

Get going with git

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Introduction

When you are getting into the nitty gritty, version control is a large topic. The git, github, github cli and github pages ... technologies can be daunting to set up and use. However, once you are setup properly and understand how things fit together at a high level, users can go a long way with a minimal set of commands.

I know, it is true that a little knowledge can be a dangerous thing, but it probably isn't quite as bad as complete ignorance.

Get going with git - aims to provide a minimal knowledge base, sufficient to get you started without having to wade through reams of documentation distributed all over the internet. It can be browsed online or downloaded as a word document for your reference.

What is version control? Setting up git Time to commit: working with a local repository Push and pull: working with a remote repository Making your first repository on GitHub Day 2: Collaborating with Others

Dealing with (git) conflicts Branching for sanity Creating pull requests Collaborating with GitHub tools Day 3: Dealing with Complications

Undoing changes Learning good repository organization principles Ignoring things (in git)
Working with large files Using the README Creating GitHub templates Extending git and GitHub with other tools

Pre-requisites

Background reading

There is no point reinventing the wheel, Jenny Bryant motivates the use of version control in the following paper: [Excuse Me, Do You Have a Moment to Talk About Version Control?](#)

Objectives

“I am no expert (in git *et al*) but I know enough to both get myself into trouble and usually find a way out of it.”

Note that you are likely to find some of this knowledge base hard and/or frustrating. The work purposefully (and unapologetically) takes a low level perspective on git. The rationale stems from experience of this being the best way to build a clear and coherent understanding.

Think of it this way, if you didn’t understand what letters and words are, you are probably going to have a hard job of understanding how to *unstructured a sentence*.

Often people get themselves in a mess simply as a result of not understanding the fundamentals. Therefore, the goal here is to understand the fundamental aspects of revision control and git in particular. Once you have that base, extending from there will be much easier for you.

The pace of the workshop will be based on the abilities of the audience but there is an expectation that the audience practices the skills. The workshop is likely to be run over a few sessions but the exact length is yet to be determined. It is mainly targeted at analysts that are new to revision control but with some effort is accessible to anyone.

Command line interfaces

A CLI is software, supplied with the operating system, that you use to interact with your operating system via your keyboard rather than a mouse. Software that implements such a text interface is often called a command-line interpreter, command processor or a shell. You enter in commands as text and the system will do something, e.g. delete a file.

People outside of software development and analysts find the command line arcane, but it provides an extremely useful set of tools that pay dividends if you make the effort to learn.

Nearly universally, if I use the word *terminal* I am referring to the operating system command line interface.

Windows refers to its CLI as the *command prompt*, and in macOS we have the *terminal*.

If you do not know how to operate your operating system CLI then you need to address that to make the most out of this text.

Windows

You can do these tutorials to familiarise yourselves:

- [How to use Windows 10's Command Prompt](#)
- [Learning Windows Terminal](#)

The following link needs admin rights (TKI people probably won't have nor will be able to obtain these rights) and is not strictly necessary here, but it gives a lot of useful commands and an opportunity to gain a bit more familiarity with the commandline.

- [40 Windows Commands you NEED to know](#)

macOS

- [How To Use Terminal On Your Mac](#)
- [What Is the Mac Terminal?](#)
- [Absolute BEGINNER Guide to the Mac OS Terminal](#)

Extra credit

- [Learn the command line](#)

Note

The reason I haven't mentioned Linux is simply because for Linux oriented people, it is reasonable to assume that this level of competence has already been met.

Operating system management - environment variables

You will need to have some minimal technical competence in driving your computer. For example, you need to know how to set an environment variable under your operating system of choice. If you do not know how to set an environment variable, then you need to address that.

Other items that are important to be familiar with are file and directory concepts. For example, if you do not know what the command `tree` does, then it would be useful to find out. Similarly, if you do not know what file permissions are then, again, it would be useful to find out.

Windows

You can do these tutorials to familiarise yourselves:

- [Environment Variables : Windows 10](#)
- [How to Set Environment Variables in Windows 11](#)

you should be able to set a user variable even if you do not have admin priviledges.

macOS

- [How to Set Environment Variables in MacOS](#)
- [PATH Variable \(Mac\)](#)
- [Use environment variables in Terminal on Mac](#)

Operating system management

Create a directory on your machine where we will store all the files for this workshop.

Simply go to the your `Documents` directory and create a sub-dir called `get-going-with-git`.

Throughout this text, if I say go to your local workshop directory, this is the location I want you to go to.

GitHub

Follow part 1 of the instructions provided by [Getting started with your GitHub account](#) to create and configure your account.

Warning

The part on **configuring 2-factor authentication** is absolutely mandatory, the rest of the 2-factor content can be skimmed. See [Configuring two-factor authentication](#).

To use the USyd GitHub Enterprise Server, you will need a unikey. If you have a unikey, you should have access. If you go [here](#) you can confirm that you can login, but note that you will not require access to the Enterprise Server to complete this course.

OneDrive

It would be beneficial if you can install the desktop application for OneDrive so that you have file system integration (i.e. so that you can see your OneDrive through your file explorer app).

You may need to go to IT Support to get them to install OneDrive for you, but it may already be installed.

Part I

Part 1 - Logistical elements

In this part we will get everything set up. This may well be the hardest part.

1 Resources

These files are used in **Part 2 - Fundamentals** from the text:

- [hello.R](#)
- [readme.md](#)
- [branching.R](#)
- [.gitignore](#)
- [random-numbers.R](#)

These files are used in **Part 3 - Collaboration** from the text:

2 What is (this thing) called revision control

2.1 The big picture

First, let's briefly introduce some minimal terminology and context.

i Note

TODO - Timelines

A **repository** is the mechanism that is used to implement version control by git.

i Note

The repository is implemented by a hidden directory called `.git` that exists within the project directory and contains all the data on the changes that have been made to the files in the project. You should never touch this directory nor its contents.



There are two types of repositories, *local* and *remote*.

The local repositories reside on your machine. Remote repositories are hosted by service providers, the most common being GitHub, GitLab and Bitbucket. We only deal with GitHub here. GitHub comes in a few varieties:

- GitHub Enterprise is hosted by the company called GitHub, see github.com. It is a commercial platform, but parts of it are made freely available.
- GitHub Enterprise Server is self-hosted; this is what USyd provides via <https://github.sydney.edu.au/>

In a nutshell, git provides a set of commands that allow you to manage the files that are retained in these local and remote repositories.

Again, I cannot sum it up better than Jenny, so please take the time to read it.

[Excuse Me, Do You Have a Moment to Talk About Version Control?](#)

2.2 Why `commandline`

Because it is the best way.

3 Git install

Inevitably there are some installation tasks that we need to take care of before we proceed.



Warning

The following steps can be a bit of a pain. Don't be disheartened, it gets less tiresome.

3.1 RStudio

Developers - is your instance of RStudio up to date? If not, update it. Ditto for R. Keep them both updated.

3.2 Install git

I am going to break this down into Mac and Windows because they are the two systems that most of AHI seem to use and the installation is somewhat different for each. If you are using Linux, you probably have no need to be reading this.

3.2.1 Mac OSX

First, do you have git installed already? Launch the `terminal` app (see the pre-requisites on the landing page if you do not know how to do this). In the terminal, type:

```
which git
```

which should show the location of the version of git in use:

```
## /opt/homebrew/bin/git
```

If you have homebrew (see below) installed, you can just type:

```
brew install git
```

and git will be installed, otherwise, follow the instructions below and then come back here.

Once git is installed run the `which git` command again and then run `git --version` which is shown (along with the output) below:

```
git --version
## git version 2.42.0
```

If you got here, then you have git installed. You can close down terminal, open it up again and then run the `git --version` command again to make certain that everything is ok.

3.2.2 Homebrew

In the previous section, you can see that the path output from the `which git` command includes `homebrew`. For macOS, `homebrew` is a package manager. This basically just lets you install and manage packages (applications) on your mac.

To use homebrew, you need to install it first. To do that, go [here](#), then follow the instructions, which amount to going to the terminal and running the commands listed below.

Please go and read the landing page for homebrew before you proceed any further.

The first command ensures that pre-requisites are met, see [here](#):

```
xcode-select --install
```

if this has already been doing you will get an error, or be asked to run Software Update. Generally, you can just move on to the next command:

```
/bin/bash -c "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/HEAD/install.sh)"
```

`curl` is a tool for transferring data from a url. It is usually stored under `/usr/bin` but if you are having issues then exporting the following might assist:

```
export HOMEBREW_FORCE_BREWED_CURL=1
```

which basically tells homebrew to use its own version of curl. After the above is complete, homebrew should be installed. Now you can run

```
brew install git
```

to install git for you.

For reference, here are a minimal set of commands for using homebrew (additional information can be found in the homebrew man pages).

Basic information on homebrew:

```
# Display the version of Homebrew.  
$ brew --version  
# Print Help Information  
$ brew help  
# Print Help Info for a brew command  
$ brew help <sub-command>  
# Check system for potential problems.  
$ brew doctor
```

Keep your homebrew applications up to date:

```
# Fetch latest version of homebrew and formula  
$ brew update  
# Show formulae with an updated version available  
$ brew outdated  
# Upgrade all outdated and unpinned brews  
$ brew upgrade  
# Upgrade only the specified brew  
$ brew upgrade <formula>  
# Prevent the specified formulae from being upgraded  
$ brew pin <formula>  
# Allow the specified formulae to be upgraded.  
$ brew unpin <formula>
```

The core commands for managing commandline applications are:

```
# List all the installed formulae.  
$ brew list  
# Display all locally available formulae for brewing.  
$ brew search  
# Perform a substring search of formulae names for brewing.  
$ brew search <text>  
# Display information about the formula.
```

```
$ brew info <formula>
# Install the formula.
$ brew install <formula>
# Uninstall the formula.
$ brew uninstall <formula>
# Remove older versions of installed formulae.
$ brew cleanup
```

Homebrew casks allow you to install GUI applications. Unless you are an advanced user, you will rarely need to use these, but for completeness:

```
# Tap the Cask repository from Github.
$ brew tap homebrew/cask
# List all the installed casks .
$ brew cask list
# Search all known casks based on the substring text.
$ brew search <text>
# Install the given cask.
$ brew cask install <cask>
# Reinstalls the given Cask
$ brew cask reinstall <cask>
# Uninstall the given cask.
$ brew cask uninstall <cask>
```

3.2.3 Windows

The official site for the git windows binary download is <https://git-scm.com/download/win>.

Download the 64-bit standalone installer, run it, agree to the conditions and license, choose the default location.

Ensure that the following install components are chosen:

- windows explorer integration
- large file support

and accept any other defaults.

With the exception of the following, for any of the other prompts, just accept the defaults.

1. You will need to nominate a text file editor for editing commit messages and so on. Unless, you know what you are doing, I would advise just select the Windows Notepad application, you can reconfigure this later if you want to.

2. You should select to override the default branch name as `main`. The reason to do this is so that git aligns with github (which uses `main` as its default branch).
3. For adjusting the PATH environment variable, ensure that you select `Git from the command line and also from 3rd-party software` which is the default.
4. Ensure that line ending conversion is set to `Checkout as-is, commit as-is`.
5. For the terminal emulator, select `Use Windows default console window`. This has some limitations but it is ok for an introduction.
6. Ensure that `Git Credential Manager Core` is selected when prompted.

We will run through this install for someone in the group.

To keep git up to date, you will need to go to the above site and download and reinstall git.

Open the command prompt and type:

```
git --version
## git version 2.42.0
```

4 Git setup

4.1 Configuration for git

Per the sentiment of Fred Basset, you are now up but not quite running.



Figure 4.1: Fred Basset

One of the first things we need to do is to set a username and email address:

```
git config --global user.name "Fred"  
git config --global user.email "fred.basset@comic-land.com"
```

You can list your configuration with

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

We will get into the why later, but basically any interaction you have with git will be tied to your username and email address. This has obvious benefits if we want to be able to figure out who has done what, when and why.

```
git config --global init.defaultBranch "main"
```

5 Github setup

5.1 GitHub account

As noted in the pre-requisites for using this knowledge base, you will need to have [GitHub](#) account.

While there are multiple ways to interact with GitHub from your local machine, here we will use the commandline. There are two protocols that can be used, HTTPS and SSH. We will use HTTPS.

First we need to set up a Personal access token.

5.1.1 Personal access token

GitHub introduced personal access tokens a short while ago. Personal access tokens are basically a password with some bells and whistles.

1. Login to your GitHub account.
2. Open [Creating a personal access token \(classic\)](#) in a new tab in your browser and follow the instructions.
3. Set the expiry to at least several months into the future.

5.2 Git Credential manager

The [GCM](#) is a platform agnostic credential manager (in English, that translates loosely to a *password manager*). Once it's installed and configured, Git Credential Manager is called by git and you shouldn't need to do anything special.

The next time you clone an HTTPS URL that requires authentication, Git will prompt you to log in using a browser window. You may first be asked to authorize an OAuth app. If your account or organization requires two-factor auth, you'll also need to complete the 2FA challenge.

Once you've authenticated successfully, your credentials are stored in the macOS keychain and will be used every time you clone an HTTPS URL. Git will not require you to type your credentials in the command line again unless you change your credentials.

5.2.1 GCM install

For Windows users it can be installed by selecting this option during the installation wizard, see Section 3.2.3, step 6.

For macOS, use `homebrew` again, specifically:

```
brew install --cask git-credential-manager
## ==> Downloading https://formulae.brew.sh/api/cask.jws.json
## #####
## ==> Downloading https://github.com/git-ecosystem/git-credential-manager/releases/download/
## ==> Downloading from https://objects.githubusercontent.com/github-production-release-asset-
## #####
## ==> Installing Cask git-credential-manager
## ==> Running installer for git-credential-manager with sudo; the password may be necessary
## Password:
## installer: Package name is Git Credential Manager
## installer: Installing at base path /
## installer: The install was successful.
##     git-credential-manager was successfully installed!
```

5.2.2 GCM demo

Below I demo the process by cloning a private repository from my GitHub account.

```
192-168-1-100:tmp mark$ git clone https://github.com/maj-biostat/wisca_2.git
Cloning into 'wisca_2'...
info: please complete authentication in your browser...
```

at this point the following window is launch by GCM:

selecting `Sign in with your browser` the following will launch in your default browser (Chrome, Safari, etc)

selecting `Authorize git-ecosystem` will result in

at which point you use the 2-factor authenticator tool (I use google authenticator) to respond with an authentication code.

Looking back at the terminal, the following output can be observed, which details the repository being cloned.

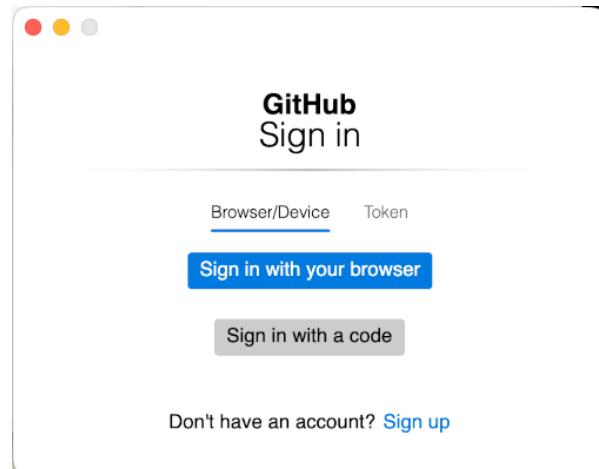


Figure 5.1: GCM

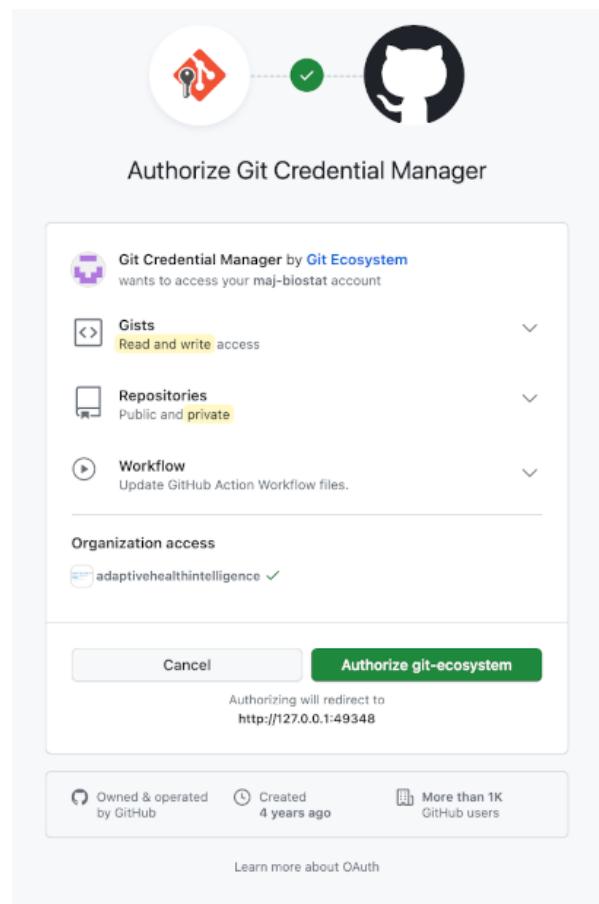
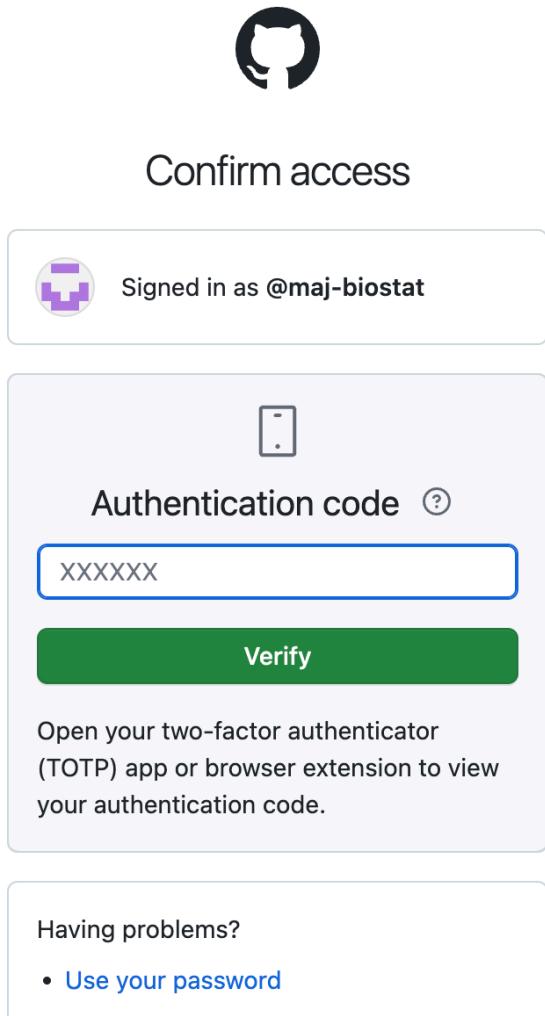


Figure 5.2: Sign in with browser



[Terms](#) [Privacy](#) [Docs](#) [Contact GitHub Support](#)

Figure 5.3: Sign in with browser

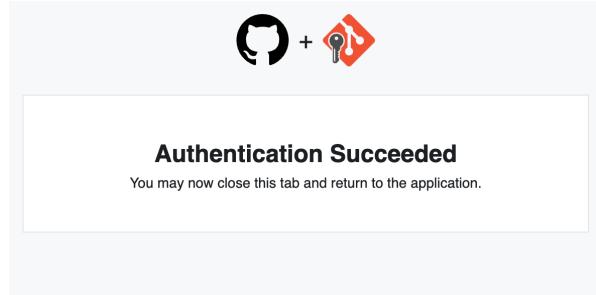


Figure 5.4: Auth success

```
remote: Enumerating objects: 297, done.  
remote: Counting objects: 100% (297/297), done.  
remote: Compressing objects: 100% (156/156), done.  
remote: Total 297 (delta 148), reused 284 (delta 137), pack-reused 0  
Receiving objects: 100% (297/297), 7.85 MiB | 2.13 MiB/s, done.  
Resolving deltas: 100% (148/148), done.
```

Finally, you will receive an email of this sort:

Hey maj-biostat!

A first-party GitHub OAuth application (Git Credential Manager) with gist, repo, and workflow permissions has been granted to your application. Visit <https://github.com/settings/connections/applications/0120e057bd645470c1ed> for more information.

To see this and other security events for your account, visit <https://github.com/settings/security>.

If you run into problems, please contact support by visiting <https://github.com/contact>.

Thanks,
The GitHub Team

On repeating this process a second time, all the authentication works in the background and there will be no need to go through various authentication handshakes again.

The same process applies irrespective of whether you are using [GitHub.com](#) or the [USyd GitHub Enterprise Server](#). However, it is advisable to get this working in GitHub first and then work on getting it to work in the USyd GitHub Enterprise Server.

The transition from the old authentication approach has (so far) proved completely seamless for macOS. It will be interesting to see what happens for the Windows platform.

5.2.3 GCM configuration (advanced only)

You can view the current credential manager by running the following commands:

```
git config --local credential.helper  
git config --global credential.helper  
# /usr/local/share/gcm-core/git-credential-manager  
git config --system credential.helper
```

Of the local, global and system, the first one checks the local repository config, the second is your `~/.gitconfig`, and the third is based on where git is installed. Note that only one credential help is configured in the above example.

In some circumstances you may need to reconfigure things. If you have to start from scratch, the following may be useful:

```
git config --local --unset credential.helper  
git config --global --unset credential.helper  
git config --system --unset credential.helper
```

For windows users check the contents of the credential manager. This can be accessed via Control Panel » All Control Panel Items » Credential Manager or by simply typing Credential Manager in the Windows task bar. Under generic credentials you should see the git entries.

5.3 GitHub CLI

In the day to day grind, having to deal with GitHub through its Web interface can be a little cumbersome. You can obviate having to interact with GitHub through the browser by using the [GitHub CLI](#). This tooling allows you to review, create and manage your repositories from the comfort of your commandline. You can think of it as an extension of git that allows you to invoke the GitHub specific functionality.

The extremely long term gh CLI manual can be found [here](#).

For Windows users, you can pick up the latest Signed MSI executables from the [release page](#).

For macOS, use `homebrew`:

```

brew install gh
## ==> Downloading https://formulae.brew.sh/api/formula.jws.json
## #####
## ==> Downloading https://formulae.brew.sh/api/cask.jws.json
## #####
## ==> Downloading https://ghcr.io/v2/homebrew/core/gh/manifests/2.37.0
## Already downloaded: /Users/mark/Library/Caches/Homebrew/downloads/331c0b76fd34aa97342ef00...
## ==> Fetching gh
## ==> Downloading https://ghcr.io/v2/homebrew/core/gh/blobs/sha256:a8c21e08d77963c2d12102ae...
## Already downloaded: /Users/mark/Library/Caches/Homebrew/downloads/d0e6a3f8f7a4b138b36484ed...
## ==> Pouring gh--2.37.0.arm64_ventura.bottle.tar.gz
## ==> Caveats
## Bash completion has been installed to:
##   /opt/homebrew/etc/bash_completion.d
## ==> Summary
##   /opt/homebrew/Cellar/gh/2.37.0: 191 files, 44.2MB
## ==> Running `brew cleanup gh`...
## Disable this behaviour by setting HOMEBREW_NO_INSTALL_CLEANUP.
## Hide these hints with HOMEBREW_NO_ENV_HINTS (see `man brew`).

```

5.3.1 GitHub CLI authentication

In order to make use of `gh` we need to go through another round of authentication setup. To do this, go to the terminal and run:

```

gh auth login
## ? What account do you want to log into? GitHub Enterprise Server
## ? GHE hostname: github.sydney.edu.au
## ? What is your preferred protocol for Git operations? HTTPS
## ? Authenticate Git with your GitHub credentials? Yes
## ? How would you like to authenticate GitHub CLI? Login with a web browser

```

For additional information, see [gh auth --help](#).

In order to use `gh` with `github.com` directly you need to authenticate for that platform too. Repeat the above, but now the responses look like this:

```

gh auth login
## ? What account do you want to log into? GitHub.com
## ? What is your preferred protocol for Git operations? HTTPS
## ? Authenticate Git with your GitHub credentials? Yes
## ? How would you like to authenticate GitHub CLI? Login with a web browser

```

You are nearly set. You can verify that what you have configured worked via:

```
gh auth status
## github.sydney.edu.au
##   Logged in to github.sydney.edu.au as mjon7053 (keyring)
##   Git operations for github.sydney.edu.au configured to use https protocol.
##   Token: gho_*****
##   Token scopes: gist, read:org, repo, workflow
##
## github.com
##   Logged in to github.com as maj-biostat (keyring)
##   Git operations for github.com configured to use https protocol.
##   Token: gho_*****
##   Token scopes: gist, read:org, repo, workflow
```

However, for `gh` to work with the desired host you need to set an environment variable to tell `gh` which platform to use. On macOS, you can set this up easily with the following entries in the `.profile` shell initialisation script (or `.bash_profile` for those inclined).

```
gh-ent() {
    export GH_HOST=github.sydney.edu.au
}

gh-std() {
    export GH_HOST=github.com
}
```

On Windows, I have no idea how you are supposed to do the above in an easy manner. You may just have to resort to running

```
set GH_HOST=github.sydney.edu.au
```

or

```
set GH_HOST=github.com
```

each time you want to switch.

Now (on macOS) when you want to interrogate `github.com` repositories we can use the following commands.

i Note

Do not worry about the meaning of the commands, this is just to establish that we have configured things correctly.

```
gh-std
gh repo list

## Showing 30 of 185 repositories in @maj-biostat
##
## maj-biostat/misc-notes                                info for manjaro/arch linux setup
## maj-biostat/wisca_2                                  Revised approach to antibiogram
## maj-biostat/motc.run                                 Simulation for motivate c trial
## maj-biostat/motc.sim                                 Stan models for motc
## maj-biostat/motc.stan                               Demo using Quarto to render to word document
## maj-biostat/quarto_demos_basic
## maj-biostat/BayesDRM
## maj-biostat/motc.modproto
```

and for the USyd Enterprise GitHub Server, use:

```
gh-ent
gh repo list

Showing 12 of 12 repositories in @mjon7053

mjon7053/motc-mgt          Monitoring statistics for Motivate-C study
mjon7053/fluvid.analyses   Analyses for fluvid coadministration study (COVID19 + FLU) vacc
mjon7053/motc.sap
mjon7053/motc-sim-report   Motivate-C simulation report
mjon7053/roadmap-notes     Notes relating to the ROADMAP project.
mjon7053/mjon7053.github.io
```

Part II

Part 2 - Fundamentals

Now we will make a start with git. Initially we will focus on using git within the confines of your local machine. Yes, that's right, for the moment, we won't be using github at all. The point of this is to give you a chance to get to grips with the basic ideas. After the main concepts are bedded in, we will move to thinking about github, which is a whole new beast.

Part III

Aside.

```
git remote add origin https://github.com/career-karma-tutorials/ck-git gh repo create my-newrepo -public -source=. -remote=upstream -push
```

The first part of the one liner: `gh repo create my-newrepo` creates and names a repo in your account (note: ‘my-newrepo’ should be replaced by the repo name of your choice) The `-public` flag makes sure the repo is public (swap this for `-private` if necessary) The `-source=.` flag specifies the source directory to be pushed Finally, the `-remote=upstream` flag specifies the remote repository to which the local repository is going to be compared with when pushing i.e the ‘upstream’ default.

6 Repositories

6.1 Git repositories

A repository is the most basic component of git. It is where you store your files and each file's history. Through a variety of mechanisms, repositories can be public or private, can involve single people or multiple collaborators and can be stored locally (on your personal computer), in the cloud (in the cloud hosted by a service provider like github) or on a physical server (a basic file server will suffice in most cases).

Using git, you can create and configure repositories, add or remove files and review history of the files in the repository.

6.1.1 Initialisation

Let's initialise a new repository. Run the following on your machine:

```
# Change dir to the local workshop directory,  
# e.g. cd ~/Documents/get-going-with-git  
mkdir first-repo  
  
cd first-repo  
  
git init  
## Initialized empty Git repository in /Users/mark/Documents/project/misc-stats/first-repo/.git  
git status  
## On branch main  
##  
## No commits yet  
##  
## nothing to commit (create/copy files and use "git add" to track)
```

If you received the output detailed above (or something very similar to it) then congratulations, you initialised a git repository.

If you have configured your file explorer to show hidden files, you will notice that the `first-repo` directory now contains a `.git` sub-directory. This directory contains the

everything related to the repository. For examples, it contains all the version history and allows you to access files at any stage in their development. Generally, you will not touch this sub-directory directly.

i Note

You can also create a repository from a pre-existing directory that has already got an established file structure and files. The process is exactly the same, just change to the directory that you want to add to version control, and run `git init`.

Additionally, when you create a new project in RStudio, you can select to initialise a new git repository. Underneath the covers, RStudio is simply invoking `git init`.

6.1.2 Repository structures

Before we start adding files to the new repository, you need to be aware of a few concepts.

There are three main structures within the repository:

1. Working directory
2. Staging area
3. Commit history

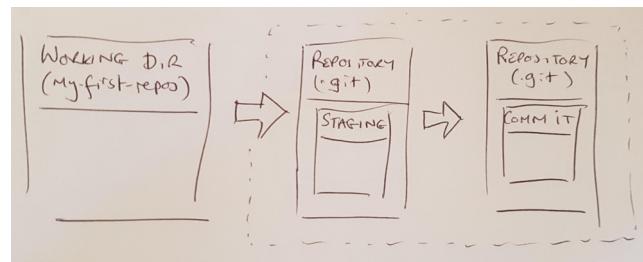


Figure 6.1: Repository structures

6.1.2.1 Working directory

Is the usual files and sub-directories within your project directory. You add, update, rename, delete files and directories in this area. When you first create a file or directory within the working directory, it is not yet under version control. Such files are referred to as *untracked files*.

6.1.2.2 Staging area

Is a special space to where you list the files that are added to be committed as a new version under version control.

6.1.2.3 Commit history

After staging files, they are committed to the repository. Once committed, files (and directories) are under version control and are referred to as *tracked files*. A commit is simply a version, but you could also think of it as a transaction with the repository. Changes to committed files are monitored and new updates to files can be committed to the repository as work on the project progresses. Every time you commit files, the *commit history* is saved.

7 Stage and Commit

7.1 Adding files to projects

Let's start to introduce files for the project. Open a text editor, enter the following contents (or download the readme.md file from the applicable section under Chapter 1) and save the file as `readme.md` in the `first-repo` directory.

```
# first-repo

A demo markdown file for the git workshop.
```

Ditto for the following and save the file as `hello.R` in the `first-repo` directory.

```
cat("Enter a string please: ");
a <- readLines("stdin",n=1);
cat("You entered")

str(a);
cat( "\n" )
cat(a, file = "log.txt")
```

Run the R script from the terminal by entering this text:

```
Rscript hello.R
```

Now from the terminal in the `first-repo` directory:

```
git status
## On branch main
##
## No commits yet
##
## Untracked files:
##   (use "git add <file>..." to include in what will be committed)
##   hello.R
```

```

##  readme.md
##  log.txt
##
## nothing added to commit but untracked files present (use "git add" to track)

```

We see that there are three untracked files, two of which we will ultimately want to store in the git repository. In contrast to the newly initialised repository as shown in Section 6.1.2 we now have the following:

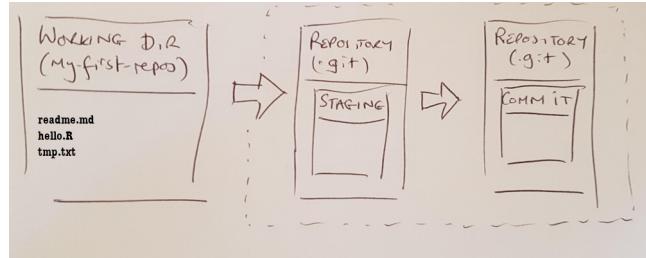


Figure 7.1: Add file to working directory

The above is idealised. You may encounter the situation where you have many files, a number of which you have no intention of tracking under version control. You can ignore these files by creating a `.gitignore` file, which tells git which files it should ignore.

Create a new text file with the following content and save the file as `.gitignore`. This is a special configuration filename that git recognises. The `.` at the front of `gitignore` is important.

If you missed the `.` or mistakenly added a `.txt` extension then the `.gitignore` functionality will not work.

```

# .gitignore file contains files
# that the repository will ignore
log.txt
*.txt

```

If you list (`ls -la`) the files in the `first-repo` directory, you should see the following (or something very similar):

```

192-168-1-100:first-repo mark$ ls -la
total 32
drwxr-xr-x  7 mark  staff  224  7 Nov 10:15 .
drwxr-xr-x  8 mark  staff  256  7 Nov 10:12 ..
drwxr-xr-x  9 mark  staff  288  7 Nov 10:15 .git

```

```
-rw-r--r--@ 1 mark staff 81 7 Nov 10:15 .gitignore  
-rw-r--r--@ 1 mark staff 126 7 Nov 10:13 hello.R  
-rw-r--r-- 1 mark staff 4 7 Nov 10:14 log.txt  
-rw-r--r--@ 1 mark staff 59 7 Nov 10:13 readme.md
```

Run `git status` again and note that the `log.txt` file no longer registers with git.

```
git status  
## On branch main  
##  
## No commits yet  
##  
## Untracked files:  
##   (use "git add <file>..." to include in what will be committed)  
##   .gitignore  
##   hello.R  
##   readme.md  
##  
## nothing added to commit but untracked files present (use "git add" to track)
```

7.2 Commit process

Now we want to add the new file to the repository. The steps are

1. Add the file (or files) that we want to include in the repository to the staging area
2. Commit the staged files

7.2.1 Staging

To add the files into the staging area run the commands:

```
git add hello.R readme.md .gitignore
```

Note that the `.gitignore` file was added as well as the `hello.R` and `readme.md` files. Now run

```
git status  
## On branch main  
##  
## No commits yet
```

```

## 
## Changes to be committed:
##   (use "git rm --cached <file>..." to unstage)
## new file:   .gitignore
## new file:   hello.R
## new file:   readme.md

```

We can see that no commits have occurred but that we have staged the files that we want to add to the repository.

What happens if we accidentally add a file that we did not want to add (the `-f` says we want to add a file that is included in the `.gitignore` list)?

```
git add -f log.txt
```

if you run `git status` you will see that `log.txt` is also staged. To remove `log.txt` from the staged area:

```
git reset log.txt
```

Now the picture looks like this.

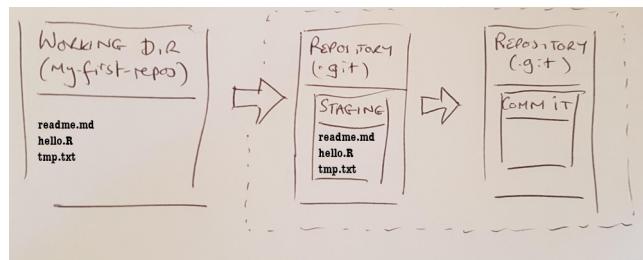


Figure 7.2: Add file to staging area

7.2.2 Commit

To commit the files that have been staged:

```

git commit -m "First commit"
## [main (root-commit) 728d107] First commit
## 3 files changed, 15 insertions(+)
## create mode 100644 .gitignore
## create mode 100644 hello.R
## create mode 100644 readme.md

```

the `-m` flag is necessary. When you make a commit, you need to provide a message that describes the nature of the changes.

What is the weird stuff that is output prior to the commit message ([main (root-commit) 728d107]) in the commit history? It is a unique hash code that identifies this specific version of the project. Note, you will have a different hash code (and that is fine).

When we run `git status` we see that the repository is up to date with the working area files. We also see that the files have been removed from the staging area.

```
git status
## On branch main
## nothing to commit, working tree clean
```

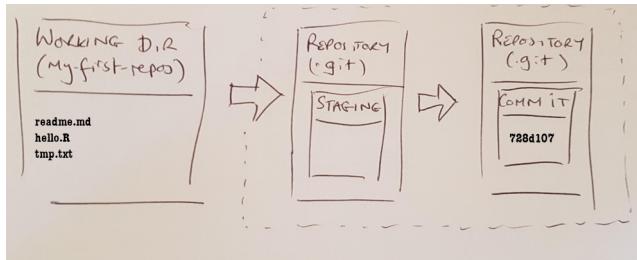


Figure 7.3: Commit files to history

7.3 Exercises

Exercise 7.1. Create a new R script in the working directory, it can contain anything you like. If you are lost, just use:

```
library(survival)
print("My script")
```

and save it as `myscript.R`.

Exercise 7.2. Add the new script to the staging area by following Section 7.2.1 ensuring that you review the status.

Exercise 7.3. Commit the staged files to the repository by following Section 7.2.2 making sure that you record a message for your commit.

Exercise 7.4. Edit the `readme.md` (use notepad or rstudio) file adding a new line with some arbitrary text. Stage the file and commit.

7.4 Tracking commit history

One of the most notable features of revision control is that you can review your project file history. The simplest way to do this is with `git log` which will report all of the commits in reverse chronological order. You can see

- who made the commits
- when they were made and why (the commit messages)
- the hash code associated with project version at each commit
 - note that the full hash is reported whereas previous a truncated version is shown

The commit followed by (`HEAD -> main`) shows what part of the history our working directory currently reflects.

Here is an example (your repository will look different but that is ok)

```
git log

## commit 327170a6bc4d39463c4cfbc0f257420496642cb5 (HEAD -> main)
## Author: Mark <mark.jones1@sydney.edu.au>
## Date:   Tue Nov 7 10:25:23 2023 +0800
##
##       Minor edit
##
## commit b078716e80498c2fa7abfb8ae27b204b2dc603d8
## Author: Mark <mark.jones1@sydney.edu.au>
## Date:   Tue Nov 7 10:24:58 2023 +0800
##
##       New file
##
## commit 0cd2d52e989059a61315525a3488e06d22cd04a5
## Author: Mark <mark.jones1@sydney.edu.au>
## Date:   Tue Nov 7 10:23:23 2023 +0800
##
##       First commit
```

You can format the logs in a variety of ways. For a more condensed view you can use the `--oneline` flag:

```
git log --oneline
## 327170a (HEAD -> main) Minor edit
## b078716 New file
## 0cd2d52 First commit
```

If you want the commit history for the last n commits, or between specific dates, or by author or even via searching for a specific string in the message you can run the following

```
git log -n 2
git log --after="2013-11-01" --before="2023-10-15"
git log --author="Mark\|Fred"
git log --grep="first" -i
```

Try them.

The first restricts to the last two commits, the second returns commits between mid Oct and the start of Nov, the second returns commits made by Mark or Fred and the third returns any commits where the word first was included in the message text (ignoring case).

The log command is powerful and it lets you see who updated the files, when they made the update and why they did it. Obviously, this has less utility when you are working on a repository in isolation but it still does have value (especially to your future self). For example, you might simply want to review when specific changes were made to the files or you might want to pick up some update that has been removed from the code and reintroduce it.

When you are working on a repository in collaboration (see later) the value of the logs increases many fold as a way to be able to understand the evolution of the project and to work out who you need to contact if you think a problem has been introduced.

To establish what files were included in any given commit, you can use `git show`:

```
git show --name-only 0cd2d52
## Author: Mark <mark.jones1@sydney.edu.au>
## Date:   Tue Nov 7 10:23:23 2023 +0800
##
##      First commit
##
## .gitignore
## hello.R
## readme.md
```

8 Reviewing differences

8.1 Comparisons with the working directory

Git allows you to compare different versions of files that exist in the repository. In its vanilla form, the difference functionality compares the differences in a file (or files) in the working directory to the repository version.

Update the contents of the `hello.R` script to match what follows.

```
cat(paste0("What is your name?\n"));
nme <- readLines("stdin",n=1);
cat(paste0("Hi ",nme, " enter a string please: \n"));
a <- readLines("stdin",n=1);
cat("You entered the following string: ")
cat(paste0(a, "\n"));
cat(a, file = "log.txt")
```

Similarly, edit the `readme.md` file as below.

```
# first-repo

A demo markdown file for the git workshop.

A new line for testing.

Contains standalone R scripts.
```

Running `git status` you will see that the working directory uncommitted changes

```
git status
## On branch main
## Changes not staged for commit:
##   (use "git add <file>..." to update what will be committed)
##   (use "git restore <file>..." to discard changes in working directory)
##     modified:   hello.R
```

```

## modified:    readme.md
##
## no changes added to commit (use "git add" and/or "git commit -a")

```

If we want to know what changes were made, we can run `git diff` but let's look at the differences on a file by file basis, comparing the old with the new.

```

git diff readme.md
## diff --git a/readme.md b/readme.md
## index 7501d7c..6929e2c 100644
## --- a/readme.md
## +++ b/readme.md
## @@ -4,5 +4,7 @@ A demo markdown file for the git workshop.
##
## A new line for testing.
##
## +Contains standalone R scripts.
## +

```

You interpret the above as follows.

- Anything prefixed with `-` belongs to the old file and anything prefixed with `+` belongs to the new.
- The section labelled with `@@` gives you some context as to where the change has happened. In this case we can see that the text *A minor revision* has been removed and replaced with the text *The main script implements a loop to capture input from a user*.

Now compare the working version of `hello.R` with the repository version, but this time look at the word by word differences:

```

git diff --word-diff hello.R
## diff --git a/hello.R b/hello.R
## index 0c6d38c..5f09b06 100644
## --- a/hello.R
## +++ b/hello.R
## @@ -1,7 +1,9 @@
## [-cat("Enter-"){+cat(paste0("What is your name?\n"));+}
## {+nme <- readLines("stdin",n=1);+}
## {+cat(paste0("Hi ",nme, " enter+} a string please: [-");-]{+\n});+}
## a <- readLines("stdin",n=1);
## cat("You [-entered")-]
## 

```

```
## [-str(a);-]
## [-cat( "\n" )-]{+entered the following string: "+}
## {+cat(paste0(a, "\n"));+}
## cat(a, file = "log.txt")
```

The diffs can take a bit of getting used to and some alternative tools are available that we will put to use in due course. For now, we will just deal with the commandline output.

Once satisfied that the changes are benign, stage and commit the edits in the usual way:

```
git add hello.R readme.md
git commit -m "Revised approach in capturing user input"
```

8.2 Comparisons with staged files

If you want to restrict your attention to the differences that will be made to a repository due to committing staged files, you can use `git diff --cached`.

8.3 Comparisons across commit versions

Once working directory changes have been committed to the repository it is still possible to review the differences between commit.

The most common difference that is of interest is that between the last two commits. To achieve this run

```
git diff HEAD 327170a
```

To inspect differences between any commits, you simply supply the commit hashes that you want to compare:

```
git diff b078716 0cd2d52
## diff --git a/myscript.R b/myscript.R
## deleted file mode 100644
## index a12204c..0000000
## --- a/myscript.R
## +++ /dev/null
## @@ -1,3 +0,0 @@
## -library(survival)
```

```
## -print("My script")
## -
```

If you want to restrict attention to a particular file, just add the filename that you want to compare to the end of the command

```
git diff HEAD 327170a readme.md
## diff --git a/readme.md b/readme.md
## index 6929e2c..7501d7c 100644
## --- a/readme.md
## +++ b/readme.md
## @@ -4,7 +4,5 @@ A demo markdown file for the git workshop.
##
## A new line for testing.
##
## -Contains standalone R scripts.
## -
```

9 Branches

9.1 What is a branch?

⚠ Warning

We are going to step it up a notch. The topic of branching can be challenging for beginners. Practice and repetition is key to understanding. Try not to panic. At a basic level, it is actually straight forward once you get familiar with the processes.

When you run `git status` you saw the text - *On branch main* as part of the output. Similarly, when you ran `git log` the last commit reported is suffixed with *(HEAD -> main)*. Both of these were a reference to the version on the branch that is currently linked to the working directory.

Branching is simply a mechanism that allows you to diverge from the main line of development and continue to do work without messing with that main line. They allow multiple pieces of work to be progressed independently within the same project.

For example, initially there is a singular progression of the project, but at some point you will want to create a release for a software product, or a piece of documentation or an analysis. Later you may want to revise the release due to changes in project direction, new data, bugs etc. You use branches to facilitate this process in a logical and coherent way.

In the examples encountered so far, the branching we have encountered is just a stem (specifically, the *main* branch). Here is a common type of representation of the kind of branch that we have dealt with so far. The circles represent each commit, which would refer to changes in one or more files. The repository has gone through a series of commits (1, 2, 3, 4 etc.) and the working directory is currently looking at the repository version 4.

The arrow pointing at 4 is the current *HEAD* of the repository. *HEAD* is a special concept in git. It answers the question “What am I currently looking at?”

9.2 Time travel

The concepts associated with branching are easiest understood by demonstration and experimentation.

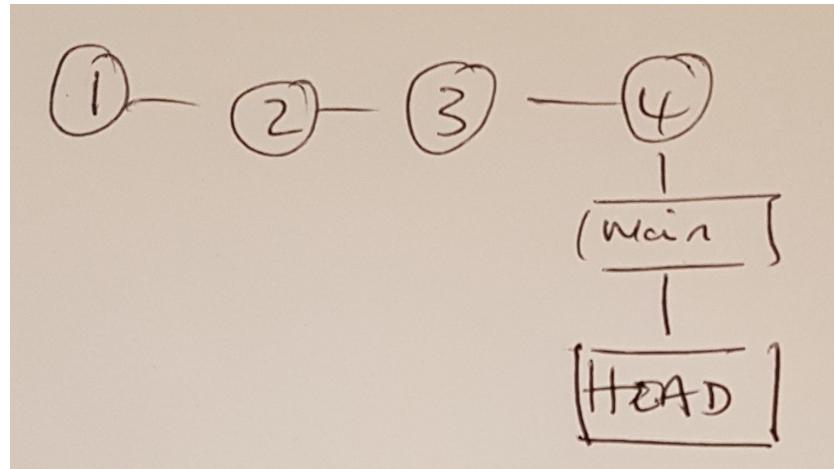


Figure 9.1: Branch more like a stem

When you make a new commit to git, the branch reference is updated to point to the new commit. When you move to a new branch, the HEAD reference is updated to point to the branch that you switched to.

Go to the Chapter 1 resources page and save the `branching.R` file to your `first-repo` directory.

The file contains the following:

```
# R script to demo branching
suppressPackageStartupMessages(library(data.table))
suppressPackageStartupMessages(library(survival))
suppressPackageStartupMessages(library(rtables))
suppressPackageStartupMessages(library(ggplot2))

message("-----")
message("NOW WE WILL MOVE ONTO BRUNCHING\n")
message("-----")

# Data generation -----
set.seed(1)

N <- 4000
d <- data.table(
  id = 1:N,
  u = rbinom(N, 1, 0.5)
```

```

)

d[u == 0, x := rbinom(.N, 1, 0.2)]
d[u == 1, x := rbinom(.N, 1, 0.8)]

b0 <- 3
b1 <- 1
b2 <- -2
b3 <- -1
e <- 1
w_cens <- 4

# Continuous outcome
d[, mu := b0 + b1 * x + b2 * u + b3 * x * u]
d[, y := rnorm(.N, mu, 1)]

# Binary outcome
d[x == 1, z := rbinom(.N, 1, 0.7)]
d[x == 0, z := rbinom(.N, 1, 0.3)]

# Survival outcome
# Median tte -log(0.5)/0.6 vs -log(0.5)
d[x == 1, w := rexp(.N, 0.6)]
d[x == 0, w := rexp(.N, 1.0)]
d[, evt := as.integer(w < w_cens)]
d[evt == 0, w := w_cens]

# Labels
d[x == 0, arm := "FBI"]
d[x == 1, arm := "ACTIVE"]

d[u == 0, age := "< 50 years"]
d[u == 1, age := ">= 50 years"]

# Descriptive summary -----
message("\nDESCRIPTIVE SUMMARY:\n")

lyt <- basic_table() %>%
  split_cols_by("arm") %>%
  summarize_row_groups()

```

```

analyze("y", mean, format = "xx.x")

build_table(lyt, d)

# Analyses ------

message("\n\nANALYSIS OF CONTINOUS OUTCOME (UNSTRATIFIED):\n")

lm1 <- lm(y ~ x, data = d)
summary(lm1)

```

Run the script:

```
Rscript branching.R
```

Imagine this was the first analysis for a project and will be sent to the clients. The completed work represents a milestone for the project so we stage and commit the file and then create a tag for it.

```
git tag -a v1.0 -m "Analysis 1"
```

We continue with the work for the next deliverable completing a secondary analysis on the binary outcome `z`. Add the following code to the end of the `branching.R` script, re-run with `Rscript branching.R` and then commit the file to the repository.

```

message("\n\nANALYSIS OF BINARY OUTCOME (UNSTRATIFIED):\n")

lm2 <- glm(z ~ x, data = d, family = binomial)
summary(lm2)

pr <- predict(lm2, newdata = data.table(x = 0:1), type = "response", se = T)
d_fit <- data.table(
  arm = c("PBO", "ACTIVE"),
  x = 0:1,
  pr_z = pr$fit,
  pr_z_lb = pr$fit - 2 * pr$se.fit,
  pr_z_ub = pr$fit + 2 * pr$se.fit
)

```

We are not finished with our second deliverable, but at this point we realise that the initial analysis that was sent to the client was incorrect. As you may have spotted, we should have run a stratified analysis due to the presence of a confounder. We urgently need to re-issue the

corrected analysis to the client. Bummer.

In contrast to the minor change above, in real life we might be much further along with this next deliverable, which may be vastly more complex than what I have illustrated above. For example, we may have introduced new files, restructured the original analysis, added functionality etc.

While we could go through the process of winding back all the changes, with revision control we do not have to because we can rewind to any point.

Next we go over the processes involved.

9.2.1 Commit

First thing to do is to check that your code is running ok and then commit any files that have not yet been committed to the repository. Not doing so will cause you some major headaches, so best advice is to not forget to do this.

```
git status  
git add braching.R  
git commit -m "Commit of files part way through development"
```

9.2.2 Rewind

Now we want to rewind our repository back to the time at which the deliverable was made. We can do this by using `git log` to find the commit hash or we can just use the tag that we set for the release. Using the tag is more convenient so let's do that.

```
git log --oneline  
git checkout v1.0  
## Note: switching to 'v1.0'.  
##  
## You are in 'detached HEAD' state. You can look around, make experimental  
## changes and commit them, and you can discard any commits you make in this  
## state without impacting any branches by switching back to a branch.  
##  
## If you want to create a new branch to retain commits you create, you may  
## do so (now or later) by using -c with the switch command. Example:  
##  
##   git switch -c <new-branch-name>  
##  
## Or undo this operation with:
```

```

##  

##   git switch -  

##  

## Turn off this advice by setting config variable advice.detachedHead to false  

##  

## HEAD is now at a2cc6f7 Comments from code review

```

In terms of the schematic of the repository, the environment now looks like this.

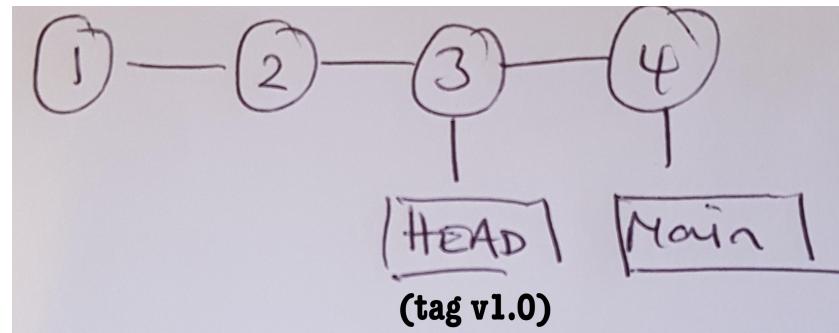


Figure 9.2: Rewind to earlier deliverable

We have move the HEAD such that our working versions now point to the files that were originally delivered to the client.

i Note

Don't panic overly about the warning about being in the *detached HEAD* state.

If you look at `branching.R` you will see that the starts of the secondary analysis has disappeared.

9.2.3 Fix issue

In order to fix the analysis we need to introduce the confounder as a covariate in the linear model. Introduce the following fixes. First to the descriptive summary:

```

message("\nDESCRIPTIVE SUMMARY:\n")

lyt <- basic_table() %>%
  split_cols_by("arm") %>%
  split_rows_by("age") %>%
  summarize_row_groups() %>%

```

```
analyze("y", mean, format = "xx.x")  
  
build_table(lyt, d)
```

and then to the analysis make these corrections and finally re-run the script to confirm that it produces what we expect.

```
lm1 <- lm(y ~ x * u, data = d)  
summary(lm1)
```

Stage and then commit these changes. We can get some insight into the state of the tree now. Below I have added one more commit so that you can get a sense of how things are progressing.

```
git log --oneline --decorate --graph --all  
## * 7ab12b3 (HEAD) Code review correction  
## * 4cca810 Added emergency fix  
## | * c82a48d (main) Started on secondary analyses  
## |/  
## * a2cc6f7 (tag: v1.0) Comments from code review  
## * fa24778 branching.R  
## * 3bdac46 Revised approach to capturing input  
## * 327170a Minor edit  
## * b078716 New file  
## * 0cd2d52 First commit
```

The equivalent illustration would look something like this:

9.2.4 Make permanent

Now that we have fixed the code, we want to make the change permanent. That is, we want to formally tell git that our alternative history should be maintained. The way to do that is to create a new branch out of the recent changes (which already look like a branch).

```
git branch fix-01  
# Switch to new branch  
git checkout fix-01
```

When we look at the tree we see both HEAD and the branch (note the first line text which says *HEAD, fix-01*).

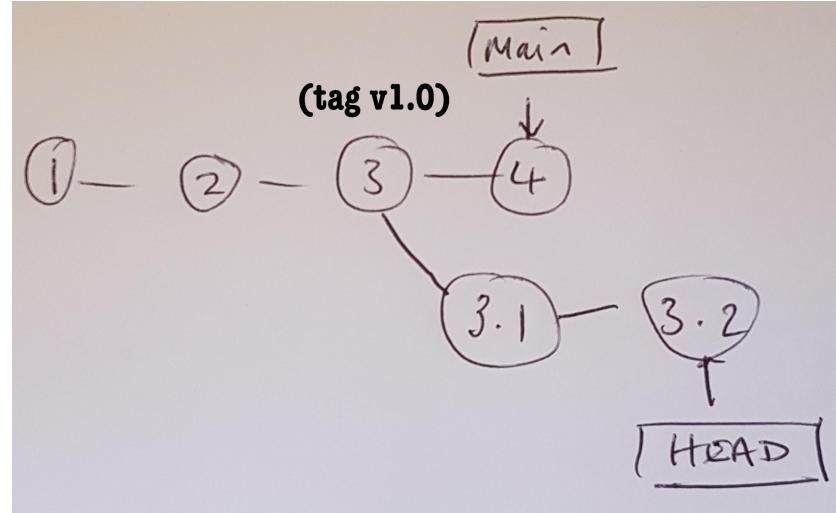


Figure 9.3: Add a fix

```
git log --oneline --decorate --graph --all
## * 7ab12b3 (HEAD, fix-01) Code review correction
## * 4cca810 Added emergency fix
## | * c82a48d (main) Started on secondary analyses
## |
## * a2cc6f7 (tag: v1.0) Comments from code review
## * fa24778 branching.R
## * 3bdac46 Revised approach to capturing input
## * 327170a Minor edit
## * b078716 New file
## * 0cd2d52 First commit
```

And now the picture is

If this is the version that we re-issue to the client, we might as well tag it.

```
git tag -a v1.1 -m "Analysis 1 (re-issue)"
```

9.2.5 Switching back to the secondary

Switching back to our partially complete secondary analysis is as simple as.

```
git checkout main
```

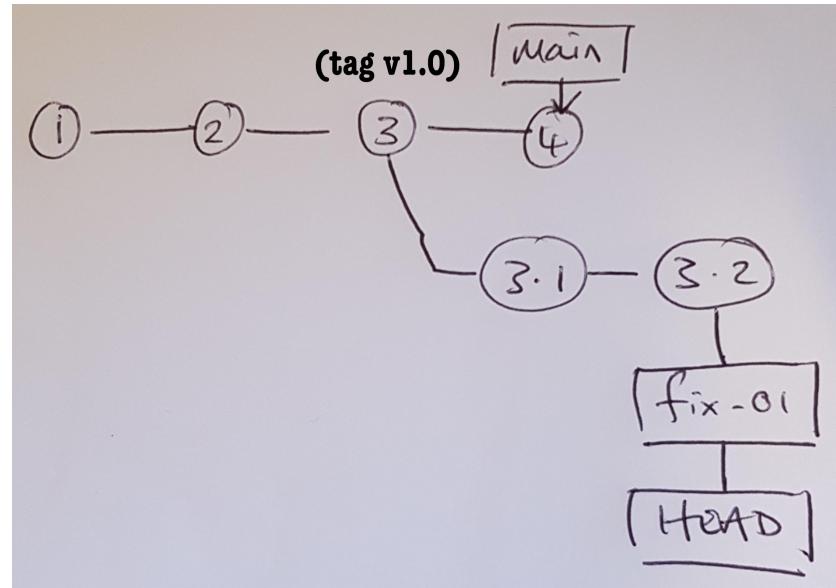


Figure 9.4: Looking at the HEAD of our new branch

If you look at the `branching.R` script you will be able to see the secondary analysis we started some time ago. However, if you look closely you will see that the changes we just made in the `fix-01` branch have not yet been propagated to the `main` branch. It is important that we pick up this fix.

This process is known as *merging* and it will be tackled later.

10 Merge

10.1 Recap

From the previous branching example -

1. We delivered stage one of an analysis to the client
2. We started on the secondary analyses
3. Before the secondary analysis was complete, we realised there was an error in the original analysis that needed an emergency fix
4. We rewound to an earlier state in the repository and then fixed the error and checked in our work
5. We made the work permanent by creating a new branch and then checking out that branch
6. We tagged the fix and re-issued the analysis to the client
7. We jumped back to our secondary analysis by checking out the main branch

Ok, so now we have a fix to the error in the original analysis in one branch `fix-01` and a partially completed secondary analysis on the `main` branch. We want to bring the changes from the fix into our present work.

10.2 Merge processes

Merging is usually a fairly automated process. Run the following.

```
git checkout main  
git merge fix-01
```

You may be prompted to enter a commit message (alternatively just provide the `-m` flag).

```
Merge branch 'fix-01'  
# Please enter a commit message to explain why this merge is necessary,  
# especially if it merges an updated upstream into a topic branch.  
#  
# Lines starting with '#' will be ignored, and an empty message aborts
```

```
# the commit.
```

and then the following output.

```
## Auto-merging branching.R
## Merge made by the 'ort' strategy.
##  branching.R | 3 +-+
##  1 file changed, 2 insertions(+), 1 deletion(-)
```

If you look at the difference between the HEAD (the HEAD~1 notation means compare with the previous commit, HEAD~2 means compare with 2 commits prior and so on) and the commit associated with the merge you will see

```
git diff HEAD~1
## diff --git a/branching.R b/branching.R
## index b60c9f0..8f1c1b3 100644
## --- a/branching.R
## +++ b/branching.R
## @@ -45,6 +45,7 @@ message("\nDESCRIPTIVE SUMMARY:\n")
##
##   lyt <- basic_table() %>%
##     split_cols_by("arm") %>%
##   +   split_rows_by("age") %>%
##     summarize_row_groups() %>%
##     analyze("y", mean, format = "xx.x")
##
## @@ -54,7 +55,7 @@ build_table(lyt, d)
##
##   message("\n\nANALYSIS OF CONTINOUS OUTCOME (UNSTRATIFIED):\n")
##
##   lm1 <- lm(y ~ x, data = d)
##   +lm1 <- lm(y ~ x * u, data = d)
##   summary(lm1)
##
##   message("\n\nANALYSIS OF BINARY OUTCOME (UNSTRATIFIED):\n")
```

We now have the changes from the emergency fix in the main branch and we can continue with the secondary analysis.

Sometimes merging doesn't work quite so smoothly and we need to iron out conflicts.

10.3 Exercises

Exercise 10.1. Complete the analysis by adding the following code to generate a figure from the fitted model.

```
p1 <- ggplot(d_fit, aes(x = arm, y = pr_z)) +  
  geom_point() +  
  geom_linerange(aes(ymin = pr_z_lb, ymax = pr_z_ub)) +  
  scale_x_discrete("") +  
  scale_y_continuous("Probability of response")  
  
ggsave("fig-sec.png", p1, width = 10, height = 10, units = "cm")
```

Here is what you need to do:

- Run the updated script `Rscript branching.R` to make sure it works.
- Edit the `.gitignore` file so that the figure does not get committed to the repository.
- Stage and commit the files and then review the commit history.
- Create a v2.0 tag with an meaningful message.

Exercise 10.2. Usually it makes sense to create a new branch for each piece of development we undertake. This ensures that the main branch continues to reflect a working version at all times. Create a new branch from the current state and call it `analysis-03`. Run the following code:

```
git branch analysis-03  
git checkout analysis-03  
git status
```

Add the analysis code into `branching.R`

```
message("\n\nANALYSIS OF SURVIVAL OUTCOME (UNSTRATIFIED):\n")  
lm3 <- coxph(Surv(w, evt) ~ x, data = d)  
summary(lm3)
```

Run the script to make sure it works then stage and commit along with an updated `.gitignore` files that excludes all `.png` files.

Checkout main:

```
git checkout main
```

Add the following change to the `branching.R` code (just adding a new theme to the ggplot figure)

```
p1 <- ggplot(d_fit, aes(x = arm, y = pr_z)) +
  geom_point() +
  geom_linerange(aes(ymin = pr_z_lb, ymax = pr_z_ub)) +
  scale_x_discrete("") +
  scale_y_continuous("Probability of response") +
  theme_bw()
```

Run the script, then stage and commit.

Checkout `analysis-03` branch:

```
git checkout analysis-03
```

Add the following code:

```
png("fig-surv.png")
plot(survfit(Surv(w, evt) ~ x, data = d), lty = 1:2)
dev.off()
```

Run the script to make sure it works then stage and commit. Treat this as the release by tagging it as `v3.0`. Checkout the `main` branch and merge the analysis into main.

```
git checkout main
git merge analysis-03
```

Review the commit history:

```
git log --oneline --decorate --graph --all
## * 2829471 (HEAD -> main) Merge branch 'analysis-03'
## |\
## | * be09457 (tag: v3.0, analysis-03) Finished surv
## | * 7a5e7b9 Surv analysis
## * | 53115b6 minor
## |/
## * 1a9dfcb (tag: v2.0) Edits from code review
## * d1586df Completion of secondary analysis
## * bf34b9c Merge from fix-01
## |\
## | * b8de16c (tag: v1.1, fix-01) Edits from code review
## | * 12561d9 Emergency fix
```

```
## * | d88f9e5 WIP
## |/
## * a2cc6f7 (tag: v1.0) Comments from code review
## * fa24778 branching.R
## * 3bdac46 Revised approach to capturing input
## * 327170a Minor edit
## * b078716 New file
## * 0cd2d52 First commit
```

At this point, you have the fundamentals. However, there are things that are going to catch you out. For example, in the above work, we used three-way merges. These are convenient but can also get messy when your branching structure gets complex. In most of our daily work merges will probably suffice, but know that there is another way. The other way is rebasing, but we will not deal with it here.

11 GitHub introduction

Rightly or wrongly, GitHub has become the defacto tool for storing and sharing work. GitHub is a hosting service for git repositories. It is not part of the git software and unfortunately, it is owned by Microsoft.

Around 10,000 companies (3M, Dell, Airbnb, Netflix ...) use GitHub as part of their development stack. It sources literally 100's of millions of projects with billions of contributions to these projects per year. Around 95% of developers use git as the version control system of choice.

Alternatives that aim to serve similar goals include [GitLab](#) and [Bitbucket](#).

You should have set up an account, configured 2FA and created a personal token per the pre-requisite notes so that isn't going to be covered here. We will use <https> to access GitHub, which is the default, so you do not need to set up any other protocols.

11.1 Walk around the interface

When you log into [GitHub](#) you will be taken to your dashboard (homepage) which is a bit of a feed, quick links to some of your repositories and other things that might be of interest. Day to day, what you probably want to see and interact with is your repositories and their settings.

Go to the top right hand corner and click the far right icon to get the drop down, then select your profile. All of the following is based on my account but you can follow along under your login as well, just replace my username with yours in the relevant places.

From there you can edit various details pertaining to yourself, review your stats and so on and then jump into the git repositories that you have put onto GitHub.

Select the repository link to see a list of all your repositories. You can also get here directly from your landing page via the 'Your repositories' link. I have highlighted the `get-going-with-git` repo. You won't have this repository at this stage (you might not have any) but that's ok, just follow along.

Selecting a specific repository brings up its landing page which includes the repository files, a description file, stats on the repository, settings and various other items. The page that

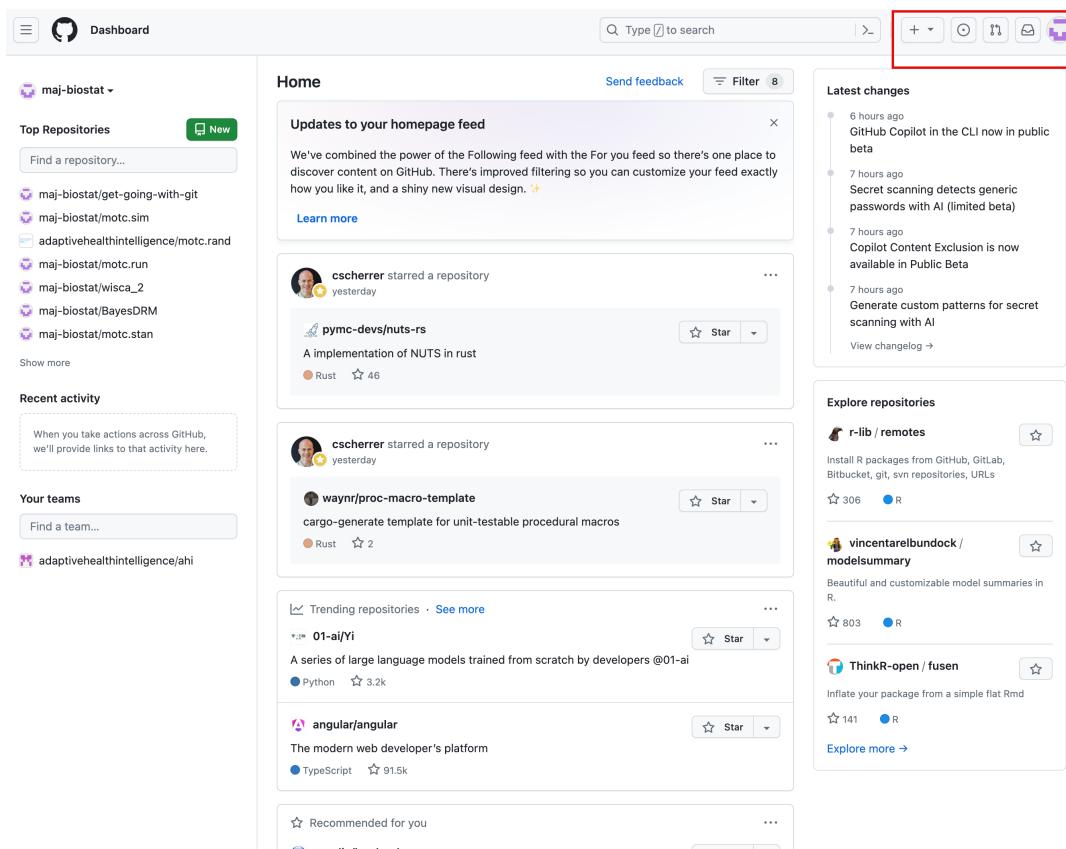


Figure 11.1: GitHub landing

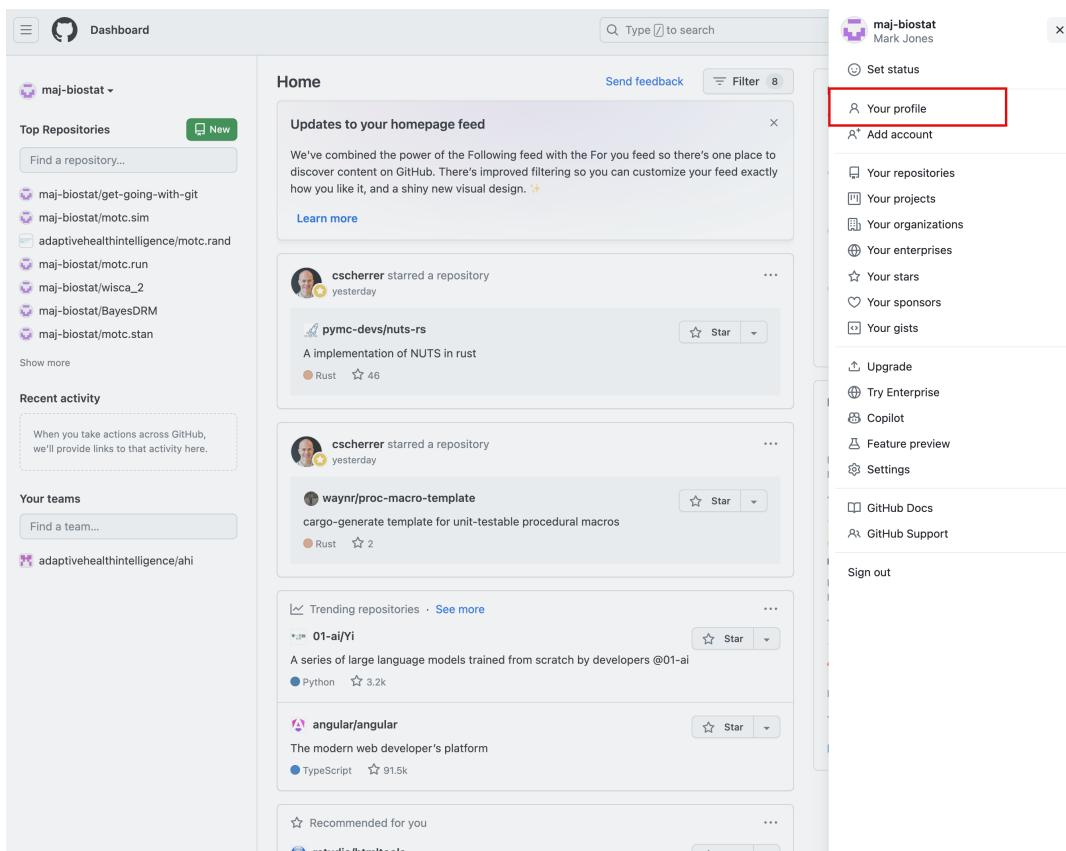


Figure 11.2: GitHub landing dropdown

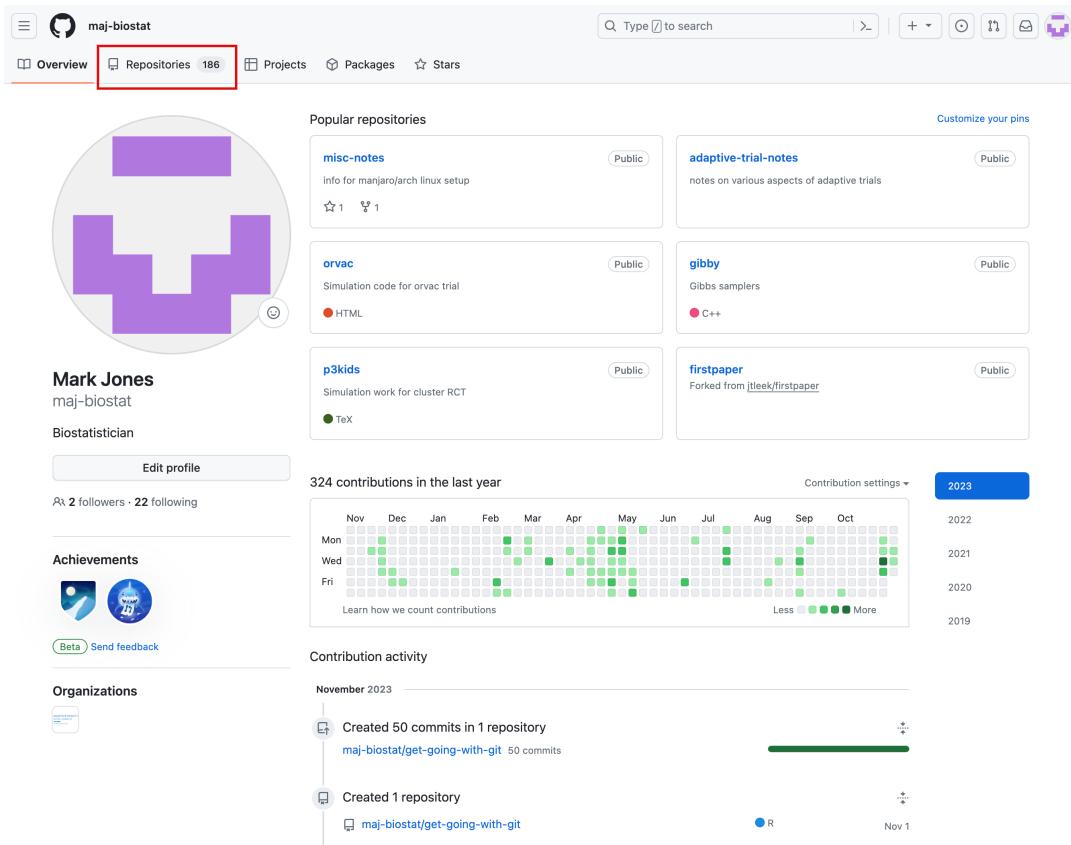


Figure 11.3: GitHub profile

The screenshot shows a GitHub repository listing for the user 'maj-biostat'. The top navigation bar includes links for Overview, Repositories (186), Projects, Packages, and Stars. A search bar and various filter options are also present. The main area displays a list of repositories:

- get-going-with-git** [Public]
Knowledge base for beginner version control (git, github, ...) workshop
github git gh-pages version-control
R Updated 18 hours ago
- misc-notes** [Public]
info for manjaro/arch linux setup
1 star 1 fork 1 license GNU General Public License v3.0 Updated last week
- wisca_2** [Private]
Revised approach to antibiogram
R Updated on Oct 7
- motc.run** [Private]
Updated on Sep 11
- motc.sim** [Private]
Simulation for motivate c trial
R Updated on Sep 11
- motc.stan** [Private]
Stan models for motc
Stan Updated on Sep 7

On the left side, there is a profile summary for 'Mark Jones' (maj-biostat) with sections for Biostatistician, Edit profile, and Achievements (two icons). There is also a section for Organizations.

Figure 11.4: GitHub repository listing

is shown below corresponds to the git repository used to manage this knowledge base and website.

The screenshot shows the GitHub repository landing page for 'get-going-with-git'. The repository is public and has 35 commits. The code tab is selected. The repository description is 'Knowledge base for beginner version control (git, github, ...) workshop'. It includes links to 'maj-biostat.github.io/get-going-with-...', 'github', 'git', 'gh-pages', and 'version-control'. The README.md file contains a brief introduction and a section titled 'Updating site'. The Languages section shows R (71.5%), Makefile (28.1%), and CSS (0.4%).

Figure 11.5: GitHub repository landing page

11.2 Common functions via GitHub

Some (if not all) of the functionality that git implements has been integrated into the GitHub platform. Let's go over some of them briefly.

11.2.1 Initialise repository

There are a few ways to do this. The simplest is to initialise the repo on GitHub then clone it down to your machine. The preferred way to start with pre-existing local work (repo) and connect it with a remote on GitHub.

11.2.1.1 Initialise on GitHub

You can achieve this directly from any page.

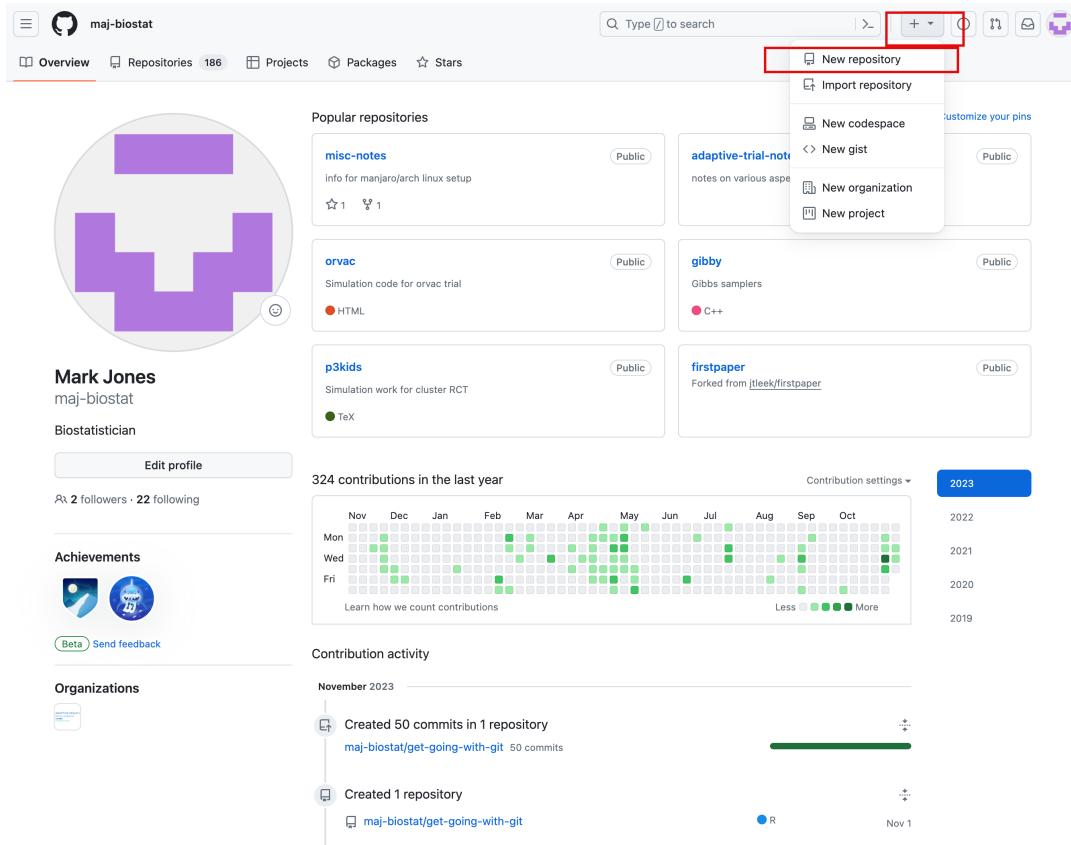


Figure 11.6: GitHub initialise new remote repository

The configuration is largely self-explanatory.

And then you are taken to your new shiny repository page.

Clicking on Settings (highlighted above) if you were to want to add collaborators.

And if you want to change the visibility (public/private) of the repository it is down at the bottom of the general settings under the Danger Zone section.

11.2.1.2 Initialise from existing repository

Again, you can achieve this directly from any page.

Create a new repository

A repository contains all project files, including the revision history. Already have a project repository elsewhere? [Import a repository](#).

Required fields are marked with an asterisk (*).

Owner * maj-biostat

Repository name * demo-01

demo-01 is available.

Great repository names are short and memorable. Need inspiration? How about [redesigned-doodle](#) ?

Description (optional) First demo repo

Public Anyone on the internet can see this repository. You choose who can commit.

Private You choose who can see and commit to this repository.

Initialize this repository with:

Add a README file

This is where you can write a long description for your project. [Learn more about READMEs](#).

Add .gitignore

.gitignore template: None

Choose which files not to track from a list of templates. [Learn more about ignoring files](#).

Choose a license

License: None

A license tells others what they can and cannot do with your code. [Learn more about licenses](#).

This will set `main` as the default branch. Change the default name in your [settings](#).

ⓘ You are creating a public repository in your personal account.

Create repository

Figure 11.7: Configure the repository

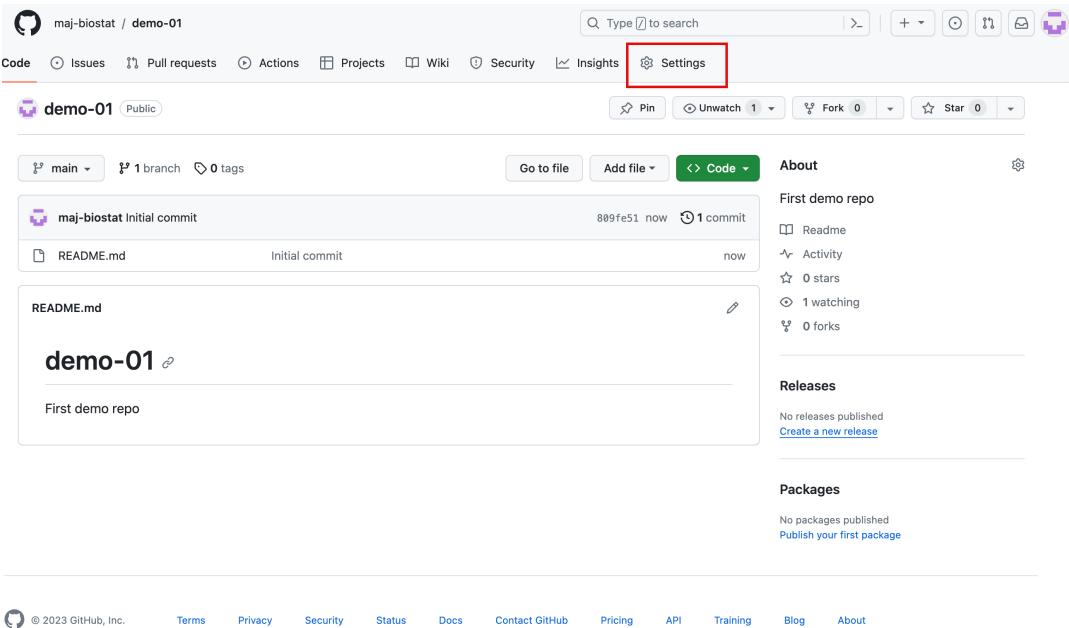


Figure 11.8: New repository page

The only difference in the setup is that you **do NOT to initialize the repository with a readme**. You will then be shown the following instructions. The latter case is the one that is applicable, as shown.

If you recall from the previous discussion on fileserver remotes, we had set the remote for the `first-repo` repository to be a OneDrive remote. Recapping:

```
pwd
## /Users/mark/Documents/project/misc-stats/first-repo
git remote -v
## origin  /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-r
## origin  /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-r
```

While we can technically have multiple remotes, it might be easier to simply unlink from this current remote.

```
git remote rm origin
git remote -v
##
```

And now add GitHub as the new remote.

The screenshot shows the GitHub repository settings page for 'maj-biostat / demo-01'. The 'General' tab is selected. On the left, a sidebar lists various settings sections: Access (Collaborators, highlighted with a red box), Code and automation (Branches, Tags, Rules, Actions, Webhooks, Environments, Codespaces, Pages), Security (Code security and analysis, Deploy keys, Secrets and variables), Integrations (GitHub Apps, Email notifications), and Features (Wikis, Restrict editing to collaborators only). The main content area displays the 'General' settings for the repository 'demo-01'. It includes fields for 'Repository name' (demo-01) and 'Default branch' (main). There are also sections for 'Template repository' and 'Social Preview'.

Figure 11.9: Collaborators setting

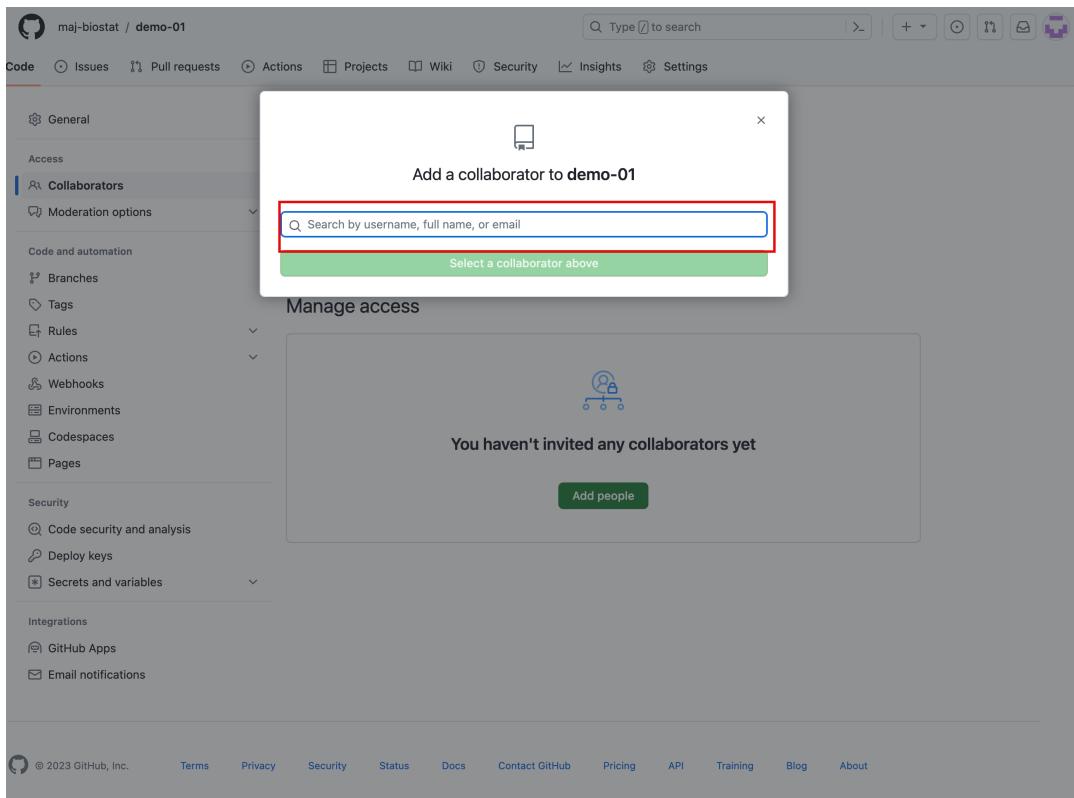


Figure 11.10: Enter collaborator details

The screenshot shows a GitHub user profile for 'maj-biostat'. The top navigation bar includes links for Overview, Repositories (186), Projects, Packages, and Stars. A search bar and a '+' icon are also present. A red box highlights the '+ New repository' button in the top right corner of the header. Below the header, there's a section for 'Popular repositories' featuring five repositories: 'misc-notes', 'adaptive-trial-note', 'orvac', 'gibby', and 'p3kids'. To the right of these repos is a 'Customize your pins' sidebar with options for 'New repository', 'Import repository', 'New codespace', 'New gist', 'New organization', and 'New project', all under the 'Public' tab. The main profile area shows a circular profile picture with a purple geometric pattern, the name 'Mark Jones', the handle 'maj-biostat', and the title 'Biostatistician'. It also displays 'Edit profile' and follower counts ('2 followers - 22 following'). The 'Achievements' section lists two items: a blue gear icon and a blue rocket icon. The 'Contributions' section shows a heatmap of activity from November 2023, with a legend indicating contribution levels from 'Less' to 'More'. The 'Contribution activity' section lists recent events: 'Created 50 commits in 1 repository' for 'maj-biostat/get-going-with-git' on Nov 1, and 'Created 1 repository' for 'maj-biostat/get-going-with-git' on Nov 1. The year selector at the bottom right shows '2023'.

Figure 11.11: GitHub initialise new remote repository

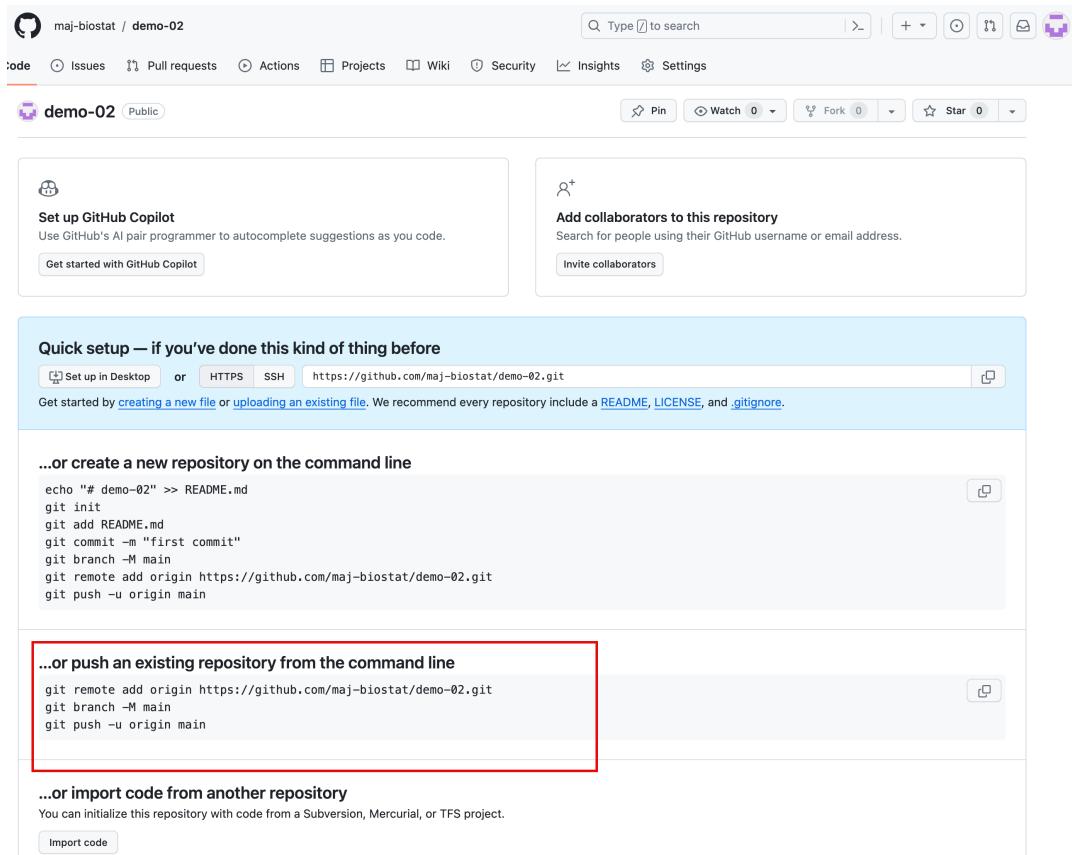


Figure 11.12: Link a local repo with the new remote

```

git remote add origin https://github.com/maj-biostat/demo2.git
git branch -M main
git push -u origin main

## Enumerating objects: 68, done.
## Counting objects: 100% (68/68), done.
## Delta compression using up to 8 threads
## Compressing objects: 100% (67/67), done.
## Writing objects: 100% (68/68), 6.51 KiB | 3.25 MiB/s, done.
## Total 68 (delta 41), reused 0 (delta 0), pack-reused 0
## remote: Resolving deltas: 100% (41/41), done.
## To https://github.com/maj-biostat/demo2.git
## * [new branch]      main -> main
## branch 'main' set up to track 'origin/main'.

```

i Note

The `git branch -M main` simply renames the current branch to `main`. In practice, this isn't a problem if you create all of your repositories with a default branch called `main` instead of `master` which is the legacy git preferred name.

i Note

The `git push -u` pushes up the branch information and the evolution of the repository. The `-u` is basically telling git to link your local `main` branch with the remote `main` branch. You only need to use this flag once and thereafter you can use `git fetch` and `git push` and git will know which remote you want to communicate with.

When we refresh the github page <https://github.com/maj-biostat/demo-02> (replacing my user-name with your own) then we see that the `first-repo` now appears on GitHub. It doesn't matter that the remote repo is called something other than `first-repo`. Generally you will give things the same names, but not always.

11.2.2 Clone a GitHub remote

In the first approach to initialising a remote (Section 11.2.1.1) we did not bring the remote down to the local machine. However, this is fairly trivial process to achieve by using `git clone` in a similar manner to how we used it previously.

Navigate back to the `demo-01` repository on GitHub, select the green clone button and copy the link to your clipboard.

The screenshot shows a GitHub repository page for 'demo-02'. At the top, there's a navigation bar with links for Code, Issues, Pull requests, Actions, Projects, Wiki, Security, Insights, and Settings. Below the navigation is a header for 'demo-02' with options to Pin, Unwatch (1), Fork (0), and Star (0). The main content area shows a list of files and commits. A sidebar on the right provides details about the repository, including its purpose ('Second demo repo'), activity (1 watching), and statistics (0 stars, 0 forks). The bottom of the page includes a footer with links to GitHub's Terms, Privacy, Security, Status, Docs, Contact GitHub, Pricing, API, Training, Blog, and About pages.

Code review comments

516ad1a 2 days ago 21 commits

.gitignore Finished surv 3 days ago

branching.R Code review comments 2 days ago

hello.R Revised approach to capturing input 3 days ago

myscript.R New file 3 days ago

readme.md Merge remote-tracking branch 'refs/remotes/ori... 2 days ago

readme.md

first-repo

A demo markdown file for the git workshop.

A new line for testing.

Contains standalone R scripts for staged deliverables to client.

Test by Sylvie

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Figure 11.13: first-repo is now on GitHub

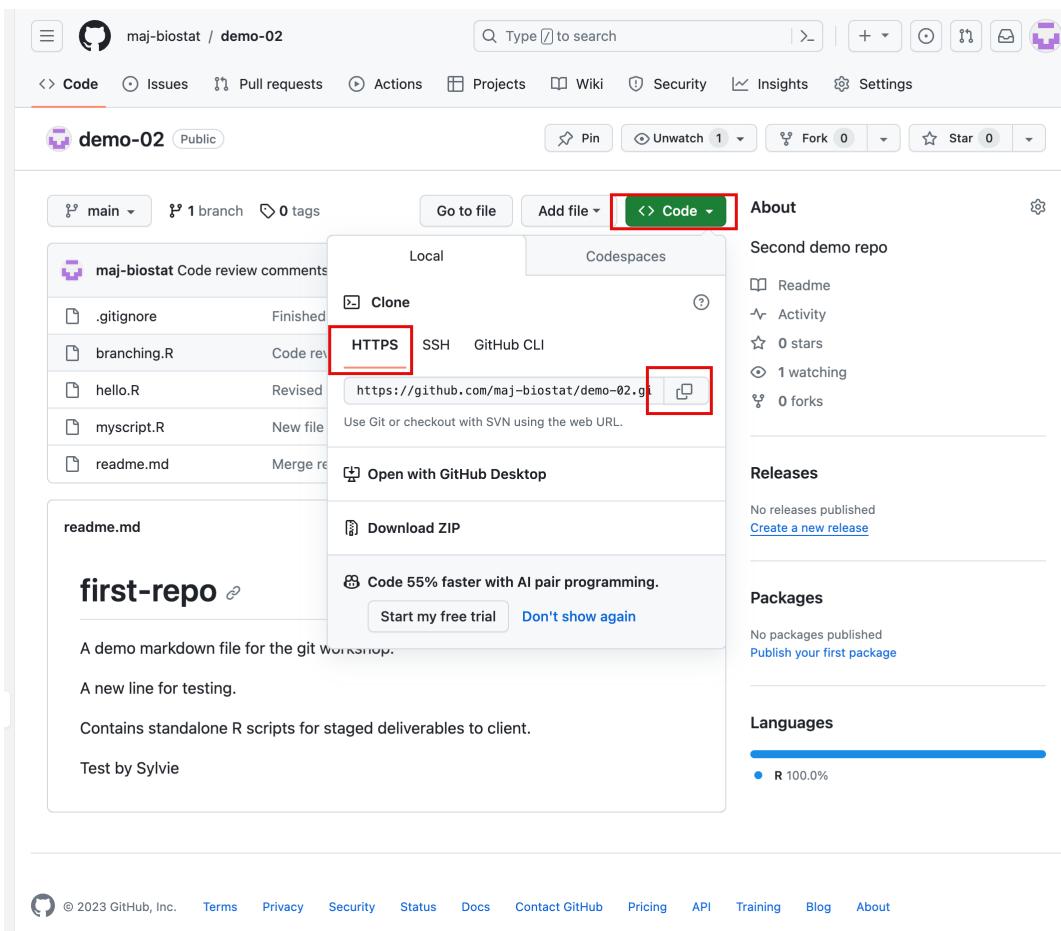


Figure 11.14: Cloning from GitHub

Now head back to your terminal, change directory out of `first-repo` into the local workshop directory and run the following which clones the `demo-01` repository to a local directory named `demo-01`.

i Note

Locally, you can give the remote repository any name you want. Here we have just used the same repository name as the remote, but we could call it `my-demo-01` or anything else you want.

```
git clone https://github.com/maj-biostat/demo-01.git demo-01
## Cloning into 'demo-01'...
## remote: Enumerating objects: 3, done.
## remote: Counting objects: 100% (3/3), done.
## remote: Total 3 (delta 0), reused 0 (delta 0), pack-reused 0
## Receiving objects: 100% (3/3), done.
cd demo-01/
ls -la
## total 8
## drwxr-xr-x 10 mark staff 320 9 Nov 13:29 ..
## drwxr-xr-x  4 mark staff 128 9 Nov 13:29 .
## -rw-r--r--  1 mark staff   24 9 Nov 13:29 README.md
## drwxr-xr-x 12 mark staff 384 9 Nov 13:29 .git
```

11.2.3 Fetch and push

Once you have linked your local and remote repositories, the workflow is identical to what has been previously introduced.

Let's work through the process again.

Following best practice, prior to making a change we create a feature branch and then switch to that branch.

```
git branch dev-01
git checkout dev-01
## Switched to branch 'dev-01'
```

Rather than code something up, simply download the `random-numbers.R` script (also listed on resources, Chapter 1 page) and save it to the `demo-01` repository folder on your machine. Run the script with `Rscript random-numbers.R` to make sure that it works.

```
Rscript random-numbers.R
##           categorical      normal      gamma   poisson
## Min.          -3 -3.56987408 0.0329983   3.00
## 1st Qu.       -2 -0.56524365 0.2845135   8.00
## Median        0  0.03029335 0.7235894  9.00
## Mean          0  0.07900788 1.0749329  9.82
## 3rd Qu.       2  0.74139889 1.3816200 12.00
## Max.          3  3.18586281 5.3176913 20.00
```

Now make an arbitrary change to the `README.md` file then stage and commit the files to the `dev-01` branch.

```
git status
## On branch dev-01
## Changes not staged for commit:
##   (use "git add <file>..." to update what will be committed)
##   (use "git restore <file>..." to discard changes in working directory)
## modified: README.md
##
## Untracked files:
##   (use "git add <file>..." to include in what will be committed)
## random-numbers.R
git add README.md random-numbers.R
git status
## On branch dev-01
## Changes to be committed:
##   (use "git restore --staged <file>..." to unstage)
## modified: README.md
## new file: random-numbers.R
git commit -m "Development for demo-01 project"
## [dev-01 fc5f874] Development for demo-01 project
## 2 files changed, 12 insertions(+), 1 deletion(-)
```

Switch back to the main branch and get ready to merge your piece of work¹.

```
git checkout main
```

Looking at the logs, you can see the `dev-01` branch is one step ahead of what we are currently viewing in our working directory.

¹I know this is a bit artificial, but it is just for practice

```
git log --oneline --decorate --graph --all
## * fc5f874 (dev-01) Development for demo-01 project
## * 809fe51 (HEAD -> main, origin/main, origin/HEAD) Initial commit
```

and the working directory reflects this reality as only the `README.md` file currently exists.

```
ls -la
## total 8
## drwxr-xr-x 4 mark staff 128 10 Nov 11:44 .
## drwxr-xr-x 10 mark staff 320 10 Nov 09:19 ..
## drwxr-xr-x 13 mark staff 416 10 Nov 11:44 .git
## -rw-r--r-- 1 mark staff 26 10 Nov 11:44 README.md
```

Merge the `dev-01` branch into `main`

```
git merge dev-01
## Updating 809fe51..fc5f874
## Fast-forward
## README.md      | 2 ++
## random-numbers.R | 11 ++++++
## 2 files changed, 12 insertions(+), 1 deletion(-)
## create mode 100644 random-numbers.R
```

We now have all the files and updates:

```
ls -la
## total 16
## drwxr-xr-x 5 mark staff 160 10 Nov 11:49 .
## drwxr-xr-x 10 mark staff 320 10 Nov 09:19 ..
## drwxr-xr-x 14 mark staff 448 10 Nov 11:49 .git
## -rw-r--r-- 1 mark staff 66 10 Nov 11:49 README.md
## -rw-r--r-- 1 mark staff 203 10 Nov 11:49 random-numbers.R
```

And the logs indicate that we are now up to date (note the location of `HEAD`)

```
git log --oneline --decorate --graph --all
## * fc5f874 (HEAD -> main, dev-01) Development for demo-01 project
## * 809fe51 (origin/main, origin/HEAD) Initial commit
```

Finally, push these updates to the remote, remembering to use the `-u` flag on this first occasion.

```
git push -u origin main
## Enumerating objects: 6, done.
## Counting objects: 100% (6/6), done.
## Delta compression using up to 8 threads
## Compressing objects: 100% (4/4), done.
## Writing objects: 100% (4/4), 513 bytes | 513.00 KiB/s, done.
## Total 4 (delta 0), reused 0 (delta 0), pack-reused 0
## To https://github.com/maj-biostat/demo-01.git
##     809fe51..fc5f874  main -> main
## branch 'main' set up to track 'origin/main'.
```

i Note

If you wish to push all branches (i.e. both `main` and `dev-01`) in this case then you would need to add the `--all` flag to the `git push`. In the present example, this would push all the branches up to the remote. All people reviewing the remote can then review the complete history should they need to.

```
git push --all
## Total 0 (delta 0), reused 0 (delta 0), pack-reused 0
## remote:
## remote: Create a pull request for 'dev-01' on GitHub by visiting:
## remote:     https://github.com/maj-biostat/demo-01/pull/new/dev-01
## remote:
## To https://github.com/maj-biostat/demo-01.git
## * [new branch]      dev-01 -> dev-01
```

And the change can be observed once the GitHub page is refreshed.

11.2.4 Reviewing history

GitHub provides an interface to review the changes that have occurred on the repo. Clicking on a file within your repository will take you to the file history page where you can review the evolution of the file.

Once the history page opens you can navigate to various versions of a file. On the left you can select the branch of interest (here `main` is shown). You can view the code or the commit with syntax highlighting or in raw form (which also lets you copy and paste the raw text should you need it). Over on the right are the latest commit point and an open to review the full timeline (History).

When you review the blame view, you can see determine who did what and when.

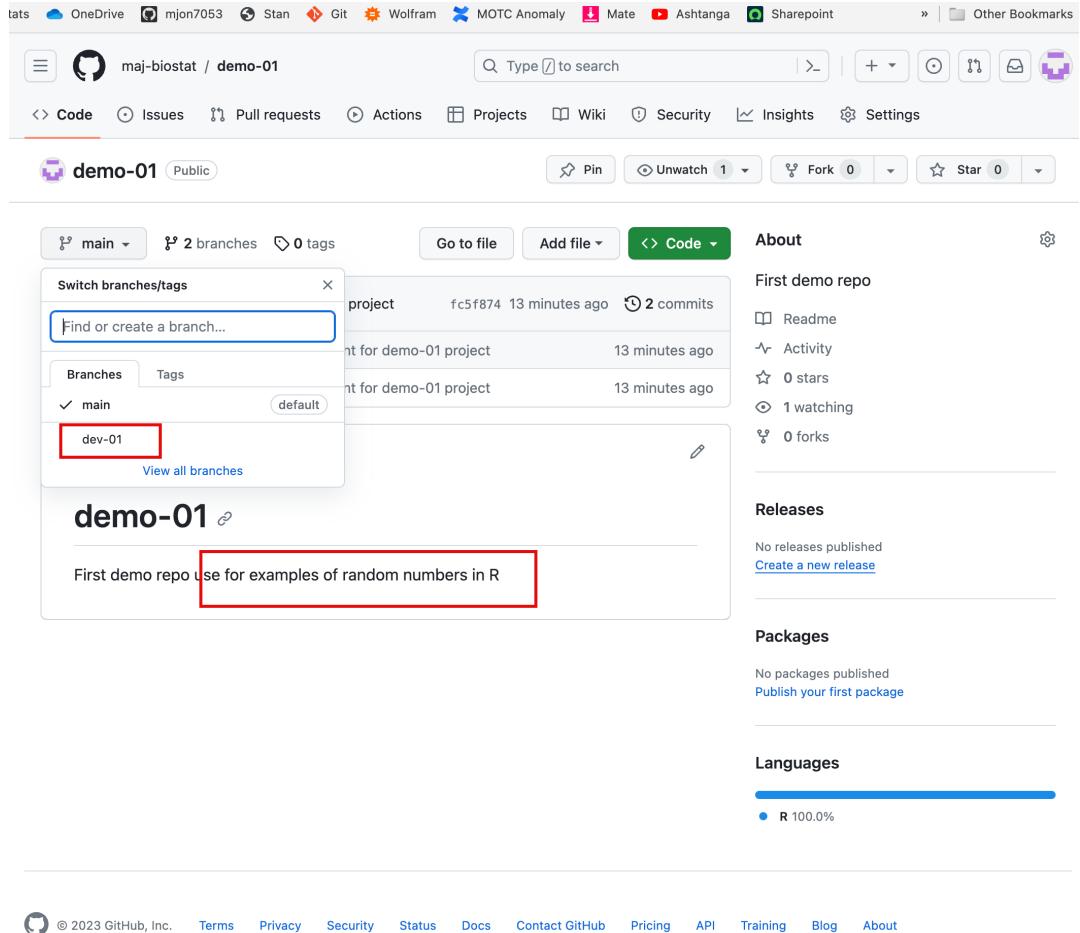


Figure 11.15: Updated files pushed to GitHub

The screenshot shows a GitHub repository page for 'maj-biostat / demo-01'. The repository has 2 branches and 0 tags. The README.md file contains the following content:

```
demo-01
First demo repo use for examples of random numbers in R
```

The 'random-numbers.R' file is highlighted with a red box. The repository has 2 commits, 0 stars, and 1 watching. The Languages section shows 100% R usage.

Figure 11.16: Updated readme and pushed to GitHub

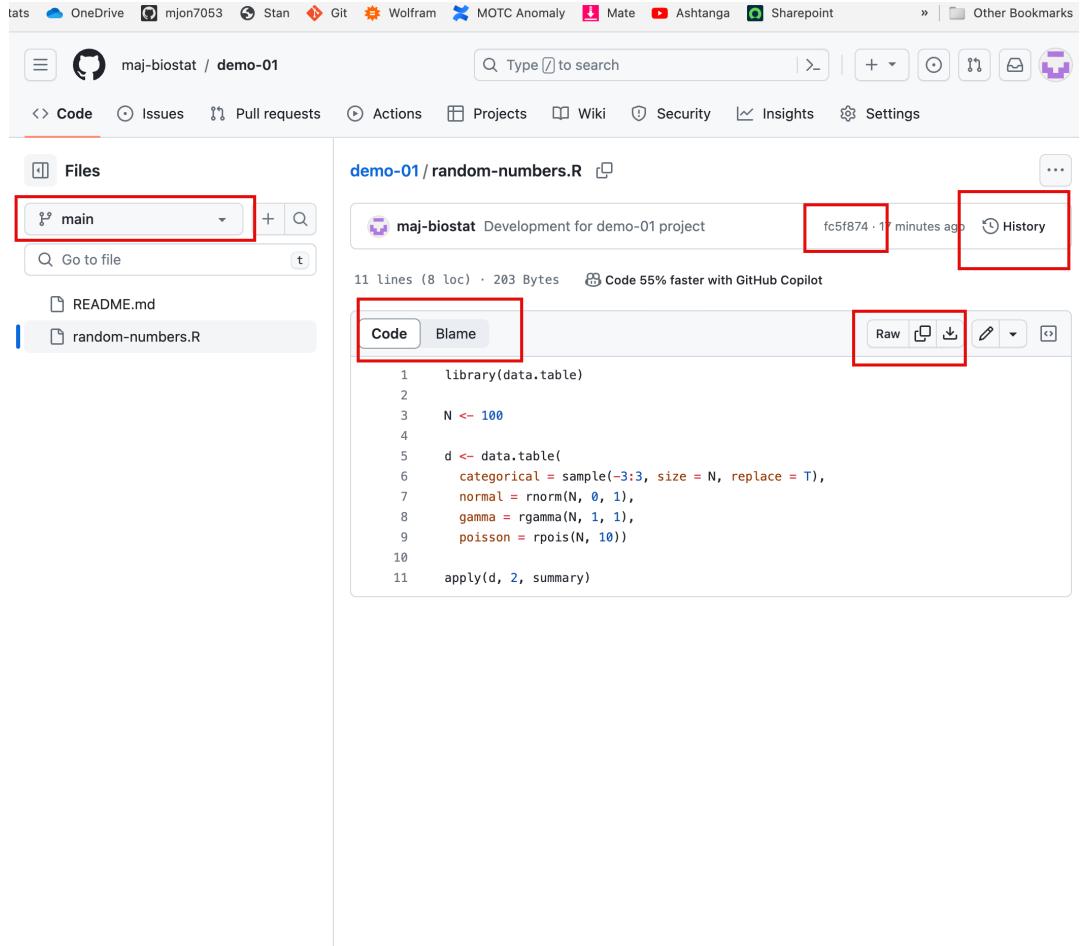


Figure 11.17: File review

The screenshot shows a GitHub repository page for 'maj-biostat / demo-01'. The 'Code' tab is selected. On the left, there's a sidebar with 'Files' and a dropdown for 'main'. Below it are buttons for 'Go to file' and 'random-numbers.R'. The main area shows a file named 'random-numbers.R' with 11 lines of code. A red box highlights the 'Blame' tab. The blame interface shows the commit history for each line. The first line is 'library(data.table)'. Subsequent lines show contributions from 'maj-biostat' at 17 minutes ago, with code like 'N <- 100', 'd <- data.table()', and 'apply(d, 2, summary)'.

```

1 library(data.table)
2
3 N <- 100
4
5 d <- data.table(
6   categorical = sample(-3:3, size = N),
7   normal = rnorm(N, 0, 1),
8   gamma = rgamma(N, 1, 1),
9   poisson = rpois(N, 10))
10
11 apply(d, 2, summary)

```

Figure 11.18: Code associated with commits

11.2.5 Issues

Issues can be managed directly within GitHub, although they are repository specific. Currently, our team mostly uses Jira to track and manage issues and therefore I will not cover the GitHub functionality beyond mentioning that it is very straight forward to use. In my opinion, there is merit in division of labour. GitHub serves well as a hosting service for git and continuous integrations.

11.3 Exercises

Exercise 11.1. When creating a new branch, we have needed to take two steps. First, we created the branch and then we checked it out. Is there a way this can be done with one command? Hint - Yes What is that command?

Part IV

Part 3 - Collaboration

Remotes

Hosting git

12 Collaboration 101

What is covered here simply scratches the surface. Git is extremely flexible in the workflows that can be set up. A basic approach is that of a centralised repository. This is fairly easy to understand and is simple to set up for small teams.

The concept of *remotes* is introduced as is an associated workflow.

12.1 No github?

GitHub is a hosting service for git repositories. It also extends some of the git functionality. They have captured the market, mainly because we are all a bit dim.

Before 2005 (ish), GitHub did not exist, and it wasn't a catastrophe. What did we do? Git has the functionality built into it to allow collaboration via hosting git repositories directly on fileservers. This is a reasonable solution for small teams with access to a common network, but it has its limitations. Nevertheless, most bluechip organisations used this approach during the 2000's.

Repositories that are retained outside of your local machine are referred to as *remotes*. It doesn't matter whether they are hosted on LIQUID, or a random file server or GitHub or BitBucket or Timbuktu. They are still known as remotes.

Remotes allow you to work on a repository collaboratively with your colleagues. This has been standard practice in software development since circa 1760.

We will talk about hosting remotes on fileservers here and then move on to GitHub next.

12.2 So remote

What remote (or remotes) are associated with the example repository that we have been working on? Let's look.

```
git remote -v
```

No remotes.

If at any time you want to review the remotes associated with your repository (you can have more than one remote) then invoke the command that we just used.

12.3 Initialising remotes

Let's set up a remote on OneDrive. OneDrive is a cloud file-server, but technically we could replace OneDrive with any file-server. For example, we used to have the LIQUID drive at TKI mounted as a network drive and we could use that.

Anyway, just follow along.

```
git clone --bare first-repo /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney
```

Why USyd (or Microsoft) uses such ludicrous names for their software is beyond me.

The above takes the repository that we have been working on and moves the git database to OneDrive. If we look at OneDrive then we see:

```
pwd
## /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-repo.git
ls -lrita
## total 48
## drwx-----@ 20 mark staff 640 8 Nov 08:36 ..
## -rw-r--r-- 1 mark staff 73 8 Nov 08:36 description
## -rw-r--r-- 1 mark staff 188 8 Nov 08:36 config
## -rw-r--r-- 1 mark staff 618 8 Nov 08:36 packed-refs
## -rw-r--r-- 1 mark staff 21 8 Nov 08:36 HEAD
## drwxr-xr-x@ 11 mark staff 352 8 Nov 08:36 .
## drwxr-xr-x 3 mark staff 96 8 Nov 08:36 info
## drwxr-xr-x 16 mark staff 512 8 Nov 08:36 hooks
## drwxr-xr-x 105 mark staff 3360 8 Nov 08:36 objects
## drwxr-xr-x 5 mark staff 160 8 Nov 08:36 refs
## -rw-r--r--@ 1 mark staff 6148 8 Nov 08:36 .DS_Store
```

The first thing to note is that there is no working directory.

Now let's imagine that I Sylvie has just joined the team as naive Bayesian statistician. Sylvie needs to start work on the `first-repo` project. First, we need to get the repository onto her local machine.

The process is as follows.

1. Go to you Documents folder (or wherever you intend to store your projects)
2. Clone the remote

Obviously, I am working off a single laptop clone the repo to some alternative name. I will refer to this location as *Sylvie's repo* vs *Mark's repo* which is the one that I have been referencing when demonstrating examples.

In contrast to the bare repository remote, we (Sylvie) now has the example files that we have been developing to date.

i Note

Note that I called the repo `sylvie-first-repo`. We can call the local version of the repo whatever we want.

```
cd /Users/mark/Documents/
git clone /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney\ (Staff\)/first-repo
ls -lrlta
## total 40
## drwxr-xr-x  3 mark  staff   96  8 Nov 11:07 ..
## -rw-r--r--  1 mark  staff  100  8 Nov 11:07 .gitignore
## -rw-r--r--  1 mark  staff 2274  8 Nov 11:07 branching.R
## -rw-r--r--  1 mark  staff  242  8 Nov 11:07 hello.R
## -rw-r--r--  1 mark  staff   38  8 Nov 11:07 myscript.R
## drwxr-xr-x  8 mark  staff  256  8 Nov 11:07 .
## -rw-r--r--  1 mark  staff  138  8 Nov 11:07 readme.md
## drwxr-xr-x 12 mark  staff  384  8 Nov 11:07 .git
```

Look at the details of the remote associated with Sylvie's repo:

```
cd /Users/mark/Documents/sylvie-first-repo/
git remote -v
origin  /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-repo.
origin  /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-repo.
```

The picture now looks like this

Over on the left we have the remote git database. On the right we have Mark who created the remote from his local repository and Sylvie who cloned the remote repository to her local machine. Git isn't restricted to this centralised architecture (it is possible to have multiple remotes and other variations) but it is a common paradigm.

GitHub uses a different workflow that commonly relies on a project owner pulling a developer's updates into a main project repository rather than the developer pushing their work directly to the project repository. We will see more about this later.

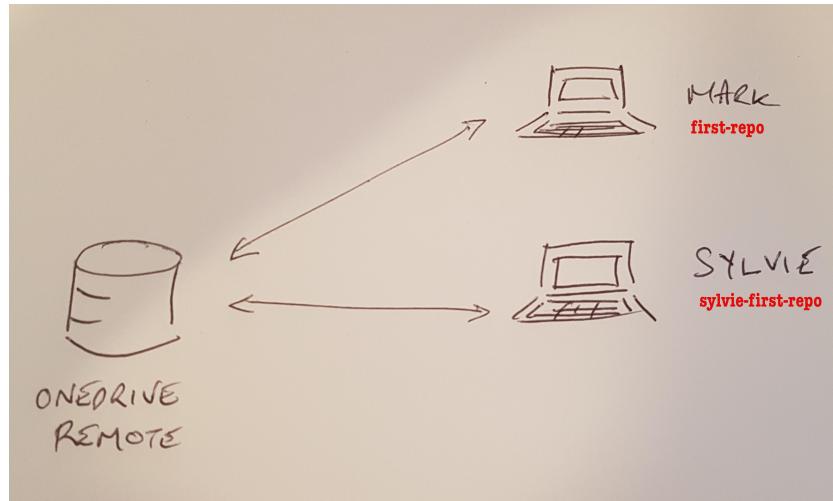


Figure 12.1: Clone repository

12.4 Keeping remotes up to date

For now, you can think of a remote as the hub around which collaboration revolves. As a project progresses, the local files are updated and we need to get these files into the remote so that our colleagues can keep their work in sync. However, someone else may send their files to the remote prior to you completing your work.

This would mean that the state of the remote is ahead of your local repository.

git (and GitHub) will not allow you to send your updates to the repository unless you are sync'd. In other words, you have to be up to date in order to send your changes to the remote.

To be able to push your work up to the remote, the steps are:

1. ensure that all your changes are committed to the local repository
2. run `git fetch` to establish whether you are up to date with the remote
3. if necessary, merge any changes into your local repository to get up to date
4. ensure that all your changes are committed to the local repository
5. `git push` your modifications up to the remote

Here is another picture.

It sounds (and looks) a bit involved, but in practice it is simple. We will go over the steps below.

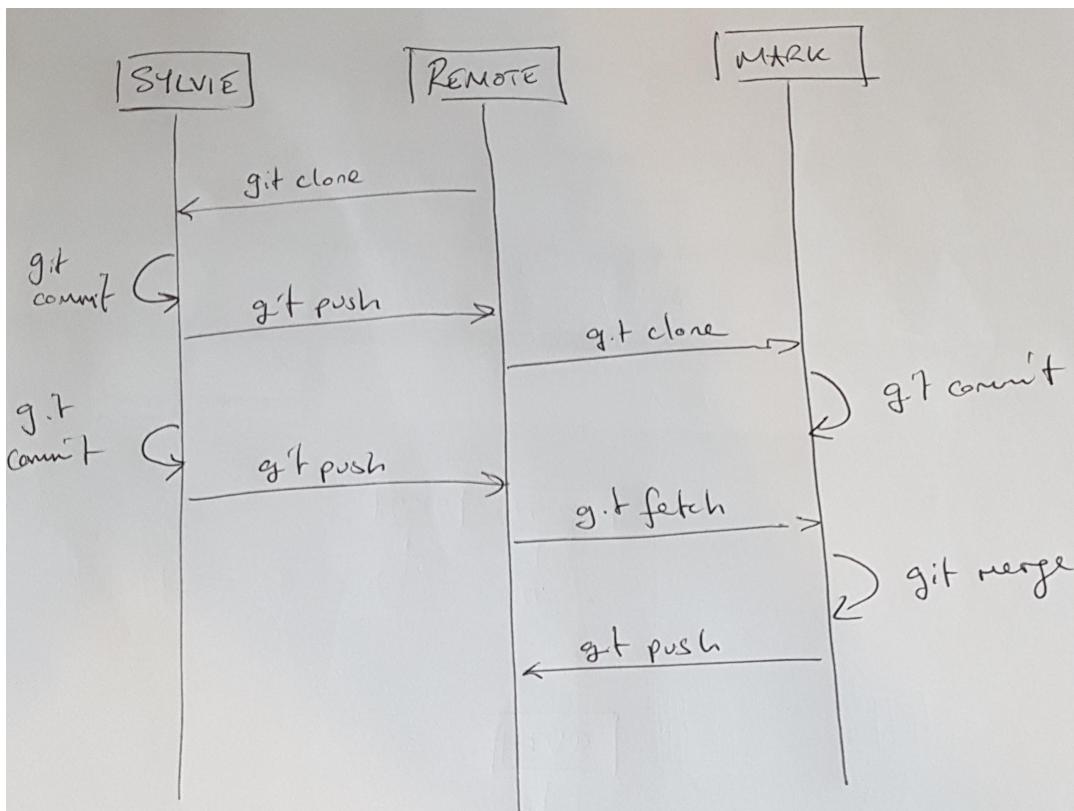


Figure 12.2: Centralised workflow

12.4.1 Fetch and push (simple case)

First Silvie ensures that all her local changes are committed to the repository. It looks like Silvie made a change to the `readme.md` when we were not looking.

```
cd sylvie-first-repo
git status
## On branch main
## Your branch is up to date with 'origin/main'.
##
## Changes not staged for commit:
##   (use "git add <file>..." to update what will be committed)
##   (use "git restore <file>..." to discard changes in working directory)
## modified:   readme.md
##
## no changes added to commit (use "git add" and/or "git commit -a")

git add readme.md; git commit -m "Minor change for testing fetch"
```

No changes have been made to the remote by anyone else so when we run `git fetch` there is no response. Therefore we can go and push the changes.

```
git push
## Enumerating objects: 5, done.
## Counting objects: 100% (5/5), done.
## Delta compression using up to 8 threads
## Compressing objects: 100% (3/3), done.
## Writing objects: 100% (3/3), 342 bytes | 342.00 KiB/s, done.
## Total 3 (delta 2), reused 0 (delta 0), pack-reused 0
## To /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-repo.git
##    7eee4b5..49225cc  main -> main
```

Looking at the logs we see the following

```
git log --oneline
## 3a3dd8d (HEAD -> main, origin/main, origin/HEAD) Testing Silvie
## 2829471 Merge branch 'analysis-03'
## be09457 (tag: v3.0, origin/analysis-03) Finished surv
## 53115b6 minor
## 7a5e7b9 Surv analysis
## 1a9dfef (tag: v2.0) Edits from code review
## d1586df Completion of secondary analysis
```

```
## bf34b9c Merge from fix-01
## b8de16c (tag: v1.1, origin/fix-01) Edits from code review
## 12561d9 Emergency fix
## d88f9e5 WIP
## a2cc6f7 (tag: v1.0) Comments from code review
## fa24778 branching.R
## 3bdac46 Revised approach to capturing input
## 327170a Minor edit
## b078716 New file
## 0cd2d52 First commit
```

12.4.2 Fetch and push (merge required)

In the interim Mark has been working on the `first-repo` and will want to get these changes into the remote. However, Mark hasn't yet linked his local repository with the remote.

```
git remote -v
## nothing
```

To fix this we use `git remote add` which, predictably tells git to configure a link between a local and remote version of the repository. This is a one time process and once we have set the remote, we do not need to do it again until we need to add a new remote.

```
git remote add origin /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney\ (Staff)
git remote -v
## origin   /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-repo
## origin   /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-repo
```

Note

The use of the word *origin* below is just convention to indicate the primary remote. It is a shortcut for the full directory path (or URL) for the remote. You can call the remote anything you want but most people stick with the convention of *origin*, which is a bit like the GitHub convention of using *main* for the main branch. If you were to add a second remote, you would call it something other than *origin*.

Next, we need to tell the local repository to reference this remote.

```
git remote add origin /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney\ (Staff)
git remote -v
```

```
## origin  /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-r
```

We see that the remote has been added for both push and fetch. Before we use these, we need to make an existing local branch track a specific remote branch which is achieved with

```
git fetch # pulls down information on the branches in the remote  
git branch --set-upstream-to=origin/main main # links a local with remote branch
```

Checking the status we see that the change that Sylvie pushed has left us out of sync.

```
git status  
## On branch main  
## Your branch and 'origin/main' have diverged,  
## and have 1 and 1 different commits each, respectively.  
##   (use "git pull" if you want to integrate the remote branch with yours)  
##  
## nothing to commit, working tree clean
```

If I try to push my change anyway, git barfs:

```
git push  
## To /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-repo.gi  
## ! [rejected]      main -> main (non-fast-forward)  
## error: failed to push some refs to '/Users/mark/Library/CloudStorage/OneDrive-TheUniver  
## hint: Updates were rejected because the tip of your current branch is behind  
## hint: its remote counterpart. If you want to integrate the remote changes,  
## hint: use 'git pull' before pushing again.  
## hint: See the 'Note about fast-forwards' in 'git push --help' for details.
```

This is what I was referring to earlier. Git will not allow you to screw up the remote without some strenuous effort on your part. It would be nice if git had told us what was different, but it forces us to do this via the following:

```
git fetch # this was done previously, but just to be clear that you need to do a fetch fir  
git diff main origin/main  
## diff --git a/readme.md b/readme.md  
## index 0165627..797358c 100644  
## --- a/readme.md  
## +++ b/readme.md  
## @@ -4,7 +4,9 @@ A demo markdown file for the git workshop.  
##
```

```
## A new line for testing.  
##  
## -Contains standalone R scripts for staged deliverables to client.  
## +Contains standalone R scripts.  
## +  
## +Test by Sylvie
```

You can see the line that I introduced and also the change that Sylvie added and committed to the remote. There are a few options to resolve this. Most people use `git pull` which runs a two-step process. In my opinion, while this is convenient, it can get you in to trouble. It is generally safer to split the process up into a `fetch` and then a `merge`.

```
git fetch  
git merge  
## Auto-merging README.md  
## Merge made by the 'ort' strategy.  
## README.md | 3 +++  
## 1 file changed, 3 insertions(+)
```

And in this case, the merge appears to have worked correctly.

```
# first-repo  
  
A demo markdown file for the git workshop.  
  
A new line for testing.  
  
Contains standalone R scripts for staged deliverables to client.  
  
Test by Sylvie
```

12.5 Remotes and branches

One key aspect that I have not mentioned to date is for the scenario where new branches are created in a local repository.

To list all known branches in both your local repository and the remote (or remotes)

```
git branch -a  
## analysis-03
```

```
##   fix-01
## * main
##   remotes/origin/analysis-03
##   remotes/origin/fix-01
##   remotes/origin/main
```

Let's say that Mark is asked to develop a new analysis. Learning from past mistakes, he creates an `analysis-04` branch and adds the following content to run a non-parametric survival analysis.

```
git branch analysis-04
```

To complete the analysis, the following is added to the `branching.R` script, which is tested, staged and committed.

```
message("\n\nANALYSIS OF SURVIVAL OUTCOME (UNSTRATIFIED, NON-PARAMETRIC):\n")

lm4 <- survdiff(Surv(w, evt) ~ x, data = d)
print(lm4)
```

Following the earlier process, Mark then switches back to main and merges in the new analysis.

```
git checkout main
git merge analysis-04
```

and then pushes the change up to the remote repository.

```
git push
```

Unfortunately, this does not establish the `analysis-04` branch within the remote. This may or may not be a problem (usually not) but it is worth being aware of, because other users will not be able to get access to the evolution of the files that occurred on the development branch. To push the `analysis-04` branch we use:

```
git push --set-upstream origin analysis-04
## Total 0 (delta 0), reused 0 (delta 0), pack-reused 0
## To /Users/mark/Library/CloudStorage/OneDrive-TheUniversityofSydney(Staff)/first-repo.git
## * [new branch]      analysis-04 -> analysis-04
## branch 'analysis-04' set up to track 'origin/analysis-04'.
```

And now users can fetch and review this branch within the context of their local repositories.

12.6 Comparing differences

TODO - Using the .. notation.

13 Collaboration with GitHub

13.0.1 Fork repository

13.0.2 Commit

13.0.3 Releases

13.0.4 Issues

13.0.5 Pull requests

About

Repository status

Details on github repository files, tags, commits follow:

```
Local:    main /Users/mark/Documents/project/misc-stats/get-going-with-git
Remote:   main @ origin (https://github.com/maj-biostat/get-going-with-git)
Head:     [b8020b7] 2023-11-10: Updated figs for gh101
```

```
Branches:      2
Tags:          1
Commits:       38
Contributors:   1
Stashes:        0
Ignored files: 5
Untracked files: 29
Unstaged files: 2
Staged files:   0
```

Latest commits:

```
[b8020b7] 2023-11-10: Updated figs for gh101
[c92a9f8] 2023-11-10: rejigged resources
[67f7cdc] 2023-11-10: First pass at collab and github
[a7e516b] 2023-11-08: First pass at collaboration 1
[6e58a92] 2023-11-07: First pass at merge
```