R Workshop 5

Welcome back to the R Workshop. Last Spring we emphasized

- base R,
- the command line, and
- random variables.

You can go a long way with a strong grounding in these topics. This Fall we're going to explore the **tidyverse**, a confederation of utilities designed to work together to address short comings of some legacy utilities. Which one you ultimately use is a choice you make depending on your comfort level and the problem at hand.

The command line is great for interactive work and consumes minimal processing resources. However, an IDE like RStudio is indispensible for

- converting interactive explorations into scripts that reproduce analysis;
- documenting analysis transparently for peer review, i.e. RMarkdown;
- exposing analysis interactively through JavaScript, i.e. Shiny applications.

So we'll be mixing RStudio sessions into our workshops.

Finally, we'll apply our knowledge of random variables to study the distribution of error likelihoods that form the basis of point estimates and confidence intervals. This will help us select the appropriate R function for inferential analysis and understand the results. It will also serve as the foundation for assessing the validity of statistical models that we plan to study in the Spring.

The random variables section will be moved to a separate LaTeX document for the following reasons.

1. While Jupyter notebook does a good job of rendering an equation here and there, it's not optimal for rendering more extended derivations. LaTeX handles it well.
2. It will be easier to refer to previous workshop material if it's all in the same document.
3. Some of you may eventually be writing LaTeX documents yourselves to formalize your own analysis for publication. The LaTeX source may be helpful as a reference or a template.

Henceforth the math content will be referenced from these workshop documents.

The Tidyverse

The **tidyverse** packages can be installed with the following R commands.

```
install.packages('tidyverse')
install.packages('nycflights13')
```

The first command will install the `tidyverse` package along with its dependencies. The **nycflights13** package provides datasets on which to practice. These have all been installed on the lab machines.

This Fall's workshops will appeal directly to sections from the book R for Data Science (http://r4ds.had.co.nz/). Rather than copying them here, I will simply reference the online sections that we will cover. We won't be working through the book linearly.

Recall last Spring that we often worked with vectors and data frames in R. We covered various techniques to create them, manipulate them, and process them. The tidyverse notion of a data frame is a **tibble**. It's a contraction of the words tidy-table. (We'll address more formally the notion of a tidy dataset (http://r4ds.had.co.nz/tidy-data.html) soon.)

The `filter` Function

At this point in the workshop, let's jump to the first two sections of Chapter 5 to learn about the **tibble** and **filter** function from the **dplyr** package.

Lab

http://r4ds.had.co.nz/transform.html#introduction-2 (http://r4ds.had.co.nz/transform.html#introduction-2)

Work through Sections `5.1` and `5.2.1` through `5.2.3` to cover the following topics.

- a summary of `dplyr` functions
- default output of a tibble
- the `filter` function
- comparing floating point numbers with `near`
- logical operators within the `filter` function
- missing values, `is.na()`

Notes

- The **dplyr** package has been around for a while. It's in common use; but I avoided it in the workshop last Spring in order to focus on base R. We'll embrace **dplyr** function this Fall.
- The section on conditionals emphasized the usage of `|` and `&` for the "`or`" and "`and`" conditionals respectively. These are the so-called *vectorized* conditionals. Do **not** use these in R **if** statements. For **if** statements, use the *short-circuit* conditionals designated by `||` and `&&`. An R **if** predicate will only evaluate the first element of a boolean vector. A warning will result from a vectorized predicate.

Try It

Take a few minutes to work through or ponder the exercises in Section `5.2.4`. The exercises will be the starting point for this thread in the next workshop to serve as a review before we move on to the next **dplyr** function.

Counting Processes

In the criminal justice community, much of the data we encounter are rendered as counts of occurrences over a fixed time period. Examples might include crimes reported in a certain zip code over the period of a week, a month, or a single day. Modeling such a process has been the subject of much study. It generally involves a counting function $N(t)$ for $t \geq 0$ such that

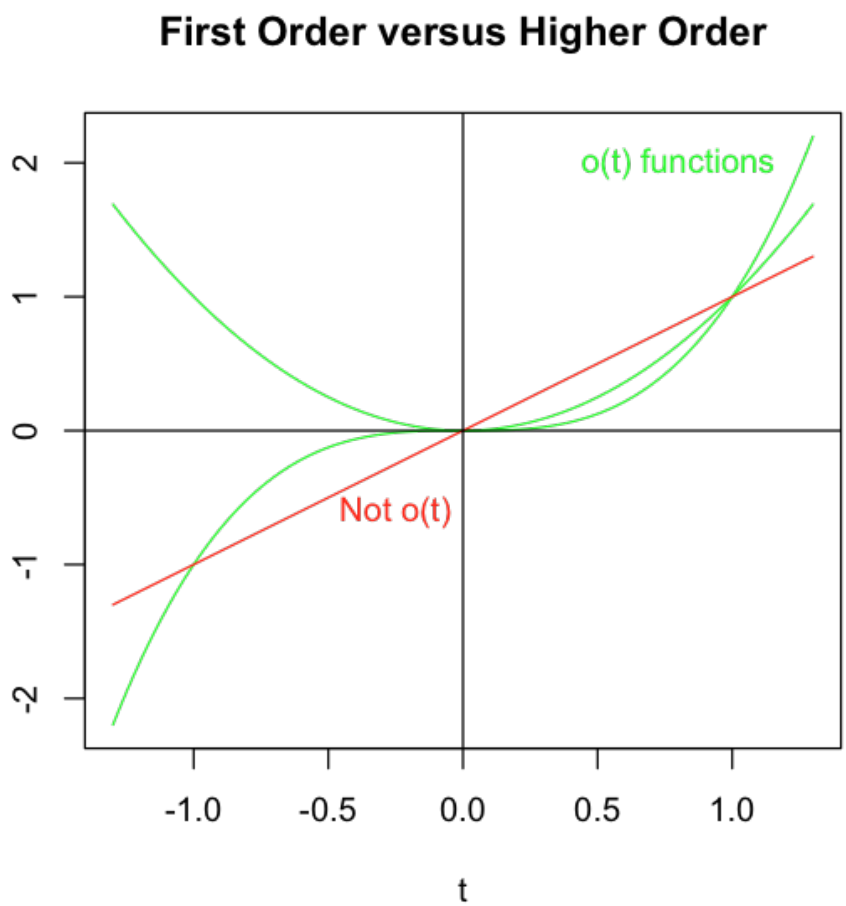
- $N(0) = 0,$
- $N(t) \in \{0, 1, 2, \dots\}$ for $t > 0,$
- N never decreases.

When we speak of *modeling* such a process, we usually speak of calculating quanities such as $P[N(t) = C]$ for some time t and count C. The most popular model for a counting process is the *Poisson Process*. There are four qualities of a Poisson process.

1. **Non-overlapping intervals are independent**. This means that an occurrence of an event in one interval does not impact the probability of the occurrence in a another non-overlapping interval.
2. **Poisson processes are stationary**. A *stationary process* is one in which the probability of the counts depend only on the size of the interval, not on where the interval lies. More formally, it means that $P[N(t+h) - N(t) = C]$ is independent of t. (It depends only on h and C.)
3. **First Count:** $P[N(t) = 1] = \lambda t + o(t)$.
4. **More Counts:** $P[N(t) > 1] = o(t)$.

The $o(t)$ that appears in `3` and `4` is pronounced "oh-of-tee". It represents any function that satisfies $o(0) = o'(0) = 0$. If we consider a Taylor series expansion of $o(t)$, the first two terms are zero. So it looks like $o(t) = a_2 t^2 + a_3 t^3 + \dots$. The visual way to think of a representative of $o(t)$ is that it's horizontal at the point $t = 0$.

In [6]:
```
options(repr.plot.width=5, repr.plot.height=5)
t <- seq(-1.3, 1.3, length.out=101)
plot(t, t^3, type='l', col='green',
     main="First Order versus Higher Order", xlab='t', ylab='')
lines(t, t^2, type='l', col='green')
lines(t, t, type='l', col='red')
abline(h=0, col='black')
abline(v=0, col='black')
text(0.8, 2, "o(t) functions", col='green')
text(-0.25, -0.6, "Not o(t)", col='red')
```



It can be shown that a Poisson counting process with parameter λ has the following probability mass function for the number of counts that will occur within the time period.

$$f(i;\lambda) = e^{-\lambda}\frac{\lambda^i}{i!}, \quad i \in 0, 1, 2, \ldots$$

Exercises

1. Find the moment generating function for the Poisson random variable.
2. Determine the expected value of the Poisson random variable.
3. Determine the variance of the Poisson random variable.
4. Work through the **Poisson Distribution** section of the Distributions Workshop (https://github.com/lacounty-isab/workshops/tree/master/distributions/r).
5. Work through the **Exponential Distribution** section of the Distributions Workshop (https://github.com/lacounty-isab/workshops/tree/master/distributions/r).

Grammar of Graphics

Last Spring we experimented with various aspects of the **plot** command along with its related functions. You saw them again in the preceding section on the Poisson distribution. In this section we introduce an alternative plotting system for R called **ggplot2**. The "gg" stands for *grammer of graphics* which is an abstraction applied to plotting figures from data.

The abstraction is not something absent from how we ourselves plot with regular base plot. It simply provides explicit support for concepts like

- splitting elements into layers,
- applying data values to colors and shapes, and
- separating global graphical properties from data-driven properties.

ggplot2 takes a little getting used to. But once you get the hang of it, it's hard to go back to base. So let's dig into Sections 3.1 and 3.2 of R for Data Science (http://r4ds.had.co.nz/data-visualisation.html) and discuss the **Exercises** in `3.2.4`.