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Article

Proposal of Redefinition of the Terms Geomatics and Geoinformatics on the Basis of Terminological Postulates

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Abstract: The article attempts to redefine the names for the research area, which is the use of information systems for the analysis and management of spatial data. To resolve the nomenclature issues, the studies were conducted into the structure evolution of spatial data, and on software for these data processing, GIS acronyms were reviewed; another study was performed by means of terminological analogies, comparing definitions of similar, in terms of word formation, names referred to other areas of research. Moreover, questionnaires of job positions were analysed and, based on a literature review, the nomenclature used to define the field of studies on spatial data was analysed. The conducted studies resulted in the development of seven terminological postulates intended for the formulation of limitations and rules to give new definitions. The new author's definitions of geomatics and geoinformatics terms are presented at the end of the paper.

Keywords: geomatics; geoinformatics; spatial database; GIS; spatial data

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1. Introduction

Geomatics is a relatively new term that has been around in the scientific literature and in higher education for more than thirty years. The origins of geomatics' definition are due to Canadian academics such as Michel Paradis [1] and Pierre Gagnon and David Coleman [2]. Thanks to them, a profound change took place in the Canadian education system in the 1990s to replace the name geodesy with geomatics. There, the names of academic university departments, faculties and other units were changed by withdrawing the word geodesy or surveying. One of the researchers who made these changes at the time was Yvan Bédard [3]. However, globally, no such substitution has taken place. The term geomatics itself was, to some extent, popularised, but its use to replace the term geodesy or surveying did not take place. In Europe, a new ISO/TC 211 committee was formed in 1994 to standardise geographic information, whose name "Geographic information/Geomatics" links geomatics more to geography then to geodesy [4]. In 2003, Barry Kavanagh published a book "Geomatics" [5], in which the main content concerns the field of geodesy. He thus continued the "tradition" of renaming geodesy as geomatics, defining the term in his own way. In a review of this book [6], James P. Reilly stressed that the term geomatics is fine to use in the education system but should not refer to the professional profession. In the 2000s, many researchers attempted to modernise or improve the definition of geomatics. Li Deren [7], in turn, incorporates the term geomatics into the more general term of geospatial technology. In 2008, this topic was again addressed by Yvan Bédard [8]. A year later, Mario Gomarasca, in his book, provides another version of the definition of geomatics [9]. In 2017, Brian Coutts questions the existing definition and application of the name geomatics in the context of geodesy and, in this context, highlights the need to redefine it [10].

A few years after the term geomatics came into existence, a new, similar term appeared in Europe, namely geoinformatics. The term was introduced by Samuelson as early as 1988 in Sweden, despite this author's knowledge of the existence of the term geomatics [11]. In

1992, Michaël-Charles Le Duc formalised and described the term more broadly [12]. In 1993, Manfred Ehlers formulated the principles for defining geoinformatics as the science of integrating four technologies: GIS, remote sensing, photogrammetry and cartography [13]. In 1994, Holmberg presented his own definition of geoinformatics and pointed out its applications in the field of regional planning [14]. Kotlarczyk in 1999 [15], like Ehlers, defines geoinformatics as a multidisciplinary science. In 2003, Michael N. DeMers published a book [16] in which he defines geoinformatics as the science of spatial data processing functions by computer systems. Ehlers in 2008, however, departs from the multidisciplinarity of geoinformatics and in publication [17] gives its definition related to the description of GIS functions, as well. It is significant that in the 2019 publication, the authors emphasise: *The bottom line is that there is no globally accepted definition of geoinformatics* [18], and they are right.

Another third term defining the scientific applications of GIS systems arose in those countries where informatics is called computer science. By analogy with this term, the term GIScience was formed by Michael F. Goodchild in 1992 [19]. Not five years later, in 1997, the authors Dawn Wright, Michael F. Goodchild and James D. Proctor wrote an article describing the ambiguity of the term GIS, which came to be regarded as both a "tool" and a "science" [20]. By the term "tool", the authors meant GIS technology. In 2006, members of the University Consortium for Geographic Information Science (UCGIS) expanded the acronym GIS to GIS Science and Technology [21]. In subsequent scientific publications, Goodchild continues to popularise the terms GISystem and GIScience [22,23].

From the current perspective, it is visible that the definition of the term and the context of its use undergoes certain successive changes. These changes are due to the fact that the concept of geomatics is still developing in the "space of interaction" between traditional disciplines such as informatics (computer science), cartography, geography, geodesy, remote sensing and photogrammetry, and modern technologies such as GNSS (Global Navigation Satellite Systems), and information technologies for spatial data processing such as GIS (Geographic Information Systems), SpatialDB (Spatial Data Infrastructures), SDI (Spatial Data Infrastructures), or BIM (Building Information Modelling). In addition, there are huge advances in data acquisition from satellite sensors (radar, optical and hyperspectral) and 3D photogrammetry, which also includes the development of data acquisition platforms from various types of drones and mobile devices.

However, the development and revaluation of terms used, intended for their description, do not keep up this progress. With the appearance of the next new technologies, immediately, new proposals of new sciences, new subdisciplines, appear. Many authors with great ease announce the origination of a new science, frequently not caring for the proper justification of its name definition. The old definitions, developed in the context of previous technological conditions, remain in the shadow of new technologies, and are not modernised. The lack of specific terminological conditions, determined boundaries, or scopes of such definition use, encourages one to define the next terms, and the next science and research disciplines.

Therefore, in this paper, an attempt was made to formulate nomenclature conditions in the form of "terminological postulates", of which justifying or challenging is crucial to develop and justify new or modernised definitions. If the postulates will work well and will not be challenged, the definition of a notion itself will then retain its sense and will be true. It is also easy to demonstrate a postulate, which justifies why in a given definition a specific element exists, and in which it does not.

The use of a term or name to define a science is an entirely separate issue. This paper is not going to consider aspects of a term usage to determine its scientific representation. The fact, whether a specific term is, or was, or will be, a science or discipline, or only a common practice, will be shown by other authors or by the time. The paper will only formulate a suggestion in this field.

2. Materials and Methods Used in Reserach

To resolve the issue of nomenclature and definitions of the research area, which is the use of information technology for spatial analysis, a series of studies was performed with the use of several different research methods. The purpose of all analyses is to determine terminological postulates, which enable one to define the limitations and rules used to verify the existing definitions and opinions on the hitherto nomenclature. The main research material comprises scientific publications, which have been supplemented by a review of job offers, taught in fields of studies, and in software-based experiments.

One of the research methods used to perform the analyses was the method of searching for patterns in the texts of the definitions of the concepts under study. It involved the extraction of text fragments having identical or similar meanings. The extraction of patterns then made it possible to define the terminological postulates 7 and 6. The research methods used to formulate the postulates 1 and 2 were based both on a classic literature review and on performing our own simple experiments related to testing the selected software functions and analysing data structures on our own test bench. The topic of this research was the technology of spatial information systems in terms of the evolution of spatial data structures on the example of two commercial products and the functionality of spatial analyses embedded in non-GIS software. Postulates 3 and 4, on the other hand, were formulated on the basis of research methods used in semantics: syntactic analysis, conceptual unambiguity and terminological analogy. The study was concerned with comparing definitions of similar, in terms of vocabulary, names relating to other fields of research and the concept itself. In formulating postulate 5, the usual statistics were used, which relate to a review of the number of job vacancies for geoinformaticians and geomaticians. Altogether, 7 analyses were carried out.

2.1. Review of Software and Its Data Structures Dedicated to Spatial Data Processing

2.1.1. Review of Software for Spatial Data Processing

The beginning of the 1980s was characterised by the development of Geography Information Systems, which in the next few years were widely popularised. These systems are characterised by the combined application of a few solutions, which define the structure of spatial data [24]. They support the geographic and geodetic systems of coordinates. They allow one to represent the geometry of physical objects or phenomena referred to the Earth surface in a vector or raster form; the objects, which have descriptive (text) attributes attached to their geometry, creating a Feature. A relational database is responsible for structuring the descriptive attributes, and the topology is responsible for structuring the geometry. Combining these five features of data structures, we obtain a consistent characteristic of data structure of the GIS. The history of GIS origination and the possibilities and methods for spatial data processing were described in detail in the literature [24]. The second technology for spatial data processing comprises the Spatial Databases Management Systems. From the moment of defining the structure of spatial data saving in the BLOB (Binary Large Object) data type, the relational databases can store the geometry of spatial objects, together with a defined system of coordinates. The bases have analytical functions, which allow one to perform spatial analyses on such types of data. They can independently perform tasks of acquisition, processing, and publication of spatial data. The SDI, which is the Spatial Data Infrastructure, is the third technology for spatial data processing. This technology introduced a new paradigm of network processing of spatial data. The SDI is based on the SOA (Service-Oriented Architecture). In a technological sense, the SDI is nothing more than an http (Hyper Text Transfer Protocol) protocol, expanded with queries allowing to process the resources of spatial data using the existing WWW (World Wide Web) web services, equipped with additional functions for spatial data processing. The SDI consists of three basic components: infrastructure nodes (geoportals), which contain sets of services providing a possibility to review the geodata and to download them, standardised vector (GML) and raster spatial data, and the third element, metadata. The SDI concept results from a new architecture of IT systems, which allows to make available data in various formats by means of the standardised web services of scanning and downloading the spatial [25], and also book [25] data.

Historically, the CAD (Computer Aided Design) systems were the first technology for spatial data processing. The CAD software, originally designed to create technical drawings with the use of vector computer graphics, had a number of applications in the cartographic reproduction of 2D geodetic, geographic, and geological maps. The CAD technology has been enhanced now with the advanced technologies for 3D models' development and the application of computer graphics effects (animation and photorealistic rendering). Because of that, the CAD technology experiences new redevelopment in the field of processing point clouds from LiDAR (Light Detecting and Ranging) laser scanning and of modelling the geometry of objects from photographs made from a mobile platform, which are processed by means of SfM (Structure from Motion) techniques to the form of a 3D geometry of any object situated on the ground surface, and a model of the ground itself. Adding to that, the current CAD capabilities of building a model in a defined system of coordinates (geodetic or geographical), and together with attaching text attributes to the model in the CAD form, we obtain an advanced tool for spatial data processing. The effect of such capabilities consists in the development of software dedicated to the creation of virtual cities of 'SmartCity' type/class. Hence, the CAD technology is another technology for spatial data management, apart from the GIS and the SDI.

The BIM (Building Information Modelling) is the most advanced technology for spatial data representation in computer systems. Recognition of this technology, as a method for the processing of spatial data referred to the Earth surface, is obviously related to the second and third phase of a building life cycle (use and decommissioning). Meanwhile, it is partly related to the phase of designing. Moreover, the BIM technology is technologically definitely more advanced than the GIS. Because of that, many scientists undertook the performance of research work related to the development of the concept of data exchange between these systems [26] and to the use of BIM models for cartographic presentations [27]. The integration of data structures is important due to the increasing importance of the work in the field of building so-called 'smart cities'. Albeit, the BIM software develops in various ways, which results in certain differences in defining the building's design in the geodetic or geographical space, but the majority of products already provide such a functionality. The performed analyses have demonstrated that, e.g., the Revit system of the Autodesk applies a simple solution of the geospatial location, carried out by the PBP (Project Base Point) mechanism, where only one point is the reference for the system of geodetic coordinates, which is additionally supplemented with the information about the direction of the north. It is entirely sufficient for a proper spatial orientation of a building's design. Instead, such a solution for BIM as OpenBulidings by Bentley immediately places the entire BIM design in a determined spatial location of the geodetic system of coordinates.

At the end of software related considerations, it is necessary to draw attention to the platforms of data processing in the 'Data Science' field [28,29]. The R compiler [30] is one of the more important tools used in this new field of research, in which a developed subsystem of libraries related to spatial analyses was also implemented. It contains tools for spatial data import and export, provides great possibilities of their visualisation, and also the support of space-time data, the analysis of models for the spatial distribution of points, interpolation and geo-statistics, analyses of density distributions, and the analysis of aeronautical and satellite data [31].

At the turn of the 20th and 21st century, numerous scientists clearly emphasised differences between the GIS and CAD or DBMS systems, highlighting differences between them [32]; however, the technological development of databases in 2006 brought a new point of view on the relationship between these three technologies. For this year, Oracle launched CADView-3D Studio. A tool that allowed three-dimensional CAD data to be stored in a relational database in VRML format. The change consists in taking over the role of spatial data integration by the DBMS, both for the CAD and GIS [33]. The development of 3D data processing technologies after 2006 resulted in studies on the combination of the previously separate worlds of CAD and GIS into a single spatial database space [34].

Both CAD/BIM and SDI, Spatial DBMS, and also the R language platform acquire, process, and publish the spatial data such as the GIS software. It authorises one to formulate the first terminological postulate:

Terminological postulate No 1—there are many computer systems and applications, apart from the GIS, which are capable of spatial data processing. The GIS does not have exclusivity for spatial data processing, and the software engineering enables the integrating structures of spatial data into various IT platforms and systems.

2.1.2. Structures of Spatial Data in Database Systems and GIS

The development of formats and structures of spatial data in the IT was a crucial factor, which was allowed to come into existence for geographical information systems already in place in the 1960s and 1970s. The success of the ESRI company development to a large extent depended on two factors: the programming of a storage method (recording of topological spatial data) and algorithms for their processing. The POIS and the Polygon Information Overlay System was the first system, which resolved these problems in a comprehensive way and was implemented in the administration of San Diego city in the USA [24]. It should be emphasised that this very system may be an example of the development of the origins of software used for the analyses of spatial data.

The next stage in the development of data structures consisted in the development of technology for curvilinear geometry processing, which was next reflected in the name of Arc/Info software. The name symbolised the combination of words 'Arc' (curvilinear geometry of polygons) and 'Info' (that is the database of polygon attributes). At that time, one information layer (set of data for one type of objects) occupied one directory and consisted of (in the maximum version) as many as 23 files managed by the application [35] to display one class (type) of objects. Such a large number of files was necessary to save the information about the vector geometry, which describes one set of data together with attributes and the topology saved on the disk. Another achievement of the geoinformatics' beginnings consisted in developing and writing software supporting the "map algebra" [36] for spatial data processing in a raster format. It should be emphasised that each IT company, which undertook the development of the geoinformatic software, was starting from defining a proprietary, most frequently closed, structure of spatial data in the form of file groups. In the mid-1990s, this situation resulted in a deadlock in the field of spatial data exchange between producers of various types of software. The year 1994 brought a major breakthrough in this issue, when Intergraph and Oracle companies developed and placed on the market new relational structures of spatial data. The direction of changes consisted in developing data structures, which directly saved the vector geometry in fields of relational tables in databases. The Intergraph company developed a new product, Geomedia, which had a closed format of geographical vector data, comprised inside the BLOB data type, already used earlier in databases. The closing of this data format within the Geomedia application did not allow one to popularise it. Instead, the Oracle company presented a new type of SDO_Geometry data for their database, intended for the storage of spatial data in fields of relational data table in a text form, not a file form as the BLOB. The structure of such data type initially did not take into account the geometry of arcs and circles. The remaining structures appeared only in the next versions of the software. The opening of this definition, and making the program access interfaces available for free, popularised this method of information storage, and provided the company with a commercial success. During the next 10 years, the storage of geometrical data referring to the Earth surface in relational databases became widespread. In this period, the ESRI company (around 2005) abandoned the data structure from 1983 and the old Arc/Info software with the topology of geometrical data saved on disk, and replaced it with a record with topology reconstructed from a usual record of vector data; a so-called "polygon". Thereby, a system named ArcGIS originated, and again the key technology, of the entirely new software edition, was a change of data structure, which consisted in the application of reading and recording in systems of relational databases. A new system for recording received a marketing name of "geobase". This term means a structure of ESRI company spatial data, which may be saved in three various data formats: *.mdb, *.gdb, or in the database server by means of ArcSDE extension.

The importance of the change introduction in the spatial data format and structure is emphasised by the fact that the new version of the system initially had significantly less functionalities as compared with the previous version. Because of that, to the new ArcGIS version, the company, at request, attached the older Arc/Info software in the Workstation version. Thus, at the cost of limiting the functionalities of its main software, the company made a decision on the entire change in data saving structure in its applications, which was reflected in the product's name. In a similar way, the Oracle company in 1994 started the research and development of the spatial data storage in their products. It has turned out that this is a continuous process and within recent 20 years the company carried out a big scope of R&D work to represent the next features of the geographical space, in the form of spatial data types in its databases system. The designers, carrying out this work, also took care of preparing data types for new measuring technologies, e.g., 'point clouds' from laser scanning. The integration of this additional type of data into the relational table of spatial data was required to define appropriate spatial indices, and also to develop SQL queries, which perform the selection of data for further analyses. Another extremely important aspect of development consisted in building-in possibilities of data types storage in 3D vector geometry, including the surface grids. Such data remind the geometry used in the CAD type and vector graphics software. Because the objects exist in the database, they automatically also have a possibility to assign a large number of descriptive attributes. Such a data structure was almost a ready product to implement in the storage of objects prepared in the BIM (Building Information Modelling) technology. Table 1 presents in detail the consecutive stages of spatial data types' development and methods for their processing in the Oracle relational database.

Table 1. Development of spatial data types of the Oracle database.

Version of Oracle Database	Year	Description of Features of Spatial Data Structure
7.1.6. Multidimension	1994	Only points of geodetic and geographic coordinates
7.3.3. Spatial Data Option	1995	Points, lines, polygons, and operators of spatial analyses
8i Spatial	1998	Additional geometry of circles and arcs, and additional spatial operators
8i R3	2001	Linear reference system and transformations of coordinate systems
9i	2003	Spatial aggregation, geodetic coordinate systems, and replication of spatial data
10g	2005	Storage topology, grids, GeoRaster handling, and new functions of spatial analyses
11g	2010	3D objects, including: simple geometry, grid surfaces and TIN surfaces (data type: SDO_TIN), new grid analyses, storage of point clouds from laser scanning (data type: SDO_PC)
12c	2014	Support of GeoJSON objects handling, raster algebra and raster analyses, virtual data mosaicking, saving and reading the BIM data structure, Oracle Spatial Locator
19c Spatial and Graph	2019	GeoSPARQL support for storing and querying spatial data stored in Graph data model

An incessant increase in the number of spatial data types in the Oracle database or drastic changes in data formats of the ESRI company ArcInfo/ArcGIS systems allow for considering that the process of construction of spatial data structure has not been completed. The structures of spatial data saving in computer systems were described in the paper [35], which described both the file and relational models of saving spatial objects. In the next few years, one should expect a development of the next data types, which results from a few reasons. The first reason is the inadequacy of existing simple structures to define a more complex structure of spatial data. Such data types exist, which cannot be defined by means of simple types of data used in the GIS. Programmers create then software handling complicated types of data in solutions implemented to order. The second reason is the development of new concepts of spatial data saving, which are being developed only theoretically and are waiting for implementation in spatial information systems. Such types of data as "geofield" and "geo-atom" are very good examples, of which the concept was developed already in 2007 [37]; there is also research on the application of graph databases for the storage of topological data [38]. The third reason is new measurement technologies, which provide the data saved in new formats, which must be integrated with the existing structure of spatial data for their co-use, analysis, and making available together with other, previously used, types of data. In the past, the GPS system was a new source of data and data structures appear now, which save in the spatial database such data as clouds of points originating from measurements by means of laser scanning, or acquired by photographic methods from the SfM. The aforementioned reasons demonstrate that the representation of the surrounding world in computer memory structures will still be the subject of research and development of software for spatial data processing for many years. The parallel development of IT allows one to use increasingly convenient computing technologies, for example in the computing clouds technology, of which efficiency will multiply capabilities of large amounts of data processing. It is authorised to formulate the second terminological postulate:

Terminological postulate No 2—Structures of spatial data are subject to continuous development and modernisation, which strictly links the area of spatial data management with IT, in particular with the software engineering.

2.2. Selected Analyses of Terminology and Its Applications

The GIS technology originated and developed in the field of geography, but it also affected in parallel the development of scientific research in such areas as cartography, history, geology, mining, archaeology, geodesy, remote sensing, epidemiology, power industry, and many others. With the development of GIS technology applications in other fields of science, a need arose for the modernisation of the definitions of nomenclature used for the description of the results of studies and spatial analyses carried out via IT systems.

2.2.1. Overview of Variants of the GIS Abbreviation Expansion

Over the last 40 years, it is possible to identify a few methods of introducing changes in the name of GIS technology via a name of the acronym itself. As a rule, the suggested changes are aimed at the generalisation of the scope of this technology use to applications in a broader range of fields than only geography, and in a broader context than only technology. This is in such a way as to be capable of using this term in a wider context, and in particular in other areas of scientific research and business applications. During the carried out bibliographic surveys, many such attempts were identified, which may be grouped in three categories: substitution of one of the words creating the GIS acronym, the addition of the next word to the GIS acronym, and the most radical—the replacement of the GIS acronym with another acronym.

1. Substitution of one of the words creating the GIS acronym—this method resulted in the introduction of changes in the GIS acronym meaning, which received many new interpretations. Therefore, it is frequently possible to encounter other ways of the GIS acronym explanation; for example, the substitution of the meaning of the last word of the GIS acronym. Instead of the original meaning of "Systems", it is explained as "Sciences". It is necessary to emphasise that, especially in the USA, the GIScience term

gained recognisability in the US in a certain period, because it is close to a widely used term of “Computer Science”. The character S achieved also interpretation as “Society”. Another type of proposals for new interpretations of the GIS acronym is brought by these, which instead of the word “Geographic” suggest other definitions, such as “Geo” or “Geospatial”. Table 2 synthetically presents the suggested modernisations of the original GIS acronym.

Table 2. Identified expansions of the GIS acronym.

Author (Year)	Geograpic	Information	Systems
Tomlinson (1967) [39]	Geo-	Information	Systems
Goodchild (1992) [19]	Geograpic	Information	Science
Burrough and McDonnell (1998) [40]	Geograpic	Information	Society, science and systems
Forer and Unwin (1999) [41]	Geographic	Information	Studies
DiBase et al. [42]	Geographic	Information	Science and technology
Johnson (2018) [43]	Geospatial	Information	Systems

The acronyms built in this way allow one to cancel the limitation of GIS application only to geography, which provides the basis to apply the so-defined GIS technology beyond geographic sciences with references to the science or society. However, the introduction of a dual explanation of this acronym is a drawback of this solution. Both geographers and commercial companies (e.g., ESRI) will continue to use the original expansion of this acronym, which in the future can result in the ambiguity of these terms' use.

2. Addition of the next word to the GIS name—in many fields, there were attempts to adapt the GIS acronym to the area in which it was used. Characters meaning other fields of science or industrial sectors were added to the GIS acronym. The HGIS acronym may be a good example, which is defined both as a Health Geographic Information System [44] or as a Historical Geographic Information System [45]. Even funnier results may be obtained analysing the MGIS acronym, which can mean the Marine Geographic Information System [46], Mobile Geographic Information Systems [47,48], and also Mine Geographic Information System [49]. In a broader context, the maintaining of such acronyms over a longer period of time seems unreasonable.
3. Merging the two previous methods—replacing one of the words that created the GIS acronym, combined with adding the next word to the GIS name. An example of such a name is GIS&T, which should be explained as Geographic Information Science and Technology [42] Another author proposes to translate the acronym GIS&T in a slightly different way, as Geospatial Information Science and Technology [50].
4. Replacement of the GIS acronym with another acronym—in the 1990s, the term SIS (Spatial Information Systems) [51] was suggested and popularised to some extent. Such a definition of the processing technology of spatial data is more universal and allows a free use of this acronym in various branches of industry or in scientific research. This term also comprises geography-related research, however, without distinguishing the geography. In English speaking countries, the term spatial is more and more frequently used, and is slowly replacing the term geographic in non-geographic applications of the GIS technology.

The analysis of Table 2 and of the other subparagraphs indicates two issues related to the original expansion of the GIS acronym. These are trials to “make scientific” this term or to generalise its definition beyond geography. In an extensive paper on “making scientific” the GIS term [52], the author definitely supported the explanation of character S as Science. Already 23 years have passed from this paper and the original expansion of the GIS acronym still prevails. The time has demonstrated that the replacement of the character S expansion in the acronym as Science failed.

If the GIS acronym cannot fulfil the role of a terminological base, it is necessary to define and use a separate name, which will next be used to name the area of GIS technology applications, and also of the other technologies of spatial data processing. The performed review of acronyms allows one to formulate another terminological postulate:

Terminological postulate No 3—The name of the area of research on spatial data should not be an acronym, and in particular it should not contain the name of GIS technology or its derivatives.

2.2.2. Studies on the Terminological Analogy

A terminological analogy is an interesting example, which so far was entirely neglected in discussions on the choice of definition for the area of research on spatial data. Moreover, such a point of view should be considered. The analysis was carried out for such terms as geomatics and geoinformatics. For these terms, the analogy exists in the field of telecommunication and communications [53], where the IT earlier carried out basic transformations in the information transmission. To illustrate this issue, in the language layer in Poland two terms appeared: teleinformatics and telematics, in which definitions caused a similar problem with explaining, and also with these two terms' application [54]. In 2016, seven universities in Poland offered a new field of study, called teleinformatics. Six fields of studies were taught at IT faculties, and the seventh was taught at the electrical faculty. Instead, the term of telematics appeared in names of second-degree specialities in fields of studies not related to IT. This is in such a way that terms such as transport telematics or telematics in administration have originated and are functioning. The name of the speciality at the Faculty of Transport of the Warsaw University of Technology, "Transport Telematics", is a good example of that; this is the speciality in the "Transport" field of study. In a similar way, the speciality "Transport and Logistics Telematics" in the "Logistics" field of study is proposed at the University of Economics in Katowice. Moreover, in the field of telecommunication two close in meaning terms have appeared, however, which were accepted, defined, and used in a different way and they are not synonyms. Thus, the term of telematics is used in relation to sectoral applications of ICT systems. So another argument in favour appears to closely link the geoinformatics, such as teleinformatics, with the IT, and to consider geomatics, such as telematics, as a sectoral application of IT techniques in a given science, sector, or field.

Terminological postulate No 4—Names of similar word-formation origin should be used and defined in a similar way.

So far, these issues have not been analysed in the discussions on the definitions of the areas of knowledge and skills of research on the spatial data.

2.2.3. Nomenclatural Analysis in the Context of Performed Profession

The context of the performed profession in the field of spatial data processing—it is necessary to emphasise that in all quoted publications related to the defining and specifying the geomatics and geoinformatics terms, the analyses of given term uses in the economic and industry dimension are definitely missing. Therefore, supplementing these considerations, it is necessary to identify the analysed research discipline in relation to a specific performed profession or job position held. With respect to the geoinformatics' definition, as a scope of skills required for such a profession, the requirements formulated in relation to graduates, written in the form of job advertisements, have turned out to be very helpful. On account of that, job offers have been analysed from the point of view of searching by employers for persons with education as a geoinformatic, GIS, and geomatic. This review was conducted for the need of the first Faculty Commission for a New Field of Study at the Faculty of Mining Surveying and Environmental Engineering, which was working from November 2014 until January 2016. This case study concerned only the labour market in Poland and concerned job offers in Polish and English. The results of the study have not been made public by the university. The analysis yielded 15 job offers in the general field of GIS work In the analysed job offers, related directly to the GIS in the group of commercial companies' advertisements, the requirement of applicants having higher education in geoinformatics appeared in 5 of 15 advertisements. All these offers were related to job positions connected with the GIS (application or network) software. The results of the questionnaire demonstrate, that a pretty clearly expressed term of geoinformatics' education definitely dominates among employers. No offer was found among these analysed, which was related to the need for geomatic education. While in the area of administration involved in the infrastructure of spatial data, the term geomatics appeared very seldom in the context of a profession, and in no advertisement was there a requirement of education named geomatics. Only one job offer from a city office was related to the recruitment of an inspector for geomatics, and in the requirements on the education it comprised such fields of study as IT or geodesy and cartography or related. In 2014, employees with the geoinformatics education were sought on the labour market. Meanwhile, fields of studies, which enable receiving such education, are being started from 2014, and the first graduates of the field of studies named geoinformatics appeared only in 2018. The five analysed job offers for geoinformatics turned out to be pretty consistent in the field of required skills. Employers look for graduates of geoinformatics as employees having knowledge and skills from the field of production (that is primarily programming), implementation, and use of network and workstation Geography Information Systems. They also expect the skill of programming in a multilayer environment (including databases programming) and programming of web services (including geoportals). In this case, it is visible that employers treat the geoinformatics as a sub-field of IT, where programming is primarily taught. Thus, it is possible to conclude that the scope of knowledge and skills held by graduates of geoinformatics for some time has already been defined by employers and sought on the labour market. Among expectations related to geoinformatics, the requirements of knowledge and skills about designing the ergonomic interfaces of web applications for geoportals are defined. In no job offer the employer expected from applicants geoinformatics or the skill of data acquisition.

Terminological postulate No 5—It is advisable that the name of a term also functions as a performed profession on the market (existing in the area of economy and administration).

2.3. Analysis of Terms Defining Spatial Data Processing and Analyses

Within the last 40 years, many definitions appeared worldwide, which defined the area of research related to the spatial data, after all. None of the proposed definitions were universally recognised and adopted for application in the scientific practice, economy, or in the society. During the bibliographic surveys, six such terms, and their definitions or descriptive characteristics, were identified. The most important should include: geomatics [8,55], geoinformation [56], geocomputation [57], geoinformatics [58], geotechnology [59], and GIScience [19,22], GIS&T Body of Knowledge [21]. Any attempt to build mutual relationships between these terms is very difficult to make, because these terms are ambiguous. Many scientific centres frequently interpreted and defined the same term in another, frequently different, way. It also happened that the same definition is used to define two different terms. This situation substantially hinders the application and use of proper terminology in scientific research other than geography. Thus, a key question arises, which of the aforementioned six terms should be used in the application context of technology for spatial data processing?

The first definition of the GIScience term was proposed by Goodchild as Geographical Information Science [19] and defined concisely as *the science behind the systems*. The Clarke's definition is a competitive one, who defined it as follows: *the discipline that uses geographic information systems as tools to understand the world* [60]. These definitions were commented on in a broader sense by Mark in 2003, *GIScience is the storehouse of knowledge that is implemented in GIS and that makes GIS possible* [61]. The description of GIScience field was developed in the next publication by Goodchild [22]; however, no new definition was presented.

At a similar time, the popularity of the acronym GIS&T Body of Knowledge [21] has grown, which has been defined and popularised by the University Consortium for Geographic Information Science (UCGIS) formally since 2006. This association defines the term Geographic Information Science & Technology (GIS&T) as a composite of three interrelated domains. *The first sub-domain is geographic information science, which is a multidisciplinary research enterprise that addresses the nature of geographic information and the application of geospatial technologies to basic scientific questions [19]. The second sub-domain is geospatial technology, which is a specialised set of information technologies that handle georeferenced data. The third sub-domain, which they define as Applications of GIS&T, covers the increasingly diverse applications of geospatial technology in government, industry, and academia.*

These definitions focus on one technology, the GIS. More various technologies are used now to represent the space in IT systems and to perform spatial analyses (vide Terminological postulate No 1). Moreover, the share of a new type of measurement data acquisition, such as LiDAR or SfM, increases, which are processed not only in the GIS technology, but frequently are more efficiently processed in the BIM or CAD, which causes that the actual data can be represented in the computer system in many ways (vide Terminological postulate No 2). This name uses the acronym reconstructed from the original meaning of GIS (vide Terminological postulate No 3). In 2013, the GIScience term was quite thoroughly criticised by Reitsma [62], who stated that it was not a science. The GIScience name fulfilled its role in the popularisation of GIS software application in scientific research, but in the future, another, more adequate, name should be defined. Therefore, the GIScience name should be excluded from the identified terms.

The next identified term, referring to the spatial data processing, is geocomoputation [57]. It originated from a previously functioning term, "computational geography", as one of the fields of computational techniques. Thus, the genesis of this term refers primarily to geography. The definition of geocomputing is now connected with HPC (High Performance Computing) techniques, and AI, where proper GIS are only suppliers of data for computations [63]. Both the "computational geography" and "geocomputation" up to date have opponents of their use [64] and have not become overly popular, but they have not disappeared. The main drawback of these terms is their limitation to only one stage of data processing. The application of AI to spatial data processing may obviously be defined more generally as the application of "geocomputation", but it does not contribute anything useful to the very research. Considering the overall issue, this term is not fit to define the area of spatial data acquisition, processing, and publishing.

The third interesting term, related to the spatial data processing, is geotechnology. This term originates from the combination of "geospatial technology" terms [7] and does not refer to the field of scientific research, and is used to describe the developing market of services as well of hardware and software in the field of spatial data processing. This term originated in the USA and applies primarily to the labour market [59]. This term is similar to such a field of technology as "Geotechnical engineering", also referred to as geotechnics, and because of that it may be wrongly interpreted. The lack of connotation to science in this term, and a similarity to the name from another sector, cause this term to not be used to define the discussed area of research. However, this term perfectly describes the sector of manufacturers of the equipment used to work with the spatial data, such as GPS receivers, measuring instruments, or navigation systems. The term of geoinformation is very important, which is based on the information as such. The term of information belongs to general scientific terms, such as social, human, economic, and technical sciences [65] and as a research term that already existed at the end of the 19th century. The theory of information is undoubtedly a more precise term, which in the modern form developed after 1945, and is based on mathematical formalisms, which was, for the first time, developed by an American scientist Claude E. Shannon, the author of a quantitative theory of information (also referred to as classical or mathematical) [65]. In the field of geoinformation, however, the development of this field has not been mathematicised [56], which results in the ambiguity related to its application and geoinformation structuring. In the field of processed data, the geoinformation term, as against the information term, narrows the type of information, which is subject to research. However, this information should be supplemented with the geospatial data and enhance possibilities of information processing, as the entire data are about the reality that surrounds us. In addition, the lack of implication of spatial data processing automation is a drawback of this term. This brings another consequence, consisting in the fact that the term functions in relation to any form of geospatial data, also including all forms of analogue data. Hence, the 'geoinformation' term contains a connotation of spatial data processing by traditional analogue techniques, and modern computer technologies. This is another drawback of this term. It is necessary to consider that if theories from the field of information are implemented for processing by computer sciences, the geoinformation should be implemented to use by geocomputation, geoinformatics, geomatics, or geotechnology. Because of this, the term of geoinformation is not fit for the use in the sought context.

In recent years, another term has appeared, which defines a new scientific discipline related to geography, Geographic Data Science (GDS) [66]. Such a definition of a scientific discipline was criticised by the authors of the paper [67], who emphasised that the GDS was not a scientific discipline, but rather a Community of Practice within the basic scientific discipline, which is geography, under which the Data Science type research methods have been applied. Because of that, hereinafter the GDS term has been omitted in the considerations. Summing up, two terms remained for further analysis: geomatics and geoinformatics, which will be analysed in more detail.

2.3.1. Review of Hitherto Definitions of the Geomatics Term

In 1969, a French speaking Canadian, Bernard Dubuisson, surveyor and photogrammetrist by education, suggested to combine the prefix "geo" (reference to Earth) and the core of "matique" word (from the word "informatique") so as to create initially a French word "geomatique", which was translated into English as "Geomatics" [55,68]. The idea of this neologism invention resulted from his personal experience related to the necessity for learning IT technologies, which allowed photogrammetrists and surveyors to use the latest technologies of digital detection. The new term also comprised achievements of the initial GIS, which enabled the creation of digital ground maps. Unfortunately, the author of this term did not provide its unambiguous definition. It is only possible to conclude from the description and context that the term 'geomatics' meant 'the IT application in digital remote sensing and digital cartography'. However, immediately after this term coining, it was not widely used. However, in the 1970s, the term "geomatique" was used in France to establish a "Permanent Commission for Geomatics".

We owe the reappearance of the geomatics term to Michel Paradis, who worked as a surveyor for the Ministry of Natural Resources of Quebec. In 1981, he published a paper on geomatics [1] and next, in April 1982, he published an abstract about this topic on the occasion of the centenary of the Canadian Institute of Geodesy. In later years, the name of this institute was changed to the Institute of Geomatics. At that time, in Canada, the term geomatics found many supporters of its use, both in science and in practice. The beginning of the 1990s brought the next interpretations of the definition of geomatics itself and its relationships with other fields of Earth sciences and technology: *Geomatics is the science and technology of gathering, analysing, interpreting, distributing and using geographic information. 'Geomatics encompasses a broad range of disciplines that can be brought together to create a detailed but understandable picture of the physical world and our place in it. These disciplines include surveying, mapping, remote sensing, geographic information systems (GIS), and global positioning system (GPS)* [2]. This definition of geomatics contains the integration of existing disciplines under its framework.

The next, this time encyclopaedic definition, was published in the 2010 edition of the Oxford Dictionary of English: *the application of computerization to information in geography and related fields. Origin: from Geography and Informatics* [69]. This definition very concisely explains the term of geomatics, albeit wrongly explains the origin of the geo element. Over time, a greater need for the use of a more scientific term related to the GIS technology, appeared [8]. This resulted in the publication of books, which contain the next definitions of geomatics. A definition, which much better describes the term of geomatics, is the definition of 2009 [9]: *Geomatics is defined as a systemic, multidisciplinary, integrated approach to selecting* *the instruments and the appropriate techniques for collecting, storing, integrating, modelling, analysing, retrieving at will, transforming, displaying and distributing spatially georeferenced data from different sources with well-defined accuracy characteristics' continuity and in a digital format* [9].

This definition emphasises a significant common core of many definitions, which is the integration of spatial data from various research areas, carried out in such a way that it enables their processing and analysing to gain new knowledge about spatial relations, with a possibility of modelling changes. In this case, a uniform spatial reference to all the data is crucial. The basic strength of geomatics is its integration of geographical data processing with the processing of detailed and accurate surveying data. The above definition has one significant deficiency, its subject consists of spatial data, and not phenomena and spatial objects existing on the Earth surface and its spheres. The subject of the definition should not be the very data, but objects and phenomena, which in the IT system are represented in the form of digital data.

2.3.2. Review of Hitherto Definitions of the Geoinformatics Term

When analysing the scientific literature, it is very difficult to identify publications presenting a concise and unambiguous definition of the geoinformatics term. Many papers are published that use the term of geoinformatics, but these publications do not refer to the source definition. In most cases, the authors independently describe this term or provide examples of geoinformatics applications, which are to characterise this term.

The name of geoinformatics was originating in circles of town planners and architects in Sweden [11]. One of the first definitions of geoinformatics available for studies, was formulated in Sweden and presented in the Computers, Environment and Urban Systems journal, where the author, Le Duc [12], defined the geoinformatics as GeoInformatics (GeoI) is the scientific and technical discipline aimed at solving real-world problems by geoinformation, i.e., information that can be related to a specific position on Earth. A GeoInformatic System (GeoIS) is a concrete informatic system where GeoI, and other pertinent disciplines, have guided its design and implementation and for which geoinformation is critical. This definition originated despite the author's knowledge of the existence and use of the geomatics term. In turn, Holmberg [14] formulated in the years 1987–1992 the next owned definition of geoinformatics, which is worded as follows: *Geoinformatic systems are sociotechnical systems for sensing, modelling, representing, visualizing, monitoring, processing, and communicating geoinformation in support of urban and regional planning and design and similar activities. Geoinformatics is the technological and scientific discipline guiding the design of such systems*. In Germany, the first identified scientific publication on geoinformatics appeared in the Geo-Informations Systeme journal in 1993, and was defined by Ehlers as *art, science, or technology involved in acquisition, storage, processing, production, presentation, and dissemination of geoinformation* [13].

In Poland, the first publication, written by Kotlarczyk, appeared in the first number of Geoinformatica Polonica journal in 1999 and then it was defined as a *. . . science about methods of collecting, storing, processing, analysing, and presenting the data, defined in the terrestrial space-time, with the use of an appropriate technology* [15].

In the 2008 paper, Ehlers [17] defined geoinformatics, quoting his definition in German language of 2006 as: *The important factor is that Geoinformatics must be more than a patchwork of more or less unconnected components. It has to offer an integrated approach to the acquisition, storage and retrieval, modelling, management and analysis, and presentation and visualisation of geo-processes* [70]. In the paper of 2006, he emphasises that the geoinformatics as a whole is not a part of geography, geodesy, or computer science, but an independent (new) scientific discipline. However, in the paper of 2008 [17], he emphasises the location of the new discipline in the field of IT, which is computer science. For him, the computer science is the basic area, and the processed spatial data are a field of computer science applications. Such an approach places the geoinformatics rather as a subdiscipline of computer science, and not an independent science, which is a much more reasonable approach. The geoinformatics fully uses formal methods and theoretical grounds of the computer science.

2.4. Selected Aspects of the Characteristics of Geoinformatics and Geomatics Terms

The phenomenon of the mutual relationship between geoinformatics and geomatics, and external relationships with respect to other technical sciences, is a significant issue in the use of names for new terms. This is because one can frequently encounter in the literature definitions of geoinformatics, which to a smaller or greater degree repeat definitions used to define geomatics and vice versa. In turn, in publications, in which both terms exist together, the authors very often exclude one of them as such, which should not be used at all (exclusion), or treat it as an indeterminate, undefined term, without making an attempt to describe it (disregard).

2.4.1. Problems of Multidisciplinarity

In many definitions of geomatics and geoinformatics, a sequence (pattern) appears that defines the concept by including other existing sciences in the definition. Below are examples of two definitions highlighting (written in bold) this type of pattern:

- *Geoinformatics is the latest branch of science, which includes **Photogrammetry, Remote Sensing,** Global Positioning System (GPS) and Geographical Information System (GIS). A basic understanding of these components is essential for carrying out various types of surveys, navigation, geodynamics, hydrology, disaster management, etc. In view of its utility in multifarious activities [71].*
- *Geomatics encompasses a broad range of disciplines that can be brought together to create a detailed but understandable picture of the physical world and our place in it. These disciplines include **surveying, mapping, remote sensing,** geographic information systems (GIS), and global positioning system (GPS) [2].*

These two examples indicate that authors defining close terms define them using the names of other scientific disciplines. The sets of these disciplines vary between definitions and depend mainly on the conviction of the author concerned about the scope of the data they are processing. The use of the name of another science in the definition of a new term complicates the application of that old term to the scientific practice included in the definition of science. For example, when dealing with remote sensing at what point, do we start to deal with geomatics or geoinformatics, and at what point will it continue to be simple remote sensing. Defining a new term in this way causes conflicts in the research areas of traditional technical sciences. For this reason, there is no basis for interfering with the names. This justifies the exclusion of other scientific disciplines from the definition of geoinformatics and geomatics.

An additional problem is the replacement of the old term by a new one. In Canada, in the 1990s, actions were taken to replace the geodesy term by the geomatics term. However, the 2017 paper [10] summarised failures related to this process. Despite the introduction of many changes, the geodesy as a science still functions in Canada. In no other country was one term replaced by the other, even partially. The surveying sector in many countries takes the view that the geodesy name is immutable. The existing scientific disciplines develop in their research areas and there are no grounds to replace them or to integrate within one new discipline. The defining of a new term, which excludes other terms, is a movement motivated by other non-scientific factors, which are not the subject of studies within this paper. Therefore, in relation to the definition of the area of knowledge and skills in spatial data management, the next terminological postulate should be adopted:

Terminological postulate No 6—In the definition of a name of the area of spatial data management, the names of other technical sciences should not be indicated and used (geology, geodesy, remote sensing, etc.), the more so that there should be no defining of the succession or replacement with the new name for the existing and established technical sciences.

Paradis, defines geomatics as a science that includes other sciences in its definition: geodesy, cartography, remote sensing [1]. This procedure is inappropriate, as each of these sciences has its own path of development and should not be limited by the development of other sciences. For this reason, terminological postulate No 6 is essential to use in formulating a new definition.

2.4.2. The Use of Functional and Non-Functional Characteristics of IT Systems in Definitions

In many definitions of geomatics and geoinformatics, a sequence (pattern) appears that defines the concept through a set of information system functions. Below are examples of two definitions highlighting (written in bold) this type of pattern:

- *Geomatics is defined as a systemic, multidisciplinary, integrated approach to selecting the instruments and the appropriate techniques for collecting,* ***storing, integrating, modelling, analysing, retrieving at will, transforming, displaying and distributing*** *spatially geo-referenced data from different sources with well-defined accuracy characteristics continuity and in a digital format [9].*
- *The important factor is that Geoinformatics must be more than a patchwork of more or less unconnected components. It has to offer an integrated approach to the* ***acquisition, storage and retrieval, modelling, management and analysis, and presentation and visualisation*** *of geo-processes [70].*

In this way, a typical naming pattern was identified—the set of functions performed by an information system. These terms are closely related to those found in software engineering and there they have been defined and are used to describe the functions of any information system. It is software engineering that provides the terms used to describe the functional and non-functional characteristics of information systems. It is from it that these terms are derived; there is no reason to use them in the context of definitions of new concepts. Such a naming pattern definitely fits the definition of the term GIS rather than the concept being a proper name. The functions of an information system cannot be used to define terms for the names of spatial research areas, nor can they describe the research field or the professional activities of the users of such systems. Such an approach is wrong, because information systems are used in practically every field of life on Earth, which always and everywhere perform almost the same data processing activities. For this reason, it is neither necessary nor desirable to detail the entire list of system functions within the definition of a new research area. The entire set of IT system functions is a description, which in reality applies to the GIS IT system, and it should be used just at the GIS definition, and not in the description of a new term, which represents a new area of research.

Terminological postulate No 7—the definition of a spatial data management area must not use terms related to the definition of the functions of an information system, such as acquiring data, processing them, analysing them, publishing them, etc.

2.4.3. The Issue of Geoinformatics and Geomatics Terms Coexistence

In the years 2000–2001, in Poland, there was an exchange of opinions in the Geological Review, in the form of a paper and two polemics on the definition and use of geomatics and geoinformatics terms in Poland. Michalak, in the paper [72], introduced the definition of geomatics and justified the need to name this discipline just by this term, treating the geoinformatics definition as a synonym of geomatics. He based his definition on the scope of the work of Technical Committee ISO/TC211 (International Standardization Organization) and the OGC (Open Geospatial Consortium) consortium. Meanwhile, Kotlarczyk [73] polemicised with the use of the geomatics term and was persuaded to apply the geoinformatics term, suggesting that the geomatics term was wrong and should not be used. In his assessment, a broadly defined field of geoinformatics comprises the scope, in which the geomatics was defined, which he suggested to possibly treat as a narrow field of geoinformatics. A great difference in the attitude to definitions of those terms is visible. Kotlarczyk summarised his polemic with a suggestion for further considerations and discussions about the relationship of these two terms. In his answer, Michalak [74] justified the use of the geomatics term, indicating that the geoinformatics term defined by Kotlarczyk is a too general term. However, the geomatics defined based on the terminology used in the work of ISO/TC 211 Committee, Geographic Information/Geomatics, is very precisely determined, in his opinion.

In the 2008 paper, Ehlers [17] also presented both terms and chose to use geoinformatics based on one reason: *In the following, the term Geoinformatics will be used because it emphasises a formal scientific approach to handle geoinformation which Geomatics does not imply* [17]. This was without providing earlier any information on the "formal scientific approach" of geoinformatics and examples of shortages of such approach in geomatics. Because of that, it is difficult to polemicise with this premise.

Ehlers [17] also emphasised the situation of geoinformatics in the field of IT, which is computer science. Such an approach breeds certain consequences, such as a question, on which areas of computer science should be a part of geoinformatics, and there is no answer to this question. However, this statement supports and links with the second terminological postulate. The development of data structures and data formats imminently links the spatial data management with computer science.

3. Results

As a result of the conducted studies, seven terminological postulates have been formulated, which determine boundaries and introduce rules related to the contents and meanings of geomatics and geoinformatics terms:

- Terminological postulate No 1—there are many computer systems and applications, apart from the GIS, which are capable of spatial data processing. The GIS does not have exclusivity for spatial data processing, and the software engineering enables integrating structures of spatial data into various IT platforms and systems.
- Terminological postulate No 2—structures of spatial data are subject to continuous development and modernisation, which strictly links the area of spatial data management with IT, in particular with the software engineering.
- Terminological postulate No 3—the name of the area of research on spatial data should not be an acronym, and in particular it should not contain the name of GIS technology or its derivatives.
- Terminological postulate No 4—names of similar word-formation origin should be used and defined in a similar way.
- Terminological postulate No 5—it is advisable that the name of a specific term also functions as a profession (existing in the area of economy and administration).
- Terminological postulate No 6—in the definition of a name of the area of spatial data management, the names of other technical sciences should not be indicated and used (geology, geodesy, or remote sensing), the more so that there should be no defining of the succession or replacement with the new name for the existing and established technical sciences.
- Terminological postulate No 7—the definition of a spatial data management area must not use terms related to the definition of the functions of an information system, such as acquiring data, processing them, analysing them, publishing them, etc.

Such an approach will allow one to formulate and suggest new definitions for them. An interesting observation is the fact that the geomatics term originated in the society of Canadian surveyors and photogrammetrists, and the geoinformatics term developed in the society of town planners and architects in Sweden.

3.1. Proposal for a Definition of Geomatics Term

It is worth emphasising at the beginning that none of the geomatics definitions assumes it to be an imminent part of computer science. In many definitions, the analytical aspect of geomatics is emphasised, which is the use of technology for spatial research and analyses. It does not have a direct relation with the software development, programming, or other typical IT functions. Instead, it 'willingly' integrates a few definitions of geomatics into the definition other fields of science, such as geodesy, remote sensing, or geology. This happens because those fields apply and develop own methods for spatial data acquisition, which geomatics as such do not have. However, the spatial data are its very quintessence and the sense of this term existence. Already, the very gathering of spatial data and their structuring and visualisation are a part of the area of knowledge and skills, which is geomatics. Hence the following definition of geomatics may be proposed:

Theorem 1. *Geomatics is the knowledge and ability to use information systems to integrate data about spatial objects and space-time phenomena relating to the Earth's surface, in order to perform spatial analyzes, forecast and visualize their state and changes.*

The presented definition releases us from the limitation of this term use only to GIS, implementing thereby terminological postulate No 1. It emphasises the most important characteristic of this field, which is the spatial analyses and modelling of phenomena existing in this space. In the case of geomatics, the knowledge of objects and phenomena occurring in the space referred to the Earth surface is crucial, and the geomatics itself is the skill of integrating the data on a given phenomenon and analysing these phenomena with a possibility to develop a model of changes in their state or behaviour. The results of geomatic studies allow for better learning of the processes of Earth itself functioning, and for their forecasting. Because of that, it is necessary to suggest locating this research area in the Earth Sciences in connection with technical sciences. Moreover, it is necessary to notice that the spatial data are increasingly often processed beyond classical GIS. There are more and more data in BIM systems or in other sectoral systems, while the GIS themselves are increasingly often involved in the implementation of more complex systems of data processing, e.g., systems for the SmartCity or so-called digital twins.

3.2. Proposal for a Definition of Geoinformatics Term

Geoinformatics is primarily a technical science, being a part of the Computer Science area, and may be defined as follows:

Theorem 2. *The geoinformatics is the programming of applications, spatial data structures, and analyses of objects and space-time phenomena referred to the Earth surface, together with designing, developing, and maintaining the software and web services intended for modelling and analysing the spatial data.*

A geoinformatic is primarily a computer scientist (and this is his/her basic education), who has knowledge of the software architecture and computer networks. He/she has the skills of designing, programming, and maintaining IT systems, and only next he/she learns the specific nature of computer science application for spatial data processing, spatial information modelling, and analyses used in this field. Undoubtedly, the knowledge of the issues of geospatial services' construction and maintenance, and the programming of network and mobile systems, must be a significant skill in geoinformatics.

The defining of geoinformatics allows one next to define its research areas. Based on the presented definition, it is possible to formulate research areas in the field of education, research conduct, and the performed profession of a computer scientist, from whom the knowledge and skills from the following research areas should be expected:

1. Spatial databases - this is the modelling of spatial information saved in relational and non-relational databases. For example, the studies on the use of graph structures of databases for spatial data processing, spatial databases programming and optimising, taking into account spatial indices and the use of spatial databases for BigData processing and analysing, and also, simplifying the 'programming of any databases containing simple, complex, and own types of spatial data', considering the server and cloud technological solutions.

2. Spatial data in the web environment—research and application of technologies for building infrastructures of spatial data for the government and local government administration, and the technology for web processing of data not related to the SDI (e.g., Google Maps, OpenStreetMaps, and others), and studies on the use of 'Linked Data' technology for spatial data processing, combination of technology for spatial data storage in a computing cloud with the data acquisition by means of the IoT (Internet of Things) technology.
3. Sensor systems for spatial data processing—programming of the hardware collecting the data for various GIS, BIM and CAD, and ETL systems and applications, considering the specific nature of spatial data, and programming of sensor devices for networks and local systems of spatial information.
4. Programming autonomous transport systems in real time, and programming of navigation systems.
5. Designing the architecture of spatial information systems together with a skill of carrying out the implementations of spatial information systems in the entire cycle of software development, implementation, and maintenance, including the supply systems.
6. Building ergonomic interfaces for spatial data processing (UX) and developing visualisation methods for multidimensional spatial data in various environments of their use (smartphone, tablet, desktop, and others).

Obviously these areas are a proposal, but they well illustrate the location of geoinformatics in the field of computer science and in the future should be specified and probably broadened. Simplifying, it is possible to assume that the geoinformatics in general is "the engineering of geoinformation software". The results of scientific research in the field of geoinformatics should enhance and expand the computer science, and develop the analytical possibilities of the geomatics.

3.3. Mutual Relation between Geoinformatics and Geomatics Terms

To present similarities and differences in the scope of knowledge and skills of these two areas of spatial data processing, a table 3 was prepared, which presents differences between these two terms. The table presents tasks performed in the area of spatial data processing and the scope of knowledge and skills of a geoinformatic and geomatic within this task.

Table 3. Comparison of selected characteristics of geomatics and geoinformatics

Application	Geomatics	Geoinformatics
Application in industry	Knowledge of data (data acquisition and properties) of a given field of their processing	Creation of new structures and formats of data storage, and modifications of existing ones
Data acquisition	Knowledge of measuring techniques, of the use of remote sensing methods and GNSS, and knowledge of measurements' accuracy	Knowledge and operation of ETL (Extract, Transform, Load) processes, and transformation of data formats
Modelling	Spatial data representation in systems of their processing	Adaptation of spatial data structures and production of systems for their processing
Data processing	Skill of selection of spatial data structures for available methodologies of spatial analyses	Skill of programming new analyses and optimising the time of their performance, and creation of interface for their operation

Table 3. *Cont.*

Application	Geomatics	Geoinformatics
Software implementation	Knowledge of software development and practical capability of IT projects management	Full range of knowledge and skills in the field of software development and implementation
Standardisation	SDI standardisation (UML, XML languages)	Adaptation of new formal means to applications in the field of spatial data processing, e.g., geoREST, geoJSON, and other solutions
Web Services	Operation and feeding with data of web services	Installation and programming of web services operation for specific applications
Software architecture	Knowledge of software architecture basics	Knowledge and skills of shaping the architecture of IT systems

4. Discussion

The paper deliberately has not considered the problem of whether geoinformatics and geomatics terms are scientific terms. This is because the most important issue consists in defining these names, and establishing terms related to them, which only later may be analysed in view of whether they define a science or not. According to the author, the geoinformatics may be treated as a subdiscipline of the computer science, and as such it may be considered a science, while the geomatics still relies on the knowledge (and primarily on data) from other fields, hence the geomatics is rather not a science, but it is still a common practice, which already has its achievements, but which has not yet been developed as a separate scientific discipline.

The definition of geoinformatics that has been formulated is definitely closer to the concept of computer science than any previously formulated definitions of this kind. This definition develops Echlers' idea that geoinformatics is part of computer science [17] and concretises it. It is by far the most important in defining and programming the processing of spatial data structures in fixed systems and in mobile devices or IoT more broadly. The proposed definition of geomatics completely dissociates itself from earlier definitions that were intended to replace the concept of geodesy [1]. It dispenses with the duplication of definitions of information system functions and does not incorporate other sciences or other disciplines into the definition. It focuses on the use of information systems to discover knowledge about spatial relationships in our social, economic, or administrative environment.

It should be emphasised that the hasty, often careless defining of a new term results from the willingness of a scientist to distinguish, only to, as fast as possible, announce the origination of a new science. Ultimately, such a hurry is more harmful to this term, than actually affecting its popularisation. Such a situation is observed now in the field of Data Science, where a possibility of separating and announcing 'a new science' based on the spatial data was seized. In the situation where a new professional profile originated, which has been developed in companies processing large amounts of data and obtained a "data scientist" name [30], certain universities undertook to educate in this field. A skill characteristic of this profession is the skill to obtain answers to important business questions of corporations, based on analyses of gathered, previously not structured, data. The Master of Data Scientist fields of studies have been originating at many universities after 2012, and a new research discipline is defined as "Data Science" [29]. The definition of "data scientist" term adopts the existing collected data as the starting point of research. However, referring to the scope of spatial data, it has turned out that again various terminological proposals have appeared. Starting from Spatial Data Science [75], then Geographic Data Science [66], or also Earth Data Science [76], and there is even GeoData Science term [77]. Thus, one can have an impression, that the history repeats again, and once more we have an inflow of many new names built on the basis of a very similar research concept. For example, it is possible to suggest Geomatics Data Science, and then we have a new quality, but this is a subject for a separate research.

5. Conclusions

No concept is ever complete when there are no outlined directions for the development of its applications. Geoinformatics is primarily the implementation of spatial data structures in new information technologies, and handling and process spatial data in graph databases. There is a wider use of NoSQL databases to process spatial data and the use of LinkedData paradigm to describe spatial data. We conducting research into effective 3D data structures and methods for their analysis, and programmed mobile systems and multidimensional data structures together with tools for performing analyses. Geomatics is now the virtualisation of urban space, the integration of different data sources to increase the efficiency of design and planning and, above all, space management. It is the design and implementation of decision support systems. Geomatics is the knowledge of data and its meaning and appearance. In the field of geomatics, the development of geovisualisation, data semantics, and mapping of datasets is also important. It is necessary to emphasise, that irrespective of the way of defining the geomatics term and its current problems, scientists now obtain brand new dimensions, which are identified by various authors. For example, Jeansoulin has noticed that there is a permanent increase in the spatial data volume, rate (pace) of their acquisition, and an increasing diversity of data types, and also of those not structured, which causes that the geomatics must now be perceived as the area of large amounts of spatial data generating and analysing, which are analysed by means of BigData technology [78].

In conclusion, these two terms are worth using and applying in practice because they clearly describe two overlapping areas of knowledge and skills, but indeed they differ significantly from each other.

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