



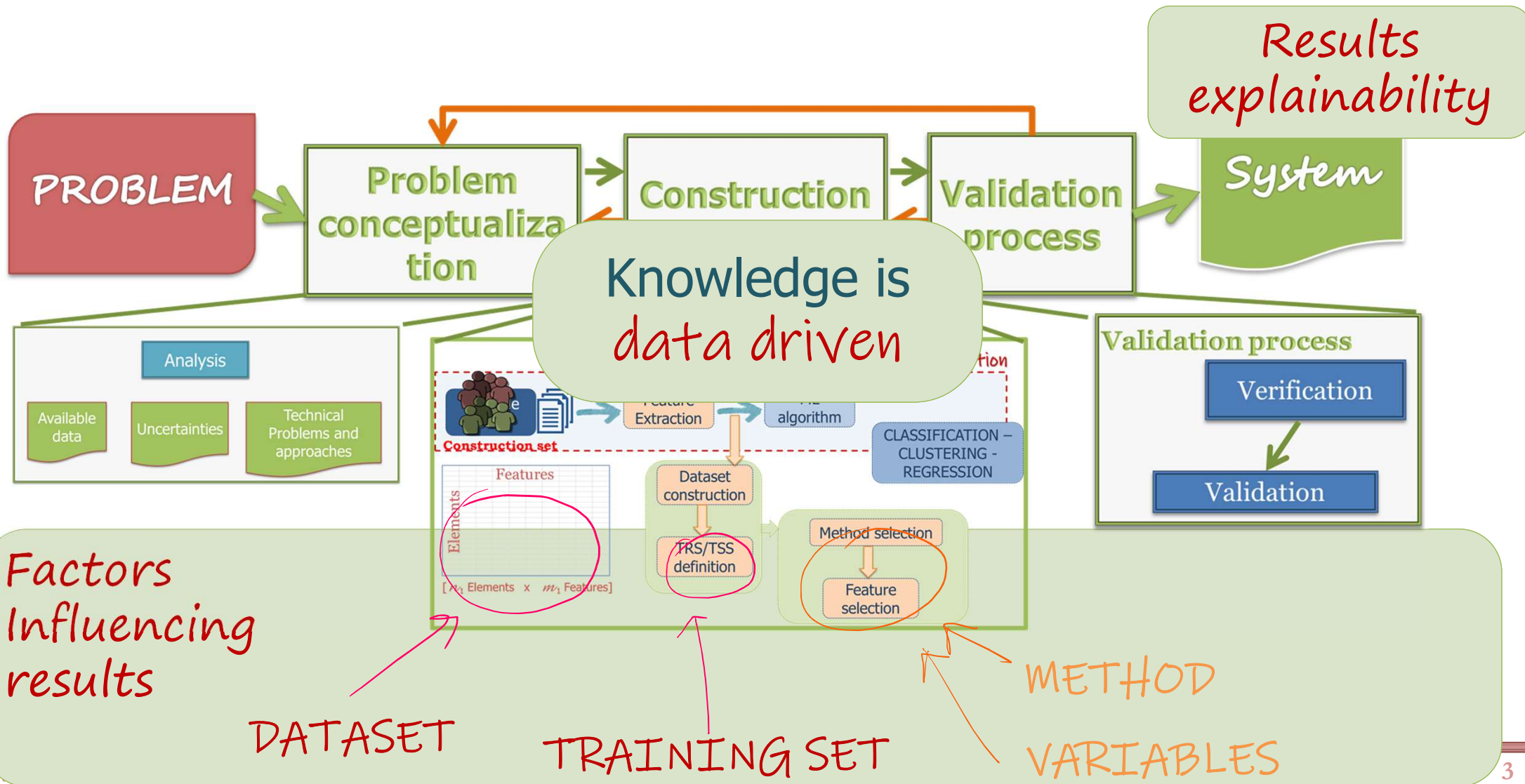
Lezione 9

19 Maggio 2023



Artificial Intelligence

The steps to construct an intelligent systems



Dimensionality Reduction

A new problem is: if we have a great number of variable are we sure that all of them are useful?

There are a lot of different applications (multiple regression, classification, clustering)...

.... and also different methods to solve the problem.

Dimensionality Reduction (DR) of multivariate data represents a set of powerful methods for automatically

- ✓ deleting those attributes that are not predictive of the final state of the system (*irrelevant*) or highly correlated with other variables and interchangeable with them (*redundant*),
- ✓ highlighting the features relevant for the system description.

Dimensionality Reduction

Two different approaches are available for performing DR on datasets:

Feature construction

generates a completely new set of features from the original ones;
it results in a more difficult interpretation because the new features do not correspond to the original ones;
since the new attributes are obtained as a linear or non-linear combination of all initial ones, all features needed to be always collected

Feature selection

selects a minimal number of relevant and informative features from the initial set of variables;
the amount of information with respect to the original variables is kept intact;
the meaning of the features is preserved.

Feature selection

It is quite possible for two features to be useless individually, and yet highly predictive if taken together.

In FS terminology, they may be both redundant and irrelevant on their own, but their combination provides invaluable information.

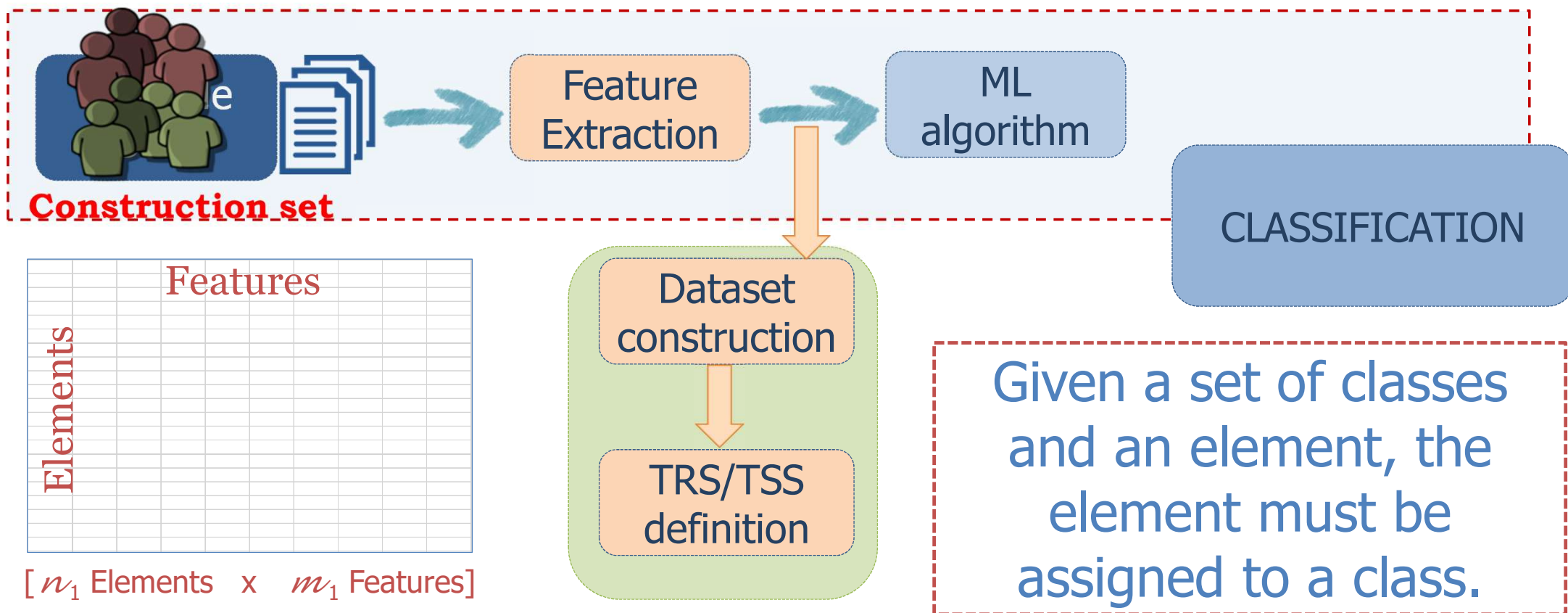
The selection of features can be achieved in two ways:

- ✓ **Ranking** the features according to some criterion and select the top k features
- ✓ **Selecting** a minimum subset of features without learning performance deterioration.

Subset selection algorithms can automatically determine the number of selected features, while feature ranking algorithms need to rely on some given threshold to select features.

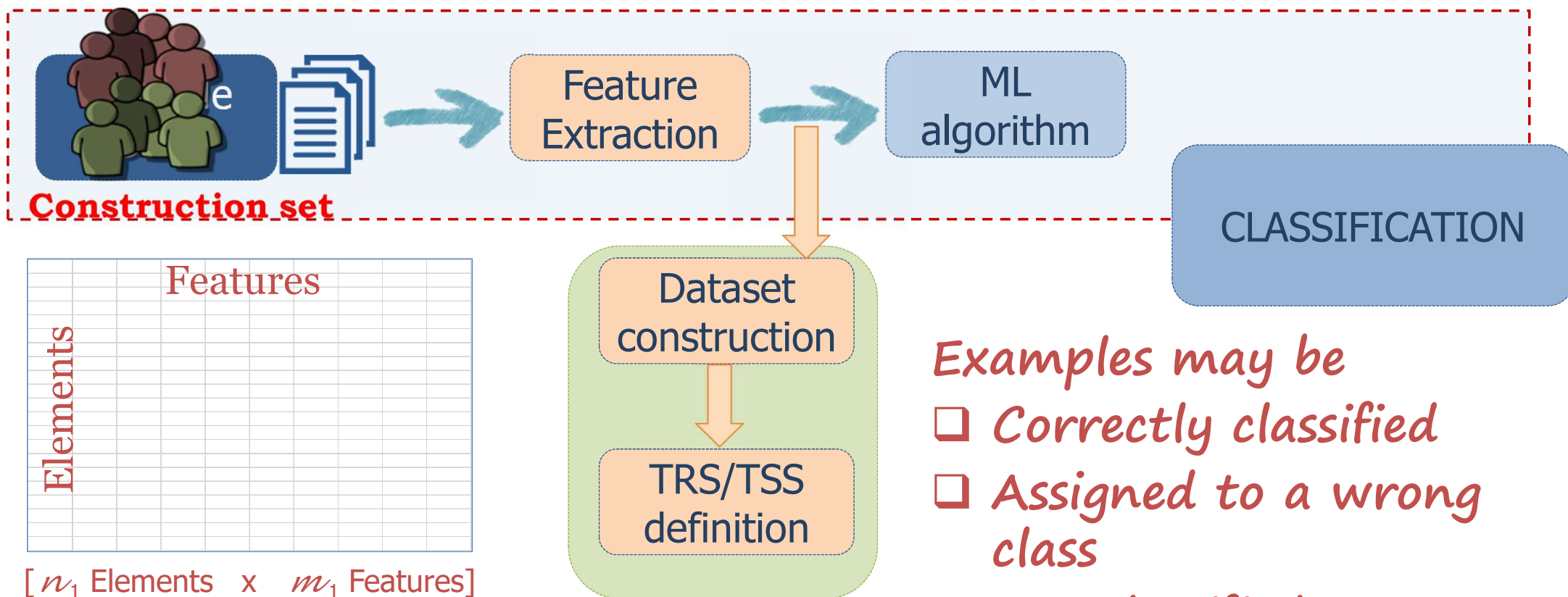
Classification means...

Construction



Classification results

Construction

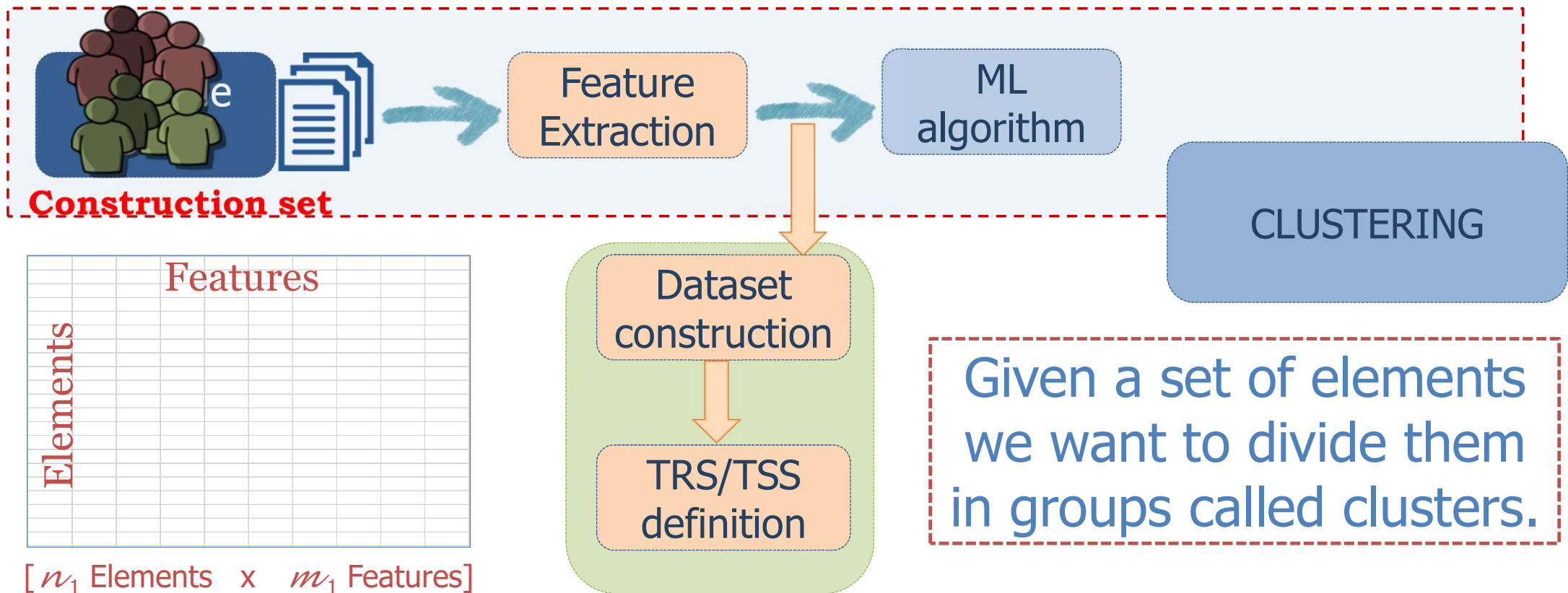


Examples may be

- ☐ Correctly classified
- ☐ Assigned to a wrong class
- ☐ Not classified

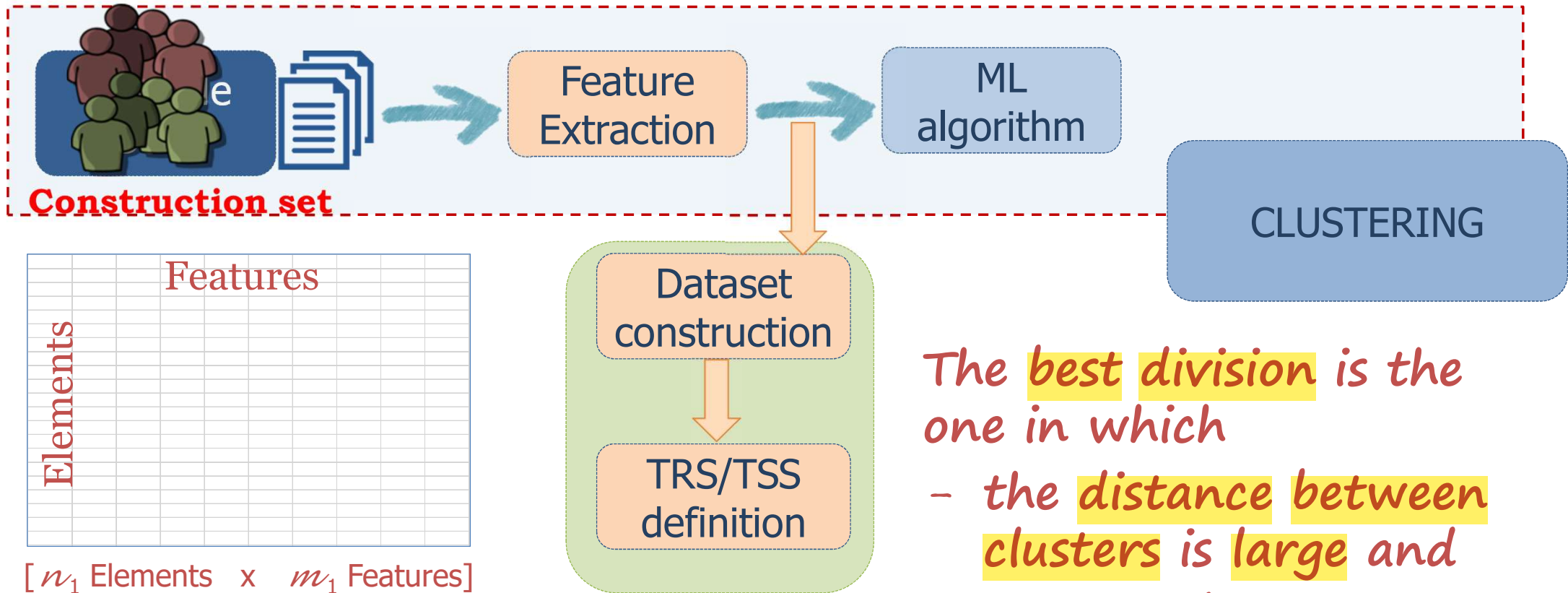
Clustering means...

Construction



Clustering results

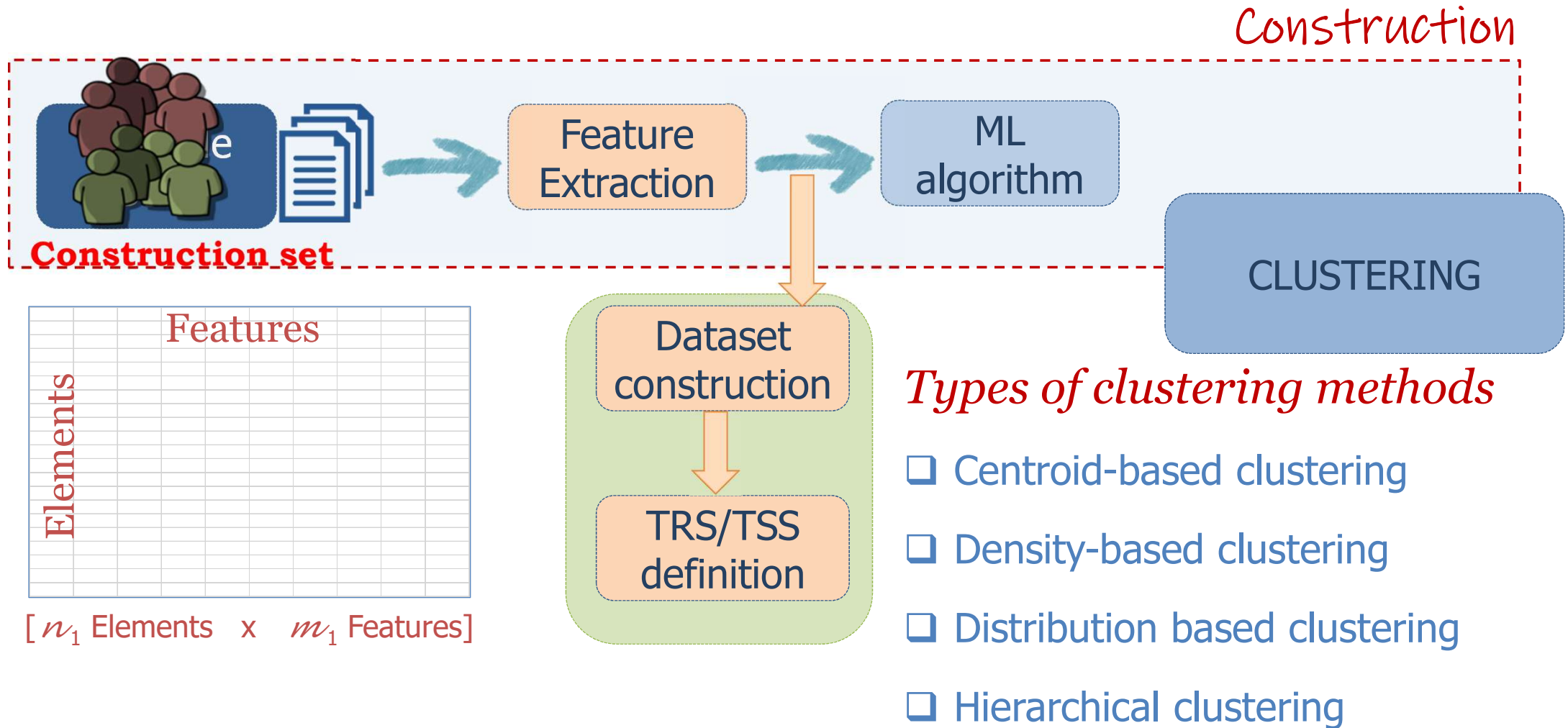
Construction



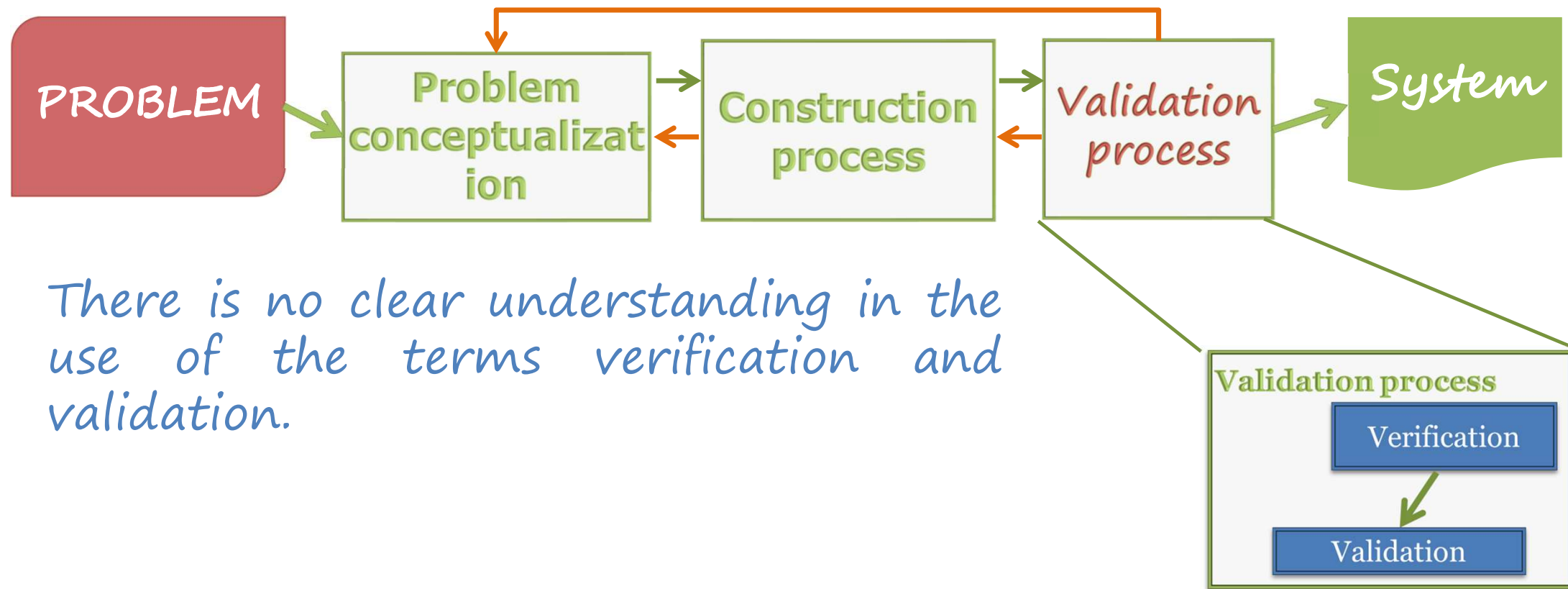
The **best division** is the one in which

- the **distance between clusters** is **large** and
- the **variability inside each cluster** is **small**.

Clustering methods



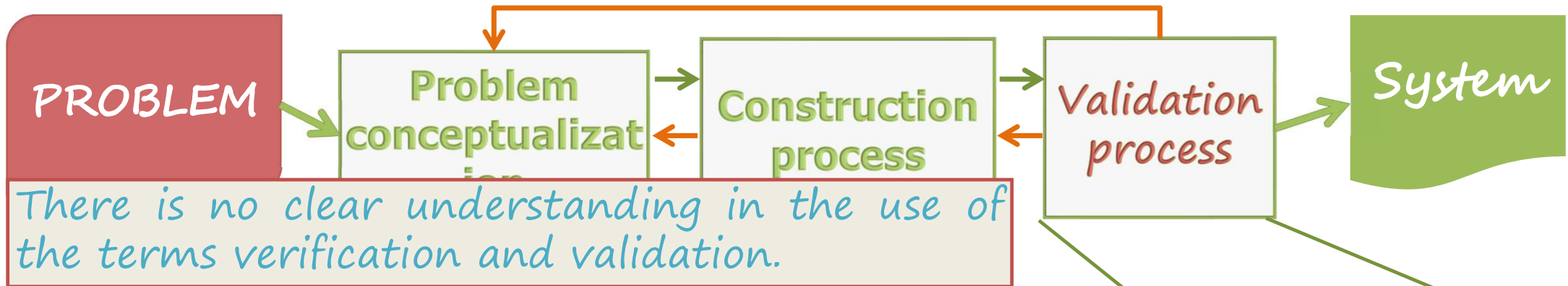
Intelligent Systems Development



There is no clear understanding in the use of the terms verification and validation.

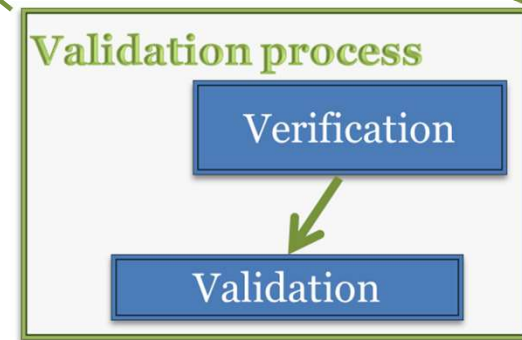
**Results
explainability**

Intelligent Systems Development



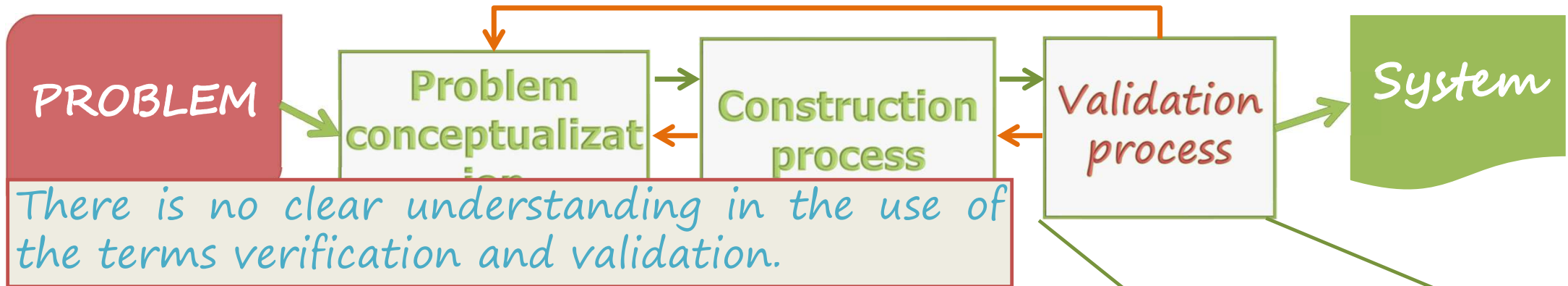
The difference between verification and validation is:

- ✓ **Verification** is the experimental process of ensuring that *you did things right*, e.g. the system meets the requirements
- ✓ **Validation** is the experimental process of demonstrating that the design implementation (e.g., the actual product, process, or service) meets the user needs; it is the process of ensuring that *you did right thing*.



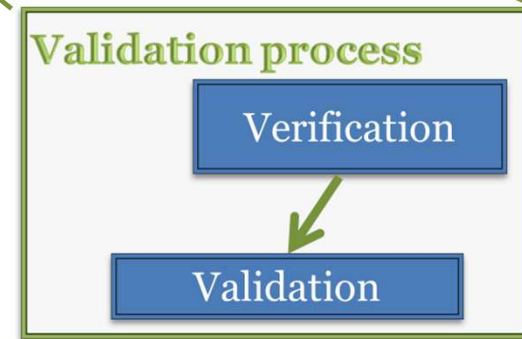
**Results
explainability**

Intelligent Systems Development



The difference between verification and validation is:

- ✓ **Verification** (the system meets the requirements)
possible checks: every example we have is classified, performances are satisfactory, clusters are homogeneous and well separated, ...
- ✓ **Validation** (the system meets the user needs)
possible checks: generalization performances, clusters have clinical meaning, ...



**Results
explainability**

Intelligent Systems Development

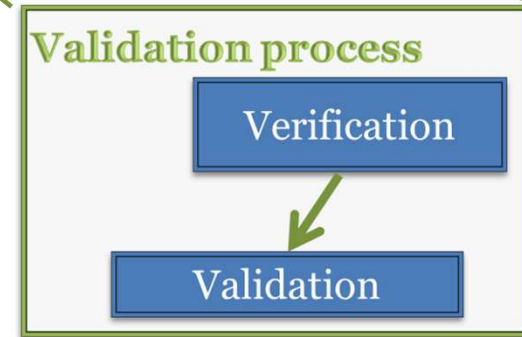


There is no clear understanding in the use of the terms verification and validation.

Different activities are performed during the **Verification** process and the **Validation** process

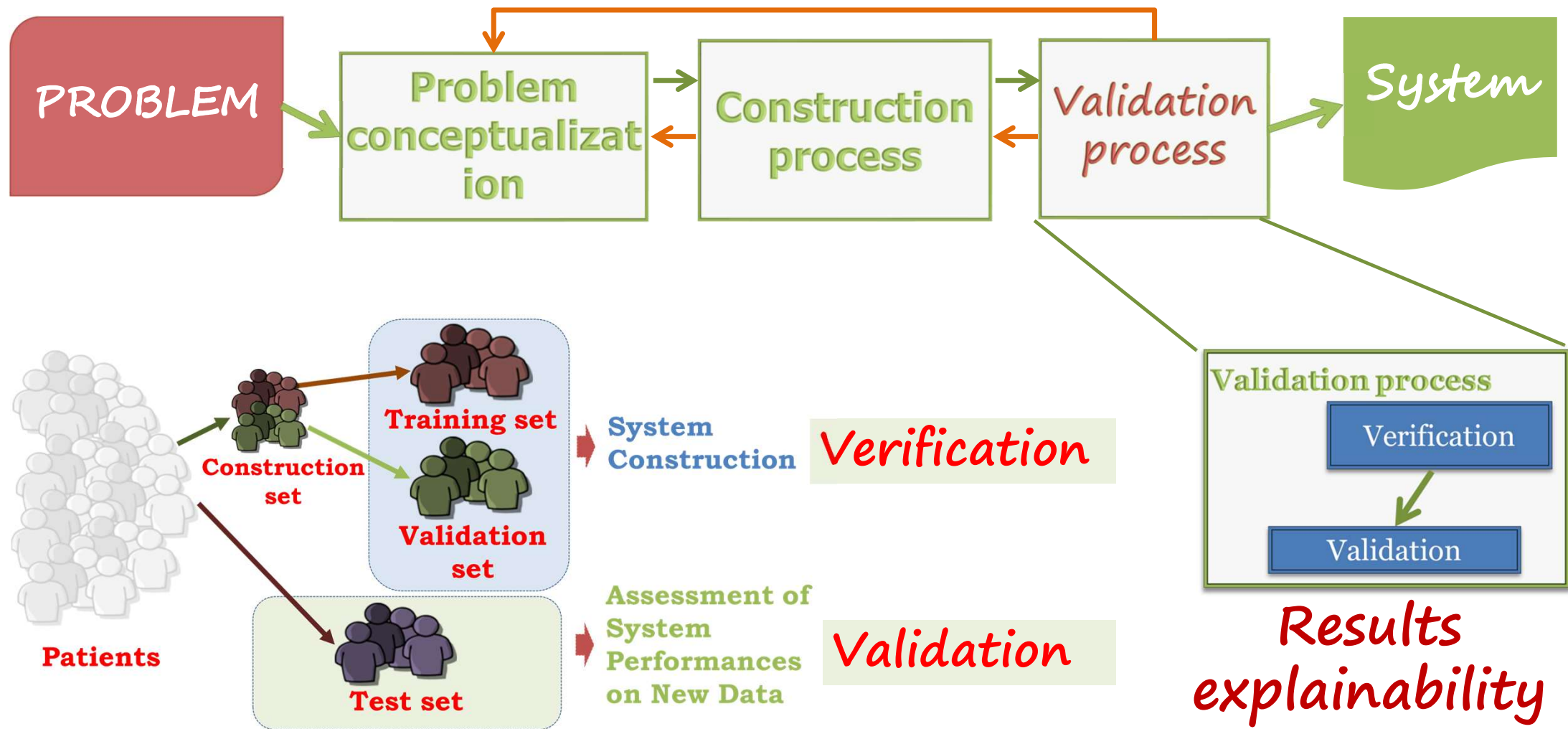
In general, **we use the term testing to refer to these activities**

Activities related to the verification process are performed both during and at the end of the construction process.

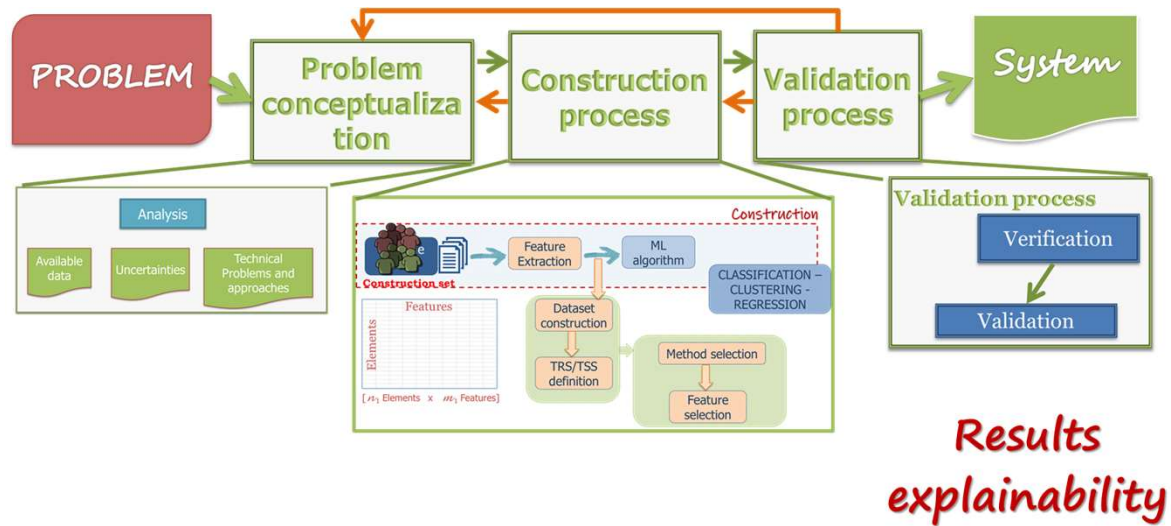


Results explainability

Intelligent Systems Development

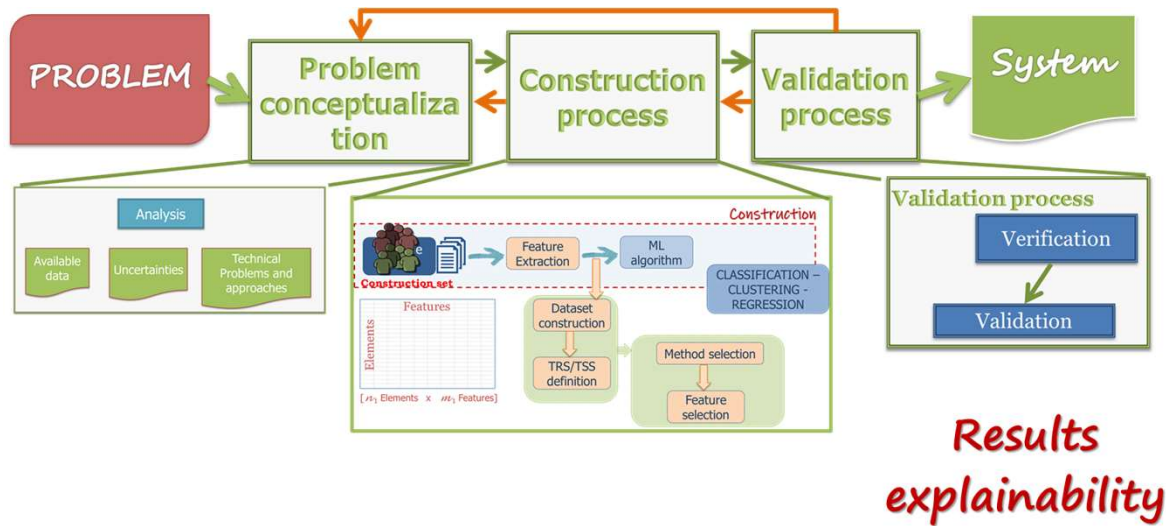


Explanability: an open problem



There are methods that are more suited for giving explanation of their results but not always they give the better results

Explanability: an open problem



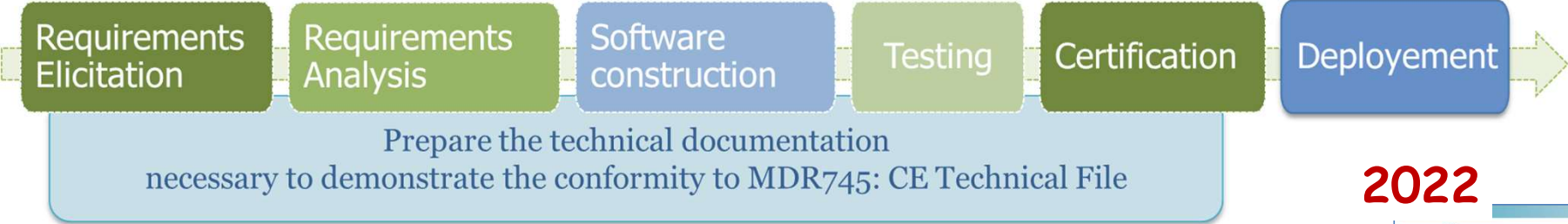
There are methods that are more suited for giving explanation of their results but not always they give the better results

Rules as a knowledge representation technique

vs

Black box as a knowledge representation technique

MEDICAL DEVICE SOFTWARE



**MEDICAL
DEVICE
SOFTWARE**
2022

2014

Politecnico di Torino
Corso di Laurea Magistrale in Ingegneria Biomedica

Metodologia di sviluppo di un software medicale basata sul suo ciclo di vita e conforme alle normative vigenti

Tesi di Laurea Magistrale

Relatrice: Prof.ssa Gabriella Balestra
Candidata: Irene Quagliari

ANNO ACCADEMICO 2013-2014

Flowchart details: The process starts with 'Definizione di contesto' and 'Definizione di requisiti', leading to 'Progettazione software' (CEI EN 60601-1:2010 art. 4, art. 61; IEC 62366:2007). This is followed by 'Implementazione software' (CEI EN 60601-1:2010 art. 4, art. 61; CEI EN 60601-1:2010 art. 4, art. 61; CEI EN 60601-1:2010 art. 4, art. 61), 'Verifica software' (CEI EN 60601-1:2010 art. 4, art. 61; CEI EN 60601-1:2010 art. 4, art. 61; CEI EN 60601-1:2010 art. 4, art. 61), and 'Validazione software' (CEI EN 60601-1:2010 art. 4, art. 61; CEI EN 60601-1:2010 art. 4, art. 61; CEI EN 60601-1:2010 art. 4, art. 61). The final steps are 'Marcatura CE', 'Pubblicazione sul sito del Ministero della Salute', 'Deployment', and 'Monitoraggio'.

2020

POLITECNICO DI TORINO
Corso di Laurea Magistrale in Ingegneria Biomedica

Tesi di Laurea Magistrale
Analisi della legislazione e della normativa relativa ai dispositivi medici software

Relatrice: Prof.ssa Gabriella Balestra
Candidata: Irene Quagliari

Anno Accademico 2019/2020

KEY ASPECTS TO TEACH MEDICAL DEVICE SOFTWARE CERTIFICATION

Noemi GIORDANO, Samanta ROSATI, Marco KNAFLITZ, Gabriella BALESTRA
Department of Electronics and Telecommunications, Politecnico di Torino, Torino, Italy

Medical Software

Most software associated with clinical processes are medical devices. Medical Device software (MDS) development requires several different competencies. EU Medical Device Regulation 2017/745 has increased the requirements to obtain certification. Safety and efficacy are key aspects to be addressed

Medical device software design and development phases

Requirements Elicitation, Requirements Analysis, Software construction, Testing, Certification, Deployment

Prepare the technical documentation necessary to demonstrate the conformity to MDR745: CE Technical File

Technical skills

Requirements Elicitation, Requirements Analysis, Software construction, Testing, Certification, Deployment

There is a set of technical skills associated with each phase. The main objectives are:

- to analyze processes
- Design and construction of software
- Correctly apply regulation and standards
- To guarantee patient safety and data security

MDS Safety

Due to its double-sided nature, the safety of a MDS should be evaluated both:

- in terms of cybersecurity (because it is a software) and
- in terms of hazards for the physical person (because it is a medical device)

Cybersecurity: there are established guidelines that apply also to other types of software

MDS Effectiveness

To assess effectiveness of a MDS, it is important to compare its performance with those of similar applications. To this purpose, two methodologies should be introduced in the syllabus: the systematic review of literature and the meta-analysis.

Systematic review of literature

PICO framework, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

Risk analysis as medical device

Example: Risk analysis as medical device

Meta-Analysis

Forest plot

We presented a syllabus to teach the basics of MDS design and development focused on certification. It requires both lessons and laboratory work.

SIBIM, **EFMD Special Topic Conference 2022**, **Politecnico di Torino**, **BIOLAB**

[Global Edition](#) [Artificial Intelligence](#)

FDA action plan puts focus on AI-enabled software as medical device

The agency plans to take a "multi-pronged approach" to advancing oversight of machine learning-enabled devices – with an eye toward ensuring patient safety, algorithm transparency and real-world results.

Healthcare IT News

[The Diverse Roles of AI & ML](#) [Global Edition](#)

FDA issues landmark clearance to AI-driven ICU predictive tool

CLEW Medical's ICU tool uses machine learning models to identify patients whose conditions are likely to deteriorate.

By [Kat Jercich](#) | February 04, 2021 | 11:42 AM



The U.S. Food and Drug Administration has authorized the use of CLEW Medical's artificial intelligence tool to predict hemodynamic instability in adult patients in intensive care units, the company announced on Wednesday.

The tool, CLEWICU, uses AI-based algorithms and machine learning models to identify the likelihood of occurrence of significant clinical events for ICU patients.

9 novembre 2021



Ministero della Salute

Consiglio Superiore di Sanità

Sessione LII (2019-2022)

Presidente: Prof. Franco Locatelli

Sezione V*

Presidente: Prof. Giuseppe Remuzzi
Segretario tecnico: Dr. Franco Abbenda

*“I sistemi di intelligenza artificiale come strumento
di supporto alla diagnostica”*

L'Intelligenza Artificiale (Artificial Intelligence, AI nella dizione anglosassone), in questi ultimi anni, ha rivoluzionato la quotidianità dei cittadini e, considerando la velocità dello sviluppo tecnologico, ne modificherà i comportamenti e le abitudini anche nel prossimo futuro.

Il mondo sanitario in generale, e quello della diagnostica per immagini in particolare, seppur con comprensibile ritardo data la maggior complessità dei processi, sta subendo il medesimo sconvolgimento. La prospettiva, più o meno a breve termine, sarà di doversi confrontare con sistemi esperti in grado di modificare significativamente i percorsi diagnostici e terapeutici, le modalità decisionali del Medico e, in ultimo, anche il rapporto Medico-Paziente.


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... la comunità internazionale ha definito delle procedure standard per il reporting degli studi che coinvolgono l'AIM.

Fra questi, lo *standard MINIMAR (MINimum Information for Medical AI Reporting)* richiede che vengano sempre rispettati i seguenti principi:

- (1) includere informazioni sulla popolazione che fornisce i dati di addestramento, in termini di fonti di dati e principi di selezione della coorte;
- (2) includere i dati demografici della popolazione da cui è stato appreso il modello, in un modo che consenta un confronto con il proprio gruppo di pazienti o la nuova popolazione a cui si vuole applicare il modello stesso;
- (3) fornire dettagli sull'architettura computazionale e sullo sviluppo del modello in modo che sia chiara la finalità del modello di AI, sia possibile confrontarlo con modelli simili e sia possibile la replica dello studio; e
- (4) venga riportata in modo trasparente la procedura di valutazione statistica del modello e le procedure impiegate per la stima dei parametri liberi, sempre al fine di poter replicare i risultati.



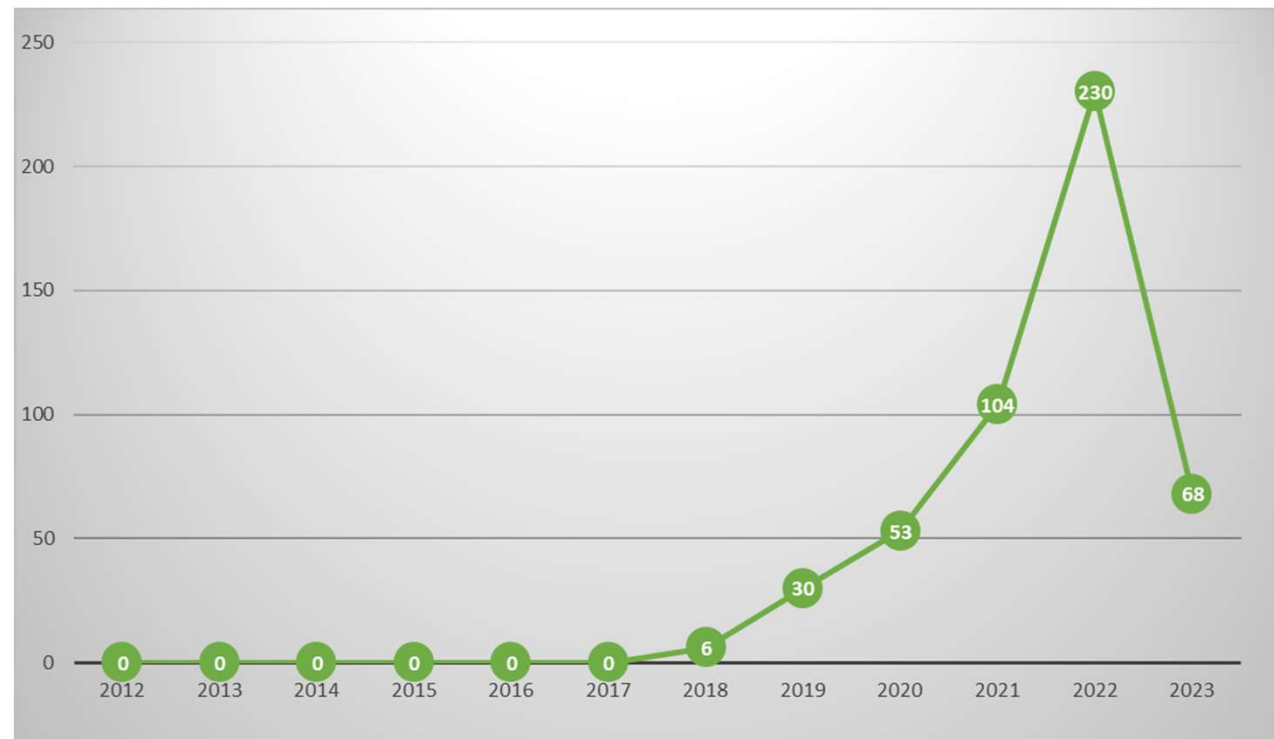
Healthcare applications of Digital Twin technology

Digital Twin Thechnology

Digital twins may be defined as artificial intelligent virtual replicas of physical systems.

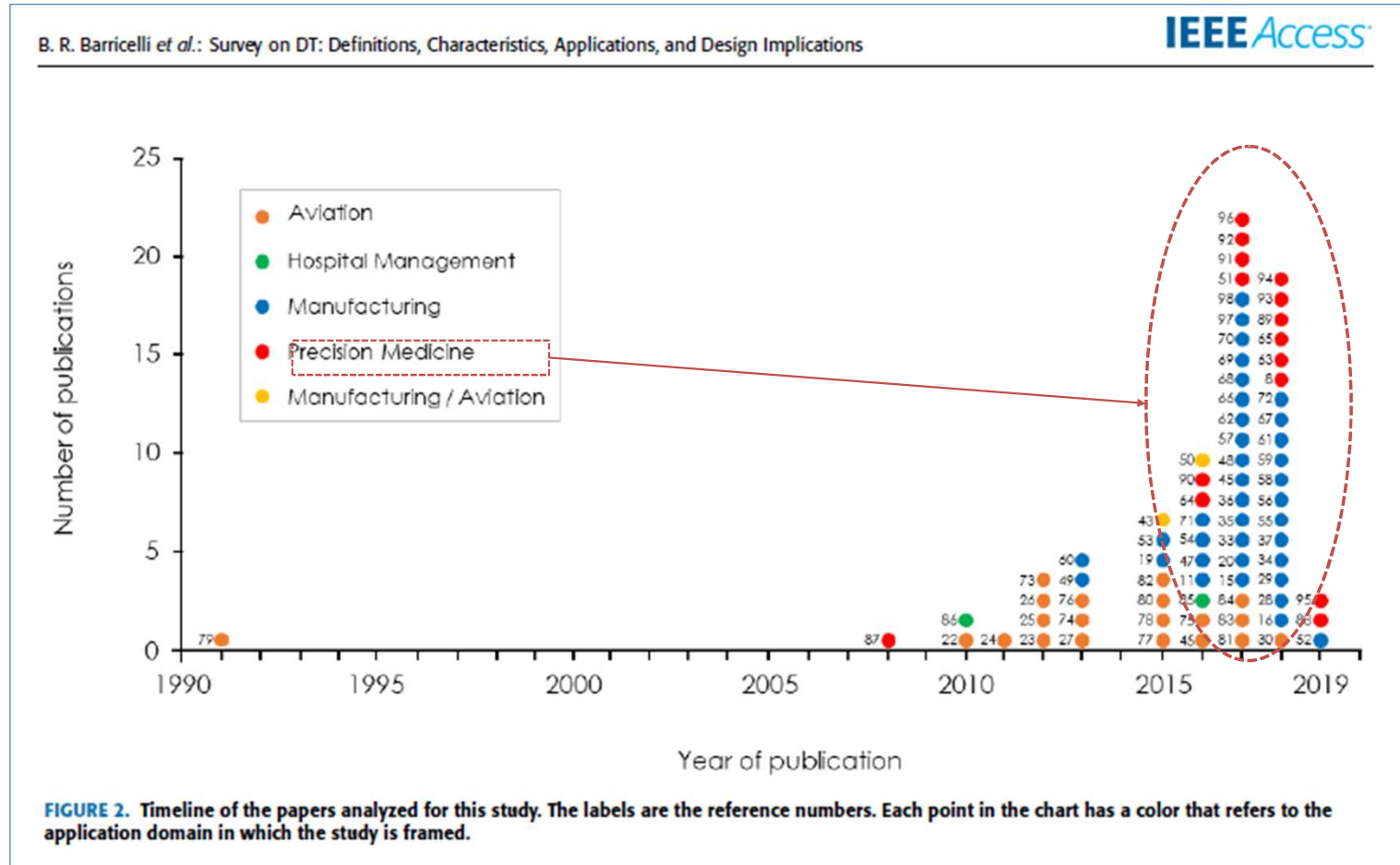
SCOPUS search 12/05/2023

Digital Twin and (Medical or Healthcare)



491 documenti

Digital Twin Thechnology



A survey on digital twin: Definitions, characteristics, applications, and design implications,
Barricelli, B.R., Casiraghi, E., Fogli, D., IEEE Access, Volume 7, 2019, Article number 2953499

Digital Twin Thechnology

Digital Twin



Digital Twin and Healthcare

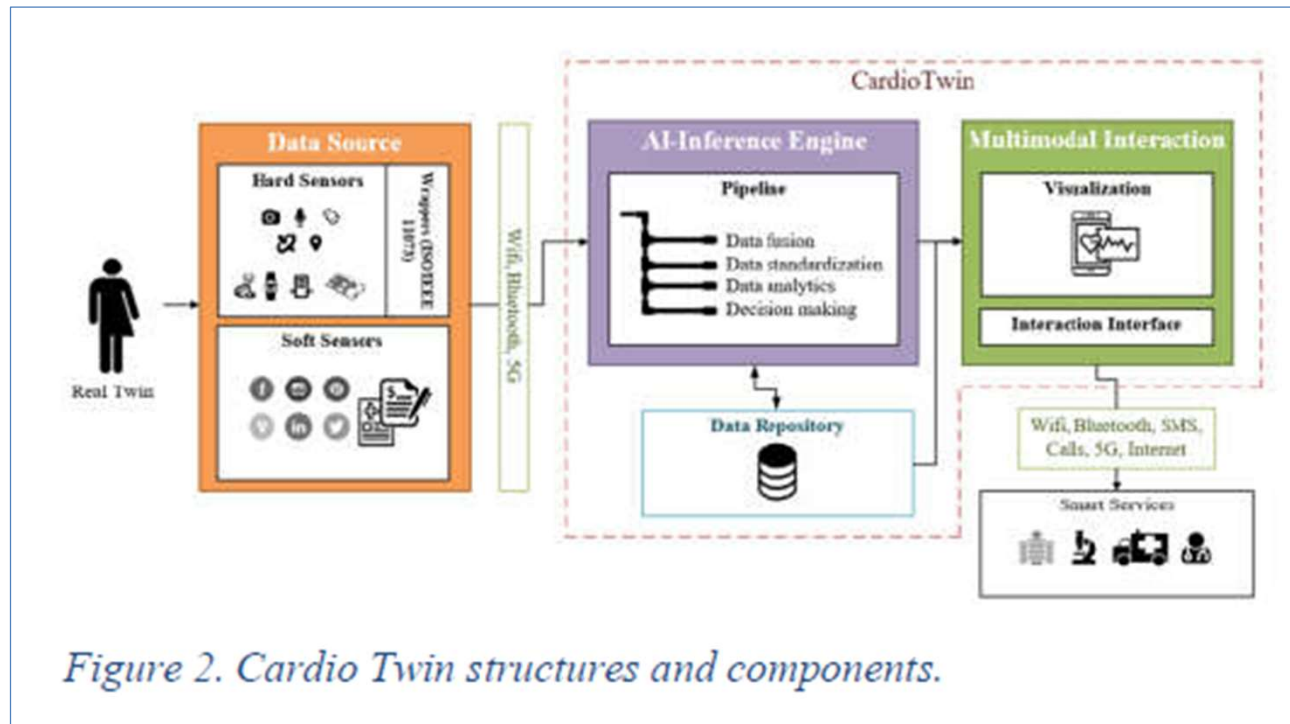


Digital Twin and Healthcare and Artificial Intelligence



Application: Cardio Twin

Cardio Twin: A Digital Twin of the human heart running on the edge
Martinez-Velazquez, R., Gamez, R., Saddik, A.E.
Medical Measurements and Applications, MeMeA 2019



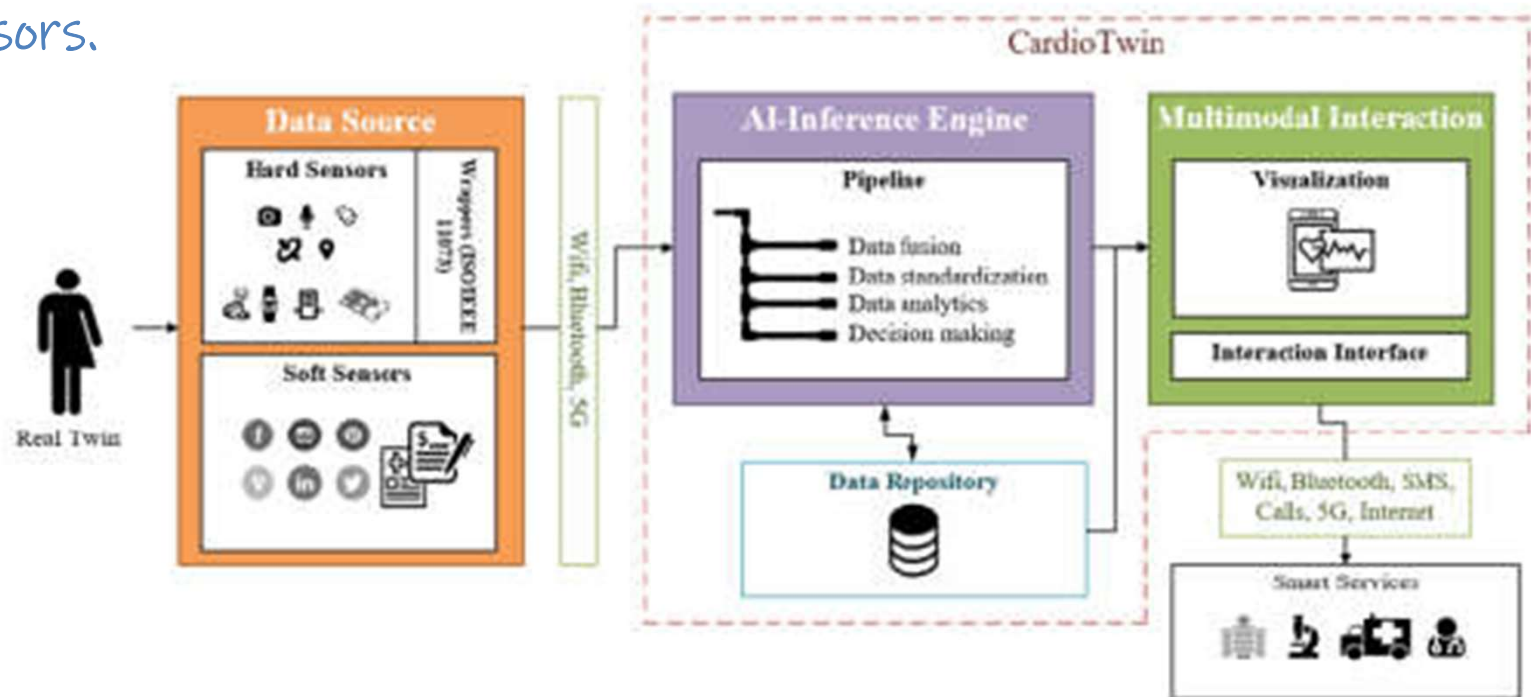
AIW

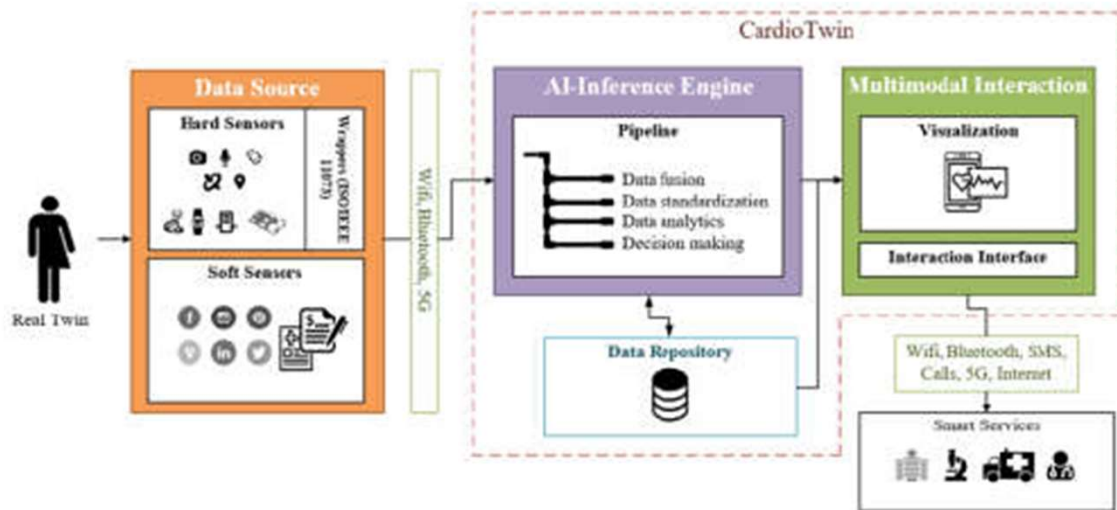
Cardio Twin is an architecture of a Digital Twin for healthcare and well-being running on the edge to help in the event of a IHD (Ischemic Heart Diseases) situation.

It is a platform conceived as a twin of a human heart with the idea of detecting, preventing and reduce the risk of suffering heart diseases.

Cardio Twin collects data from sensors (body area network), medical records, social networks and external sensors.

Machine learning interprets all the collected data and take appropriate action through the execution of instruction pipelines.

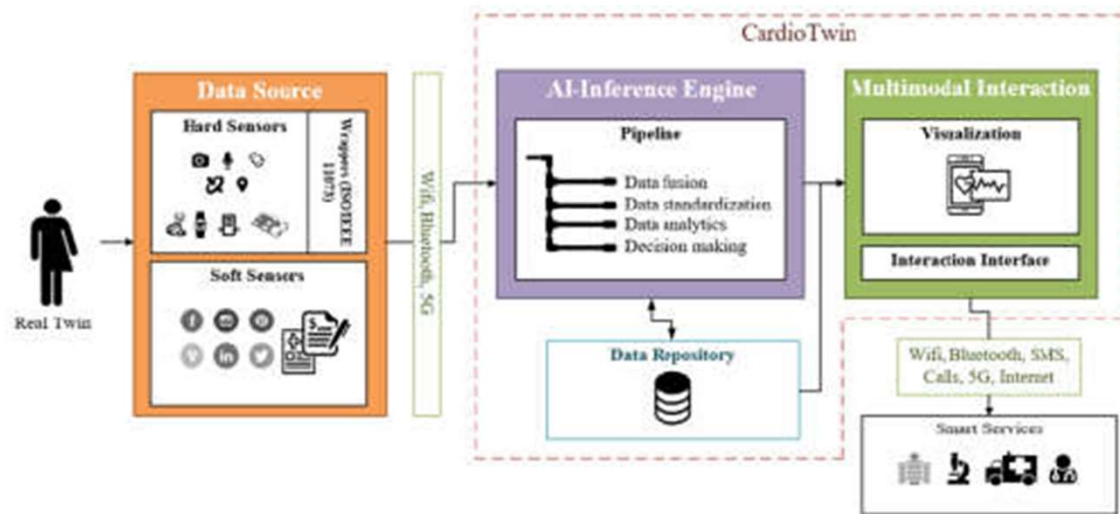




Imagine that a doctor wants to see the patient heart's current condition during a visit in the screen of his/her office.

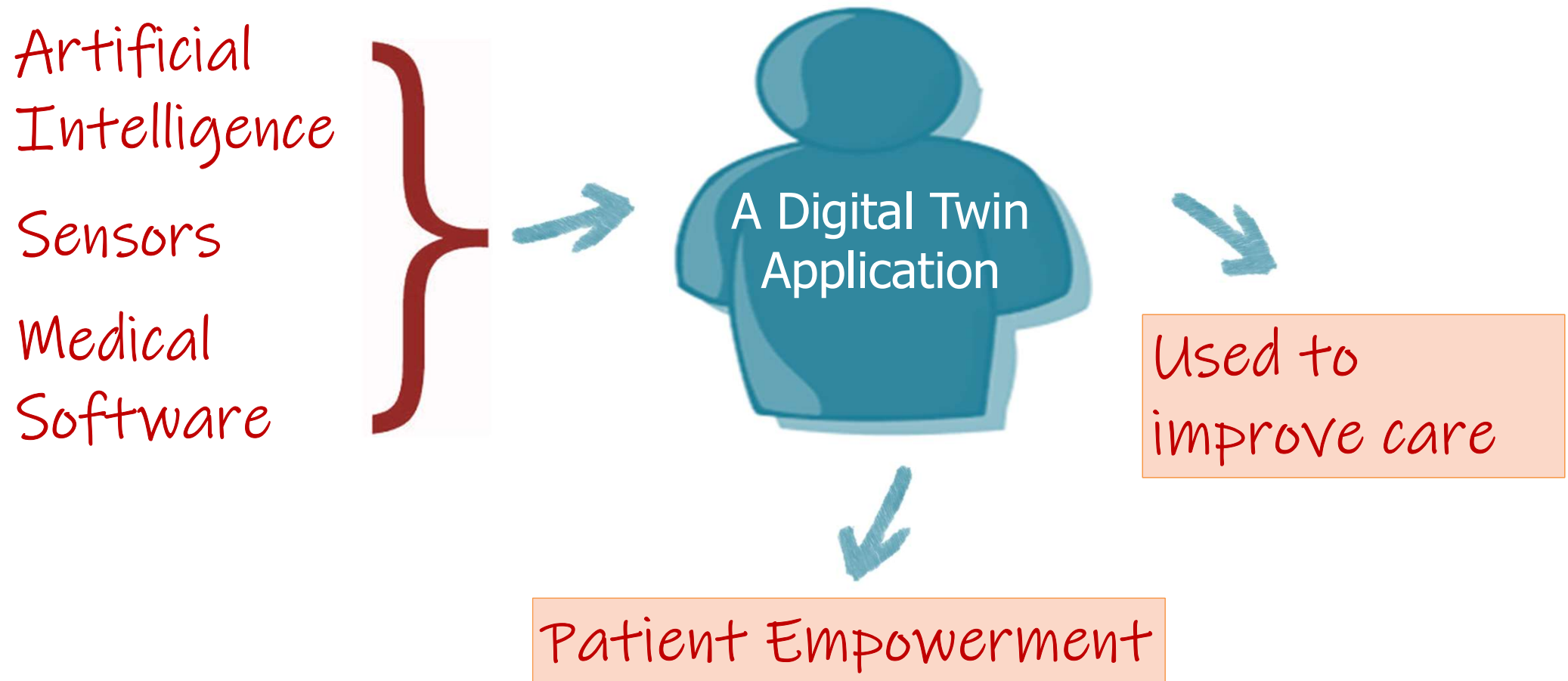
The interaction interface and the visualization service will take care of the data transmission and the whole process.

With this feature, a patient could be virtually present in the doctor's office regardless of distance and the actual visit might not even be necessary.



Even if the authors do not explicitly declare it among the possible actions of the platform we can imagine that the system can assist the subject in taking care of her/his cardiac problems

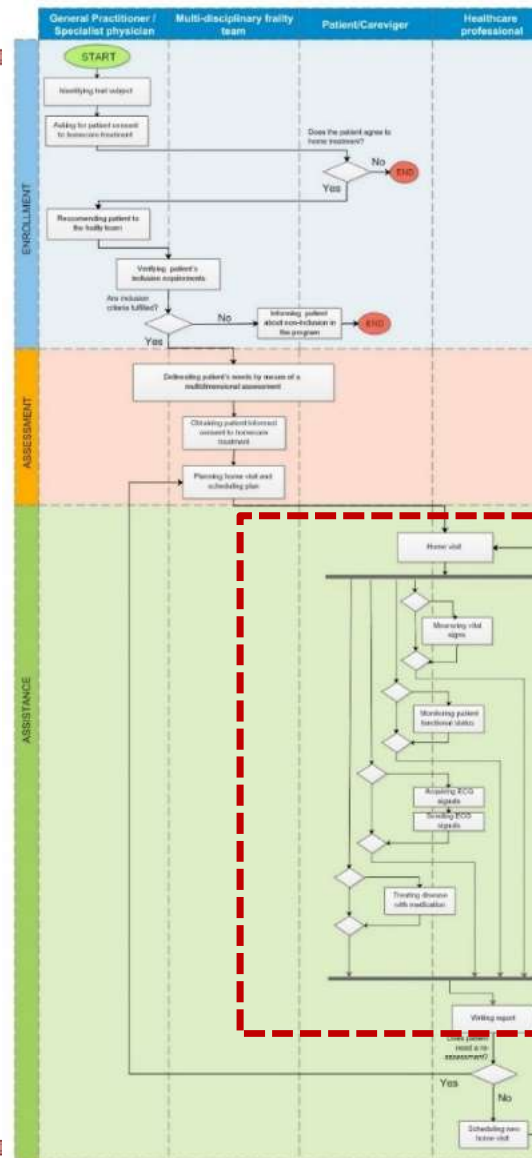
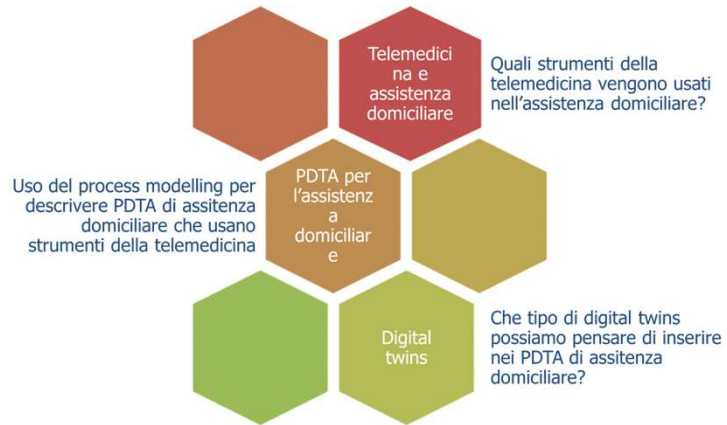
... the future



A stack of several books with light brown, aged pages and dark grey or black covers. The books are stacked vertically, with their spines facing left. The edges of the pages are slightly uneven, showing some wear. The stack is positioned on the left side of the slide, against a light blue background.

Lavoro di gruppo

Lavoro di gruppo



personalizzare

