# 550.400: Mathematical Modeling and Consulting

Lecture Notes

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## Outline







## What is that on the slide?

http://connect.johnshopkins.edu/welcome/





## How to add a figure in your work statement?

Note that <++> denotes a thing that you need to fill in. See the `lecture.tex` for (many) examples.

```
\begin{figure}
    \caption{<+caption text+>}
    \begin{center}
        \includegraphics[width=<++>\textwidth]{<++>}
    \end{center}
\end{figure}<++>
```

# Commit? Add? What is the difference?

## An imperfect analogy

- Just like doing your HW with many questions
- For each question, first you do some work
- `git add` is like you being satisfied with your current version of your answer
- `git commit` is like you transcribing your solution to your paper that you will actually submit
- `git push` is like submitting your solution to the instructor so that they can see





# Sorry . . . but still confused about git . . .

http://gitref.org/index.html





# Class Exercise I

## Exercise 1

This is called a *commit* graph

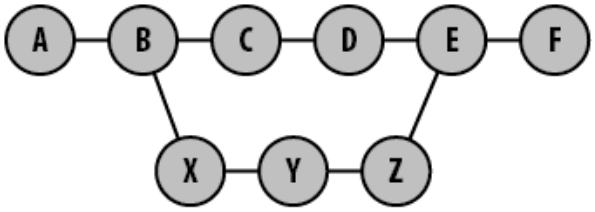



*Figure 14-3. History of two branches*





# Class Exercise II

## Create a git folder with the following history

- Each node's label signifies the commit
- The folder contains only one single file `main.txt` throughout the history
- Keep "the story" simple
- Push it to your github (remote) repository

## Exercise 2

Collect all 8 stanzas of the "Elephant" poem from the course github remote repositories and then push the resulting one to *your* github repository.

You will need the following addresses:

# Class Exercise III

```
git://github.com/nhlee/550400.stanza1.git
git://github.com/nhlee/550400.stanza2.git
git://github.com/nhlee/550400.stanza3.git
git://github.com/nhlee/550400.stanza4.git
git://github.com/nhlee/550400.stanza5.git
git://github.com/nhlee/550400.stanza6.git
git://github.com/nhlee/550400.stanza7.git
git://github.com/nhlee/550400.stanza8.git
```





# Spurious Causality I

```
cbe.loc<-'http://www.massey.ac.nz/~pscowper/ts/cbe.dat';
cbe <- read.table(cbe.loc,header=T);
plot(cbe[,1],cbe[,3]);
```

---

```
set.seed(10);
x <- rnorm(100);
y <- rnorm(100);
for(i in 2:100) {
    x[i] <- x[i-1] + rnorm(1);
    y[i] <- y[i-1] + rnorm(1);
}
plot(x,y);
```





# Spurious Causality II

```
x <- y <- mu <- rep(0,1000);
for(i in 2:1000) mu[i] <- mu[i-1] + rnorm(1);
x <- mu + rnorm(1000);
y <- mu + rnorm(1000);

xrate.loc <-'http://www.massey.ac.nz/~pscowper/ts/us_rates.dat';
xrates <- read.table(xrate.loc,header=T);
plot(xrates$UK,xrates$EU,pch=4);
```

---

Then, how to detect the underlying factors?





# Spurious Causality III

```
require(tseries)
adf.test(x)$p.value
adf.test(y)$p.value
po.test(cbind(x,y))

pp.test(xrates$UK)
pp.test(xrates$EU)
po.test(cbind(xrates$UK,xrates$EU))
ukeu.lm <- lm(xrates$UK ~ xrates$EU)
ukeu.res <- resid(ukeu.lm)
```

---

## Assessing Causality (527)

- Consistency of association:

  *The association is observed in several different populations using different types of study design.*

- Strength of association

  *A bigger difference in outcomes between cases with and without the purported causal factor indicates a stronger association.*

- Temporal relationship

  *The cause preceded the effect. A correlation between two variables measured at the same time gives weaker evidence than one measuring the relationship between changes in the supposed cause and subsequent responses in the outcome.*

- Mechanism

  *There is a plausible means by which the alleged cause could affect the outcome.*





## Writing about Causality (549)

### Vocab. Issues

*Carefully select the words you use to describe associations: verbs such as "affect" or "cause" and nouns such as "consequences" or "effects" all imply causality. "Correlated" or "associated" do not.*

### Limits of Study Design

*. . . it is much more difficult for one study to simultaneously show that all for criteria are true. . . . For study designs that do not allow a cause-effect pattern to be tested well, point out those weaknesses and their implications for inferring causality; . . .*





## Intro. to work-statement template I

```
\documentclass[12pt,letterpaper][aritcle]
\usepackage{amsmath,amsthm,amssymb,amsfonts} # for popular math add-on
\usepackage{graphicx} # for inserting png, jpeg, pdf files as figure
\usepackage{bm} # for bold math
# some preamble stuff omitted (see the actual template)
\begin{document}
\section{A}
    \section{a}
        \paragraph{Hello World}
        \begin{align*}
            &f(x) = \int_0^1 \sin(u+x) du, \\
            &f(\bm x) = \int_0^1 \sin(u+\|\bm x\|) du.
        \end{align*}
\end{document}
```





## Introduction to beamer I

Basic Body Layer

```
\begin{document}
\section{Hello World}
    \section{hello world}
        \begin{frame}
            \frametitle{hi world}
            \begin{columns}
                \begin{column}{0.5\textwidth}
                    \begin{itemize}
                        \item Alice!
                    \end{itemize}
                \end{column}
                \begin{column}{0.5\textwidth}
                    \begin{block}{hey world}
                        Bob!
                    \end{block}
                \end{column}
            \end{columns}
        \end{frame}
\end{document}
```

# Introduction to beamer II

Basic Preambles

```
\documentclass[hyperref={colorlinks=false},handout,10pt]{beamer}
\usetheme{Singapore}
\usecolortheme{lily}
\usefonttheme[onlymath]{serif} % What does this do?
```

OR

```
\documentclass[hyperref={colorlinks=false},handout,10pt]{beamer}
\usetheme{Berlin}
\usecolortheme{wolverine}
\usefonttheme[onlymath]{serif} % What does this do?
```

For a more complete array of themes, go to:

http://www.hartwork.org/beamer-theme-matrix/





# Introduction to beamer III

SO, how to put a code in the slide? and it looks like codes?

```
\begin{lstlisting}
require(tikzDevice)
x = rnorm(100)
plot.ts(x)
dev.off()
\end{lstlisting}
```

```
require(tikzDevice)
x = rnorm(100)
plot.ts(x)
dev.off()
```

But, this requires the following in the preamble portion of your tex file:

```
\usepackage{listings}
\lstset{
basicstyle=\footnotesize\ttfamily,
numbers=left,
frame=bottomline,
framextopmargin=50pt,
}
```





# Introduction to beamer IV

Where to get more help:

http://en.wikibooks.org/wiki/LaTeX/Presentations





# How to do software documentation (via R)

```
myfun <- function(x) {x^2}
package.skeleton(name='MYPAC',
                 list='myfun',
                 path='~/')
#Do the documentation
system('R CMD check ~/MYPAC')
system('R CMD build ~/MYPAC')
system('R CMD install MYPAC')
```

# Using R to do System Admin Stuff I

```
for(itr in 1:8) {
    stanzaname = paste("stanza",itr,sep="")
    gitaddress = paste("git://github.com/nhlee/550400.",
                       stanzaname,".git",sep="")
    bashcommand = paste("git remote add ",
                       stanzaname," ",gitaddress,sep="")
    system(bashcommand)
}
```

---

- `1:8` creates a vector that ...
- `X = 1` assigns 1 to X
- `X <- 1` also assigns 1 to X
- lots of things are done through function
- `paste` and `system` are functions that ...
- functions has none or more arguments





# Using R to do System Admin Stuff II

- arguments are implicitly ordered but the order can be overridden

```
system(`ls -ld .*')
system(`cat .Rprofile')
system(`cat .bashrc')
system(`cat .gitignore')
system(`cat .vimrc')
```

---

- .xxx files are hidden
- ls -ld .* show the hidden files
- .Rprofile set up your R behavior
- .bashrc set up your bash behavior
- .gitignore set up your git behavior
- .vimrc set up you vim behavior
- these files are equivalent to Preference part of your GUI software





# Vim for efficient editing

Vim is a *highly customizable* text editor

1. LaTeX, R, C/C++, Java, Python, Git and etc.
2. Regular expression, syntax coloring, auto-completion
3. <ESC>-mode
   - :-mode, aka., the last line mode
   - i-mode, aka., the insert mode

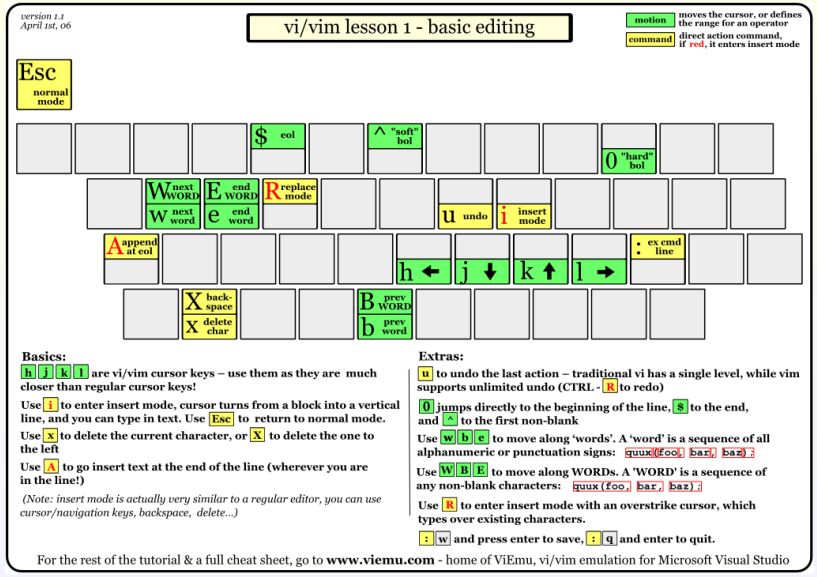




# Vim for efficient editing

- Download & Install GVim or MacVim
- Download & Install tetris.vim
- Download & Install minibufexpl.vim
- Download & Install Gundo
- Download & Install Vim-LaTeX

# Vim for efficient editing








# A Word Problem

*To encourage Elmer's promising tennis career, his father offers him a prize if he wins (at least) two tennis sets in a row in a three-set series to be played with his father and the club champion alternately: father-champion-father or champion-father-champion, according to Elmer's choice. The champion is a better player than Elmer's father. Which series should Elmer choose?*

- What is that you wish to know?
- unimportant, exogenous, and endogenous?
- if the model fits the situation, will we be able to use it?
- Test the model





# Arguments from Scale I

Cost of Packing

Speed of Racing Shells

Size Effect in Animal