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Design and Develop of a Smart City Digital Twin with 3D Representation and User Interface for What-If Analysis

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- **Challenges vs Technologies**
- **DSS, Decision Support Systems**, with multiple objectives:
 - Quality of life for citizens, improvements of services, cost reduction, innovation, attractiveness for tourists and/or industries and/or commercial activities, etc.
- provide the decision-making process with simulation tools integrated with short-, long- and very long-term prediction algorithms
 → what-if analysis
 - Analyse *incipient events* to cope with events;
 - Analyse future situations for structural planning: tactics/strategic.
- Opportunities and needs
 - exploit huge amounts of heterogeneous data (Big Data) that come from the territory, from the structures and services of the city and from the stakeholders;
 - flexible, dynamic and interoperable models and analysis tools;
 - accessible for:
 - Operators, decision-makers, stakeholders;



In some measure also for citizens: as a tool for illustrating and discussing possible solutions and development plans with them: cowork











Digital Twin

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- Connected with real systems
- Modelling aspects: structural, visual, informative, real time data sensors (context), POI, functional, resources, etc.
- Integration: AI/XAI techniques, simulations, users' needs, etc.

• Utility to

- Experiment via simulations and analysis by case
 - Reduction of costs to experiments new solutions
 - Share the possibilities with city users
- Virtual Representation
 - Easier to understand the context, review from multiple points of view
- Who



- Discussion with city users, decision makers
- Support: decision makers, proposers of solutions













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DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE



	CityGML [3]	Helsinki	Rotterdam	Berlin [21]	Stockholm [22]	Wellington	DUET [24]	Snap4
		[19]	[20]			[23]		City (our)
RD1.i	Yes	No	No	No	No	No	Yes	Yes
RD1.ii	Yes (LoD3)	Yes	Yes (LoD2)	Yes (LoD2)	Yes (LoD3)	Yes (LoD3)	Yes (LoD2/LoD3)	Yes
RD1.iii	No	No	No	No	No	Probably	No	Yes
RD2	No	Yes	Yes (C)	Yes (C)	Yes	Yes	Yes	Yes
RD3	No	No	No	Yes	No	Probably	Yes	Yes
RD4	No	Yes (C)	Yes (C)	No (x)	Yes	Yes	No	Yes
RD5	No	No	No	No	Yes	Yes	No	Yes
RD6	Yes	Yes	No	No	Yes	Yes	Yes	Yes
RD7.i	Yes	Yes	No	No	Yes	Yes	Yes	Yes
RD7.ii	Yes	No	No	No	No	Yes	No	No
RI1	No (*)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RI2	No (*)	No	No	No	No	Yes	No	Yes
RI3	No (*)	No	Yes	No	Yes	Yes	No	Yes
RI4.i	Not clear (maybe)	Yes (s)	Yes	Yes	No	Probably	No	Yes
RI4.ii	No	No	No	No	No	Probably	No	No
RI4.iii	No	No	No	No	No	Yes	No	No
RI5	No	No	No	Yes	No	Yes	No	Yes
RI6	No (*)	No	No	No	Yes	No	Yes	Yes
RI7	No (*)	Yes (**)	Yes (**)	No (x)	No	No	No	No
RI8	No	No	No	No	Yes	Yes	No	Yes
RO1	No	No	No	No	No	No	No	Yes
RO2	No	No	No	No	No	No	No	Yes
RO3	No	No	No	No	No	No	No	Yes
RO4	No	No	No (not specified)	No	No (not specified)	No (not specified)	No	Yes
RO5	No	No	No	No	No	No	No	No
RO6.i	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RO6.ii	n/a	Non-free	Free	Free	Non-free	Non-free	Non-free	Free
RO7	No	Yes	Possible (x)	Possible (x)	Possible	Yes	Possible	Yes
RO8.i	No	Yes	Yes	No	Yes	Yes	Not clear	Yes
RO8.ii	n/a	Non free	Non free		Non free	Non free	Not clear	Yes



High Level Types

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- POI, IOT Devices, shapes,..
 - FIWARE Smart Data Models,
 - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ...
- Satellite data, ..
- traffic flow, typical trends, ..
- trajectories, events, Workflow, ..
- 3D Models, BIM, Digital Twins, ..
- OD Matrices of several kinds, ..
- Dynamic icons/pins, ..
- Synoptics, animations, ..
- KPI, personal KPI,..
- social media data, TV Stream,
- routing, multimodal, constraints, ...

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• decision scenarios,

etc.

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3D Map Global Digital Twin -Newgui2



https://youtu.be/JLzT9k3Xbc0

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KM4City Knowledge Base

 Collected static and real-time data are semantically indexed in an graph based RDF Knowledge Base, named KM4City

 Several API have been defined in order to retrieve data from the KB using relational, spatial, and temporal queries



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Data Analytics in Snap4City

More than 90 data analytics processes are available!

Mobility and Transport

Traffic flow reconstruction from sensors

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- Predictions for traffic flow, smart parking, smart bike sharing, people flows, etc.
- Public Transportation analysis of the demand mobility vs offer (DORAM)
- Accidents heatmaps, anomaly detection ٠
- Routing: multimodal, constrained, dynamic
- Computing OD Matrices, typical trajectories
- Slow and Fast Mobility 15 Minute City ٠ Indexes
- Typical time trends for traffic flow and IoT Time series
- Impact of COVID-19 on mobility and transport
 - What if analysis

- **City Users and Social**
 - People detection, classification, counting, and tracking
 - People flows prediction, reconstruction, analysis
 - User engagement and suggestions
 - User's behaviour analysis
 - Social media analysis (Twitter Vigilance)

Environment and Weather

- Predictions of NOX, PM10, CO2 pollution
- Prediction of landslides, 24 hours in advance ٠
- Heatmaps production for Weather, Pollutants and Aerosol
- Impact of COVID-19 on Environmental aspects

Time Series

- **Time Series Anomaly detection**
- Data quality assessment and control
- Short and long term predictions

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Semantic Reasoning

- Ontology Modelling and integration
- Knowledge modelling and reasoning
- Virtual Assistant construction

Maps and 3D Digital Models

- Conversion of Satellite data images
- 3D Digital Twin of Cities and Objects

Management and strategies

- Early warning computation
- **Production Optimization**
- Planning and Monitoring ٠
- **Predictive Maintenance**
- **Resilience and Risks Analysis** •
 - Resilience analysis wrt European Guidelines on Resilience of critical infrastructure, and transport systems
 - Risk analysis: natural and non-natural disaster



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Snap4City Analytics

- Decision support systems
- Improvement of life quality
- Sustainable Solutions
- Reduction of costs
- Risk Assessment
- Resilience



Decision Support System targeting Indicators: Quality of Life, PUMS, SUMI, KPI, SDG, 15MinIndex,...



2023



What-if analysi based on AI and simulations

More than **90 data analytics processes** are available!

 Traffic flow reconstruction based on a fluid-dynamic model













What-if analysi based on AI and simulations

More than **90 data analytics processes** are available!

Traffic flow reconstruction based on a fluid-dynamic model

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Analysis of public transport offer and demand











What-if analysi based on AI and simulations

More than **90 data analytics processes** are available!

- Traffic flow reconstruction based on a fluid-dynamic model
- Analysis of public transport offer and demand
- Assessment of the **15-minute index**
- Capabilities to perform What-If analysis for routing and traffic congestion







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3D Map Texturing

Orthomaps

Building shapes

Input

Deep network

alignment





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Integration and distribution

- Acquired and produced data are integrated into the digital twin model
- The model is distributed as a Snap4City dashboard
- A **3D multi-data map** is built as an interactive web interface



widgets can be integrated and sync. in the same dashboard to focus on particular information





2023





Cached

GLB Layer

Tile

Cached GLB Layer

Tile

Cached

GLB Layer

Tile

GLB Layer

Tile

GLB Layer

Tile

GLB Lave

Tile

Tile Layer

GLB Tile Laver



IconLayers: array of layers used to show PINs for IoT sensors, POI, SVG.

Sensor3DLayers: array of layers composed by Scatterplotlayer, ColumnLayer, and TextLayer. Used to represent 3D pillars.

CrestLayers: array of layers used to represent the 3D Traffic Crests

WhatIfLayer: used to show the results of a What-If analysis. It includes a PathLayer, a GeoJSONLayer, and an IconLayer.

TreeLayer: used to present the trees (and eventually other additional 3D entities). It is implemented with the same layer structure of the BuildingLayer.

BuildingLayer: to show the Realistic Buildings. As for the 3D terrain a tiled solution is adopted using CachedGLBLayers instead of TerrainMeshLayer. When using the monolithic approach, different layers are used (see text).

BusLayers: array of layers. Each one is composed by a PathLayer and an IconLayer. Used to represent the bus lines

PathLayers: array of layers used to display cycling paths

ManagedTerrainLayer : used to display the 3D terrain with Orthomaps, Heatmaps, etc. In the case of flat terrain, this layer is substituted with a series of tiled BitmapLayers (see text).

DeckGL Layered Structure







3D traffic flow animation in real time













Dyamic Routing in 3D space





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ella.





- The development of the SCDT of Florence has been presented, highlighting its construction phases
- The development activities were carried out to fulfil a series of requirements on data, on interactivity functionalities, and on the integration and distribution
- Our SCDT is not limited to a 3D representation of the city, but it includes information coming from different sources
- This capability to handle huge amount of data is powered by Snap4City, the IoT platform on top of which the SCDT is developed









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7-9 November 2023, Barcelona, Spain

SMARTCITY EXPO WORLD CONGRESS

Visit Snap4City in Hall 1



CONTACT

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