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### THE METHODOLOGY OF DATA VISUALIZATION BY MEANS OF ANIMATED GRAPHICS INFORMATION TECHNOLOGY

**Abstract.** Charts offer a convenient visual representation of numerical values. This allows the user to draw conclusions about the relationships between different data series, identify trends in their change, and explore the structural properties of the data series. Visual presentation of data is a means that helps improve the perception of information, and its comprehensibility, allows you to quickly and easily convey your thoughts and ideas to other people who are consumers of information. Physiologically, the perception of visual information is more inherent to humans than other senses' perception of different data types. This helps to increase labor productivity in the data processing. The application of the MS Excel spreadsheet processing system, which is used in most domestic educational institutions on a legal basis, provides a powerful toolkit for data processing, including their visualization. The growing amount of data to be analyzed gives rise to the non-trivial task of graphically presenting it in an easy-to-understand form since displaying all the data often leads to overloading of the diagram, confusion, and, ultimately, incorrect conclusions. This requires using interactive charts that allow to visualization of data in portions. The paper aims to investigate the capabilities of MS Excel for the visualization of large data sets in an easy-to-understand form and to offer a toolkit for the practical implementation of such visualization. The main result of the study is the description of a tool for visualizing large data sets by selecting the required range of data using form controls. The



material presented in the article implements only one of the possible approaches to using a spreadsheet processor in constructing animated diagrams. It does not require special knowledge, in particular, of programming, and can be implemented in the educational process. Examples of practical implementation of the proposed data visualization approach accompany the material's presentation.

**Keywords.** Animated graphics, data sets, dynamic arrays, dynamic charts, OFFSET function, form controls.

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## МЕТОДОЛОГІЯ ВІЗУАЛІЗАЦІЇ ДАНИХ ЗАСОБАМИ ІНФОРМАЦІЙНОЇ ТЕХНОЛОГІЇ АНІМАЦІЙНОЇ ГРАФІКИ

**Анотація.** Діаграми пропонують зручне візуальне представлення числових значень. Це дозволяє користувачеві зробити висновок щодо взаємозв'язків між різними серіями даних, виявляти тенденції в їх зміні, досліджувати структурні властивості серій даних. Візуальне подання даних є засобом, який сприяє покращенню сприйняття інформації, її зрозумілості, дозволяє швидко і зрозуміло для сприйняття формі донести до інших осіб, які є споживачами інформації, власні думки та ідеї. Фізіологічно, сприйняття візуальної інформації більш притаманним для людини в порівнянні зі сприйняття інших типів даних іншими органами чуття. Це сприяє підвищенню продуктивності праці при опрацюванні даних. Застосування системи обробки електронних таблиць MS Excel, яка використовується в переважній кількості вітчизняних закладів освіти на легальній основі, надає досить потужний інструментарій для опрацювання даних, у тому числі їх візуалізації. Зростання обсягів даних, які підлягають аналізу, породжують нетривіальне завдання їх графічного подання у зручній для сприйняття формі, оскільки відображення всього обсягу даних часто призводить до перевантаження діаграми, її заплутаності і, зрештою, до неправильних висновків. Це зумовлює використання інтерактивних діаграм, які дозволяють візуалізувати дані порціями. Метою статті є дослідження можливості системи обробки



електронних таблиць MS Excel з візуалізації значних масивів даних в зручній для сприйняття формі, запропонувати інструментарій практичної реалізації такої візуалізації. Основним результатом дослідження є опис інструментарію для візуалізації великих масивів даних шляхом вибору необхідного діапазону даних за допомогою елементів керування форми. Представлений в статті матеріал реалізує лише один з можливих підходів до застосування табличного процесора при побудові анімованих діаграм. Він не вимагає спеціальних знань, зокрема, з програмування, і може бути просто реалізований в навчальному процесі. Викладення матеріалу супроводжується прикладами практичної реалізації запропонованого підходу до візуалізації даних.

**Ключові слова:** анімована графіка, набори даних, динамічні масиви, динамічні діаграми, функція зміщення, елементи керування формою

**Problem statement.** During data processing, there is always the task of their convenient presentation for processing and visualization of initial data and results. The graphic form facilitates the perception of information as a whole and visualizes its features, trends, and anomalies. Scientists in medicine established [1] that if there is the only text in the instructions for medicines, a person learns only 70% of the information from it. If you add pictures to the instructions, a person will retain 95% of the information.

Visual information is better perceived and allows you to quickly and effectively convey your thoughts and ideas to other people who are data consumers. Physiologically, the perception of visual information is fundamental for a person. Research results [2] state that:

- a person perceives nearly 90% of information through sight;
- 70% of the sensory receptors are in the eyes;
- about half of the human brain neurons are involved in the processing of visual information;
- the brain's cognitive function, which is responsible for the processing and analysis of information, is used 19% less when dealing with visual data;
- a person who works with visual data has a higher performance of 17%;
- the details of visual information are better mentioned by 4.5%;
- visual information is perceived 60,000 times faster than text or numbers.

We agree with E. Tuft's opinion [3] that visualization is a tool for showing data; encouraging the consumer of information to think about its essence and not the methodology of obtaining it; avoiding distortion of what the data is supposed to say; displaying of many numbers in a small space; showing a large set of data in a coherent and unified whole; encouraging the viewer to compare pieces of data;



serving fairly specific purposes: description, research, arrangement, or improvement.

It is known that one of the most common tools for solving data processing tasks is spreadsheet processing software, in particular, MS Excel. A spreadsheet's tabular form of data presentation is quite suitable for storage and processing. Still, a graphic representation of the data, usually implemented in various diagrams, is more appropriate during the analysis phase.

During the education, all participants often have to deal with significant volumes of data and present the results of their processing in a visual form. In particular, such a need arises when presenting the results of scientific research, defending course or diploma theses by HEI's students, explaining the trend of changing values of a dynamic series of large dimensions, etc.

Therefore, issues related to the formation of HEI's student's skills in presenting spreadsheet data in an easy-to-understand form, particularly diagrams, are relevant issues. Their solution will contribute to the formation of digital competence in the context of the formation of computational thinking and the use of information and communication technologies in professional activity.

**Literature review.** Trends in the growth of data volumes to be analyzed give rise to the non-trivial task of graphically presenting it in an easy-to-understand form since the display of the entire amount of data often leads to overloading of the diagram, its confusion and, as a result, to incorrect conclusions. Under such conditions, it is appropriate to display the data in portions, but this leads to the complication of the process of constructing static diagrams or the perception of visualization results. The way out of the situation can be a dynamic data visualization. In combination with means of automating the selection of the required portion of data for constructing a diagram, which is implemented using form control elements, such a toolkit will allow solving the task of data visualization in a convenient form even for users who are not developers of this toolkit.

One of the main directions of using visualization tools is their application in teaching various educational disciplines.

One of the main areas of visualization tools is their application in teaching and learning different training courses. In particular, an investigation [4] presents animated drawings in spreadsheets for physics training. The benefit to students is evident. Instead of looking at still photos in a textbook, they can watch a physical event and see how it happens over time. Paper [5] presents the results of studies in conflict modeling, diplomatic research, trade disputes, electoral processes, and political and legal debates by creating simulations of these situations. The authors of the study [6] have explored the feasibility of using MS Excel, in particular its graphical capabilities, in teaching the basics of statistics and its impact on the attitude of future teachers to the use of statistics and the understandable presentation of data. The study of the possibilities of animated graphics when displaying dynamic processes is considered in the article [7]. The article [8] discusses the effects of using



animated graphs when solving mathematical problems. The authors stated that such tools contribute to developing computational thinking and realizing the STEM education concept. Pamela Liebig, with co-authors [9], investigated the use of interactive graphics in studying biomedical disciplines in training veterinary students. Based on the results of a survey of applicants and teachers of the Institute for Animal Breeding and Genetics, Hannover University of Veterinary Medicine, it was concluded that there is an increase in interest in the content of the relevant courses and a growing desire to increase the number of topics that are taught using animation tools. The use of spreadsheet visualization tools in financial and economic calculations and business analytics is presented in [10, 11].

Thus, based on the results of the review, it can be concluded that the use of computer-animated graphics in learning academic disciplines contributes to students' motivation, increasing their cognitive interest in learning.

**The aim of the paper** is to investigate the capabilities of MS Excel for the visualization of large data sets in an easy-to-understand form and to offer a toolkit for the practical implementation of such visualization.

**Presenting study results.** MS Excel software is included in the basic MS Office package and is widely used in education. Most domestic HEIs have a license to use it, so it does not require additional costs, unlike commercial software products that support animated graphics. In addition, the study of this product is included in the basic training for most of the specialties, followed by the educational process in domestic HEIs, and therefore does not require special knowledge. This makes it attractive for the use of processing various data, in particular dynamic visualization.

Dynamic visualization capabilities are provided in MS Excel by defining source data for the chart as a dynamic array (that is, spreadsheet cell range) that changes both its boundaries and the number of elements. The most straightforward approach is to create an additional data table in which all the columns (rows) are combined into a single column or row. This simplifies the further creation of a dynamic array. This array is created using the OFFSET function of the spreadsheet processing system, which determines the starting point (spreadsheet cell) of dynamic range elements and its length (number of array elements). The dynamic array can be rectangular, containing multiple series of data. The peculiarity of this approach is that the ranges used and created must be named. The Define Names option in the Defined Names group of Formulas tab should be used to do this. In detail, the technology for creating dynamic arrays is presented in particular by references [12, 13, 14].

To create a chart, it is necessary to select an arbitrary part of the dynamic data range constructed and build a static chart. The next step is to choose the graphic object corresponding to the graphical data representation and change the static range to the named dynamic one in the SERIES function that forms the chart, using the Formula bar. To improve the chart's perception, creating a dynamic array of data is recommended to generate the set of categories. To create a user-friendly interface to



choose the initial value and length of the dynamic array, it is advisable to use form controls like Spin Buttons or Scroll Bars. When the original dataset contains values of several indicators, it is necessary to use the Check Boxes to select the indicators you want to display on the chart. If you want to build a chart for only one indicator from their set, it is advisable to use the form controls like Option Button, List Box, or Combo Box. Let us consider the application of the presented approach in practice. Let us suppose we have data about the income of some trading enterprises over the past ten years (Table 1). Graphic representation of the complete data set in the form of a graph is inconvenient because, on the one hand, the chart is too cumbersome to represent all points. When it is reduced in size to a comprehensive view (Figure 1), it becomes unrepresentable. Not all initial points will be displayed when setting a chart size for easy data perception (Figure 2). Therefore, for the convenience of analyzing such data, we create a dynamic chart with an interface to manage reflected data using form controls.

Table 1.

**Initial data to create a chart**

Month	Income. thsd. USD									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Jan	160.3	167.0	155.0	251.8	272,1	287,7	308,4	326,7	353,0	385,5
Feb	161.7	164.1	161.0	232.5	245,6	270,0	286,0	298,6	312,3	335,3
Mar	145.9	183.0	185.7	196.2	232,7	244,7	254,7	269,9	291,9	310,9
Apr	93.6	209.0	188.9	174.5	187,8	213,2	233,6	255,6	269,7	280,5
May	78.4	271.6	203.9	157.3	154,4	173,5	196,5	220,8	247,7	262,5
Jun	52.4	330.9	240.2	142.6	129,6	151,4	165,0	176,0	195,5	218,5
Jul	63.8	326.3	235.1	150.3	132,9	151,1	159,5	173,1	202,5	214,2
Aug	86.5	314.5	216.7	156.6	141,3	171,1	206,1	227,2	230,4	246,7
Sep	93.9	314.0	191.2	194.9	163,3	178,1	193,0	227,8	241,2	254,2
Oct	137.1	303.4	187.2	205.1	183,1	196,1	210,8	240,6	259,6	284,2
Nov	189.6	246.5	156.4	238.9	258,0	271,5	290,8	298,0	331,9	361,8
Dec	249.3	216.0	147.8	270.6	245,8	281,9	291,8	316,4	331,3	336,9

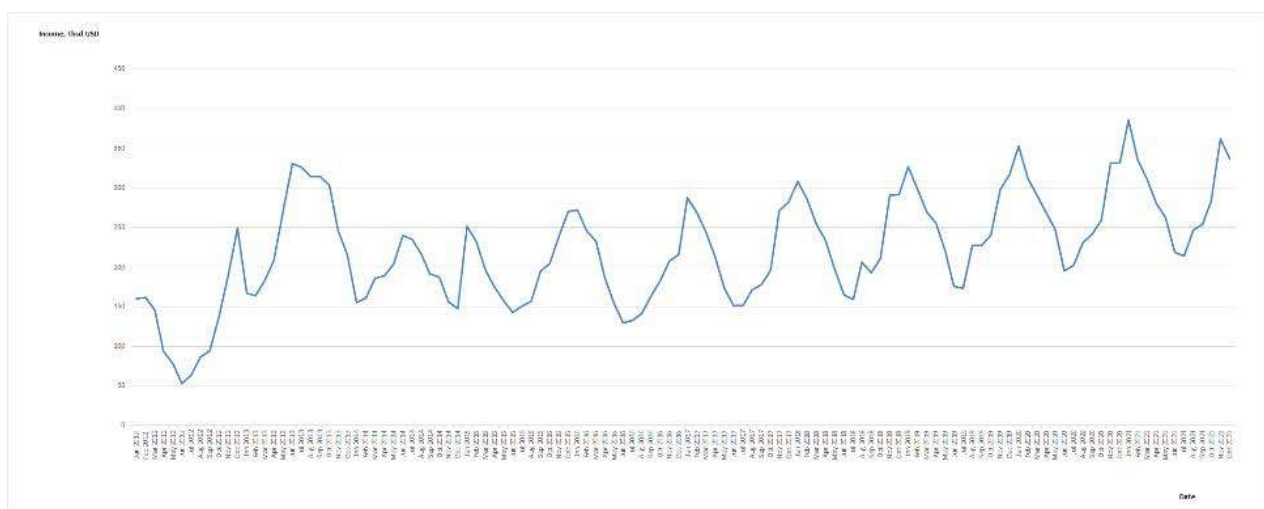


Fig. 1. Displaying all set of data

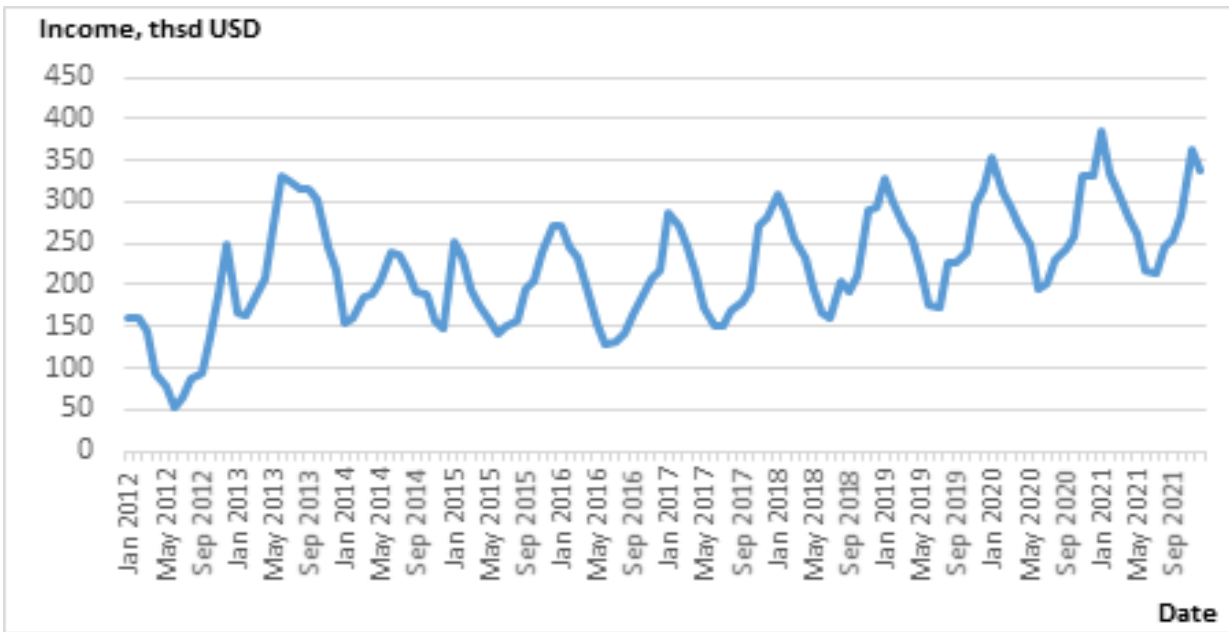


Fig. 2. Displaying data for easy perception

Let's put the initial data in the table with a one-row range form. A fragment of this table is presented in Figure 3. The interface to select the data range to be displayed on the chart contains two scroll bars and is shown in Figure 4.

2																			
3		<b>Initial data for creating chart</b>																	
4	Number	1	2	3	4	5	6	...	115	116	117	118	119	120					
5	Date	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	Jun 2012	...	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021					
6	Profit	160,3	161,7	145,9	93,6	78,4	52,4	...	214,2	246,7	254,2	284,2	361,8	336,9					
7																			
8																			

Fig.3. Presenting initial data in one-row range form

9																				
10		<b>Start value for creatigh chart (date)</b>																		
11		<input type="text" value="Jan 2012"/>																		
12																				
13		<b>The length of the period to plot the chart (month)</b>																		
14		<input type="text" value="8"/>																		

Fig. 4. Interface to select the data range

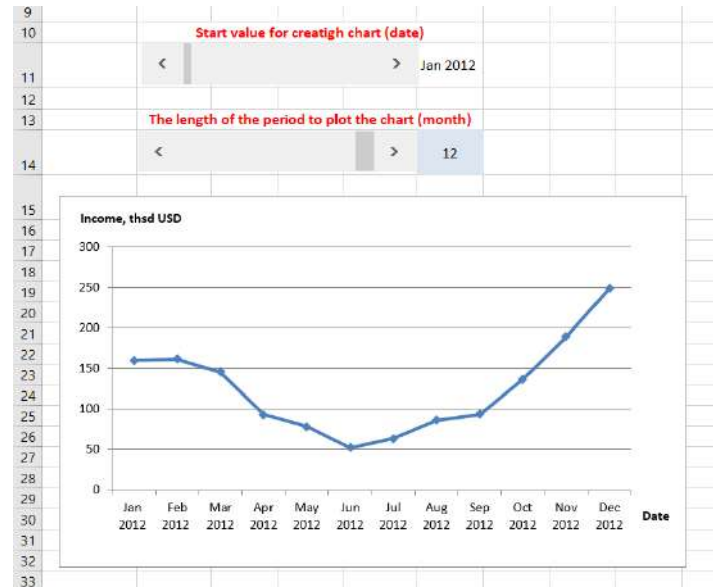
Creating named dynamic data arrays is shown in Figure 5. In this case, they use cells whose change is related to the Scroll bars made. Note that for the first Scroll bar that sets the start date (the start point for the chart), the corresponding numeric value is hidden because it has a supporting role. The result of creating a chart when



the start point coincides with the beginning of the initial data range and the length of the displayed data series is 12 periods is shown in Figure 6.

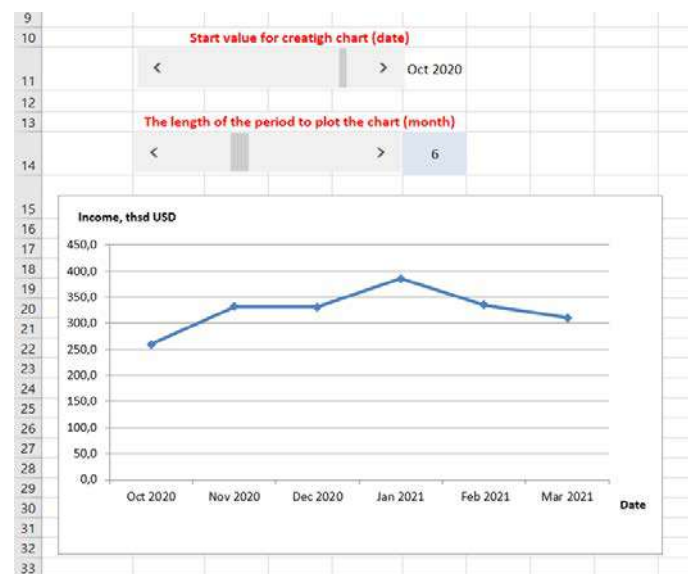
Dyn_Array	{...}	=OFFSET(Dyn_Chart!\$B\$6;0;Dyn_Chart!\$H\$11;1;Dyn_Chart!\$H\$14)
Label	{...}	=OFFSET(Dyn_Chart!\$B\$5;0;Dyn_Chart!\$H\$11;1;Dyn_Chart!\$H\$14)

**Fig.5.** Creating named dynamic data arrays



**Fig. 6.** Chart for the start point coincides with the beginning of the initial data range and the length of the displayed data series is 12 periods

A chart for another value of the starting point and another length of the data series is shown in Figure 7.



**Fig. 7.** Chart for another value of the starting point and another length of the data series



The presented approach demonstrates the convenience of managing data views and the ability to use them in various implementations for the graphical representation of large data arrays in an easy-to-read form.

**Conclusions.** A visualization is a powerful tool for delivering thoughts and ideas to the end-user, an assistant for data perception and analysis. With skillful application, data visualization makes the material comfortable to perceive and sufficiently visual.

Data visualization has advantages over tabular form, in particular focusing on different aspects of the data; analysis of a large set of data with complex structure; reducing the information overload of the user, and keeping his attention; the uniqueness and clarity of the data.

The main research result is a description of the capabilities of a spreadsheet processing system to create and use dynamic charts and develop a managerial interface by using form controls. The study's results can be used in the learning process in the study of dynamic processes, in presentations of large volumes of data, as a business analytics tool, etc.

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