DIHCUBE

Digital **I**talian **H**ub for **C**onstr**U**ction and the **B**uilt **E**nvironment

[UNIVPM] – DIHCUBE Services
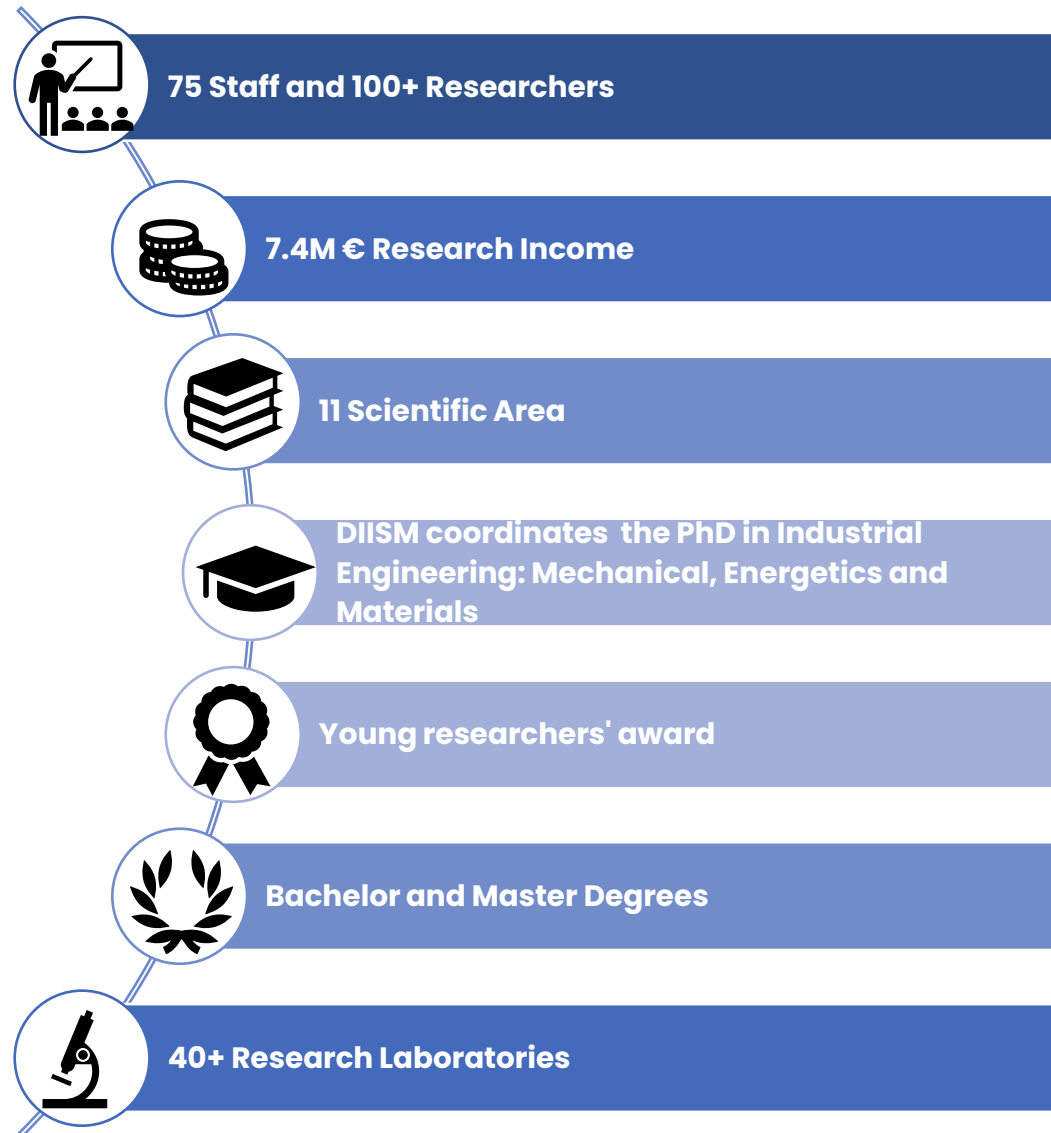
ANCE|Perugia|21.06.2024

Department of Industrial Engineering and Mathematical Sciences

Director: Prof. Michele Germani

UNIVERSITÀ POLITECNICA DELLE MARCHE

DIISM

- **75 Staff and 100+ Researchers**
- **7.4M € Research Income**
- **11 Scientific Area**
- **DIISM coordinates the PhD in Industrial Engineering: Mechanical, Energetics and Materials**
- **Young researchers' award**
- **Bachelor and Master Degrees**
- **40+ Research Laboratories**

The Department of Industrial Engineering and Mathematical Sciences (DIISM) was established in July 2011 following the merger of the previous departments of Mechanics, Energetics and Mathematical Sciences of the Faculty of Engineering of the Università Politecnica delle Marche.

DIISM is one of the 180 Italian University Departments of Excellence defined by ANVUR and has obtained a five-year funding of approximately € 7.3 million for an investment project on the themes of ADDITIVE MANUFACTURING and INDUSTRY 4.0.

The project envisages many improvement actions including the recruitment of highly qualified staff, advanced teaching and the construction of the Laboratory of Excellence.

https://www.diim.univom.it

Department of Science and Engineering of Matter, Environment and Urban Planning (SIMAU)
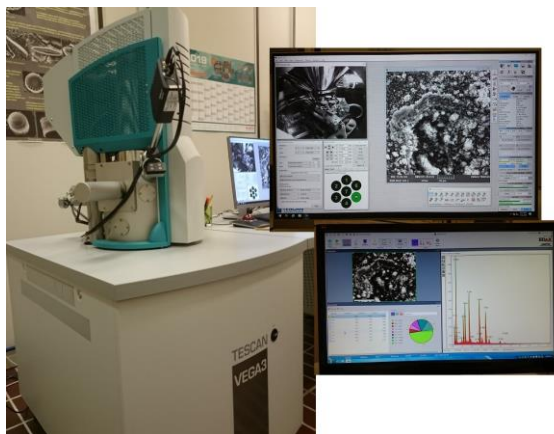
(http://simau.univpm.it/)

Structure where the **confluence of different expertises**, provides high-level teaching and high-profile international research in the field of **Science of Matter** and **Earth Sciences** with a special focus toward the **Environment**.

It operates within the **Engineering Faculty** offering, at the same time, teachers specialised in the so-called «hard sciences» (**Chemistry** and **Physics**) and teachers involved in more «applicative» fields, such as **Materials Engineering**, **Geotechnics**, **Geology**, **Environmental Engineering** and **Urban Planning**.

Research Areas

- TECHNICAL ARCHITECTURE
- APPLIED GEOLOGY AND HYDROGEOLOGY
- ENVIRONMENTAL CHEMICAL ENGINEERING
- GEOTECHNICAL ENGINEERING
- CHEMISTRY (ORGANIC)
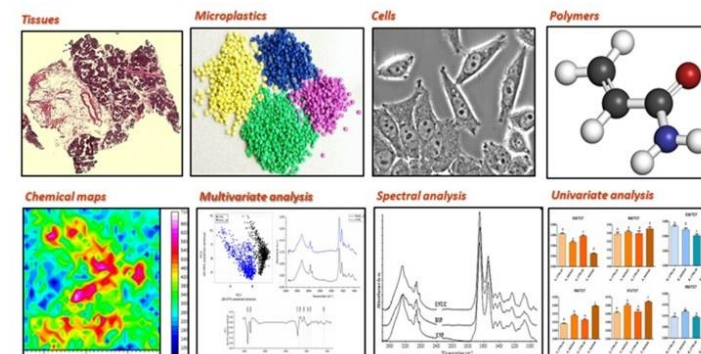- MATERIALS SCIENCE AND TECHNOLOGY
- EXPERIMENTAL PHYSICS

People Involved

- 12 FULL PROFESSORS
- 22 PROFESSORS
- 10 ASSISTANT PROFESSORS
- 22 PhD STUDENTS
- 12 POST DOC RESEARCHERS
- 11 TECHNICAL AND ADMINISTRATIVE STAFF

128 ISI/WOS/Scopus papers in 2023

**more than 6 million Euros research income in the last 3 years
with 11 European projects funded**

The Department of Information Engineering
Director: Prof. Franco Chiaraluce

The Department of Information Engineering (DII) was established in 2011 following the merge of the previous DIBET (Department of Biomedical, Electronics and Telecommunication engineering) and DIIGA (Department of Computer, Management and Automation engineering).

The Department is a self-managing organizational branch of the university which is dedicated to scientific research, teaching, and contributing to the so called Third Mission of the Higher Education Institution through the dissemination of scientific research findings amongst the community.

Its main aims are to plan, organize and regularly assess the quality of the research activities carried out in the scientific sectors and disciplines under its jurisdiction; to plan, organize and manage bachelor and master courses in Information Engineering and, last but not least, to provide cultural and educational activities and contribute to training and guidance issues according to the students needs.

https://www.dii.univpm.it

AT A GLANCE

DII   2023

250+ Publications

> 4 M€ Research income

11 Scientific Area
ING-INF/01 ING-INF/02
ING-INF/03 ING-INF/04
ING-INF/05 ING-INF/06
ING-INF/07 ING-IND/31
ING-IND/35 MAT/09
SECS-P/06

65 Staff

100 PhD, Post-doc, Research fellows

Bachelor Degree in: Biomedical Engineering, Electronic Engineering and Digital Technologies, Computer and Automation Engineering, Information Engineering for Videogame and Virtual Reality.
Master Degree in: Biomedical Engineering (in english), Electronic Engineering, Computer and Automation Engineering.

Bachelor Degree with professional orientation in Industrial and Information Systems (based in Pesaro).

DII coordinates the PhD in Information Engineering, organized in two curricula:
- Biomedical, Electronics, Telecommunication Engineering and Nanotechnologies (IBETN)
- Computer, Management and Automation Engineering (IIGA)

Research laboratories 32

UNIVERSITÀ POLITECNICA DELLE MARCHE

Department Description

The Department of Construction, Civil Engineering and Architecture (DICEA) is among the mostly active departments of construction and civil engineering, as well as, architecture, in Italy, generating (*research*) and transferring (*training*) knowledge and value of the highest quality on such topics.

DICEA is arranged in 4 main sections: Architecture, Constructions, Infrastructures and Structures. DICEA was ranked first in 2017 among the best University departments of Italy (Department of Excellence) and awarded with a grant of 6,6 M€ in the period 2018-2022. In 2022 the DICEA was again ranked first and then awarded with a new Department of Excellence grant (about 6,5 M€) for the period 2023-2027.

DICEA brings together a wide range of disciplines, being leading contributor to the undergraduate programmes in civil and environmental engineering, building engineering, architectural engineering. DICEA also offers postgraduate programmes in civil, environmental, building engineering and architecture.
In the last 5 years, DICEA gathered resources >23 M€ (about 1M€/y from the third mission), of which: 2 EU HE MSCA-DN, 2 EU Interreg, 1 EU Internal Security Fund, 1 EU LIFE, 3 EU Erasmus+, 1 USA DoD and 9 National projects of Relevant Interest.

Coherently with the current global challenges, DICEA has individuated 4 main development axes for the next 5 years: Heritage Science; Safety of structures, infrastructures and natural systems; Digital management of constructions and built environments; Climate change, and constructions and transportation sustainability.

https://www.dicea.univpm.it/

AT A GLANCE

2023

229 Publications

15 Scientific Area
ICAR 01, ICAR 02, ICAR 04,
ICAR 06, ICAR 08, ICAR 09,
ICAR 10, ICAR 11, ICAR 14,
ICAR 17, ICAR 18, ICAR 19,
ICAR 21,
MAT 05, IUS 07

72 Staff

**>2.7 mln €** Research income

71 PhD, Post-doc, Research fellows

Teaching programs for FIRST CYCLE DEGREE (Building Engineering, Civil and Environmental Engineering), **PROFESSIONAL DEGREE COURSE** (Technics for Territorial Design and Management), **MASTER DEGREE** (Civil Engineering, Building Engineering, Environmental Engineering) **& SINGLE CYCLE DEGREE** (Building Engineering-Architecture)
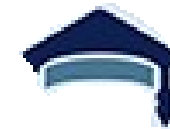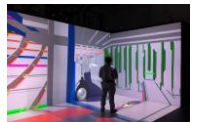
Department of Excellence (from Italian National Agency for the Evaluation of Universities and Research Institutes)
- 2018-2022
- 2023- 2027

Research laboratories **9**

1 Digital Education Lab

DIHCUBE/servizi

//testing before investing- WP3
valutazioni, consulenze e progetti pilota su specifiche tecnologie

//training and skill development-WP4
analisi delle competenze, formazione e mentoring

//support to find investment
monitoraggio e valutazione di incentivi a livello locale, nazionale
e europeo. promozione del microcredito

//networking and access to innovation ecosystem
incubazione e accelerazione di start-up, open-innovation, b2b,
eventi e dimostrazioni

//tecnologie
#Cybersecurity
#Artificial Intelligence
#IoT
#Building Information Modeling
#3D printing
#Platforms
#Digital surveying
#Smart safety
#Machine control
#Building energy monitoring
#Indoor environmental quality
#AR/VR
#Digital Twin
#Smart living

DIHCUBE/ WP3 TESTING BEFORE INVESTING

ADVISING	Analisi e mappatura delle tecnologie
	Analisi tecnica (technical assesment)
	Analisi e valutazione dei processi aziendali AS-IS
SISTEMI INFORMATIVI DIGITALI	BIM Modelli Informativi di edifici, infrastrutture e impianti
	BrIM (Bridge Information Modelling) - Modelli informativi di Ponti
	HBIM (Heritage Information Modelling) Modelli informativi di Edifici Storici
	Scan to BIM - Modelli informativi da rilievi digitali
	Sistemi BIM based per la gestione dell'asset management
SISTEMI INFORMATIVI TERRITORIALI E INTEGRATI	GIS (Geographic information system)
	Sistemi integrati GIS-BIM
STRUMENTI PER RILIEVI	Rilievi laser scanner
	Rilievo tramite satelliti
	Rilievo tramite droni
	Rilievo 3D stato igrometrico
	Rilievo stato termico e igrometrico
	Rilievi integrati, basati su sistemi di mapping, e generazione di database informati anche su indagini non distruttive

| CANTIERE 4.0	Sensoristica di cantiere
	Dematerializzazione della documentazione di cantiere
	AI e Computer Vision in ambienti di lavoro
	Digitalizzazione della gestione e del controllo dei costi e dei tempi del cantiere
	Sistemi di localizzazione e tracking
	Esoscheletri ed ergonomia
	DPI digitalizzati
	Dispositivi di sicurezza sanitaria epidemiologica
	Soluzioni di automazione robotica per le attività di cantiere
	Dispositivi per la gestione della sicurezza delle attività in cantiere
	Sistemi per il Construction Management
PROTOTIPAZIONE E PREFABBRICAZIONE	Stampa 3D

SENSORISTICA E MONITORAGGIO DEGLI EDIFICI	
	Dispositivi di monitoraggio del traffico
	Dispositivi per monitoraggio qualità dell'aria e comfort termico
	Analisi dei dati relativi al monitoraggio del traffico
	Analisi dei dati relativi al monitoraggio della qualità dell'aria
	Dispositivi di monitoraggio qualità dell'aria
	Sistemi di monitoraggio strutturale
	Reti di sensori wireless per il monitoraggio sismico e strutturale h24
	Robot assistivi per il supporto e monitoraggio degli operai in cantiere
	Analisi dei dati relativi al monitoraggio strutturale
	Dispositivi per il monitoraggio energetico dell'edifico
	Analisi dei dati relativi al monitoraggio energetico
	Digital twin su larga scala
	Digital twins
	Sistema di rilievo di movimento e posizione individui nello spazio
	Sistema di eye-tracking
	Sistemi di acquisizione dati biometrici
	Sistemi di acquisizione parametri neurologici
	Sistemi di diagnostica digitale avanzata
	DSS Digital Platform for Risk Management

MODELLI DI SIMULAZIONE DIGITALI	
	Modelli digitali di simulazione per l'analisi, la progettazione energetica, antincendio, sismica, sicurezza
	Accesso alle risorse di calcolo per la modellazione, l'analisi e la visualizzazione di modelli digitali del costruito e delle strutture
	LCA - Life cycle Analysis
	LCCA - Life cycle cost analysis
	Simulazione di protocolli e reti di comunicazione
	Tecniche digitali per l'analisi e la progettazione delle strutture sanitarie
REALTA' VIRTUALE E AUMENTATA	Dispositivi di realtà virtuale
	Interfacce e protocolli di comunicazione per l'implementazione di sistemi di ER e VR
	Ambienti immersivi
	Dispositivi di realtà aumentata e mixata
DIGITALIZZAZIONE DI PROCESSI	Applicazioni digitali per asset, property e facility management
	Supply chain management
	Filiera circolare di progettazione digitale
	Sensor Networks
	Smart contract
	Tecniche AI per la gestione dei processi manutentivi
	Tecniche digitali per persone fragili (Active and assisted living)

| SISTEMI DI GESTIONE ED ELABORAZIONE DATI	
	Accesso a banche dati
	Integrazione delle basi di dati aziendali
	Sharing online
	Digital marketing a supporto delle aziende
	Tecniche di process mining per l'ottimizzazione dei processi aziendali
	Informatizzazione con metodologia BIM di prodotti manifatturieri
	Piattaforme di social computing per la collaborazione dell'utenza
CYBERSECURITY	Valutazione del livello di sicurezza informatica

- **Technical Analysis:** Evaluation of company technologies and integration prospects, including security, productivity, and emerging technologies like **3D mapping** and **remote sensing.**

- **Process Assessment: AS-IS** and **TO-BE analysis** to enhance efficiency and minimize errors through technological solutions and virtual prototypes, integrating PDM/PLM systems.

- **Technology Mapping:** Identification and application of the **best digital solutions** based on the company's specific needs
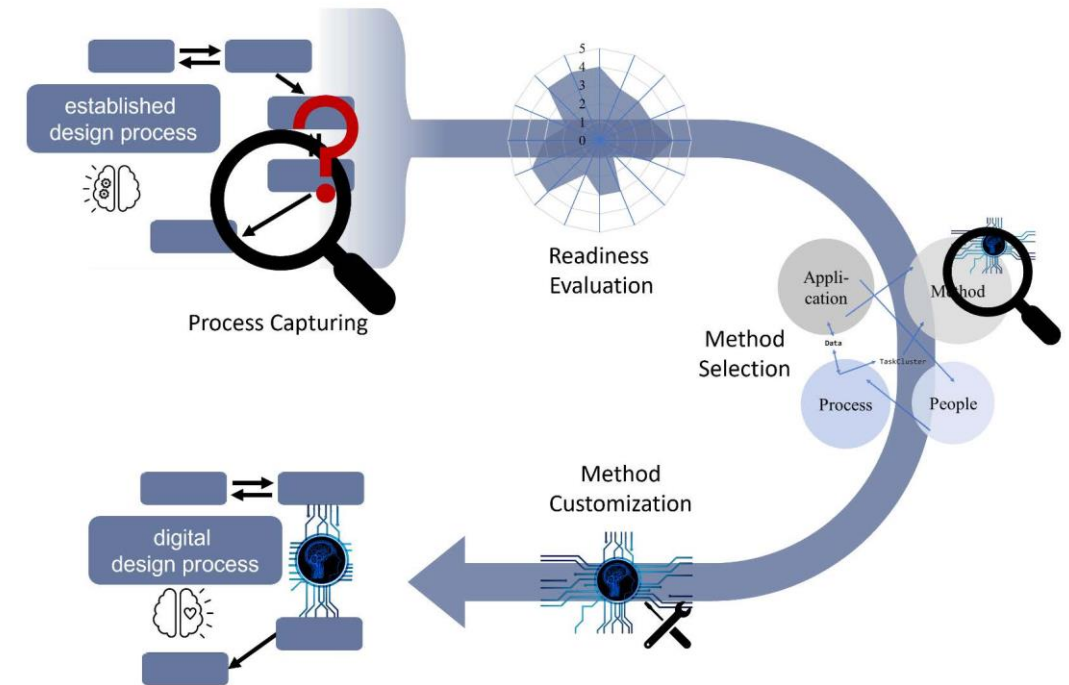
- **BIM (Building Information Modeling):** Digital system featuring a 3D model of buildings, infrastructure, or facilities, integrated with structured, technically coherent, and interoperable data.

- **BrIM (Bridge Information Modeling):** Digital system comprising a 3D model of bridges integrated with structured, technically coherent, and interoperable data.

- **HBIM (Heritage Information Modeling):** Testing activities for HBIM pipelines and standardized data enrichment focused on degradation mapping, construction characteristics, supporting restoration projects.

- **Scan to BIM**: Testing of ScanToHBIM processes (including point cloud integration from TLS+photogrammetric UAV) and optimization of existing procedures with semantic segmentation of 3D data based on Deep Learning.

- **BIM-based Asset Management Systems**: Digital system based on BIM for facility and asset managemen
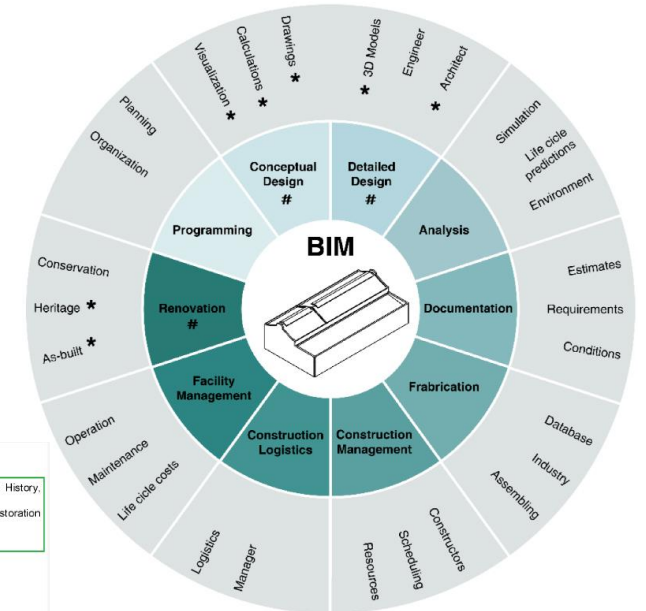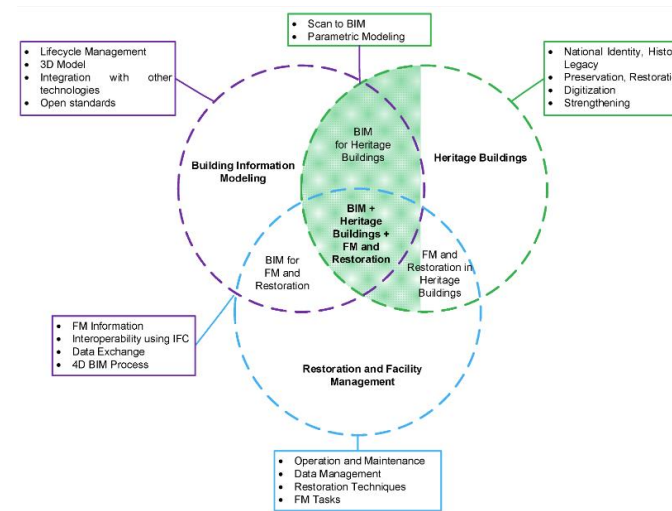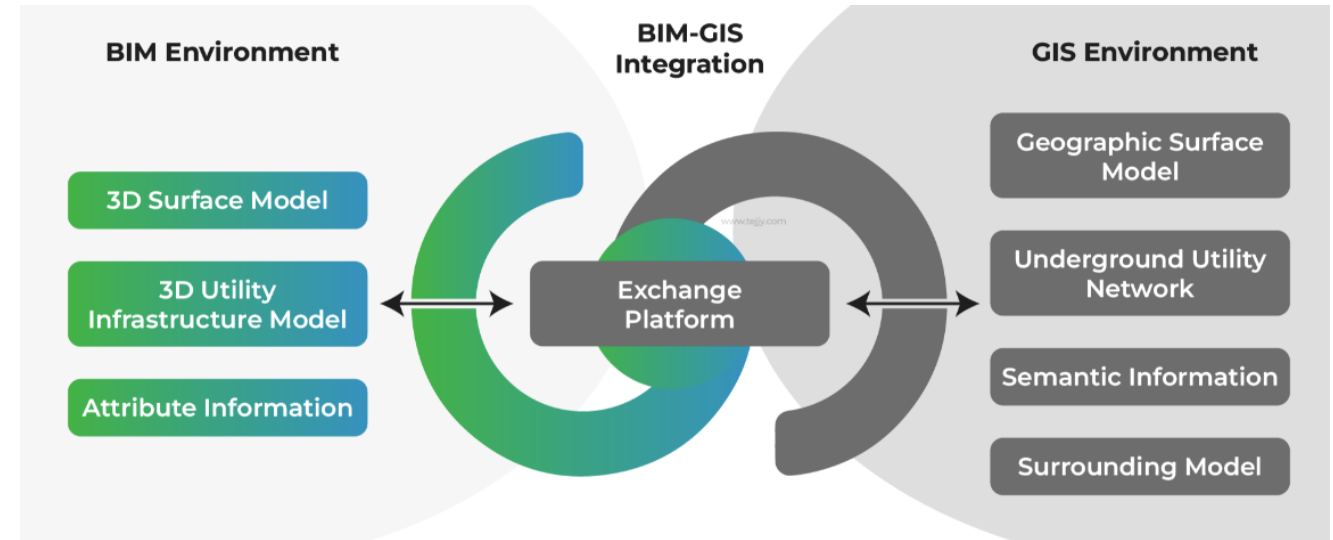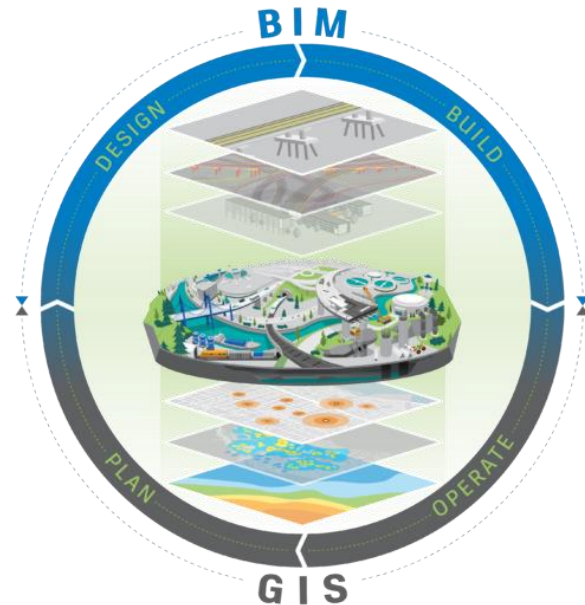
- **GIS**: Computer system that records, stores, controls, and visualizes data on locations across the Earth's surface.

- **Integrated GIS-BIM Systems:** Digital asset information system with 3D BIM models at a territorial scale integrated on 3D GIS (e.g., roads, aqueducts, and networks).

- **CIM (City Information Modelling):** Integrated multiscale platforms of territorial and architectural information systems. Two-hour module aimed at SME entrepreneurs, introducing the topic starting from foundational concepts.

- **Laser Scanner Surveys**: Digital survey technique reconstructing buildings, industrial plants, civil works, and infrastructure by acquiring three-dimensional coordinates of regularly distributed points on an object's surface automatically and systematically, with high density and directly.

- **Satellite-based Surveys:** Survey systems based on satellite acquisitions (RGB, radar, etc.) employing signal processing, data fusion, and Artificial Intelligence algorithms.

- **Drone-based Surveys:** Survey system based on data acquisition via drones. Surveys from SAPR and topographic supports for control point management and georeferencing.

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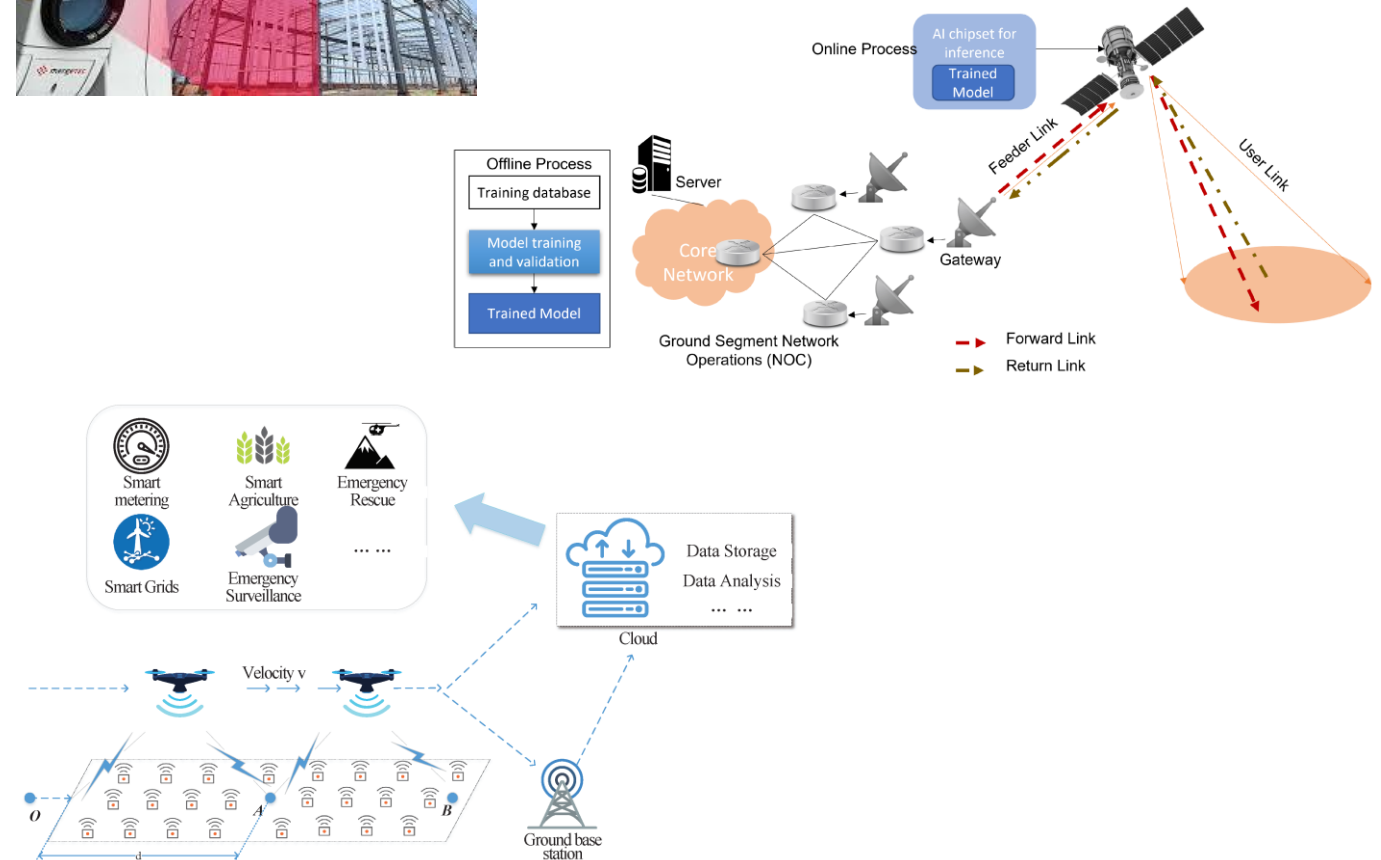
- **3D Hygrometric State Survey**: 3D survey system based on microwaves for mapping the hygrometric state of buildings, bridges, and tunnels.

- **Thermal and Hygrometric State Survey:** FT-IR survey system and capacitive/resistive devices for the thermal and hygrometric state of buildings, bridges, and tunnels.

- **Integrated Surveys**: Surveys based on mapping systems and generation of informed databases, including non-destructive investigations. Introduction of advanced Mobile Mapping systems replacing manual survey operations today.
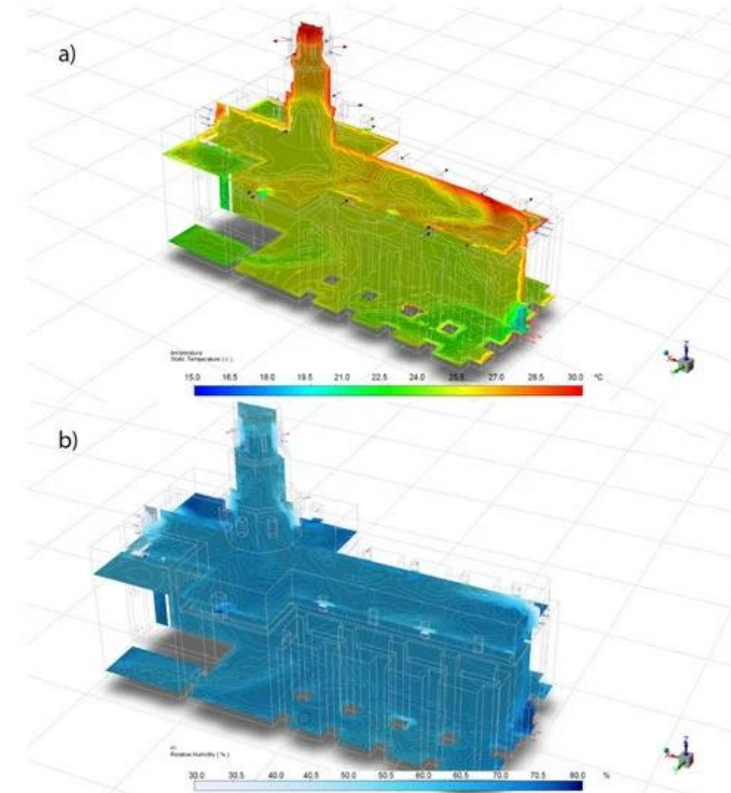
DIHCUBE/**CONSTRUCTION SITE 4.0**

- **Site Sensors**: Monitor noise, temperature, dust, and speeds; warn of hazards.

- **Documentation Dematerialization:** Streamline construction paperwork digitally.

- **AI & Computer Vision**: Analyze worker postures and movements, ensuring safety and compliance.

- **Cost & Time Management**: Digital tools for efficient resource tracking.

- **Location & Tracking**: Wireless systems for personnel and asset tracking.

- **Exoskeletons & Ergonomics:** Assess and improve worker ergonomics with technology.

- **Digitized PPE**: Smart protective gear tracking worker position and health.

- **Health Safety Devices**: Monitor worker density and health risks.

- **Robotic Automation:** Robots for tasks like assembly and heavy lifting.

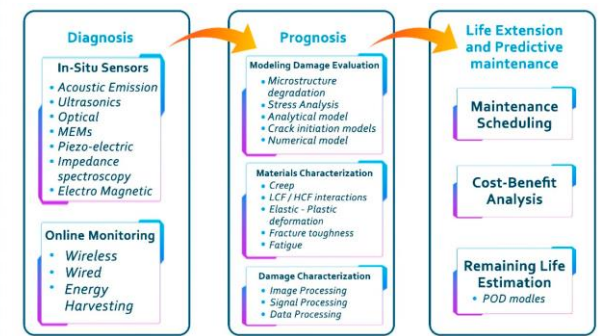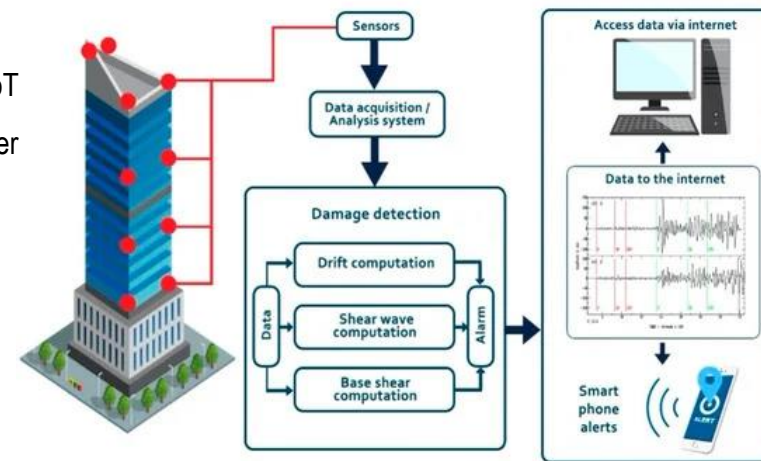- **Safety Management**: Devices detecting worker-machine interactions
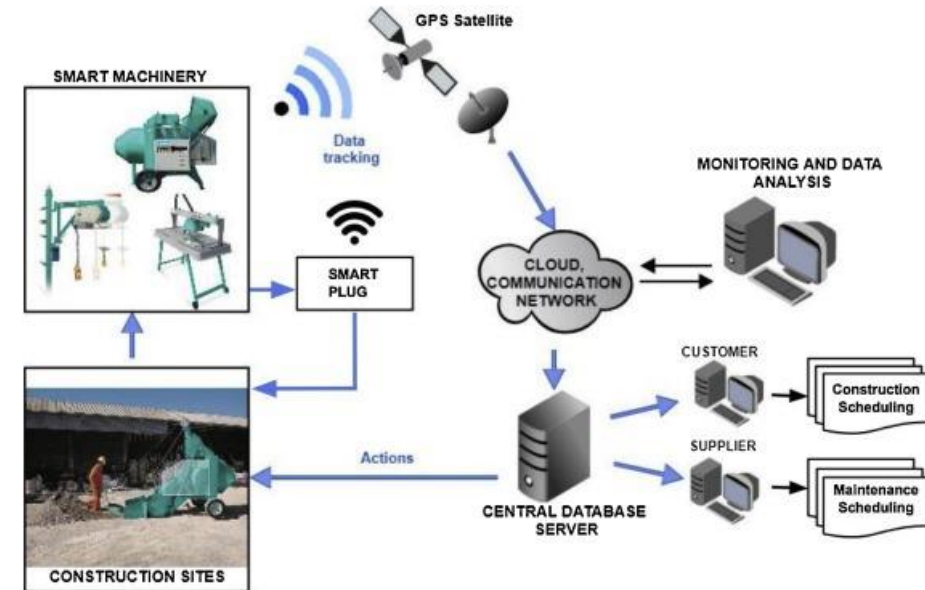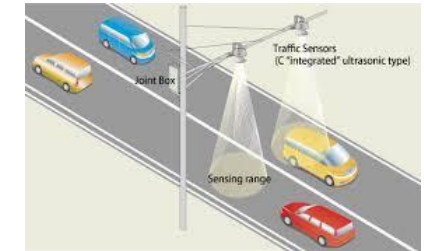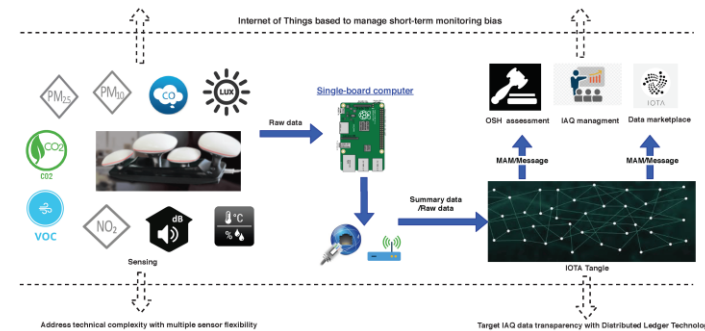
- **3D Printing:** Creation of 3D prototypes using 3D scanning and CAD modeling. Technical analysis to assess 3D printing feasibility for architectural, decorative, functional, and structural elements like metal bridges, clay housing modules, cementitious materials, etc.

- **Digital Support for Prefabrication:** Optimization of BIM modeling for prefabrication processes.
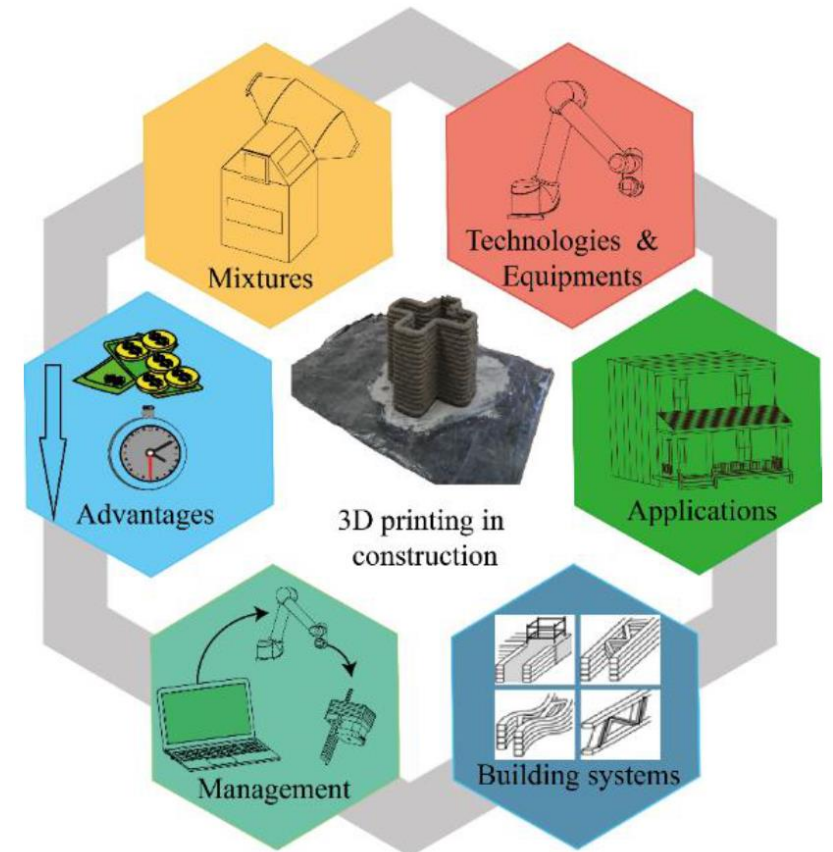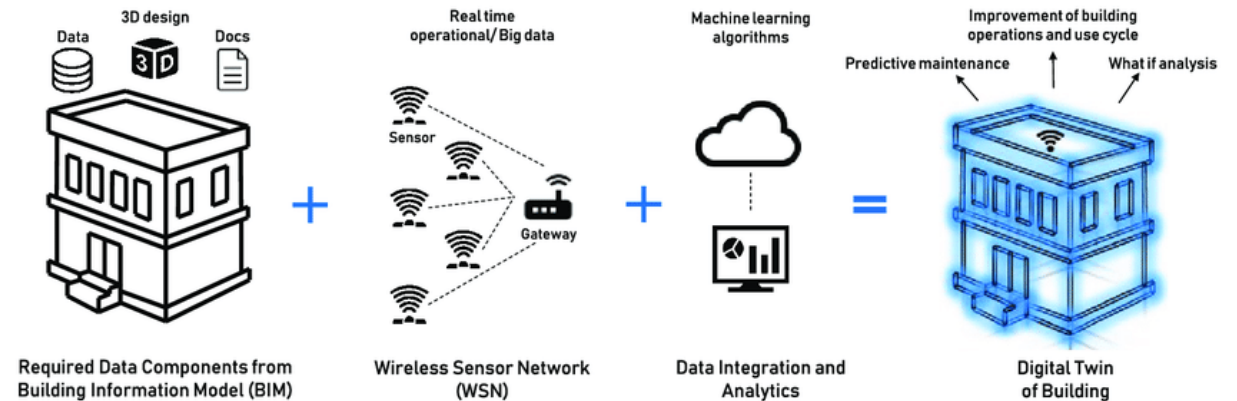
DIHCUBE/ **BUILDING MONITORING**

- **Traffic Monitoring Devices**: Automatic systems for traffic data collection. Machine learning techniques for traffic and air quality data.

- **Indoor Air Quality Monitoring:** Multi-domain indoor air quality measurements. Analysis of pollutants, occupant interactions, and thermal-comfort interactions. Systems detecting indoor and outdoor air quality data.

- **Structural Monitoring Systems**: Static or dynamic structural monitoring devices. Building damage control and vibration detection.

- **Advanced Digital Diagnostics**:Integration of hygrometric and thermohygrometric detection systems.

- **Wireless Sensor Networks for Seismic and Structural Monitoring**: IoT architectures for 24/7 wireless vibration and environmental parameter monitoring. Integration with Cloud/Edge/Fog computing services.

- **Large-Scale Digital Twins:**Integration of territorial-scale Digital Twins (Smart City, Smart Infrastructures).

- **Digital Twins**:Virtual models processing real-time data from building sensors.

- **DSS Digital Platform for Risk Management:**Decision support system based on sensorics and digital twins.

- **Building Energy Monitoring Devices**: Automatic systems monitoring energy consumption.

- **Energy Data Analysis**: Machine learning techniques for energy consumption data analysis

Required Data Components from Building Information Model (BIM) + Wireless Sensor Network (WSN) + Data Integration and Analytics = Digital Twin of Building

- **Robots for Site Monitoring**: Robotic systems for worker monitoring and support.

- **Movement & Position Detection System:** Monitoring of individual and collective movement in spaces.

- **Eye-Tracking System:** Monitoring attention and focus via pupil movement tracking.

- **Biometric & Neurological Data Acquisition Systems:** Wearable sensors for biometric data collection. EEG helmet for neurological data collection.
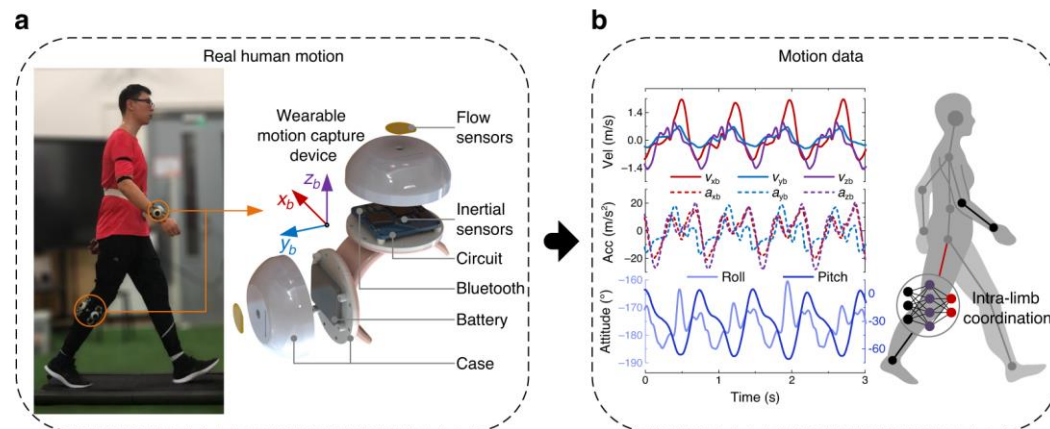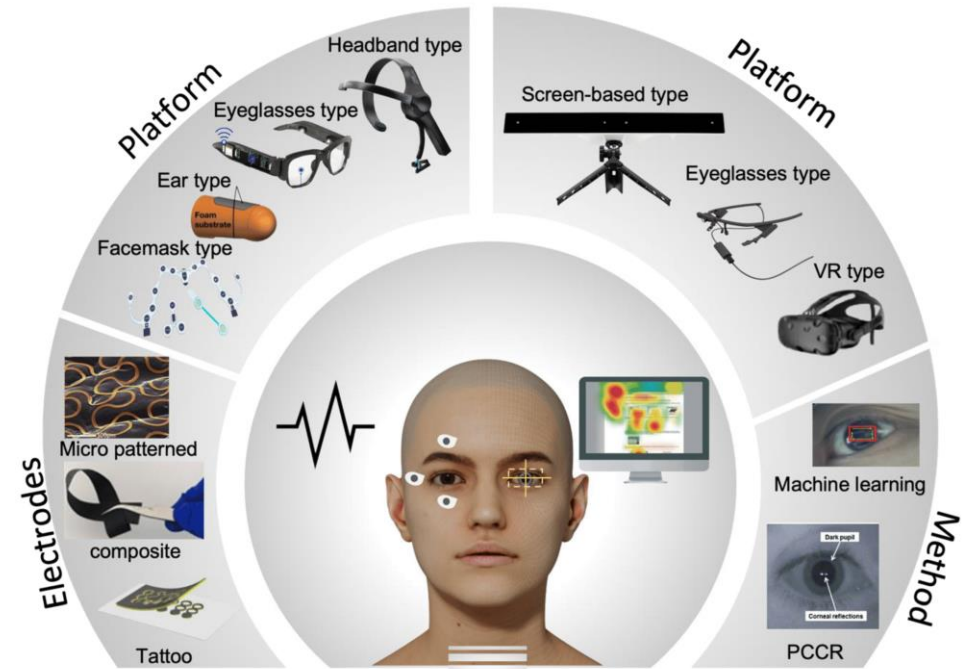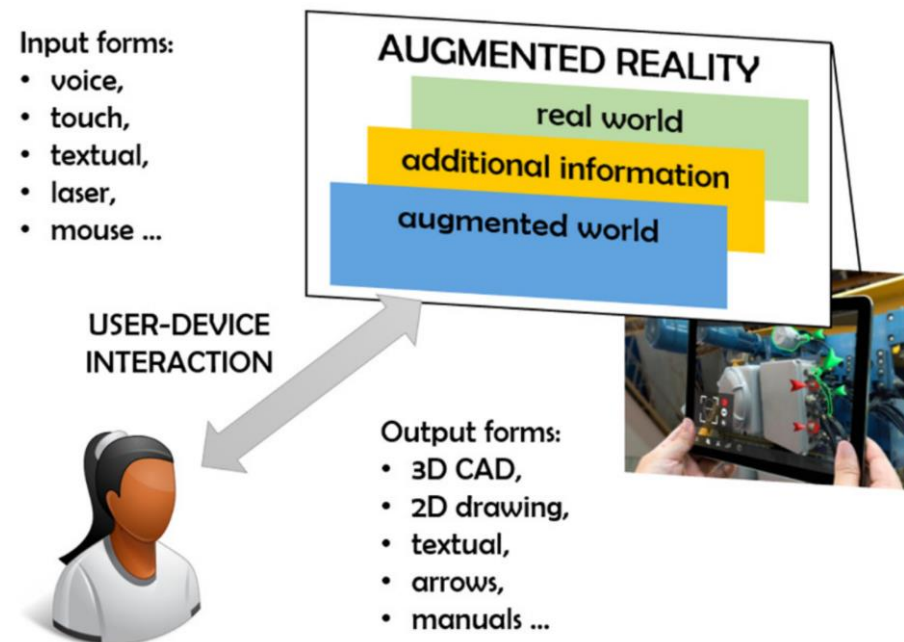
DIHCUBE/ DIGITAL SIMULATION MODELS

- **Simulation Models**:Energy, fire, seismic, safety analysis.

- **Calculation Software:**Energy, fire, seismic, structural, safety design.

- **Computational Resources Access**:Modeling, analysis, and visualization of built structures.

- **Data & Mathematical Models Access**:Simulation software across various disciplines.

- **Life Cycle Analysis (LCA):**Environmental impact assessment.

- **Life Cycle Cost Analysis (LCCA):**Cost assessment over project lifecycle.

- **Communication Protocol Simulation**:Network architecture and communication node design.

- **Healthcare Structure Digital Techniques**:Analysis and design of healthcare structures.

Life Cycle Costing LCC	Life Cycle Assessment LCA	Social Life Cycle Assessment Social Hot Spot Assessment
• Numeric information • Same unit (money)	• Numeric information • Difficult aggregation and interpretation	• Only a few meaningful numeric information, Scale based assessment • Important non-numeric meta information, difficult interpretation
Economy	Ecology	Social

Operational data: Temperature, Flow rate, Equipment

Geometry data

Pre-processing → Data analysis → Modelling → Calibration

Simulation tools: TRNSYS18, EnergyPlus, MATLAB, MODELICA

Optimization
Optimal operational setting
- Setpoints
- On/off
- Schedules
...

Control level: system, equipment, component

DIHCUBE/ VIRTUAL &AUGMENTED REALITY

- **Virtual Reality Devices**:Immersive technology projecting into a digital environment.

- **Communication Interfaces & Protocols**:Design and optimization for ER & VR systems in Industry 5.0.Ultra-low latency communication modes and high QoS via 5G and future 6G.

- **Immersive Environments**:Immersive VR technology via CAVE for digital environment projection.

- **Augmented & Mixed Reality Devices:**Overlaying digital data and models on physical reality, managing interaction between physical and virtual.

Input forms:
- voice,
- touch,
- textual,
- laser,
- mouse ...

AUGMENTED REALITY
real world
additional information
augmented world

USER-DEVICE INTERACTION

Output forms:
- 3D CAD,
- 2D drawing,
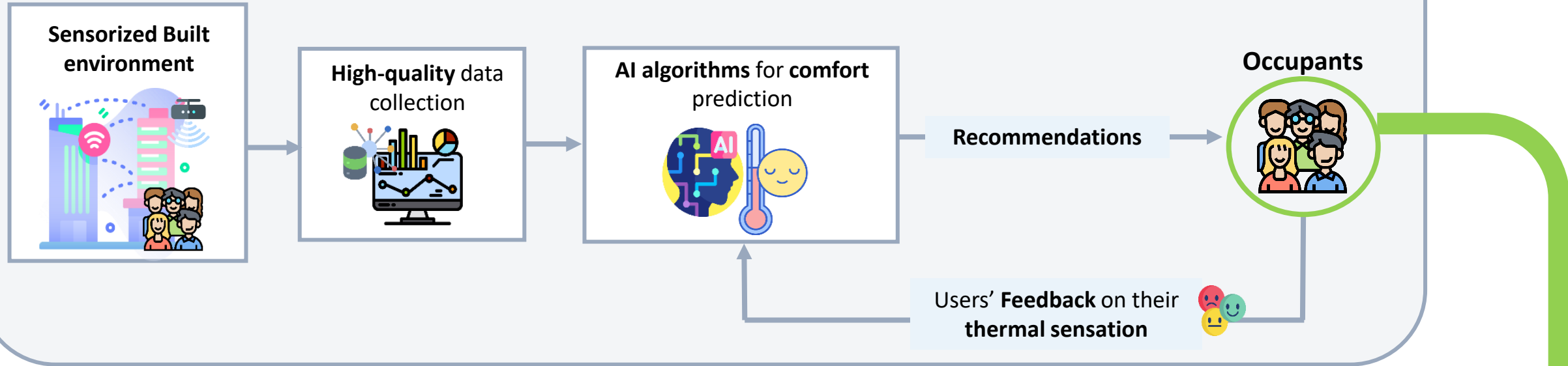- textual,
- arrows,
- manuals ...

DIGIBUILD PROJECT

High-Quality Data-Driven Services for a Digital Built Environment towards a Climate-Neutral Building Stock

- **Data Impact:** Data influences every aspect of buildings, from user interactions to energy consumption, aiding informed decision-making and operational efficiencies.
- **Objective:** Convert traditional silo buildings into smart, interoperable, energy-efficient structures using reliable data.
- **Solution:** Replace siloed data management with integrated digital systems (AI Services and DTs), placing stakeholders at the core.
- **Current Issue:** European buildings are highly energy-consuming and inefficient, with slow renovation rates.
- **Data Integration:** Increasing ICT technology adoption generates extensive data within buildings, crucial for moving towards a Smart Building Landscape.
- **DigiBUILD Role:** Facilitates this transformation by leveraging high-quality data and advanced digital services, ensuring trust, transparency, and improved decision-making.

ENHANCED COMFORT AND WELLBEING SERVICE

Sensorized Built environment → **High-quality** data collection → **AI algorithms** for **comfort** prediction → **Recommendations** → **Occupants**

Users' **Feedback** on their **thermal sensation**

Recommendations = actions by occupants on the environment

- Improvement of Indoor comfort
- Optimization of building's energy performance
- Reduction of Energy consumption
- Enhancement occupants' experience and productivity

AMBITO

1. Competences Assessment
2. Training services for the development of digital skills: base level
3. Training services for the development of digital skills: advanced level (including train the trainers)
4. Virtual Reality/ Gamification support in trainings
5. 1 to 1 Entrepreneurship mentoring

Artificial Intelligence e Big Data

1. Gestione e analisi dei dati con tecniche Artificial Intelligence
2. Big Data e Business Intelligence

Imprenditorialità

1. 1 to 1 entrepreneurship mentoring
2. Innovation Management

Robotica e Automazione

1. Simulazione e programmazione dei robot
2. Robot e normative di sicurezza
3. Introduzione ai dispositivi robotici indossabili
4. Sistemi di monitoraggio strutturale

5. Sistemi di monitoraggio sismico e in esercizio di edifici residenziali con sistemi di alert e report automatici

Ergonomia e Sicurezza

1. Ergonomia ed esocheletri
2. Introduzione all'ergonomia fisica e ai metodo e strumenti per la valutazione dei fattori di rischio

Sostenibilità Ambientale

1. Digitalizzazione della valutazione della sostenibilità ambientale attraverso i protocolli di sostenibilità
2. Soluzioni di training per progettazione e gestione sistemi di monitoraggio di tipo ambientale

Misurazione e Diagnostica

1. Misure ambiente costruito
2. Misure per ambiente costruito
3. Misure per efficienza energetica
4. Competenza per l'elaborazione di dati di monitoraggio strutturale ed ambientale per il damage detection
5. Training calibrazione automatica modelli numerici tramite algoritmi genetici

Additive Manufacturing e Stampa 3D

1. Corso sui principi della stampa 3D
2. Corso sulle tecnologie di additive manufacturing per materiali metallici e analisi dei materiali

Modellazione e Visualizzazione

1. Accesso alle risorse di calcolo per la modellazione l'analisi e la visualizzazione di modelli digitali del costruito e delle strutture
2. Realizzazione modelli MEP (BIM per impiantistica)
3. Training realizzazione di gemelli digitali in ambiente BIM
4. Digitalizzazione dell'analisi energetica degli edifici

Realtà Virtuale e Aumentata
1. Soluzioni di training di operatori e lavoratori in ambito di sicurezza negli ambienti costruiti tramite simulatori individuali in realtà virtuale
2. Training su gestione ambienti virtuali con piattaforme di game engine
3. Soluzioni di training di operatori e lavoratori in ambito di sicurezza negli ambienti costruiti tramite ambienti immersivi per realtà virtuale
4. Tecnologia di realtà virtuale immersiva tramite visori individuali per proiezione di ambienti digitali
5. Extended reality technologies per la competitività delle imprese nel settore delle costruzioni

Fotogrammetria e Scansione Laser
1. Training sul progetto di presa fotogrammetrico da drone e trattamento dati
2. Training sull'utilizzo degli strumenti di rilievo TLS

Digitalizzazione e Impiantistica
1. Digitalizzazione e impiantistica negli edifici
2. Digitalizzazione dell'analisi energetica degli edifici