CO-053

BERTIN'S GRAPHIC PROCESSING IN THE CITY MAPS CONTENT ANALYSIS

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ABSTRACT
The article presents classification of selected European city maps thematic content. The thematic content was analyzed using Bertin's graphic processing method. As the result of classification five groups with similar city maps content were distinguished.

KEYWORDS
city map, thematic content, Bertin's graphic processing method

1. INTRODUCTION

Modern cartography is dominated by problems related to the use of computer technology. At the same time it becomes more common, that this technology is only the efficient tool and while extending possibilities of cartography it did not change the essence of maps and their basic functions. Such approach can be related to treating map as a social product, which serves society for referencing to the world (E. Casti, 2005) and creates specific knowledge about surroundings and global space, as well as presents its identity (J.B. Harley, 1989). W. Żyszkowska (2005) mentions that "maps should be treated not only as the effect and tool for studying reality, but also as an artefact, i.e. product of human mind, which reflects social and historical situation".

Social, political and economic determinants of cartography are clearly visible in concept and content of city maps. These maps are typical example of rapid dissemination and hence increase in significance of cartographic presentations. Last years of XX century brought an important changes, concerning richness, diversity, graphic level and level of detail of city maps. This effect is distinct especially in countries of Central and Eastern Europe. It is a result of political transformations of the beginning of 1990s., which caused abolishment of censorship and introduction of free-market economy. This may be considered as a cartographic breakthrough in the representation of cities in the considered region. Some, however smaller, changes may be observed in the West. It is related to higher political stability of this region and wider usage of conventional, verified solutions (P. Martyński, W. Ostrowski, 2003).

Taking into account an importance of city maps among other cartographic products it seems surprising, that there are no analyses helpful in finding answers to the following questions: what are the determinants of thematic content of city map? Is it possible to speak about national (or over-national) styles, considering diversity of thematic content? Which objects and characteristics of city space are presented commonly on each map, regardless of geographic location of the presented area? Do city maps reflect character of the presented city, or there are no important regional differences?

Author of the paper searches for the answer to above stated questions via extended analyses of thematic content of selected city maps. The analyses contains well established processing method such as Bertin's graphic processing as well as custom developed content classification.

2. INCREASE OF IMPORTANCE OF CITY MAPS

The development of mass and individual tourism, as well as ever-increasing migration for non-tourist purposes (industry, business, conferences, etc.) further the purpose and importance of city maps and caused higher demands on these cartographic products. Development of computer technology and Internet decreased costs and made city maps preparation and production more efficient, extending also forms of their usage (analogue maps, internet, mobile cartography). At last, higher demand on city maps was also created by rapid urban development, which resulted in large increase of urban areas. As a result of all these changes city maps became presumably the mostly often used cartographic source of information, applied by tourists, city visitors coming in non-tourists purposes, as well as by city inhabitants.

These civilization changes, especially intensive in second part of twentieth century, caused increase of social demand on city maps, as well as increase of their diversity. They also contributed to city maps' content enrichment, particularly by tourist, recreation and service elements.

3. SELECTION AND PREPARATION OF CARTOGRAPHIC MATERIAL FOR ANALYSIS

After preliminary review of several hundreds of city maps originating from 30 European countries, 50 maps from 20 countries were selected for further analysis. In order to ensure high comparability, the following criteria played an important role, while selecting the cartographic material:

- Prestige and size of city. City maps presenting only large urban centres were selected. It was implied by a fact, that in such centres there are many objects, which do not exist in small towns (like concert halls or governmental buildings). Comparison of large city and small town would give non-reliable results and would lead to wrong conclusions, therefore maps of capital cities were mostly selected (fig. 5).
- Publisher. For European city maps content analyses, city maps elaborated by national or international companies, originating from the country where city is located, were studied.
- City maps' validity. Taking into account dynamics of cartographic market only recent city maps, issued after 2000 (majority even after 2005), were analyzed .

The gathered cartographic material was very comprehensive and diversified, what made its analysis more difficult. It is worth to mention that city maps' content analyses were performed by taking into consideration not only the map legend, but the whole map canvas. 354 types of objects were distinguished on the analyzed maps. These 354 features were next divided into 18 groups, which were in turn joined into six main categories.

Grouping content's elements into categories and sub-categories puts in order the collected material to some extent, but still did not allow to determine similarities of content's between maps. It is not sufficient just to collect data, in order to arrive at a decision. Items of data do not supply the information necessary for decision-making (like grouping maps according to their content). What must be seen are the relationships which emerge from consideration of entire data set of data. In order to observe these similarities, it was indispensable to segregate data in such a way, to make mutual relations visible. For this purpose method of graphical data organizing proposed by J. Bertin was applied. It enabled to segregate content of the analyzed city maps.

4. BERTIN'S GRAPHIC PROCESSING METHOD

Preparation of two-dimensional binary matrix, with columns representing city maps and rows representing content's elements, was the first stage of data processing (segregation; J. Bertin, 1967). In every cell value "1" was put, when content's element appeared on city map, whereas "0" when it was not present. In this way the matrix containing all content's elements presented on analyzed city maps, has been prepared.

Data organized in the form of binary matrix revealed both, content's elements presented commonly on city maps and those existing (appearing) rarely (on single maps). Both element types cannot be treated as a basis for further classification, due to their common or sporadic appearance. Hence it was necessary to assume classification thresholds, which would exclude elements not usable in the course of classification. It was assumed, that these thresholds are 80% and 10%, respectively. Content elements existing on more than 80% of maps and those under 10% are not taken into account at further stages of segregation.

As a result of the performed preprocessing of map contents, 3 separate groups of features presented on city maps were distinguished. First group includes commonly appearing objects, i.e. on above 80% of analyzed city maps (they are called common elements); 17 content's elements belong to this group (see, tab. 1). They are treated as a basis of each map, which is further extended with other elements. These elements are independent from richness of map content and thematic level.

Table 1. Content's features appearing commonly on European city maps

No	Content's features	Sub-category	Category
1	Main streets	Road and street network	Road network and infrastructure
2	Secondary streets		
3	Other streets		
4	Paths		
5	Parking lots	Road infrastructure	
6	Railway lines	Public transportation	Public transportation
7	Railway stations		
8	Subway stations		
9	Forests		Land use, built-up areas and topographic objects
10	Parks	Land use	
11	Cemeteries	Built-up areas	
12	Built-up areas		
13	Public buildings		
14	Christian churches	Sacred objects	Services
15	Museums	Culture objects	
16	Hospitals	Health service objects	
17	Universities	Education objects	

Second group consists of objects regarded as a basis of diversity of the analyzed maps. They are called the classifying elements. There are 99 such objects and their number changes on particular maps, e.g.: from 10 (city map of Rome) to 56 (city map of Warsaw). They appear in all analyzed cities physically, but are not always presented on maps, therefore can be treated as a basis for diversification of European city maps thematic content. Objects such as one-way streets, pedestrian zones, police stations, post offices, hotels, restaurants or swimming pools may serve as the examples.

Third, the most numerous group, contains objects (called characteristic elements) shown only on a single map or on maps published in one country. There are 238 such elements, i.e. 67% of all elements distinguished on analyzed maps. This group contains objects, which usually exist in cities, but most often do not appear on maps (e.g. limited traffic or parking zones, shopping streets, photoradars, skyscrapers), as well as those, which are characteristic only for selected cities (e.g. lighthouses, castles, flood routes, windmills, toboggan tracks, vineyards). Figure 1 shows the distribution of the features within aforementioned groups for selected city maps.

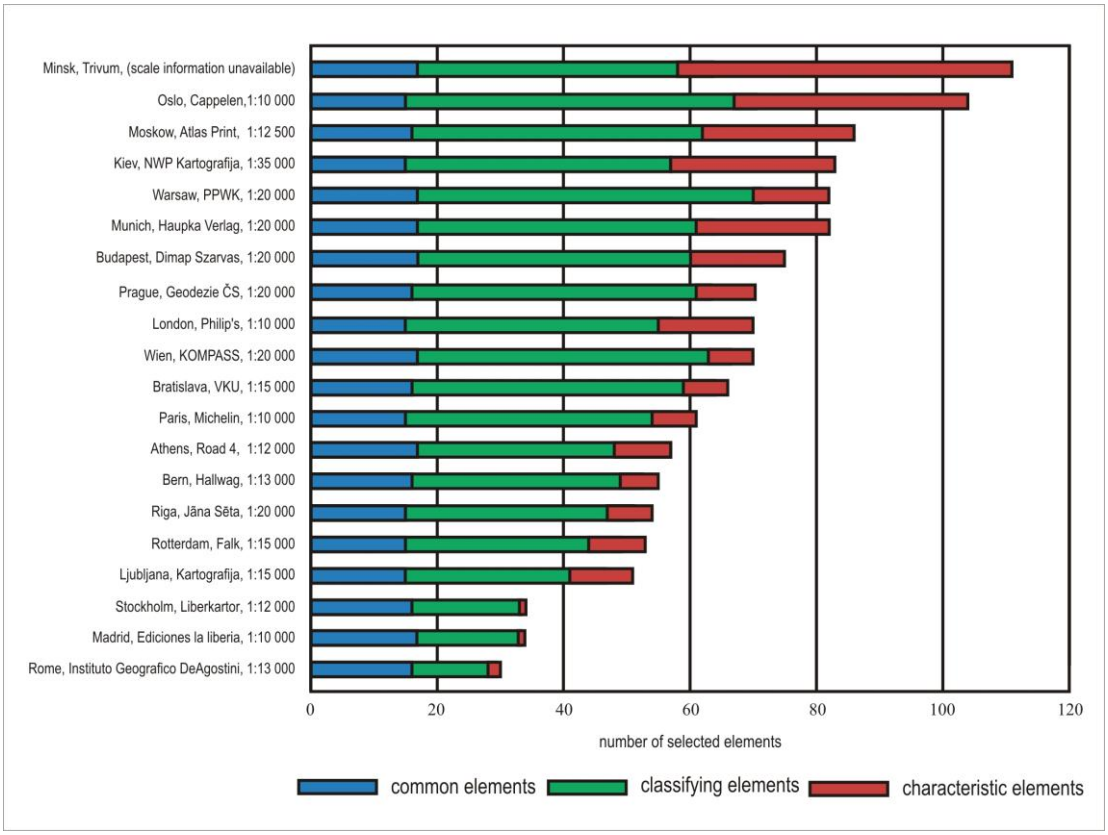

Fig. 1. Distribution of the features within 3 groups for selected city maps.

After eliminating common and characteristic elements, 99 content's elements remained for further analyses. They were a basis for segregation and than for classification of the European city maps content. It should be noted that order of appearance of content's elements in rows and city maps in columns had no impact on result of segregation using Bertin's method, therefore input data in both, rows and columns, were arranged in alphabetical order. The input matrix is presented in figure 2.

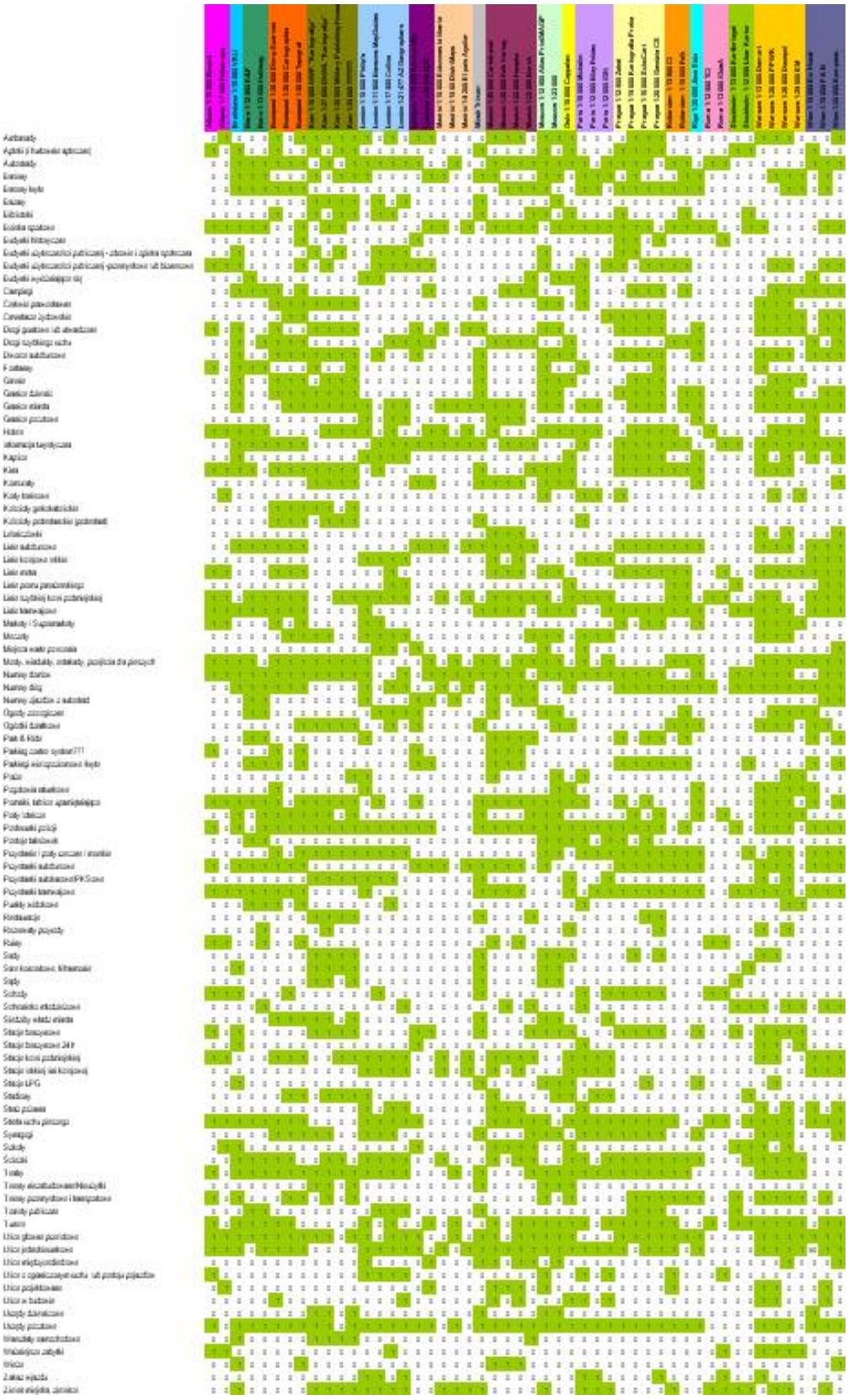

Fig. 2. The input matrix showing features presented on analyzed city maps.

Organization of input data in the form of binary matrix allowed getting straightforward information on the selected city map content richness, furthermore comparing different maps with respect to their thematic content. On the other hand, data relations revealing groups of maps with similar thematic content were not visible. Hence, the next step of work was aimed at such data sorting that would make similarities visible.

Graphical permutation of rows and columns of input matrix, in order to obtain uniform groups in output matrix, was a basis of data segregation using Bertin's method. Uniformity is defined as a set of maps containing the same content's elements. At preliminary phase of processing the succeeding rows are compared in matrix and segregated according to maximum similarity. As a result of this operation, position of selected matrix rows is changed, while columns remain unchanged. Next matrix is divided into independent columns (with changed order of elements), which are also compared and rearranged according to maximum similarity. In this way position of selected columns is also changed. As a result output matrix, which reflects relations existing between data (J. Bertin, 1981), is obtained (see fig. 3).

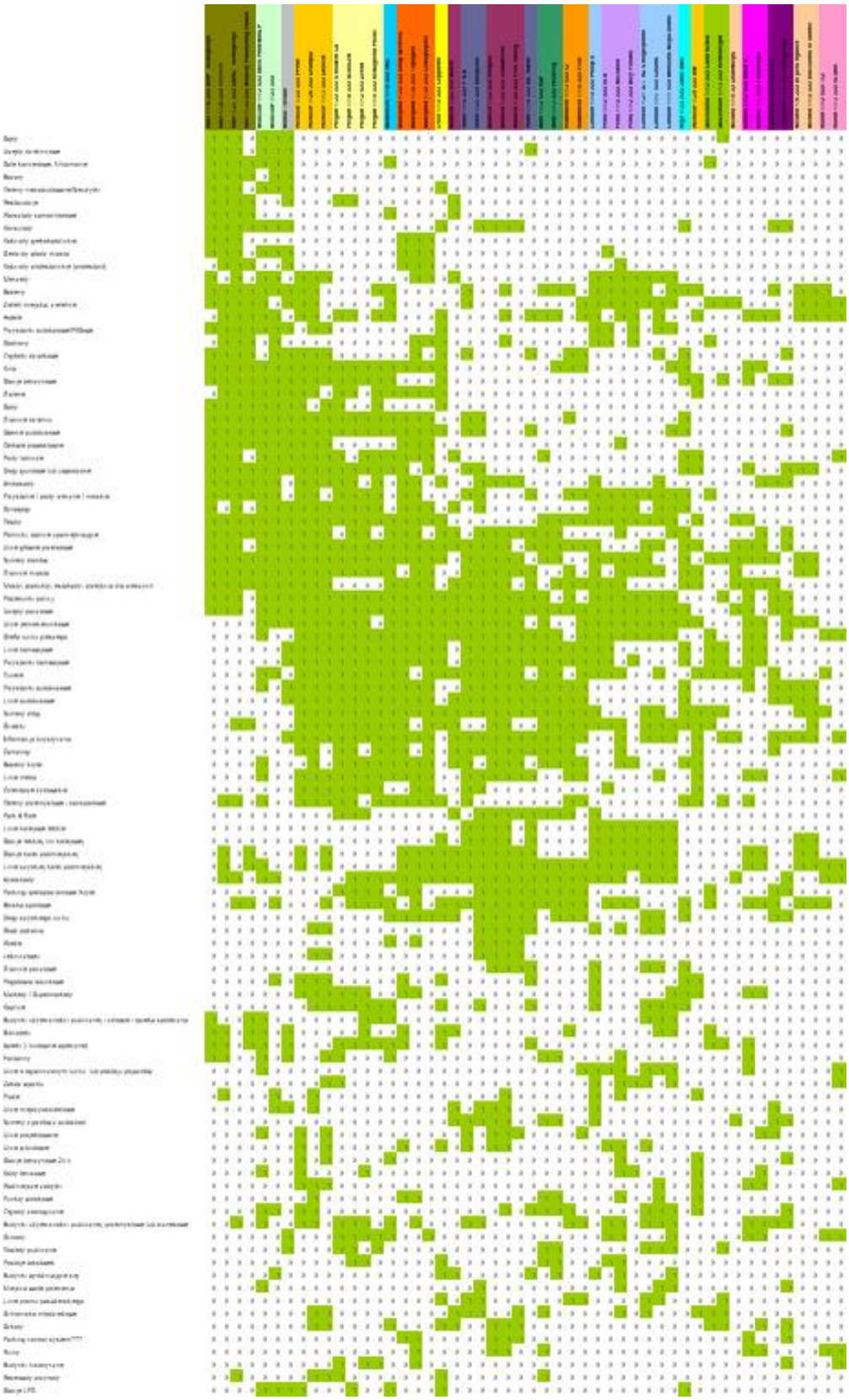

Fig. 3. The output matrix obtained after Bertin's graphic processing.

For segregation of both, rows and columns, the same computational algorithm is used. The main aim of the algorithm is to calculate similarity between two compared vectors of data (two selected rows or columns). Similarity is proportional to logical conjunction of the element of these vectors. Due to possible different number of elements appearing in each vector (numbers of entries denoted as "1") logical conjunction itself is not reliable and needs to be normalized. Normalization is done through calculation of logical disjunction

of compared vectors. Resultant similarity of two compared vectors is calculated as their logic conjunction divided by logical disjunction. At the applied method of data reorganization iterative comparison of succeeding vectors and positioning them according to maximum similarity, with respect to previously selected, was used. Initial vector is selected and its similarity to each succeeding vector in the input matrix is calculated. Vector with the highest similarity is selected and placed next to the one, which served for comparison. At the consecutive step the remaining vectors are compared to lately selected one. Again, vector with highest similarity is chosen and placed next to that, which served for comparison. The procedure is repeated until all vectors are arranged in proper order. As a result, the output matrix with most similar neighbouring vectors (rows or columns) is formed. The similarity covers number and spatial arrangement of data. It should be noted, that change of position of vectors (rows or columns) in matrix does not change thematic content of data.

5. CLASSIFICATION OF THEMATIC CONTENT OF EUROPEAN CITY MAPS

Classification of city maps according to their content was the further stage of data processing. The matrix processed using Bertins' method served as the input data. The aim of this stage was to separate areas with uniform set of data from the input matrix. In case of matrix containing information on city maps in columns and content's elements in rows conducted classification allowed isolating groups of maps with similar sets of features.

Classification algorithm searches the input matrix for the largest areas containing the defined number of features. This number is determined through so-called acceptance coefficient. This coefficient is defined as a ratio of entries denoted as "1" to all entries appearing within studied area. Acceptance coefficient was set to 0.8 – i.e. in the currently analyzed window at least 80% of all matrix fields had to reach value "1". In the performed calculations minimum size of selected area was assumed to be 4 columns and 3 rows, representing 4 city maps and 3 elements, respectively. The applied calculation algorithm passes through input matrix iteratively, searching for areas fulfilling the assumed coefficient, starting from maximum size calculation window (size of window is the same as size of input matrix), and then decreasing window size by 1. It should be mentioned, that the decrease of window size is not done simultaneously in two dimensions. First number of calculating window columns, leaving number of rows unchanged, is decreased. When minimum size of columns is reached, number of rows is decreased by 1 and number of columns is set to a maximum value again. At the consecutive run number of columns is decreased to a minimum value.

Algorithm is repeated until the analyses with the use of the smallest window is performed. In case of finding an area fulfilling acceptance condition a given area is marked and excluded from further calculations, while computations in the remaining parts of matrix are continued. Input matrix with marked areas (with different size), which fulfil acceptance condition, is the result of this stage of data processing. Further processing aim was to select groups of city maps with as many as possible features they have in common. Defined groups are shown in figure 4.

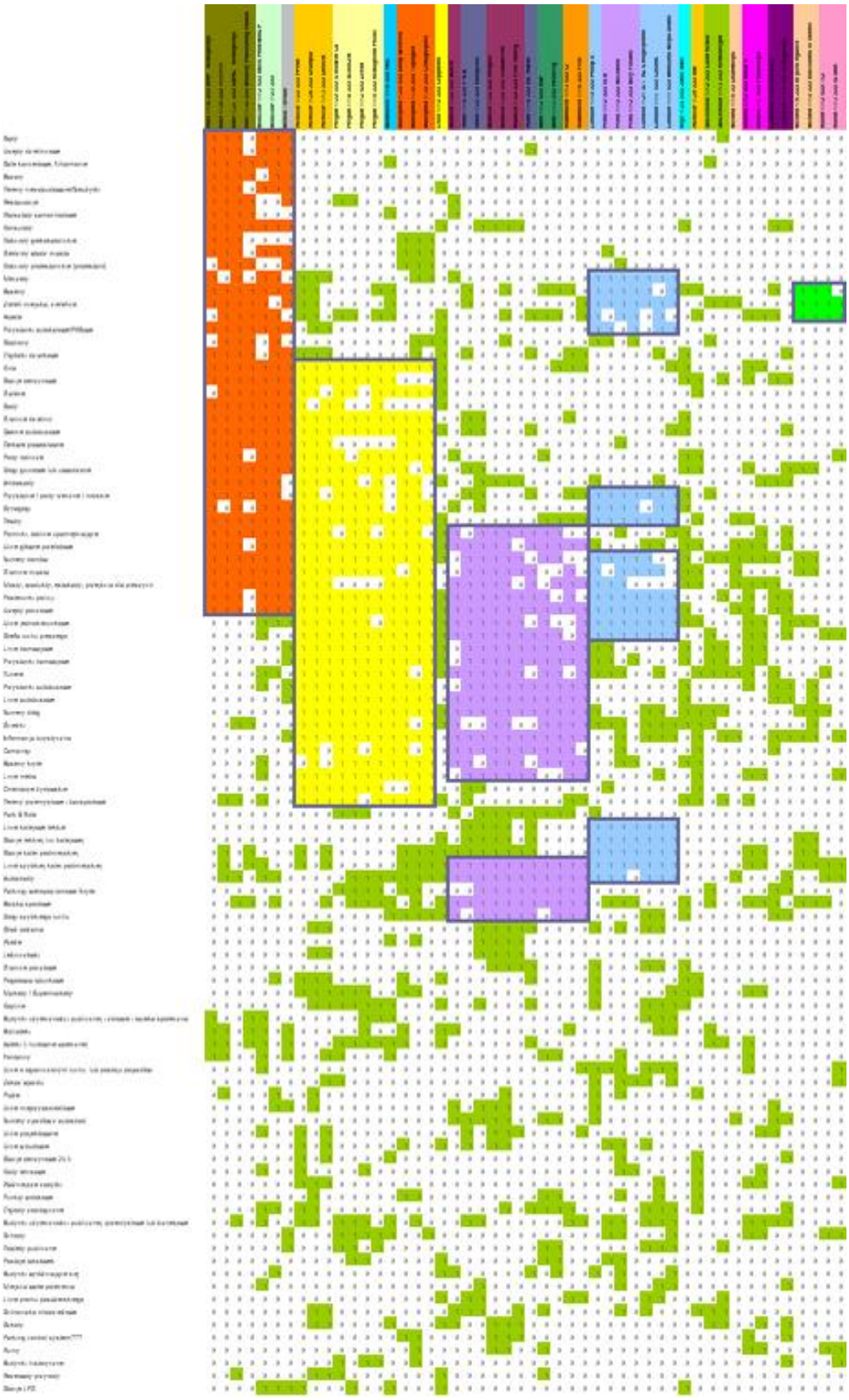

Fig. 4. The output matrix with classified groups.

6. RESULTS OF CLASSIFICATION OF EUROPEAN CITY MAPS ON BASIS OF THEIR THEMATIC CONTENT

The conducted analyses enabled to distinguish five groups of city maps (see fig. 5), which reveal similarity considering their thematic content. Five cities have maps with so diverse thematic content, that they cannot be assigned to any of the distinguished groups.

Fig. 5. Geographical distribution of classified groups.

Group 1

This group is formed by maps of Italian and Spanish cities. These cities belong to the most attractive in Europe from tourist point of view, however thematic content of their city maps is the lowest from all examined maps. Commonly existing content's elements were supplemented only with additional information on roads and public transportation. On the average only 29 content's elements are distinguished on these maps, which is far under European average (59).

Group 2

French and British city maps are characterized by more rich thematic content, than those in group 1. On the average there are almost 60 elements on these maps, which is close to European mean. It should be mentioned, that number of distinguished elements on British maps is slightly higher than on French ones. Presentation of such objects, as information for motorized users, multi-religious places of worship and selected cultural features is characteristic for this group of maps.

Group 3

This group contains four countries: Austria, Germany, Switzerland and the Netherlands. The most rich thematic content in this group is represented by German city maps, which are somewhat similar to maps of Central Europe. Number of the presented elements distinguished on German city maps is slightly higher than European mean, in case of Austrian maps is equal and in case of Swiss and Dutch maps slightly lower than mean. Wide information on public transportation and similar presentation of sport and recreation objects is characteristic for this group of maps.

Group 4

This group is formed by Poland, Czech Republic, Slovakia and Hungary. Number of features distinguished on city maps exceeds European mean. The richest thematic content in this group may be found on Polish city maps (with average equal to 73 elements). Maps in this part of Europe are characterized by similar, rich way of presentation of public transportation, which is derived from German and Austrian maps (P. Martyński, 2006). Maps from Central-Eastern Europe include more service objects than those from the West, but less than maps of cities from former Soviet Union. They were enriched by the selected services for motorized users, detailed classification of objects of religious worship, culture objects and sport-recreation objects.

Group 5

City maps from former Soviet Union, when compared with maps from Western Europe, are characterized by wealthier thematic content concerning information on services and administrative divisions. Objects presented on these maps are not presented on maps from other European cities, e.g. seats of authorities, fiscal offices, tax police, diplomatic services, numerous shops, circuses, night clubs, laundries and beauty saloons. Fascination by freedom in map editing and use of technical means caused, that maps published by cartographic companies in these countries are very detailed (as topographic maps) and colourful, using usually symbolic or picture symbols. It should be emphasized, that map of Minsk contains 111 elements, which is the highest number among all analyzed maps.

Maps not assigned to previous groups

Maps of Athens, Ljubljana, Riga, Oslo and Stockholm were not assigned to previous groups, as they differ in thematic content from other city maps.

In this group Norwegian maps are characterized by the richest content. They characterize with similar number of elements as maps of former Soviet Union, but their thematic content is different. Map of Oslo contains lot of information on sport and recreation. There is also abundant information on culture and education objects, accommodation and transportation services. Maps of Stockholm, published in Sweden, have more limited thematic content, comparable to South European countries, as far as number of elements is concerned. Thematic content of map of Riga shows no similarities to other post-socialistic countries. Number of the presented elements and their content is similar partly to Dutch and partly to Swedish maps.

Greek maps are characterized by the richest thematic content among maps published in Southern Europe. Comparing to maps from group 1 they contain more information on road classification, public transportation and services belonging to "culture objects" sub-category. Maps from Slovenia have slightly modest thematic content.

7. CONCLUSIONS

The conducted analyses of thematic content of European city maps allowed answering questions asked at the beginning of the article.

The results from the study show that consequences of recent political history of countries, where maps were published, mainly influenced thematic content of European city maps. Maps designed and published in Western Europe were not disturbed by external factors like censorship, so their cartographic tradition was developed continuously. Therefore they are differentiated as far as thematic content and way of presentation are concerned. On the other hand, their content is limited comparing to maps from Central and Eastern Europe. It is primarily a result of touristic purpose of these maps.

In Central and Eastern European countries decisions concerning thematic content of maps were taken outside of cartography for years. Political factors were crucial for these decisions. "(…) maps have always been about knowledge and power – selecting what to show and how to show it" (D. Dorling, D. Fairbairn, 1997). Hence selection of features to be presented and way of presentation have fundamental significance. That is why communistic regime influenced the thematic content of all maps including city maps. Moreover, the historical conditions greatly formed user needs, as well as cartographic traditions of publishing companies. Presentation of petrol stations on city maps from Central-Eastern and Eastern Europe is the example of forming such tradition. The stations were presented, as their number before political transformation was limited and information on their location was desirable. In this way tradition of showing petrol stations, which is continued despite an increase of their number in recent years, was built.

Maps of cities published in Central-Eastern and Eastern Europe, comparing to those in Western Europe, are usually more detailed. Purpose of these maps is universal – they can serve both tourists or transit drivers and inhabitants themselves.

The conducted analyses of thematic content revealed national and over-national styles existence. Maps, including city maps, reflect problems important for society. Society can express through maps its identity

and describe the surrounding reality (J.B. Harley, 1989), so maps originating from regions with similar history and social-political conditions reveal some analogies in selection of content's elements.

The conducted analyses allowed to distinguish 17 content's features (tab. 1), which are presented on all city maps regardless of the presented region, place of publishing, abundance of content and thematic level. Features, which form a basis of European city maps, present mainly road network and infrastructure, public transportation and land use.

Uniqueness of cities is still a factor which is not sufficiently taken into consideration while preparing city maps. The conducted analyses do not allow confirming relationships between size of cities or their tourist attractiveness and thematic content. Map of London metropolis has limited thematic content, comparing to map of much smaller Oslo. Maps of cities, recognized as tourist attractions, like Rome, Paris, Vienna, London, Prague or Budapest have very diversified thematic content, which is mainly determined by historical factors.

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