with objects on the ground and time intervals provides opportunities to determine cause-and-effect relationships, to identify groups of similar data, and to predict future events.

On the one hand, the representation, integration and processing of spatially referenced data is the task of a corresponding class of systems called geographic information systems (GIS). On the other hand, the focus on using spatially referenced data to establish semantic links between spatially referenced data and the knowledge of the subject areas for which the GIS is being developed indicates the need to use artificial intelligence technologies and design intelligent systems.

It is noted in the work [6] that at the current level of development geographic information systems have become practically the main tool for modeling natural, economic, social processes and situations, tracing their relationships, interactions, predicting further development in space and time, and most importantly a means of providing (supporting) decision-making management. Modeling in geographic information systems is based on databases and knowledge bases. The former integrate digital cartographic, aerospace, statistical and other data reflecting the spatial position, state and attitude of objects, and the latter contain sets of logical rules, information, concepts necessary for modeling and decision-making. At the same time, GIS is a special technology based on computer complexes and software tools.

Consequently, from the very definition of GIS follows the need to implement intelligent tasks: analysis, modeling, forecasting and environmental management, because all these tasks are intelligent and require decision support in their implementation, and systems that use spatially referenced data belong to the class of intelligent systems with integrated spatially referenced data (ISRD).

In the past decade, remote sensing data have been the main source of new data about the Earth, which necessitates the creation of an information system with specialized services that allow scientists and specialists to perform thematic processing of remotely sensed data by changing the data processing parameters in a certain way and to analyse the obtained information independently [4]. At the same time, large crowdsourced geographic datasets have been generated about the Earth today as a result of the observed web phenomenon known as Volunteered Geographic Information (VGI) [7] through the development of spatial information systems and web mapping projects, the main ones being:

- Yandex search and information mapping service [2];
- a non-commercial web-mapping project to create a detailed free and free geographical map of the world OpenStreetMap (OSM) by the community of participants — Internet users [1];
- Google Maps is a set of applications built on top of the mapping service provided by Google [3].

The [8] argues that the growth of web services and applications for geographic information systems has made large archives of spatial data available over the Internet. Significant advances in GIS web service development technologies have resulted in several examples of mapping and graphics services that conform to web service standards and provide geospatial data and digital maps to enterprise developers. Thus, both government surveying and mapping services and private sector enterprises have recently experienced a surge in the development of web services and web-based applications for GIS, making large archives of spatial data available over the Internet.

In this regard, the role of the map as an image-sign geoinformation model of reality for quick and adequate perception of information is acquired. Creation of maps in electronic form, using GIS–technologies, is the most important task of modern society, because it is the map that becomes the tool with which a person can make a decision, from the simplest to the most complex, even in emergency situations. Accordingly, the society makes more and more demands to maps, the user, referring to the map, wants to receive reliable information and from a huge array of data to choose only the information that would be more suitable for making the right decision [9].

In addition, new and more sophisticated data collection technologies (knowledge bases based on wiki technologies, classifiers, natural language parsing, etc.) are now available. The large amount of accumulated geospatial data generated by Earth observation satellites as well as ground-based devices and sensors offers enormous potential to address global social issues related to natural disasters, health, transportation, energy and food security [10], [11]. Interoperability is particularly important as the level of cooperation between information sources at national, regional and local levels increases, requiring new methods to develop interoperable geographic systems [12]. Therefore, the use of terrain objects as integrating elements in information systems is essentially interdisciplinary in nature, as they integrate research in economics, ecology, climate forecasting, terrain development, formation of optimal routes, and more.

In the industry of geoinformation systems development nowadays there is a need in their intellectualization, i. e. in solving problems traditionally related to geoinformatics with the use of artificial intelligence methods. First of all, these are the tasks of intelligent search. Existing instrumental GIS, which are the means of development of applied GIS, do not solve the problems of intelligent search for a number of reasons, among which we will emphasize the following:

- practically all of them are based on internal (closed) formats of spatial data representation, and exchange open formats serve only as a means of map data exchange between different GIS tools;
- thematic data are mapped to specific spatial objects

and exclude the possibility of establishing links and relationships between such data;
- implementation of applied tasks of geoinformatics is carried out in internal programming languages, thus only simplifying access to spatial data, and the map serves as a means of visualization.

In the field of GIS development it is necessary to emphasize the problem of formation of cartographic images from information resources, for the solution of which the methods of dynamic representation of spatial data in GIS [13] are proposed, as well as the unsolved to date problem of information integration.

Thus, a group of international geographic and environmental scientists from government, industry, and academia brought together by the Vespucci Initiative for the Advancement of Geographic Information Science, and the Joint Research Centre of the European Com mission [14], argue that despite significant progress, the ability to integrate geographic information from multiple sources is very limited and in order to facilitate such integration, an understanding of the statistical challenges of integration at different scales is needed, as well as the study of linguistic services

A mathematical model is proposed to facilitate the integration of spatial information and attribute data, which enabled the researcher to reduce the time to obtain data for management decision making in municipal services [15].

It should be noted that the need for information integration requires semantic geo-interoperability and harmonized understanding of the semantics of geodata [16]. Interoperability is an indicator of effective communication between systems [17]–[19].

On the other hand, known technologies of designing intelligent systems use cartographic materials, as a rule, in the form of raster images, i. e. there is no possibility to consider a map as a set of geographical objects with specified topological and subject-oriented (depending on the type of map) relations, while it is argued in the paper [9] that we need new maps, the content of which is supplemented with spatial knowledge, corresponding to the subject area for the preparation of spatial maps.

Besides, for a fixed territory the same objects of terrain and phenomena are used in different application areas: epidemiology, construction, environmental protection and nature management, land relations, etc., which determines the necessity to harmonize the ontology of subject areas with the objects of terrain and phenomena inherent in a given territory, thus providing a vertical (subject-oriented) level of GIS design.

Note that when designing a GIS for a new territory, the basic functional requirements are preserved and it is necessary to take into account not only the previous experience of GIS design, but also to use previously designed functional components, i.e. we are talking about the horizontal level of GIS design, when the territorial area is expanded and systems are designed for new territories.

The third aspect is the temporal component, relevant for retrospective analysis and modeling, thus providing a dynamic GIS that can deal with terrain objects and phenomena within a specific time period.

Currently proposed GIS tools have "weak" compatibility due to the lack of unification of subject knowledge with ontologies of terrain objects and phenomena, as well as with temporal components.

Known research on the integration of spatial data and domain knowledge to ensure semantic interoperability has been conducted for systems based on the Semantic Web technology stack RDF, RDFS, OWL and the Web Ontology Language OWL provides advanced capabilities for describing the subject areas of interacting systems and provides machine-interpretable definitions of fundamental concepts in the subject area and the relationships between such concepts in the ontology.

Recently, due to the development of Semantic Web technology, the key element of which is ontologies, it has become possible in GIS to emphasize the semantics of subject knowledge, to integrate and merge different datasets in related fields, to establish subject rules and their recording using RDF (Resource Description Framework) [20]–[22]. This capability certainly enhances the capabilities of GIS technologies. However, in order to do so, several important tasks must be solved. These are, first, justifying the use of tools to integrate spatial data and subject knowledge [23], and second, computing the similarity between geospatial objects that belong to different data sources [24]–[26].

For example, the paper [27] states that there are research problems related to the integration of different types of geographic information. The authors propose to base the GIS architecture on ontologies acting as a system integrator in order to ensure smooth and flexible integration of geographic information based on its semantic value. In this approach, the ontology system is a component, such as a database or knowledge base (in general case, an information component), interacting to achieve the goals of the geographic information system, and viewing the ontology, allows the user to obtain information about the existing (formalized) knowledge in the system. The use of several ontologies eventually allows to extract information at different stages of classi- fication, i. e. for different types of information used for the purposes and in the interests of GIS. These ideas are developed in the works of [28]–[30].

The process of ontology development is called ontology engineering and according to the concept of ontology engineering, ontologies must be developed before they can be used in a GIS. Thus, a GIS is based on a subject area described initially by an ontology model, with ontologies acting as a tool for knowledge generation [31].

At present, scientific areas are developing so-called Smart-systems aimed at qualitative improvement of technical and economic indicators within the subject area. The application of geoinformation technologies for scientific research in the subject areas in conjunction with traditional tools, methods and models of artificial intelligence allow obtaining qualitatively new scientific results, as well as aimed at reducing the time of searching for acceptable solutions for the set tasks. At the same time, the authors pay special attention to the integration of terrain objects and data and knowledge in system research of a particular subject area.

Thus, Massel L. V. et al. proposed a methodical approach to the integration of remotely sensed earth observation data based on the methods of data and knowledge integration in energy system research [32], [33]. For this purpose, the authors developed a theoretical model of hybrid data based on the fractal stratified model (FS-model) of information space.

The hybrid data model is based on the development of a system of ontologies of the remote sensing information space, including a metaontology describing the layers of the FS model and ontologies of individual layers (subject areas).

As a result of ontological modeling, an ontological space including a set of ontologies is created, which should allow working not only with data, but also with knowledge, including descriptions of scenarios of various situations, models and software complexes, and integrate them into the IT infrastructure of interdisciplinary research.

The Open Geospatial Consortium (OGC) GeoSPARQL standard supports representing and querying geospatial data on the Semantic Web [34], [35]. GeoSPARQL defines a vocabulary for representing geospatial data in RDF, and it defines an extension to the SPARQL query language for processing geospatial data. In addition, GeoSPARQL is designed to accommodate systems based on qualitative spatial reasoning and systems based on quantitative spatial computations.

Thanks to Semantic Web technology and ontology engineering, as well as standardization processes for ontology development in the web ontology language, the problem of declarative knowledge representation has been solved, which contributes to the understanding of map objects and allows querying spatial data explicitly represented in spatial data storage formats [36], [37].

However, subject domain formalization and ontology engineering is only one step in intelligent systems design technology and by itself is not sufficient for knowledge-based inference, since ontology engineering allows for the description of declarative knowledge of subject domains, whereas procedural knowledge allows for the design of problem solvers and knowledge-based inference.

The above-mentioned possibilities of the technology based on the semantic web have certainly contributed to the development of geographic information systems with the ability to process colossal volumes of crowdsourced data. At the same time, decision making in problem domains of human activity requires obtaining an intel- ligent reference, i. e. actually solving a problem when the answer is not available in the datasets themselves or represented knowledge in the current version of the knowledge base or in the repository. A way of expressing such a need is the question [38]–[40]. In the process of communication there is always a context, which determines additional information that contributes to the correct understanding of the meaning of the message. Systems that are able to provide background information on the user's question belong to the class of intelligent help systems.

In intelligent reference systems, the problem is formulated in the form of a question, and the answer to the question requires specialized knowledge in science, technology, art, craft or other fields of activity, which is represented in knowledge bases. In other words, within the framework of the considered technologies it is neces- sary to first generate knowledge of the problem domain necessary for giving an answer. At the same time, the capabilities of knowledge bases of intelligent systems allow not only to represent and structure knowledge about the surrounding world, but also to quickly obtain and form this knowledge about it, thus satisfying the information need of the user [41].

One of the key features of an intelligent system is that the user has the ability to formulate his/her information need. The peculiarity of information representation in the knowledge bases of intelligent systems simplifies the formation of the user's information need, since the presented information in the knowledge bases is already structured and the relations defined on a certain concept, in respect of which the question-problem situation is solved, are known. In the work [42] it is shown that the question-problem situation cannot be solved within the framework of formal logic and the nature of the question can be understood in the system of subject- object relations. In connection with the fact that at formation of knowledge bases of intellectual systems the formation of subject-object relations within the given sub- ject area takes place, thereby simplifying the expression of information need by the user by means of knowledge representation languages.

The proposed approaches to optimize information retrieval currently lie in the development of question- answer systems (QAS) in which user questions are matched with the required information. Such systems carry out a dialog between the user and the system in the form of the procedure "QUESTION-Answer" in the