Specialized Interactive Methods for Using Data on Radar Application Models

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Abstract. The article analyzes the existing technologies and methods of data visualization, presents basic research in this field and presents arguments on the relevance of the work done. The analysis showed that it is advisable to use the algebra of algorithms for mathematical description of interactive data visualization. In accordance with the properties of the signs of the algebra algorithms operations, we minimized the created models by the number of units. Also, according to the properties of the algebra algorithms formulas, the rendering of the corresponding uniterms for the signs of operations was performed, resulting in a model of interactive data visualization. In accordance with the analysis of available development methods and technologies, a system was created that is intended to visually display information on radars and to provide recommendations for the installation of new ones. The conducted research creates the preconditions for the design of related software modules that extend the functionality of the developed software system in the direction of decision support in this subject area.

Keywords: visualization, model, radar algebra of algorithms, information graphics, Human-Computer Interaction.

1 Introduction

Every day, humanity is confronted with some data. This can be a variety of news, statistics, research findings, and more. But most of what individuals are confronted with, is the inability to extract the necessary information from the continuous stream of everything that surrounds them. An important problem today is the structuring of information, the ability to see or find the data needed at a particular point of time and be able to use it for the right purposes. In order to manage the large-scale information that is used daily in various spheres of human life effectively, there is a need for its structuring, filtering and visual presentation. The fulfillment of these tasks depends on how well it will be understood, whether it will be easy to operate and how well it will be assimilated [1].

Nowadays, computer technology is an integral element of information processing. Because the human brain is not able to perform so many large-scale and complex tasks so quickly and simultaneously, this tool has become the most important tool in human work in many areas of human life. The discipline that studies human interaction with the computer, the assessment and implementation of interactive computing systems and phenomena, and how computer technologies affect human work and development, is Human-Computer Interaction (HCI) [2]. Data visualization is a component of HCI. This process is important and necessary because the unstructured data provided by the symbols are difficult for human to perceive. Infographics is a section of HCI that studies visualization and develops new methods for it [3].

Information graphics has gained important status in many areas of our lives, including political, educational, etc. Of great importance was the visualization of data in air traffic systems, namely the display of the location of both existing and potential radars on the terrain map. Important aspects of information visualization are interactivity and dynamics of visual representation [4]. Existing methods allow the user to modify the model in real time, thereby enabling its perception based on abstract data. Visualization uses interactive visual representations of data to increase cognition. This means that the data is converted into an image that is displayed on the operator screen. In this case, the image can be changed, and this interaction is important as it allows for permanent redefinition of goals [5].

1.1 Analysis of Recent Researches and Publications

Since the inception of the information visualization field, many researchers are still working on the topic, looking for new methods and improving the results of their precursors. One of them is the famous American scientist Stewart C. Kard. He was a senior scientist at Xerox PARC and one of the founders of the human factor in human-computer interaction. His research is devoted to the fields of development and support of human interaction and information and visual-semantic prototypes for the purpose of their greater understanding [6].

Fernanda Viégas and Martin M. Wattenberg are known for their groundbreaking work in the field of social data visualization. They represent a data visualization research group and are the authors of the Many Eyes concept. In the work [7] was developed an interactive, animated map of the United States, showing the country's wind flows at a particular point in time, their intensity and direction (Fig. 1).

Much of the work is devoted to the features of data visualization in the process of human-computer interaction, such research is undertaken by research teams led by George William Furnas (Professor at the School of Information at the University of Michigan), James D. Hollan (Director of Distributed Cognition and Human-Computer Interaction Laboratory at the University of California, San Diego). The following organizations also deal with the topic of visual presentation of information: International Symposium on Graph Drawing (GD), Human-Computer Interaction Lab of the University of Maryland [8].

Fig. 1 Map of US wind currents

As can be seen from the analysis, this area is extremely important but has not been fully studied yet, given that the actual task is to create a system for displaying existing radars and the area they cover and identifying locations for the installation of new objects to cover the entire territory [9-11].

1.2 The Main Tasks of the Research and Their Significance

The purpose of the study is to create a system of interactive data visualization on the example of radar models. The study will provide a means of displaying existing radars, displaying their technical status and characteristics, and providing guidance on the optimal location of new objects. To achieve this goal, it is necessary to solve the following main tasks: to analyze the existing scientific research and approaches used in the field of interactive visualization; to identify the main tasks that arise, to build models according to which the process of data visualization can be carried out and to implement the proposed approach in the software. The results of the study solve the urgent task of creating a mathematical software for the process of displaying existing radars and identifying places for the installation of new objects to cover the entire territory.

2 Major Research Results

Interactive visualization is part of graphical visualization in the field of computer science, which involves exploring how people interact with computers to create graphic displays and how this process can be made more effective. In order for visualization to be considered interactive, it must meet the following criteria [12]: control of the basic aspects of visual presentation of information must be performed by a person, and changes made must be reflected in real time. One type of interactive visualization is virtual reality (VR), where visual representation of information is obtained by inputting a display such as a stereo projector into the device. VR is also characterized by the use of spatial display and the creation of a presence effect. Another type of interactive visualization is consistent visualization in which several people interact with the same computer visualization: discuss their ideas with one another or jointly explore information. Often, consistent visualization is used when people are geographically distributed using cross-platform Internet resources [13].

The conducted analysis showed that for today the following basic patterns, visualizations of information are used: maps (geographical maps, infographic maps, cartograms); linear time graphs (used to visualize temporal information, such as Gantt charts); networks (used to visualize dependencies, relationships, and hierarchies). A classic example of the use of linear time graphs is the image shown in fig. 2. This is a graph of Caltrain trains, departure times shown on the X-axis, stations on the Y-axis. This visualization meets the standards of 'good visualization' [14].

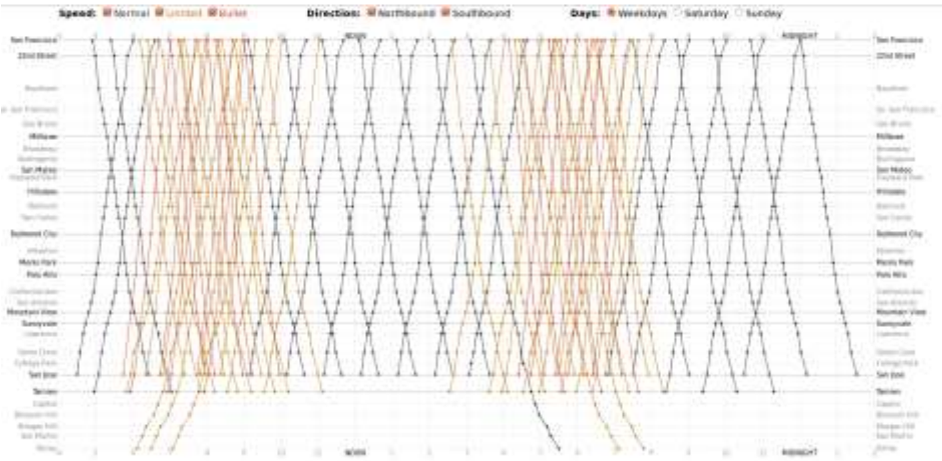


Fig. 2 Visualizing information using linear time graphs

It can seen from Figure 2 that the stations are separated in proportion to the distance between them. The slope of the line reflects the real speed of the train: the steeper the line, the faster the train. However, this view has limitations in terms of user interaction at the data filtering level.

Taking into account the peculiarities, the algebra of algorithms was chosen to create models of the designed system, by means of which it is possible to perform synthesis and minimization of mathematical models [15]. The first stage of synthesis is the synthesis of unimers, sequences and eliminations [16].

Uniterms:

R(d) – read radar data;

B(m) – construction of a radar placement model;

O(m) – overlaying the model on a map using mapping services;

$V_1(r)$ – visualization of results without taking into account the technical characteristics of radars;

$Q(t)$ – sending a request for radar specifications;
$V_2(r)$ – visualization of results taking into account the radar specifications;
i – the number of iterations to determine the signal coverage level;
$S(s)$ – providing recommendations for optimization of settings;
$D(p)$ – location determination of new stations;
$V_3(r)$ – visualization of the simulated scene.

Synthesis of sequences

The model will contain the following sequences (Fig.3, Fig 4)

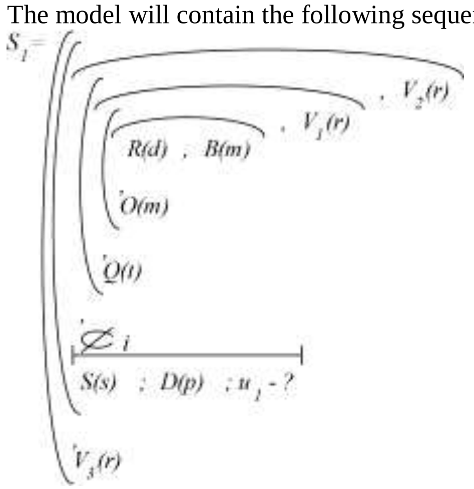


Fig 3. Sequence of description of results visualization in the presence of radar specifications

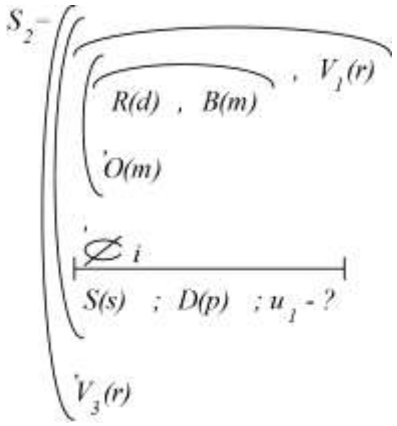
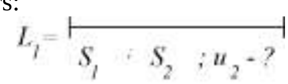


Fig.4. Sequence of description of results visualization in the absence of radar specifications.

Synthesis of eliminations

The model will contain elimination under condition (u_2) for checking the technical characteristics of the L_1 radars:



After substituting sequences S_1 and S_2 for elimination we get the following model:

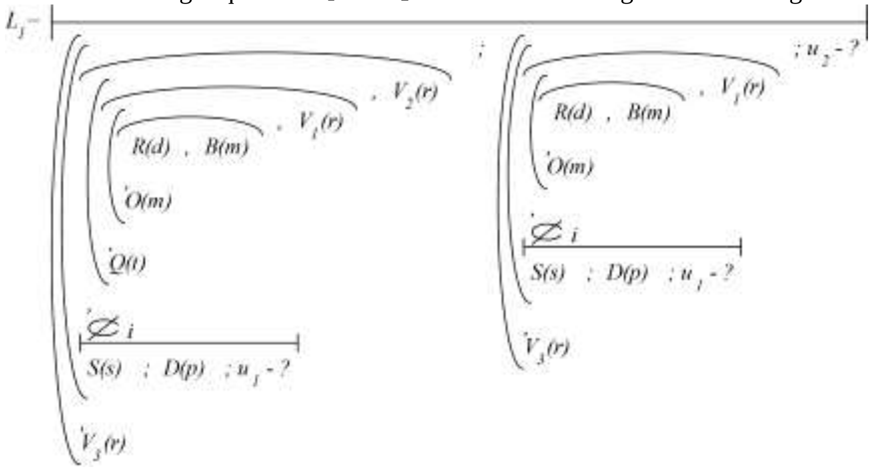


Fig.5. Model was generated

Using the properties of signs of operations of formulas in the algebra of algorithms [17], we derive the uniterms *R(d), B(m), O(m), Q(t),* $V_1(r)$ and $V_2(r)$ for the sign of the elimination operation L_1. The operation of the projected system can be represented in the form of a model (Sequence S_3), which describes the visualization of data on the example of radar systems (Fig.6).

It uses the mechanisms of algorithms algebra: elimination, sequences, uniterms, and cyclic operations. The algorithm algebra was used to synthesize and minimize the number of uniterms of the data visualization model on the example of radar systems.

After the models were built, well-known map rendering tools were analyzed. The most famous resource is Google Maps, which is a suite of applications built on the free mapping service and technology provided by Google [18]. The service is a map and satellite images of the entire world (as well as the Moon and Mars). The business directory and road map are integrated with the service, with search for routes that cover the United States, Canada, Japan, Hong Kong, China, United Kingdom, Ireland and European countries. There is an opportunity to use the service to create their products by third parties. To use the service, it is convenient to use JavaScript to control the functionality of the maps.

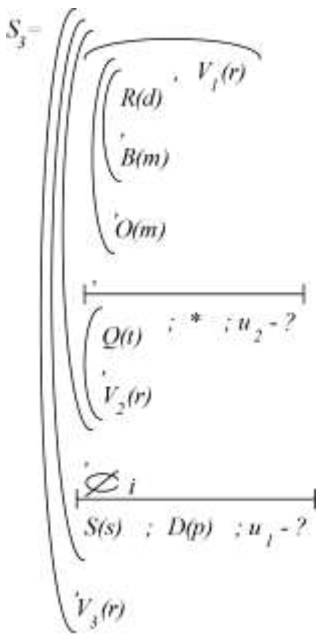


Fig.6. The ultimate model

The Google Static Maps API lets you build static maps using custom URLs. There are also API versions for different types of mobile devices. OpenStreetMap is an open source project to create public world maps by community forces. The project was based in the UK in July 2004 by Steve Coast. The OpenStreetMap resource provides a sliding map interface based on JavaScript from the Leaflet Library (until November 23, 2012 on OpenLayers), which displays the map in real time using tiles generated by Mapnik and tiles from other sources [19]. You can generate maps locally by installing Mapnik and downloading data. Map editing is possible directly in the browser through the editor of iD, an HTML5 application written using MapBox using D3.js. A browser written in Flash is also available through the browser.

The JetBrains WebStorm environment was chosen to develop the online resource. This is an integrated development environment for JetBrains JavaScript, HTML and CSS [20-24]. WebStorm is a specialized version of PhpStorm that contains many plugins for JavaScript. WebStorm's main advantages are: modifying .css, html, js files while viewing the results; HTML5 support cross-platform environment; the possibility of refactoring code. In order to create a data visualization system, it is necessary to implement a class that can be used to solve the above problems. The Figure class was developed to display the necessary elements and has such basic features as: draw yourself, define the space, overlay with other objects. This class has the following subclasses: Character, Ractangle, Circle, Polygon, Line and Icon. They all override the Draw () and Intersect () functions. The MonoFigure class is used for image rendering. Object encapsulation is the goal of the Strategy class model. The key parts in the structure are the objects of the strategy (which encapsulates the various algorithms) and the context in which they operate. The purpose of the Strategy class is to develop strategy interfaces.

The main window of the system with placed radars is shown in Fig. 7.

Fig. 7. Display radars on the map

To display the technical status of the radars, their icons are colored in different colors. Working radars are also complemented by animated circles. In the left corner of the window is a menu and scrollbar with the ability to zoom the map and change position. A graphical representation of the radars of radar action is shown in Fig. 8.

Fig. 8 Radar range

Each radar has its own info window which contains detailed technical information. To open it, it is necessary to click on the appropriate radar station (Fig. 9).

Fig. 9 Radar Specifications

It is also possible to view the radar range, and the 'invisible' radar area for the radar (Fig.10).

Fig. 10 Radar invisible area

The system has the function of determining the optimal locations for the placement of new radars to fill all the 'invisible' areas. The proposed radars are displayed on the map in green as shown in Fig. 11.

Fig. 11 Display the proposed radars

If necessary, the user can change the appearance of the map and turn off the labels to indicate geographical units.

3 Conclusion

As a result of the conducted research, the existing technologies and methods of data visualization that are used in the process of data display are analyzed and the main tasks that arise are shown. In accordance with the algorithms algebra, domain modeling was performed, which made it possible to synthesize and minimize a mathematical model of data visualization on the example of radar station models. The proposed approaches were used in the process of implementing the task using JavaScript in the JetBrains WebStorm environment. Further research will be directed towards the creation of related software modules, their verification and harmonization of functioning.

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