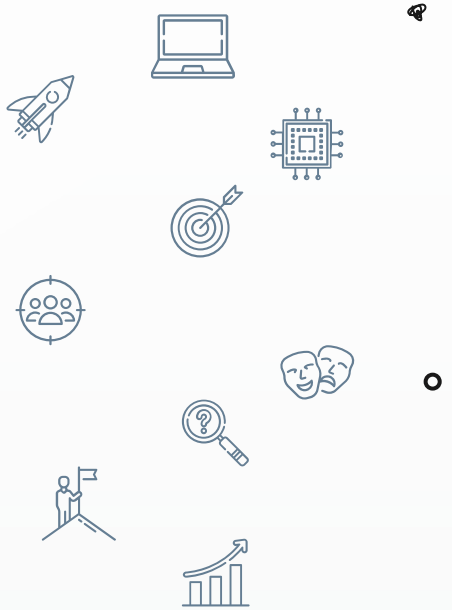
Giovanni Saggio, PhD

Desing / User experience

✓ Linkedin share by Lukas Henkel
✓ Mesh generation: Salome_Meca
✓ Solver: Code_Saturne
✓ Visualization: Paraview - NVIDIA Index Plugin

Contents

Here's what we will consider:



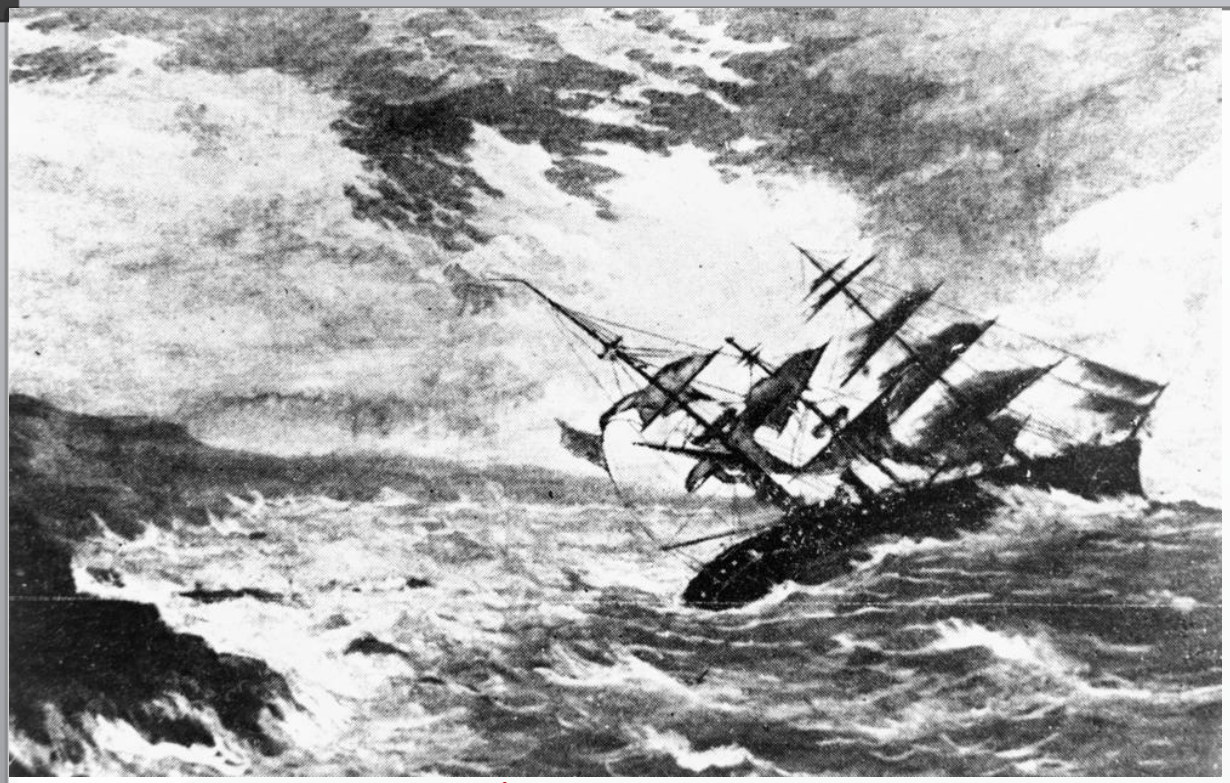
Science answers questions and discovers information

Engineering creates products/processes to solve problems

foreseeing

Weather Forecast (1859)

forecast



The sinking of the Royal Charter ship

RF developed weather charts, he described as "forecasts" (the first known usage of the term)

Robert FitzRoy

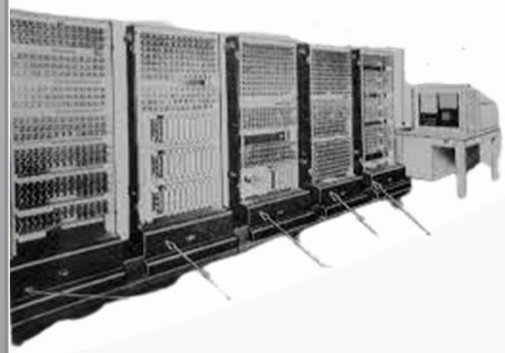
(Virtual) Simulation (Bell Labs, 1950s)

forecast
simulate

Simulation:
imitation of the operation of a real-world process or system (over time)

weather
electronics

An electromechanical-relays based computer was successfully adopted for



- simulating the sinusoidal steady state of a linear network
- optimizing designs of electric filters

Graham (1953). Relay computer for network analysis. Bell Labs. Rec. vol. 31. pp. 152-157.

Aaron (1956). The use of least squares in system design. IRE Transactions on Circuit Theory, 3(4), 224-231.

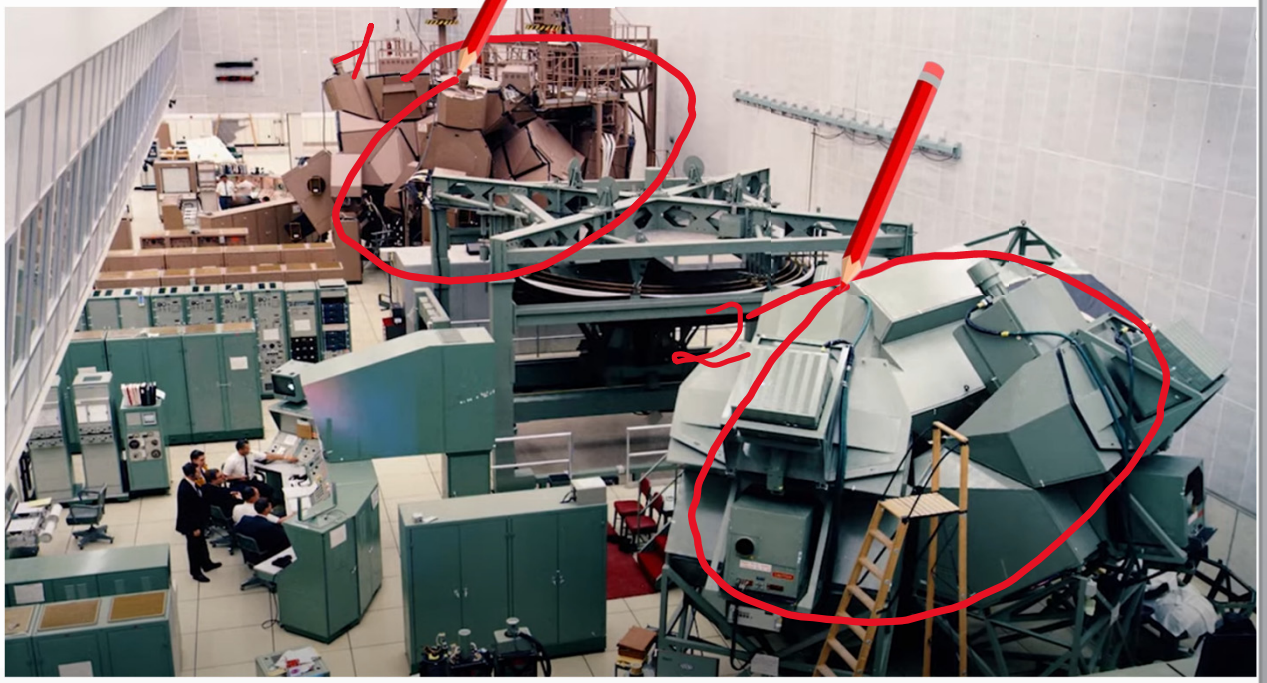
Banks (2001). Discrete-Event System Simulation. Prentice Hall

(Physical/virtual) Simulation (NASA, 1960-70s)

forecast
simulate

NASA uses mirroring technology to replicate space conditions

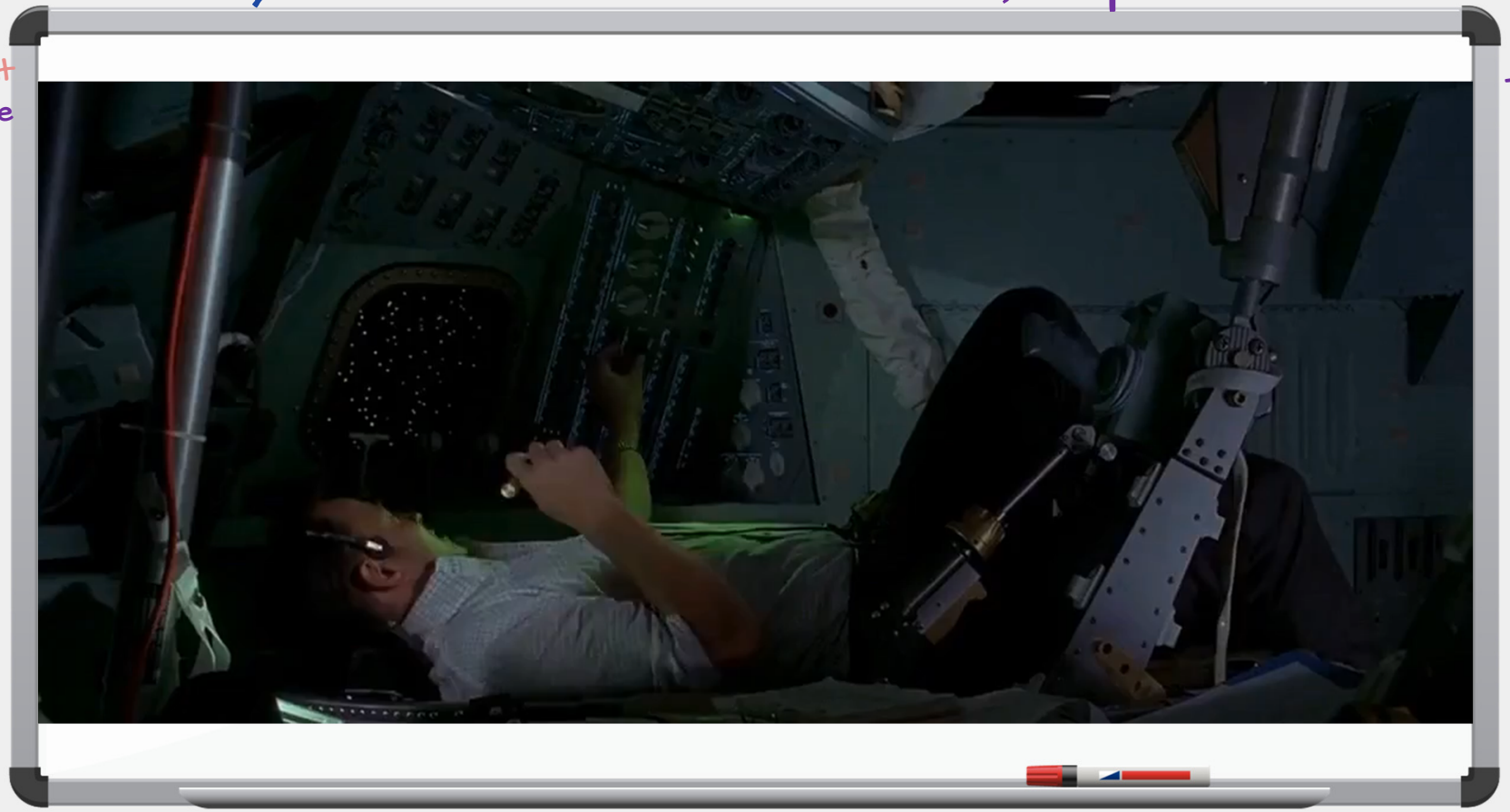
two identical space vehicles were built to allow mirroring the conditions of the space vehicle during the mission



Weather
Electronics
Space

(Physical) Simulation (NASA, Apollo 13)

forecast
simulate



Weather
Electronics
Space

Crew: Jim Lovell, Jack Swigert, Fred Haise

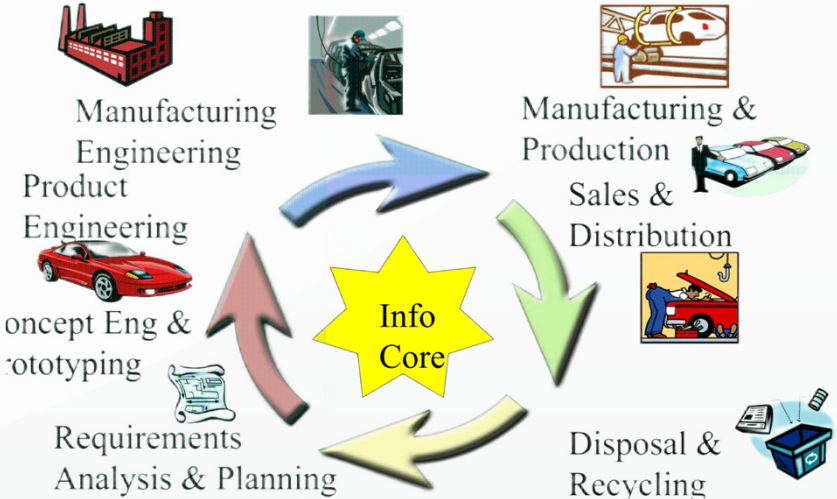
Product Lifecycle Management (PLM) (2002)

forecast
simulate
PLM

PLM is an integrated, information-driven approach
comprised of people, processes/practices, technology,
to all aspects of a product's life

Weather
Electronics
Space

Economics
Manufacturing



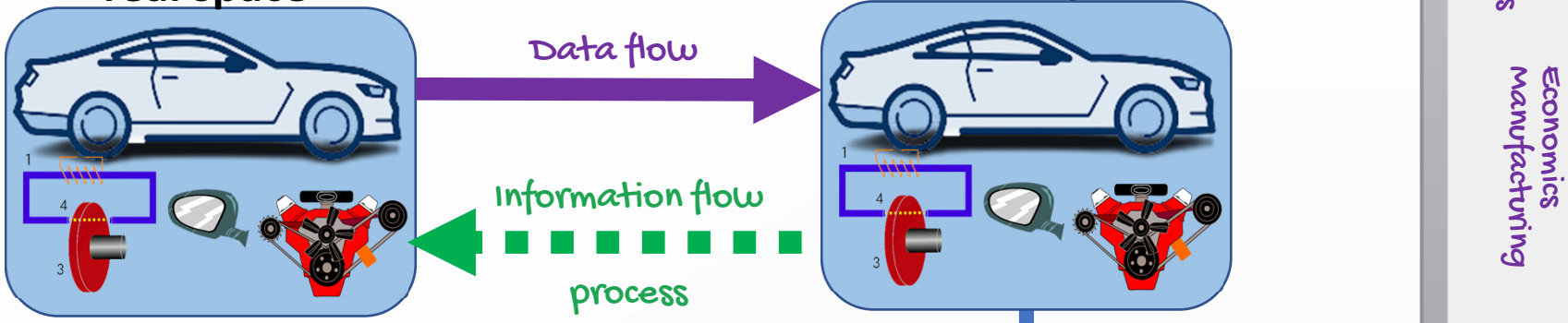
Grieves, M. W. (2005). Product lifecycle management: the new paradigm for enterprises. Int. J. of Product Development, 2(1-2), 71-84.
Grieves, M. W. (2006). PLM: Driving the Next Generation of Lean Thinking. McGraw-Hill

Florida Institute of Technology

Mirror Space Model (MSM) (2003-5)

forecast
simulate
PLM
MSM

The informational core enables PLM.
The informational core is based on the MSM.



data are not organized by their function,
but by the physical object

Sub*1* Sub2 ..... Sub*n*

Weather
Electronics
Space

Economics
Manufacturing

Information Mirror Model (2006-10)

forecast
simulate
PLM
MSM
IMM

real ←→ virtual system connections
during the 4 phases of production:

1. development

2. manufacturing

3. operation

4. disposal

Weather
Electronics
Space

Economics
Manufacturing

Digital Twin (2011)

forecast
simulate
PLM
MSM
IMM
DT

Weather
Electronics
Space

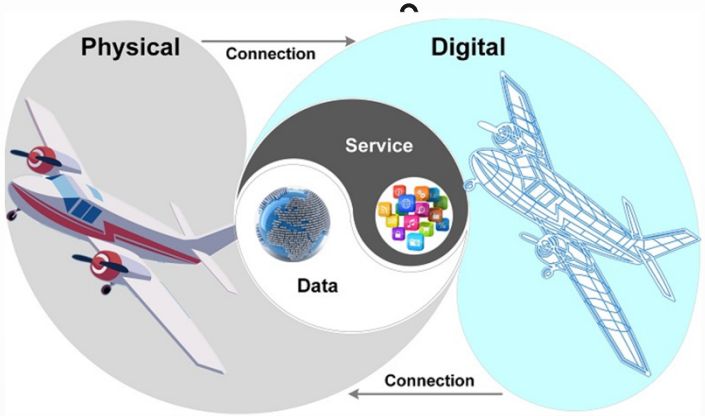
Economics
Manufacturing

Digital Twin (2011)

forecast
simulate
PLM
MSM
IMM
DT

NASA (Technology Area 11):

"A DT is an integrated multiphysics, multiscale, probabilistic simulation of an as-built vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its corresponding flying twin"*



Grieves:

"A DT is a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level"

Weather
Electronics
Space

Economics
Manufacturing

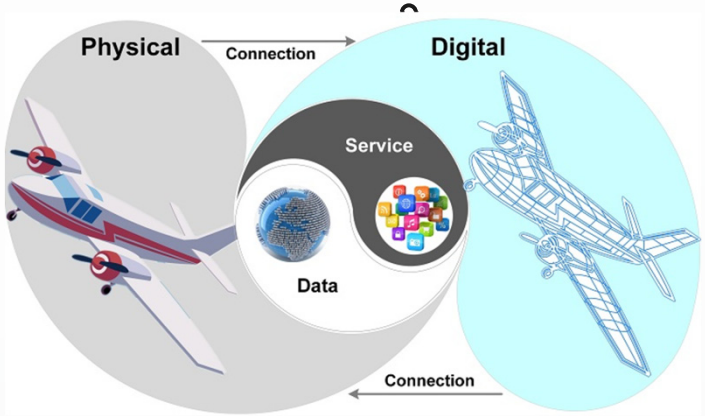
* Shafto et al. (2010). Draft modeling, simulation, information technology & processing roadmap. Technology Area 11, 2010

Digital Twin (2020)

forecast
simulate
PLM
MSM
IMM
DT

AIAA Institute position paper:

"A DT is a set of virtual information construct that mimics the structure, context and behavior of an individual unique asset, is dynamically updated with data from its physical twin throughout its lifecycle, and informs decisions that realize value"

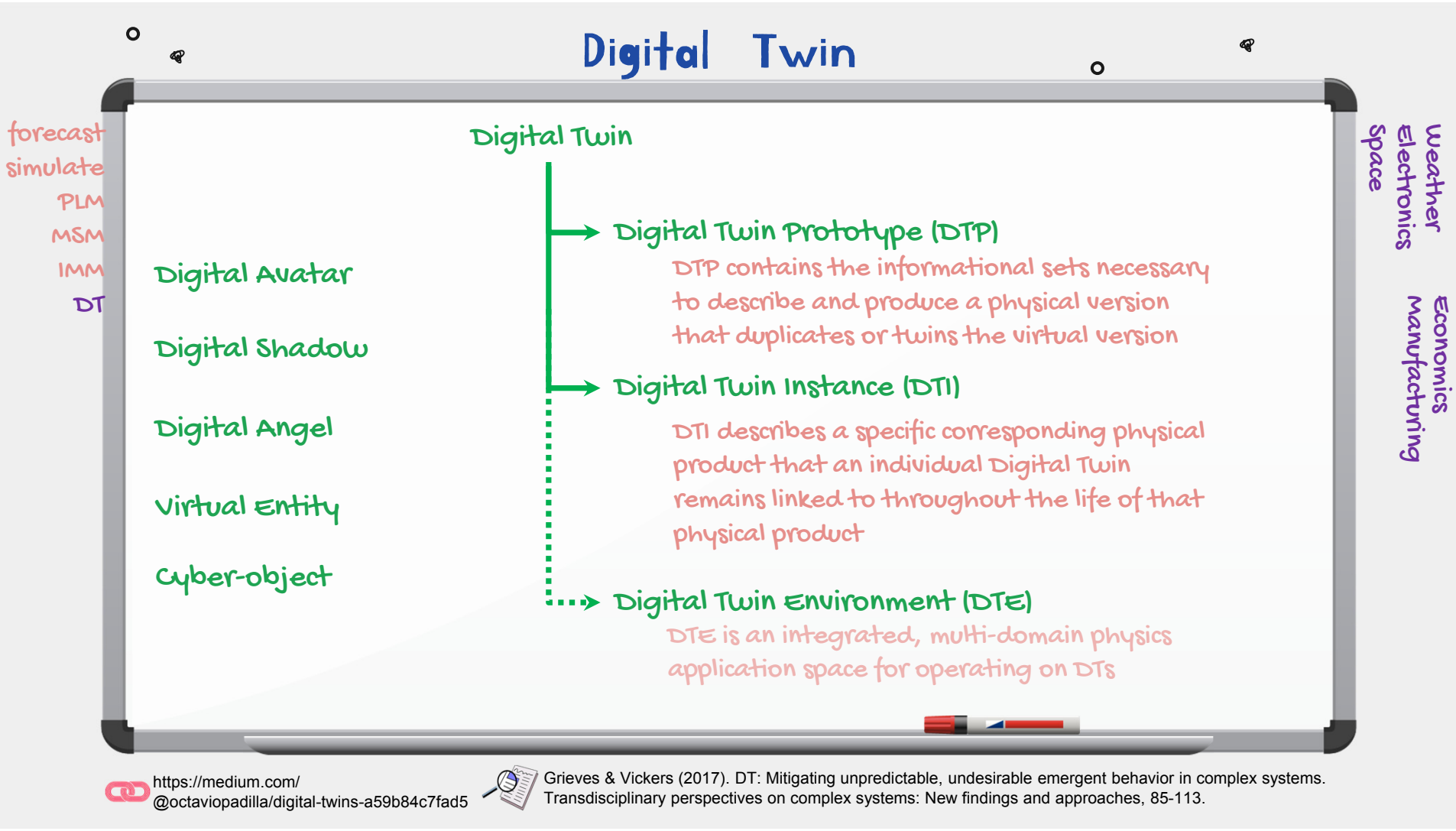


Details?
Down to atomic/molecular level?

Weather
Electronics
Space

Economics
Manufacturing

Digital Twin



https://medium.com/@octaviopadilla/digital-twins-a59b84c7fad5

Grieves & Vickers (2017). DT: Mitigating unpredictable, undesirable emergent behavior in complex systems. Transdisciplinary perspectives on complex systems: New findings and approaches, 85-113.

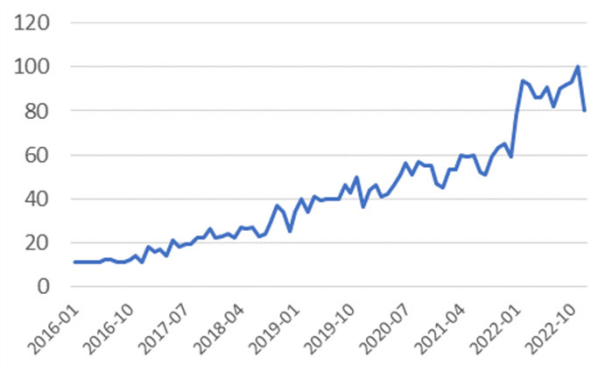
Digital Twin

forecast
simulate
PLM
MSM
IMM
DT

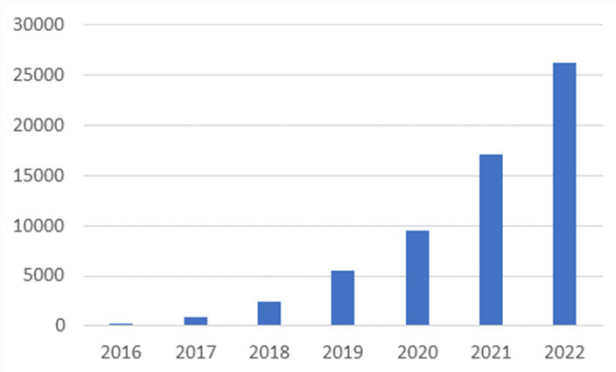
Weather
Electronics
Space

Economics
Manufacturing

a)



b)



c)

a) google search of "Digital Twin" since 2016

b) # papers including "DT", ys 2016-2022

c) google search differenced in Countries

Digital Twin

forecast
simulate
PLM
MSM
IMM
DT

Weather
Electronics
Space

Economics
Manufacturing

advantages:

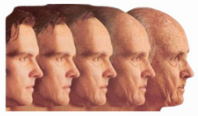
- reduction of tests and checks (time and cost savings)

- reduction time-to-market

- lower any product defect

- intercept potential problems before happen

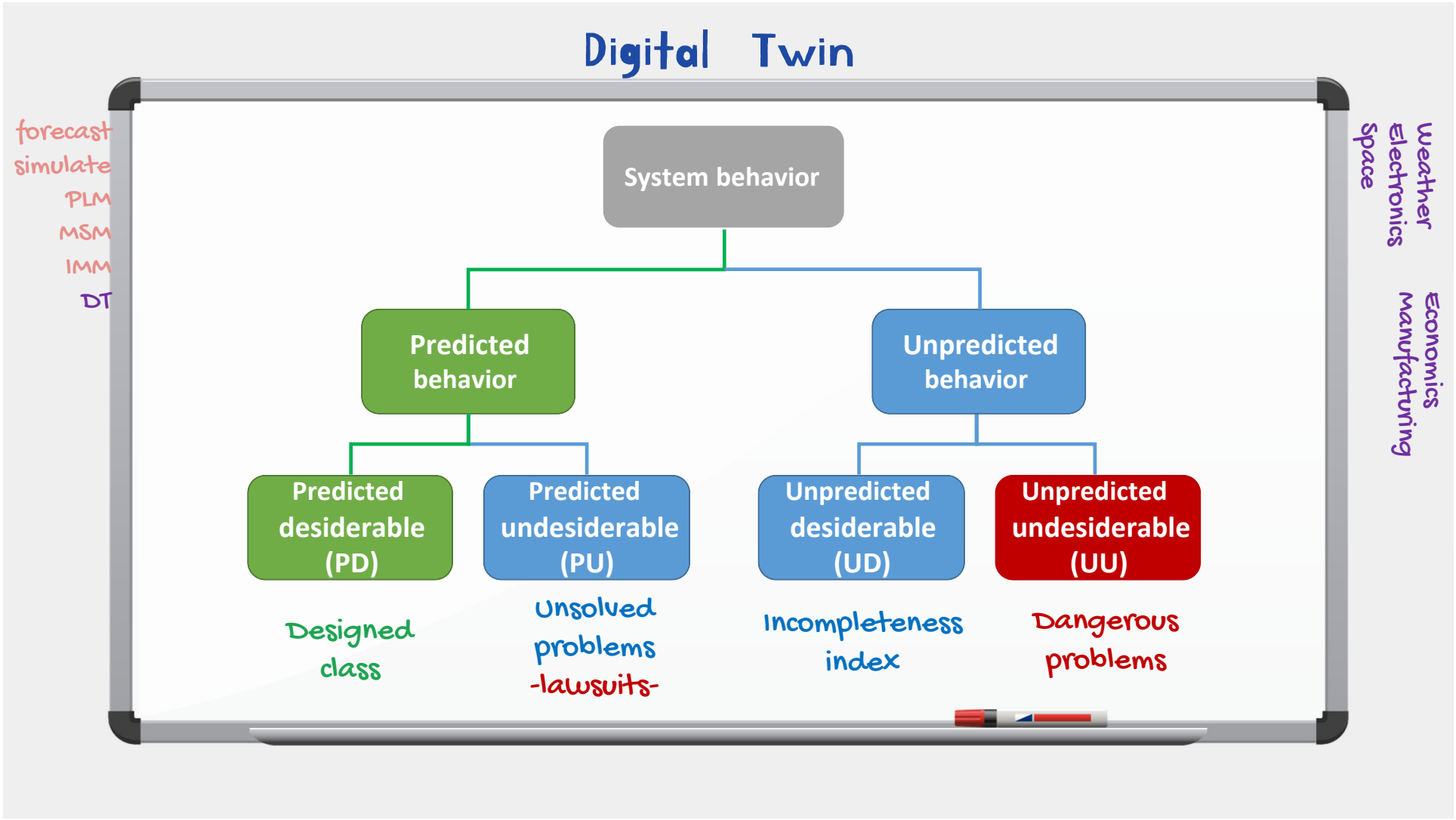
- simulate events, no causing them in reality



- evaluate aging effects

- evaluate all parameters at once (not one-by-one)

- limit the production as a final step only


Digital Twin
forecast
simulate
PLM
MSM
IMM
DT
System behavior
Predicted behavior
Unpredicted behavior
Predicted desiderable (PD)
Predicted undesiderable (PU)
Unpredicted desiderable (UD)
Unpredicted undesiderable (UU)
Designed class
Unsolved problems -lawsuits-
Incompleteness index
Dangerous problems
Space
Electronics
Weather
Economics
Manufacturing

Matrix of DT characteristics

forecast
simulate
PLM
MSM
IMM
DT

	Physical Asset	Models	Communi-cations	Services	Data	Product	Autonomy	Environnement	User
Van der Valk (2021)	•	•	•	•	•		•		•
Jazdi (2021)	•	•	•	•	•		•	•	
Zhang (2021)	•	•	•	•	•	•	•		
Sturm (2021)	•	•	•	•	•	•		•	
Semeraro (2021)	•	•	•	•	•			•	
Minerva (2020)	•	•	•	•	•	•	•	•	
Sharma (2020)	•	•	•	•	•		•		•
Liu (2020)	•	•	•	•	•	•			•
Stark (2019)	•	•	•	•		•	•	•	•
Seal (2018)	•	•	•	•		•			
Tao (2018)	•	•	•	•	•				
Parrot (2017)	•	•	•	•	•				
Rosen (2015)	•	•	•	•		•	•		
Rios (2015)	•	•	•			•			
Grieves (2015)	•	•	•						

Weather
Electronics
Space

Economics
Manufacturing
Environment

Ascone & Vanderhaegen (2022). Towards a Holistic Framework for Digital Twins of Human-Machine Systems. IFAC-PapersOnLine, 55(29), 67-72.

Digital Twin (2011)

forecast
simulate
PLM
MSM
IMM
DT

Active (real-digital in sync, seamlessly, continuously updated, virtual and real exist simultaneously)

Semi-Active (post analysis after pre data collection)

Passive (some data are collected, other assumed)

Weather
Electronics
Space

Economics
Manufacturing
Environment

Chakshu et al. (2019). A semi-active human digital twin model for detecting severity of carotid stenoses from head vibration. International journal for numerical methods in biomedical engineering, 35(5), e3180.

..as a matter of principle..

any physical system  (an object, a component, a mechanism, a network, an implant, a machinery, a structure, an asset, ...)

potentially of any level of complexity  (whether inanimate, vegetative, and animate)

can be fully described by its features (data) 

Electronics allow gathering
whatever amounts of whatever data
from any system
during any time periods

(sensors, transducers, ...)
(full information)

Weather
Electronics
Space

Economics
Manufacturing
Environment

Whatever

Augmented Digital Twin

forecast
simulate
PLM
MSM
IMM
DT
ADT

The concept of ADT moves manufacturers and operators closer to the goal of selling outcomes (results) instead of products (machines)

1 ADT: virtual multiple-interacts with its real entity, with its surroundings and other DTs too

2 ADT enhances the data from the connected asset with derivative data, correlated data from federated sources, and/or intelligence data from analytics and algorithms*

3 ADT concerns visualizing the DT data by using AR**

4 ADT is also fed with data of other objects and resources and are shaped using AI techniques***

Whatever

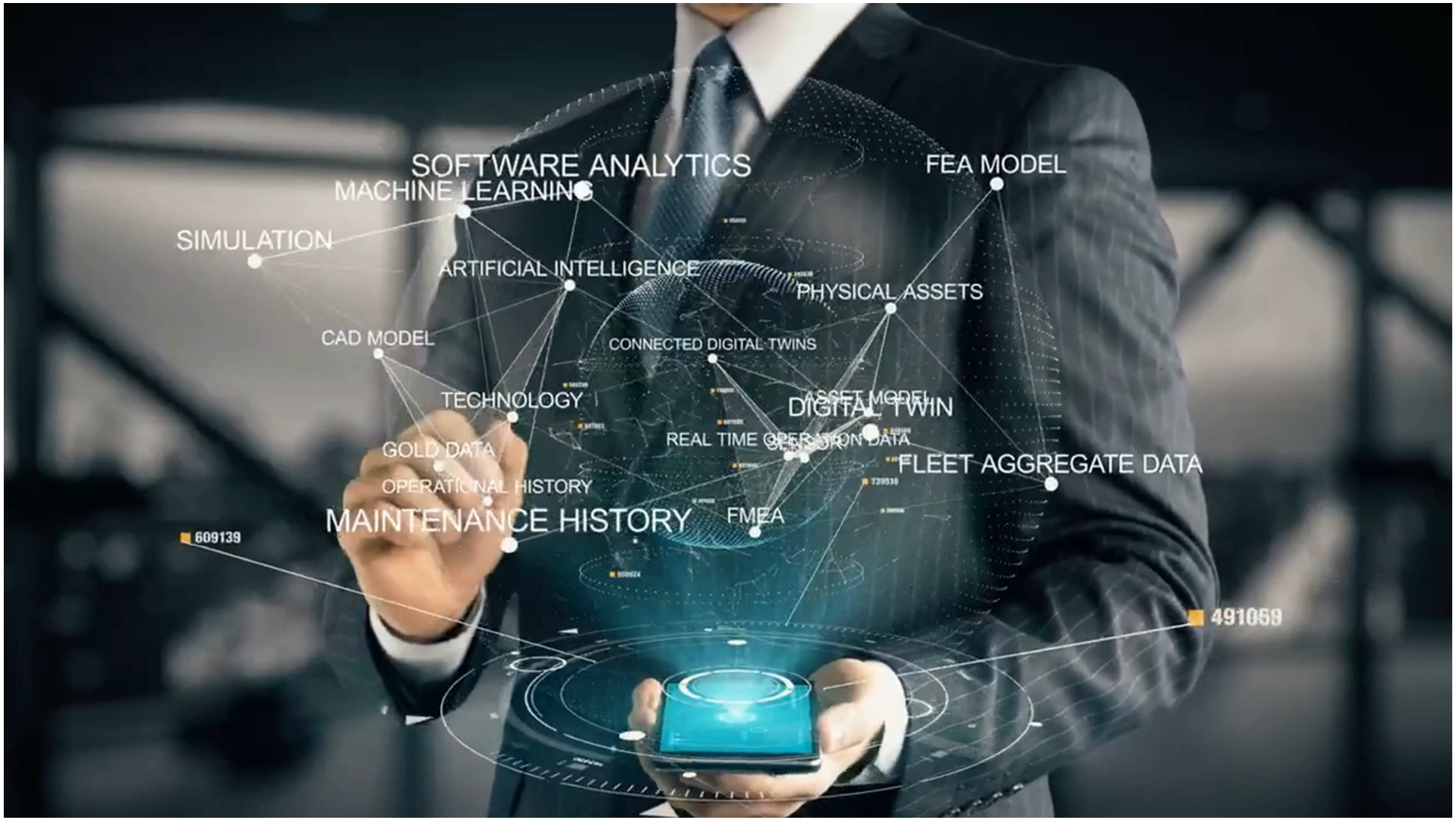
*Kucera et a. (2017). The augmented digital twin.
**Zhu et al. (2019). Visualisation of the digital twin data in manufacturing by using AR. Procedia Cirp, 81, 898-903.
***Pool (2021). Digital Twins in Rail Freight-The foundations of a future innovation. Master's thesis, University of Twente.

Intelligent Digital Twin

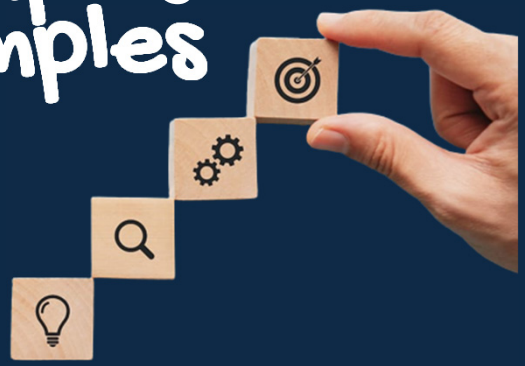
forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

IDT: When DT meets artificial intelligence, machine learning, deep learning algorithms

Whatever


SOFTWARE ANALYTICS
MACHINE LEARNING
FEA MODEL
SIMULATION
ARTIFICIAL INTELLIGENCE
PHYSICAL ASSETS
CAD MODEL
CONNECTED DIGITAL TWINS
TECHNOLOGY
DIGITAL TWIN
GOLD DATA
FLEET AGGREGATE DATA
OPERATIONAL HISTORY
MAINTENANCE HISTORY
FMEA
609139
491059

Examples
Samples



Wuhan Raytheon hospital (14 days)

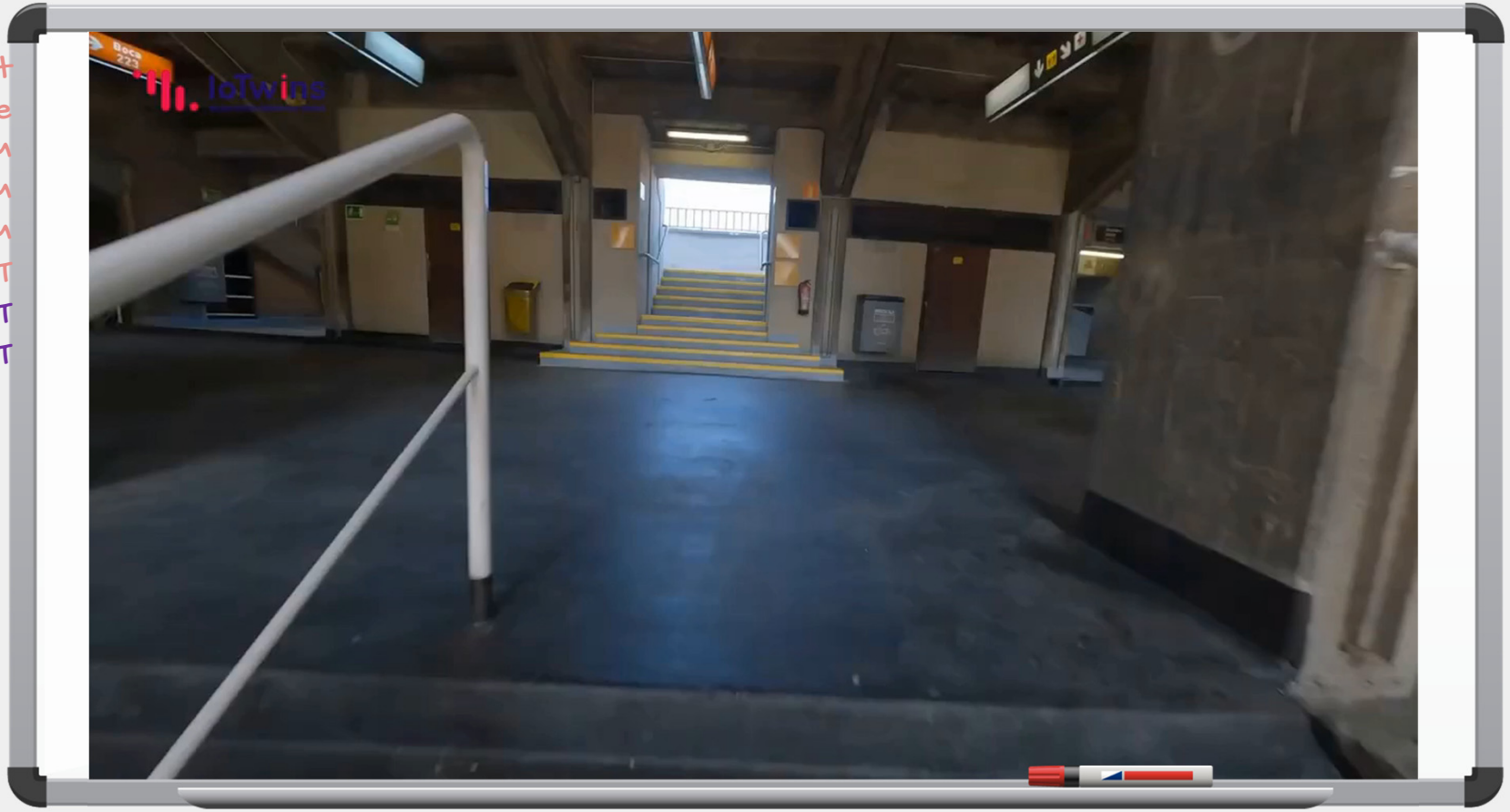
forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

CSADI 中南建筑设计院

Central South Architectural Design Institute

Stadium in Barcelona

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT



IoTwins
BIG DATA OPTIMIZE INDUSTRY AND SERVICES

www.iotwins.eu

City

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

VIRSPATIAL

Ivanov, S. et al. (2020). Digital twin of city: Concept overview. Global Smart Industry Conference (GloSIC) (pp. 178-186). IEEE.

Water sites

forecast
simulate
PLM
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IMM
DT
ADT
IDT

51 WORLD

https://www.51aes.com/

Interest

forecast
simulate
PLM
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IMM
DT
ADT
IDT

https://digitaltwin1.org/

Pasteur's quadrant

NO consideration for use YES

quest for fundamental understanding

YES

NO

Bohr's

basic research

Pasteur's

use-inspired basic research

Edison's

applied research

Interest of Companies

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IMM
DT
ADT
IDT

The challenges on open and public funded research vs. big tech research initiatives

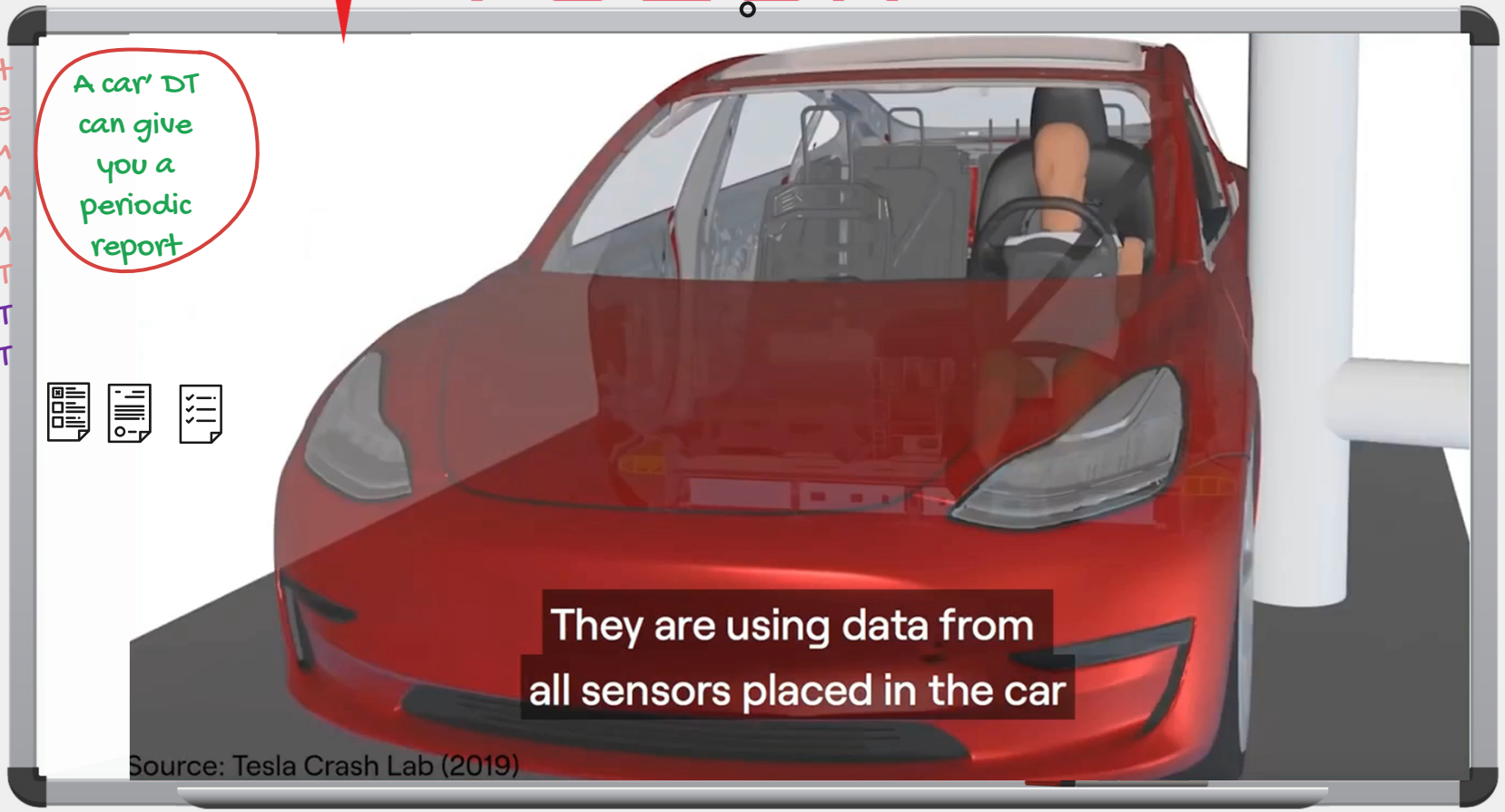
SIEMENS

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

Production plant

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

A car' DT can give you a periodic report



Car testing

Formula 1

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

Formula 1

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

on track

elsewhere in the world

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

BOEING

Boeing achieved a 40% improvement rate in the first-time quality of parts by DTs.

The company plans to digitize all of its engineering and development systems

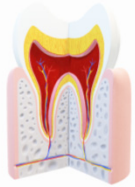
Aircraft design

Human?

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT
HDT

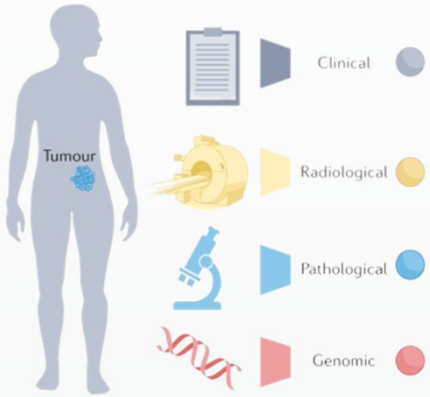
Human digital twin (HDT)

Health digital twin (HDT)

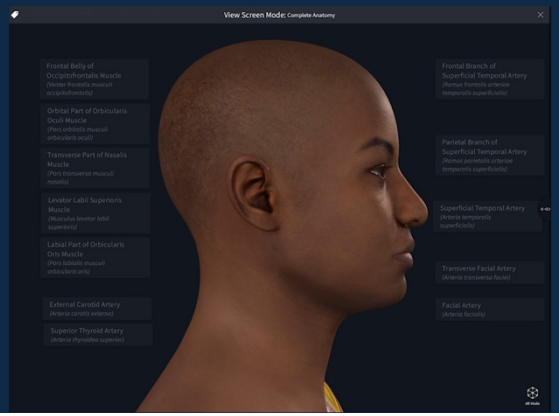


virtual representations of patients

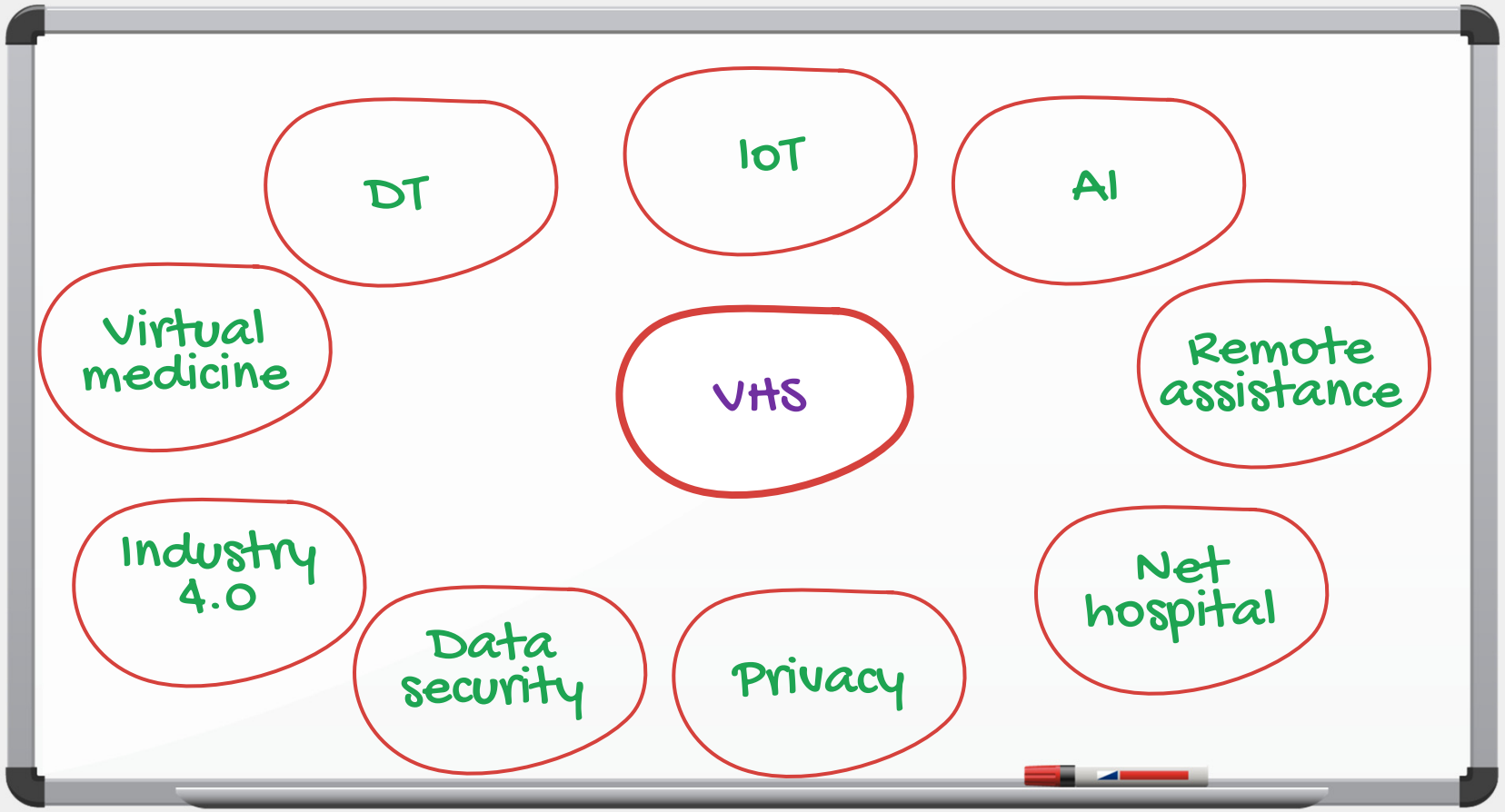
from patient (& environ.) data,
population data,
real-time updates



Virtual Human Simulator



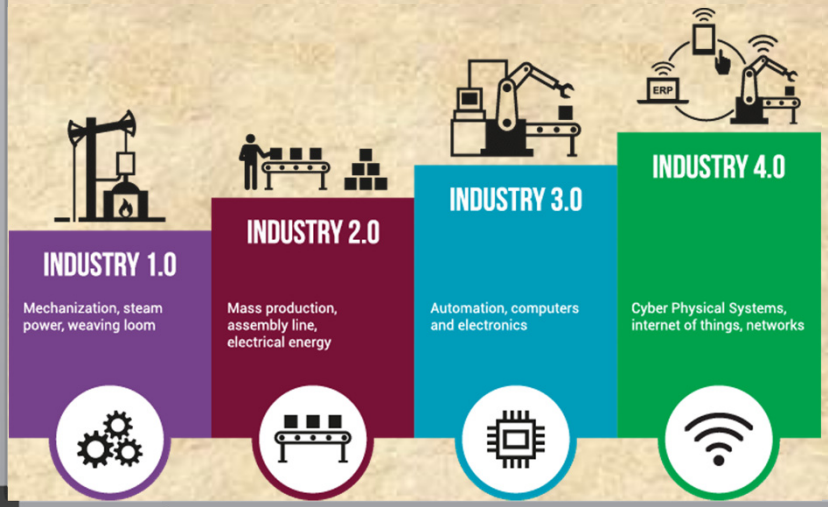
PLM
MSM
IMM
DT
ADT
IDT
HDT
VHS



PLM
MSM
IMM
DT
ADT
IDT
VHS

Virtual Human Simulator

1

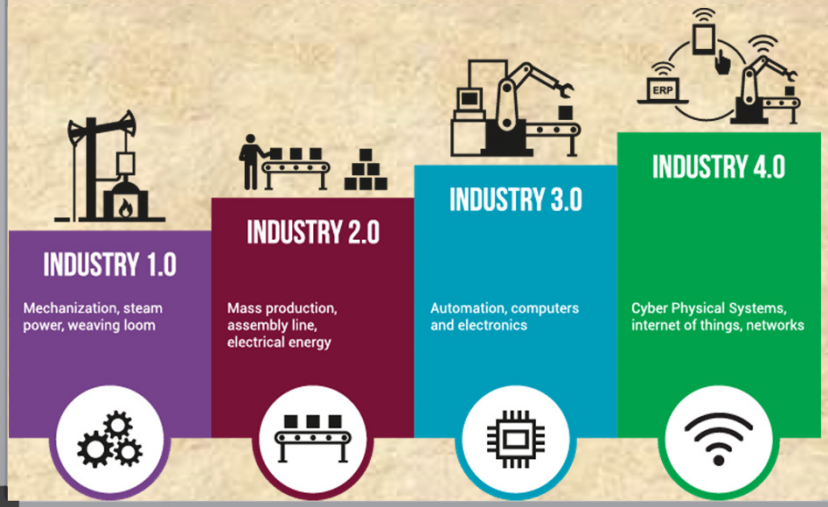


TECHNOSCIENCE
PARCO SCIENTIFICO E TECNOLOGICO

PLM
MSM
IMM
DT
ADT
IDT
VHS

Virtual Human Simulator

2



Università di Roma Tor Vergata

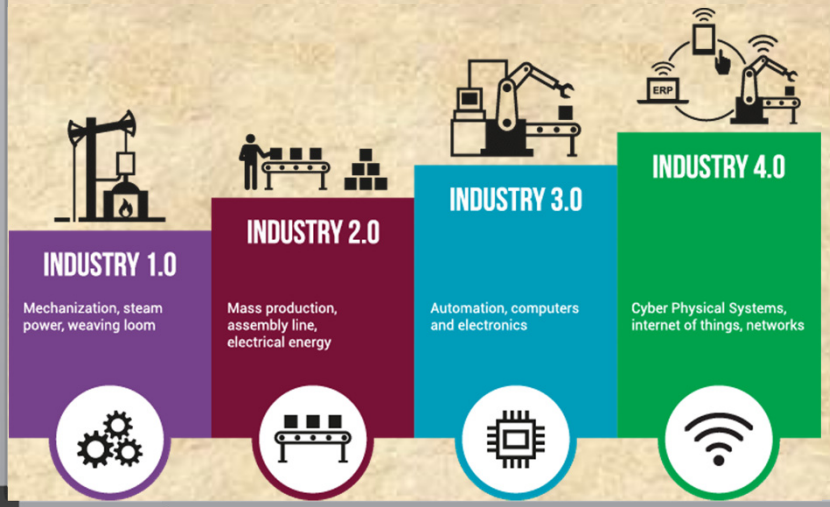
SEEUTI

Electronic Services and Innovative Technology

PLM
MSM
IMM
DT
ADT
IDT
VHS

Virtual Human Simulator

3



UniSR
Università Vita-Salute San Raffaele

I.R.C.C.S. Ospedale San Raffaele

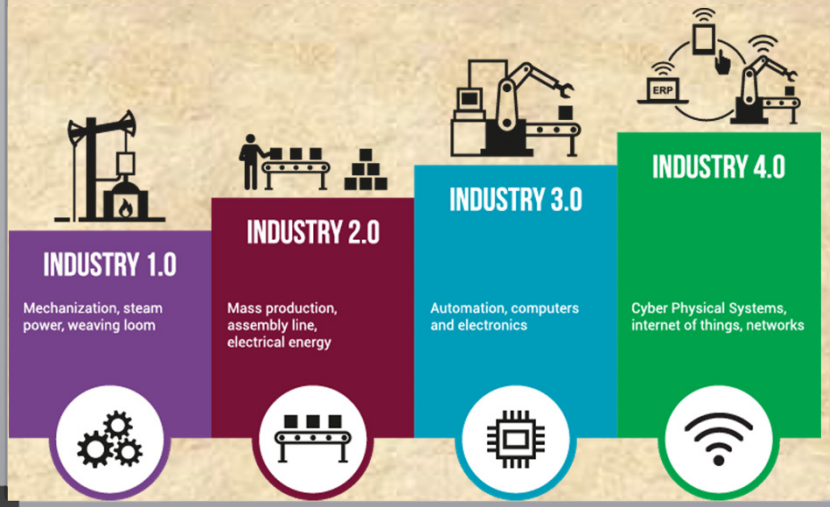
NEUROMED
I.R.C.C.S.
ISTITUTO NEUROLOGICO MEDITERRANEO

Gruppo MultiMedica
Passione, ricerca e innovazione per la salute

PLM
MSM
IMM
DT
ADT
IDT
VHS

Virtual Human Simulator

4

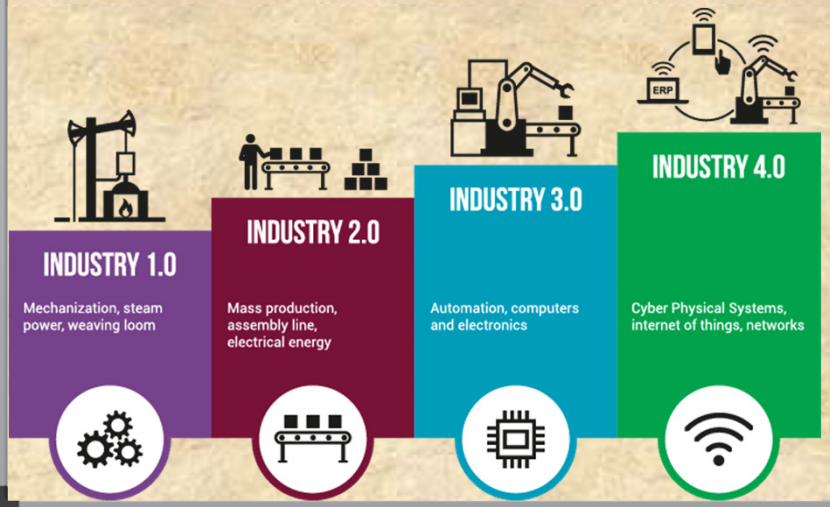


cisco

vodafone

PLM
MSM
IMM
DT
ADT
IDT
VHS

Virtual Human Simulator



TECHNOSCIENCE
PARCO SCIENTIFICO E TECNOLOGICO

Università di Roma Tor Vergata

SEETI
Electronic Services and Innovative Technology

NEUROMED I.R.C.C.S.
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Passione, ricerca e innovazione per la salute

I.R.C.C.S. Ospedale San Raffaele

vodafone

CISCO


Technoscience San Raffaele VHS - Virtual Human Simulator
alter ego virtuale
partners
Università San Raffaele Roma
SCHOOL OF EXCELLENCE IN PHLEBOLOGY
CISCO
sourcesense
making sense of open source
UNIVERSITÀ degli STUDI di ROMA TOR VERGATA
NEUROMED I.R.C.C.S.
Gruppo MultiMedica
TECHNOSCIENCE – SAN RAFFAELE
RIN – RAGGRUPPAMENTO INTERDIPARTIMENTALE NAZIONALE
NET HOSPITAL
online medicine
big medical data
PST – Parco Scientifico e Tecnologico
TECHNOSCIENCE
BANCA DATI RETE PROCESSI OSPEDALIERI
Biobanca Interistituzionale Multidisciplinare San Raffaele
BANCA DATI NEUROMED
BANCA DATI MULTIMEDICA
BIG MEDICAL DATA
MANGIONI H.
IRCCS - MULTIMEDICA
PST BIOKER
IRCCS - NEUROMED
IRCCS SR - PISANA
UNI SAN RAFFAELE
SR - TERMINI
SR - TUSCOLANA
SR - APPIA
VILLA GIOIA
SR - PORTUENSE
SR - RSA TROIA
SR - RSA MODUGNO
SR - OSTUNI
SR - CAMPI SALENTINA
SR - CASSINO
SR - SUESSOLA
VILLA SERENA
VILLA DEI GERANI
BIOKER

Virtual Human Simulator

Virtual Human Simulator

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT
VHS

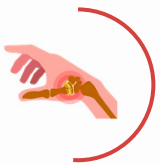
Ineffectiveness of drug*

38-75% of common diseases' patients do not respond to drug treatment*

Same-diagnosed patients will respond differently to the same treatment

70%

Alzheimer's patients



50%

Arthritis patients

40%

Heart arrhythmia

«average patient» treatments cannot be suited to the «actual patient»

*US Food and Drug Administration

Virtual Human Simulator

VHS allows trying out alterations too risk to try on the real counterpart

**Linköping University Studies

Virtual Human Simulator

VHS allows trying out alterations too risk to try on the real counterpart

VHS allows trying out adjustments too expensive to try on the real counterpart

**Linköping University Studies

Virtual Human Simulator

VHS allows trying out alterations too risk to try on the real counterpart

VHS allows trying out adjustments too expensive to try on the real counterpart

VHS allows tailored medical treatments

**Linköping University Studies

Virtual Human Simulator

VHS allows trying out alterations too risk to try on the real counterpart

VHS allows trying out adjustments too expensive to try on the real counterpart

VHS allows tailored medical treatments

VHS allows enhancement in effectiveness of drugs **

**Linköping University Studies

Virtual Human Simulator

VHS allows trying out alterations too risk to try on the real counterpart

VHS allows trying out adjustments too expensive to try on the real counterpart

VHS allows tailored medical treatments

VHS allows enhancement in effectiveness of drugs **

**Linköping University Studies

Virtual Human Simulator

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT
VHS

Virtual Human Simulator

UNITED NATIONS

Virtual Human Simulator

Virtual Human Simulator

Virtual Human Simulator

UNITED NATIONS

Virtual Human Simulator

Giovanni Saggio

IDIH
INTERNATIONAL COLLABORATION
DIGITAL TRANSFORMATION
HEALTHY AGEING

Yves Joanette

Steven S. Charlap

Ranked priorities:

1. Longitudinal study
2. International standards
3. Modelling (Digital Twin,..)
4. Information sources
5. Eco-system for wearables
6. Data access

Hye-Jin Kim

Yiqiang Chen

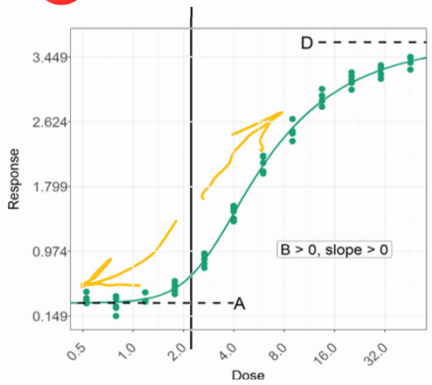
Takao Tashiro

https://idih-global.eu/expert-groups/expert-group-preventive-care/

Virtual Human Simulator

why

1 Longitudinal study



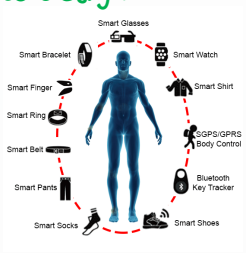
2 International standards

IDIH
INTERNATIONAL COLLABORATIO
DIGITAL TRANSFORMATION
HEALTHY AGEING

4 Information sources

5 Eco-system for wearables

co-creation and co-design
Academia /
Industry /
Consumers /
Institutions



6 Data access

Support learning health and wellness and social systems through the access to data, procurements, etc.

https://idih-global.eu/expert-groups/expert-group-preventive-care/

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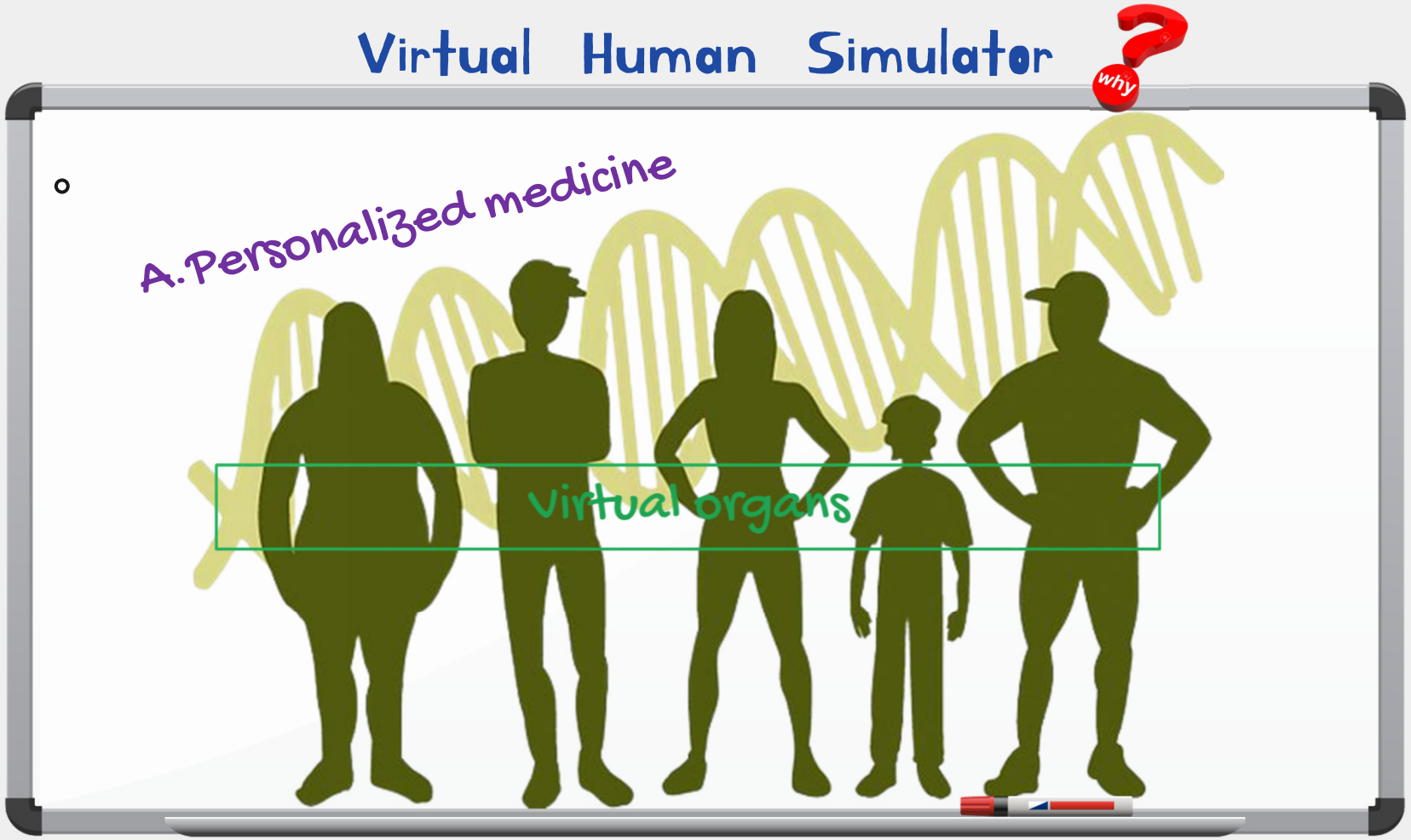
Virtual Human Simulator



https://venturebeat.com/business/21-ways-medical-digital-twins-will-transform-healthcare/

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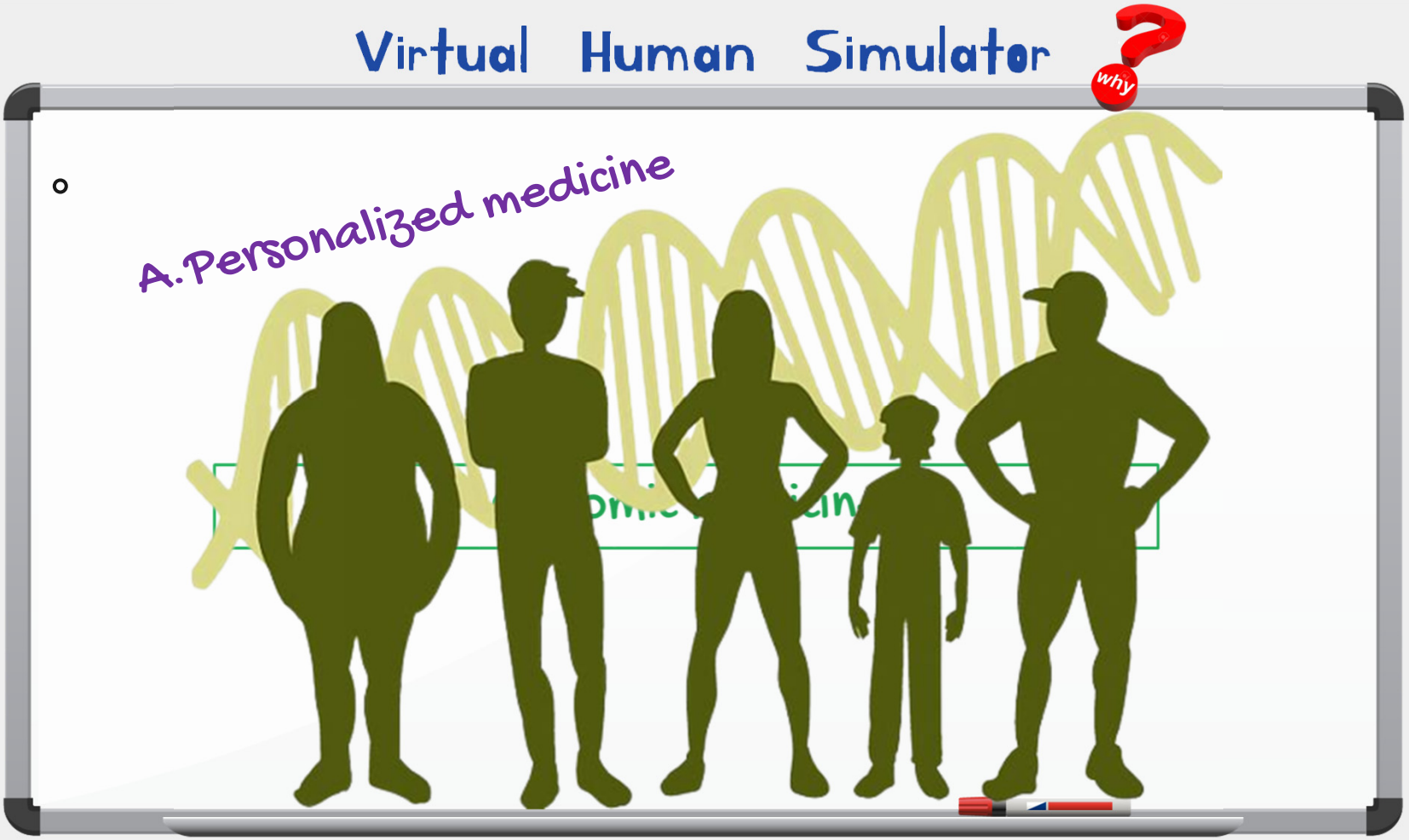
Virtual Human Simulator



Virtual Human Simulator

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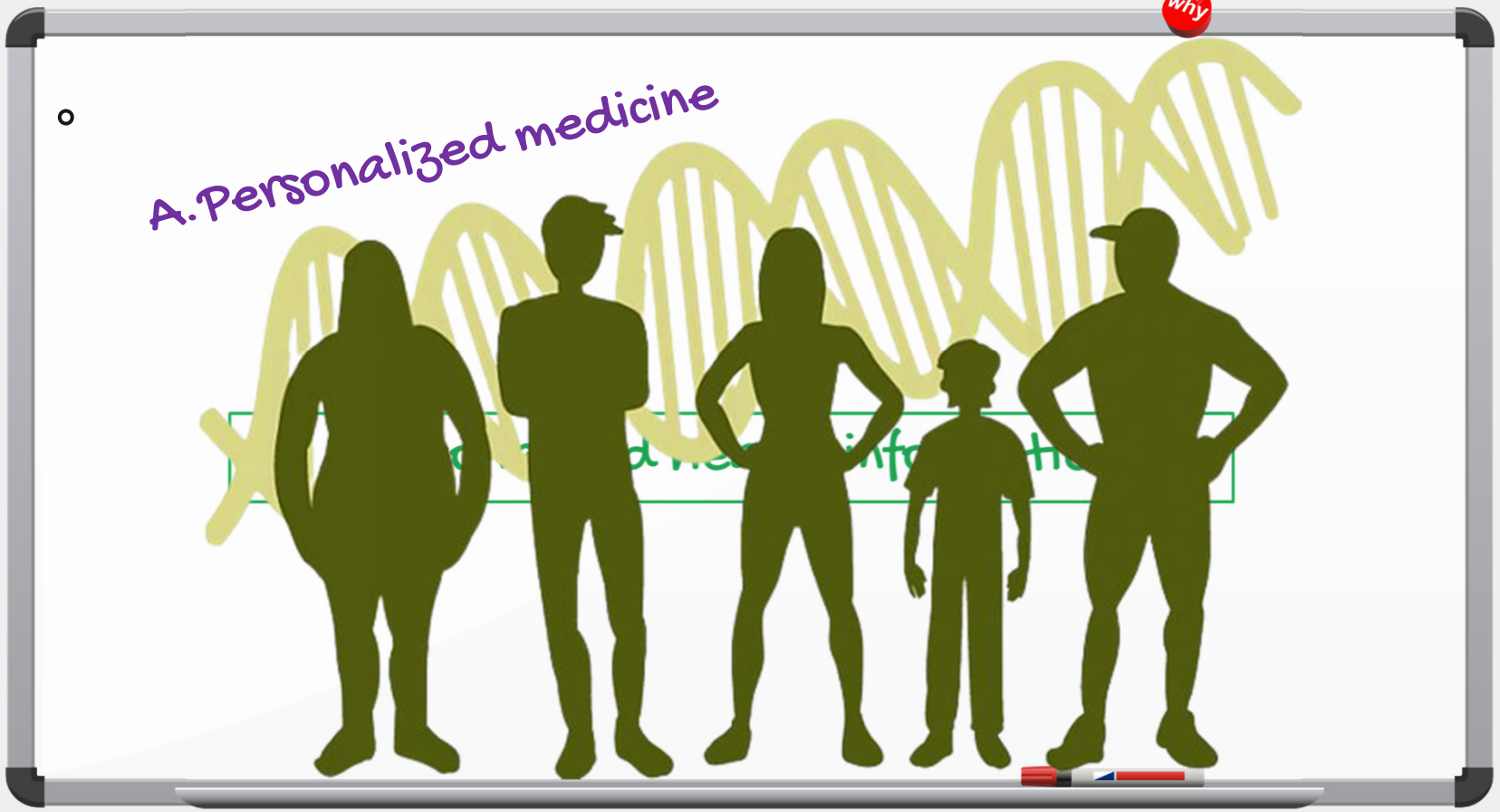
- A. Personalized medicine



Virtual Human Simulator

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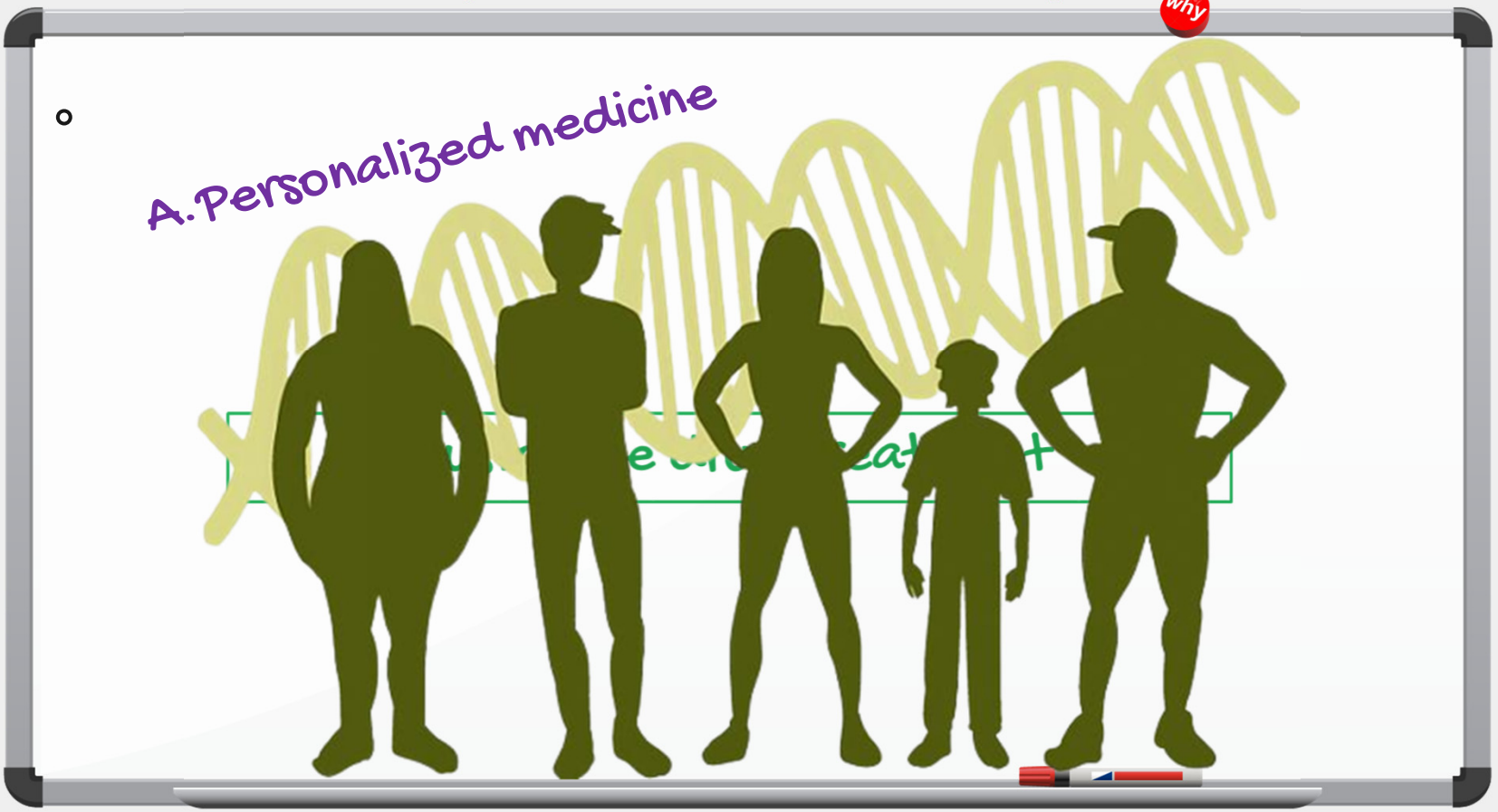

Virtual Human Simulator

PLM
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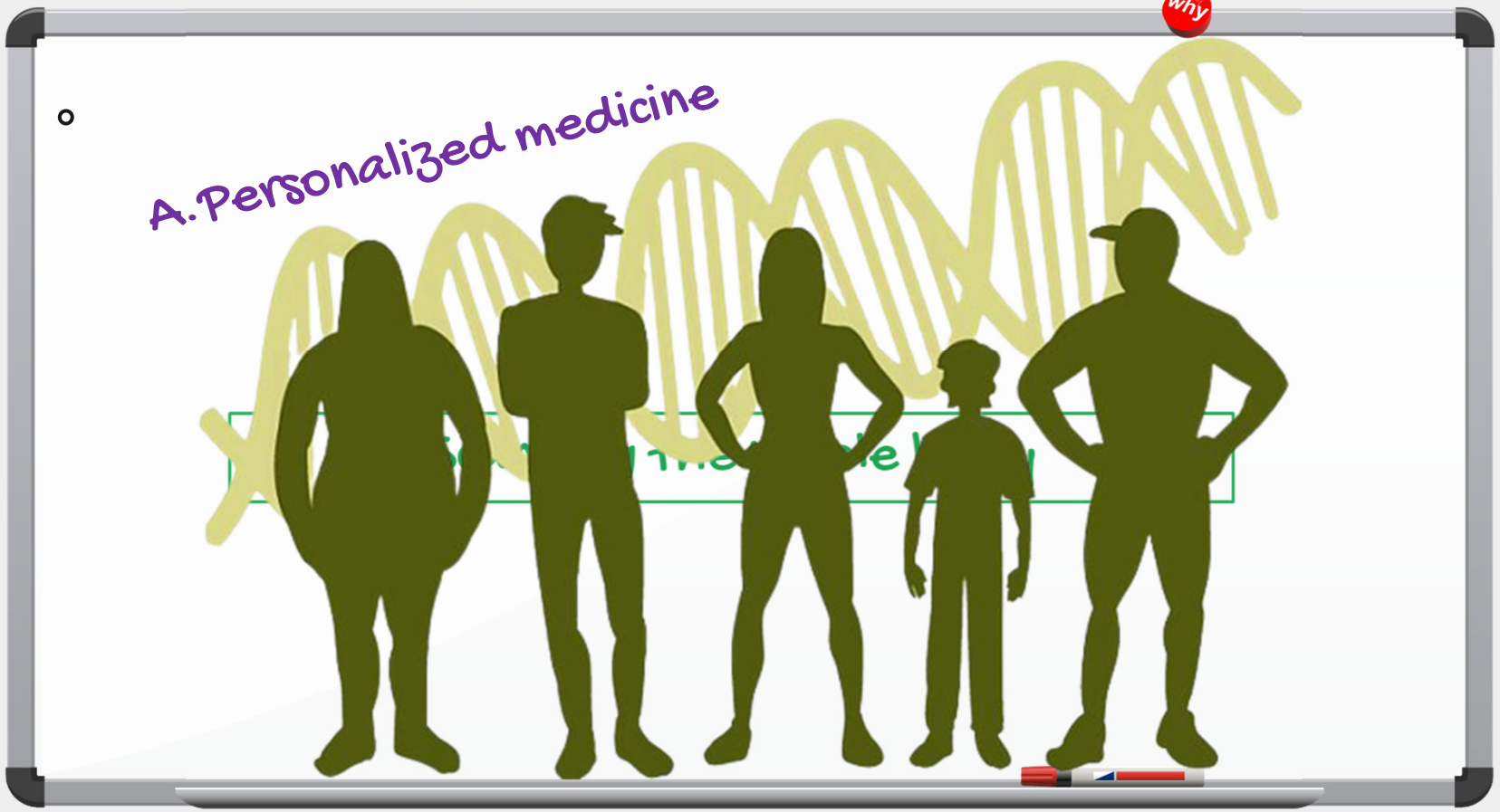
- A. Personalized medicine



Virtual Human Simulator

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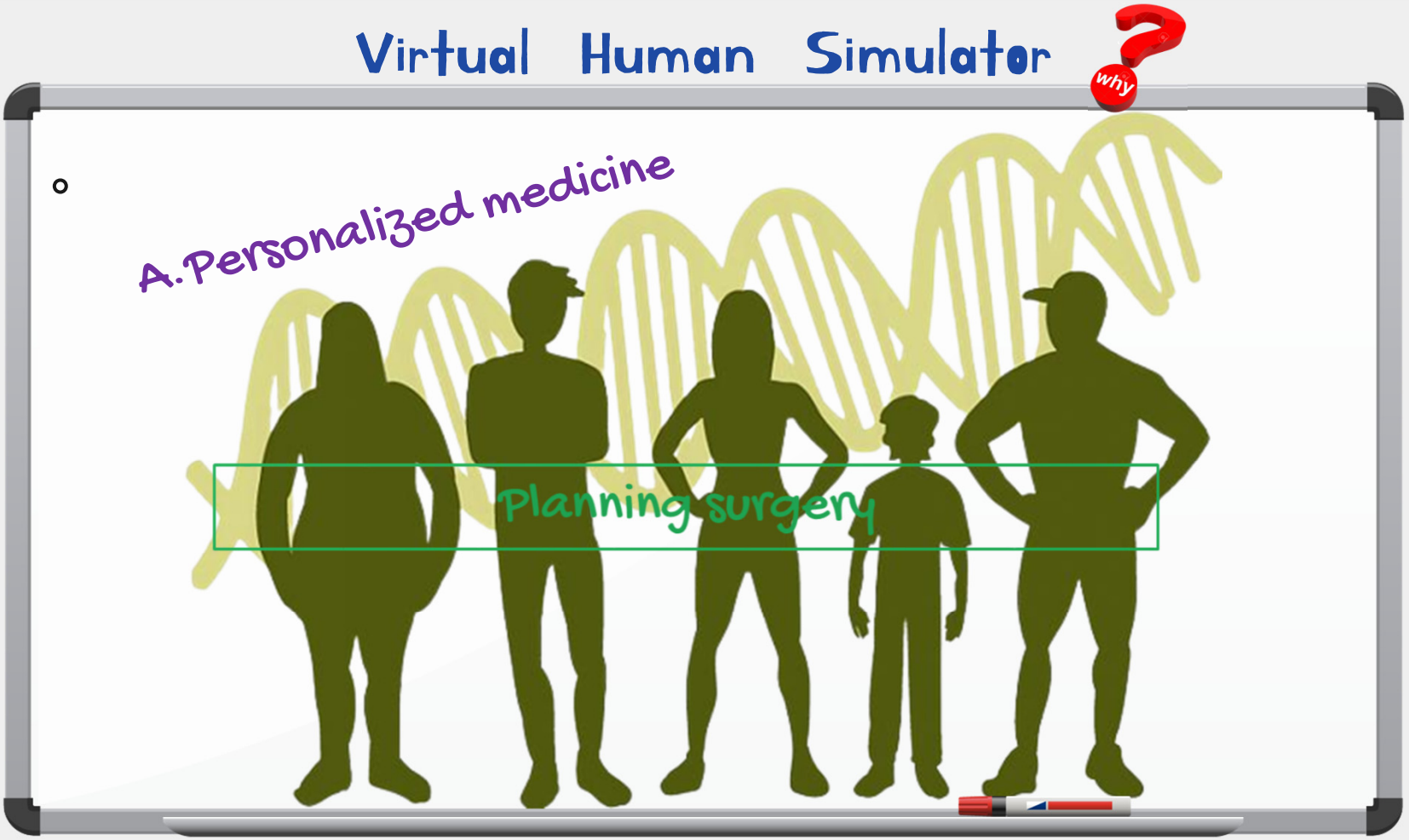

Virtual Human Simulator

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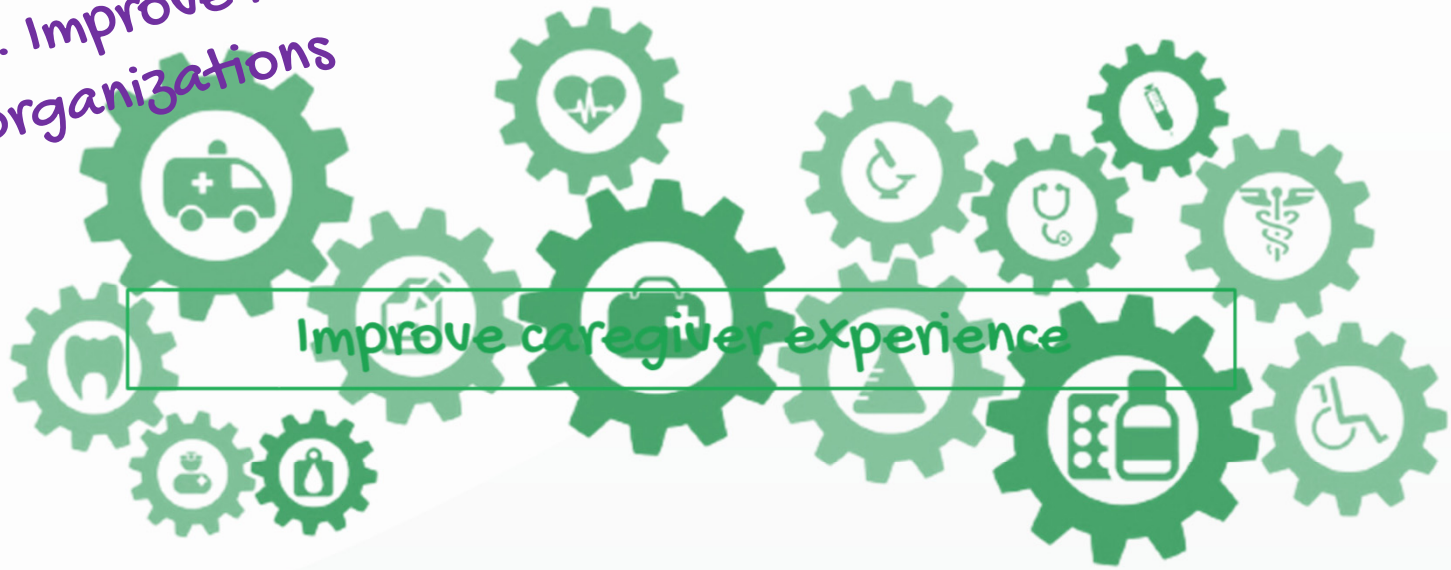
VHS

- B. Improve healthcare organizations



Virtual Human Simulator

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- B. Improve healthcare organizations

Virtual Human Simulator

PLM
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DT
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VHS

- B. Improve healthcare organizations

Virtual Human Simulator

PLM
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VHS

- B. Improve healthcare organizations

Virtual Human Simulator

PLM
MSM
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VHS

- B. Improve healthcare organizations

*capacity for resistance and recovery

Virtual Human Simulator

PLM
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- B. Improve healthcare organizations

Virtual Human Simulator

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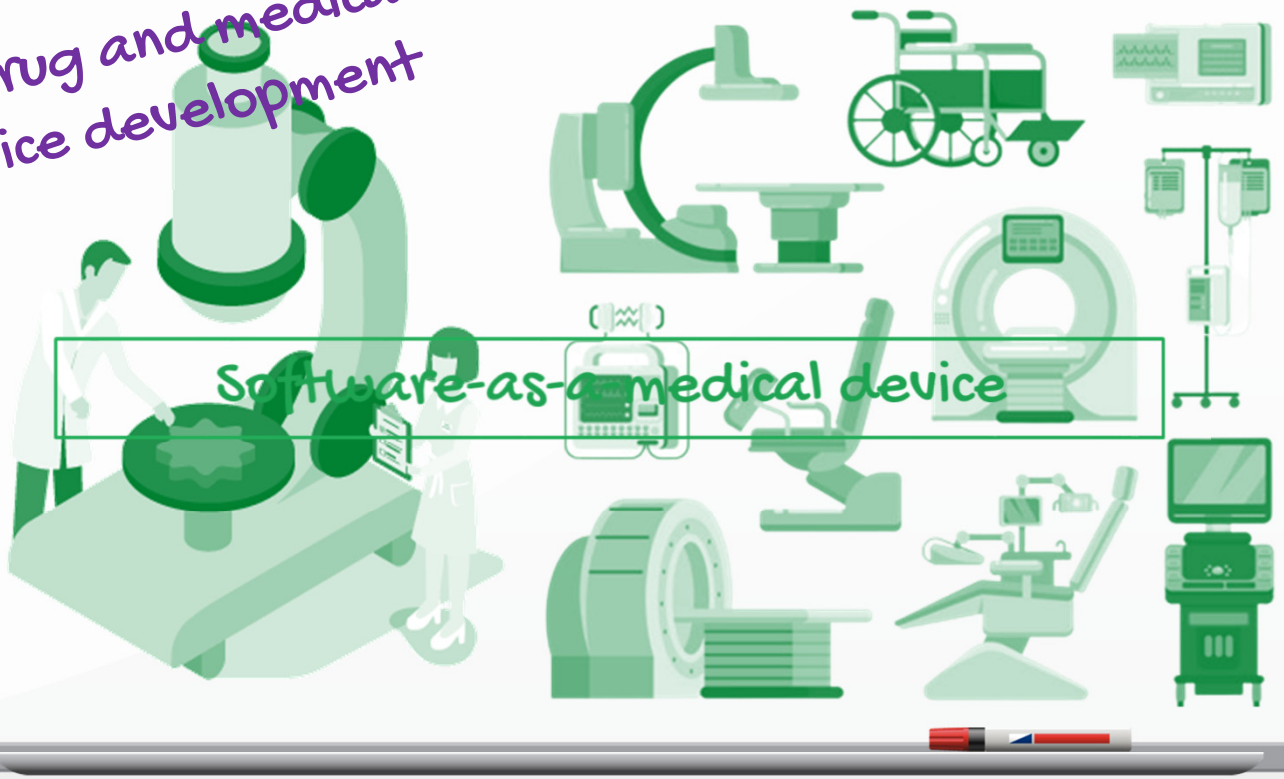
VHS

- C. Drug and medical device development



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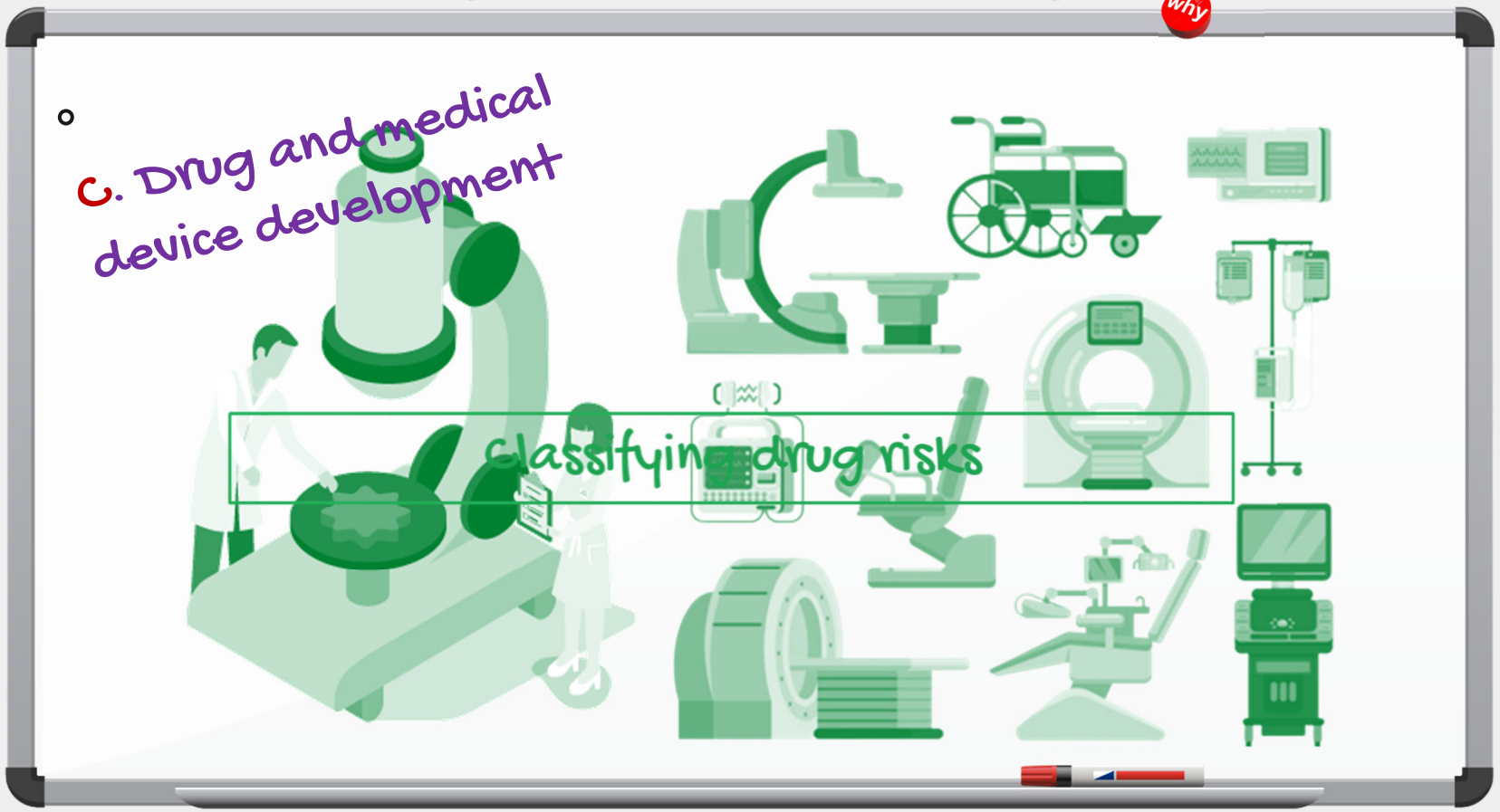
Virtual Human Simulator



Virtual Human Simulator

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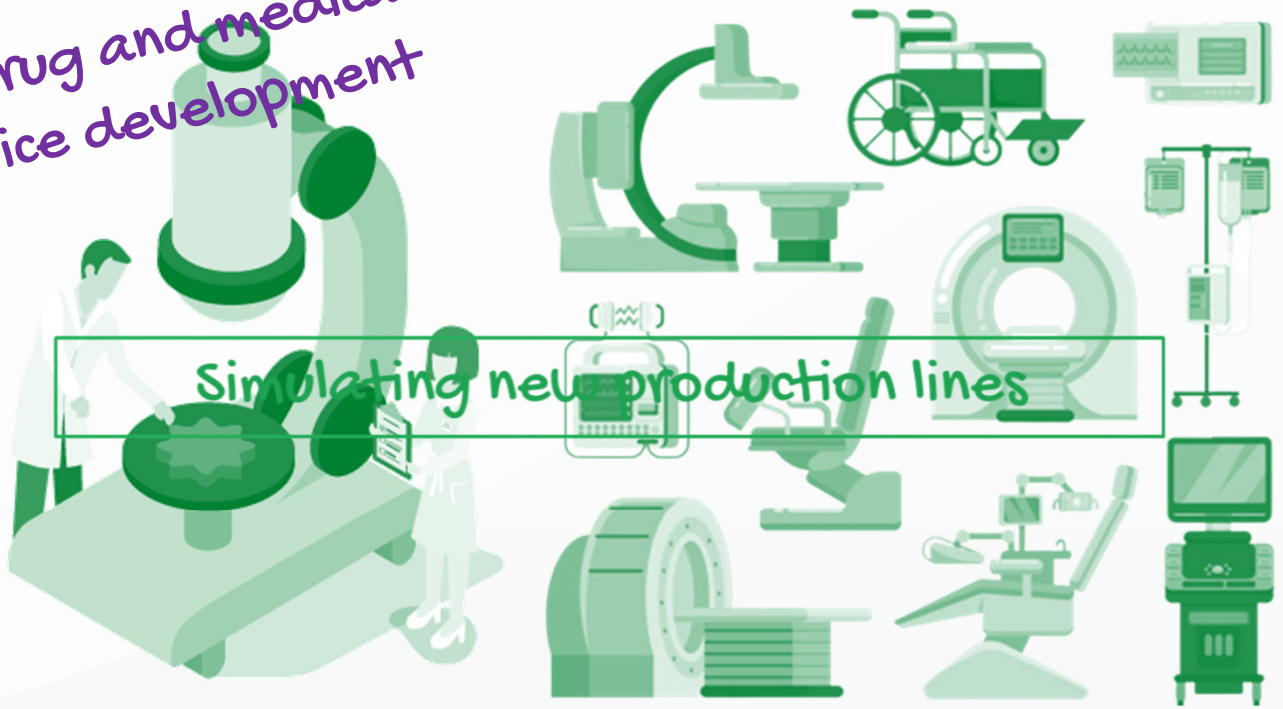
- c. Drug and medical device development



Virtual Human Simulator

PLM
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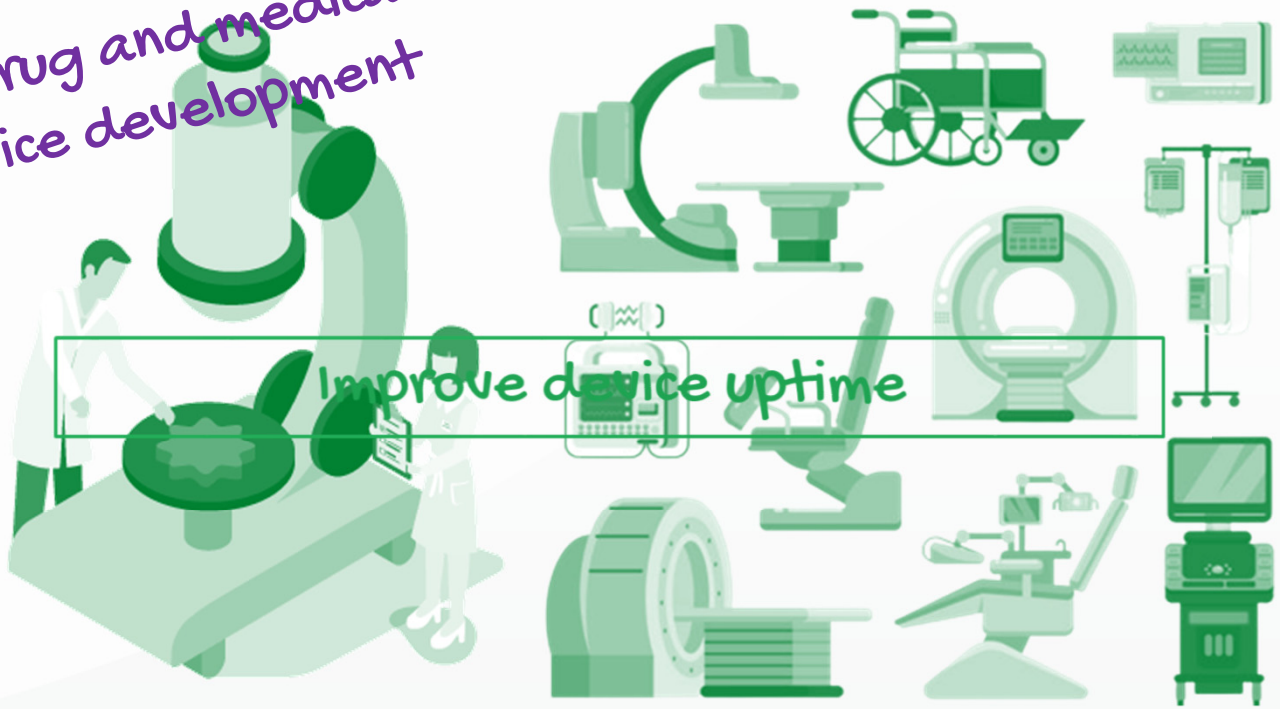
- C. Drug and medical device development



Virtual Human Simulator

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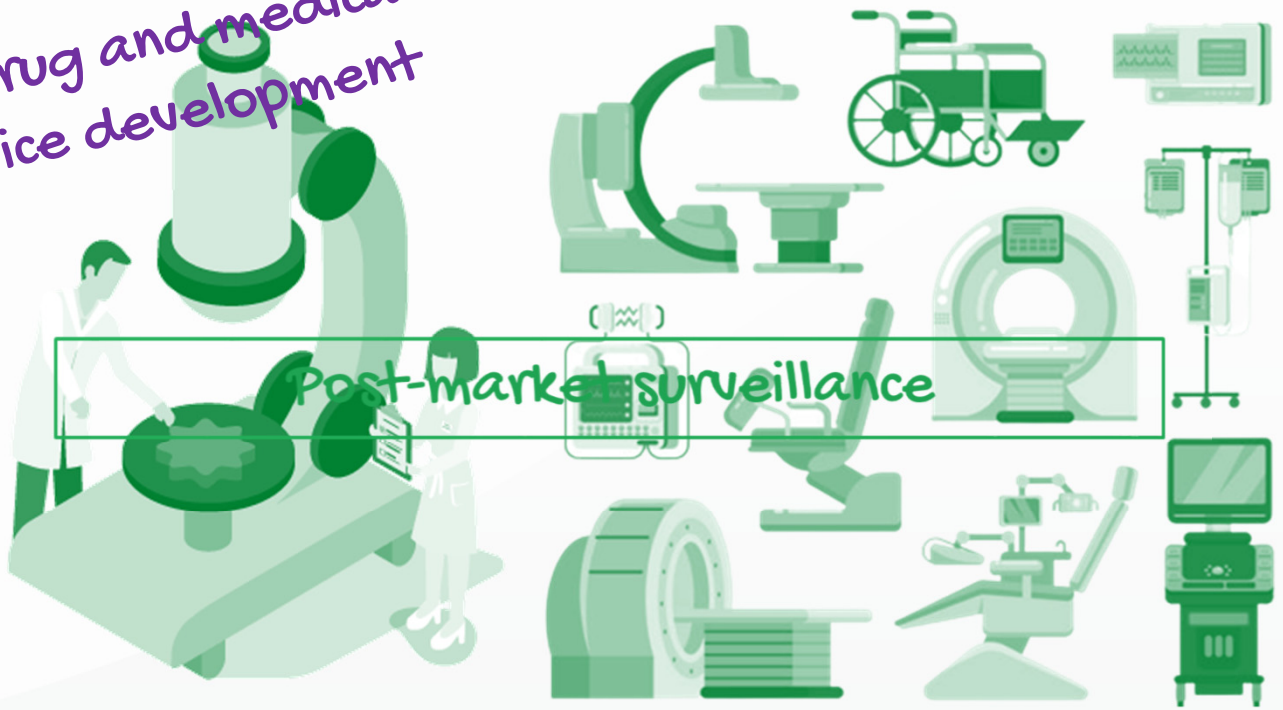
- C. Drug and medical device development



Virtual Human Simulator

PLM
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VHS

- C. Drug and medical device development

Virtual Human Simulator

PLM
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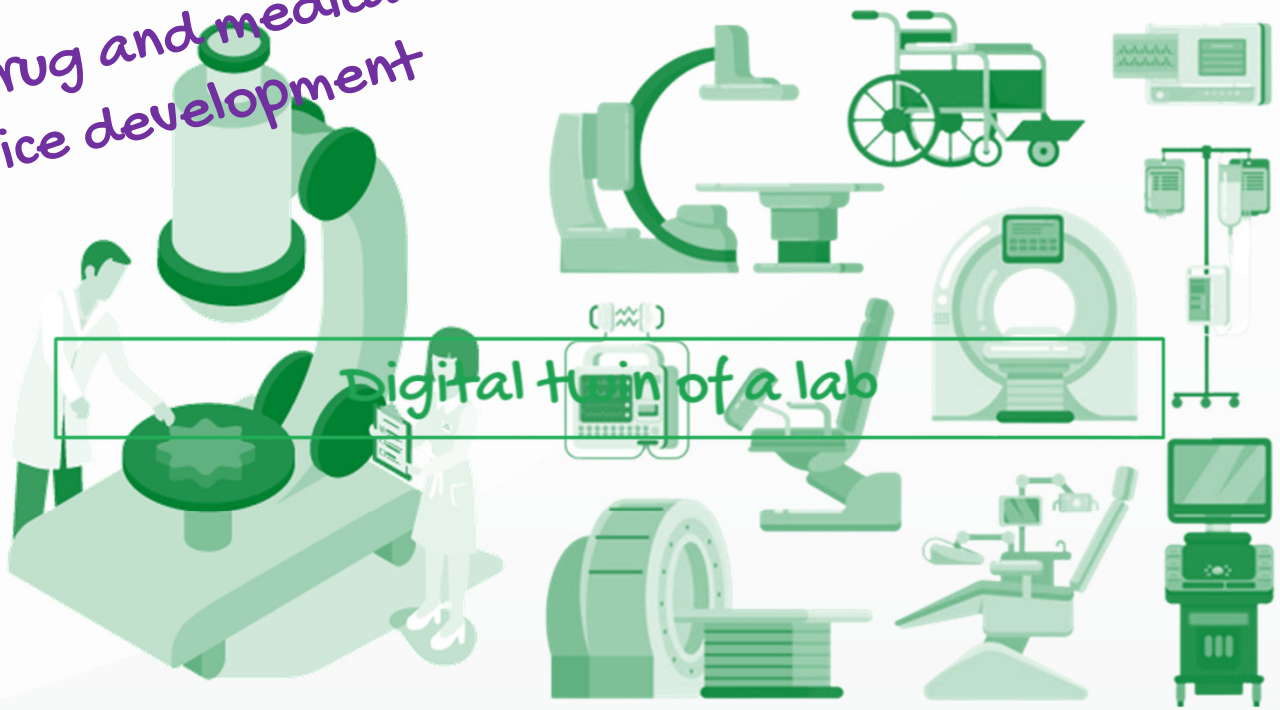
DT
ADT
IDT
VHS

- C. Drug and medical device development



PLM
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VHS

Virtual Human Simulator

A. Personalized medicine

1. Virtual organs
2. Genomic medicine
3. Personalized health information
4. Customize drug treatment
5. Scanning the whole body
6. Planning surgery

B. Improving healthcare organizations

7. Improving caregiver experience
8. Driving efficiency
9. Shrinking critical treatment window
10. Value-based healthcare
11. Supply chain resilience
12. Faster hospital construction
13. Streamlining call center interactions

C. Drug and medical device development

14. Software-as-a-medical device
15. Classifying drug risks
16. Simulating new production lines
17. Improve device uptime
18. Post-market surveillance
19. Simulating human variability
20. Digital twin of a lab
21. Improving drug delivery

https://venturebeat.com/business/21-ways-medical-digital-twins-will-transform-healthcare/

Virtual Human Simulator

PLM
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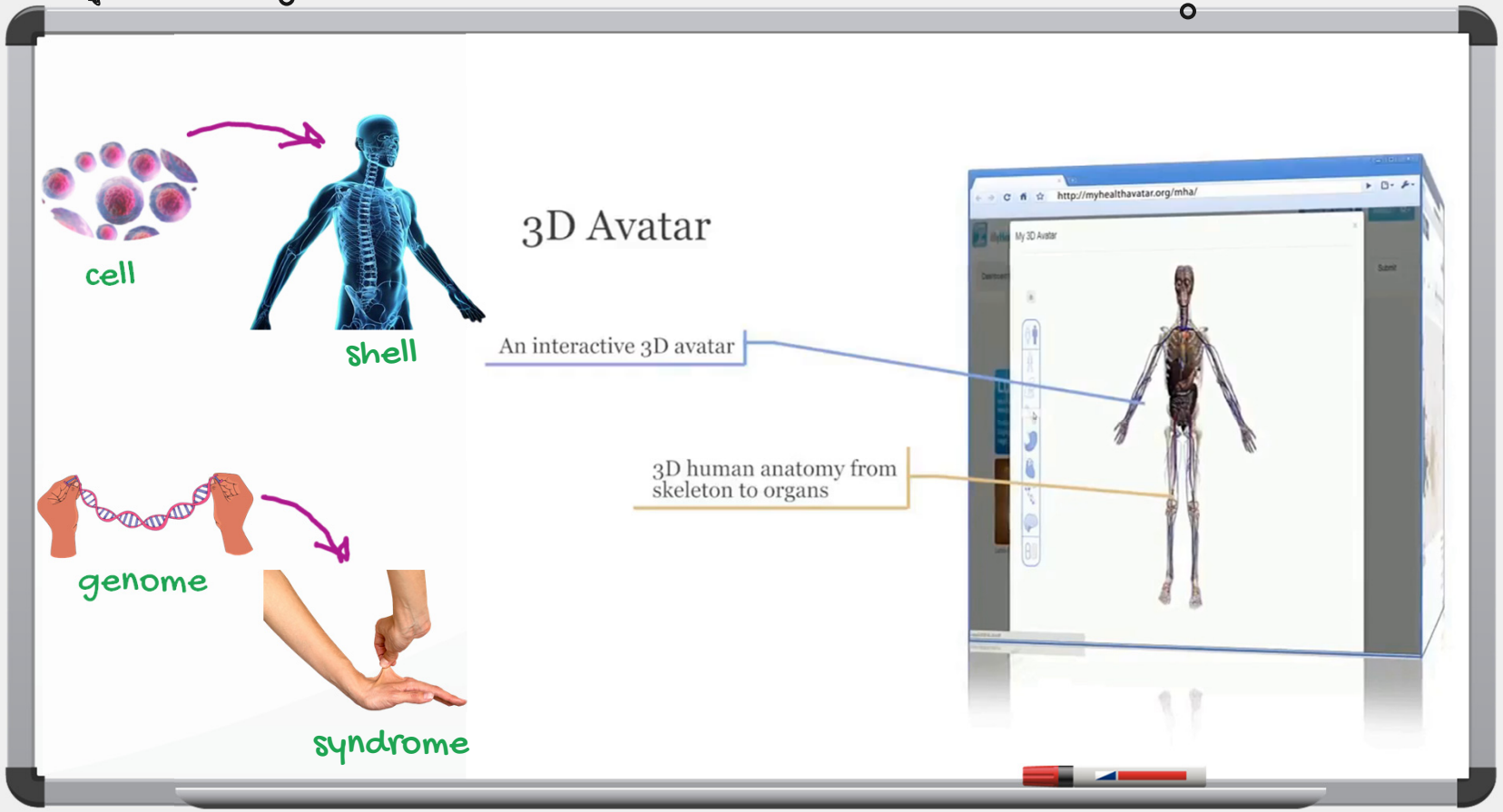
VHS



Martinez-Velazquez et al. (2019). Cardio Twin: A Digital Twin of the human heart ….
IEEE International Symposium on Medical Measurements and Applications (MeMeA)

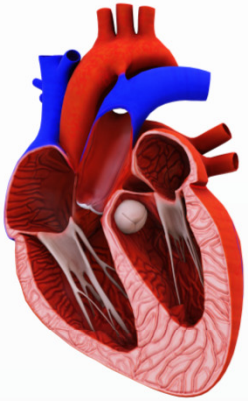
Spanakis et al. (2014, November). MyHealthAvatar ……..
4th IEEE International Conference MOBIHEALTH, pp. 331-334

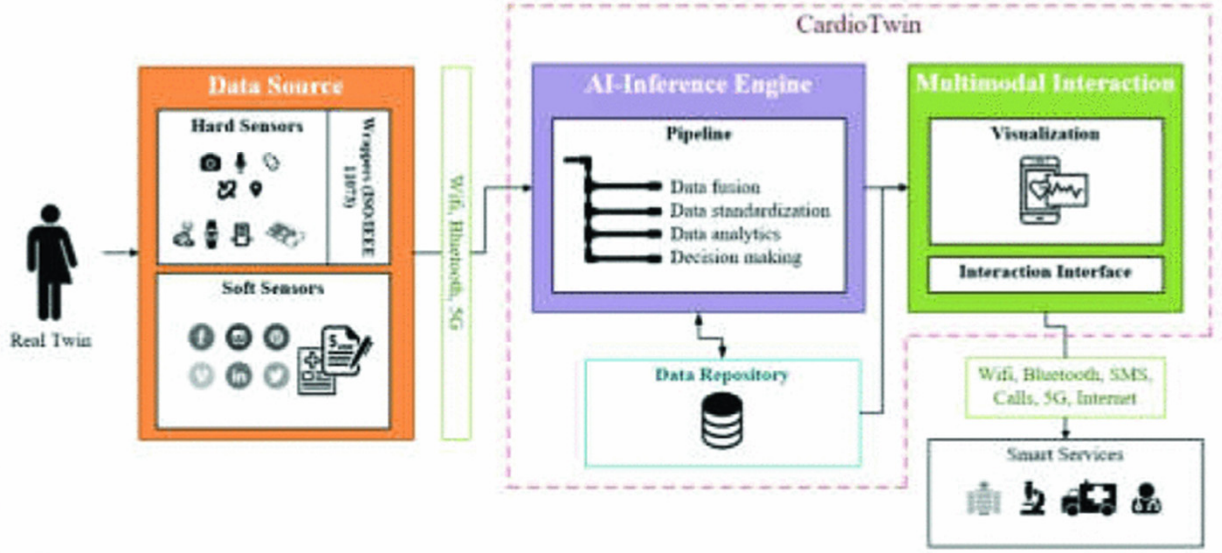
Cardio Twin

PLM
MSM
IMM
DT
ADT
IDT
VHS

EXAMPLES

Cardio Twin: an architecture of a DT for healthcare and well-being running on the edge to help in the event of an Ischemic Heart Diseases (IHD) situation





Martinez-Velazquez et al. (2019). Cardio Twin: A Digital Twin of the human heart running on the edge. IEEE International Symposium on Medical Measurements and Applications (MeMeA)

Cardio Twin

PLM
MSM
IMM
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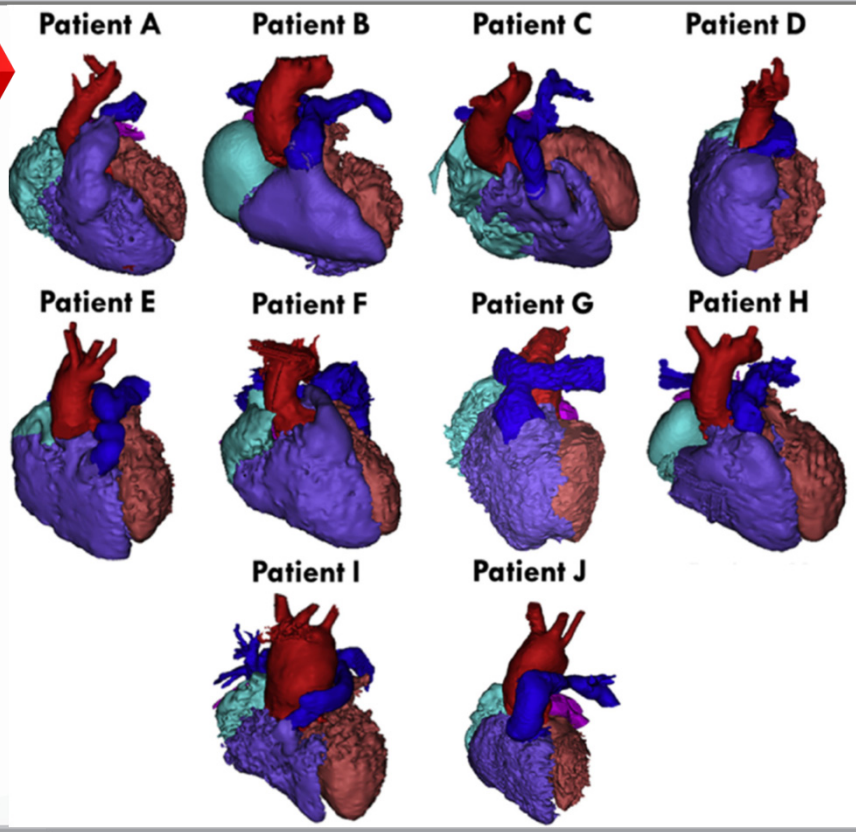
ADT
IDT
VHS

EXAMPLES



3D models of the patients' hearts created by segmentation.

Patients A-E, Pulmonary atresia with ventricular septal defect.

Patients F-J, Truncus arteriosus

Ebrahimi et al. (2020). Evaluation of personalized right ventricle to pulmonary artery conduits using in silico design and computational analysis of flow. JTCVS open, 1, 33-48.

Breast cancer

PLM
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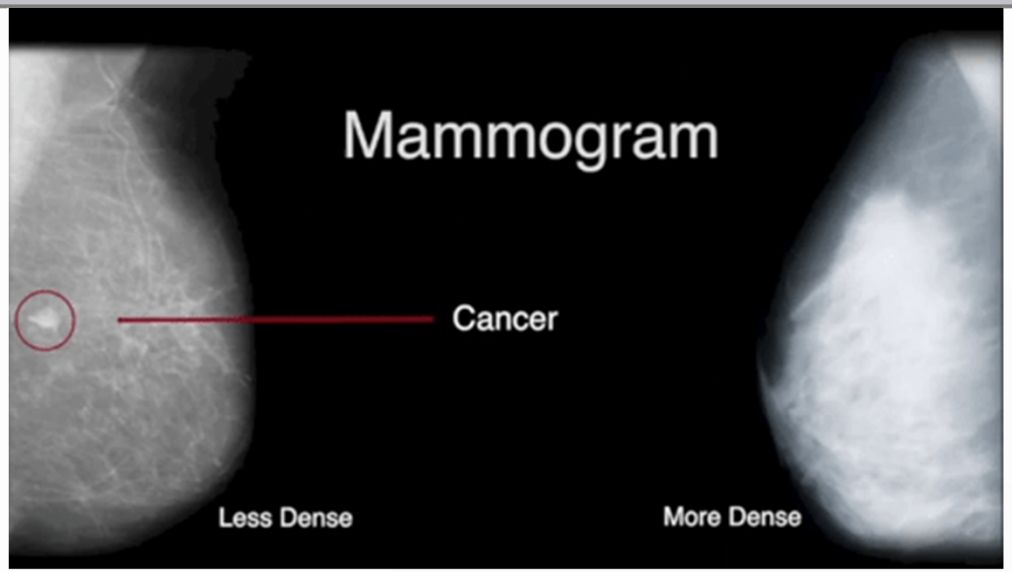
ADT
IDT
VHS

EXAMPLES



Physical state — anatomy,..

observational data — metabolism,..

control inputs — biopsies,..

focus variables — shape,..

rewards — efficacy,..

DT state — dynamics,..

THE CENTER FOR COMPUTATIONAL ONCOLOGY https://cco.oden.utexas.edu/

EPFL CIS Center for Intelligent Systems https://www.epfl.ch/research/domains/cis/

Interest

forecast
simulate
PLM
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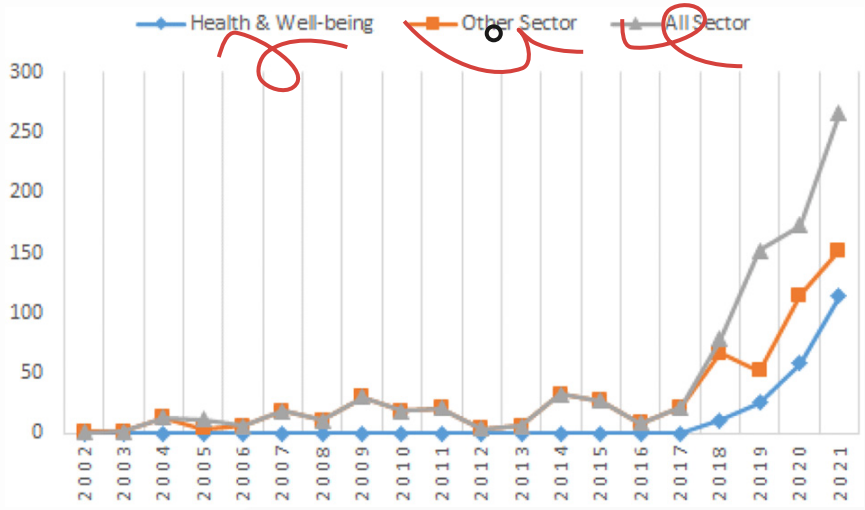
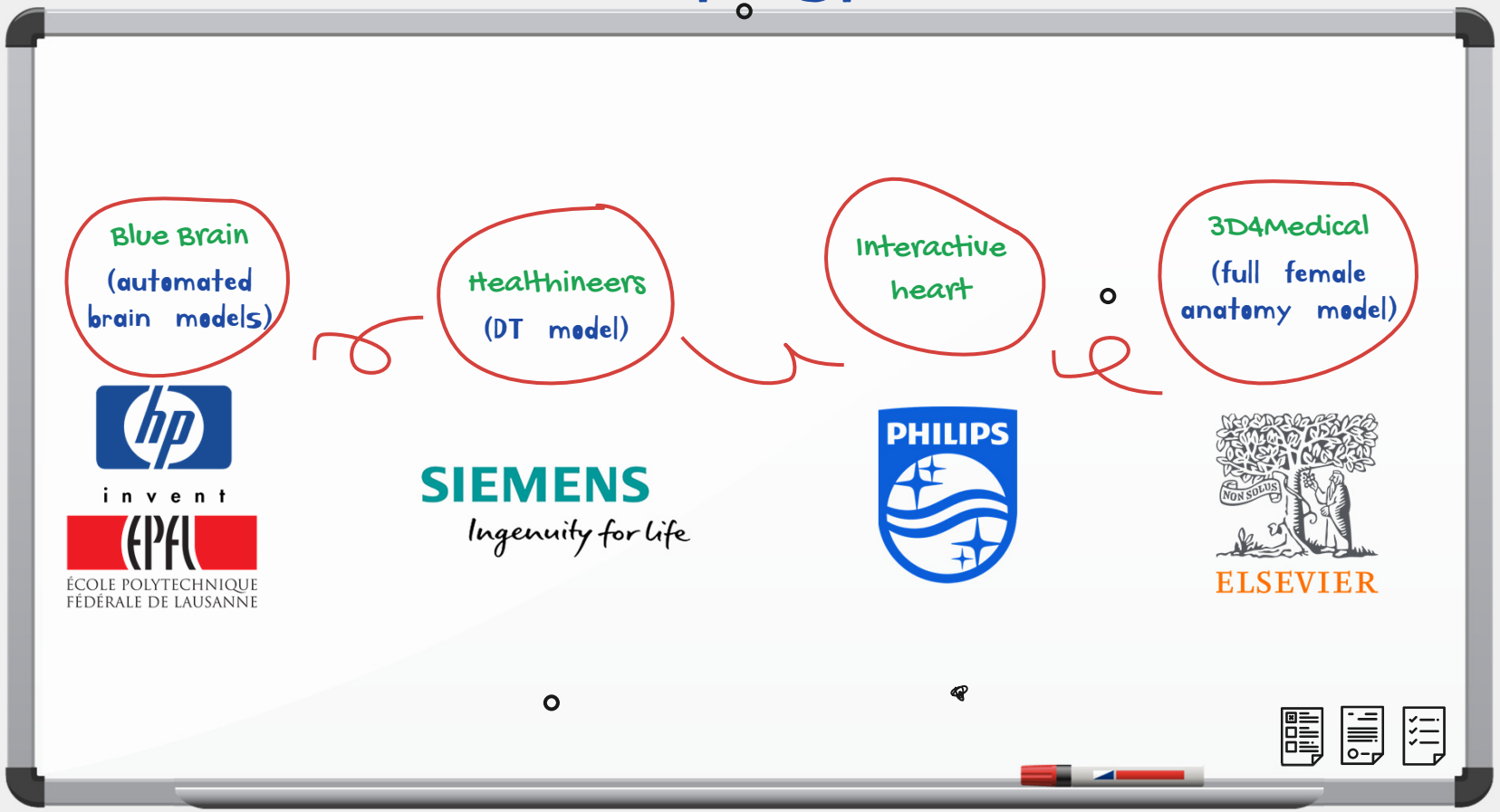


# of digital twin publications in different fields based on surveyed papers between 2002 and 2021

Ferdousi et al. Digital twins for well-being: an overview. Digital Twin 2022, 1:7

Interest

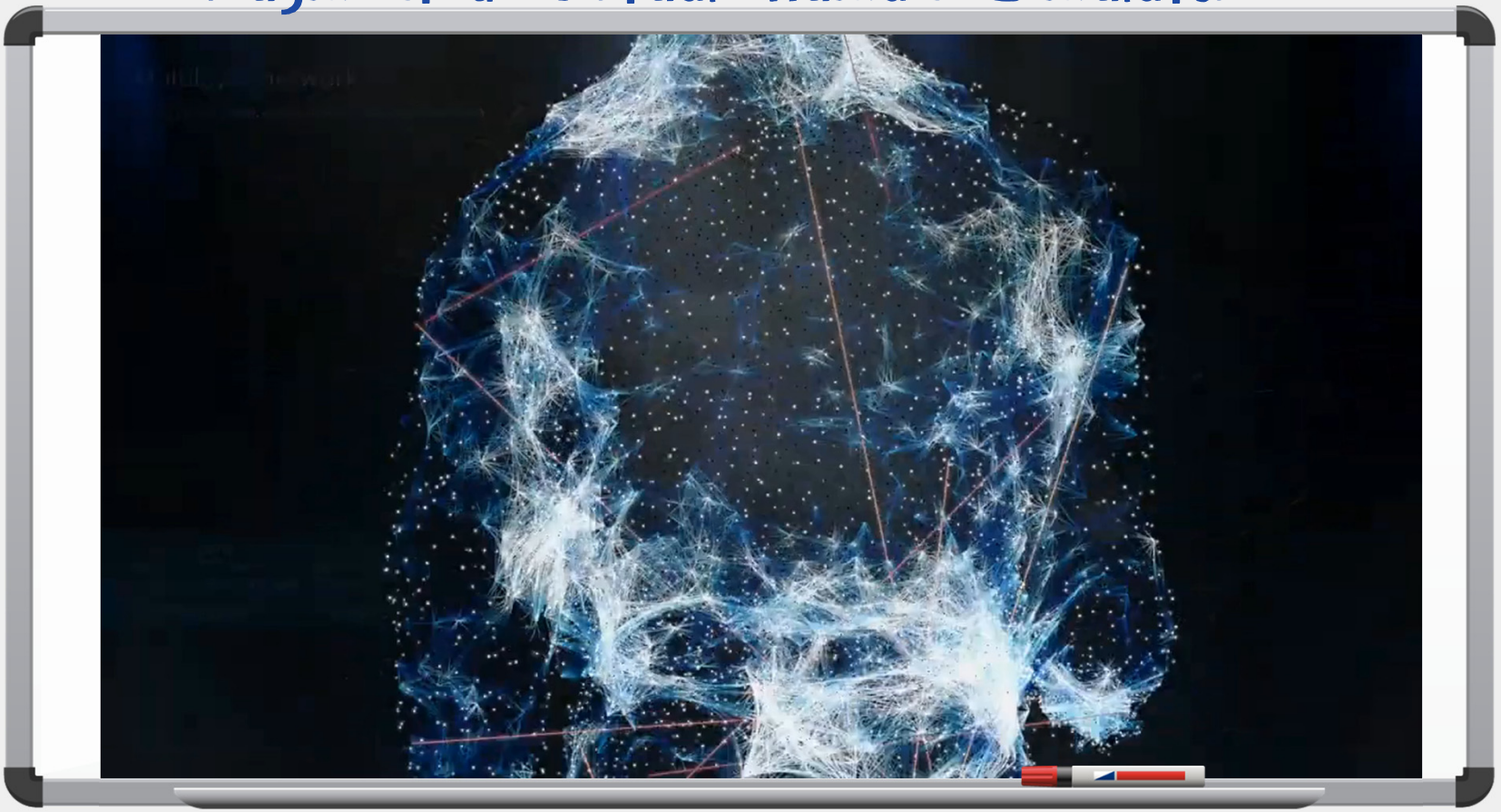


Garg, H. (2021). Digital twin technology: Revolutionary to improve personalized healthcare Science Progress and Research (SPR), 1(1), 32-34.

https://3d4medical.com/

Augmented Virtual Human Simulator

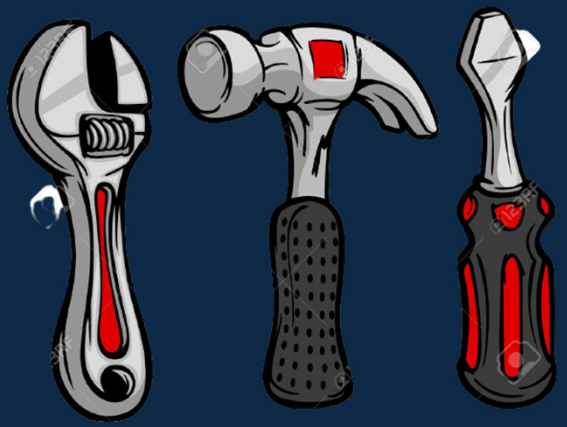
PLM
MSM
IMM
DT
ADT
IDT
VHS
AVHS



AVHS interacts with its real entity, with its surroundings and other VHSs too

DT is trendy, but..

Resources



Resources

ditto

ECLIPSE FOUNDATION

OPEN SOURCE CODE

www.eclipse.org/ditto

Eclipse Ditto™ implements DT in the IoT.
It mirrors potentially billions of DTs residing in the digital world with physical "Things".
It is "middleware" between IoT devices and IoT solutions

Resources

Azure DTs is a platform as a service (PaaS) that enables the creation of knowledge graphs based on digital models of entire environments:

buildings,
factories,
farms,
energy grids,
railroads,
stadiums, ...,
entire cities.

Microsoft

https://azure.microsoft.com/it-it/products/digital-twins/

Resources

GPT: (Generative Pre-trained Transformer) autoregressive language model that uses deep learning to produce human-like text

Chat-GPT: interacts in a conversational way

Bio-GPT: for Biomedical Text Generation and Mining

Microsoft

https://github.com/microsoft/BioGPT

How far HVS?

Mindy

EXAMPLES

https://www.scienzenotizie.it/2022/11/09/ecco-come-saremo-nel-3000-cervello-piccolo-gobba-e-occhi-spiritati-centra-la-tecnologia-1062679

EXAMPLES

J. S. Castro

EXAMPLES


Cloud nine
Ceilings

The 10 Scariest Future Tech Trends

AI Singularity

When AI becomes smarter than humans





1 — 2 — 3 — 4 — 5

Forbes

https://www.forbes.com/sites/bernardmarr/2023/01/16/the-10-scariest-future-tech-trends-everyone-must-know-about-right-now/

Jan 16, 2023

The 10 Scariest Future Tech Trends

Editable Humans

Gene editing

1 — **2** — 3 — 4 — 5

Forbes

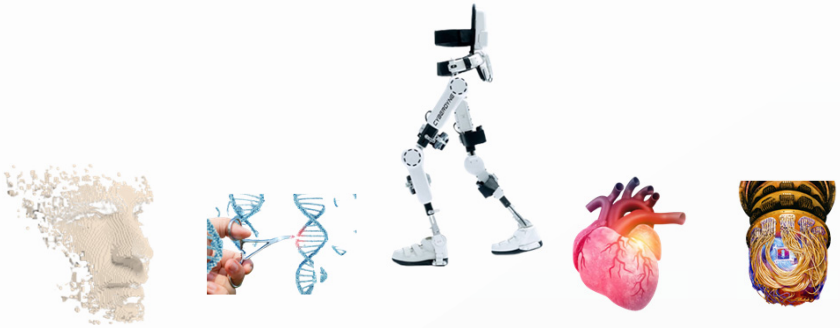
https://www.forbes.com/sites/bernardmarr/2023/01/16/the-10-scariest-future-tech-trends-everyone-must-know-about-right-now/

Jan 16, 2023

The 10 Scariest Future Tech Trends

Human-machine merging

Prosthetic, exoskeleton,..



1 2 **3** 4 5

Forbes

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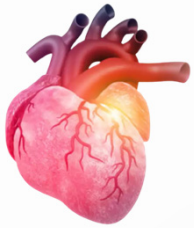
Jan 16, 2023

The 10 Scariest Future Tech Trends

3D printing ability

guns, organs,..




1 — 2 — 3 — **4** — 5

Forbes

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Jan 16, 2023

The 10 Scariest Future Tech Trends

Quantum Computing

trillion times + powerful than supercomputers

1 — 2 — 3 — 4 — **5**

Forbes

https://www.forbes.com/sites/bernardmarr/2023/01/16/the-10-scariest-future-tech-trends-everyone-must-know-about-right-now/

Jan 16, 2023

The 10 Scariest Future Tech Trends

6 **Autonomous Smart Robots** can make their own decisions

7 **Killer Drones** identify, track, and destroy targets

8 **Digital Surveillance** track everything

9 **Deep Fakes** create images and videos of anyone

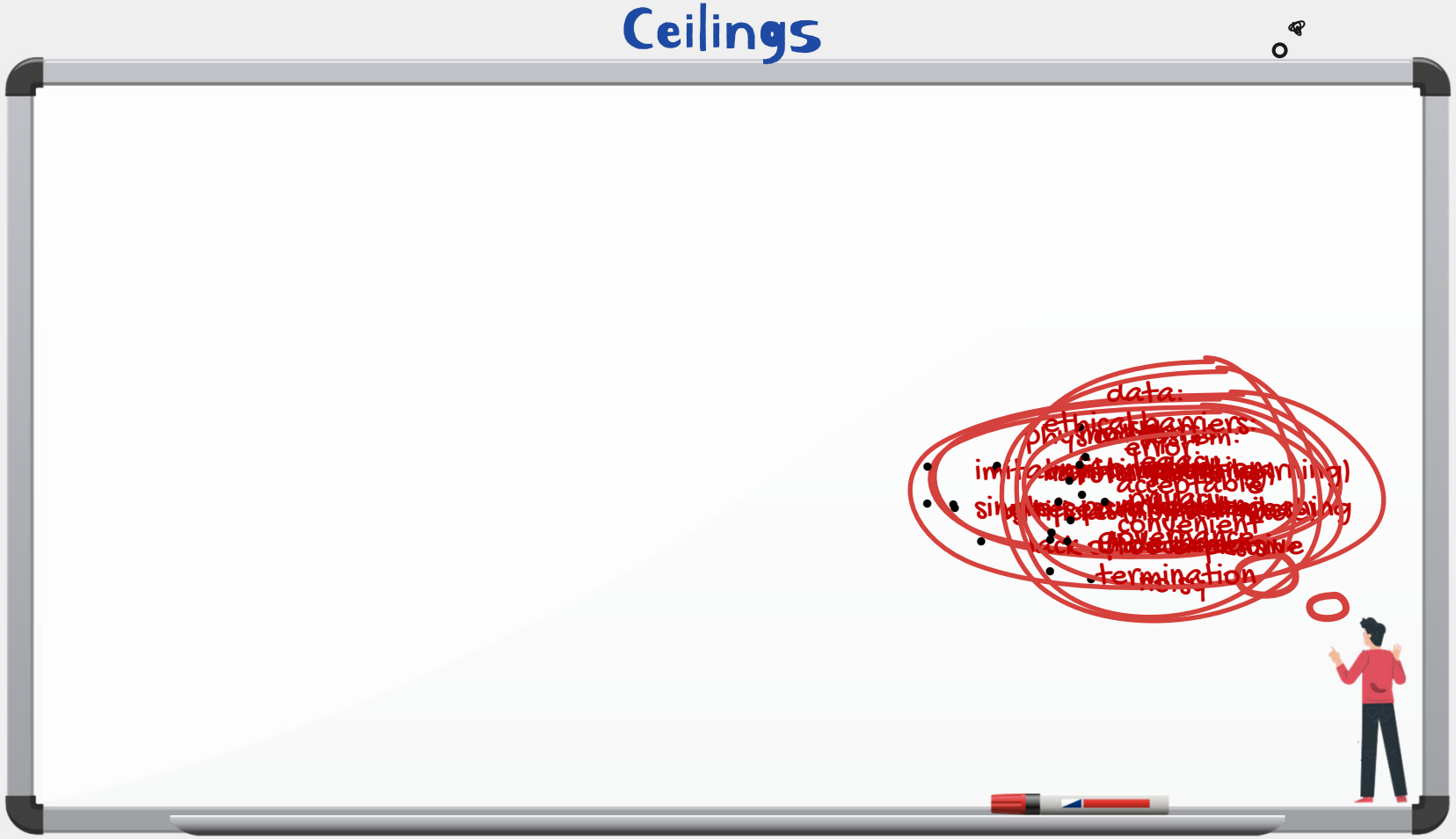
10 **Nanobots** robots at nanoscale

Forbes

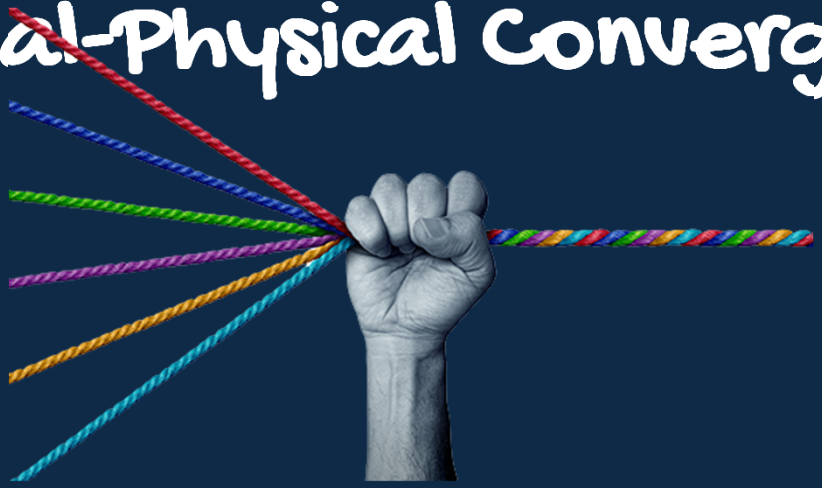
https://www.forbes.com/sites/bernardmarr/2023/01/16/the-10-scariest-future-tech-trends-everyone-must-know-about-right-now/

Jan 16, 2023

Ceilings


data:
ethical
problem:
error
acceptable
convenient
termination

Virtual-Physical Convergence



The (human) Digi-Real duality

wave–particle duality

PLM
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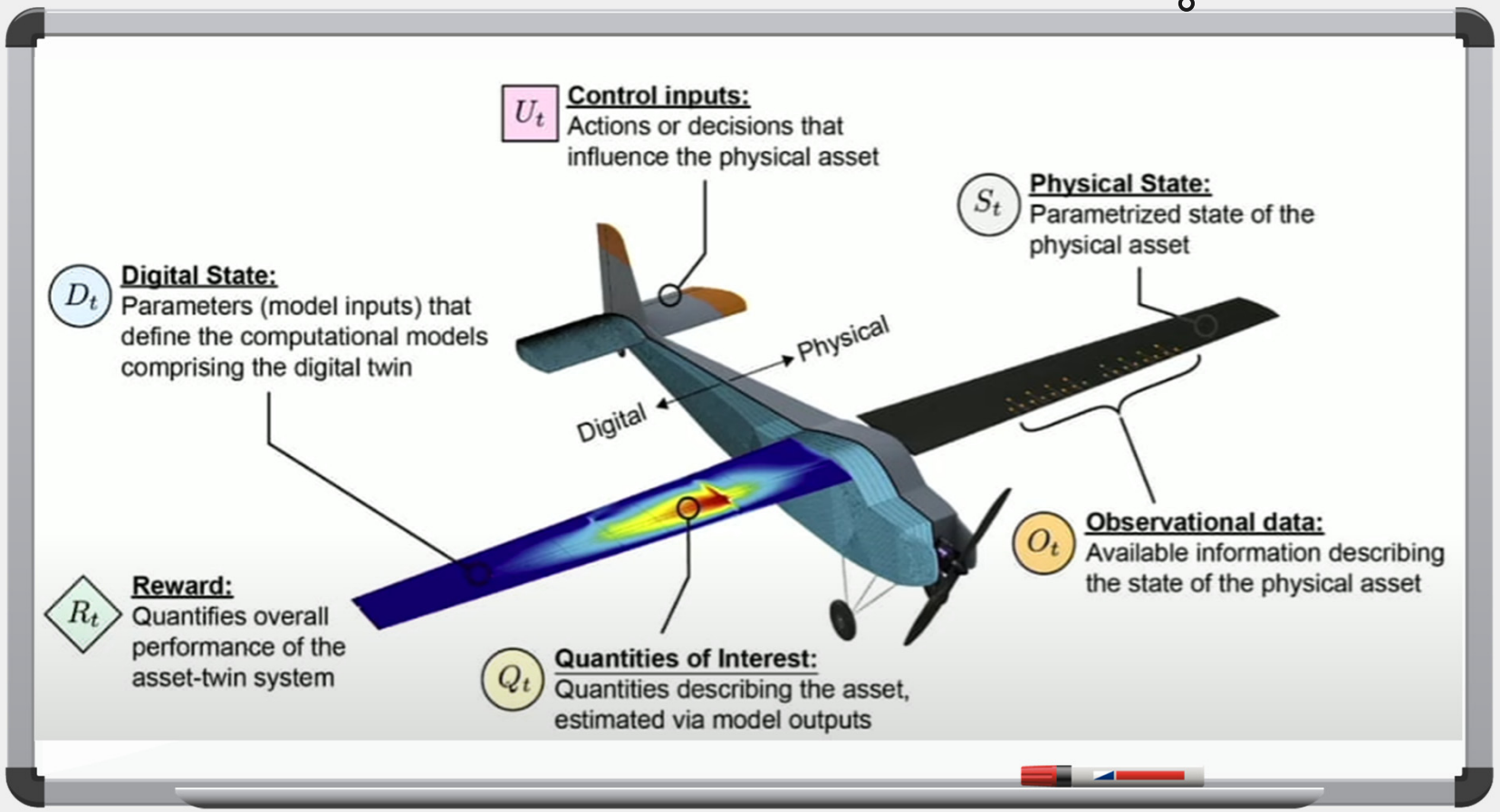
VHS
AVHS
DRD



Kapteyn et al. (2021). A probabilistic graphical model foundation for enabling predictive digital twins at scale. Nature Computational Science, 1(5), 337-347.

Willcox, K. E. Predictive Digital Twins.

PLM
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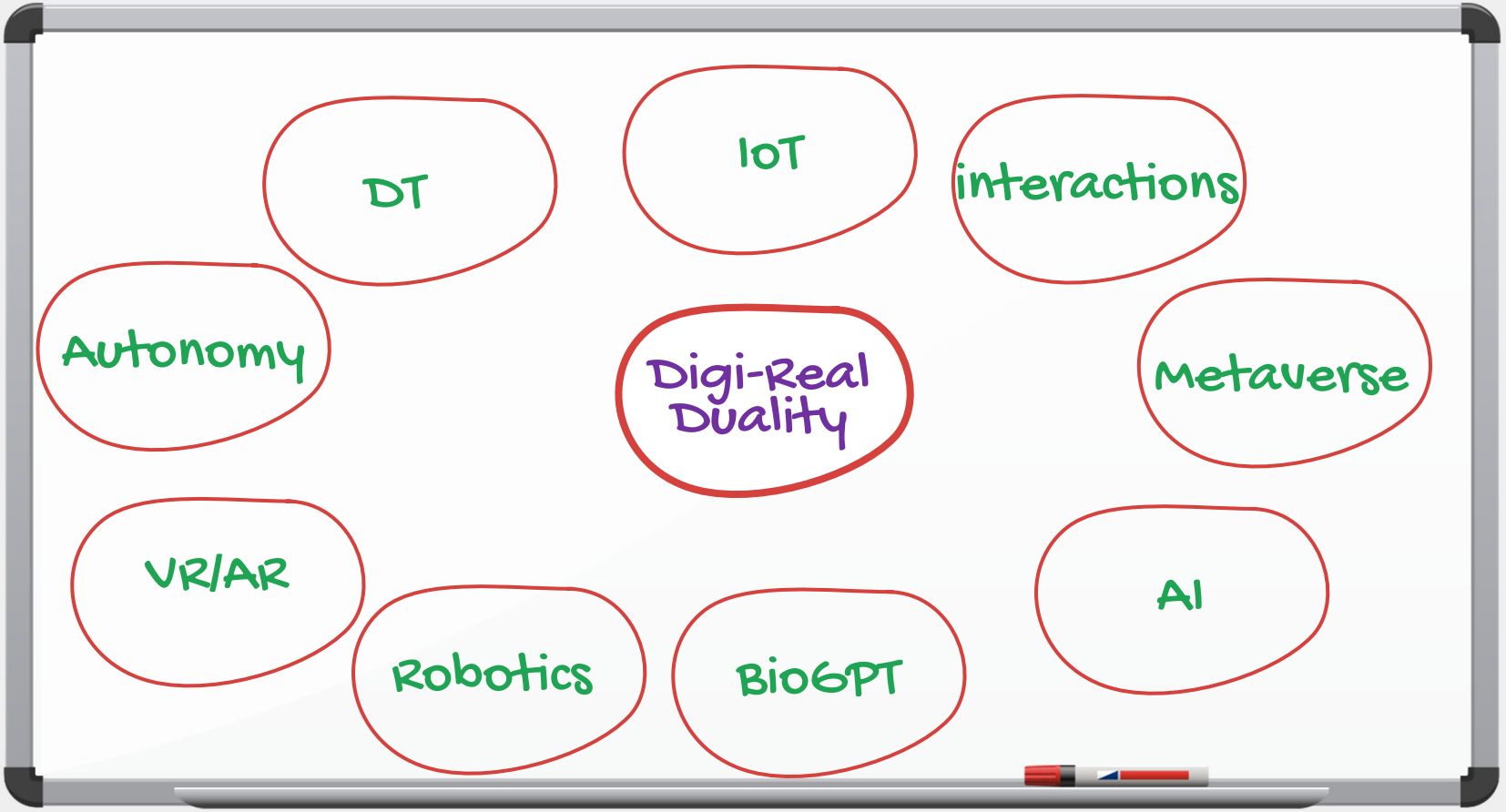
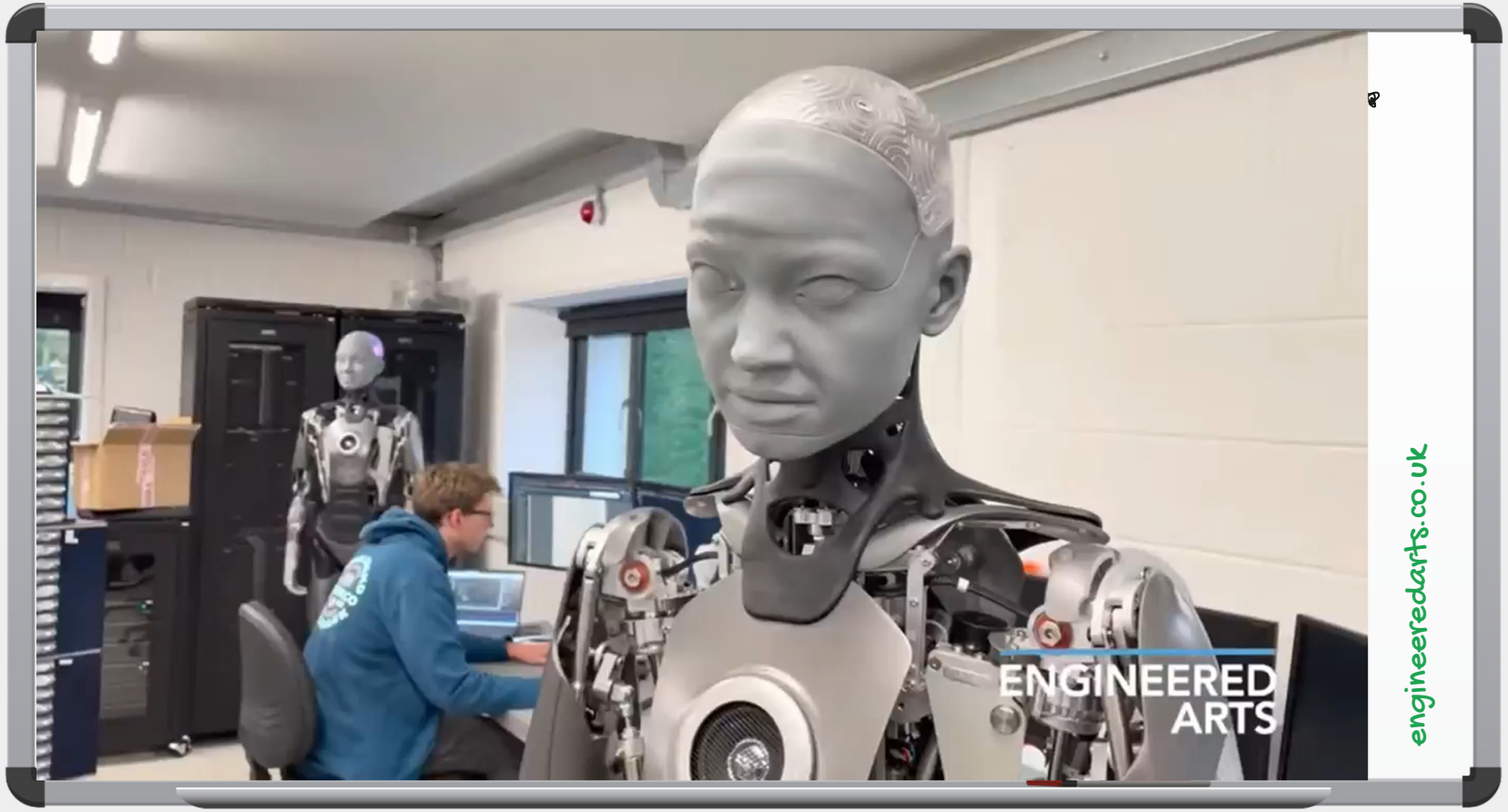
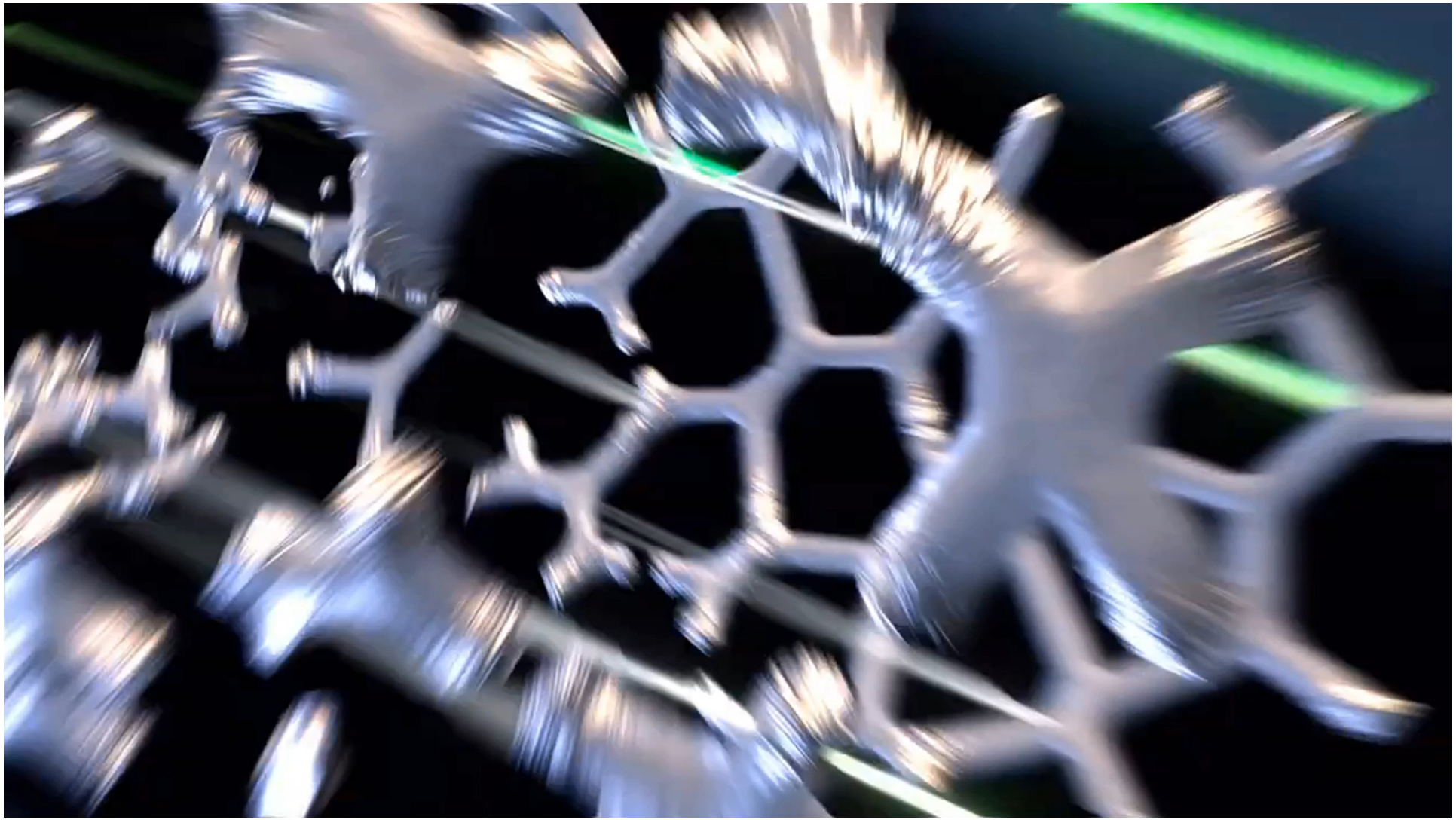
DRD




ENGINEERED
ARTS
engineeredarts.co.uk

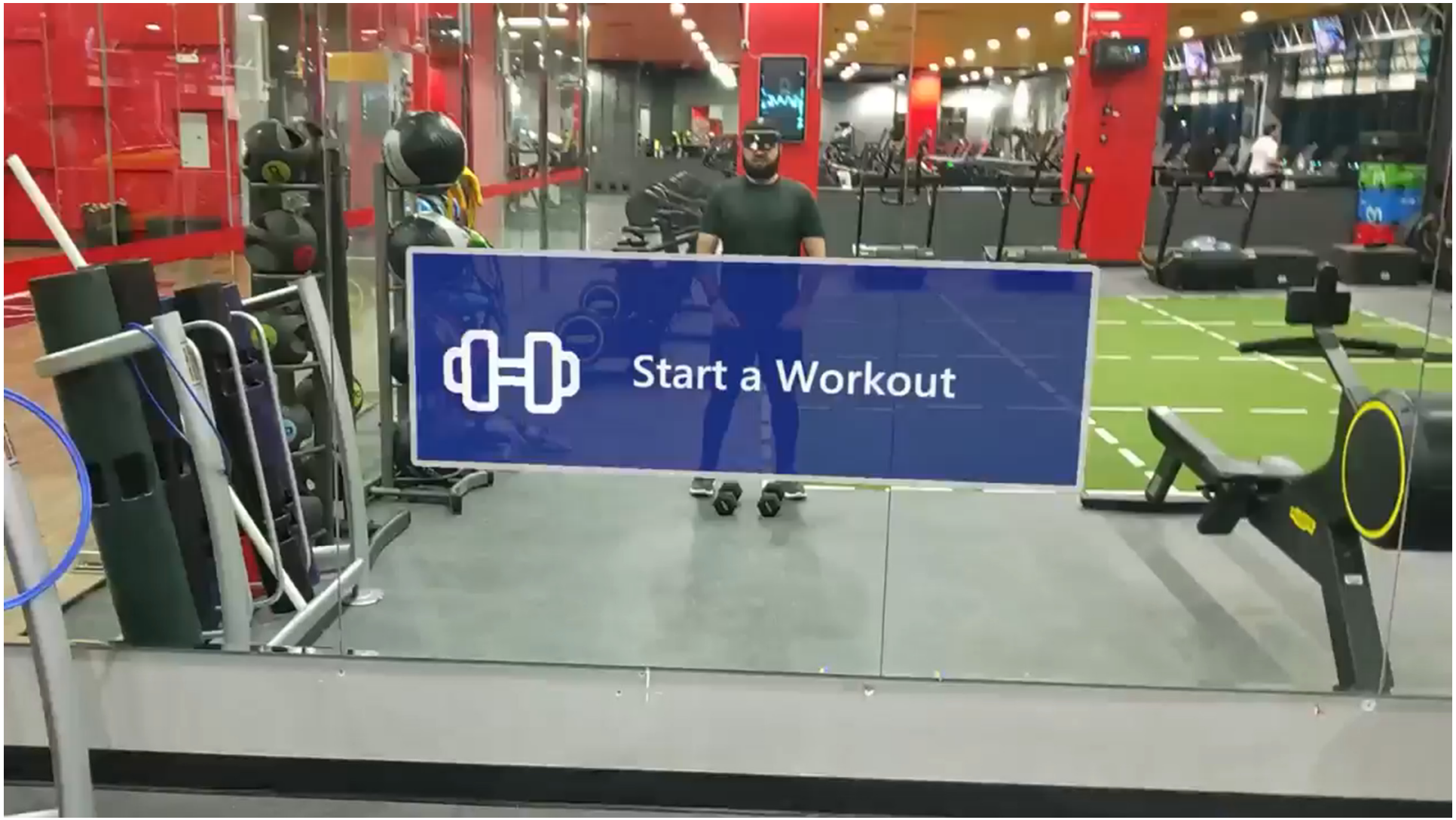

NEILHARBISSON




Circuit Board EM370
Step 4
Ready!
Circuit board EM370 assembly


ORIGINAL SCENE - R RATED


TED
Hugh Herr


Start a Workout

Boston Dynamics

Key enabling technologies

KET

KET: sensors

Wearable
skin
subcutis
immersive
pervasive

CAPTIKS Capturing Kinematics

Ricci … & Saggio, G. (2022). The Impact of Wearable Electronics in Assessing …..
IEEE Journal of Biomedical and Health Informatics, 26(7), 2920-2928.

plux

KET: sensors

Wearable
skin
subcutis
immersive
pervasive

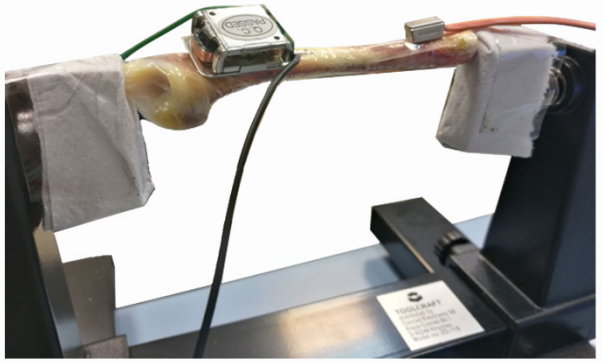
Zhang et al. (2020) Wearable circuits sintered at room temperature ....
ACS Applied Materials & Interfaces, 12(40), 45504-45515.

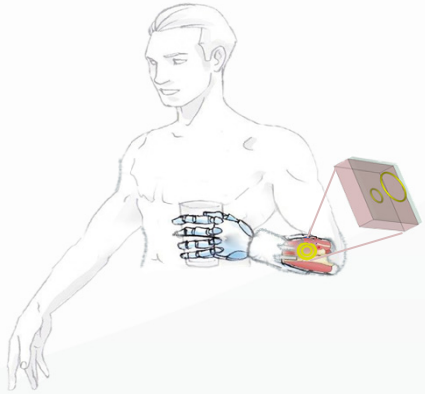
KET: sensors

wearable
skin
subcutis
immersive
pervasive

HITEG
IGS Group

RADIOSENSE





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INAIL Centro Protesi

Miozzi, Saggio, ... (2021). Near-field circular array for the transcutaneous telemetry ..... IEEE J. Electromagnetics, RF and Microwaves in Medicine and Biology, 6(2), 219-227.

Saggio et al. (2021). A Novel Actuating–Sensing Bone Conduction-Based System for ... IEEE Transactions on Instrumentation and Measurement, 70, 1-7.

KET: sensors

wearable
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immersive
pervasive

VOICEWISE

Costantini... & Saggio, G. (2022). Deep learning and machine learning-based voice analysis for the detection of COVID-19…. Knowledge-Based Systems, 253, 109539.

KET: sensors

Wearable
skin
subcutis
immersive
pervasive

Detect

Count

Identify

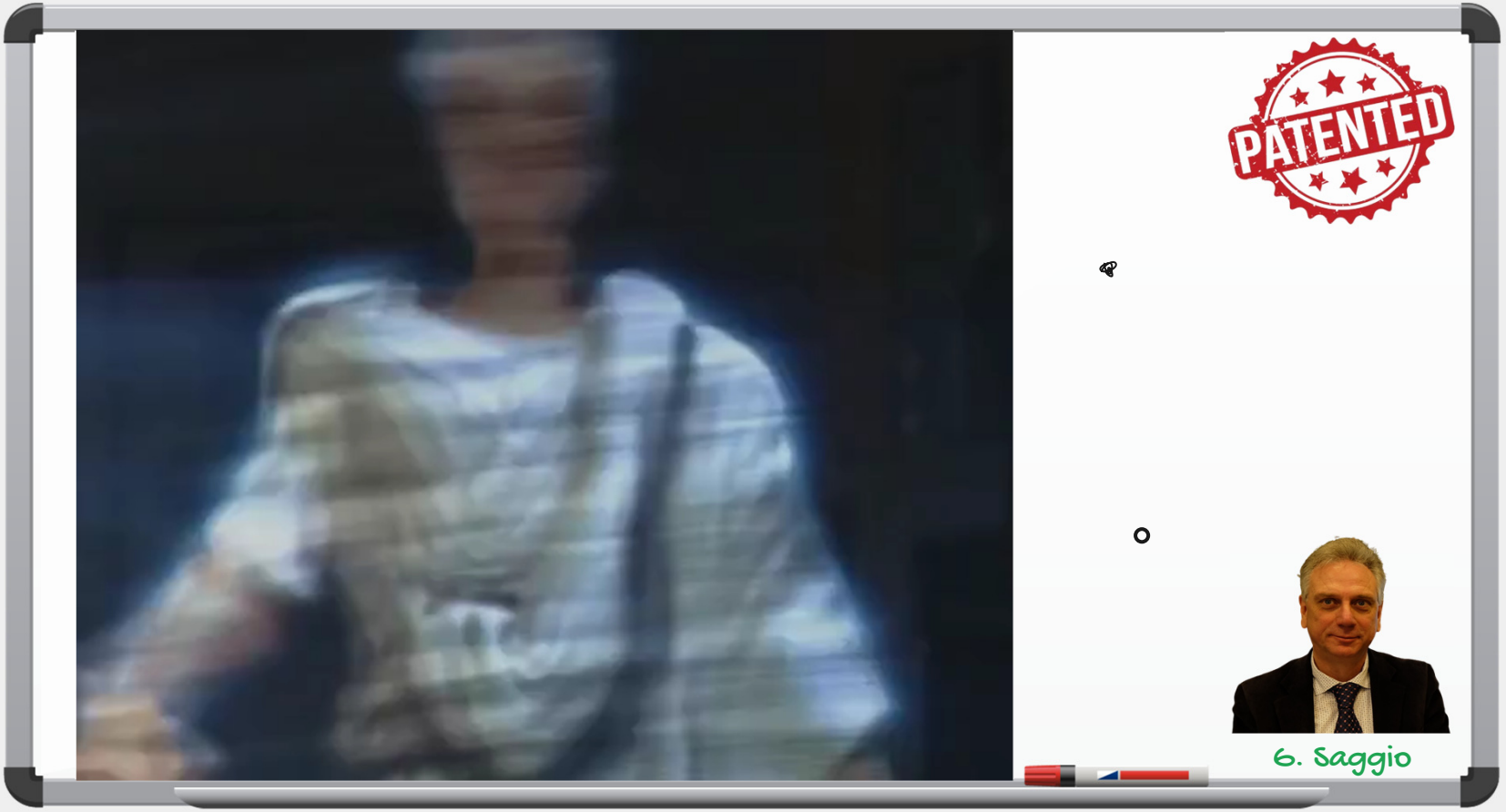
Recognize

Localize

RadioPoints

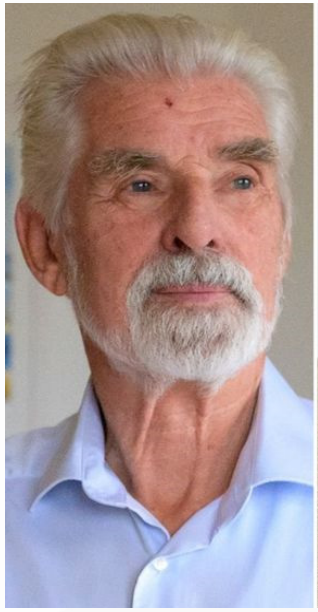
De Sanctis et al. (2022). Rf-based device-free counting of people waiting in line: A modular approach. IEEE Transactions on Vehicular Technology, 71(10), 10471-10484.

KET: visualizaton



KET: math/model

The Nobel Prize in Physics 2021



Syukuro Manabe

Klaus Hasselmann

Giorgio Parisi

scientists who paved the way for studies of disordered systems

KET: computing

The Nobel Prize in Physics 2021

Anton Zeilinger, John F. Clauser, Alain Aspect

scientists who paved the way for quantum computing

KET: computing

New analog quantum computers to solve previously unsolvable problems

nature physics

Article

https://doi.org/10.1038/s41567-022-01905-4

Quantum simulation of an exotic quantum critical point in a two-site charge Kondo circuit

Received: 21 January 2022

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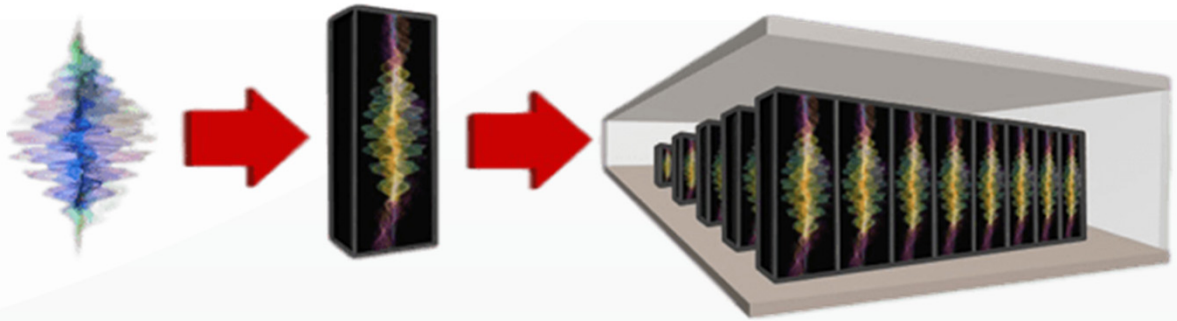
Winston Pouse[1,2,3,9], Lucas Peeters[3,4,9], Connie L. Hsueh[1,2,3], Ulf Gennser[5], Antonella Cavanna[5], Marc A. Kastner[2,4,6], Andrew K. Mitchell[7,8] ✉ & David Goldhaber-Gordon[2,4] ✉

KET: computing

DARPA Collaborates with Commercial Partners to Accelerate Quantum Computing

Three companies selected to explore novel approaches to viable, fault-tolerant quantum computers

OUTREACH@DARPA.MIL
1/31/2023



Conclusions

Conclusions

01 DRD is the pioneer of precision health paradigm

02 For DRD development, it is ma among Medicine, Biology, Eng Science,..

03 ..to Monitor, Analyze, Simulate, to make it Descriptive, Integrati

Conclusions


THANK YOU
大家好，我是Giovanni Sagg
Hello I am Giovanni Saggio
Giovanni Saggio, PhD

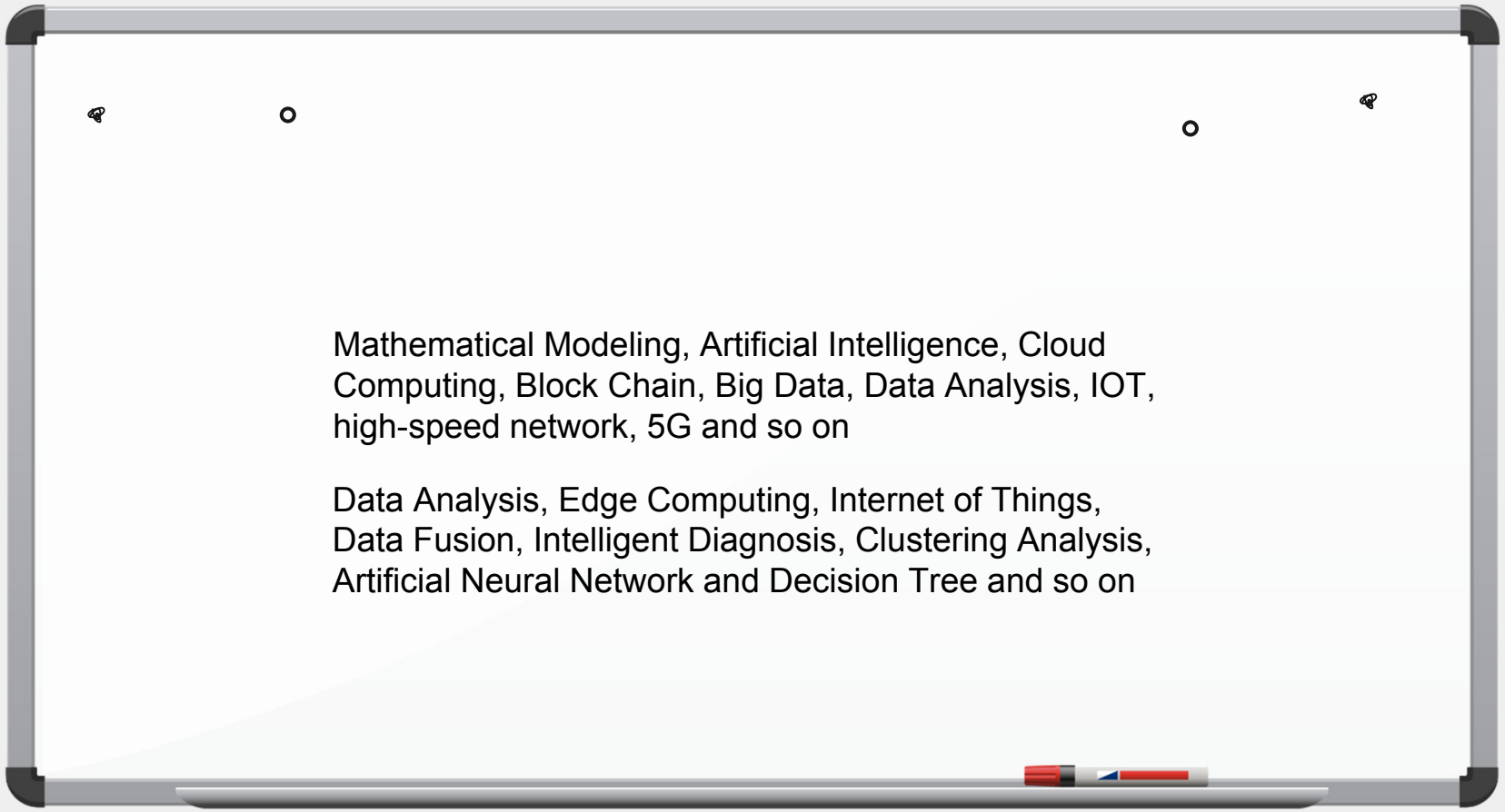
CNH's Dynamic Simulator (for tractor)

forecast
simulate
PLM
MSM
IMM
DT
ADT
IDT

3D
https://www.youtube.com/watch?v=slOavC73qas

https://www.youtube.com/watch?v=o12PIUTskS0&t=75s

KET: sensors



Mathematical Modeling, Artificial Intelligence, Cloud Computing, Block Chain, Big Data, Data Analysis, IOT, high-speed network, 5G and so on

Data Analysis, Edge Computing, Internet of Things, Data Fusion, Intelligent Diagnosis, Clustering Analysis, Artificial Neural Network and Decision Tree and so on

Verrelli, … & Saggio, G. (2021). Generalized finite-length Fibonacci sequences in healthy and pathological human walking ... Frontiers in Human Neuroscience, 15, 649533.