550.400: Mathematical Modeling and Consulting

Lecture Notes

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Notes

Outline

Notes

Intro. to Using Git for Off-Line Teamwork I

Places to set up a git for your group work:

- Git Hub
- Dropbox

Why does it matter?

- It allows you to collaborate with others off-line
- You leave a trail of your contributions to the project

In-Class Activities for setting up a github account

- go to github.com
- initiate a git project from github
- set up your local folder
- populate the folder with new contents

Notes

Intro. to Using Git for Off-Line Teamwork II

as shown in Figure 9-1.

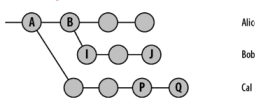


Figure 9-1. Criss-cross merge setup

Imagine that Cal started the project and Alice joined in. Alice worked on it for a while, then Bob joined in. In the meantime, Cal has been working away on his own version.

Eventually, Alice merged in Bob's changes, and Bob kept on working without merging Alice's changes back into his tree. There are now three different branch histories (Figure 9-2).

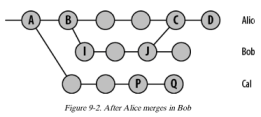


Figure 9-2. After Alice merges in Bob

Let's imagine that Bob wants to get Cal's latest changes. The diagram is looking pretty complicated now, but this part is still relatively easy. Trace up the tree from Bob, through Alice, until

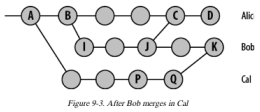


Figure 9-3. After Bob merges in Cal

TIP

You can always find the *merge base* between two or more branches by using *git merge-base*. It is possible for there to be more than one equally valid merge base for a set of branches.

So far, so good.

Alice now decides that she, too, wants to get Cal's latest changes, but she doesn't realize Bob has already merged Cal's tree into his. So she just merges Cal's tree into hers. That's another easy operation because it's obvious where she diverged from Cal. The resulting history is shown in Figure 9-4.

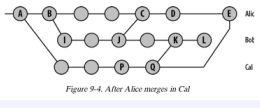


Figure 9-4. After Alice merges in Cal

Notes

```
1 git branch alice
2 git checkout alice
```

Focus Problem

- Objective: your own copy of the poem
- Rule 1: You write one stanza of the poem into the `main.tex` file
- Rule 2: You can collect all the others only by using the following commands:

```
1  git remote
2  git pull
3  git push
4  git fetch
5  git merge
```


Notes

Adv. Git Mehod for Off-Line Teamwork I

```
1  git format-patch master~2..master
```


Notes

Adv. Git Mehod for Off-Line Teamwork II

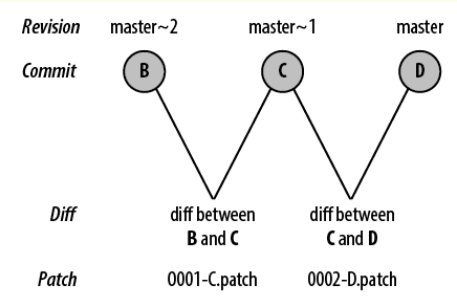


Figure 14-1. git format-patch with a commit range

Notes

Git Exercise I

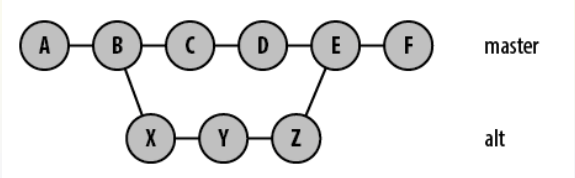


Figure 14-3. History of two branches

Notes

Git 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
- KISS (See WMA for its meaning)

Class Exercise

Collect all 8 stanzas together with your neighbor.

- You do four of them
- Your teammate do four of them
- Then, you combine yours with your teammate's

Notes

Introduction to beamer I

Basic Body Layer

```
\begin{document}
\section{Hello World}
    \subsection{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}
```


Notes

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/

Notes

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:

Notes

Introduction to beamer IV

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


Notes

Using R to do System Admin Stuff I

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

- `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

Notes

Using R to do System Admin Stuff II

- arguments are implicitly ordered but the order can be overriden

Notes

A brain-teaser

"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"

- 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

Notes

Arguments from Scale I

Cost of Packing

Speed of Racing Shells

Size Effect in Animal

Notes

Spurious Causality I

```
1 CBE <- read.table('http://www.massey.ac.nz/~pscowper/ts/cbe.dat')
2 Ets <- ts(CBE[,3], start = 1958, freq=12)
3 Cts <- ts(CBE[,2], start = 1958, freq=12)
4 plot(as.vector(aggregate(Cts)),as.vector(aggregate(Ets)))
```

```
1 set.seed(10)
2 x <- rnorm(100)
3 y <- rnorm(100)
4 for(i in 2:100) {
5     x[i] <- x[i-1] + rnorm(1)
6     y[i] <- y[i-1] + rnorm(1)
7 }
8 plot(x,y)
```


Notes

How to do software documentation using R

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


Notes

Outline

Notes

Seven Basic Principles

1. Set the context
2. Choose effective examples and analogies
3. Choose vocabulary to suit your readers
4. Decide whether to present #s in text, tables, or figures
5. Report and interpret #s in the text
6. Specify the direction *and* size of an association between variables
7. For many #s, summarize overall pattern

Notes

Outline

Notes

Models and Reality: "Disclaimer"

Here we are concerned exclusively with mathematical models, that is, models that mimic reality by using the language of mathematics. Whenever we use "model" without a modifier, we mean "mathematical model."

Notes

Models and Reality

What makes Mathematical models useful? If we "speak in mathematics,",

- *We must formulate our ideas precisely and so are less likely to let implicit assumptions slip by,*
- *We have a concise "language" which encourages manipulation,*
- *We have a large number of potential theorems available,*
- *We have high speed computers available for carrying out calculations.*

Notes

Properties of Models

A mathematical model is an abstract, simplified, mathematical construct related to a part of reality and created for a particular purpose.

Since a dozen different people are likely to come up with a dozen different definitions, don't take this one too seriously;

rather, think of it as a crude starting point around which to build your own understanding of mathematical modeling.

Notes

Properties of Models

As far as a model is concerned, the world can be divided into three parts:

1. *Things whose effects are neglected,*
2. *Things that affect the model but whose behavior the model is not designed to study,*
3. *Things the model is designed to study the behavior of.*

Notes

Building a Model: "Disclaimer"

Model building involves imagination and skill. Giving rules for doing it is like listing rules for being an artist; at best this provides a framework around which to build skills and develop imagination.

It may be impossible to teach imagination. I won't try, but I hope this book provides an opportunity for your skills and imagination to grow. With these warnings, I present an outline of the modeling process.

Notes

Building a Model

With these warnings, I present an outline of the modeling process.

1. *Formulate a problem*
2. *Outline the model*
3. *Is it Useful?*
3. *Test the model*

Notes

Building a Model

Some models may require no data. If a model makes the same prediction regardless of the data, we are not getting something for nothing because this prediction is based on the assumptions of the model.

To some extent, the distinction between data and assumptions is artificial. In an extreme case, a model may be so specialized that its data are all built into the assumptions.

Notes

Building a Model

The manager of a large commercial printing company asks your advice on how many salespeople to employ.

Qualitatively, more salespeople will increase sales overhead, while fewer salespeople may mean losing potential customers.

Thus there should be some optimum number.

Notes

IMM Problem: "Disclaimer"

Some of the problems in this book lead you step by step through the development of a model and thus resemble the mathematics problems you have seen in other courses;

however, many problems are closer to real life: They are vaguely stated, have multiple answers (models), or are open ended.

I strongly recommend working in small groups on the problems to bring out various ideas and evaluate them critically.

Notes

Models and Reality

The ultimate test of a model is how well it performs when it is applied to the problem it was designed to handle.

A model is used, it may lead to incorrect predictions. The model is often modified, frequently discarded, and sometimes used anyway because it is better than nothing. This is the way science develops.

Notes

Outline

Notes

What is Mathematical Modeling?

Trillion Dollar Bet

NOVA Online | **Trillion Dollar Bet**
www.pbs.org/wgbh/nova/stockmarket/
Welcome to the companion Web site to "**Trillion Dollar Bet**," originally broadcast on February 8, 2000. The film tells the fascinating story of the invention of the ...
The Formula that Shook The ... - Transcripts - A Trader's Lexicon - Resources

Videos for **trillion dollar bet** - Report videos

Trillion Dollar Bet 1 - YouTube
youtube.com
Jan 8, 2009

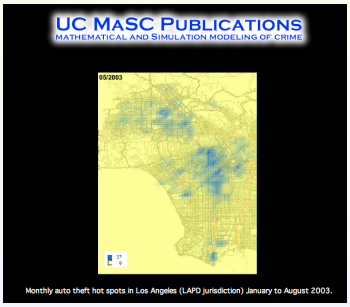
The Trillion Dollar Bet - YouTube
youtube.com
Sep 15, 2007

The Midas Formula Stockmarket ...
youtube.com
Aug 23, 2011

Notes

What is Mathematical Modeling?

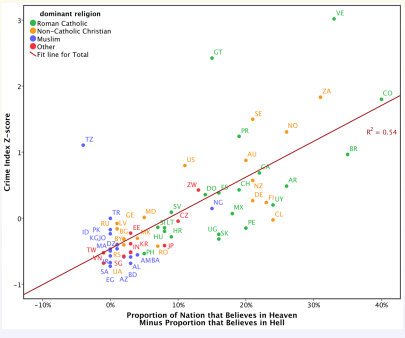
LAPD Fighting Crime with Math



Notes

What is Mathematical Modeling?

Crime rates and religious beliefs



Notes

More Project Ideas

http://www.stat.berkeley.edu/

http://www.math.msu.edu/

http://www.mathgoespop.com/

http://www.math.hmc.edu/clinic/

Prof. Bender's Notes

Notes

Outline

Notes

Insurance Redlining

Insurance Redlining

Insurance redlining refers to the practice of refusing to issue insurance to certain types of people or within some geographic area.

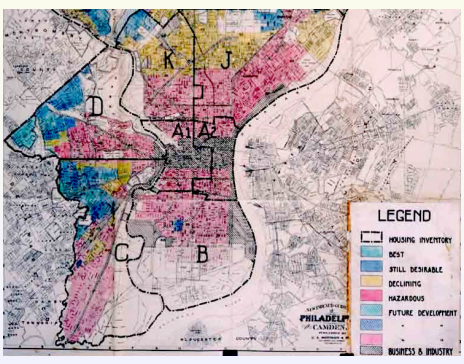
FAIR

The FAIR plan was offered by the city of Chicago as a default policy to homeowner who had been rejected by the voluntary market.

Notes

Insurance Redlining

Insurance Redlining



Notes

Insurance Redlining

Sponsor

The U.S. Commission on Civil Rights examined charges by several Chicago community organizations that insurance companies were redlining their neighborhoods.

Data

The number of FAIR plan policies written and renewed in Chicago by zip code for the number of months of December 1977 through May 1978.

Notes

Insurance Redlining

Variables to consider:

- `race` Racial composition in percentage of minority,
- `fire` Fire per 100 housing units,
- `theft` Theft per 1000 population,
- `age` percent of housing unit built before 1939,
- `involact` New FAIR plan policies and renewal per 100 housing units,
- `income` Median family income in thousands of dollars,
- `side` North or South side of Chicago.

Notes

Insurance Redlining: Ecological Fallacy

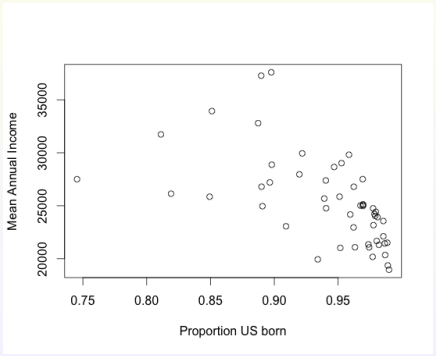
Ecological Fallacy

When data are collected at the group level, we may observe a correlation between two variables. The ecological fallacy is concluding that the same correlation holds at the individual level.

Notes

Insurance Redlining: Ecological Fallacy

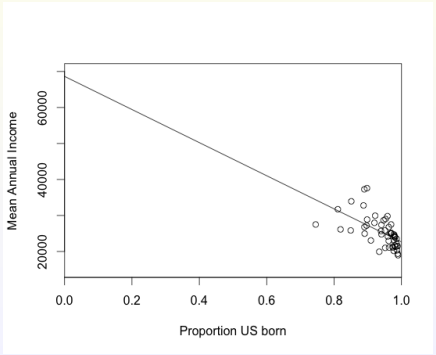
1998 annual per capita income and proportion U.S. born for 50 states plus D.C.



Notes

Insurance Redlining: Ecological Fallacy

1998 annual per capita income and proportion U.S. born for 50 states plus D.C.



Notes

Insurance Redlining

For the ecological fallacy example, the assumption would be that the incomes of the native born do not depend on the proportion of native born within the state (and similarly for naturalized citizens).

For the insurance redlining example, we only have aggregate data. We must inform the sponsor that unless more detailed data becomes available, the results for the aggregated data may not hold true at the individual level.

Notes

Work Statement: Introduction

The work statement should contain a short description of your sponsor.

For the insurance redlining example, *U.S. Commision on Civil Rights* would be the sponsor.

Boilerplating from the sponsor's webpage is often acceptable.

http://www.usccr.gov

Notes

Work Statement: Problem Statement

Can the insurance companies claim that the discrepancy is due to greater risks in some zip codes?

The insurance companies could claim that they were denying insurance in neighborhoods where they had sustained large fire-related losses and any discriminatory effect was a by-product of legitimate business practice.

Notes

Outline

Notes

Sherlock Holmes and the Bicycle Tracks: Problem Statement

Which one is the front wheel?

Notes

Sherlock Holmes and the Bicycle Tracks

"This track, as you perceive, was made by a rider who was going from the direction of the school."

"Or Toward it?"

"No, no, my dear Watson. The more deeply sunk impression is, of course, the hind wheel, upon which the weight rests. You perceive several places where it has passed across and obliterated the more shallow mark of the front one. It was undoubtedly heading away from the school."

– *The Adventure of the Priory School* by Arthur Conan Doyle

Notes

Sherlock Holmes and the Bicycle Tracks

$$f_x(t) = r_x(t) + \frac{L}{\sqrt{1 + (r_y'(t)/r_x'(t))^2}}$$

$$f_y(t) = r_y(t) + \frac{L r_y'(t)/r_x'(t)}{\sqrt{1 + (r_y'(t)/r_x'(t))^2}}$$

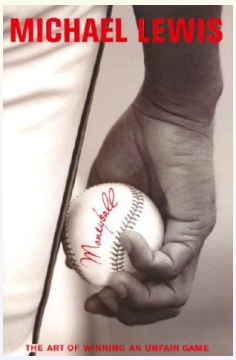
Notes

Outline

Notes

Is a Sport Game Fair?: Problem Statement

How can we decide if a game with two competitors is fair?



Notes

Is a Tennis Match Fair?

One simple answer is:

> *If the roles of the competitors are reversed, their probability of winning does not change.*

Isn't that always true? No. For example, going first may give a player an advantage of disadvantage.

Notes

Is a Tennis Match Fair?: Problem Statement

How can we decide if a game with two competitors is fair?

Notes

Is Tennis Fair?

Review of our work done last time.

- What is tennis (for our mathematical modeling purpose)?
- What was assumed to be ignored?
- How was the server's advantage modeled?
- What did we do to simplify our model?
- Is there a "generalized" rule that models the tennis set winning determination?
- Who could be your sponsor/client? (Try USTA)

Notes

Programmings in this class

- LaTeX :
  - `moderncv`
  - `beamer`
  - `report`
  - `pgf/TikZ`
- Git
  - `git gui`
- R:
  - `lm`
  - `ggplot2`
  - `tikzDevice`
  - `R CMD build`

Notes

Where to get some help for LaTeX

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

Notes

Tutorial: LaTeX

LaTeX is a computer language for writing a scholarly paper:

Table: HTML vs LaTeX

	HTML	LaTeX
Code		
	`<html>`	`\begin{document}`
	`. . .`	`. . .`
	`</html>`	`\end{document}`
Compiler	Firefox and etc.	pdflatex and etc.
Output	Web-page	PDF file

Notes

Tutorial: LaTeX

TeXworks is:

- an editing tool that is separate from LaTeX,
- available in Linux, OSX and Windows,
- avaiable in:

http://code.google.com/p/texworks/

Notes

Tutorial: LaTeX

- Demo on preparing a resume using LaTeX `moderncv` package:
  - Install LaTeX (MikTeX in Windows and MacTeX in OSX),
  - Download `moderncv` package files from the course folder,
  - Change file names to reflect you,
  - Edit the TeX file,
  - Compile using your favorite LaTeX editor,
  - Look at the resulting PDF file.

Notes

Tutorial: LaTeX

Typing mathematics in LaTeX:

```
1 Hello $\int_0^1 \sin(x) dx$ World
2 \vskip0.5in
3 Hello $$\int_0^1 \sin(x) dx$$ World
```

Hello $\int_0^1 \sin(x)dx$ World

Hello

$$\int_0^1 \sin(x)dx$$

World

Notes

Cautions: LaTeX

There are numerous quirky LaTeX rules:

- opening quotation is not the same as the closing quotation,
- period yields *two* blank spaces,
- for %, need to type \%,
- for \, need to type `\textbackslash`,
- for /, need to type /,
- for {, need to type \{,
- for $, need to type \$,
- ~ yields a single blank space,
- and etc.

Notes

Tutorial: LaTeX

How to make slides with notes:

```
1 \usepackage{handoutWithNotes}
2 \pgfpagesuselayout{4 on 1 with notes}[a4paper,border shrink=5mm]
```

This will

- put four scaled-back slides in one page with ruled-note space on the right
- make the "hyper links" invalid

Notes

The place to get some Git helps

http://git-scm.com/doc/

Notes

Tutorial: Git

```
1 sudo apt-get install git
```

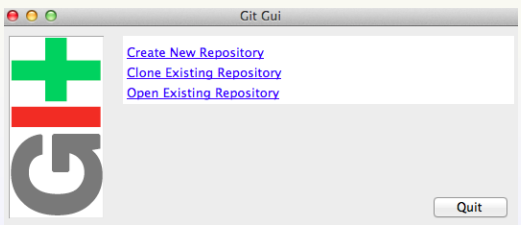
An alternative: `git gui`

Notes

Tutorial: Git

```
1 cd ~/
2 git clone http://cis.jhu.edu/~nhlee/550400.git
```

An alternative: `git gui`

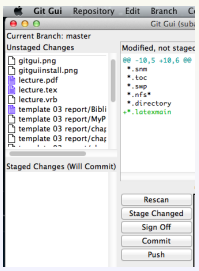


Notes

Tutorial: Git

```
1 cd ~/550400
2 git reset --hard HEAD
3 git pull origin master
```

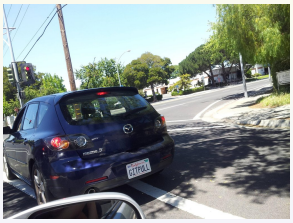
An alternative: `git gui`



Notes

Tutorial: Git

After years of using git, you might find this funny:



```
1 git pull origin master
```


Notes

Tutorial: Git

After years of using git, you might find this funny:


```
1 git push origin master
```


Notes

Tutorial: Git

For $19.99, you can also have your own:


```
1  cd ~/
2  mkdir hub.git
3  mkdir computerA.git
4  mkdir computerB.git
5
6  git init --bare hub.git
7
8  cd hub.git
9  cd hooks
10 cp post-update.sample post-update
```


Notes

Tutorial: Git

```
1 cd computerA.git
2 git init
3 git remote add origin ~/hub.git
4 echo 'Hello A' >> commonfile.txt
5 git add commonfile.txt
6 git commit -am 'from A'
7 git pull origin master
8 git push origin master
```

```
1 cd computerB.git
2 git init
3 git remote add origin ~/hub.git
4 echo ' World B' >> commonfile.txt
5 git add commonfile.txt
6 git commit -am 'from B'
7 git pull origin master
8 git push origin master
```


Notes

Tutorial: Git

```
1  cd ~/550400
2
3  git gui
4  git reset --hard HEAD
5
6  git branch personal
7  git branch
8  git checkout personal
9
10 edit some file
11 git status
12 git add .
13 git commit -am 'personal edit'
14
15 git checkout master
16 git branch -D personal
```

- checks if there has been any change to the folder
- build and update the `master` git branch
- create and update a `personal` git branch

Notes

Tutorial: Git

`.gitignore`?

- N.B. the course folder already has one
- Use it to let *git* know the files to *ignore* while version controlling
- one particular usage: create `.gitignore` at the root of your git folder
- files already been list under the git watch list will not be ignored even after creation of `.gitignore`

Notes

Vim

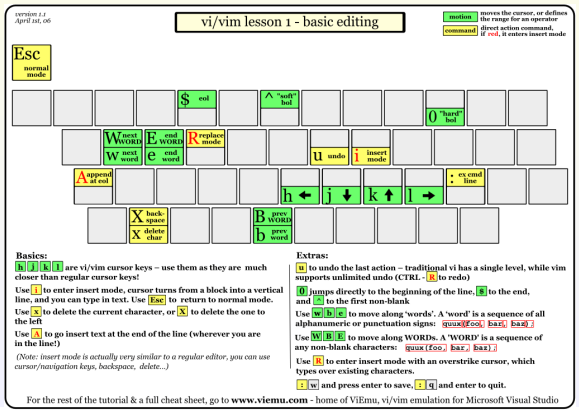
Vim

Vim is a highly customizable text editor

1. LaTeX, R, C/C++, Java, Python, Git and etc.
2. Regular expression, syntax coloring, autocompletion
3. Try Firefox + Wasavi/Vimperator/Vimium
4. <ESC>-mode
   - :-mode, aka., the last line mode
   - i-mode, aka., the insert mode

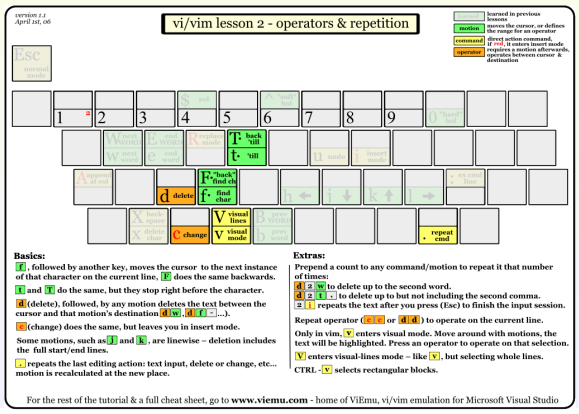
Notes

Tutorial: Vi



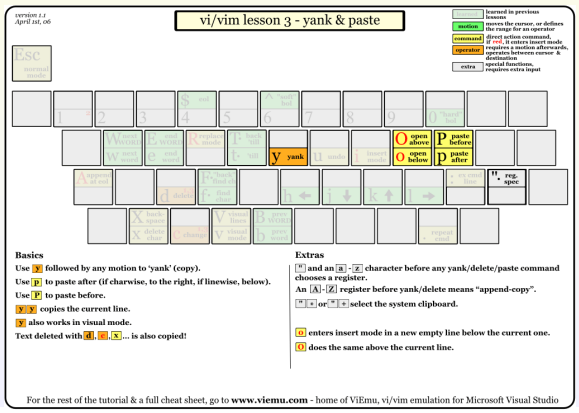
Notes

Tutorial: Vi



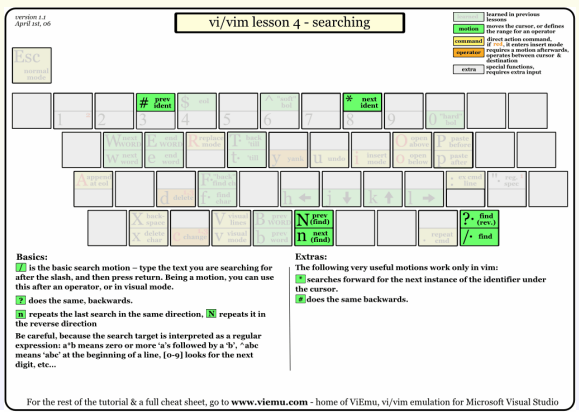
Notes

Tutorial: Vi



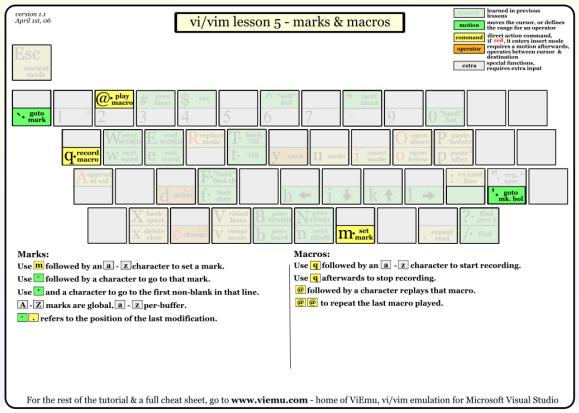
Notes

Tutorial: Vi



Notes

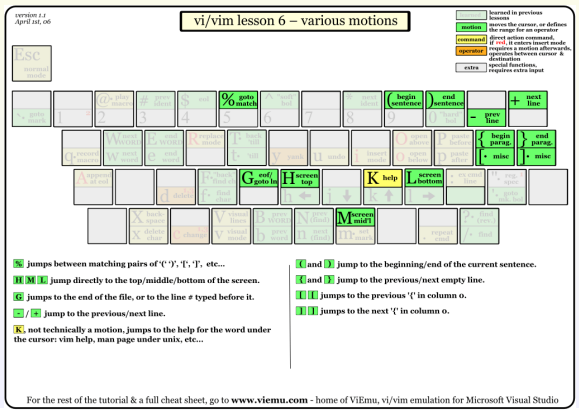
Tutorial: Vi



For the rest of the tutorial & a full cheat sheet, go to **www.viemu.com** - home of ViEmu, vi/vim emulation for Microsoft Visual Studio

Notes

Tutorial: Vi



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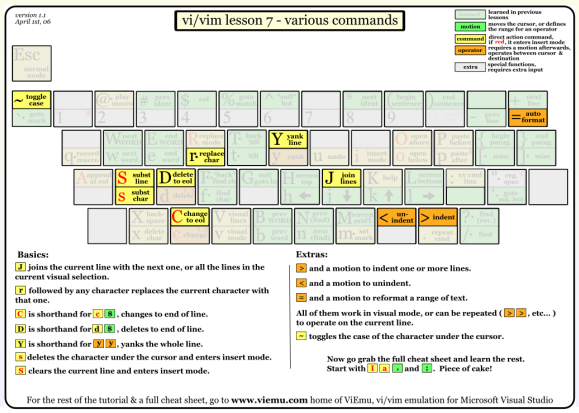
Notes

Tutorial: Vi



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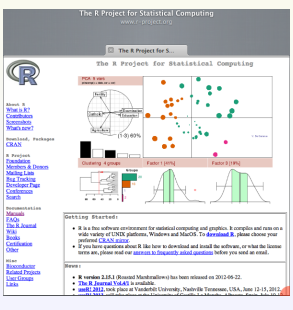
Notes

Demo: R + LaTeX

R Studio

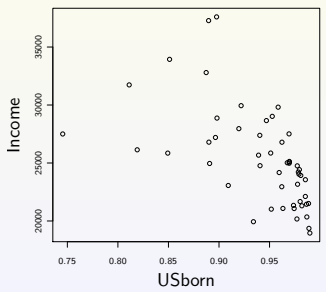
R



Notes

Demo: R + LaTeX

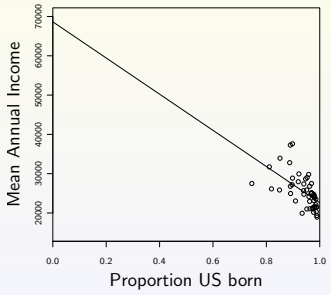
```
1  install.packages(faraway)
2  install.packages(tikzDevice)
3  require(faraway)
4  require(tikzDevice)
5  data(eco)
6  tikz('embeddedfig1.tex',
7       standAlone=F,
8       width=5,height=5)
9  plot(income ~ usborn,
10      data=eco,
11      xlab='Proportion US born'
12      ylab='Mean Annual Income'
13      )
14 dev.off()
```



Notes

Demo: R + LaTeX

```
1  tikz('embeddedfig2.tex',
2       standAlone=F,
3       width=5,height=5)
4  plot(income ~ usborn,
5       data = eco,
6       xlab='Proportion US born',
7       ylab='Mean Annual Income',
8       xlim=c(0,1),
9       ylim=c(15000,70000),
10      xaxs='i')
11 g<-lm(income~usborn,eco)
12 abline(coef(g))
13 dev.off()
```



Notes

Outline I

Notes

Outline II

Notes

WMA Problem 2.5a & 2.6a

The Williams family's income of $25,000 falls below 185% of the Federal Poverty Threshold for a family of four, qualifying them for food stamps.

Problem 2.5a Identify terms that need to be defined or restated for a nontechnical audience

Problem 2.6a Rewrite the sentences in the previous questions for an audience with a fifth-grade education. Convey the main point, not the calculation or the jargon.

FYI Off-the-chart

Notes

WMA Problem 2.8a

Rewrite each of these sentences to specify the direction and magnitude of the association:

In the United States, race is correlated with income.

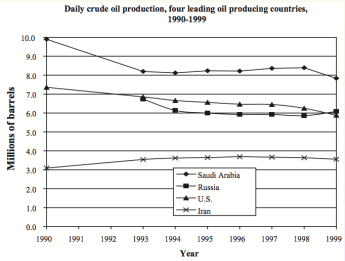
Table: **Median income by race and Hispanic origin, United States, 1999**

Race/Hispanic origin	Median Income
White	$42,504
Black	$27,910
Asian/Pacific Islander	$51,205
Hispanic (can be of any race)	$30,735

Notes

WMA Problem 2.9

Use the GEE approach to describe the patterns in the figure below, including an introductory sentence about the purpose of the chart before summarizing the patterns.



Notes

IMM Problem 1.1

Suppose people enter the elevators in a skyscraper at random during the morning rush. The result will be several elevators stopping on each floor to discharge one or two passengers each.

- Discuss schemes for improving the situation.
- How could improvement be measured?
- How could you model the situation to decide what scheme to adopt?

Notes

IMM Problem 1.6

Unless you have been extremely lucky, you have had a large class in a poorly designed lecture hall.

(a) What are some criteria to be considered in designing a large lecture hall?

Notes

IMM Problem 1.6

Unless you have been extremely lucky, you have had a large class in a poorly designed lecture hall.

(b) One criterion is legibility of material written on the boards.

- Construct a model of legibility as a function of
  - *the distance* your seat is from the board
  - *the angle* at which you look at the board
- What will the curves of constant legibility look like on a floor plan?
- How can you test this prediction? Try it.
- Does this suggest shaping the back of the hall differently than is usually done? How?

Notes

IMM Problem 1.6

Unless you have been extremely lucky, you have had a large class in a poorly designed lecture hall.

(c) Can mathematical modeling help with any other criteria besides the one mentioned in (b)? Try to pick a criterion from among these possibilities and develop a model for it.

Notes

Collect All: LaTeX + Git

The Blind Men and the Elephant

In-class Group Exercise (Scavenger hunt):

- Start up a git folder,
- Create and edit the `.gitignore` file,
- Download the template for a beamer file,
- Look up the poem from the book,
- One slide per stanza,
- Use `verse` environment,
- Compile after each stanza,
- Commit after creating each stanza,
- Repeat until done.

Notes

Outline

Notes

Mission Impossible?: an analogy

Mission Impossible Season 2 Episode (00:00 – 06:25)

Notes

Project in Industry: Frequently Recurring Elements

A stylized timeline:

1. Work Statement,
2. Midterm Presentation,
3. Progress Report,
4. Final Presentation,
5. Final Report.

Institute for Pure & Applied Mathematics
IPAM
University of California, Los Angeles

Notes

Outline

Notes

What is Work Statement

This is the written proposal and definition of the project and constitutes the team's "contract" with the sponsor. It should be approximately 2-5 pages long. It sets forth the nature of the project, the specific objectives of the project, the results expected, and the "deliverables" for the project. The scope of the project must be within the timetable for the program and that the deliverables are reasonable and appropriate; given the nature of research, it should not include promises that the team cannot be certain to achieve. It is ultimately given to the sponsor for review and signature.

Notes

Template 1

1. Abstract
2. Background
3. Problem description
4. Approach ("time permitting" clause for some work)
5. Schedule (dates for completing milestones and tasks and for deliverables)
6. Milestones (major checkpoints your team will use to stay on track)
7. Deliverables (specific work products you will deliver to the sponsor)

Notes

Templates 2

1. Introduction
2. Problem background
3. Mathematical background
4. Computing background
5. Possible solutions and project objectives
6. Deliverables ("time permitting" clause for some work)
7. Timeline

Notes

Template 3

1. Project background
2. Goals (major direction you see the work aimed at, not necessarily what you bid to do)
3. Proposed mathematical approach
4. Objectives (specific aims of your project, and schedule of results you expect to achieve)
5. Optional objectives
6. Deliverables
7. Milestones
8. Work flowchart
9. Schedule

Notes

Template 4

1. Abstract
2. Problem background
3. Problem description
4. Approach
5. Deliverables
6. Timetable
7. Team members

Notes

Work Statement

In the initial segment ("Abstract", "Introduction", "Background")

- Brief description of the company
- Major product lines(s)
- A brief (abstract) description of the project

Notes

Work Statement

Throughout

- Spell out terminology – avoid undefined jargon or acronym
- When options must be resolved, give dates by which they must be resolved
- Give modest objectives, not boastful ones

Notes

Work Statement

List of deliverables should include

- Site visits (to be arranged)
- Midterm oral presentation
- Midterm report
- Final presentation
- Final report
- Software (if appropriate)
  - Specify sponsor-approved OS, platform
  - Documentations

Notes

Work Statement

Work Statement Examples

See *Protein Pathways* Project Work Statement

Notes

Glossary I

GOAL
The overall, long range, end result that your research is aimed at, what you are trying to achieve ultimately. Stating a goal does not mean you believe you will get there this time around. It is the grand view towards which you strive. The goal of AIDS research is to find a cure for AIDS.

Notes

Glossary

OBJECTIVES
The specific things you will try to achieve in your project, the immediate targets of your research. Your objectives spell out how you have parsed the problem of heading towards the goal into smaller pieces that you will work on. The objectives set practical limits on your work. They point to where the project can reasonably expect to wind up. It should be clear that the objectives fit into and work towards the long-range goal.

Notes

Glossary

TASKS
These are the specific things you will do in order to achieve your objectives. The tasks drive your determination of what skills and other resources (such as data, software, hardware, written materials, work environment) will be needed for your project. If among the resources needed are ones that must be supplied by the sponsor, then you will need to specify these items in your Work Statement.

Notes

Glossary

DELIVERABLES

The things you promise to deliver to the sponsor. For a project, these include a mid-term and final report, a mid-term presentation and a final presentation on Projects Day. They may also include site visits to the sponsor (usually one near the beginning of the project to get acquainted with the sponsor, and one after Projects Day to present the work at the sponsor's location), software, perhaps hardware in some cases, written results of literature searches, white papers (i.e., written background information on such things as plans, methods or concepts prepared for internal use), etc. These additional items are to be decided by you in consultation with your sponsors mentor.

Notes

Glossary

MILESTONES

A list of specific accomplishments that you may use to mark progress and maintain pace and coordination within your project. They are used to help your team stay on track and to determine the success of a chosen line of attack on your problem. Milestones may or may not be included in your Work Statement, but you should definitely think these through for your own use as you plan your project and Work Statement. They are check-points for you (and for your sponsor, if they are included in the Work Statement), not necessarily deliverables. You may want to specify major milestones in your Work Statements to indicate what you would do if your research leads to the conclusion that some objective cannot be accomplished. For example, "if by such a date we have found it impossible to achieve X, then we will begin Y." Research is exploration of the unknown, so you may encounter an intractable obstacle and need to work around it. You can't know everything ahead of time. Give some thought to this and try to allow for milestones by which you can judge where you are and what you need to do to proceed effectively in the event you don't meet a milestone.

Notes

Glossary

SCHEDULE

This specifies when you will finish major parts of your research and provides a timetable for completion of deliverables. Internally, you should maintain as fine-grained a schedule as you need to keep your team coordinated and on track, but in your Work Statement it is best to make the schedule and list of deliverables as modest as the sponsor will allow.

Notes

Notes