A N N A L E S
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN — POLONIA
VOL. LVIII, 10 SECTIO B 2003

Department of Cartography
Institute of Earth Sciences, Mariae Curie-Skłodowska University
Zakład Kartografii, Instytut Nauk o Ziemi UMCS

MIROSŁAW W. MEKSUŁA

The role of animation in the cartographic relay

Rola animacji w przekazie kartograficznym

The cartographic relay, whose advantages had been discerned by the oldest civilisations, has been subjected to permanent improvement. Technical and technological developments (for example the invention of paper, printing etc.) have contributed to its progress as well as to creating and improving the theoretical bases. Reciprocal connections between the level of technology and the progress of the ways of presentation have always been very strong in cartography. This concerns particularly the dependence between the way of the cartographic relay and the medium, which has been used for preserving and disseminating maps. The dependence has become especially clear nowadays, when paper, traditionally applied in cartography, has been supplemented with new information media, such as: film tape, videocassettes, magnetic and magnetooptical memory, CD and DVD disks, the Internet and many others.

Dynamic progress of the new ways of storage and dissemination of information has influenced the possibilities and the range of the cartographic relay in a fundamental way. Since the beginnings of the cartographic relay, until the nineteenth century, the only possibility which cartography had at its disposal was to present a static picture of the world, frequently limited to a description of only one point on the time axis. This situation allows a perfect analysis of some aspects of phenomena, such as distribution, spatial conditions etc. But it also imposes many constraints when the subject of study involves a description of processes, cause-and-effect sequences or a presentation of arbitrary alterations in time. These constraints can be partially declined using a series of statistical maps, showing the successive phases of the progress of the phenomenon, polyphone maps, balance maps or maps of types of dynamics. However, such presentations are always of an indirect character. A direct illustration of the dynamics of phenomena, especially the one related to displacement in space, is only possible with the employment of animated maps (Thrower 1959, 1961; Imhof 1972; Stams 1973; Arnberger 1977).

The effect of animation takes advantage of the phenomenon of an image lingering in memory for a while. In order to obtain the impression of liquidity of movement, the projection of at least 18 images per second (usually about 24) is necessary (Rase 1974). First animation took place in France in 1831, when Joseph Antoine Plateau obtained the effect of movement using a device consisting of two rotational disks with drawings of individual phases (Levitan 1977). This animation antedated the invention of the cinematograph by the Lumière brothers by over 60 years (1895) and the creation of the photographic technique (dagerotype) by Daguerre and Niépce in 1839.

The technique of movement presentation by means of a series of drawings, used by Plateau, hasn't been widely employed and the progress of animation had to wait over 80 years until the cinema technique was created and developed. Constant development of the animation technique began in 1906, when Stewart Blackton built the first animated cartoons in the USA, mainly owing to the Walt Disney film company (Levitan 1977; Campbell, Egbert 1990).

The first animation sequences of cartographic nature were created in the interwar period. Unfortunately, until the mid-fifties, no cartographers participated in the production of the animated cartoons. The first theoretical articles on this subject, discussing the possibilities of applying the film technique in cartography, were published as late as the end of the 1950s. Analyses of the animated cartographic sequences made by Thrower [1961] indicate many features distinguishing the cartographic films from the static map. The most important of these include: lack of the scale (sometimes the time scale appeared), lack of the map graticule, substitution of the legend in a classical form by a voice comment.

This state observed by Thrower was not the result of neglect by the animation creators but simply followed from the specificity of the film transfer. Cartographic animations recorded on a film tape and projected in the cinemas made it impossible to specify a scale, given a variable distance between the screen and the projector. A time scale was added due to the necessity of providing relevant information for the estimation of the speed of the changes (alterations), i.e., the presentation time-actual duration time ratio of the phenomenon. The abandoning of the legend was a consequence of the difficulties to show it in the classic form. It could be projected before the film started, but it was impossible to refer to it during the projection. Simultaneous projection of the map and its legend was practically impossible if we take into consideration the short duration of cartographic sequences. The same pertained to the perception of the legend by the viewer. One of the best solutions to the problem turned out to be supplementing the map with an audio commentary explaining all the current changes taking place on the map.

Thrower (1961) observes the high degree of generality in the content of the film map, which accounts for the illustration of the course of the phenomenon in a very simplified form. Such high generality ensues from two reasons. First of all, it is not possible for the viewer to register a large number of details in a short time. Secondly, developing a large number of map-frames is very expensive and time-consuming.

The first stage of the development of cartographic animation, which was limited to film sequences, lasted until the first half of the1960s, when cartographers gained an access to the computer technology. The first computer maps were a simulation of the classic printed maps (Taylor 1985), but fast development created the possibility of visualisation of large quantities of space and time data, both in a static and an animated form (Morrison 1974). Examples of computer animations typical of the second stage of the development include: a three-dimensional model of population growth in Detroit by H. Tobler, the animation of the influence of lighting direction on shading by D. Douglas, and the animation map of the occupation of the North American Indians' lands by the Government of the USA by S. Hillard (Campbell, Egbert 1990).

The animations created with the application of computers had a definite advantage over the film maps. It stemmed from another kind of medium that was used for recording and presentation of the maps. While the projection of a film map usually holds in integrity not allowing to halt and repeat, the presentation on the computer screen gives a possibility of a considerable interference in the projection of the animation. It has made possible not only halting, retraction, cyclic repetition of whole or parts of the animation, but also changing its rate or performing mathematical calculations in individual map-frames or their groups.

The specification of procedures, which enabled an automatic production of animations on the basis of key frames, was of great significance for the editing of animated computer maps. It ensues from the fact that the data the cartographer very often has at his disposal can only be used to compile maps representing selected time periods. The creative process of animation requires on average the production of 24 maps per one second of animation. As a result, the production of a 1-minute-long animated cartographic sequence is connected with the necessity of making over 1,400 maps. The problem, very difficult in the era of cartographic film, can now be solved successfully using appropriate computer applications. The construction of inter-frames between the frames for which statistical data have been supplied (support-frames or key-frames) is a kind of interpolation performed in time, not in space. Therefore, it can be referred to as time interpolation or "tweening" (Rase 1974; Burtnyk, Wein 1974).

The progress of computer techniques of creating an animation in the 1970s did not find a true reflection in cartographic literature. Amongst very few theoretical descriptions from this period the following deserve consideration: Cornwell and Robinson's works concerning the application of the picture of vectors to the creation of animated maps; Halas, Levin, Hunter and Raise's works working out theoretical bases of the animation and a notion apparatus and also Monmonier and Worth's works dealing with the role of azimuth and scale in the animations.

The turn of the 1970s brought about the third stage of the development of computer animations (lasting up to now). It has brought to emergence relatively cheap microcomputers and personal computers. A considerable decrease in the costs of creating animated maps, an avalanche development of the computer's peripheral devices and means of data storage and distribution, and full use of the Internet, have been breakthrough changes in the development of the computer animation. Perfect hardware and software allowed performing computer animations at an increasingly high level and made it possible to present them not only on the computer screen but also with a variety of projectors.

The development of the computer technology has caused a growth of interest in cartographic animations and has influenced significantly the development of cartographic literature in this field. The common feature of all the theoretical works published in the eighties was abandoning the traditional animation forms, such as a plain animation map with a clearly defined beginning, end and presentation pace, for the sake of interactive presentations and animations, where the map user chooses the method of projection (Tobler 1981, 1987; Allard, Hodgson 1987; Monmonier 1989).

The creating of the cartographic animation requires a different publishing approach than in the case of static maps. An elementary problem is the necessity of converting the huge quantities of input data in order to generate the map-frames, which are necessary for animation. Such problems can be simplified to a large extent by the application of the procedures of tweening, but it is necessary to obtain the data required for the creation of the based-frames and use highly efficient computer equipment. In spite of the considerable development in the way of storing and assembling, these data are relatively expensive and difficult to obtain and the efficient computer equipment is very costly. Certain hopes are raised by the fact of a progressive decrease of computer hardware production costs, accompanied by a steady growth of the calculation power, increasing quantity and advancement of software and the general availability of Internet databases. However, it will take long before we are able to carry out tweening in the real time.

Another serious problem facing the cartographer editing animation maps is caused by the varying approach to the accuracy and the measuring of a map. The accuracy of animation maps depends on the way of their presentation and storage as well. The most approximate as regards the level of graphic accuracy to the static printed maps are maps recorded on a film stock or microfilms. If the film map is presented on a screen, the accuracy of the elaboration depends on the vision system which is used by the devices. Standard TV-picture definition is 525 or 625 lines (standards: NTSC, PAL, SECAM) or 1250 lines on the screen by state-of-the-art HDTV standards. The problem of computer monitor resolution presents itself quite differently. Apart from the functioning standards of VGA (640 x 480), SVGA (800 x 600), XGA (1024 x 768), SXGA (1280 x 1024) and UXGA (1600 x 1200), there are many other picture definitions, varying from below VGA values to higher than UXGA values.

The above-mentioned values refer to the number of lines or points projected on the screen, but not to the actual precision of the picture, which depends on the size of the diagonal of the monitor or the TV set. The same picture definition, which on the screen corresponds to the accuracy of the order of 0.2 mm, grows to a few centimetres when a projector is used and the image is projected on the screen. Generally, it can be claimed that the accuracy of the animation map increases with the growth of the screen definition and decreases with the growth of the diagonal of the picture and its value is from a several to a dozen times lower than for the printed map.

Map measuring and the fidelity of imaging colours are a big problem of computer animations. Geometrical parameters of an image and visible colours depend to a large degree on the monitor model and its calibration. If we take into account the fact that almost every monitor has large possibilities of adjustment and its picture parameters are changing with time of its heating and usage, it is obvious that map-measuring of the map on the screen is difficult to set in constant. This fact, together with the influence of the graphic variables on the correctness map reading, well-documented in cartographic literature, makes the process of editing animation maps very difficult. The future is bound to bring solutions to these problems in the shape of self-calibrating monitors, but at present it is fiction rather than reality.

A very important element in the process of making film maps and animation is maintaining the appropriate map format. If in the case of printed maps the editor has a relatively large freedom in this respect, in the case of film or computer maps he is restricted by the proportions of the screen (most often the proportion of sides averages 4:3). Additionally, the picture on the monitor or

TV screen more often has a horizontal orientation, which can significantly influence the presentation (for example, in the case of areas of large meridian stretch). Solutions to this problem exist in the form of rotational monitors operating in the PIVOT system, which make it possible to change the picture latitude from horizontal to vertical and inversely, yet such devices are expensive and relatively scarce. Despite the above-mentioned impediments, using the animation map has an advantage. It is a significant extension of the graphic capacity of the means of imaging. Inasmuch as on a static map the editor can only apply traditional Bertain's visual variables (in a constant non-variable form for a given element of the map), in the case of an animation map each of the variables can be modified optionally, and transformed into a visual-dynamic variable (Meksuła, Cebrykow 2001). In the future, the application of the visual-dynamic variables will enable a more accurate rendering of the character of the presented dynamic phenomenon in the form of a map, however, at present, this research area remains almost untouched.

When editing an animation map, the time of the presentation should be taken into consideration. This problem, not existing in the case of a static map, becomes very important when we use animation maps for presentation. Research into the reception of TV maps carried out in the USA revealed that the time of the presentation of a single static map should not be shorter than 5 seconds, otherwise the recipient won't be able to read even a very simple map. The time that is needed for perception to take place mainly depends on the sort and content of the map and it lengthens with the growth of animation advancement.

A solution to the problem of the duration of the animation is only apparently easy. The elongation of the time of animation is in practice strictly limited. This results from both high costs of production (each additional second means the necessity of producing another several dozen maps) and emission restrictions (viewing time is often more expensive than the production of the animation). Moreover, longer animations take decidedly more room on the carrier. They are more difficult to send through the computer nets. In the future, solutions to these problems will be searched for in the progress of information vehicles and the speed of transmission, however it concerns only the computer systems, because TV emission of animation, will probably be subjected to restrictions similar to the present ones.

Problem of the duration of the dynamics presentation is practically absent in the case of computer animations projected on the screen, especially if they are of an interactive character. Then, the user can change the rate of the presentation, stop it and repeat it in cycles, wholly or partly. The possibilities of the user's interference grow when the animation is based on the processing of the data from relation databases, although the price of the data and the transmission time may pose a limitation.

The general fascination with the possibilities issuing from the application of computers, particularly in the area of animation, leads to the question whether animation maps, and especially interactive computer maps, can and should be an alternative for static maps? Presently, it is difficult to give a satisfactory answer. Inasmuch as film maps can supplement static maps, showing in a more pictorial but less accurate way the dynamics of the discussed phenomenon, interactive computer animations seem to be a much better way of presentation, since they combine many advantages of both animations and static maps.

It is difficult to predict which means will dominate the cartographic relay. The development of interactive computer animations seems to be the most plausible direction (Baranowski 1996; Kraak, Ormeling 1998). Such animations, using information from the databases and operating in the real time, will most probably become one of the basic research instruments in the future. In spite of many editorial difficulties, labour consumption and high expenses, cartographic animations can become one of the best methods of investigating the phenomena characterised by space and time variability.

REFERENCES

Allard L., Hodgson M. J. 1987: Interactive graphics for mapping location-allocation solution. The American Cartographer, Vol. 14, nr 1.

Arnberger E. 1977: Thematische Kartographie. Westermann Verlag, Braunschweig.

Baranowski M. 1996: Problemy opracowania atlasów w dobie technik komputerowych. [W:] Polska kartografia lat 90-tych. Materiały Ogólnopolskich Konferencji Kartograficznych, T. 18, Warszawa.

Burtnyk N., Wein M. 1974: Computer-generated key-frame animation. [In:] Computer Graphics. Hastings House Publishers. New York.

Cambell G. S., Egbert S. L. 1990: Animated cartography: thirty years of scratching the surface. Cartographica, Vol. 27, nr 2.

Imhof E. 1972: Thematische Kartographie. Walter de Gruyter. Berlin, New York.

Kraak M.-J., Ormeling F. 1998: Kartografia – wizualizacja danych przestrzennych. Wydawnictwo Naukowe PWN, Warszawa.

Levitan E. L. 1977: Electronic Imaging Techniques: A Handbook of Conventional and Computer-Controlled Animation, Optical and Editing Processes. Van Nostrand Reinhold Company. New York.

Meksuła M. W., Cebrykow P. 2001: Komputer a zmienne wizualne. Materiały XXVIII Ogólnopolskiej Konferencji Kartograficznej „Mapa w systemach komputerowych", Szczecin.

Monmonier M. 1989: Visualization of geographic time-series data: a conceptual framework. Annual Meeting of the Association of American Geographers. Baltimore.

Morrison J. L. 1974: Changing philosophical-technical aspects of thematic cartography. The American Cartographer, Vol. 1, nr 1.

R a s e W.-D. 1974: Kartographische Darstellung dynamischer Vorgänge in computergenerierte filmen. Kartographische Nachrichten, 24 sohrgang, Heft 6.

S t a m s W. 1973: Die Möglischkeiten der Kartographie zur Darstellung. Wissenschaftliche Zeitschrift der Technische Univerität Dresden, Bd. 22, H. 1, Dresden.

T a y l o r D. R. F. 1985: The educational challenges of a new cartography. Cartographica, Vol. 22, nr 4.

T h r o w e r N. J. W. 1959: Animated Cartography. [In:] The Professional Geographer. Vol. 11, nr 6.

T h r o w e r N. J. W. 1961: Animated cartography in the United States. Jahrbuch für Kartographie, Vol. 1.

T o b l e r W. R. 1981: Depictingfederal fiscal transfers. Professional Geographer, Vol. 33, nr 4.

T o b l e r W. R. 1987: Experiments in migration mapping by computer. The American Cartographer, Vol. 14, nr 2.

STRESZCZENIE

Pomimo że pierwsze animacje powstały przeszło 140 lat temu, to historia ich wykorzystania do przekazywania treści kartograficznych jest znacznie krótsza. Rozwój animacji kartograficznych można podzielić na trzy etapy, różniące się zarówno sposobem opracowania i prezentowania, jak też ilością powstających map animowanych.

Pierwszy etap dotyczy okresu, w którym powstawały filmy o charakterze kartograficznym. Ilość ich była niewielka, a dystrybucja możliwa jedynie za pośrednictwem kina i telewizji. Jednorazowy, ulotny charakter prezentacji, bez możliwości ingerencji odbiorcy map w ich animację oraz bardzo wysokie koszty i pracochłonność produkcji, stanowiły poważną barierę w rozwoju animacji kartograficznych.

Pojawienie się, w połowie lat sześćdziesiątych XX wieku, techniki komputerowej i wynikające z tego faktu nowe możliwości dały początek drugiemu etapowi rozwoju enimacji kartograficznych. Charakteryzował się on zwiększeniem liczby powstających animacji oraz znacznym postępem w ich redagowaniu. Największe ograniczenia, jakim wówczas podlegał rozwój technik animacyjnych, wynikały z wysokiej ceny urządzeń komputerowych, niskiej mocy obliczeniowej oraz słabo rozwiniętego oprogramowania.

Przełomowy był koniec lat siedemdziesiątych i początek osiemdziesiątych, kiedy to radykalny spadek cen, a w efekcie upowszechnienie komputerów osobistych i dynamiczny rozwój oprogramowania, spowodowały olbrzymi skok zarówno w ilości, jak i w jakości powstających animacji. Trzeci etap rozwoju animacji kartograficznych charakteryzowała dominacja animacji komputerowych. Pomimo wielu trudności związanych z redagowaniem, wizualizacją, pracochłonnością i kosztami produkcji animacji kartograficznych wydaje się, że nie ma innej alternatywy w rozwoju kartografii. Animacje kartograficzne są najlepszym sposobem pozwalającym na bezpośrednie pokazanie jednoczesnych zmian w czasie i w przestrzeni. W efekcie stają się one nieodzownym narzędziem przy badaniu wielu procesów i przestrzennych związków przyczynowo-skutkowych.