What is a scatter diagram

A scatter diagram shows the relationship between two variables. For example, you might want to compare the speed you drive with the time it takes you to get to work, or to compare the heights and weights of children, or to compare the steam usage in a plant to the outside temperature. This is what scatter diagrams do. Suppose you are a warehouse manager. Overtime is a concern to you since it is something your boss watches closely. There is overtime every day. You have a theory that the overtime is simply caused by the work level – the number of lines that are picked each day in the warehouse. How do you prove your theory? One way is to construct a scatter diagram. You need paired data sets to construct a scatter diagram. So, each day you collect data on the number of lines picked and the overtime. Once you have enough paired data points, you plot the data. The lines picked per day are plotted on the x-axis. The overtime hours - which you think depends on the lines picked – is plotted on the y-axis. An example of a scatter diagram for this situation is given below. What relationship do you see? It appears, that in general, as the lines picked increases, the overtime hours increase as well. This is a positive correlation – one variable tends to increase when the other variable increases. There are three basic correlations that a scatter diagram can identify: positive, negative or no correlation Positive Correlation: as X increases, Y increases. For example, if you are paid by the hour, the more hours you work the more pay you receive. Negative Correlation: as X increases, Y decreases. For example, your heating bill increases as the temperature outside decreases. No Correlation: a change in X does not impact the value of Y. For example, the hours I spend reading have no impact on your heating bill. You can “visually” see these correlations between two variables by constructing a scatter diagram. The relationship may be linear – or it may not be. Of course, there are some statistics you can calculate to determine if the relationship is statistically significant. Our next blog will give a brief overview of those statistics for linear relationships. The scatter diagram above was made using the SPC for Excel software, a simple but powerful package for statistical analysis within the Excel environment A scatter diagram (Also known as scatter plot, scatter graph, and correlation chart) is a tool for analyzing relationships between two variables for determining how closely the two variables are related. One variable is plotted on the horizontal axis and the other is plotted on the vertical axis. The pattern of their intersecting points can graphically show relationship patterns. Edit this Diagram Most often a scatter diagram is used to prove or disprove cause-and-effect relationships. While the diagram shows relationships, it does not by itself prove that one variable causes the other. Thus, we can use a scatter diagram to examine theories about cause-and-effect relationships and to search for root causes of an identified problem. For example, we can analyze the pattern of motorcycle accidents on a highway. You select the two variables: motorcycle speed and number of accidents, and draw the diagram. Once the diagram is completed, you notice that as the speed of vehicle increases, the number of accidents also goes up. This shows that there is a relationship between the speed of vehicles and accidents happening on the highway. Scatter Diagram Correlation Patterns The degree to which the variables are related to each other depends on how the points are scattered over the chart. The more the points plotted are scattered over the chart, the lesser is the degree of correlation between the variables. The more the points plotted are closer to the line, the higher is the degree of correlation. The degree of correlation is denoted by “r”. The following types of scatter diagrams show in the table tell about the degree of correlation between variable X and variable Y. Correlation Pattern X / Y Values Strong Positive Correlation The value of Y increases as the value of X increases. Strong Negative Correlation The value of Y decreases as the value of X increases. Weak Positive Correlation The value of Y increases slightly as the value of X increases. Weak Negative Correlation The value of Y decreases slightly as the value of X increases. Complex Correlation The value of Y seems to be related to the value of X, but the relationship is not easily determined. No Correlation There is no demonstrated connection between the two variables. Strong Positive Correlation Edit this Diagram Strong Negative Correlation Edit this Diagram Weak Positive Correlation Edit this Diagram Complex Correlation Edit this Diagram No Correlation Edit this Diagram Scatter Chart Example: Arm Length on Grade 11 The scatter graph shows information about the height and the arm length of each of 8 students in Year 11. If we see the correlation between the student’s height and arm length exhibit a trend, we can estimate the arm length of a student with a certain value of height given and vice-versa. The chart above shows there is a positive correlation between arm length and height. Edit this Diagram After determining the correlation between the variables, you can then predict the behavior of the dependent variable based on the measure of the independent variable. This chart is very useful when one variable is easy to measure and the other is not. For example, a student in Year 11 has a height of 148 cm, we can estimate the arm length of this student is around 84 cm. Diagram image by MichaÅ‚owski Dominik from Fotolia.com By: Jonathan Lister Updated September 26, 2017 A diagram is a graphic designed to communicate information. This can appear in a variety of ways from the symbol-based "Don't Walk" signs you see on the street every day, to the pie charts that break down cost percentages in the business world. Diagrams provide an alternative means for people to connect with information and process its significance. Diagrams offer a way for your audience or classroom to visually conceptualize the material and engage with it in a way that isn't necessary possible with lecture alone. Certain types of diagrams, such as Venn Diagrams, show the interrelation of concepts by placing interrelated words in overlapping bubbles. This can help students understand lessons that may seem too complicated when communicated in a purely lecture-based teaching situation. A diagram is essentially a picture that communicates information. You can often explain statistical data and other important information, like how a particular system functions, quickly and with less of a strain on resources. Using a diagram is more effective than a narrative-based process. This is especially important in the business world where information constantly disseminates and the need for accuracy, speed and comprehension is paramount. In the bright and shiny world of desktop publishing, colorful presentations that catch the eye can mean the difference between listeners absorbing your information or turning your concept down. A presentation depending heavily on diagrams can both maintain your listener's attention by giving them something engaging to look at and by allowing them to absorb the information in consumable, memorable chunks. A diagram is also helpful in distilling your lesson plan or presentation into simple concepts, which allows your listeners or students to quickly comprehend your outline. A scatter plot (aka scatter chart, scatter graph) uses dots to represent values for two different numeric variables. The position of each dot on the horizontal and vertical axis indicates values for an individual data point. Scatter plots are used to observe relationships between variables. The example scatter plot above shows the diameters and heights for a sample of fictional trees. Each dot represents a single tree; each point’s horizontal position indicates that tree’s diameter (in centimeters) and the vertical position indicates that tree’s height (in meters). From the plot, we can see a generally tight positive correlation between a tree’s diameter and its height. We can also observe an outlier point, a tree that has a much larger diameter than the others. This tree appears fairly short for its girth, which might warrant further investigation. When you should use a scatter plot Scatter plots’ primary uses are to observe and show relationships between two numeric variables. The dots in a scatter plot not only report the values of individual data points, but also patterns when the data are taken as a whole. Identification of correlational relationships are common with scatter plots. In these cases, we want to know, if we were given a particular horizontal value, what a good prediction would be for the vertical value. You will often see the variable on the horizontal axis denoted an independent variable, and the variable on the vertical axis the dependent variable. Relationships between variables can be described in many ways: positive or negative, strong or weak, linear or nonlinear. A scatter plot can also be useful for identifying other patterns in data. We can divide data points into groups based on how closely sets of points cluster together. Scatter plots can also show if there are any unexpected gaps in the data and if there are any outlier points. This can be useful if we want to segment the data into different parts, like in the development of user personas. Example of data structure diameter height 4.20 3.14 5.55 3.87 3.33 2.84 6.91 4.34 … … In order to create a scatter plot, we need to select two columns from a data table, one for each dimension of the plot. Each row of the table will become a single dot in the plot with position according to the column values. Common issues when using scatter plots Overplotting When we have lots of data points to plot, this can run into the issue of overplotting. Overplotting is the case where data points overlap to a degree where we have difficulty seeing relationships between points and variables. It can be difficult to tell how densely-packed data points are when many of them are in a small area. There are a few common ways to alleviate this issue. One alternative is to sample only a subset of data points: a random selection of points should still give the general idea of the patterns in the full data. We can also change the form of the dots, adding transparency to allow for overlaps to be visible, or reducing point size so that fewer overlaps occur. As a third option, we might even choose a different chart type like the heatmap, where color indicates the number of points in each bin. Heatmaps in this use case are also known as 2-d histograms. Interpreting correlation as causation This is not so much an issue with creating a scatter plot as it is an issue with its interpretation. Simply because we observe a relationship between two variables in a scatter plot, it does not mean that changes in one variable are responsible for changes in the other. This gives rise to the common phrase in statistics that correlation does not imply causation. It is possible that the observed relationship is driven by some third variable that affects both of the plotted variables, that the causal link is reversed, or that the pattern is simply coincidental. For example, it would be wrong to look at city statistics for the amount of green space they have and the number of crimes committed and conclude that one causes the other, this can ignore the fact that larger cities with more people will tend to have more of both, and that they are simply correlated through that and other factors. If a causal link needs to be established, then further analysis to control or account for other potential variables effects needs to be performed, in order to rule out other possible explanations. Common scatter plot options Add a trend line When a scatter plot is used to look at a predictive or correlational relationship between variables, it is common to add a trend line to the plot showing the mathematically best fit to the data. This can provide an additional signal as to how strong the relationship between the two variables is, and if there are any unusual points that are affecting the computation of the trend line. Categorical third variable A common modification of the basic scatter plot is the addition of a third variable. Values of the third variable can be encoded by modifying how the points are plotted. For a third variable that indicates categorical values (like geographical region or gender), the most common encoding is through point color. Giving each point a distinct hue makes it easy to show membership of each point to a respective group. Coloring points by tree type shows that Fersons (yellow) are generally wider than Miltons (blue), but also shorter for the same diameter. One other option that is sometimes seen for third-variable encoding is that of shape. One potential issue with shape is that different shapes can have different sizes and surface areas, which can have an effect on how groups are perceived. However, in certain cases where color cannot be used (like in print), shape may be the best option for distinguishing between groups. The shapes above have been scaled to use the same amount of ink. Numeric third variable For third variables that have numeric values, a common encoding comes from changing the point size. A scatter plot with point size based on a third variable actually goes by a distinct name, the bubble chart. Larger points indicate higher values. A more detailed discussion of how bubble charts should be built can be read in its own article. Hue can also be used to depict numeric values as another alternative. Rather than using distinct colors for points like in the categorical case, we want to use a continuous sequence of colors, so that, for example, darker colors indicate higher value. Note that, for both size and color, a legend is important for interpretation of the third variable, since our eyes are much less able to discern size and color as easily as position. Highlight using annotations and color If you want to use a scatter plot to present insights, it can be good to highlight particular points of interest through the use of annotations and color. Desaturating unimportant points makes the remaining points stand out, and provides a reference to compare the remaining points against. Scatter map When the two variables in a scatter plot are geographical coordinates – latitude and longitude – we can overlay the points on a map to get a scatter map (aka dot map). This can be convenient when the geographic context is useful for drawing particular insights and can be combined with other third-variable encodings like point size and color. A famous example of scatter map is John Snow’s 1854 cholera outbreak map, showing that cholera cases (black bars) were centered around a particular water pump on Broad Street (central dot). Original: Wikimedia Commons Heatmap As noted above, a heatmap can be a good alternative to the scatter plot when there are a lot of data points that need to be plotted and their density causes overplotting issues. However, the heatmap can also be used in a similar fashion to show relationships between variables when one or both variables are not continuous and numeric. If we try to depict discrete values with a scatter plot, all of the points of a single level will be in a straight line. Heatmaps can overcome this overplotting through their binning of values into boxes of counts. Connected scatter plot If the third variable we want to add to a scatter plot indicates timestamps, then one chart type we could choose is the connected scatter plot. Rather than modify the form of the points to indicate date, we use line segments to connect observations in order. This can make it easier to see how the two main variables not only relate to one another, but how that relationship changes over time. If the horizontal axis also corresponds with time, then all of the line segments will consistently connect points from left to right, and we have a basic line chart. The scatter plot is a basic chart type that should be creatable by any visualization tool or solution. Computation of a basic linear trend line is also a fairly common option, as is coloring points according to levels of a third, categorical variable. Other options, like non-linear trend lines and encoding third-variable values by shape, however, are not as commonly seen. Even without these options, however, the scatter plot can be a valuable chart type to use when you need to investigate the relationship between numeric variables in your data. The scatter plot is one of many different chart types that can be used for visualizing data. Learn more from our articles on essential chart types, how to choose a type of data visualization, or by browsing the full collection of articles in the charts category.

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