Reproducible science: Module7

Version control Git and Github

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Part 1. Using Version Control

Version Control

- Research papers have many versions before publication
  - typically written over a long period of time, in numerous sittings
  - at the end of every sitting, essentially a different version of the same manuscript is created*

Version Control

- Research papers have many versions before publication
  - typically written over a long period of time, in numerous sittings
  - at the end of every sitting, essentially a different version of the same manuscript is created
- With many versions created over time, there emerge at least two challenges
  - keeping track of changes and versions
  - reverting to a previous version when necessary
- We all version control, in different ways, such as
  - edit, rename, save
  - use applications or websites such as Dropbox, Google Docs, Overleaf
  - use distributed version control systems such as Git and GitHub

Version Control — Manual Attempts

Typically, hand-made attemps to version control lead to cluttered folders

```
manuscript
    |
    |- journals_FINAL_19May.Rmd
    |- journals_FINAL.Rmd
    |- journals_26APRIL_newliterature.Rmd

    ...

    |- journals.Rproj
    |- references.bib
    |- apa_7th.csl
```

Version Control — Git and GitHub — Definitions

- Git
  - a software that keeps track of versions of a set of files
  - it is *local* to you, the records are kept on your computer

- GitHub
  - a hosting service, or a website, that can keep the records
  - it is *remote* to you, like the Dropbox website
  - but unlike Dropbox, GitHub is specifically structured to keep records with Git

- Repository, or repo
  - a set of files whose records are kept together, by Git and/or on GitHub
  - it is like a folder, which can keep files and other folders containing files

Version Control — Git and GitHub — Definitions

- To commit
  - to take a snaphot of, or to version, a repository
  - it is like saving a new version of all files and sub-folders in your project folder with a new name
  - it is local, the records are kept on your computer unless you `push`
- To push
  - to move the records from Git to GitHub, from your computer to online server
  - it is like uploading (the new versions of) your files and sub-folders to a website,
  - it also involves merging, if this not the first push

* For projects that are single-authored on a single computer, merging is typically automatic. It becomes an issue for collaborated projects, which we will cover in the next section — Part 9.

Version Control — Git and GitHub

Version control with Git and GitHub requires

1. initial setup, done once*
    - unless for a new computer or, if ever, a new GitHub account
    - a bit technical, but worth the hassle
2. project setup, repeated for every paper
    - shorter, less complicated

* We have started this process already, in Part 1 of the workshop, by downloading and installing Git and signing up for GitHub. Back to the relevant slide.

Part 2. Getting the Tools Ready

Git — Download from the Internet and Install

- For Windows, install 'Git for Windows', downloading from https://gitforwindows.org
  - select 'Git from the command line and also from 3rd-party software'
- For Mac, install 'Git', downloading from https://git-scm.com/downloads

GitHub — Open an Account

Sign up for GitHub at https://github.com

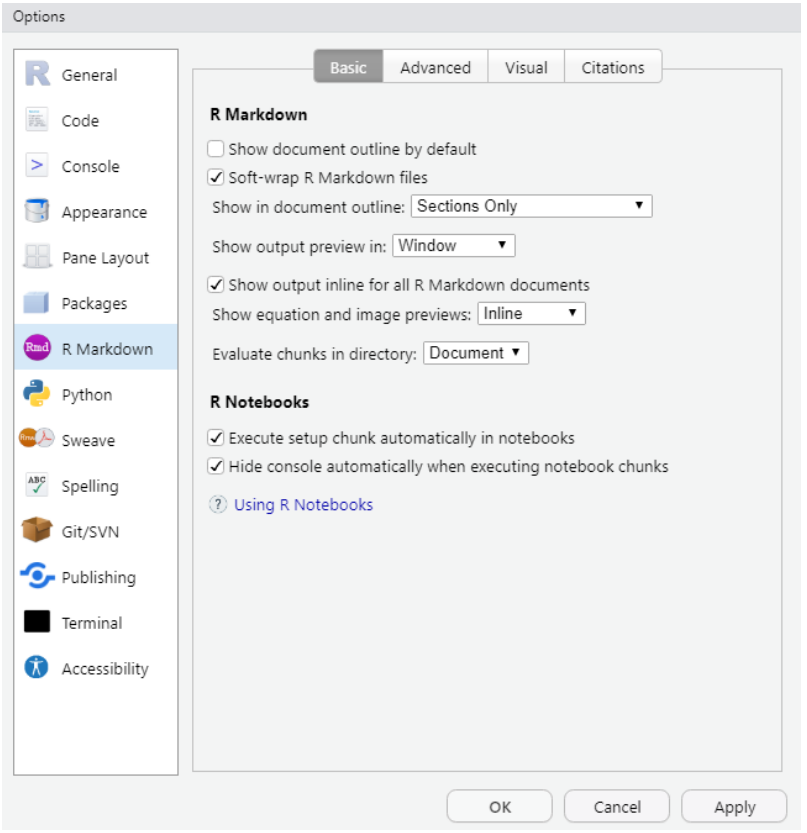
- registering an account is free
- usernames are public
  - either choose an anonymous username (e.g., `asdf029348`)
  - or choose one carefully — it becomes a part of users' online presence
- usernames can be changed later

RStudio — R Markdown Options

RStudio offers various functions that facilitate working with .Rmd documents, which can be controlled at two locations:

- global settings that apply to all markdown projects, located at:

  > `Tools -> Global Options -> R Markdown`



RStudio — R Markdown Options

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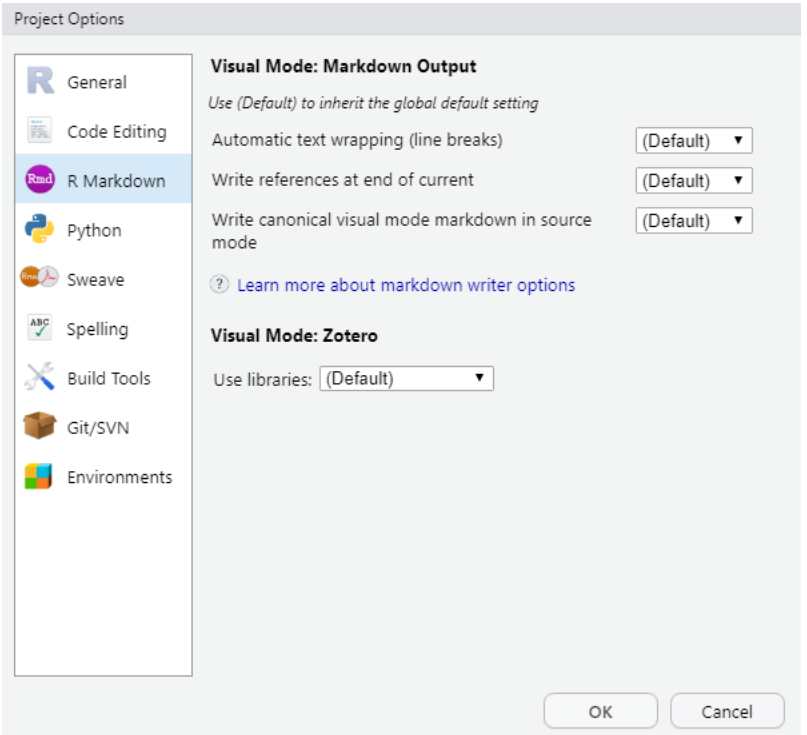
- global settings that apply to all markdown projects, located at:

  ```
  Tools -> Global Options -> R Markdown
  ```

- project settings that apply to a given markdown project, located at:

  ```
  Tools -> Project Options -> R Markdown
  ```



Introduction to command line interface

What is the Command Line Interface?

Nearly ever computer comes with a CLI

- Windows: Git Bash (See "Introduction to Git")
- Mac/Linux: Terminal

Introduction to command line interface

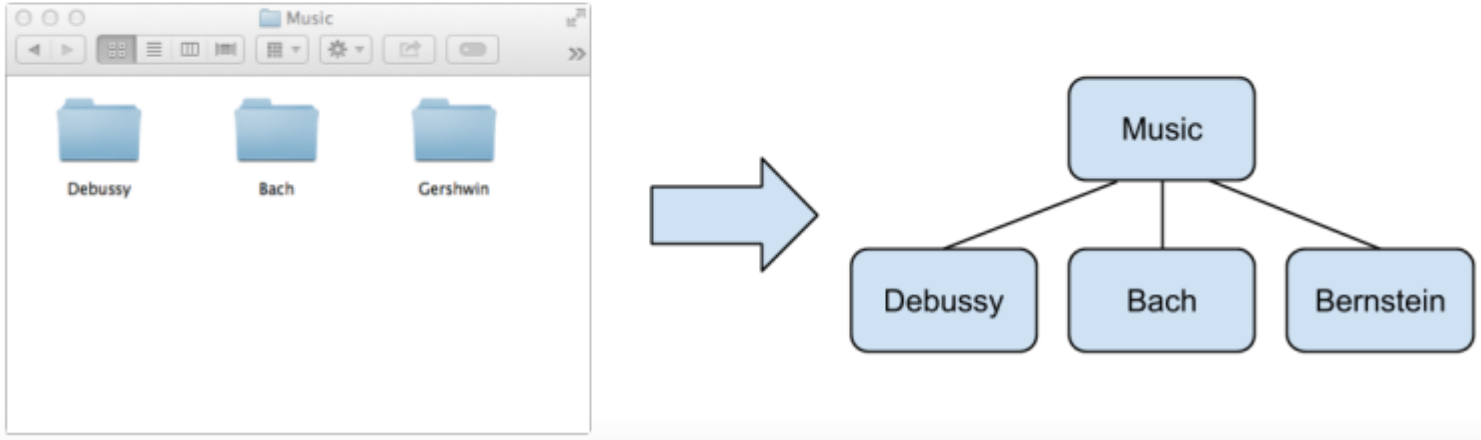
What can the CLI do?

The CLI can help you:

- Navigate folders
- Create files, folders, and programs
- Edit files, folders, and programs
- Run computer programs

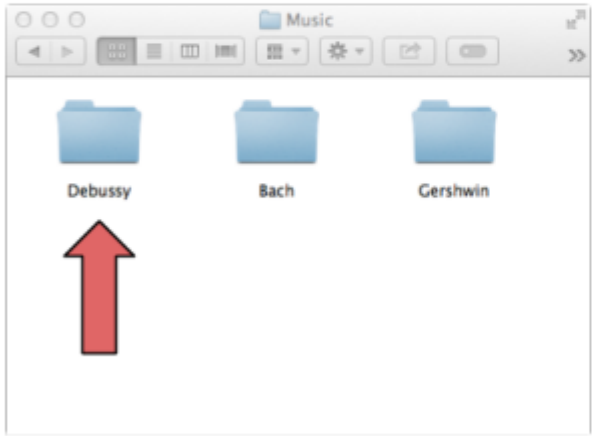
Basics of Directories

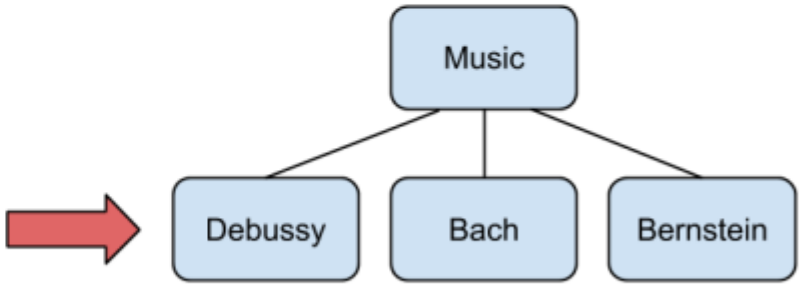
- "Directory" is just another name for folder
- Directories on your computer are organized like a tree
- Directories can be inside other directories
- We can navigate directories using the CLI



Basics of Directories

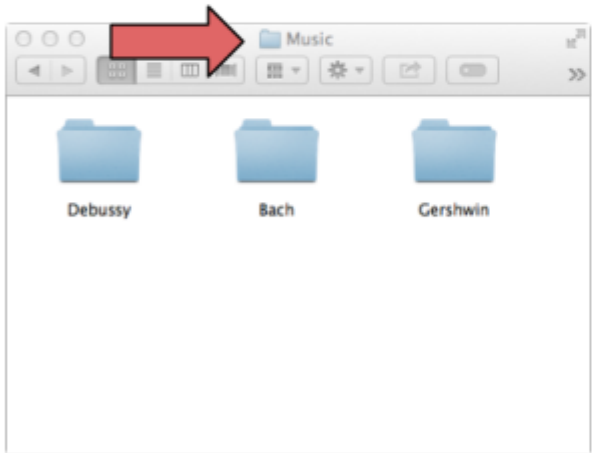
- My "Debussy" directory is contained inside of my "Music" directory

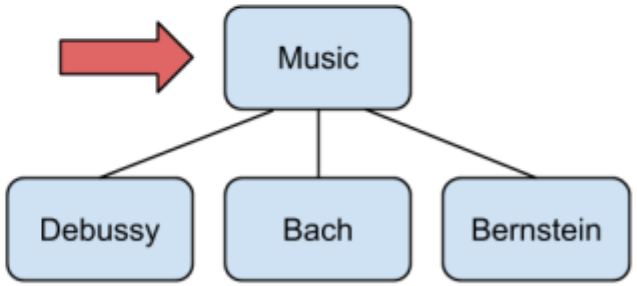




Basics of Directories

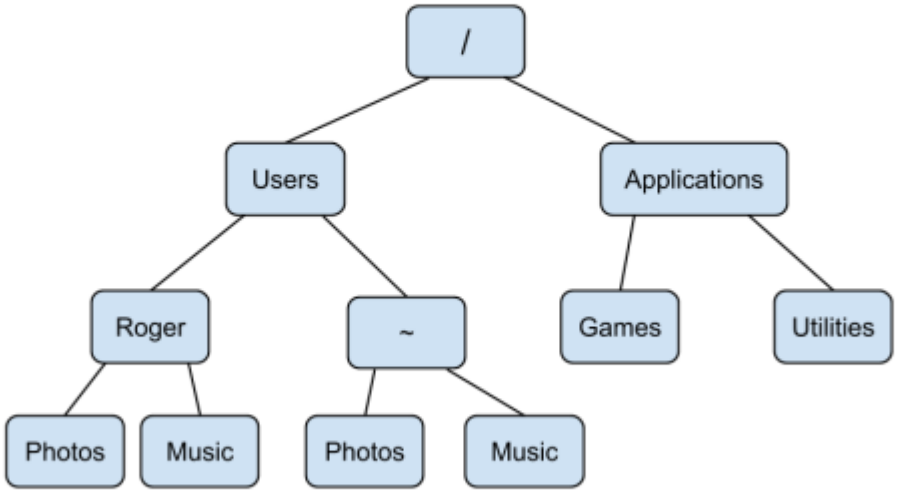
- One directory "up" from my Debussy directory is my Music directory





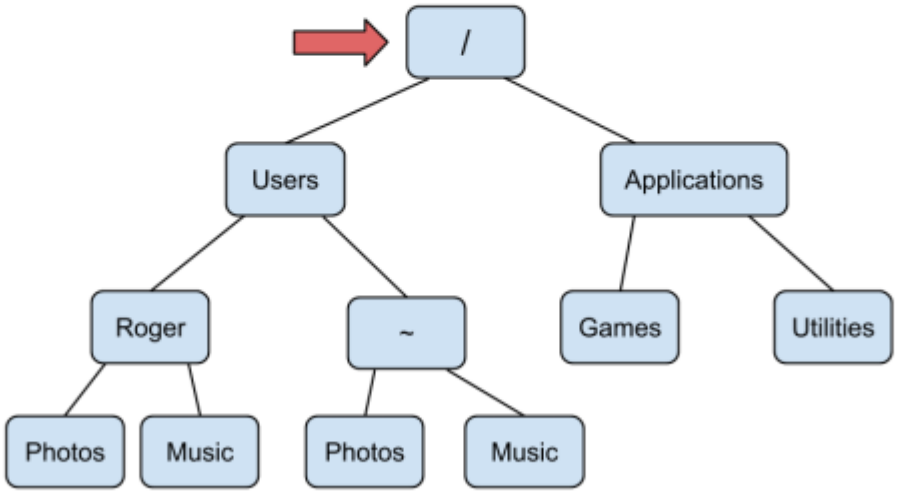
Your computer's directory structure

- The directory structure on your computer looks something like this



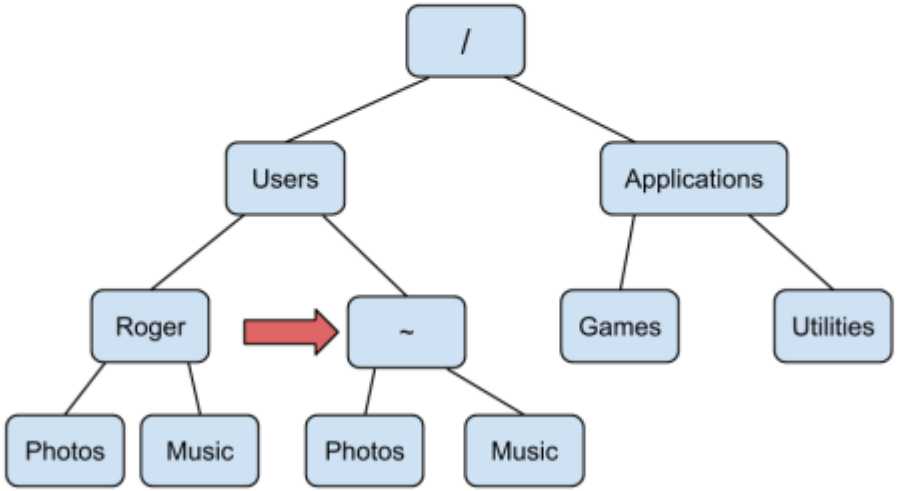
Special directories: root

- The directory at the top of the tree is called the root directory
- The root directory contains all other directories
- The name of this directory is represented by a slash: /



Special directories: home

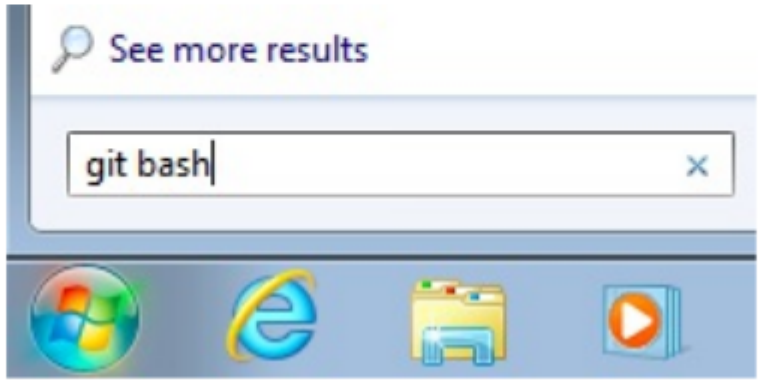
- Your home directory is represented by a tilde: ~
- Your home directory usually contains most of your personal files, pictures, music, etc.
- The name of your home directory is usually the name you use to log into your computer



Navigating directories with the CLI

Windows users:

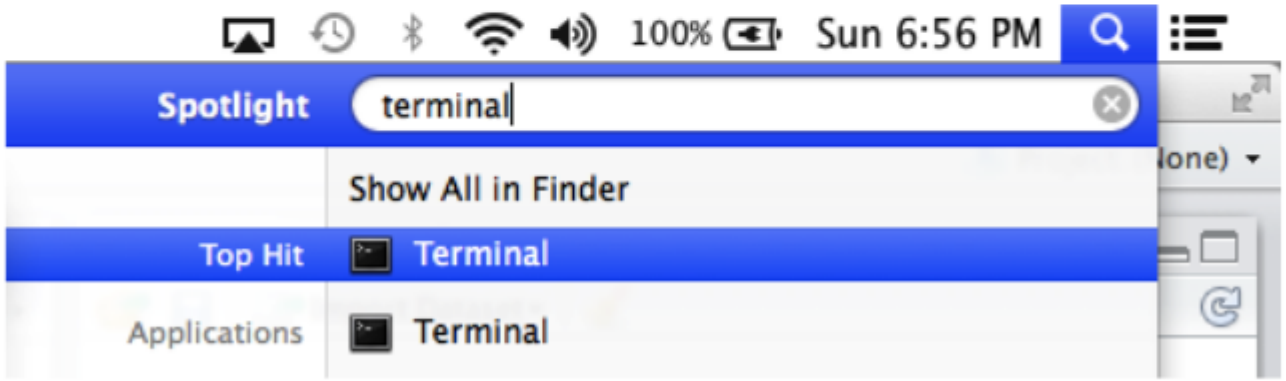
- Open the start menu
- Search for Git Bash
- Open Git Bash



Navigating directories with the CLI

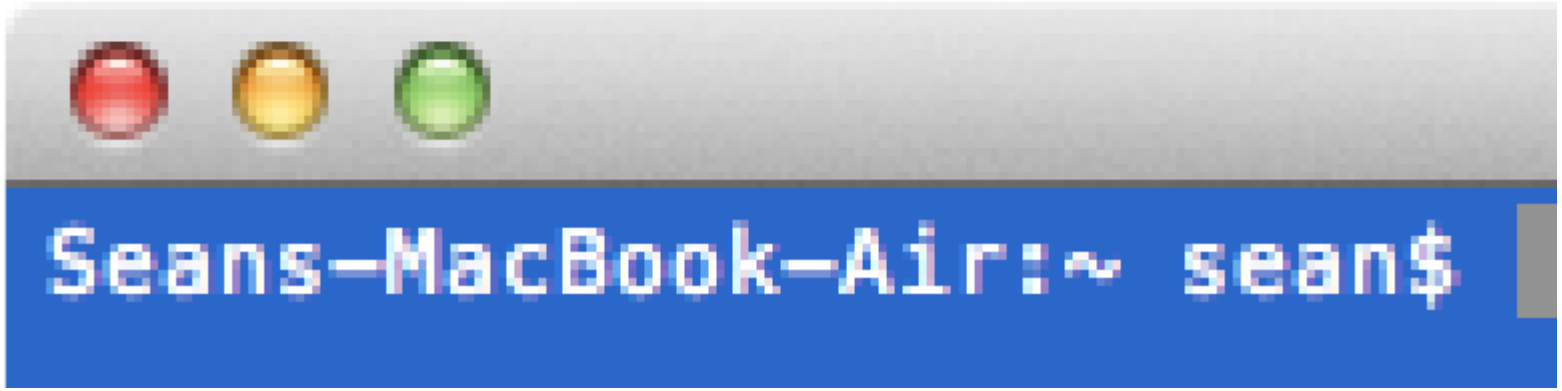
Mac users:

- Open Spotlight
- Search Terminal
- Open Terminal



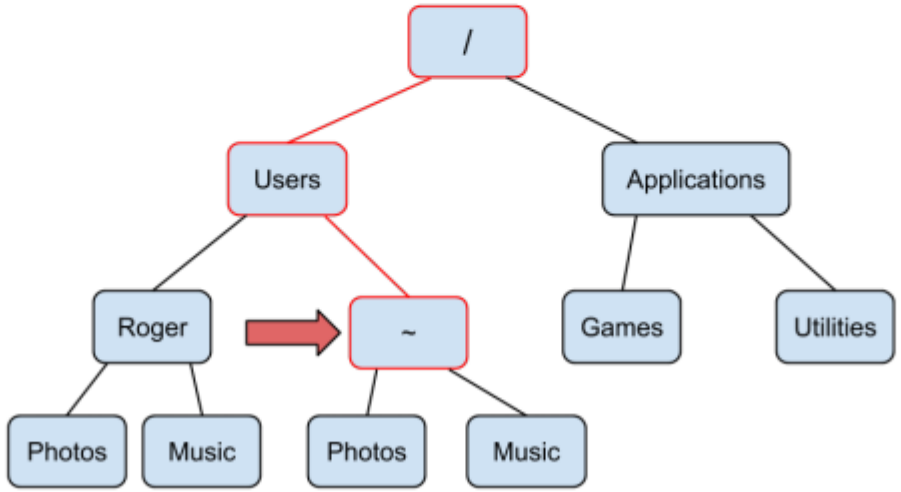
CLI Basics

- When you open your CLI you will see your prompt, which will looks something like the name of your computer, followed by your username, followed by a `$`
- When you open your CLI you start in your home directory.
- Whatever directory directory you're currently working with in your CLI is called the "working directory"



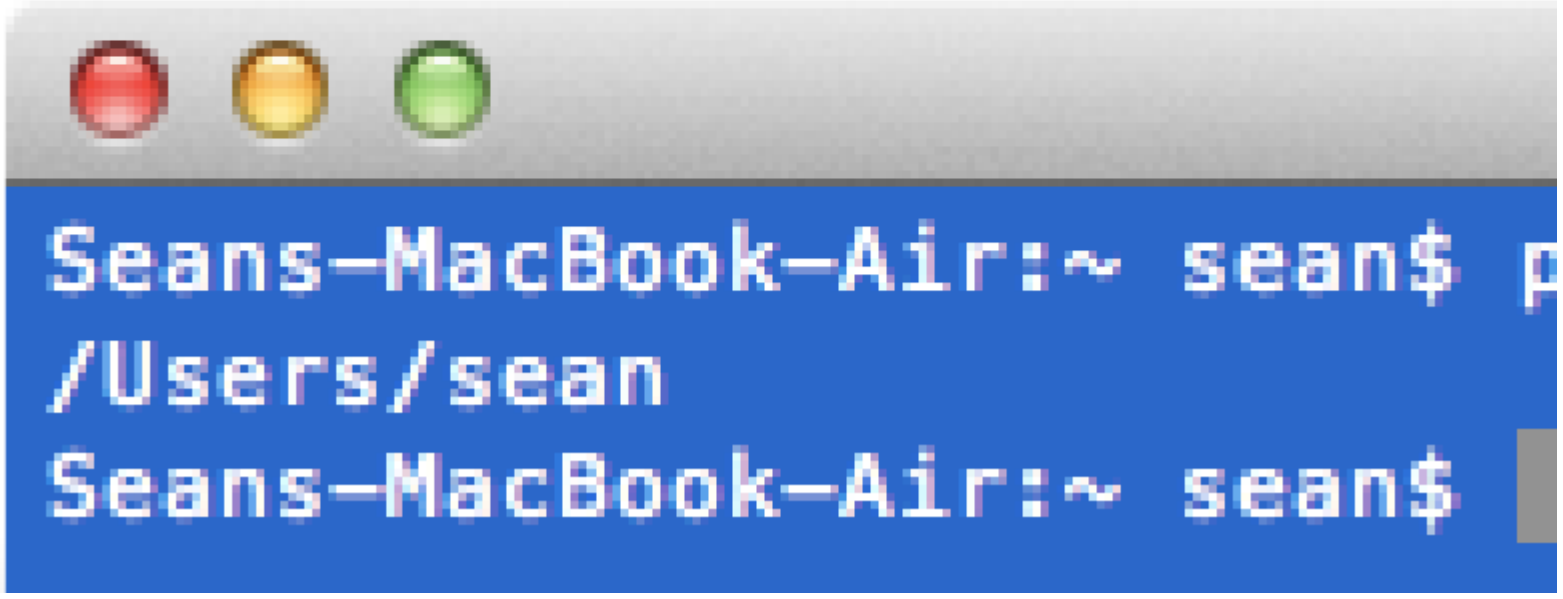
CLI Basics

- You can imagine tracing all of the directories from your root directory to the directory you're currently in.
- This is called the "path" to your working directory.



CLI Basics

- In your CLI prompt, type `pwd` and press enter.
- This will display the path to you're working directory.
- As you can see we get the prompt back after entering a command.



CLI Commands

- You use the CLI prompt by typing in a command and pressing enter.
- `pwd` can be used at any time to display the path to your working directory (`pwd` is an abbreviation for "print working directory")

CLI Commands

- CLI commands follow this recipe: ***command flags arguments***
- ***command*** is the CLI command which does a specific task
- ***flags*** are options we give to the ***command*** to trigger certain behaviors, preceded by a **-**
- ***arguments*** can be what the ***command*** is going to modify, or other options for the ***command***
- Depending on the ***command***, there can be zero or more ***flags*** and ***arguments***
- For example `pwd` is a ***command*** that requires no ***flags*** or ***arguments***

CLI Commands

- `pwd` displays the path to the current working directory

```
jeff$ pwd
/Users/jeff
jeff$
```

CLI Commands

- `clear` will clear out the commands in your current CLI window

```
jeff$ pwd
/Users/jeff
jeff$ clear
```

```
jeff$
```

CLI Commands

- `ls` lists files and folders in the current directory
- `ls -a` lists hidden and unhidden files and folders
- `ls -al` lists details for hidden and unhidden files and folders
- Notice that `-a` and `-l` are flags (they're preceded by a `-`)
- They can be combined into the flag: `-al`

```
jeff$ ls
Desktop   Photos   Music
jeff$ ls -a
Desktop   Photos   Music  .Trash  .DS_Store
jeff$
```

CLI Commands

- `cd` stands for "change directory"
- `cd` takes as an argument the directory you want to visit
- `cd` with no argument takes you to your home directory
- `cd ..` allows you to chnage directory to one level above your current directory

```
jeff$ cd Music/Debussy
jeff$ pwd
/Users/jeff/Music/Debussy
jeff$ cd ..
jeff$ pwd
/Users/jeff/Music
jeff$ cd
jeff$ pwd
/Users/jeff
jeff$
```

CLI Commands

- `mkdir` stands for "make directory"
- Just like: right click -> create new folder
- `mkdir` takes as an argument the name of the directory you're creating

```
jeff$ mkdir Documents
jeff$ ls
Desktop   Photos  Music   Documents
jeff$ cd Documents
jeff$ pwd
/Users/jeff/Documents
jeff$ cd
jeff$
```

CLI Commands

- `touch` creates an empty file

```
jeff$ touch test_file
jeff$ ls
Desktop   Photos  Music   Documents   test_file
jeff$
```

CLI Commands

- `cp` stands for "copy"
- `cp` takes as its first argument a file, and as its second argument the path to where you want the file to be copied

```
jeff$ cp test_file Documents
jeff$ cd Documents
jeff$ ls
test_file
jeff$ cd ..
jeff$
```

CLI Commands

- `cp` can also be used for copying the contents of directories, but you must use the `-r` flag
- The line: `cp -r Documents More_docs` copies the contents of `Documents` into `More_docs`

```
jeff$ mkdir More_docs
jeff$ cp -r Documents More_docs
jeff$ cd More_docs
jeff$ ls
test_file
jeff$ cd ..
jeff$
```

CLI Commands

- `rm` stands for "remove"
- `rm` takes the name of a file you wish to remove as its argument

```
jeff$ ls
Desktop   Photos  Music   Documents   More_docs   test_file
jeff$ rm test_file
jeff$ ls
Desktop   Photos  Music   Documents   More_docs
jeff$
```

CLI Commands

- You can also use `rm` to delete entire directories and their contents by using the `-r` flag
- **Be very careful when you do this, there is no was to undo an `rm`**

```
jeff$ ls
Desktop   Photos  Music   Documents   More_docs
jeff$ rm -r More_docs
jeff$ ls
Desktop   Photos  Music   Documents
jeff$
```

CLI Commands

- `mv` stands for "move"
- With `mv` you can move files between directories

```
jeff$ touch new_file
jeff$ mv new_file Documents
jeff$ ls
Desktop   Photos  Music   Documents
jeff$ cd Documents
jeff$ ls
test_file   new_file
jeff$
```

CLI Commands

- You can also use `mv` to rename files

```
jeff$ ls
test_file   new_file
jeff$ mv new_file renamed_file
jeff$ ls
test_file renamed_file
jeff$
```

CLI Commands

- `echo` will print whatever arguments you provide

```
jeff$ echo Hello World!
Hello World!
jeff$
```

CLI Commands

- `date` will print today's date

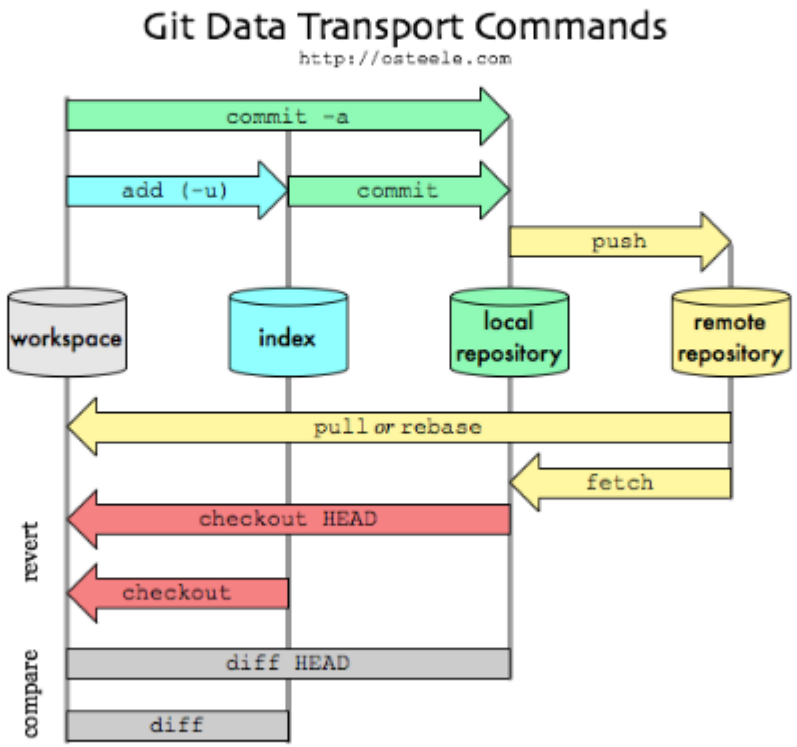
```
jeff$ date
Mon Nov  4 20:48:03 EST 2013
jeff$
```

Summary of Commands

- `pwd`
- `clear`
- `ls`
- `cd`
- `mkdir`
- `touch`
- `cp`
- `rm`
- `mv`
- `date`
- `echo`

Overview of commands in git

Pushing and pulling



http://gitready.com/beginner/2009/01/21/pushing-and-pulling.html

Adding

- Suppose you add new files to a local repository under version control
- You need to let Git know that they need to be tracked
  - `git add .` adds all new files
  - `git add -u` updates tracking for files that changed names or were deleted
  - `git add -A` does both of the previous
- You should do this before committing

Committing

- You have changes you want to commit to be saved as an intermediate version
- You type the command
  - `git commit -m "message"` where message is a useful description of what you did
- This only updates your local repo, not the remote repo on Github

Pushing

- You have saved local commits you would like to update on the remote (Github)
- You type the command
  - `git push`

Branches

- Sometimes you are working on a project with a version being used by many people
- You may not want to edit that version
- So you can create a branch with the command
  - `git checkout -b branchname`
- To see what branch you are on type:
  - `git branch`
- To switch back to the master branch type
  - `git checkout master`

Pull requests

- If you fork someone's repo or have multiple branches you will both be working seperately
- Sometimes you want to merge in your changes into the other branch/repo
- To do so you need to send a pull request.
- This is a feature of Github.

Time to be a hacker!

- Git documentation http://git-scm.com/doc
- Github help https://help.github.com/
- Google/Stack Overflow are great for Github

Version Control — Git — Initial Setup

1) Enable version control with RStudio

- from the RStudio menu, follow:

  ```
  Tools -> Global Options -> Git/SNV -> Enable version control interface for
  RStudio projects
  ```

- RStudio will likely find Git automatically. In case it cannot, Git is likely to be at
  - `c:/Program Files/Git/bin/git.exe` on Windows
  - `/usr/local/git/bin/git` on Mac

Version Control — Git — Initial Setup

2) Set Git Bash as your shell (Windows-only step)

- from the RStudio menu, follow:

```
Tools -> Global Options -> Terminal -> New terminals open with: Git Bash
```

Version Control — Git — Initial Setup

3) Introduce yourself to Git

- from the RStudio menu, follow:

  ```
  Tools -> Terminal -> New Terminal
  ```

- enter the following lines in the Terminal, with the email address that you have used to sign up for GitHub

```
git config --global user.name "YOUR-NAME"
git config --global user.email "YOUR-EMAIL-ADDRESS"
```

- enter the following line in the Terminal, to observe whether the previous step was successful

```
git config --global --list
```

Version Control — Git and Github — Project

1) Initiate local version control with Git

- from the RStudio menu, follow:

  ```
  Tools -> Version Control -> Project Setup... -> Version Control System -> Git
  ```

- after confirming your new repository, and restarting the session, observe that
  - now there is now a Git tab in RStudio, documenting the differences between you local repository and the one on GitHub. When you change a file, it will appear here.
  - your project now includes a `.gitignore` file
    - this is where you can list files and/or folders to be excluded from being tracked

Version Control — Git and Github — Project Setup

2) Create a new GitHub repository

- on GitHub, follow:

  ```
  Repositories -> New -> Repository name (e.g., "rwd_workshop") -> Public ->
  Create repository
  ```

- observe that
  - repository URLs have the following structure: https://github.com/USER_NAME/REPOSITORY_NAME
    - this is the address to view the repository online
    - for use in the `Terminal`, the address gets the `.git` extension
      - e.g., https://github.com/USER_NAME/REPOSITORY_NAME.git

Version Control — Git and Github — Project Setup

3) Push an existing repository

- from the RStudio menu, follow:

  > `Tools -> Terminal -> New Terminal`

- enter the following lines in the `Terminal`, with your username and repository name

```
git remote add origin https://github.com/USER_NAME/REPOSITORY_NAME.git
git add .
git commit -m "first commit"
git push -u origin master
```

- if this is your first time using GitHub with RStudio, you will be prompted to authenticate
  - follow the instructions on your screen and in your email
- observe that your project files are now online, listed on the GitHub repository

Version Control — Git and Github — Workflow

1) Edit and Save

- work on one or more files under version control
  - e.g., delete the first sentence of the abstract in `journals.Rmd`, and save it
  - under the Git tab in RStudio, find the list of files that you edited since the last push
  - these will have `M`, for modified, as `Status`

2) Commit and Push

- tick `Staged`* for one or more files that you would like to commit
  - enter a `Commit message` that summarises the edits
  - click `Commit` to create a record of the new version locally to your computer
  - click `Close -> Push` to push the version to GitHub

* To stage is to add files to be committed. It allows us to commit files individually or together with other files.

Version Control — Git and Github — Workflow

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- work on one or more files under version control
  - e.g., delete the first sentence of the abstract in `journals.Rmd`, and save it
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- tick `Staged` for one or more files that you would like to commit
  - enter a `Commit message` that summarises the edits
  - click `Commit` to create a record of the new version locally to your computer
  - click `Close -> Push` to push the version to GitHub
- observe the changes in the Git tab in RStudio and on the GitHub repository

Version Control — Git and Github — `.gitignore`

- `.gitignore` specifies which file(s) and/or folder(s) should be excluded from version control
  - a set of project-specific files are ignored by default
    - see your `.gitignore` file
- `.gitignore` lists one item per line
  - each line has a pattern, which determines whether one or more files or folders are to be ignored
- See the documentation at https://git-scm.com/docs/gitignore
  - for pattern formats and further details

Version Control — Git and Github — `.gitignore`

- There might be good reasons to ignore some others, including files
  - that contain information that we do not want others to see
    - e.g., personal API keys
  - that we do not have the right to share with others
    - e.g., secondary data with user agreements otherwise
  - that we (re-)create automatically as outputs
    - e.g., `journals.pdf`, as opposed to journals.Rmd

Version Control — Git and Github — `.gitignore`

- Observe that, by default, `.gitignore` has a list of project-specific files
  - you can delete, or comment out, any or all to start including them in version control

```
.Rproj.user
.Rhistory
.RData
.Ruserdata
```

Version Control — Git and Github — `.gitignore`

- Observe that, by default, `.gitignore` has a list of project-specific files
- In addition, you can ignore, for example,
  - a specific folder, relative to the root directory

```
.Rproj.user
.Rhistory
.RData
.Ruserdata
/manuscript/      #<<
```

Version Control — Git and Github — `.gitignore`

- Observe that, by default, `.gitignore` has a list of project-specific files
- In addition, you can ignore, for example,
  - a specific folder, relative to the root directory
  - a specific file in a specific folder, relative to the root directory

```
.Rproj.user
.Rhistory
.RData
.Ruserdata
/manuscript/
/manuscript/journals.pdf          #<<
```

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- In addition, you can ignore, for example,
  - a specific folder, relative to the root directory
  - a specific file in a specific folder, relative to the root directory
  - a specific file in any folder

```
.Rproj.user
.Rhistory
.RData
.Ruserdata
/manuscript/
/manuscript/journals.pdf
journals.pdf                #<<
```

Version Control — Git and Github — `.gitignore`

- Observe that, by default, `.gitignore` has a list of project-specific files
- In addition, you can ignore, for example,
  - a specific folder, relative to the root directory
  - a specific file in a specific folder, relative to the root directory
  - a specific file in any folder
  - all files with a specific extension, anywhere in the project

```
.Rproj.user
.Rhistory
.RData
.Ruserdata
/manuscript/
/manuscript/journals.pdf
journals.pdf
**.pdf
```

Version Control — Git and Github — `.gitignore` — Notes

- There are many other pattern formats
  - see the documentation at https://git-scm.com/docs/gitignore
- Starting to ignore a file or folder that is already being tracked requires clearing the cache
  - after changing and saving `.gitignore`, enter the following line in the `Terminal`
  - with your speficic `/path/to/file`

```
git rm --cached /path/to/file
```

- The following command clears *all* cache
  - might be useful after changes to `.gitignore` that involves several files or folders
  - but should be used with care, on an otherwise up-to-date repository

```
git rm -r --cached .
```

Part 3. Collaborating with Others

Collaboration

- Many research papers are written by multiple authors and/or on multiple computers
    - yourself on a different computer (e.g., laptop at home, desktop at office), poses similar challenges as collaboration
- With multiple authors and/or computers, there emerges at least two additional challenges beyond version control
    - communicating the versions to other authors and/or computers
    - working on the same project with co-authors at the same time
- We all manage collaboration, in different ways, such as
    - edit, rename, save, e-mail
    - use applications or websites such as Dropbox, Google Docs, Overleaf
    - use distributed version control systems such as Git and GitHub

Collaboration — Git and GitHub — Definitions

- To pull
  - to move the (presumably) up-to-date records from GitHub to your computer
  - it is like downloading a zipped folder of files
- To merge
  - to integrate different versions into a single version
    - e.g., the old version on your laptop, with (the changes in) the new version from GitHub
  - except the first push or pull, pushing and pulling necessiate merging
- Merge conflict
  - emerges when versions to be merged include edits *on the same line of the same file*
    - edits on different lines are not a problem as changes are tracked line by line
  - less likely to occur in one-author-multiple-computer setting
    - more likely while collaborating with others
  - requires human intervention, to decide which edit to keep and which one to discharge

Collaboration — Git and GitHub — Definitions

- Branch
  - a line of development in a repository; a copy of the repository, with all its versions, at a given time
  - by default, repositories have one branch, called *master*
- Pull request
  - a proposal to pull and merge
    - e.g., a proposal from one co-author to another, -e.g., tp merge a branch into master
  - it allows a review of changes on GitHub before merge, to deal with potential merge conflicts

Collaboration — Git and GitHub — Project Setup

- The setup depends on the users' role, on whether they are
  - the *owner* who creates the GitHub repository, or
  - the *collaborator* who is then added to that repository

- Once the project is setup
  - it continues to be associated with the owner's GitHub profile
  - at the same time, it is listed under the collaborator's profile as well
  - both the owner and the collaborator have the same rights, unless otherwise restricted

Collaboration — Git and GitHub — Project Setup — Owner

1) The setup for the owner is largely the same as in any single-author, single-computer scenario

- following the instructions on this slide forward
  - to introduce version control to a local project with Git,
  - to create a remote repository for that project on GitHub, and
  - to associate the local project with the remote repository

2) As an additional step, the owner needs to invite their collaborator(s) to the project

- following, from the relevant GitHub repository,

```
Settings -> Manage access -> Invite a collaborator
```

Collaboration — Git and GitHub — Project Setup — Collaborator

1) Notice that the remote part of the setup is done by the owner for the collaborator

- subject to acceptance of the invitation
  - invitations are available directly at https://github.com/notifications, but also sent via email
  - with an option to "Accept invitation"
  - on acceptance, projects appear among the repositories of the collaborator

2) The local part of the setup still needs to be done

- by creating a new RStudio project with version control
- following, from the Rstudio menu,*

```
File -> New Project -> Version Control -> Git
```

- the `Repository URL`, required for the above process, is the version without the `.git` extension
  - in the form of https://github.com/OWNER_USER_NAME/REPOSITORY_NAME

Colloboration — Git and Github — Workflow

1) Pull

- on the Git tab in RStudio, click `Pull` to move the up-to-date records from GitHub to your computer
  - if your collaborator has not pushed anything since your last pull, you will be noticed that `Already up-to-date`.
  - collaborative projects require pulling as well as pushing because your collaborator(s) might have pushed their commits to GitHub
  - pulling frequently minimises the risk of merge conflicts

2) Edit and save; commit and push

- the same procedure as in any single-author, single-computer scenario
  - as described on this slide forward
- pushing frequently minimises the risk of merge conflicts

- notice that you have not encountered any errors and/or merge conflicts
  - because everyone edited and merged with an up-to-date document
  - this is the default scenario in single-author, multiple computer scenario

Colloboration — Git and Github — Workflow — Alternative

- The workflow above is rather simple, but has some disadvantages, including
  - not easy, albeit still possible, to see the edits of the collaborators
  - not clear who is in charge of the overall progress
  - not possible to discuss edits
  - not possible to compromise on conflicting edits

- An alternative workflow exits
  - work on different branches of the same project
  - version control to your own branch
  - create pull requests with comments
  - merge the branch into master

Colloboration — Git and Github — Workflow — Alternative

1) Branch

- click `New Branch` on the Git tab
  - name it, and leave everything else as default
  - notice that you are now working on a new branch

2) Edit and save; commit and push

- the same procedure as in any single-author, single-computer scenario
  - as described on this slide forward
- notice, on GitHub, that your commit is in the new branch, while *master* remains unchanged

3) Pull request

- On GitHub, click

  ```
  Pull requests -> New pull request
  ```

- choose what is to be pulled, and write a note to your collaborator who can accept or reject the merge
  - if there are merge conflicts, the collaborator solves them on GitHub before merging

Colloboration — Git and Github — Workflow — Notes

- It is possible to edit `.Rmd` documents directly on GitHub
    - click on any editable file, and `Edit this file`
    - commit changes, either as a direct commit or a pull request
- A GitHub account is enough for collaboration with co-authors who do not work with Git, R, or RStudio
    - not possible to knit to see the outcome
    - would suit co-authors whose contributions are plain text

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Thank you for listening!

Any questions now or email me at **dossa@xtbg.org.cn**

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