

IdeoViz

Plot data along chromosome ideograms

Shraddha Pai (shraddha.pai@utoronto.ca), Jingliang Ren

8 December, 2017

Plotting discrete or continuous dataseries in the context of chromosomal location has several useful applications in genomic analysis. Examples of possible metrics include RNA expression levels, densities of epigenetic marks or genomic variation, while applications could range from the analysis of a single variable in a single context, to multiple measurements in several biological contexts (e.g. age/sex/tissue/disease context). Visualization of metrics superimposed on the chromosomal ideogram could provide varied insights into the metric of interest:

1. It could identify distinctive spatial distribution that could further hypotheses about the functional role of the metric (e.g. telocentric or pericentromeric enrichment)
2. It could highlight distribution differences between different groups of samples, suggesting different regulatory mechanisms; in extreme cases, visualization may identify large genomic foci of differences
3. It could confirm that a quantitative difference measured between groups of interest is consistent throughout the genome (i.e. that there are no foci, and that the change is global).

This package provides a method to plot one or several dataseries against the chromosomal ideogram. It provides some simple options (vertical/horizontal orientation, display in bars or linegraphs). Data are expected to be binned; IdeoViz provides a function for user-specified bin widths. Ideograms for the genome of choice can also be automatically downloaded from UCSC using the `getIdeo()` function.

1 Setup

```
> require(IdeoViz)
> require(RColorBrewer) ### nice colours
> data(binned_multiSeries)
```

2 Example 1: Plotting several trendlines along one ideogram

The ideogram table containing cytogenetic band information is used to render chromosomes. This table corresponds directly to the *cytoBandIdeo* table from the UCSC genome browser. There are two ways to supply an ideogram table to *plotOnIdeo()*:

1. First, it can be automatically downloaded from UCSC for your genome of choice, using the *getIdeo()* function.
2. Alternately, a pre-downloaded *cytoBandIdeo* table can be provided to downstream functions such as *plotOnIdeo()*. In this case, the table must be provided as a data.frame object with a header row and the column order matching that of the *cytoBandIdeo()* table at UCSC.

```
> ideo <- getIdeo("hg18")
> head(ideo)

  chrom chromStart chromEnd   name gieStain
1  chr1         0 2300000 p36.33    gneg
2  chr1    2300000 5300000 p36.32   gpos25
3  chr1    5300000 7100000 p36.31    gneg
4  chr1    7100000 9200000 p36.23   gpos25
5  chr1    9200000 12600000 p36.22    gneg
6  chr1   12600000 16100000 p36.21   gpos50

> plotOnIdeo(chrom=seqlevels(binned_multiSeries), # which chrom to plot?
+           ideoTable=ideo, # ideogram name
+           values_GR=binned_multiSeries, # data goes here
+           value_cols=colnames(mcols(binned_multiSeries)), # col to plot
+           col=brewer.pal(n=5, 'Spectral'), # colours
+           val_range=c(0,10), # set y-axis range
+           ylab="array intensities",
+           plot_title="Trendline example")
```



Example 2: Plotting a single series in bar format

For this example, we specify a local file to obtain the chromosome ideograms, rather than having IdeoViz download it from UCSC.

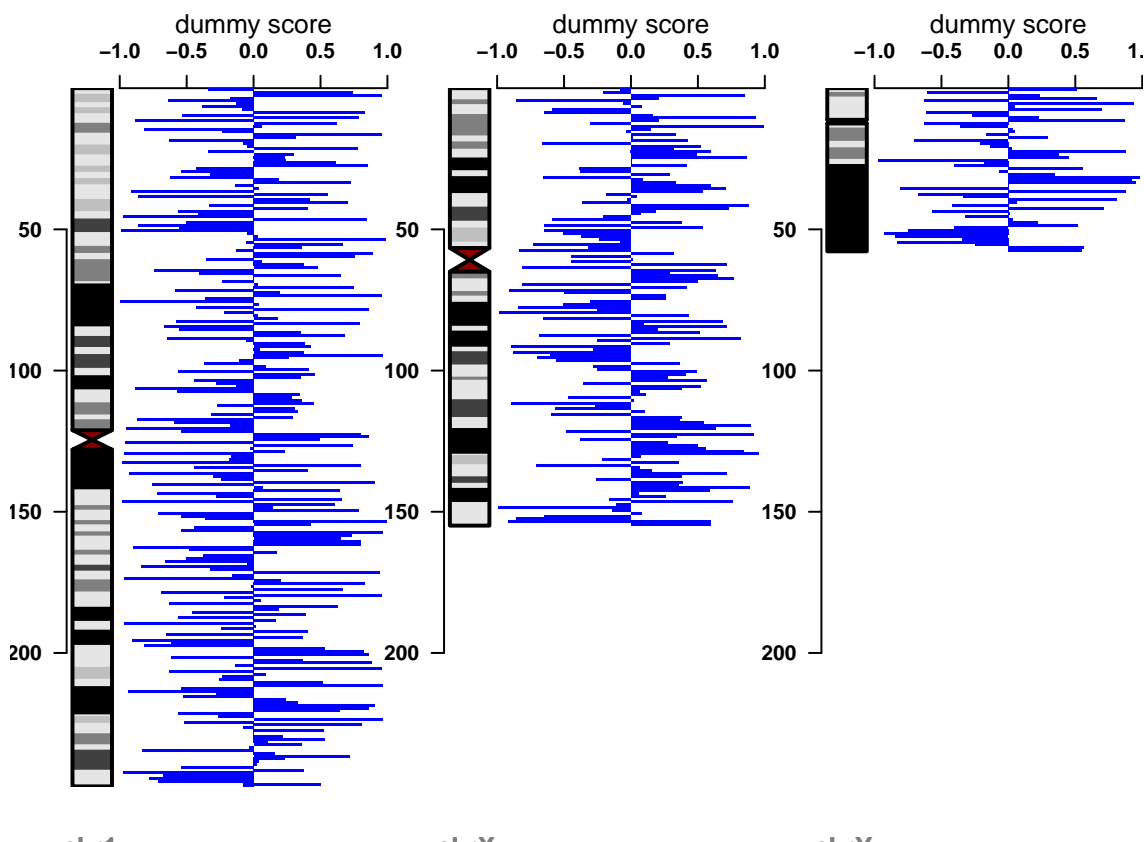
```
> data(binned_singleSeries)
> data(hg18_ideo) # cytoBandIdeo table downloaded previously and stored as a data.frame.
> plotOnIdeo(chrom=seqlevels(binned_singleSeries),
+           ideo=hg18_ideo,
+           values_GR=binned_singleSeries,
+           value_cols=colnames(mcols(binned_singleSeries)),
+           plotType='rect', # plot as bars
+           col='blue', vertical=T,
+           val_range=c(-1,1), ylab="dummy score",
+           plot_title="Discretized example")
```

Plot chromosome done

Plot chromosome done

Plot chromosome done

Discretized example



Example 3: Plotting a single series in bar format along entire genome

```
> data(binned_fullGenome)
> plotOnIdeo(chrom=seqlevels(binned_fullGenome),
+           ideo=ideo,
+           values_GR=binned_fullGenome,
+           value_cols=colnames(mcols(binned_fullGenome)),
+           plotType='rect',
+           col='orange', addScale=F, # hide scale to remove visual clutter
+           plot_title="Whole genome view",
+           val_range=c(-1,1), cex.axis=0.5, chromName_cex=0.6)
```



3 Example 4: Binning data using IdeoViz functions

In this example, we do everything in IdeoViz: download the ideogram from UCSC, bin the data, and finally, plot along chromosomes. For the example, we use histone H3K9me3 peak intensities mapped in the human lymphoblastoid cell line

GM12878 (GEO accession GSM733664, only 3 chromosomes shown for simplicity). Here, average peak signal is plotted in 500Kb bins along the chromosome. The ideogram plots show high signal in pericentromeric and telomeric regions, consistent with the association of this histone mark with heterochromatin.

Reference: ENCODE Project Consortium, Bernstein BE, Birney E, Dunham I, Green ED, Gunter C, Snyder M. An integrated encyclopedia of DNA elements in the human genome. *Nature*.(2012): **489** (7414):57-74.

```
> ideo_hg19 <- getIdeo("hg19")
> chroms <- c("chr1","chr2","chrX")
> data(GSM733664_broadPeaks)
> head(GSM733664_broadPeaks)
```

	chrom	chromStart	chromEnd	name	score	strand	signalValue	pValue	qValue
1	chr1	10141	10374	.	993	.	10.796883	10.3	-1
2	chr1	567457	567702	.	1000	.	16.590333	100.0	-1
3	chr1	569826	570047	.	1000	.	15.757614	100.0	-1
4	chr1	723167	727602	.	808	.	8.389733	14.2	-1
5	chr1	816959	817136	.	793	.	8.188648	1.7	-1
6	chr1	821181	821421	.	753	.	7.660859	3.4	-1

```
> chrom_bins <- getBins(chroms, ideo_hg19,stepSize=5*100*1000)
> avg_peak <- avgByBin(data.frame(value=GSM733664_broadPeaks[,7]),
+   GSM733664_broadPeaks[,1:3], chrom_bins)
> plotOnIdeo(chrom=seqlevels(chrom_bins),
+   ideoTable=ideo_hg19,
+   values_GR=avg_peak, value_cols='value',
+   val_range=c(0,50),
+   plotType='rect',
+   col='blue', vertical=T
+ )
```

Plot chromosome done
Plot chromosome done
Plot chromosome done



4 Example 5: Plotting a set of coordinates as tracks

Here we plot multiple `GRanges()`, each as its own track.

```
> ideo_hg19 <- getIdeo("hg19")
> x <- GSM733664_broadPeaks
> gr <- GRanges(x[,1],IRanges(x[,2],x[,3]))
> pal <- brewer.pal(n=5,name="Dark2")
> chroms <- c("chr1","chr2","chrX")
> gr <- gr[which(seqnames(gr)%in% chroms)]
> chrom_bins <- getBins(chroms, ideo_hg19,
+                         stepSize=5*100*1000)
> grList <- list(gr,gr,gr,gr,gr)
> plotOnIdeo(chrom=seqlevels(chrom_bins),
+            ideoTable=ideo_hg19,
+            values_GR=grList, value_cols="value",
+            plotType="seg_tracks",
+            col=pal, vertical=F)
```



Segments can also be colour-coded by group type. For this the GRanges object needs to have a metadata column named "group", which has the pre-defined categories

```
> # assign group categories
> for (k in 1:5) {
+   gp <- rep("type1",length(grList[[k]]));
+   gp[(k*1000):((k*1000)+4000)] <- "type2"
+   gp[1:1000] <- "type3"
+   grList[[k]]$group <- gp
+   print(table(grList[[k]]$group))
+ }
```

```
type1 type2 type3
9825  4000  1000
```

```
type1 type2 type3
9824  4001  1000
```

```
type1 type2 type3
9824  4001  1000
```

```
type1 type2 type3
9824  4001  1000
```

```
type1 type2 type3
9824  4001  1000
```

```
> # notice we don't name type3 - this is to show behaviour if a name is not specified
> namedCols <- c("orange","purple"); names(namedCols) <- c("type1","type2")
> plotOnIdeo(chrom=seqlevels(chrom_bins), ideoTable=ideo_hg19,values=grList,
+            plotType="seg_tracks",col=namedCols,vertical=F)
```




Session info

```
> sessionInfo()
```

```
R version 4.3.1 (2023-06-16)
```

```
Platform: aarch64-apple-darwin20 (64-bit)
```

```
Running under: macOS Ventura 13.3.1
```

```
Matrix products: default
```

```
BLAS: /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/lib/libRblas.0.dylib
```

```
LAPACK: /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/lib/libRlapack.dylib; LAPACK version
```

```
locale:
```

```
[1] C/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
```

```
time zone: America/New_York
```

```
tzcode source: internal
```

```
attached base packages:
```

```
[1] stats4 stats graphics grDevices utils datasets methods
[8] base
```

```
other attached packages:
```

```
[1] IdeoViz_1.37.0 rtracklayer_1.61.0 RColorBrewer_1.1-3
[4] GenomicRanges_1.53.1 GenomeInfoDb_1.37.2 IRanges_2.35.2
[7] S4Vectors_0.39.1 Biobase_2.61.0 BiocGenerics_0.47.0
```

```
loaded via a namespace (and not attached):
```

[1]	crayon_1.5.2	DelayedArray_0.27.9
[3]	SummarizedExperiment_1.31.1	GenomicAlignments_1.37.0
[5]	rjson_0.2.21	RCurl_1.98-1.12
[7]	Biostrings_2.69.2	XML_3.99-0.14
[9]	MatrixGenerics_1.13.0	grid_4.3.1
[11]	restfulr_0.0.15	bitops_1.0-7
[13]	yaml_2.3.7	compiler_4.3.1
[15]	codetools_0.2-19	XVector_0.41.1
[17]	BiocParallel_1.35.3	lattice_0.21-8
[19]	SparseArray_1.1.10	BiocIO_1.11.0
[21]	parallel_4.3.1	GenomeInfoDbData_1.2.10
[23]	Matrix_1.5-4.1	tools_4.3.1
[25]	matrixStats_1.0.0	Rsamtools_2.17.0
[27]	zlibbioc_1.47.0	S4Arrays_1.1.4