# datplot - Density Plots for Dates

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## Density Plots for Dates

A rather common problem in archaeology is the fuzzyness of dates assigned to objects. If one wants to visualize overall changes in - let's say - pottery consumption, bar charts often fall short in that regard. Let's say we have Phases a – f, then some of the objects can usually be dated to a, c, and f, as an example, but others will by classified as "a to c" or "b to c". But one can these data still be used for examining changes in a large set of objects?

First, it is handy to translate the phases into numbers, for which we should conveniently choose the 'actual' dating. I know this causes other problems in the end, since such phases are often employed to avoid dates, but it is necessary in this case and may as well be changed back later in the visualization. Ideally, we can produce a 'beginning' and 'end' date for each object, or let's say an earliest possible dating and a latest possible dating corresponding to beginning and start of each phase mentioned above.

I will demonstrate an approach of visualization that I personally found very useful, although I guess it is debatable whether it's 'valid' or not - I find that is works, however, and am very open to discussion. Let's start with a random sample of athenian pottery from the beazley archive (("Beazley Archive Pottery Database (Bapd)," n.d.)), that I converted into the format described above beforehand!

```
df <- read.table("../inst/data/testset_beazley_1000.csv", sep = ";")
kable(df[sample(1:nrow(df), 10, replace = FALSE),])
```

| | Vase.Number | Technique | DAT_min | DAT_max |
|---|---|---|---|---|
| 556 | 593 | BLACK-FIGURE | -575 | -525 |
| 40653 | 207829 | RED-FIGURE | -475 | -425 |
| 36558 | 203700 | RED-FIGURE | -525 | -475 |
| 1245 | 1343 | BLACK-FIGURE | -525 | -475 |
| 25058 | 29250 | BLACK-FIGURE | -550 | -500 |
| 63953 | 350391 | BLACK-FIGURE | -575 | -525 |
| 60149 | 310548 | BLACK-FIGURE | -575 | -525 |
| 81365 | 9001947 | RED-FIGURE | -400 | -300 |
| 43499 | 211373 | RED-FIGURE | -475 | -425 |
| 19647 | 21915 | RED-FIGURE | -500 | -450 |

## How to display a range?

Now we have to dates for each object. The earliest possible dating and the latest possible dating. In order to be able to process this to a density graph, which to me seems the most elegant means of visualization for this kind of data. (At least if the goal is merely to evaluate changes over time and not to look at actual objects counts.)

In my opinion, things that can be dated with greater confidence should have a larger impact on the overall visualisation. That is why the following function productes a column named 'weight' which contains a value that corresponds to the timespan covered by the two dating variables. The greater the timespan, the lower the weight value. Secondly, every object is duplicated a number of times equal to the dating range devided by the stepsize-variable. Each duplicate has its own 'date', one single value between the two extremes. The above mention weight variable is devided by the number of steps, so that each new fictional object or 'date

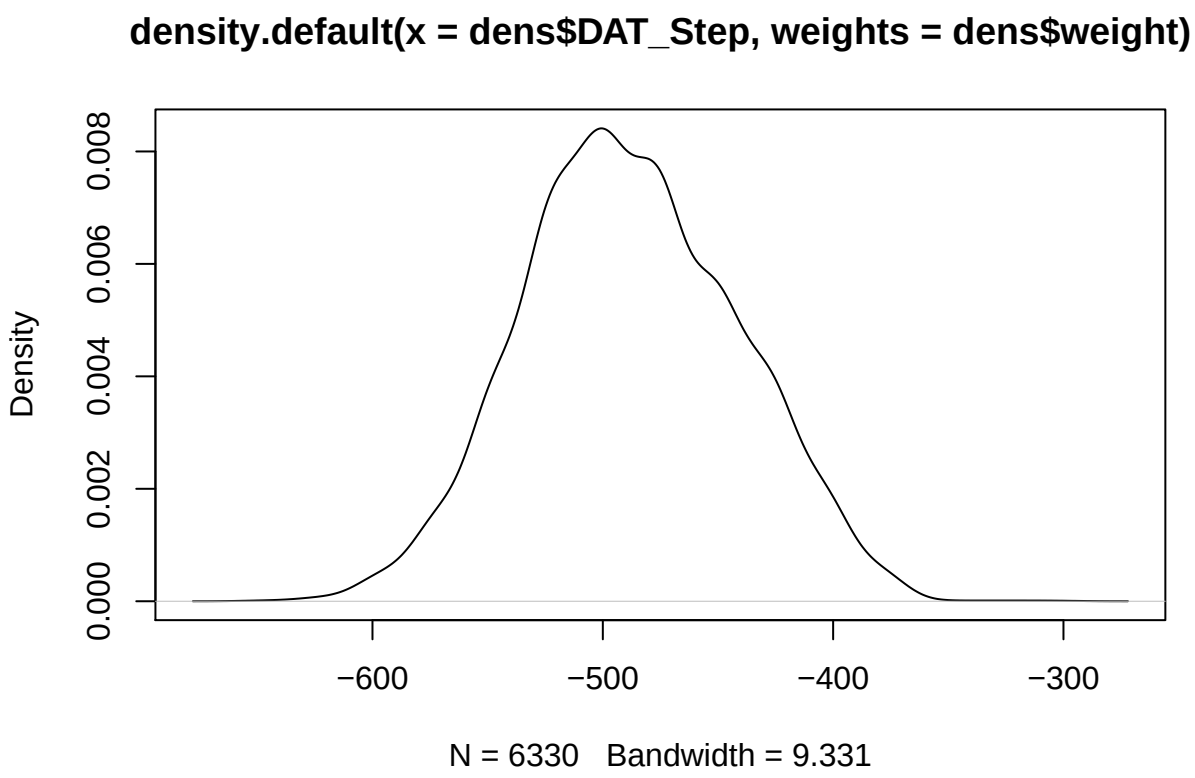
step' counts only as a fraction of the actual object. In this case the size of the dating steps will be 10 years. I find this superior to using, e.g., the median date of an objects. The outcome might often be similar, but I still have the impression that a lot of information is lost on the way when doing that. I do not claim this to be an ideal solution to everything, however. There *are* still problems and it might not be suitable for every purpose. I can't imagine this being useful for 'fine'-dating context, since it does erase the point of terminus post/ante quem, which is important on a smaller scale. I would rather imagine it being usefull to display the change in 'trends' over time, e.g. which vessel type is popular at a given time? How does style develop? Or maybe even to find occupation 'peaks' from survey data?

```
library(datplot)
result <- datsteps(df, stepsize = 10)
kable(head(result))
```

| | Vase.Number | Technique | DAT_min | DAT_max | weight | DAT_Step |
|---|---|---|---|---|---|---|
| 10110 | 10957 | BLACK-FIGURE | -550 | -500 | 8.5 | -550 |
| 101101 | 10957 | BLACK-FIGURE | -550 | -500 | 8.5 | -540 |
| 101102 | 10957 | BLACK-FIGURE | -550 | -500 | 8.5 | -530 |
| 101103 | 10957 | BLACK-FIGURE | -550 | -500 | 8.5 | -520 |
| 101104 | 10957 | BLACK-FIGURE | -550 | -500 | 8.5 | -510 |
| 101105 | 10957 | BLACK-FIGURE | -550 | -500 | 8.5 | -500 |

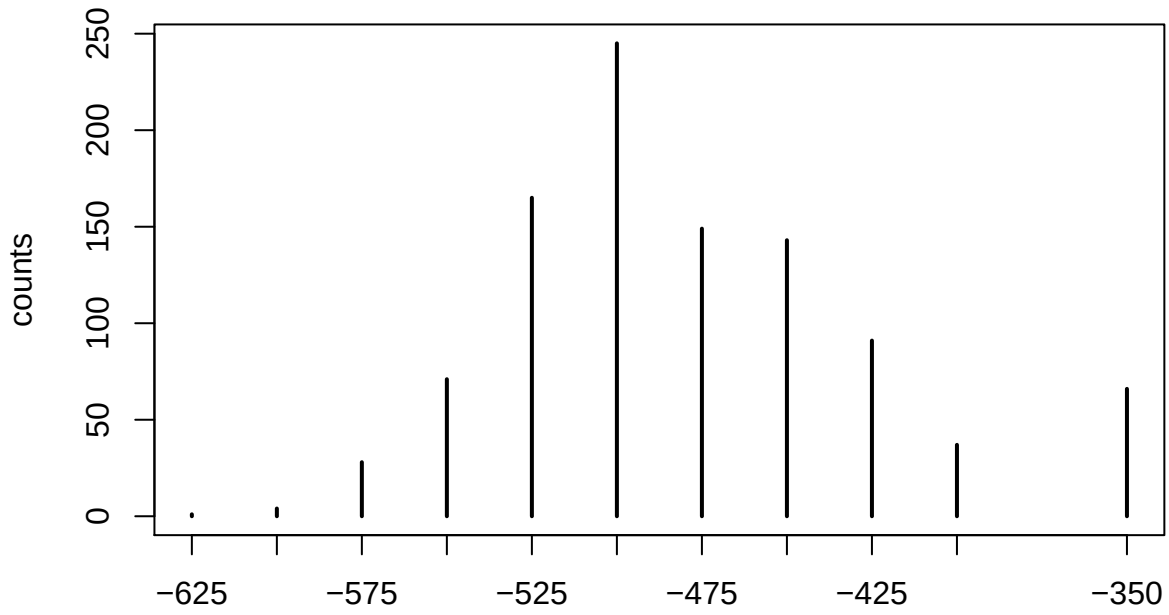
This can now be displayed as a density plot, as seen below. The peak at around -500 indicates that is area has the highest overlay, so a large part of the objects in our sample have been dated around this time. This, however, is not yet very informative.

```
dens <- result
dens$weight <- (dens$weight / sum(dens$weight))
dens <- density(x = dens$DAT_Step, weights = dens$weight)
plot(dens)
```




A simplistic approach to a bar plot however whould look like this:

```
counts <- df
counts$DAT_med <- ((counts$DAT_max + counts$DAT_min) / 2)
counts <- table(counts$DAT_med)
plot(counts)
```




### Scaling the weight along groups of objects

But: In order to display the objects seperated into groups, the weights first have to be scaled along group membership, so that the sum of all weights in a group will equal 1. scaleweight() does exactly that for a dataframe as it was returned by datsteps(). We also need to supply the group column.

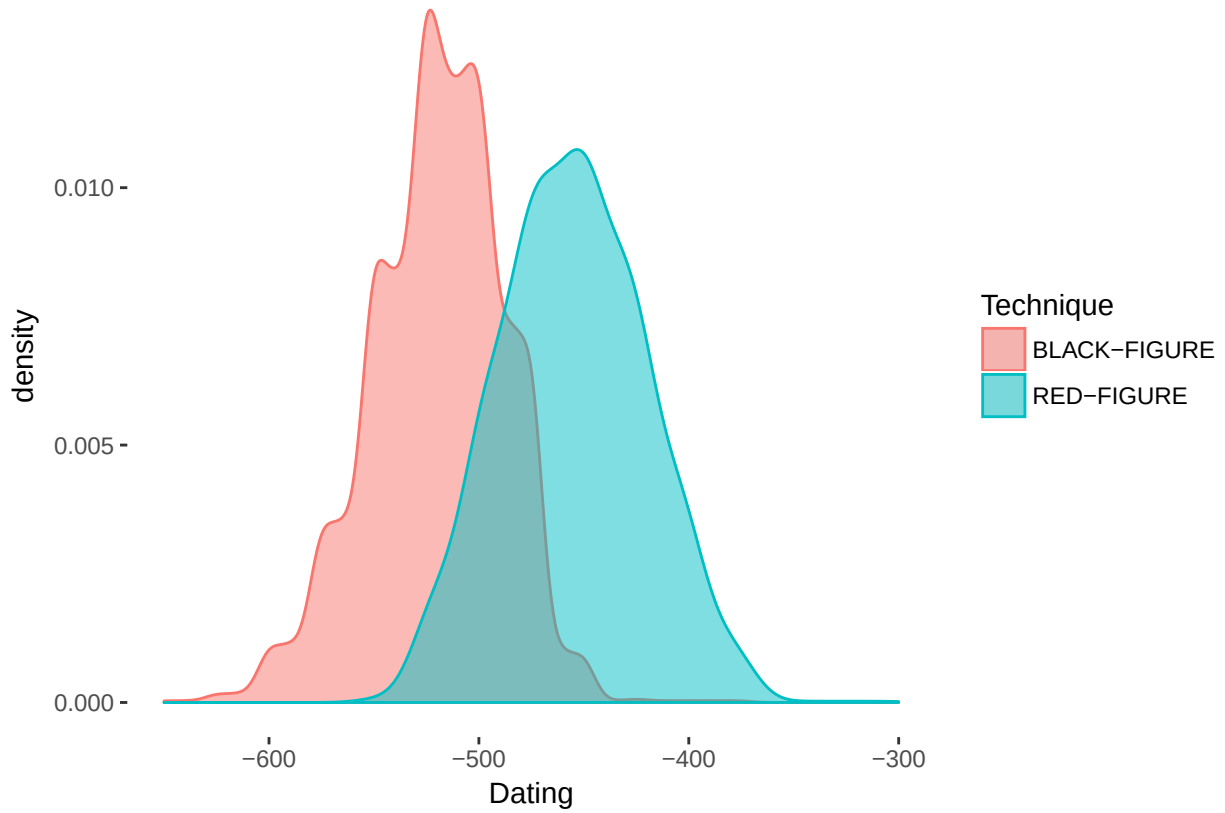
```
result <- scaleweight(result, result$Technique)
kable(head(result))
```

| | Vase.Number | Technique | DAT_min | DAT_max | weight | DAT_Step |
|---|---|---|---|---|---|---|
| 10110 | 10957 | BLACK-FIGURE | -550 | -500 | 0.0003508 | -550 |
| 101101 | 10957 | BLACK-FIGURE | -550 | -500 | 0.0003508 | -540 |
| 101102 | 10957 | BLACK-FIGURE | -550 | -500 | 0.0003508 | -530 |
| 101103 | 10957 | BLACK-FIGURE | -550 | -500 | 0.0003508 | -520 |
| 101104 | 10957 | BLACK-FIGURE | -550 | -500 | 0.0003508 | -510 |
| 101105 | 10957 | BLACK-FIGURE | -550 | -500 | 0.0003508 | -500 |

### Plots for the distribution of objects across time

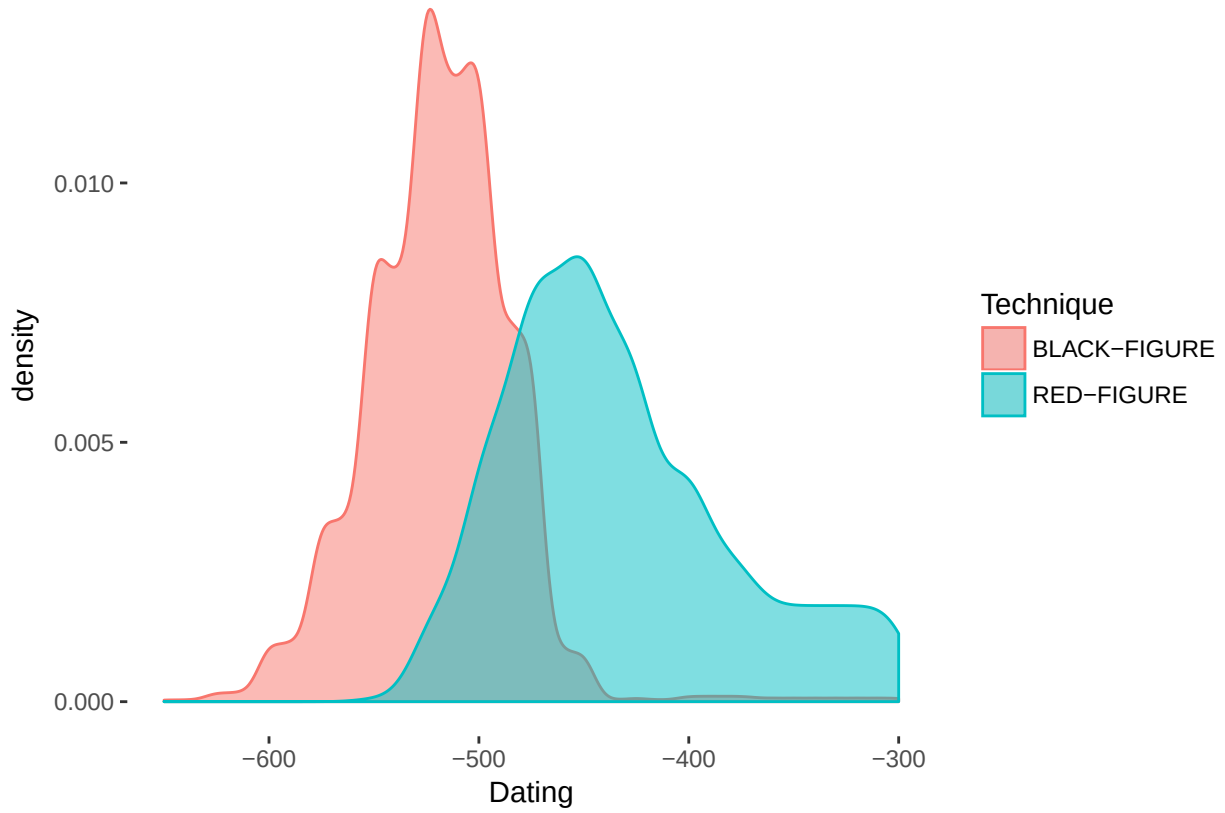
This can now be plotted a little more nicely usind ggplot2. We can clearly see now what we knew before: Black-figure pottery is older than red-figure pottery. (The data are from a random sample of athenian pottery from the beazley archive, n = 1000. Computation of the dating steps may not work with very, very large datasets, or simply take up a lot of time.)

```
library(ggplot2)
ggplot(data = result, aes(x = DAT_Step,
                          color = Technique,
                          fill = Technique)) +
  geom_density(aes(weight = weight), alpha = 0.5) +
  xlab("Dating") +
  theme(panel.background = element_blank())
```



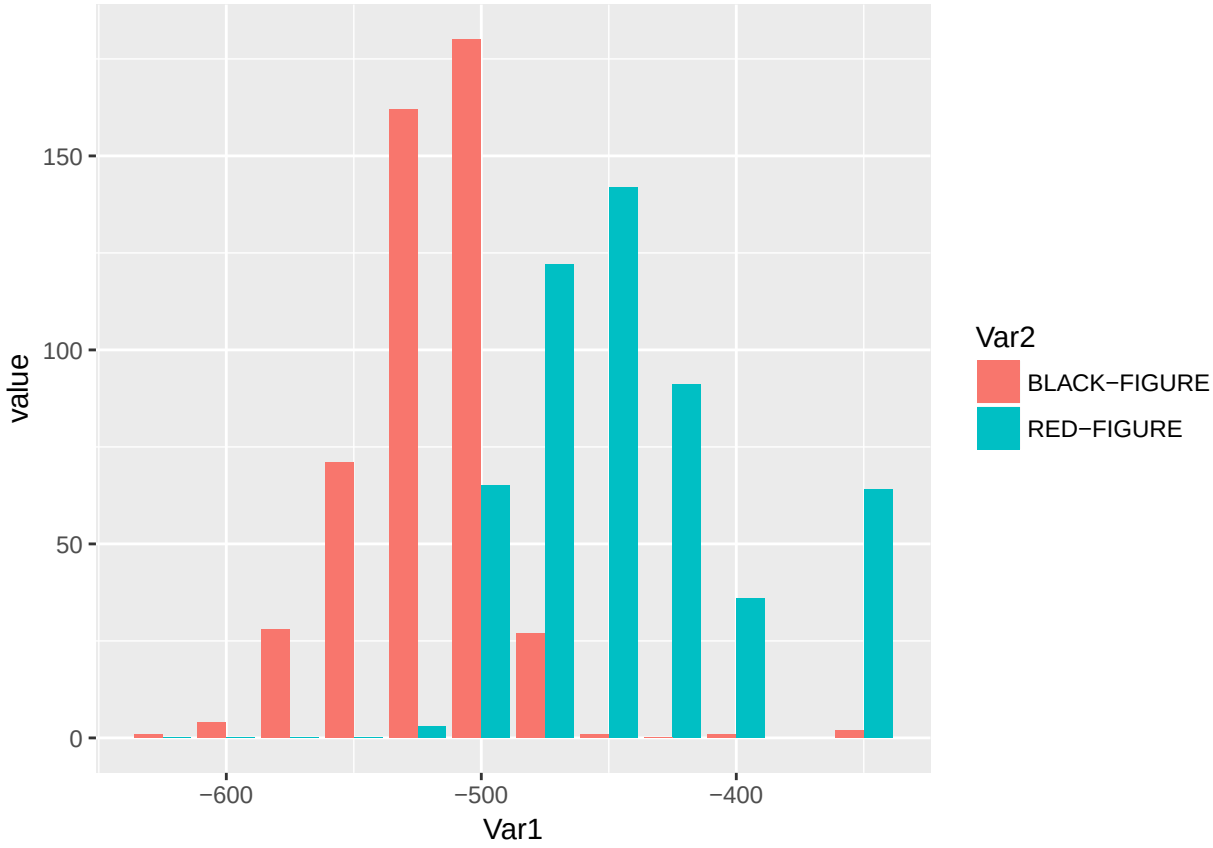

Please note that the plot does change when the weights are omitted. When every step is valued equally, a lot of steps fall into the end of the 4th century, since they were dated as e.g. "-400 to -300".

```
ggplot(data = result, aes(x = DAT_Step,
                          color = Technique,
                          fill = Technique)) +
  geom_density(alpha = 0.5) +
  xlab("Dating") +
  theme(panel.background = element_blank())
```




### Barplots for comparison

```
counts <- df
counts$DAT_med <- ((counts$DAT_max + counts$DAT_min) / 2)
counts <- table(counts$DAT_med, counts$Technique)
library(reshape2)
counts <- melt(counts)
ggplot(data = counts, aes(x = Var1, y = value, fill = Var2)) +
  geom_bar(stat = "identity", position = "dodge")
```




So, this is similar, but not quite. I find the smooth curves a more realistic approach to dating, since nothing should be fixed at one certain year alone. The production of objects was as continuous as there use, so it seems only reasonable to display it in a continuous fashion.

## References

"Beazley Archive Pottery Database (Bapd)." n.d. https://www.beazley.ox.ac.uk/pottery/default.htm.