Chapter 11
Regional Knowledge Management and Sustainable Regional Development: In Quest of a Research and Knowledge Agenda

Robert Laurini, Peter Nijkamp, Gloria Bordogna, Karima Kourtit, Fabien Duchateau, Antonio Rinaldi, Louafi Bouzouina, Michael E. Mehaffy, and Bokolo Anthony

Abstract Knowledge management technology is now ubiquitous in many businesses, yet it is much less common among local authorities. Following a "brainstorm meeting" in Lyon on knowledge management for regional planning and policymaking, a proposal was developed to set up a research agendum for future development of this topic. The main difficulty we identified is that regional knowledge encompasses many topics beyond business issues, especially those related to long-term sustainability. The goal of this paper is twofold, first to clarify the proper definitions and boundaries of regional knowledge and technology, and second, to identify the ways of using this technology effectively for governance and decision-making.

R. Laurini (✉)
KSI, Skokie, USA
e-mail: Robert.Laurini@liris.cnrs.fr

University of Lyon, Lyon, France

P. Nijkamp · K. Kourtit
Open University, Heerlen, The Netherlands

G. Bordogna
IREA, CNR, Milan, Italy

F. Duchateau
LIRIS, Claude Bernard University of Lyon, Villeurbanne, France

A. Rinaldi
Federico II University of Naples, Naples, Italy

L. Bouzouina
LAET, ENTPE, University of Lyon, Lyon, France

M. E. Mehaffy
Royal Institute of Technology, Stockholm, Sweden

B. Anthony
Norwegian University of Science and Technology, Trondheim, Norway

R. Laurini et al. (eds.), *Knowledge Management for Regional Policymaking*,
https://doi.org/10.1007/978-3-031-15648-9_11

Keywords GeoAI · Regional planning · Regional policymaking · Knowledge management · Knowledge representation · Knowledge engineering · Research agenda

11.1 Introduction

Spatial information and knowledge management belong to the discipline of spatial information science, which covers from a multidisciplinary angle all geographically relevant information that is needed for effective, inclusive, and sustainable spatial (regional and urban) planning and analysis (we refer for an informed overview to Shi et al. 2021; see also Bettencourt 2021). Over the past decades, spatial information science has developed a respectable toolbox, ranging from geo-science (including GIS) techniques or geo-design approaches to spatial syntax, digital twin analysis or BIM/morphometric models. The acceleration in the development path of spatial information science is largely due to the rapid growth in digital technology in recent decades. There is nowadays hardly any domain in regional or urban science or policy that is not based on advanced digital tools, in particular in regard to daily management operations (e.g. traffic control, waste management, health care, safety policy).

An important handicap in developing a fully-fledged professional regional information and knowledge management system is that the definition and demarcation of a region are rather fuzzy. Clearly, a region can be described on the basis of its physical features, common socio-economic characteristics or man-environmental interactions (Burch et al. 1979; Nijkamp and Rietveld 1983; Giaoutzi and Nijkamp 1988). In general, however, the boundaries of such regional concepts are imprecise. The only example of an unambiguous definition of a region is perhaps the case of administrative regions, which are normally defined on the basis of jurisdictional borders. We also note that there are several other types of regions, such as natural resource areas or planning regions, which are also used in the regional science literature. Consequently, the regional landscape displays a patchwork of largely overlapping areas or regions characterized by distinct features.

From our perspective, regions house interdependent objects, activities, and people, which can be described by means of statistical descriptors. Clearly, there is an avalanche of such spatial descriptors that altogether display a multifaceted panorama of the functioning or the profile of an area. This is where information and data enter the picture. Regions are essentially statistical geographical mappings of a complex and ever evolving space economy. Statistical principles to depict such features originate from economics, sociology, demography, culture, morphology, political science, physical geography, or related disciplines. A region thus offers an interconnected collection of relevant geographical characteristics, which can be summarized in representative databases, either statistical or visual (e.g., in the form of GIS maps or a digital twin). Meanwhile, it is increasingly recognized that in the modern digital age, the governance of regions has to be based on sound and comprehensive databases.

The management of multifaceted regional information was the subject matter of the present book.

This volume has brought together operational principles, basic cornerstones, and practical experiences of regional information and knowledge management. Such contributions have clearly a great added value, but, in retrospect, it is an important question whether such studies help us in exploring a feasible and attractive trajectory for the future of regional data science. A knowledge pathway for a promising regional information and data management calls for a system of structured guidelines in the form of a future-oriented research and knowledge agenda. This will be the aim of the last chapter in this volume, where the successive chapters in this book will be used for building up a systematic research agendum that may strengthen the field of spatial informatics. It is also the result of a brainstorm meeting by several spatial knowledge experts who met in October 2021 in Lyon to discuss the state of affairs regarding regional knowledge analysis and to pave the road toward a novel research agendum on the design and use of knowledge management technologies geared toward regional analysis and policymaking.

This last chapter of this volume is organized as follows. In Sect. 11.2 a general orientation on regional information and knowledge management will be offered, in the context of the worldwide need for sustainable spatial development in the digital age. Section 11.3 will present the basic foundations and characteristics of regional knowledge, with particular emphasis on (*i*) the prolegomena of knowledge, (*ii*) the space and time dimensions of knowledge, and (*iii*) the exploitation of knowledge. Next, in Sect. 11.4, we discuss the knowledge conditions for regional governance and decision-making, subdivided into (*i*) formal and procedural aspects, (*ii*) use aspects, (*iii*) knowledge acquisition aspects, and (*iv*) knowledge outcome aspects. Finally, Sect. 11.5 positions the present observations and findings in the context of various specific policy domains, such as mobility, environment, housing etc. The synthesis of this last chapter may act as a signpost for future innovative research and application in the spatial information sciences.

11.2 Setting the Scene

In order to enhance human quality of life, it now appears paramount to exploit the success of knowledge representation and management in domains such as business and to apply this expertise at the regional level for administration and policymaking. Especially two new directions have changed the scene of regional knowledge management, viz. the widespread introduction and use of digital technology and data science and the increasing need for citizen participation in regional and urban planning. Spatial informatics is clearly more developed in the area of smart or intelligent cities. Indeed, while there are many works and applications concerning smart cities (Caragliu et al. 2011; Albino et al. 2015; Bibri and Krogstie 2017; Laurini 2017; Voda and Radu 2018; Chang et al. 2018; Giffinger and Haindlmaier 2018; Komninos and Kakderi 2019; Kirwan and Zhiyong 2020; Kourtit 2021; Nijkamp and Kourtit

2022), very little has apparently been done for regions (Greco and Cresta 2017). In the final chapter of this book, we will focus on the forgotten regional aspects of information management.

The first section of this document is devoted to objectives, challenges, methodology, origins of regional knowledge, links with the 17 UN Sustainable Development Goals (SDGs), and cross-fertilization between research and practice. Against the background of a concise overview of these items, the remaining part of this final contribution then discusses and develops the logic of a systematic agendum design for spatial knowledge management.

11.2.1 Objectives

In the era of an advanced information-based society (including regional systems) and evidence-based policymaking, the use of data is essential, especially in the modern digital economy (see e.g. White 2019). Nevertheless, there are serious shortcomings in regional policy. To tackle this lacuna, four barriers should be overcome:

- The initial barrier is: “what are the region’s boundaries?”
- There is a wealth of information on regional concepts, but in relation to statistical data, there is much heterogeneity that hampers a consistent evaluation and comparison of regional development over time. The effects of Eurostat and ESPON in Europe have certainly been fruitful, but new data systems such as social media are not organized according to commonly accepted principles.
- The second barrier is: “what is knowledge management?” According to Girard and Girard (2015), knowledge management is the collection of methods relating to creating, sharing, using, and managing the knowledge and information of an organization. It refers also to a multidisciplinary approach to achieve organizational objectives by making the best use of knowledge. In the case of regions, it looks mandatory to link those objectives to sustainable development. We note that sometimes also the expression “territorial intelligence” is used (see e.g. Garcia-Madurga et al. 2020; Pumain and Reuillon 2017).
- The third barrier deals with acceptability of local authorities in charge of regional governance; namely, they must be put in a condition to understand and trust Artificial Intelligence (AI) techniques for assisting them in making decisions at regional level, which means—besides defining transparent and explainable AI approaches—also helping regional authorities, decision-makers and stakeholders to appropriate those novel tools. This should be done without forgetting public participation and citizen empowerment whose potential use must undergo quality assurance and assessment. This raises the question of the time lag between the instantaneous production of data, information, and knowledge resulting from Artificial Intelligence and the longer timeframe of the political decision resulting from the democratic systems in place. It also raises the question of the lack of knowledge of Artificial Intelligence and its place in relation to collective intelligence.

- The final barrier is from a computing point of view. We note that one of the main hindrances is the representation of space and time; its logic—which is the main mathematical tool to encode knowledge—presents some difficulties of neighborhoods with other domains necessary to be included in regional reasoning: those mathematical domains are ranging from topology and computational geometry to operations research, from non-classical logics such as default (Ray and Chakraborty 2011), temporal and fuzzy logic to model exceptions, time and imprecise and vague knowledge, and graph-based reasoning, among others. It should be added that knowledge acquisition and handling is not only a "software" activity but also a "socio-ware" activity based on communication exchange and learning experiences among experts and users. Examples of useful approaches are:
  - use expert opinion to draw up a tentative list of issues that in the expert's view is a critical part of the research and policy domain;
  - organize a systematic brainstorm interaction to create a logical structure and composition to relevant data issues;
  - execute a reality check by adding also some complementary issues, by structuring them into graphs or clusters and by confronting the results with prevailing practice and future needs of users.

Clearly, the interactive part of this search methodology may assume various forms (brainstorm sessions, social gaming, scenario workshops, etc.); information management has to be part of social and policy knowledge engineering.

11.2.2 Regional Concerns

Regional policymaking and planning address a multiplicity of aspects for which knowledge base systems are useful. Here we will deal with some of these. Generally speaking, by designing and implementing those systems, various theoretical difficulties may emerge, while effective practical solutions must be invented. For those issues, it is important to develop not only technological watching but also sociological watching, especially to empower citizens and to check their acceptability. Domains such as land use, economy, employment, mobility, health, tourism, education, culture, etc. are for them to be explored also in a citizen science context so as to grasp knowledge bundles in order to be used in regional policymaking and planning.

First, each region has its own peculiarities; as argued by Silva (2004), it is important to identify its so-called "DNA", i.e. the set of characteristics that are critical to shape its future (environment, extractive resources, creativity, economic resources, touristic and historical resources, etc.).

Land, for instance, is a crucial resource. A functional use of land for productive activities reduces land for rural destinations and hence, biodiversity. Here, the goal is to unveil knowledge bundles to select appropriate and sustainable activities, bearing in mind the necessity to reserve land for future generations. This argument also holds for all knowledge bundles of any kind of natural resources.

In our world, and especially for regions, the economy and employment are important. Many works have been undertaken in the knowledge-based economy, and only some at regional level, but they are almost all targeted to the economy. But it is necessary to analyze knowledge bundles also in order to develop the social economy in a region. Most likely, a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis in a region can determine a sort of framework for exhibiting knowledge devoted to the inception of businesses, start-ups, etc., see for instance (Fritsch and Wyrwich 2018; Qian 2018). Here, the research lines will overall include knowledge bundles necessary for transport planning and mobility management with a view to adapting supply to demand, connecting isolated populations and remote areas and reducing air pollution and greenhouse gas emissions.

Practically, all human activities involve the use of energy. At regional level, once the local resources and limitations are identified, novel energy possibilities must be explored in two directions, i.e. possible opportunities and aftermaths. Planning of health resources must be done at regional level taking demography into account and also medical tourism. Knowledge bundles regarding this activity must be capitalized, and also to acquire knowledge for solving medical deserts.

A final aspect that needs to be investigated concerns all issues dealing with disaster management (Weichselgartner and Pigeon 2015) and emergency organization at regional level. Here also, knowledge must be acquired, modeled, and capitalized so to allow reasoning for greater efficiency, namely quick and decisive decision-making, needs assessment and allocation, feedback and evaluation, expertise coordination practices, command and control structure, learning and knowledge transfer, etc. For a survey, see Oktari et al. (2020).

From the previous observations, it is now clear that knowledge education at all levels must be integrated, managed, and updated to stimulate sustainable development. Ideally, it should integrate demography, local needs, human resources, buildings, equipment, etc. Now that regional concerns are clearer, we will analyze in more detail the characteristics of regional knowledge, also to identify barriers and research lines.

11.2.3 Significance and Origin of Regional Knowledge

Knowledge has no meaning in itself but derives its value from its use in practice. For a region, knowledge corresponds to information potentially useful in order to address the concerns expressed in Subsect. 2.2:

- explain and make understandable its internal dynamics as well as its interactions with other adjoining regions in the same or neighboring countries.
- manage a region by some local authorities, i.e. by means of some decision-support system, in the spirit of territorial intelligence;
- monitor its daily development through feedbacks and adaptation;
- simulate the future, and design novel projects;

- orient actions for the future.

Why is regional knowledge difficult to be represented? The existence of several levels of governance and decision (state, region, city, etc.) implies different knowledge bundles, possibly from discrepancies in views to potential or real contradiction. In addition, whereas in business intelligence, knowledge is overall represented with logic, we face the difficulty of representing space: this no more logic reasoning, but also geometric reasoning.

Regional knowledge is in essence multi-disciplinary and multi-sectoral because it concerns several domains such as transportation, economy, agriculture, health organization, recreational activities, tourism, culture, folklore, education, natural resources, biotopes, infrastructures, flood and hazard mitigation, etc. Moreover, knowledge chunks and bundles come from various sources; among them we can mention:

- written documents such as books, expert reports, juridical documents, etc.;
- historic cartography, maps and images, including satellite images, aerial photos, and more recently, drone photos and videos;
- knowledge coming from experts, people, various stakeholders, activists, associations etc. as witnesses or participants recording their contribution in various formats such as forms, videos, audio,
- data and text mining from various repositories of big data and data streams (e.g., analyzing Twitter messages for obtaining recent event information);
- IoT data from cellular phones, Wi-Fi connections, and in situ sensors for climate and air pollution monitoring, and for traffic monitoring on board public transport and cars;
- dedicated components of knowledge collected for smart cities;
- social media data, in many (often unorganized) forms; etc.

It goes without saying that merging all those aspects is really a big challenge to any spatial data scientist and calls for professional expertise. Finally, we note that information ought to be functional in a broader sustainability context.

11.2.4 Links with the UN Sustainable Development Goals

The Sustainable Development Goals (SDGs) are a collection of 17 interlinked global goals decided in 2015 by the United Nations General Assembly; they can constitute a set of priorities for all administrative bodies. By examining them, it is clear that regional policymaking is concerned essentially by Goal 11 (Sustainable cities and communities), but all other goals may be partially or totally relevant at the regional level as well. In Table 11.1, possible levers are briefly mentioned.

Table 11.1 Sustainable development goals and possible regional levers

Sustainable development goals	Possible regional levers
Goal 1: No poverty	Yes
Goal 2: Zero hunger	Yes
Goal 3: Good health and well-being	Yes
Goal 5: Gender equality	Practically, not at political level
Goal 6: Clean water and sanitation	Yes
Goal 7: Affordable and clean energy	Yes
Goal 8: Decent work and economic growth	Yes
Goal 9: Industry, innovation, and infrastructure	Yes
Goal 10: Reduced inequality	Partially
Goal 11: Sustainable cities and communities	Yes, at governance level
Goal 12: Responsible consumption and production	Partially
Goal 13: Climate action	Small possible actions
Goal 14: Life below water	Perhaps for regions bordering seas or oceans
Goal 15: Life on land	Yes
Goal 16: Peace, justice, and strong institutions	Beyond regional jurisdiction
Goal 17: Partnership for the goals	Yes

11.2.5 Cross-Fertilization Between Research and Practice

It is obvious that there is a cross-fertilization or a virtuous loop between research and practice, as depicted in Fig. 11.1a. But in reality, research regarding regional policymaking and planning is not isolated, and research and practice carried out elsewhere may inspire our concerns, and conversely, our concerns may influence other domains (Fig. 11.1b).

In other words, it is important not only to develop new theoretical concepts but also to ground them on applications coming not only from SDGs but also from identified problems and ongoing projects at regional levels.

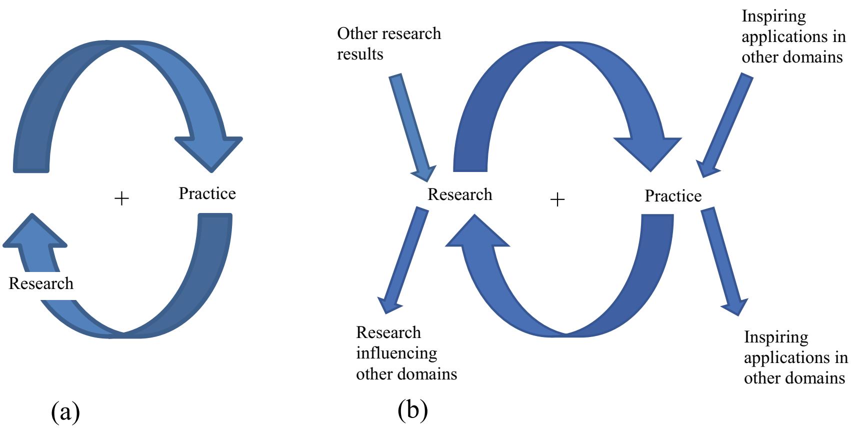

Fig. 11.1 Research and practice; **a** original virtuous loop; **b** virtuous loop embedded in other concerns

11.2.6 Framing of the Work

To keep our field of investigation focused, this paper will not to deal with many aspects of Artificial Intelligence (machine learning, etc.) for which another specific research agendum could or should be built.

In the remaining part of the document, each identified research item will concisely be presented, with its scientific or planning background and with promising research lines (RL) to be developed. At present, it is too early to specify detailed research questions (RQ) because they need to involve also a demarcated location, possible collaboration partners, existing databases, practical contextual matters, and possibly financial resources.

Many research issues can be considered as dealing with any kind of geographic knowledge bases such as modeling, designing, and implementing. However, for regional policymaking and planning, some spatial specificities must urgently be addressed and tackled, and those barriers should be overcome.

The objective of our experiment is to present those findings and research interests regarding several aspects of regional knowledge bundles, which were systematically organized along two specific axes, namely, (*i*) to unveil the characteristics of regional knowledge and (*ii*) to provide evidence-based support to governance and decision-making.

11.3 Unveiling Characteristics of Regional Knowledge

We start our endeavor with a caveat: we have to recognize the place-specific impact of the spatial context, such as: diversity of landscapes, biotopes, culture and tradition, urban organizations, regional stakeholder groups, etc.; so that a knowledge chunk that is right in a given place, can be wrong in another place. And hence, all relevant aspects must be examined carefully in their own context. Section 11.3 is devoted to uncovering the multiple dimensions of knowledge that are a sine qua non for effective and efficient regional planning. Three main classes of knowledge and its use will be distinguished: *The prolegomena of knowledge* (Sects. 3.1–3.7); B. *The space and time dimensions of knowledge* (Sects. 3.8–3.14); C. *The exploitation of knowledge* (Sects. 3.15–3.23).

A. *The prolegomena of knowledge*

11.3.1 Spatio-Temporal Knowledge

Background

At regional level, taking into account the diversity of geographic, environmental, demographic, and economic factors within a dynamic evolution, space and time must be considered simultaneously. This can be illustrated by referring to transportation projects, earthquakes, floods, coastal erosion, etc.

However, the classical knowledge models based on logic do not integrate either space or time. In other words, it is important to enrich the basic model <`subject`, `predicate`, `value`> by integrating predicates involving time and location. One way can be to start from know-how in the database community in which semantics of space and time were successfully integrated into software products for decades. Some aspects could perhaps be imported (Laurini 2019). The aspect of place names regrouped in gazetteers must be considered with caution.

So, the definition and implementation of a semantic spatio-temporal BigData (SSTBD) to manage information about regional knowledge is a mandatory task. The integration of heterogeneous data sources will be carried out proposing novel methodologies based on ontologies (Purificato and Rinaldi 2018; Rinaldi and Russo 2018).

This repository will be the base for the implementation of analytic tools used in different application domains considering typological and topological aspects of cultural elements (Cataldo et al. 2015). Due to the complexity of our scenario both from a theoretical point of view and a technological one, the project goals will be achieved by means of a multi-disciplinarily approach given by several research structures in the field of ICT, Humanities and Social Science.

It is a crucial aspect due to the importance of material and immaterial culture management in the social and economic European spaces.

Formal ontologies are traditionally being used in order to eliminate definition ambiguity in concept definition, removing problematic polysemy in human–machine interaction and enabling data and knowledge interoperability. Knowledge of cultural landscapes will always have an irreducible part of uncertainty: it is always possible that given elements belong at the same time to different landscape categories or that actor's perceptions of landscapes evaluate the same urban elements in conflicting ways.

This integrated network represents a knowledge structure in which there is a strict one-to-one relationship between the role that a spatial location plays in territorial space functioning (configurational attributes) and the meaning it has in the shared knowledge representation (ontological attributes) (Cataldo et al. 2014).

Identified research lines

Identify regional applications for which the basic models must be enriched by locational and temporal issues. Based on semantics, produce a new robust model.

11.3.2 Fuzzy Knowledge and Rules

Background

Where is the limit between a hill and a valley? In a lot of regional territories, boundaries are not clearly defined. However, for several reasons, vague and imprecise concepts are often used to describe regional information, for example involving linguistic quantifiers like in "*most* citizens of Valle d'Aosta speak French, and *a few* speak Titsch, a German dialect", and linguistic values and relations such as in "Milan is a *big* city but *smaller* and *denser* than Rome". Spatial and topological linguistic relationship values such as near, far, almost overlapped, almost included are commonly used; but others with some richer semantics could be unveiled. Last but not least, some spatial entities may have boundaries that vary in time such as the border of a river in winter and in summer, the areas subject to traffic jams that vary during the day. See Verstraete et al. (2007) and Bordogna (2022). Even when the geometries of administrative entities are crisp it may be useful to evaluate some "fuzzy" operations on them, such as "identify all metro stations of Milan which are *very crowded* in *early* morning and in *late* afternoon".

Identified research lines

Identify regional applications for which fuzzy logic can be useful maybe with new operators and characteristics. Should fuzzy logic be integrated into existing GIS, or should new tools be designed to enable this reasoning?

Approaches defined in the literature to represent fuzzy regions and fuzzy metric and topologic operations can be exploited to support more effective decisions. A representation based on fuzzy regions can be useful in environmental applications for estimating more accurately environmental status indicators, such as ecosystem loss due to wildfires or crop estimates in ecosystems.

Apart from that, application for mapping ecosystems' disturbances and anomaly detections such as burned areas due to wildfire, flooded areas, and landslides from remote sensing data can take advantage by a fuzzy representation of the areas so as to provide decision-makers with priority criteria to select the areas where to plan or apply mitigation and rescue interventions.

11.3.3 Gazetteers and Places with Fuzzy Geometries

Background

Many gazetteers have been built as repositories of place names together with some attributes and geometry. However, in regions, we have to deal with a lot of place names for which the geometry is indeterminate; think about Alps, hinterland of Milan, the Rhone valley, etc.

Identified research lines

Identify the characteristics of toponyms for territories with fuzzy geometry. Create a model in which some overlaps are possible with toponyms with precise (sometimes called crisp) geometry. Organize them possibly into a fuzzy graph.

11.3.4 Regional Ontologies

Background

In various domains, ontologies have been designed to organize concepts usually by means of three relations *is_a*, *has*, and *part_whole* (mereology). In geographic ontologies, topological relations are frequently added (Laurini and Kazar 2016). It could be of interest to design ontologies covering all aspects of regional policymaking and planning. Possibly, organize them possibly into a fuzzy ontology, that is a fuzzy graph. A fuzzy ontology allows to define concepts that are vague and imprecise with fuzzy relationships and thus can support the definition of a gazetteer in which regions are toponyms that may have fuzzy boundaries, and thus fuzzy metric and topologic relationships between each other. It further supports approximate reasoning based on fuzzy Description Logics.

Identified research lines

Create such ontologies for different types of regions, or for specific domains, for example, an ontology to represent all trails in a region that can be climbing trails, hiker trails, biker trails, historic trails, etc. to describe touristic paths in a region.

11.3.5 Rule Superseding

Background

In the Northern hemisphere, usually going North is colder, but exceptions do exist. In addition, from a juridical point of view, what was decided right in a place can be wrong at upper level or vice versa. In other terms, in some places, specific rules can supersede generic rules or vice versa (Duchateau and Favetta 2022*)*. Remember that some rules can apply to territories with fuzzy geometries. To represent and reason in cases of exceptions and superseding default logics can be applied; for a survey see (Antoniou 1999). Remember that some rules can apply to territories with fuzzy geometries. In this situation, default logic has been extended with fuzzy logic (Kumar et al. 2011).

Identified research lines

Identified applications for which superseding is important. What can be the guidelines to manage superseding? What are the connections with rule correctness?

11.3.6 Scalability of Regional Knowledge

Background

Scalability of regional knowledge is here understood here as the ability to characterize the properties of a region by "summarizing" by means of aggregation the properties of its subregions. The aggregation is not merely an average, there may be linguistic and ordinal values for the properties, and one may need to take account of majority voting, consensus and homogeneity of subregions. Suppose one has a knowledge chunk in a small territory. Maybe at its vicinity, those chunks can be a little bit different. The problem is how to regroup those chunks, and further in higher clusters. For example, in a vineyard, wine has nice qualities; in surrounding parcels, obtained wines are different. But in summary, a wine territory (Burgundy, Bordeaux, etc.) has some characteristics. At upper level, by aggregation, French wines can be characterized. Another track is considering IoT sensors for instance for meteorology and pollution, how to upscale knowledge (Caruso et al. 2022)?

Identified research lines

Identify regional applications for which scalability is important. Define methods generating upper-level knowledge. More generally, how to upscale and downscale regional knowledge?

Scalability of knowledge at the regional level can be useful to summarize some property known at municipality level, in order to identify properties at upper levels, inter-municipality, provinces, etc.

To generate scalable summaries of geographic areas, spatio-temporal clustering that work by aggregation from bottom to top can be applied as a viable means to generate summaries at distinct scales. Density-based clustering algorithms such as DBSCAN, OPTICS, and DENCLUE have input parameters that drive the algorithm to grow clusters of desired different scales.

B. *The space and time dimension of knowledge*

11.3.7 Border Effects

Background

At the borders of two different countries, it is well-known that if taxes are too different, smugglers can benefit a lot of this difference. Second example, if a plant, a little bit outside your jurisdiction is closing, it can have a lot of outcomes on employment and economic development. In other terms, your geographic knowledge base must integrate external knowledge (Laurini and Favetta 2017).

Identified research lines

What is the status of external knowledge, what are its characteristics? More, what could be the guidelines for governing the selection of external knowledge to be used?

11.3.8 Natural Continuous Phenomena

Background

Natural phenomena such as floods, pollutant diffusion, pressure, winds, lava flows, etc. are mathematically modeled as continuous fields, and in some cases can be modeled by differential equations. Alternatively, heuristic approaches based on AI exploiting either local rules such as in Ant Colony Optimization or maximization of a fitness function such as in genetic algorithms have been defined to model diffusion of lava flows, wildfires, etc.

Identified research lines

How to practically model those phenomena in a given place? What could be the links with knowledge management? How can it be linked with sensor data in real time?

Ant colony optimization and genetic algorithms need first to identify starting points, and then propagate the signal to neighboring points in an iterative process until no substantial change is obtained by new iterations. Starting points can be identified either by ground truth collected from volunteers and civil protection in the form of VGI, or by analyzing IoT and remote sensing data. For example, the active fires can be easily mapped from remote sensing optical images and from them the wildfire spreading can be modeled considering rules exploiting local data in each point such as temperature, wind direction and intensity, slope, and vegetation cover.

11.3.9 Locally Embodied Information

Background

Information is not only *about* a city but ***within*** a city. It is often produced by the actors themselves within the city, and encoded into the structure of the city (stigmergic information). See Alfeo et al. 2017 and Mehaffy and Elmund (2022).

Identified research lines

Applications of existing literature on stigmergy theory, actor-network theory (ANT), and related findings, to regional knowledge management systems. Development of specific tools, methods, and strategies.

11.3.10 Past Rules and Actual Rules

Background

A lot of regional objects exist from centuries or more (think about roads, bridges, harbors, churches, listed monuments, etc.) that are sometimes the basis for touristic activities. In other words, some actual existing objects do not follow actual rules; in a narrow meaning, they should be removed, but they are signs or stigmata of local history. However, think about derelict industrial lands that were designed with past rules and could become the sites for novel activities.

Identified research lines

Consider carefully objects that were designed according to previous rules. Provide mechanisms not to block the reasoning.

C. *The exploitation of this knowledge*

11.3.11 From Urban Analytics to Regional Analytics

Background

The question with data coming from various sorts of sensors (including citizens) has given rise to several concepts that have been coined as mass of data, data lakes, big data, etc. And recently a new domain of research has emerged in smart cities, called urban analytics (see, for instance, Sebillo 2022).

Identified research lines

Regional analytics can be seen as an extension of urban analytics by a kind of upscaling of data from sensors. Pollution abatement could be an illustrative candidate.

11.3.12 Feedforward Knowledge

Background

One aspect of regional planning and policymaking is to deal with disaster management such as volcanoes, earthquakes, floods, technological hazards, coastal erosion, etc. We may refer here to the model mitigation-preparedness-response-recovery, in which at each level, knowledge must be identified to assist decision-making (Laurini 2022a).

Identified research lines

Based on regional applications, extract the semantics of feedforward knowledge and propose a model for integrating all those issues.

11.3.13 Quality of Knowledge

Background

To infer correctly, a *sine qua non* condition is to deal with correct and robust knowledge. In the database community, research has been done on quality of metadata. This could be a good starting point for designing methodologies for quality assessment of regional knowledge. Quality dimensions of spatial data have been defined by ISO standards. Also, standard metadata have been defined for sharing spatial data to enhance quality of data and to support interoperability. FAIR principles (Findable, Accessible, Interoperable, Reusable) could be a good starting point for designing methodologies for quality assurance of regional knowledge (Bordogna 2022; Duchateau and Favetta 2022). Moreover, data and information (on which reasoning is applied) need to be recent, as complete as possible, and qualitative too. Data integration is probably required to guarantee these features, as data and information come from multiple data sources.

Identified research lines

Based on regional applications, define methodologies to get robust regional knowledge.

11.3.14 Knowledge Visualization and Sharing for Reasoning

Background

Suppose myriads of knowledge chunks have been collected, in which visual reasoning is often an interesting solution, is it possible to propose visual tools? Since graph-based systems are common in knowledge management, it would be useful to develop methods for designing knowledge graphs. Can those graphs be transformed into a cartographic representation? Is it be possible to extend data geovisualization to knowledge geovisualization? In liaison with scalability, will it be possible to zoom in or out regional knowledge?

Identified research lines

Invent methods to visualize geographic knowledge and examine cognitive outcomes. Create methods for visual reasoning on regional data.

C. *The exploitation of knowledge*

11.3.15 Dashboards for Real-Time Monitoring

Background

Real-time data collecting is now a common practice. Suppose you have myriads of sensors, how can they be visualized in a dashboard? The key problem is not to visualize the measured values of each of them, but to invent methods (*i*) to cluster by aggregation and (*ii*) to exhibit drastic changes. The usage of real-time chorems (as simplified maps showing essential characteristics) may be an interesting track (Del Fatto et al. 2007; Bouattou et al. 2016).

On-Line Analytical Processing (OLAP) in a multidimensional data warehouse offers a set of online fast and interactive operations, such as drilling, dicing, slicing, and pivoting, to explore a set of predefined aggregates (for example, sum, average, count, and variance) of some data attributes, or properties (such as population, traffic). In Spatial OLAP, these operations allow to be performed in spatial locations (for example, finding detailed measures of traffic in a city district) or slicing of a data cube with a set of constraints (for example, finding the average traffic distribution in rush hours in the city). See for instance Bimonte 2016).

Identified research lines

This task embodies in particular geovisualization but in real time.

11.3.16 Case-Based Reasoning

Background

Case-based reasoning is a knowledge-based system that offers a solution, and its rational goal is to use similar prior case(s) (problem and solution) to help address, assess, or infer a new problem. Case-based reasoning perceives knowledge as encapsulated experience and its knowledge base comprises of a case library in which the encapsulated memories are stored as actual stories. Additionally, the cases that meet the searched keyword criteria are retrieved and their solutions or any other parts of the stories required by the user are directly used or adapted to before being employed. The user can evaluate whether the retrieved solutions work well or not, and modify them before use. Thus, when a usable solution is achieved, the newly resolved problem can be retained in the case library as a new case and the knowledge of the case system improves. In business intelligence, case-based reasoning can be considered as a fruitful domain in which several existing cases are described with two parts, the description of the case and the chosen decision; and the typical query is, by giving a new description, to retrieve the more adapted solution often based on a *k*-nearest neighbor algorithm. The key problem is the manner to describe characteristic regional situations; could it be landscape, climatic conditions, population distribution, transportation facilities, sustainable energy, sustainable mobility, etc. (Anthony 2021, 2022)? Moreover, it is a challenge to transpose solutions that have been working in a region to another region. However, this challenge requires a minimal cooperation between experts to understand the cases, while also knowledge systems in both regions should be interoperable and comparable.

In addition, suppose we are tackling cases such as skiing resorts, bird sanctuaries, new technology enterprise incubators, solar farms, etc.; it is easy to see that the descriptions of those cases are very different: between a few indicators and an excerpt of the whole regional knowledge base, is there a feasible data possibility?

Identified research lines

Propose models for describing geographic characteristics of cases. Select criteria to evaluate performances. Also, such operations are needed for improving decision-making on regional development, and in developing key performance indicators related to geographic systems.

11.3.17 Cross-Border Regional Knowledge Continuity

Background

In an autonomous geographic knowledge base, measurement errors at the borders have weak influences. However, considering a project astride several neighboring regions, measurement errors can have strong influences. For instance, consider a project along the whole Danube River crossing several regions or countries, each having a knowledge base in its own language, its own ontology, etc.: working with several geographic knowledge bases is not so simple. Concerning geographic databases, the problem of cross-border continuity was treated in Laurini (1998), and the solutions may be adapted to knowledge bases to reach seamless reasoning. Among them, special attention must be paid to geographic objects artificially cut into pieces stored in various sites (for instance, rivers, roads, railway tracks, etc.), not only to reach "cartographic" continuity but overall topological continuity. Those issues will constitute a prerequisite for cross-border integration (Subsect. 3.18), interoperability (Subsect. 3.19), and unexpected outcomes (Subsect. 4.9).

Identified research lines

Identify methodologies to ensure seamless topological continuity across several geographic knowledge bases. Is it a way to ensure continuity without changing knowledge base contents and avoiding umbrella structures?

11.3.18 Cross-Border Regional Knowledge Integration

Background

When two regional knowledge bases must be integrated or fusioned, all components must be examined carefully. For instance, if each of them external knowledge is included, it must be checked to avoid duplication. See also (Laurini 2022b).

Identified research lines

Integration of two knowledge bases implies not only integration of objects but also relationships, ontologies, gazetteers, etc. As previously said, also seamless reasoning must be ensured by removing errors and by adding nodes into networks for topological continuity.

11.3.19 Cross-Border Regional Interoperability or Seamless Interoperability

Background

Interoperability refers to the capability of two or more systems or components to connect and exchange knowledge thereby overcoming differences in an execution platform, interface, or language. Integration concerns the fusion of two knowledge bases, often for two neighboring regions.

Within a few years, when several knowledge bases will be operating, the problem of interoperability arises with different meanings; remember that two knowledge bases can be built with different structures, covering the same territory but for different concerns. Difficulties to interoperate with urban knowledge and external knowledge must be identified and solved (Vertical interoperability). Due to geometric data acquisition errors, the cross-boundary problem must be addressed and solved (Horizontal interoperability).

Interoperability is considered as a top issue for regional planning and for stakeholders interested in implementing geographic solutions, so as not to limit their collaborative capabilities with partners, which implement other vendor-locked platforms.

Interoperability in regional planning today reflects the secure and seamless exchange of data digitally between authorized partners. Digital platforms exchange information based on pre-established, negotiated, and shared meanings of information terms and expressions. Knowledge interoperability for regional planning can be achieved by adding information (metadata) about the data, connecting each data component to a managed, shared vocabulary. Some of those mentioned problems arise also during the integration of knowledge bases concerning, for instance, two neighboring territories.

Identified research lines

Propose a methodology and efficient methods to make reasoning based on several knowledge platforms, either automatically by means of a specifically-dedicated inference engine, or manually and visually astride all regional knowledge bases. Also, in achieving semantic and syntactic homogeneity in achieving agreements regarding the interpretation, meaning, or intended use of the knowledge, can the methodologies designed for the interoperability of geographic databases be imported for knowledge bases? If so, how, under what conditions, and with what particularities? If each knowledge base is represented by an ontology, can methods for ontology alignment be applied?

11.3.20 Dedicated Inference and Reasoning Engines

Background

For years, there have been inference engines based on first-order logic. However, there are no inference engines able to deal with the characteristics of regional knowledge and rules. There are software tools that implement fuzzy reasoning on geographic data such as GeoFis, an open software and freely downloadable tool to define fuzzy rules and to apply them on spatial units (either pixels or areas), for example, to determine their classification (Guillaume et al. 2013).

If fuzzy inference is needed, there are several methods to elicit fuzzy rules from experts. The most common ones that can be used in combination are polling (asking questions to experts of the kind “do you agree that spatial entity *x* has a value *y*”, for example, “do you agree that Milan has a population > 1,000,000?); direct and reverse rating (asking "How much Milan is too big?); interval estimation (ask to specify an interval of possible values); or direct membership function exemplification (which can use computer graphics to give illustrative membership functions to be modified by the experts). To achieve agreed outcomes, an assessment through averaging or aggregation of the responses from several experts' assessments can be applied. Finally, semi-automatic approaches can exploit clustering of a set of data to identify groups whose property values are characterized by both an ideal value and a variability, which are submitted to the experts' revision and validation. Regarding possible evolution paths of regions, what could the role of so-called "what-if" models in representing regional metabolism, or how could one define and select alternatives of interest?

Considering interoperability, one needs to identify the requirements necessary to allow seamless reasoning.

Identified research lines

Once those characteristics are identified, design an inference engine able to manage knowledge and rules modeled not only with first-order logic but also geometries (crisp and fuzzy). Encode it and validate it on practical applications. Also, it is necessary to recognize the main characteristics of a reasoning engine dealing with the detection of problems and the design of novel projects.

11.3.21 Transparency and Explicability

Background

Any reasoning, whether automatic or visual, should be transparent and explicable. It may be seen as an output of some black box, which is the case sometimes for solutions coming from deep learning. Any professional must understand how a given recommendation has been reached.

Identified research lines

Provide tools so that the results of any reasoning should be transparent and explicable, not only to local decision-makers but also to lay citizens. This is a major concern and a challenge of current research in AI and specifically deep learning.

11.3.22 Extracting Knowledge and Rules from Written Documents

Background

Many works have been proposed to extract information from textual documents, sometimes called text analytics (Grimes 2008), but they have clear limits for the geographic domain: difficulty in extracting and identifying spatial entities, problems in extracting complex relationships (either space/time, or involving multiple entities), and challenges in representing spatial entities (visualization). So, it is of interest to design systems that are able to analyze those documents and retrieve useful knowledge. Text mining can then be a starting point.

Identified research lines

Design systems are able to extract knowledge and rules in a format in accordance with regional knowledge representations, as previously presented.

11.3.23 Configurational Ontology; Space Syntax

Background

Understanding the space is a priority and a prerequisite for the determination of actions for its management; we need to identify the homogeneous territorial contexts that contain highly related and characterizing factors. Therefore, the process of knowledge acquisition about a territory starts from the recognition of its elements and from their interpretation depending on their context (Cataldo and Rinaldi 2010). A configurational approach provides a concise and effective overview on how an anthropized space operates, but it is unable to render a formal representation of the meaning of spatial elements. Traditional approaches to configurational analysis are based on the idea that it is how things are put together that matters (Hillier 1996). From this point of view, the semantics of the built environment is completely neglected. In recent years, several approaches have been proposed to represent knowledge. Some of them, based on ontologies, aim at deleting, or at least smoothing conceptual or terminological mess, and actually provide a common view of the same information (Rinaldi et al. 2008; Rinaldi 2014). The ontological aspects of information are intrinsically independent of information representation, so that information itself may be isolated, recovered, organized, and integrated with respect to its contents (Rinaldi 2008; Cataldo and Rinaldi 2010; Rinaldi et al. 2020).

Identified research lines

Geographic congruence should effectively be used to integrate spatial analysis and knowledge representation. This latter, could in terms of ontology, be referred to spatial items, by means of associating each of them with an ontological instance.

It serves to give its shared meaning to urban elements, formally described by the regional ontology ad hoc developed. In other words, it serves to give a physical embodiment to the space ontology. This could be realized by generating a geographic database collecting urban elements as geometric features and ontological instances and relationships as their own local properties (Rinaldi and Russo 2018). The ontology, perhaps, could include cultural landscapes as well as single cultural elements, in order to create a more comprehensive image of the territory as a complex entity.

11.3.24 Regional Knowledge and Links with SDI

Background

Following international recommendations and guidelines, many local authorities have already implemented a Spatial Data Infrastructure (SDI) as an integrated framework of such data, metadata, human resources, and tools that are interactively connected in order to use spatial data in an efficient and flexible way (Masser 2010). In addition to SDI, regional knowledge should integrate national and local knowledge. This multi-level knowledge produces many issues between rules (e.g. inconsistencies, exceptions, etc.) and these relationships between rules must be identified to be processed and solved (for example, discarding redundant/equivalent rules, triggering the exception rather than its original rule, etc.). As mentioned earlier, some of those problems are linked to cross-boundary continuity, integration, and interoperability of geographic knowledge bases.

Identified research lines

Explore the possibilities to connect a regional knowledge system to SDI.

11.3.25 Regional Knowledge Indexing

Background

Practically, it is an important question how to organize knowledge chunks. In databases, one calls indexing the ways and mechanisms to rapidly accessed records. When one deals with a few records, the solutions are simple to implement (a flat file can be enough); but as soon as millions of objects must be stored and accessed, an adequate organization is necessary. For geographic databases, *R*-tree-style methods (Manolopoulos et al. 2006) seem rather efficient by regrouping geographic objects by means of a graph of rectangles covering their geometries. In the case of regional knowledge bases, we have to organize not only geographic objects but also their relations, their relationships, their gazetteers, etc., so that queries and inferences can be efficiently solved. It is worth remembering that indexing should also consider fuzziness (of the spatial objects) so that indexing techniques need to be extended.

Identified research lines

Design mechanisms so that knowledge chunks can be easily retrieved and updated, whatever the applications are in order to test integrity and completeness, to assess quality, to eliminate redundancies, or to infer novel knowledge, etc.

11.3.26 Knowledge Curation and Removal of "Fake Knowledge"

Background

In any knowledge management system, the security of valid knowledge is paramount, and there are many well-developed technologies and technology providers that fortify these systems from external attacks. Less common, and increasingly problematic, are internal corruptions of knowledge through the actions of biased or self-interested agents. A critical requirement is, for the governance of the knowledge acquisition and management processes, to remove corrupted or "fake" knowledge that has not been properly vetted or peer-reviewed. For a survey on false information detection in social media, we refer to Guo et al. (2020), in cartography, to Monmonnier (1991), and fake knowledge in sciences, to Hopf et al. (2019).

Identified research lines

Must be studied design knowledge governance systems (Laurini, 2020), curation processes, checks and peer reviews, and validation approaches—e.g., blockchain (See Balan et al. and related approaches)—, and also assessment of existing systems and their governance methodologies.

11.3.27 Epilogue

Regional development policy is not based on blueprint planning principles; it is a learning and adaptive activity that explores future pathways for regions, using past data and ex post information as a strategic anchor point for complex choices on a multifaceted landscape of regions and territories. Regional policy is based on policy considerations, in which evidence-based information plays a key role. In other words, effective regional policy should be adaptive, professional, and evidence-based (informed) in nature.

11.4 Governance and Decision-Making Based on Knowledge Management

Once the previous research problems have been solved, or even by anticipation, it is of interest to study the acceptability of such systems by local authorities and decision-makers. Of course, nobody envisions automatic decisions made by such systems but they can support any decision or action. Two antagonist visions exist: the first one is political, linked to power according to the mantra "knowledge is power" (witness the words of the Greek philosopher Euripides); the second one is scientific, stating that by using knowledge one may reach a sort of wisdom or balanced perspective.

It is noteworthy that territorial intelligence is the way through which people's intelligence can be amplified by artificial intelligence, in our case at the regional level. This research objective can systematically be broken down into several (11) derived research lines, categorized into: A. *Formal and procedural aspects* (Sects. 4.1–4.2); B. *Use aspects* (Sects. 4.3–4.5); C. *Knowledge acquisition aspects* (Sects. 4.6–4.7); D. *Knowledge outcome aspects* (Sects. 4.8–4.12).

A. *Formal and procedural aspects*

11.4.1 Data Governance—Privacy, Confidentiality, Ownership

Background

There exist statutory instruments and regulations governing data and information relative to people regarding privacy, confidentiality, human rights, ownership, etc. For instance, the General Data Protection Regulation (EU) 2016/679 (GDPR)[1] is a regulation in EU law on data protection and privacy in the European Union (EU) and the European Economic Area (EEA). Those texts should be extended to include knowledge management.

Identified research lines

Propose a generic framework for regulating the use and maintenance of knowledge systems at regional level. Propose practical recommendations to extend this framework.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679.

11.4.2 Jurisdiction and Rule Inception

Background

Regional knowledge is coming from different sources such as physical laws (e.g. floods), legislative texts, experts' reports, good practices, information issued from data mining, etc. Practically, in all places, there are authoritative bodies who can incept rules and laws, which will become knowledge. Even if there are constitutions in every country or international treaties, local authorities can create laws; this competence should be carefully reviewed.

Identified research lines

The mechanism of creating rules must be examined. An already-existing knowledge base can be a good support to simulate not only effects of creating rules but also side effects in and out the region under jurisdiction.

B. *Use aspects*

11.4.3 Combining AI-Based Collective and Knowledge Intelligence

Background

One of the major challenges of artificial intelligence is to demonstrate its ability to increase the collective intelligence (Mulgan 2018). To be effective, any decision-support system based on knowledge management must allow to easily combine collective human intelligence and artificial intelligence. The question of efficient mechanisms is important.

Identified research lines

Based on several cases, it is necessary to identify the functioning of those mechanisms, their acceptability, and to demonstrate their efficiency.

11.4.4 Formation of a Team of Professionals

Background

Political actors and local authority professionals tend to hate a "black box". They need to master the decision support tools and their outputs. Working with this kind of tool, even if the human interfaces are well designed, is not so easy, not only for decision makers but also for professionals working for them. Hence, a mechanism must be created so that they can use these tools in an efficient way and also see their limitations, understand the results and discover their weaknesses.

Identified research lines

Design of a data constellation dedicated to professionals.

11.4.5 Citizen Empowerment

Background

All local residents have an opinion about their way of living, the advantages, the drawbacks, its possible evolution, etc. We note that some of them can be lay experts. Beyond nimbies, there are citizens who have a sense of general interest, even if they are members of elected bodies (remember that sometimes some members hide their own interest behind general considerations). Moreover, any citizen can be a sort of sensor to identify problems or anomalies around him/her, to present innovative experiences made elsewhere, to suggest original projects, etc. See, for instance, Eisfeld (2019).

Identified research lines

It is important to define a methodology to identify those citizens, to collect their knowledge, to inform them and to assist them in designing projects.

C. *Knowledge acquisition aspects*

11.4.6 Decision Rules

Background

During the process of designing projects, a clear decision must be made to reject or select an alternative. Decisional rules can be applied at several levels, knowing that the ultimate level will be some kinds of vote. Different methodologies can be invoked; some of them by constructing lists of criteria knowing that different actors must have different criteria (see Huang et al. 2021). In different steps of a project, evaluation criteria can be different.

Identified research lines

It is important to develop evidence-based research concerning multi-actor multi-criteria decision-making.

11.4.7 Lessons Learnt from Accepted and Abandoned Projects

Background

Past experiences, both successful and unsuccessful, are an excellent source of knowledge. Indeed, each local authority has implemented various projects, some of them doing well, others with mixed results, or even projects abandoned for several reasons. For all of them, lessons can be learnt, and these constitute other kinds of knowledge to be included into a knowledge base.

Identified research lines

For any project, define a methodology either ex ante or ex post to analyze the results, their context, the reasons of success or failure, etc. Define the semantics of such knowledge chunks and propose a model not only to encode them, but overall to use them for future projects. Here also some sort of systems built on Case-Based Reasoning methodology can be proposed, in which this is not the project under construction which will be the core issue, but the conditions of success of failure.

11.4.8 Digital Twins for Regions

Background

In many domains, digital twins are considered as regrouping all information and knowledge regarding an entity (Batty 2018). Already, in the domain of smart cities, in recent years, several studies have been made (see, for instance, Ruohomäki et al. 2018; Deren et al. 2021). But digital twins are less developed for regions.

Identified research lines

Analyze the peculiarities, characteristics, and objectives of regions that are necessary to be integrated into a digital twin. What could be its structure? What could, for instance, be the outcomes to daily work and make decisions with this kind of tools?

D. *Knowledge outcome aspects*

11.4.9 Border Effects, Unexpected Outcomes

Background

A region is not an isolated system, but in permanent interaction with other spaces, by proximity or within a network. Each decision made by local authorities has a desired effect, and some unexpected side effects into the jurisdiction and sometimes outside. For instance, consider the inception of taxes inside a region: economic consequences may arise in borderlands by perhaps encouraging or stimulating smuggling. Significantly higher taxes in a border region can also lead to "voting by feet" and tax evasion. An efficient system must integrate enough external information, so that those outcomes can be forecasted and analyzed.

Identified research lines

By analyzing several projects having consequences outside the jurisdiction, knowledge about side effects must be identified and organized.

11.4.10 Use of Knowledge to Boost Economy/Innovation

Background

The primary role of a regional knowledge base is to assist decision-makers in policy-making, not only for the management of the local authority but also to boost economic development. By knowing the economic fabric, its characteristics, its strengths and weaknesses, useful plans could be designed either to enhance actual businesses or to create ex nihilo new economic activities. Several regions and local authorities have taken the initiative to open up their administrative data in order to encourage the creation of knowledge-based economic activities. However, these regions/local authorities have rather a laissez-faire attitude and do not intervene in the development of these activities.

Identified research lines

What could be the appropriate package of measures to develop new activities? How can successful experiences in other regions be a source of inspiration?

11.4.11 Cost of Enforcing Rules

Background

Among consequences of a rule, there are expenditures of enforcing it, such as wages for officers in charge of applying rules, or revenues such as fines for non-compliance. In addition, sometimes, citizens organize demonstrations because they do not agree, which go so far as to require the intervention of police forces or even cause major damage. Generally, those extra costs are not assigned to the rule itself but appear as police costs.

Identified research lines

By knowing precisely the context for each rule that a local authority wants to enforce, analyze the outcomes in terms of expenditures and revenues, and identify lessons that could be useful as good practices.

11.4.12 Technological and Sociological Watching

Background

Technological watching includes information about the technologies that are being researched and about technological solutions available in other regions. Clearly, sociological watching integrates novel aspects of public participation (social innovations) and their acceptancy of new systems.

Identified research lines

Two different lines must be developed. First, how to design, implement, and update a knowledge base for the multi-dimensional types of watching, perhaps by including successful experiences made in other regions. Second, by examining new systems adopted elsewhere, establish criteria not only for success or failure but also by unveiling the hidden conditions for importing them.

11.4.13 Epilogue

Regional development policy is not governed by an “automatic pilot”, but by an instantaneous response to challenges in the real-world space economy. Consequently, a systematic overview and synthesis of empirical evidence is a sine qua non, so as to contribute to practical and accepted solutions or strategies. Regional policy presupposes an intelligent use of empirical evidence and scientific knowledge. From that perspective, public trust in science is critical, especially in our era of data science with an incredible volume and inconsistent mix of heterogeneous data (ranging from standard statistics to online fluctuating social media information or big data).

11.5 Retrospect and Prospect

The development and management of an appropriate regional information system are fraught with many conceptual and practical problems. First of all, it is critical to have an unambiguous spatial demarcation, even though in practice individual data systems may pertain to different regional delineations. Another problem is the fact that in a modern digital economy the supply of data is almost limitless; it is, however, pertinent to focus on those data that are essential for regional or urban planning. Next to the identification and definition of such key indicators (or KPIs), it is also important to know when a certain development in indicators exceeds a critical threshold; such early warning systems are only effective, if in advance critical threshold values (including points of no return) are specified. And finally, since the region is the playing ground of many actors and stakeholders, it is important to have a broad coverage of up-to-date information in a regional information base, for instance, on regional labor markets or housing markets, infrastructure supply and use, migration and mobility data, industrial location, business innovation, environmental quality and so on.

In many cases, data and information are not collected from a uniform or integrated design perspective, so that the consistent integration of distinct information and databases is a major challenge for regional planning. In our digital age, the use of spatial informatics may be helpful to design and generate consistent databases, for instance, in a data warehouse setting, provided at least uniform data standards are formulated.

It goes without saying that modern ICT has meant an enormous boost to an increase in coverage, professionality, reliability, and user orientation of regional information and knowledge systems. But its basic functions, already advocated several decades back by Burch et al. (1979) remain largely the same: (i) capturing; (ii) verifying; (iii) classifying; (iv) arranging; (v) summarizing; (vi) calculating; (vii) forecasting; (viii) simulating; (ix) storing; (x) retrieving; and (xi) communicating. Next to these strategic considerations, there are also practical criteria for judging the operational significance of regional information and knowledge systems (see, e.g., Nijkamp and Rietveld 1983): (i) availability; (ii) timeliness; (iii) accessibility; (iv) consistency; (v) completeness; (vi) relevance; (vii) multiformity; (viii) comparability; (ix) flexibility; (x) measurability; (xi) comprehensiveness; (xii) effectiveness; (xiii) versatility; and (xiv) validity. Especially in recent years, with an avalanche of "big data", it is by no means sure that more and complex data enhance the quality of decision-making.

The research (and action) agenda for adequate regional information and knowledge management as presented in this last chapter are clearly vast and ambitious. It shows that regional development policy and sustainable spatial planning cannot be entrusted to "data amateurisms", but calls for professional and scientific expertise in which data analysts, computer scientists, geographers, planners, geo-scientists, architects, economists, environmental scientists, and management scientists are brought together around thematic orientations that shape in mutual combination the future well-being of regions, cities, and their inhabitants. In this regard, the "democratization" of individual and collective data on relevant spatial issues is an important megatrend leading to the question: who owns the data and who has the right to use these data for planning purposes? Professional data management has to find a balance—within legal data regulations—between private rights and collective interests. This as yet unresolved dilemma will be one of the most prominent future concerns in spatial data sciences.

References

Albino V, Berardi U, Dangelico RM (2015) Smart cities: definitions, dimensions, performance, and initiatives. J Urban Technol 22(1):3–21. https://doi.org/10.1080/10630732.2014.942092

Alfeo AL, Cimino MGC, Egidi S, Lepri B, Pentland A, Vaglini G (2017) Stigmergy-based modeling to discover urban activity patterns from positioning data. International conference on social computing, behavioral-cultural modeling and prediction and behavior representation in modeling and simulation. Springer, Cham, pp 292–301

Anthony B Jr (2021) A case-based reasoning recommender system for sustainable smart city development. AI & Soc.https://doi.org/10.1007/s00146-020-00984-2

Anthony B Jr (2022) Employing case-based reasoning to provide knowledge for sustainable regional development, pp 45–60

Antoniou G (1999) A tutorial on default logics. ACM Comput Surv 31(4):337–359

Balan A, Alboaie S, Kourtit K, Nijkamp P (2022) Blockchain systems for smart cities and regions: an illustration of self-sovereign data governance, pp 163–190

Batty M (2018) Digital twins. Environ Plann B: Urban Anal City Sci:817–820

Bettencourt L (2021) Introduction to urban science. MIT Press, Cambridge, Mass

Bibri SE, Krogstie J (2017) Smart sustainable cities of the future: an extensive interdisciplinary literature review. Sustain Cities Soc 31:183–212

Bimonte S (2016) Current approaches, challenges, and perspectives on spatial OLAP for agri-environmental analysis. Int J Agric Environ Inf Syst 7(4):32–49

Bordogna G (2022) Regional knowledge: sources, representation and management, pp 23–44

Bouattou Z, Laurini R, Belbachir H (2016) Automatic generation of an interactive, real time, web-based maps from sensor-based geographic databases. In: Proceedings of the 22nd international conference on distributed multimedia systems (DMS 2016), Salerno, Italy, November 25–26, 2016. Knowledge Systems Institute, pp 98–104. ISBN: 1-891706-40-3

Burch JG, Strater FR, Grudnitski G (1979) Information systems: theory and practice. John Wiley, New York

Caragliu A, Del Bo CFM, Nijkamp P (2011) Smart cities in Europe. J Urban Technol 18:65–82

Caruso G, Pumain P, Thomas I (2022) No "Prêt à Porter" but a multiscalar perspective to smart cities, pp 123–148

Cataldo A, Rinaldi AM (2010) An ontological approach to represent knowledge in territorial planning science. Comput Environ Urban Syst 34(2):117–132

Cataldo A, Di Pinto V, Rinaldi AM (2014) A methodological approach to integrate ontology and configurational analysis. International conference on computational science and its applications. Springer, Cham, pp 693–708

Cataldo A, Pinto VD, Rinaldi AM (2015) Representing and sharing spatial knowledge using configurational ontology. Int J Bus Intell Data Mining 10(2):123–151

Chang D, Sabatini-Marques J, Moreira da Costa E, Selig PM, Yigitcanlar Y (2018) Knowledge-based, smart and sustainable cities: a provocation for a conceptual framework. J Open Inno Technol Market Complexity 4(1). https://doi.org/10.1186/s40852-018-0087-2

Del Fatto V, Laurini R, Lopez K, Loreto R, Milleret-Raffort F, Sebillo M, Sol-Martinez D, Vitiello G (2007) Potentialities of chorems as visual summaries of spatial databases contents. In: Qiu G, Leung C, Xue X-Y, Laurini R (eds) VISUAL 2007, 9th international conference on visual information systems, Shanghai, China, 28–29 June 2007. Advances in visual information systems, vol 4781. Springer Verlag LNCS, pp 537–548

Deren L, Wenbo Y, Zhenfeng S (2021) Smart city based on digital twins. Comput Urban Sci 1(4). https://doi.org/10.1007/s43762-021-00005

Duchateau F, Favetta F (2022) Knowledge management at multiple decision levels, a use case about COVID-19 pandemic, pp 61–88

Eisfeld R (2019) Empowering citizens, engaging the public: political science for the 21st century. Springer-Verlag Nature

Fritsch M, Wyrwich M (2018) Regional knowledge, entrepreneurial culture, and innovative start-ups over time and space: an empirical investigation. Small Bus Econ 51:337–353. https://doi.org/10.1007/s11187-018-0016-6

Garcia-Madurga MA, Grillo-Manuz AJ, Esteban-Navarro MA (2020) Territorial intelligence, a collective challenge for sustainable development: a scoping review. Soc Sci 9(7). https://doi.org/10.3390/socsi9070126

Girard J, Girard JA (2015) Defining knowledge management: toward an applied compendium. J Appl Knowl Manage 3(1). International Institute for Applied Knowledge Management

Grimes S (2008) Text analytics for dummies. Alta Plana Corporation. Can be downloaded from https://www.researchgate.net/publication/228826654_Text_Analytics_for_Dummies

Greco I, Cresta A (2017) From SMART cities to SMART city-regions: reflections and proposals. In: International conference on computational science and its applications. Lecture notes in computer science. Springer International Publishing, pp 282–295. https://doi.org/10.1007/978-3-319-62398-6_20

Giaoutzi M, Nijkamp P (eds) (1988) Informatics and regional development. Ashgate, Aldershot

Giffinger R, Haindlmaier G (2018) Benchmarking the smart city. IJRS 1(2018):115–122

Guillaume S, Charnomordic B, Tisseyre B, Taylor J (2013) Soft computing-based decision support tools for spatial data. Int J Comput Intell Syst 6:18–33

Guo B, Ding Y, Yao L, Liang Y, Yu Z (2020) The future of false information detection on social media: new perspectives and trends. ACM Comp Surv 53(4). https://doi.org/10.1145/3393880

Hillier B (1996) Space is the machine. Cambridge University Press, UK

Hopf H, Krief A, Mehta G, Matlin S-A (2019) Fake science and the knowledge crisis: ignorance can be fatal. R Soc Publish 6(5). https://doi.org/10.1098/rsos.190161

Huang H, Mommens K, Lebeau P, Macharis C (2021) The multi-actor multi-criteria analysis (MAMCA) for mass-participation decision making. In: Jayawickrama U, Delias P, Escobar MT, Papathanasiou J (eds) Decision support systems XI: decision support systems, analytics and technologies in response to global crisis management, ICDSST 2021. Lecture notes in business information processing, vol 414. Springer, Cham. https://doi.org/10.1007/978-3-030-73976-8_1

Kirwan C-G, Zhiyong F (2020) Smart cities and artificial intelligence: convergent systems for planning, design, and operations,1st edn. Elsevier, May 5, 2020. ISBN: 9780128170243

Komninos N, Kakderi C (eds) (2019) Smart cities in the post-algorithmic era. Edward Elgar, Cheltenham

Kourtit K (2021) City intelligence for enhancing urban performance value: a conceptual study on data decomposition in smart cities. Asia-Pacific J Reg Sci 5:191–222. https://doi.org/10.1007/s41685-021-00193-9

Laurini R (1998) Spatial multi-database topological continuity and indexing: a step towards seamless GIS data interoperability. Int J Geogr Inform Sci 12(4)

Laurini R (2017) Geographic knowledge infrastructure for territorial intelligence and smart cities, ISTE-Wiley, 250 p

Laurini R (2019) A mathematical language for the modeling of geospatial static rules. J Vis Lang Comput 1:1–13

Laurini R (2020) A primer of knowledge management for smart city governance. Land Use Policy, 104832. ISSN 0264-8377.https://doi.org/10.1016/j.landusepol.2020.104832.Seepdf

Laurini R (2022a) Semantic analysis of feedforward knowledge for regional policymaking, pp 89–110

Laurini R (2022b) Interoperabilità semantica e geometrica nelle base di conoscenze geografiche per la pianificazione urbana e regionale. Convegno ASITA, Genova, Italy, 20–24 June, pp 319–330

Laurini R, Favetta F (2017) About external geographic information and knowledge in smart cities. In: 2nd International conference on smart data and smart cities, 4–6 Oct. The international archives of the photogrammetry, remote sensing and spatial information sciences, vol XLII-4/W3, 20

Laurini R, Kazar O (2016) Geographic ontologies: survey and challenges. J Theor Cartogr 9:1–13. ISSN 1868-1387

Manolopoulos Y, Nanopoulos A, Theodoridis Y (2006) R-trees: theory and applications. Springer, ISBN 978-1-85233-977-7

Masser I (2010) Building European spatial data infrastructures. ESRI Press, Redlands, USA

Mehaffy M, Elmlund P (2022) Smart cities: missing the stigmergy? pp 149–162

Monmonnier M (1991) How to lie with map? The University Press of Chicago

Mulgan G (2018) Artificial intelligence and collective intelligence: the emergence of a New Field. AI & Soc 33(4):631–632. https://doi.org/10.1007/s00146-018-0861-5

Nijkamp P, Rietveld P (eds) (1983) Information systems for integrated regional planning. North-Holland Publishing, Amsterdam

Nijkamp P, Kourtit K (2022) Place-specific Corona dashboards for health policy: design and application of a 'Dutchboard.' Sustainability 14:836. https://doi.org/10.3390/su14020836

Oktari RS, Munadi K, Idroes R, Sofyan H (2020) Knowledge management practices in disaster management: systematic review. Int J Disaster Risk Reduction 51. ISSN 2212-4209.https://doi.org/10.1016/j.ijdrr.2020.101881

Purificato E, Rinaldi AM (2018) Multimedia and geographic data integration for cultural heritage information retrieval. Multimedia Tools Appl 77(20):27447–27469

Qian H (2018) Knowledge-based regional economic development: a synthetic review of knowledge spillovers, entrepreneurship, and entrepreneurial ecosystems. Econ Dev Q 32(2):163–176. https://doi.org/10.1177/0891242418760981

Ray KS, Chakraborty A (2011) A fuzzy version of default logic. Int J Intell Comput Cybern:5–24. ISSN: 1756-378X

Rinaldi AM (2008) A content-based approach for document representation and retrieval. In: Proceedings of the 8th ACM DocEng'08. ACM, New York, NY, USA, pp 106–109

Rinaldi AM (2014) A multimedia ontology model based on linguistic properties and audio-visual features. Inf Sci 277:234–246

Rinaldi AM, Russo C (2018) A matching framework for multimedia data integration using semantics and ontologies. In: 2018 IEEE 12th international conference on semantic computing (ICSC). IEEE, pp 363–368

Rinaldi AM, Russo C, Madani K (2020) A semantic matching strategy for very large knowledge bases integration. Int J Inf Technol Web Eng (IJITWE) 15(2):1–29

Ruohomäki T, Kesäniemi O, Airaksinen E, Martikka M, Huuska P, Suomisto J (2018) Smart city platform enabling digital twin. In: Conference: IEEE intelligent systems 2018, Madeira, Portugal, September 2018. https://doi.org/10.1109/IS.2018.8710517

Sebillo M (2022) ICT key points in emerging spatial knowledge systems, pp 110–122

Shi W, Goodchild MF, Batty M, Kwan MP, Zhang A (eds) (2021) Urban informatics. Springer, Berlin

Silva E (2004) The DNA of our regions: artificial intelligence in regional planning. Futures 36(10):1077–1094

Verstraete J, Hallez A, De Tré G (2007) Fuzzy regions: theory and applications. In: Morris A, Kokhan S (eds) Geographic uncertainty in environmental security, NATO science for peace and security, series C: environmental security. Springer, Dordrecht. https://doi.org/10.1007/978-1-40

Voda A-I, Radu L-D (2018) Artificial intelligence and the future of smart cities. BRAIN, Broad Res Artif Intell Neurosci 9(2):110–127. http://www.edusoft.ro/brain/index.php/brain/article/view/812/918

Weichselgartner J, Pigeon P (2015) The role of knowledge in disaster risk reduction. Int J Disaster Risk Sci 6(2):107–116

White H (2019) The twenty-first century experimenting society. Palgrave Commun 5:47