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Modern scientific approaches to maps quality assessment

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SUMMARY

The peculiarities of modern trend of Industry 4.0 and its influence on maps and spatial services production are discussed. The interdisciplinary approach of maps quality assessment in geomatics and cartography is determined. The maps quality should be analyzed by cartography, cognitive sciences, usability engineering etc. The experience of spatial data and maps quality assessment is given. The conceptual model of the map's quality assessment is offered. An emphasize on values of maps for an individual, science and society is given.

Introduction

The quality of any product or service is a set of properties being suitable for its fitness for purpose while satisfying customer expectations. Nowadays quality is the basis of product competitiveness. The current trend of automation and data exchange in manufacturing technologies, including cyber-physical systems, the Internet of things, cloud computing and cognitive computer science and creating the smart factory or so-called Industry 4.0 affects the modern concept of quality and value of products and services. Industry 4.0 means a few peculiarities: (a) high economic expenditures, implicit economic benefits / excessive investment; (b) general unwillingness of stakeholders to change (low commitment of management Insufficient qualifications of employees); (c) lack of regulation, standards and forms of certification; (d) unclear legal issues, IT security and data confidentiality problems. These issues are significant for of a map quality evaluation approach.

Method and theory

Modern digital marketing is characterized by changing the schemes of value chains functioning. It sets up to provide users with advice and consultation, assistance in choosing products and services, defining user profiles (profiling) and product design to meet the requirements of a particular consumer. It means personalization of goods and services (Figure 1).

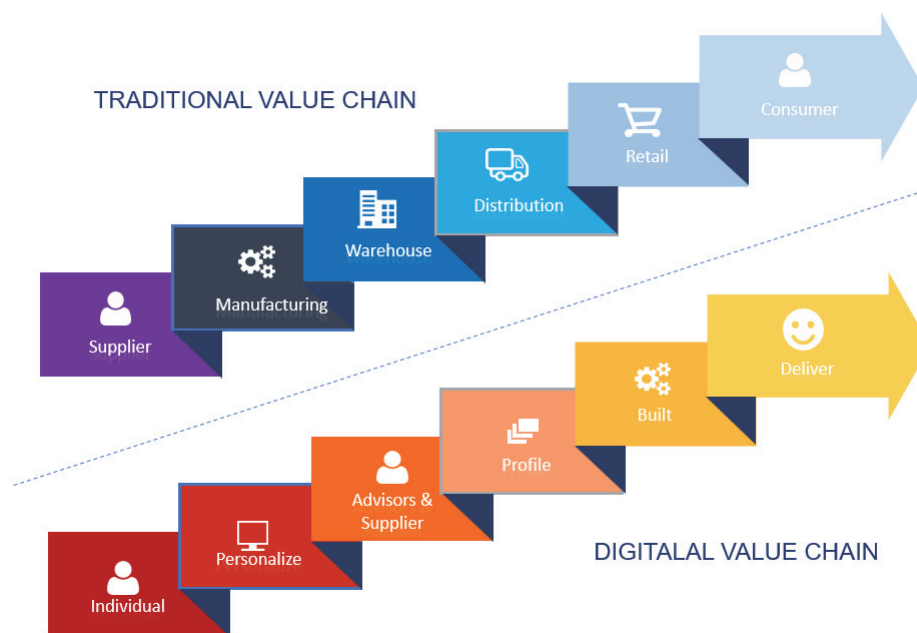


Figure 1 Comparison of value-added schemes in the traditional and digital economy according to <https://info.avasant.com/>

Recent advances in spatial data collection technologies and online services have dramatically increased the contribution of people to the creation, exchange and use of geographic information. It is as opposed to the authoritative method employed by government agencies and private industry. The collection of spatial data and its dissemination on the Internet (Voluntary Geographic Information - VGI) has become a huge source of spatial data. For example, OpenStreetMap is an international effort to produce a free source of map data through the efforts of volunteers. Another issue is a rapid changes of spatial data capture methods. This leads to that the lack of standards in the field.

Therefore, an important task is to identify approaches to assessing the quality of spatial data, GIS and geoservices, which are crucial for the maps use effectiveness in society.

Maps are used for many tasks: to inventory, assess and forecast the state of geosystem's elements. In addition, the maps reflect the achievements of geosciences at a certain stage of knowledge on Earth and Society (geology, geophysics, geo-ecology, landscapes, population, industry) and contribute to the formation of worldviews among young people.

Assessing the quality of maps as well as other geoimages is closely related to the following trends:

1. The availability, exchange and use of spatial data are growing;
2. There are a lot of users who are less aware of the quality of spatial data;
3. GIS allows one to use spatial data in all types of applications, regardless of certain data sets using expediency;
4. Modern GIS offers almost no tools for spatial quality management;
5. The distance between people those who use spatial data (end users) and those who are best informed about the quality of spatial data (professional manufacturers) is growing. The Maps quality assessment is at the intersection of a number of related disciplines (Figure 2).

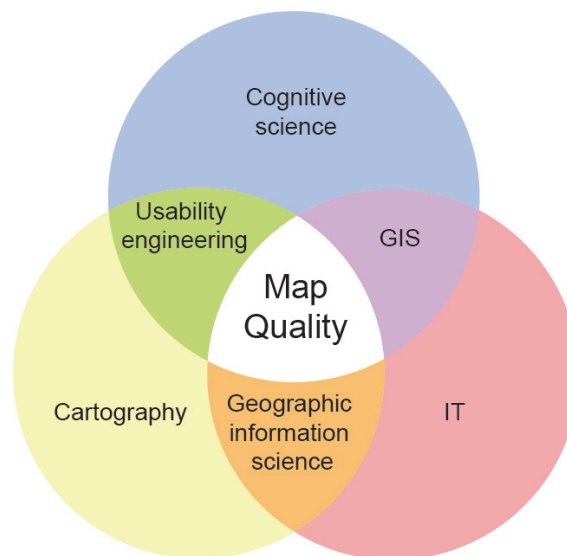


Figure 2 Interdisciplinary approach to maps quality assessment

Cartography has gained huge experience in maps quality assessment. When considering the quality of spatial data, most users consider only the positional accuracy of the data. However, spatial quality has different aspects: positional accuracy, time accuracy, completeness, logical sequence and data resolution. Analysis of maps from the standpoint of the model-cognitive concept is a comprehensive study of geographical map elements and properties to determine its quality and evaluate the degree of the map suitability for use in certain purposes. Soviet cartography determines the quality of a map by the quality of mathematical basis, geometric accuracy, completeness, reliability, modernity, design and scientific value. Nowadays state institutions are losing their monopoly on the production and dissemination of spatial data and the development of standards. As a result, voluntary mapping projects are becoming widespread, which causes flexibility in the classification of cartographic information.

GIS science is becoming leading interdisciplinary research that studies spatial data working with and processing. An important trend is the computer science technologies involved in the process of maps creation. For example, the use of Dempster-Shafer Belief Theory to determine the suitability of the use of spatial data sets. These trends in the personalization of services can be realized through the flexibility of GIS technologies and the emergence of new professions such as GIS consultants, who help users to figure out the requirements for geoservices and applications.

Usability engineering is a field that deals with human-computer interaction and, in particular, the development of user-friendly computer interfaces. It offers techniques to achieve efficiency and elegance in interface design. In our opinion, usability engineering (the basics of aesthetics, ergonomics

and design) is a valuable field for geomatics education. This can cause the development of geodesigners as a new occupation field.

Cognitive science is an interdisciplinary field that studies human intelligence and thinking, the tasks and functions of cognition (in a broad sense). Cognitive scientists are studying user's behaviour by focusing on how people present, process, and transform information. Evaluation of maps can also be based on the map's language concept, perception and memorization of its content, concentration, and emotions that arise when interacting with a map. To understand these features of the map's perception one should borrow theories and methods of linguistics, psychology, artificial intelligence, philosophy, neurology and anthropology. Cognitive scientists can evaluate map peculiarities that are useful for learning, decision-making efficiency and territory planning.

Nowadays it is obvious to distinguish differences among making the quality assessment of (a) spatial data quality, (b) geographic information system quality, (c) quality of spatial data services (DeLone and McLean, 2002).

Spatial data quality concerns the accuracy and trustworthiness of data and their fitness for use. Van Oort (Van Oort, 2006) has identified eleven elements of spatial data quality: Lineage, Positional accuracy, Attribute accuracy, Logical consistency, Completeness, Semantic accuracy, Usage/purpose/constraints, Temporal quality, Variation in quality, Meta-quality, and Resolution.

The important issue is the quality information requirements of decision-makers was determined as: immediately accessible; interpreted in the context of the task; available in a format pertinent to the decision-making environment (Paradis and Beard, 1994). They also have offered a filter that roughens the spatial data for special purposes.

Scientists (Van Exel et al., 2010) describe the peculiarities of volunteered geographic information (VGI) quality issues. The VGI collections are characterized by heterogeneous and diverse quality, due to the fact that it is collected using different methods (e.g. GPS tracks, image tracing) and by different individuals with different motivations and preferences. Also, the authors explain the Crowd Quality concept that attempts to quantify the 'collective intelligence of the crowd generating data' in a Spatio-temporal context.

The quality of GIS and geospatial services is determined by further development of standards in geomatics. These are associated with rapidly growing geospatial software development projects associated with open-source data science, researches on languages, modelling, and simulation platforms, virtual reality engines and web applications.

Also, it should be assumed that there are three approaches to maps quality assessing (Figure 3). (1) *The Production approach* involves the evaluation of technical components of maps, GIS and GIS-services. It concerns accuracy standardization and other production issues. (2) *The consumer approach* describes needs, expectations and usability (3) In our opinion, *the value approach* is also mandatory in determining the scientific and cultural significance of maps, although it concerns first of all philosophical and legal issues. It is important to determine what values an author puts on a map and what worldviews and political ideas the map transmits. It should be argued that a credible map has to have a value baseline, that, in the end, reflects cultural values which to a greater or lesser extent are characterizing most people in the society.

Philosophers determine such values that in our opinion should be used for maps evaluation: (1) logic as a sphere of the value of truth (as far as the map and its key are logically arranged people trust it); (2) aesthetics as a sphere of the value of beauty (map can be vaults because of its perfect design); (3) social values as a sphere of map's advantages (benefits of maps for society are education and problem solving); (4) ethical and legal sphere (the map is valuable as far as the message of the map corresponds to the moral principles of society).



Figure 3 Components of maps quality and value

Conclusions

The article asserts that today the quality of maps as tools for decisions making should be assessed from several positions: cartography (as a model), GIS science (as an interface to the database), usability engineering (as a product or service), cognitive and philosophical sciences (as a tool for cognition of reality).

Nowadays the quality of maps that work in a network environment is depended on the following conditions: quality and consistency of data, quality of systems (conceptual schemes, algorithms) and quality of services tailored to user needs (user interface convenience).

As a result, approaches to assessing the quality and value of maps have been identified. The maps should be developed in compliance with technological requirements (standards, technical rules); meet user requirements and are configured to perform certain tasks; to correspond to the worldview and to promote the list of cultural, ethical, legal values inherent in a certain society.

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