

JOY PLOT AS A THEMATIC MAPPING METHOD

Ing. Josef Münzberger ^a

^a CTU in Prague, Faculty of civil engineering, Department of geomatics, Thákurova 7, 166 29, Prague 6

ABSTRACT

The paper analysis a non-traditional method of thematic cartography Joy Plot. It reveals its history and origin, and subsequently focusses on the individual stages of a the workflow in the sense of commented creation process and methodology. The conclusion summarises the advantages and disadvantages of the investigated method and deduces its (non)use in cartographic outputs.

KEY WORDS

Joy Plot; Ridgeline Plot; Thematic Maps

INTRODUCTION

Probably one of the most iconic album covers was created in 1979 for the album *Unknown Pleasures* by the British band Joy Division. The author of the design, Peter Saville, based his creation on the radio-wave recording of the first discovered pulsar (CP1919), which was captured by the Arecibo Observatory in Puerto Rico. The original image of the recorded signal from space was first published in 1970 in his dissertation [1] by Harold D. Craft, from which it was subsequently taken over in The Cambridge Encyclopaedia of astronomy [2]. The above-mentioned graphic artist then converted the original into inverse colours, thereby creating a motif that resembles a mysterious, uninhabited land. [3]

This method of data visualisation is called Joy Plot, or Ridgeline Plot, referring to the resemblance to a ridge line. Basically, it is a series of line graphs that usually statistical data. In addition, placing it in the framework of the Cartesian system directly encourages the creation of maps in which the X and Y axes correspond to the geographical longitude, respectively, latitude. A whole range of spatial phenomena can then be expressed by the "height" of each line; most often, in a cartographic context, it is about elevation or population density. [4] [5]

Two figures below show the original signal record and the employed design for an album cover. The following text deals in more detail with the successive stages of creating Joy Plots in the sense of visualising spatial data.

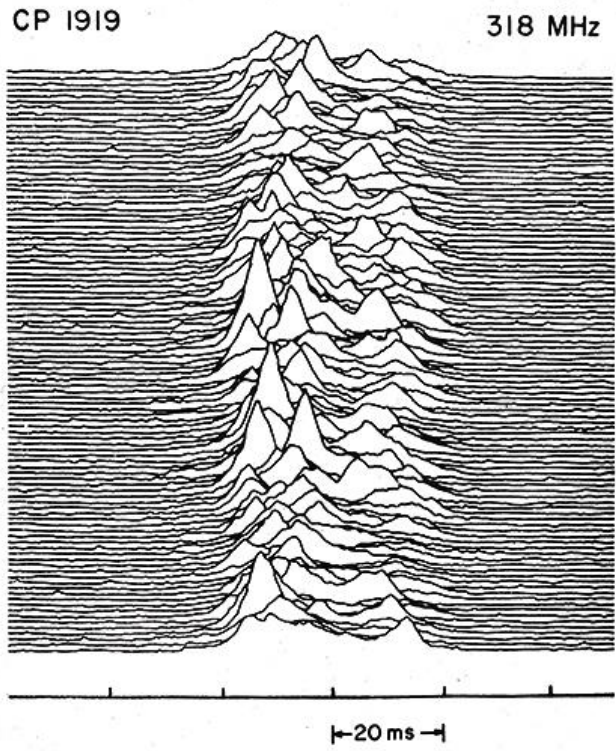


Fig. 2. - 100 consecutive pulses from the pulsar CP 1919. Time increases from bottom to top. Pulsar period is 1.34 seconds.

Figure 1: First published record of a pulsar.

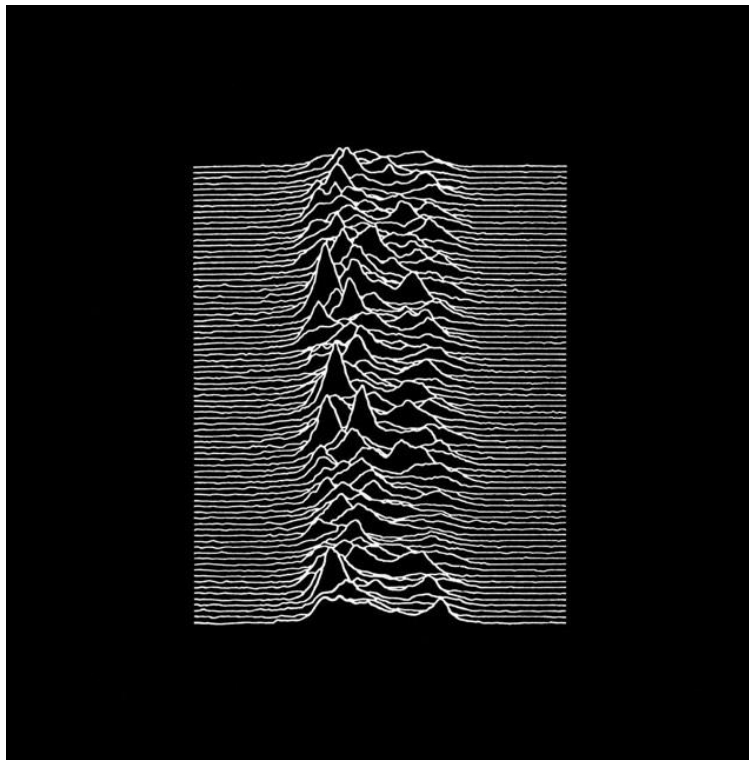


Figure 2: Unknown Pleasures album cover by Joy Division (1979).

METHODOLOGY

Editing Data in GIS

The initiation part of the entire processing takes place in ArcGIS Pro, but alternatively any GIS software can be used. For the purposes of the article, sample raster data on Czech population density in (2018) and digital elevation model of the Czech Republic (DMR5G) and the Antilles region were selected (the rendering of the relief of the islands using Joy Plots is in a certain sense authentic, as the parts of undulating lines resembling the sea level) . The workflow in this section is mainly focused on the used geoprocessing tools and their input parameters; therefore, the basic operations are not described.

The first step involves the creation of a line layer that covers the area of interest on the selected grid. For this, one can use, for example, the Create Fishnet tool, which will draw a line grid according to the specified number of columns and rows. With respect to the original, which has 80 lines, the recommended setting is 79 rows and 1 column. At the same time, it is ideal to define the Template Extent according to the input raster, if it does not significantly exceed the area of interest. In this way, 80 horizontal lines and two vertical lines were created, which were removed immediately. Optionally, it is possible to clip the line layer by the polygon of the Czech Republic, for example, if the intention is to visualise the spatial phenomenon only for a specific territory (in the case of the population density of the Czech Republic, I did so, in contrast to the work with the DMR of the Caribbean islands).

Next, it was necessary to create points along the length of the resulting lines using the Create Points Along Lines tool. A mandatory parameter is the interval between points, which should be chosen with regard to the size of the analysed area; too many points can slow down subsequent calculations (for the Czech Republic, an interval of 1 km resulted in approx. 21,000 points on 80 lines). Subsequently, it was necessary to extract information from the raster into the attribute table of the prepared point layer. For this purpose, the Extract Values to Points function is an option (only the source raster and the point feature class were selected here), which resulted in the attribution of pixel values to the position-corresponding points.

At the end of the first phase, the attribute table of height-adjusted points was enriched with X and Y coordinates by creating new columns and then using the integrated calculator (Calculate Geometry). The points were then exported to a table in CSV format, with the process being limited to only three columns with coordinates.

Data visualization in R

Rstudio is an open source platform that enables advanced statistical computing and graphics using the R programming language. The creation of Joy Plots cannot be done without installing the *ggplot2*, *ggridges*, *maps*, and *mapproj* packages. After a successful installation and creation of a new script, the code needs to be written. In this part, code sections are provided with an accompanying comment.

```
1 library(ggplot2)
2 library(ggridges)
3 library(maps)
4 library(mapproj)
5 JoyDataCzechia <- read.csv(file="ArcJoyCZ.csv", header=TRUE, sep=";")
```

The first four lines call the necessary libraries. On the 5th line, the pre-prepared CSV file will be loaded into the new variable. The `read.csv` command requires the specification of the file name, the Boolean value of the existence of the separator table header, or the type (setting the parameters in the example allows the import of CSV files exported from ArcGIS Pro according to the previous procedure).

```
6   head(JoyDataCzechia)
7   names(JoyDataCzechia)[1] <- "Pop"
8   names(JoyDataCzechia)[2] <- "Lon"
9   names(JoyDataCzechia)[3] <- "Lat"
```

The following four lines focus on listing and modifying the variable (in this case, the entire table is stored in the variable), or on updating table headers. The sixth line can then be repeated to check if it prints the table with the updated header.

```
10  CzechPop <- ggplot(JoyDataCzechia,
11                    aes(x = Lon, y = Lat, group = Lat, height = Pop)) +
12    geom_density_ridges(stat = "identity")
13  CzechPop
```

In the next step, a new variable is introduced in which the graph is stored using a combination of functions. The basis is the use of the `ggplot` function (input is entire dataset), for which it prepares coordinate axes with the necessary range of values. The transformation of source data into visual styles is provided by the `aes` function, which can be used directly in the `ggplot` constructor as a nested function. The graph rendering is done by `geom_density_ridges`. In the sample example, only the mandatory parameters of all functions were filled in to demonstrate the default display.

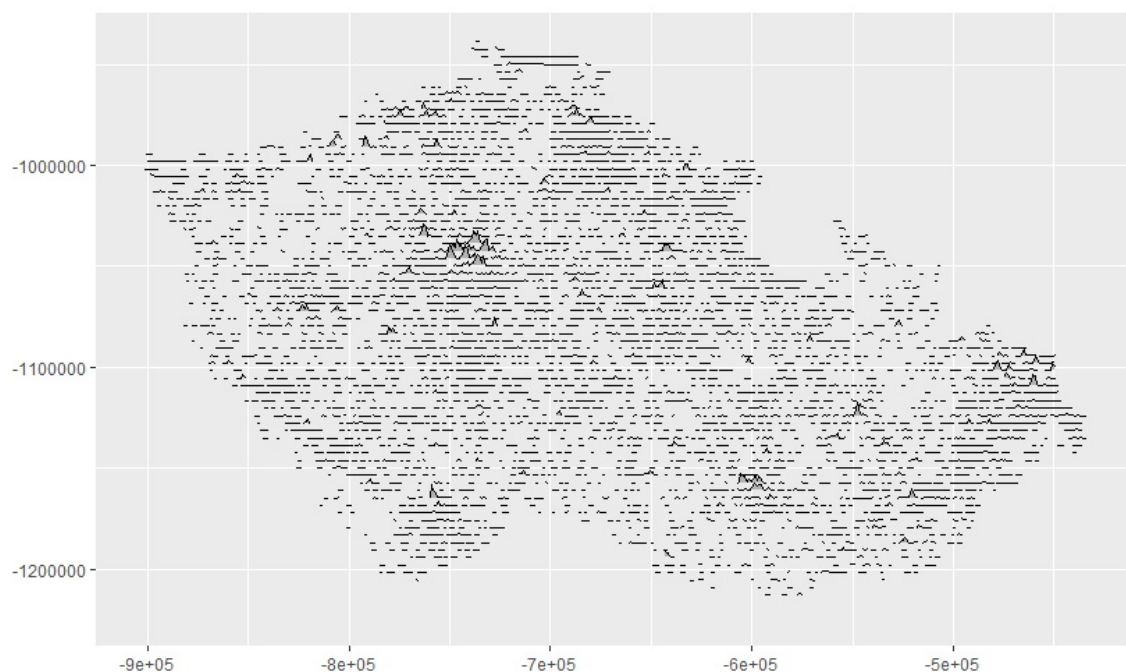


Figure 2: Basic visualization of the population density dataset of the Czech Republic (2018) in R.

```

14 CzechJoy <- ggplot(JoyDataCzechia,
15                   aes(x = Lon, y = Lat, group = Lat, height = Pop)) +
16                   geom_density_ridges(stat = "identity", scale = 5,
17                   fill="black", color="white") +
18                   ylim(-1250000, -900000) +
19                   theme(panel.grid.major = element_blank(),
20                   panel.grid.minor = element_blank(),
21                   panel.background = element_rect(fill = "black"),
22                   plot.background = element_rect(fill = "black"),
23                   axis.line = element_blank(),
24                   axis.text.x=element_blank(),
25                   axis.text.y=element_blank(),
26                   axis.ticks.x=element_blank(),
27                   axis.ticks.y=element_blank(),
28                   axis.title.x=element_blank(),
29                   axis.title.y=element_blank()) +
30                   coord_equal()
31 Czechia_Joy

```

However, it is not possible to stay limited by the basic settings of the *geom_density_ridges* function, as the result (Fig. 3) does not yet meet the specified specifications. Therefore, a fundamental part of the next code is dedicated to advanced visualisation by introducing optional parameters and calling additional functions. The potential for experimentation is provided by the scale parameter, which can be used to scale the "height" component of the source data. In addition to editing the colours of the lines and the background of the graph (parameters inside *geom_density_ridges*) or removing the description of the axes and scales (within the theme), the map window can be limited to a range of values (the interval determined according to the previous graph) using the *ylim* command. The *coord_map* function from the *mapproj* package allows one to define a projection if the source dataset contains geographic coordinates of points. For smaller territories (e.g. individual islands, small states), the argument can be left empty, but for larger areas, it is recommended implementing projected coordinate system. Planar coordinates were generated directly into the population density dataset of the Czech Republic, so it is sufficient to introduce *coord_equal* at this stage so that both axes remain on the same scale. Only the implementation of the new functions and parameters described brought about the desired effect (Fig. 4).

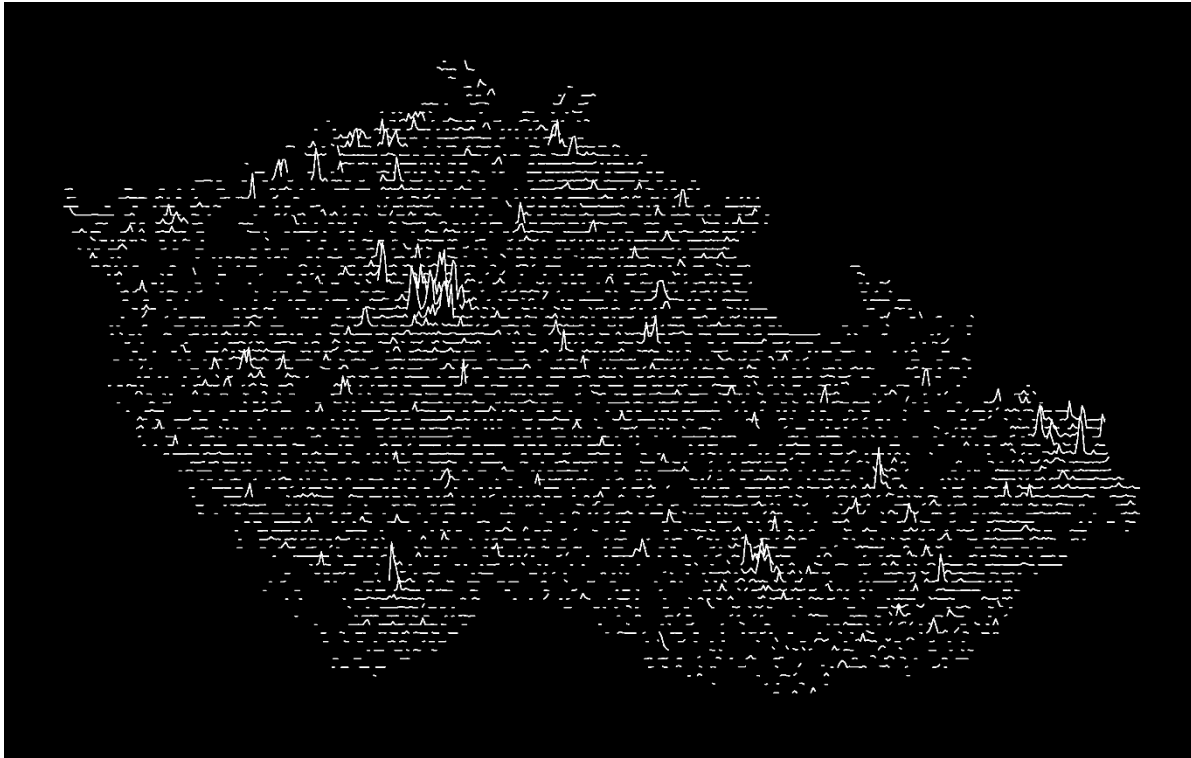


Figure 3: Population density in the Czech Republic (2018).

Post-processing in graphic editor

The final editing phase is optional, as RStudio itself produces interesting outputs. For the purposes of the article, Adobe Illustrator 2022 was used, which allows, for example, blending of multiple layers (combining elevation and population density into a single map), creating annotations, or advanced colour and gradient settings. Especially the last one seemed promising for potential experimentation, as it is possible to set a coloured or transparent transition (gradient) directly to the stroke of the lines or the filling of the area defined by them (the area below them). At the beginning of this process, a PDF file generated from RStudio, consisting of several layers, was imported to Illustrator. After layer decomposition, any line could be marked using the direct selection function. After that, all other lines were marked using the tool for selecting all the same elements according to the colour of the stroke, and after selecting Window – Transition, editing of the gradient (stroke or fill) was enabled.

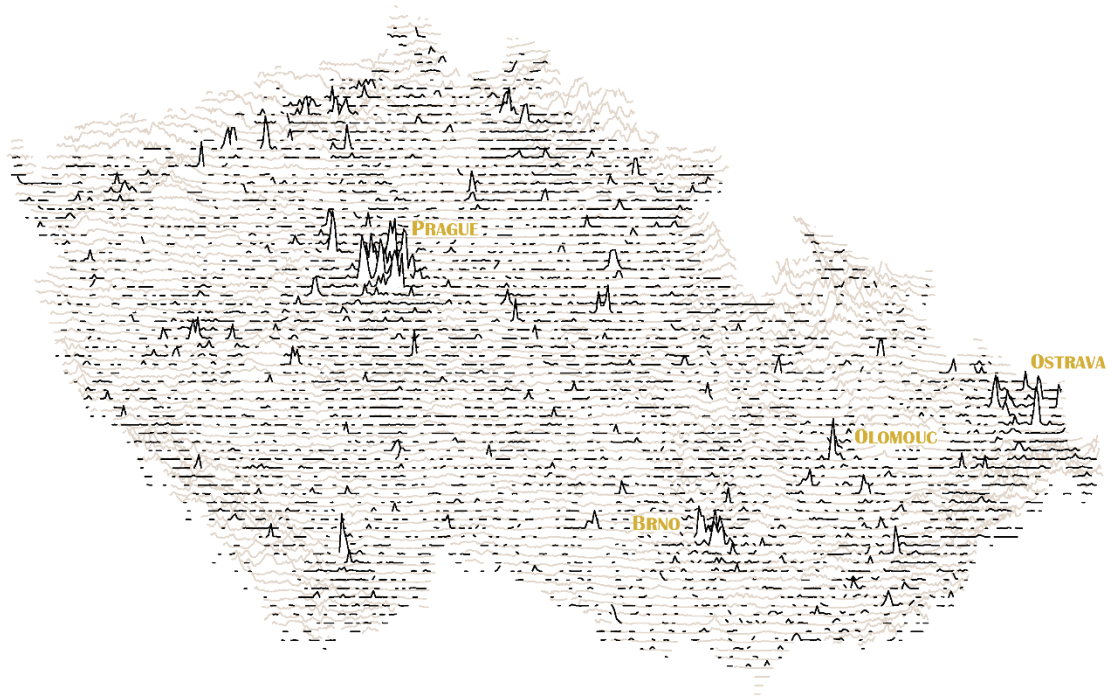
Conclusion

The map outputs in Figs. 5, 6 demonstrate the aesthetic and visualisation possibilities of the Joy Plots method, which stands on the border between cartographic and design work. At first glance it may look closer to design, but the workflow illustration above highlights its cartographic nature, its basis on spatial data, and its ability to convey information about spatial phenomena in a unique, non-traditional way.

On the other hand, the article also reveals some cons of the Joy Plot creation. The main disadvantage is the indisputable necessity of using multiple programs (GIS software, RStudio, and for aesthetically perfect result also a graphic editor). This method also does not provide enough space for annotation or labels and usually cannot represent several spatial

phenomena at once (see Fig. 5 as an exception). For reasons stated, Joy plots will not probably find wider use, for example, in thematic atlases, but as an unconventional method of thematic cartography, they can sporadically make map output unusual.

ELEV POPULATION IN CZECHIA



Obr. 5: Elevation and population density in Czechia.



Obr. 6: Joy Plot relief visualization of the island state of Martinique.

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