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Goal-Question-Metric method for evaluation of cartographic functionality in GIS software

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Abstract.
GIS software supports creating cartographic output in various qualities. Objective evaluation of amount and quality of cartographic tools in GIS software is very difficult. Suitable solution for evaluating cartographic functionality is a Goal – Question – Metric (GQM) method which was developed for multi-purpose evaluation of software. This method consists of determination of a Goal, construction of sets of Questions and possible answers. The last step is suggesting the Metric, which consists of weight coefficient for each set of answers.

Authorial team suggested suitable testing groups for cartographic functions in GIS software according to use of cartographic methods. For each group a set of questions and possible answers was created. Every group has its weight coefficient in percentage. The setting of the coefficients of the metric demands expert judgment and careful testing. Developed metric is currently being tested on selected GIS programs.

The biggest advantage of this method is its objectivity and universality for any GIS software which means that more GIS products can be tested and compared with each other in the area of cartographic functionality. This is also a contribution to users of GIS programs. They can compare the software and all its advantages and disadvantages before buying and using it. The research is supported by grant of International Visegrad Fund called „Evaluation of cartographic functionality in GIS software".

Keywords: method GQM, cartography, GIS software, testing, evaluation, map creation

1   Introduction

GIS software supports creating digital and printed cartographic outputs [2]. The cartographic support has various qualities in different GIS software. GIS products are based on their native formats and cartographic functionality is closely related with native format. Furthermore, newer version of software has new added cartographic functions. Objective evaluation of amount and quality of cartographic tools in GIS software is very difficult. The first suitable evaluation method is simple recording accessible or missing cartographic functionality by Yes or No indicator. Example of this method is in Table 1. Disadvantage of this type of evaluation is no final numerous or quantitative result, which could be used for comparing two or more GIS software [4, 5].

Table 1. Example of evaluation by Yes/No indicator

Cartographic functionality	Indicator (Y/N)
Quality express by line symbol	Yes
Quantity express by line symbol	Yes
Automatic digital scale	Yes
Optional offset of label for point feature	No
Curve labels according line feature	Yes

The second type of evaluation is star method [3]. Every aspect of cartographic functionality is evaluated from one to five stars, where one star is the lowest rank and five starts is the highest. The advantage of this evaluation method is receiving total score (Table 2). However, it is necessary to set the condition for getting one star, two stars etc. Otherwise this method would be very subjective.

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Table 2. Example of star method

Cartographic functionality of labeling	Number of star
Parameters of typeface (family, face, size)	*****
Setting of label position according feature	***
Lead line	****
Optional offset of label from feature	***
Letter interlay, vertical spacing	**
More text style for the same layer	*****
Total score	22 / 30

2   Goal-Question-Metric method

The Goal – Question – Metric (GQM) method was developed for multi-purpose evaluation of software. It is designed by Victor Basili at University of Maryland, College Park and in Software Engineering Laboratory in Goddard Space Flight Centre NASA. This is a system of questions and simple answers for evaluation of properties. GQM defines a measurement model on three levels [1]:

- ***Conceptual level*** (goal)

A goal is defined for an object for a variety of reasons, with respect to various models of quality, from various points of view and relative to a particular environment.

- ***Operational level*** (question)

A set of questions is used to define models of the object of study and then focuses on that object to characterize the assessment or achievement of a specific goal.

- ***Quantitative level*** (metric)

A set of metrics, based on the models, is associated with every question in order to answer it in a measurable way.

GQM method was used for evaluating Open Source Software (OSS) for GIS and Remote sensing under project CASCADOSS. Project CASCADOSS is European project for support spreading OSS in the area of natural monitoring [8]. The evaluation was provided in the six areas, they are: functionality, reliability, usability, efficiency, maintainability and portability. Cartographic evaluation comes under area of functionality and our researcher team worked out this part in detail.

3   GQM method for cartography functionality

Research team has suggested the first part of this method - main goals for digital cartographic creation. There are six main goals: map construction, map signs (symbols), map syntax (types of cartographic methods) stratigraphic, component and composition map syntax, cartographic generalization, cartographic conventions [7, 9, 10, 11]. The weights for each of main goals are also suggested. Weight is expressed in percentage. Sum of all weights is equal 100 % (Table 3).The highest weight has the second goal – map symbols (creation and application of point, line and area symbol), it is 30 %. Goal "B Map symbol" together with goal "C Map syntax" have more than 50 %.

Table 3. Overview of main groups of goals

Goal	Percentage
A Map construction	15 %
B Map signs/symbols (sign/symbol stock pattern book, construction of sign/symbol)	30 %
C Map syntax – type of cartographic method	25 %
D Map syntax (stratigraphical, componental and compositional)	15 %
E Cartographic generalization	10 %
G Cartographic convention	5 %
Total	100 %

Every main goal consists of partial goals. Some partial goals consist of more detailed goals. It is also necessary to set weight for partial goal. For example main goal "B Map symbols" has three partial goals. First of these goals "1. Symbols" consists of other three detail goals 1.1, 1.2 and 1.3 (Table 4).

Table 4. Partial goals for goal "B Map symbols"

Goal	Percentage	Percentage
1. Symbols		92 %
1.1 Figural symbol	34 %	
1.2 Line symbol	33 %	
1.3 Area symbol	33 %	
2. Map morfography – compound of symbol		4 %
3. Metadata of symbols		2 %
Total for B Map symbols		100 %

The second level of GQM method is construction of questions and answers. For example: "Is it possible to choose figural symbol from predefined pattern book?". Answer is "Yes" or "No". GIS software gets 0 or 1 point according to this answer. Some of the questions have more than two answers. For example question "How many figural symbol are in predefined pattern book?" has three answers: 1 – 5 symbols, 6 – 20 symbols, more than 20 symbols. According to answer GIS software gets 0, 1 or 2 point. Point score is then recalculated to percentage (Fig. 1). Preparing detail goals, corresponding questions and answers are most laborious part of GQM method. Setting weight for every level is a result of expert estimation.

Toto je ukázka přepočítání v Excelu:

GOAL	QUESTION	ANSWER	PERCENTAGE
D-MAP SYNTAX: 2. Scale bar (max.18 % goal D)			3,70
G: Graphic scale bar (max.15 %)			
1 M: 0 - no (manual creation) 1 - yes	Q: Is possible automatic create and put graphic scale to map?	1	6,7
G: Predefined shape of graphic scale (max. 10 %)			
2 M: 0 - no 1 - 2 shape 3 - and more	Q: How many shapes of scale bar are available?	2	20,0
G: Units of graphic scale bar (max. 10 %)			
3 M: 0 - no 1 - yes	Q: Is possible set unit of grafic scale?	1	10,0
G: Division of scale bar (max. 10 %)			
4 M: 0 - no 1 - yes	Q: Is possible set division of scale bar?	1	10,0
G: Possition of labels (max. 10 %)			
5 M: 0 - no 1 - yes	Q: Is possible set possition of labels for graphic scale bar? (under or above scale bar)?	0	0,0
G: Numeric scale bar (max.15 %)			
6 M: 0 - no 1 - yes	Q: Is possible automatic generate and put numeric scale to a map?	0	0,0
G: Parameters of numeric scale (max. 10 %)			
7 M: 0 - no 1 - yes	Q: Is possible set parameters (size,...) of leters of number?	1	10,0
G: Dependence scale bar on map scale change (max. 10 %)			
8 M: 0 - no 1 - yes	Q: Does change graphic or numeric scale automatic according change of scale of map window?	1	10,0
TOTAL SCORE			**66,7**

Fig. 1. Example of MS Excel sheet for evaluating scale bar

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4   Usage of method

The final aim of this research project is to suggest a complete method for objective evaluation of any GIS software in general. The goals, questions and answer are arranged in Microsoft Excel sheet for practical usage. The advantage is automatic recalculating points to percentage and recalculating sum of partial goals to main goals of method.

The main aim of research is not testing large amount of GIS software and make up final order of GIS software according to cartographic functionality. The result of testing is dependent on testing persons experience with concrete software. But not only common experience with using software and also deep experience with creation of cartographic outputs have influence to evaluation. It is possible to do cross validation of evaluation by more users for the same software. Our team tested both commercial and open source software. We tested GIS desktop applications ArcGIS Map, MapInfo Professional, AutoCAD Map 3D, Kristyna GIS, JanMap, IDRISI, Quantum GIS and others. This method is possible to use for new version of the same software and reevaluate cartographic functionality of software. It is also possible to used this method not only for GIS desktop applications but also for GIS applications for GIS map servers and GIS software for pocket PC or mobile devices.

There is also danger of not understanding of question in testing method. We prepare to supplement helps and explanations with demonstrating pictures.

5   Accessibility of method

The research is supported by grant of International Visegrad Fund called „Evaluation of cartographic functionality in GIS software". Web pages http://www.geoinformatics.upol.cz/app/visegrad [6] have been created for basic information about project. There is also possible to download MS Excel file with prepared method for free utilization by any user.

We plan to prepare language mutations of this method arranged in Excel sheet. We have started with Czech and Slovak language version. English version of the method is planed to be prepared in the end. An edition of book is also planed. It is important for usage of this method in other countries by other users.

We also suppose to refine goals, questions and metrics after using this first version of method. If there are new modern features in cartographic methods in the future, we will include them in our method as new goals and questions. We have already included the latest methods e.g. 3D symbol and animation symbol for point, line and area feature in this version of method.

The suggested GQM testing method for cartographic functionality will be universal for any GIS software in the end. It will be free to use by any GIS user before using concrete software for cartographic output or before buying software. The biggest advantage of this method is its objectivity and universality for any GIS software which means that more GIS products can be tested and compared with each other in the area of cartographic functionality.

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