git introduction

Seda Radoykova
Daniel Molinuevo

Comic credits: https://xkcd.com/1597/

September 2025

What is git?

Git is a distributed version control software system that is capable of managing versions of source code or data. It is often used to control source code by programmers who are developing software collaboratively.

Two most common git softwares

Used in BIO-210

GitHub

GitLab

This should make more sense after the lecture today!

https://en.wikipedia.org/wiki/git

Why git?

We want to avoid this:

- project_copy_copy.py
- project_copy.py
- project_dani_v1_seda_change.py
- project_dani_v1.py
- project_final_final_for_real.py
- project_final_final.py
- project_final_seda_final_final.py
- project_final.py
- project_seda_copy.py
- project_seda.py
- project.py

DON’T DO THIS

Why git?

- Version control
  - Keeps track of **all past versions** of the repo/files
  - Take home: any change done via git commands can always be **recovered**!
- Collaborative work
  - Easy to work **in parallel**
  - Easy to **review** and **integrate** other's code
- Open source :)

What we are doing today

- Live demo!
- We will go through some of the basic git commands:
  - Basic commands
  - Branches
  - Comitting and pushing changes
  - Git pull
  - Merging branches
  - Others (reset, stash, restore)

We avoid this!

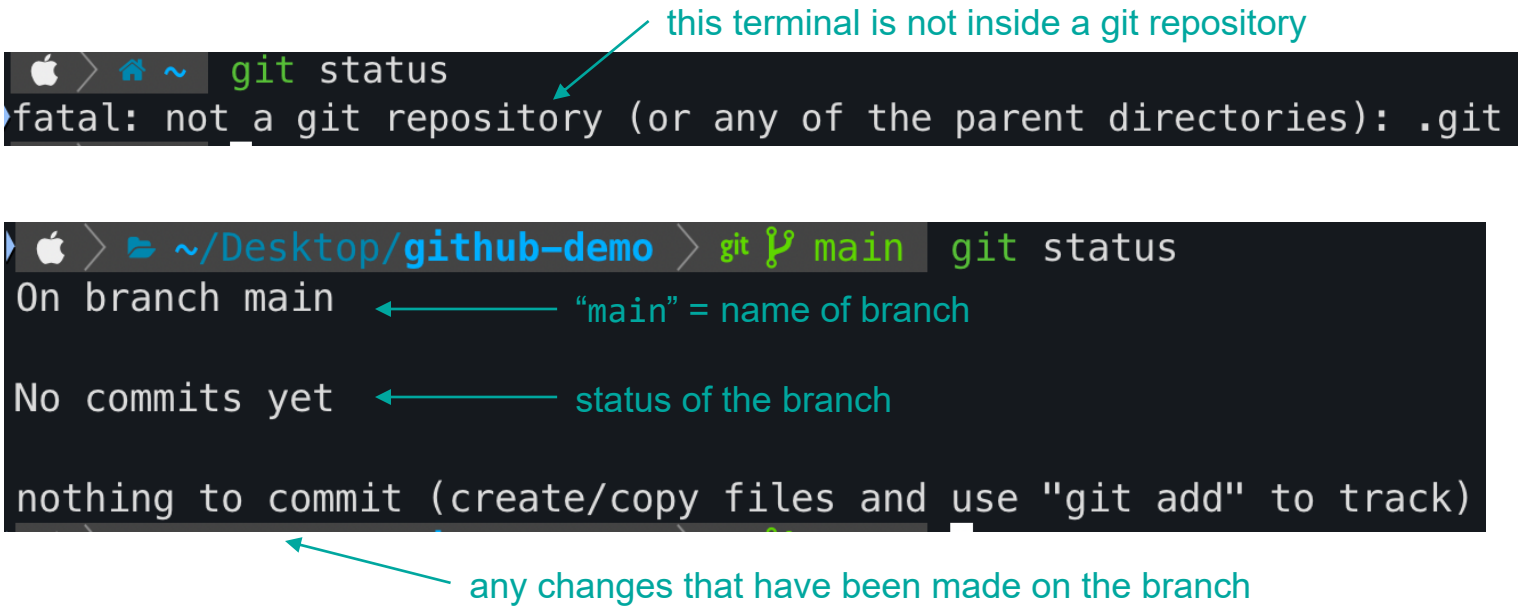
Do not blindly copy paste commands, ask us!

Basic commands
Setting up

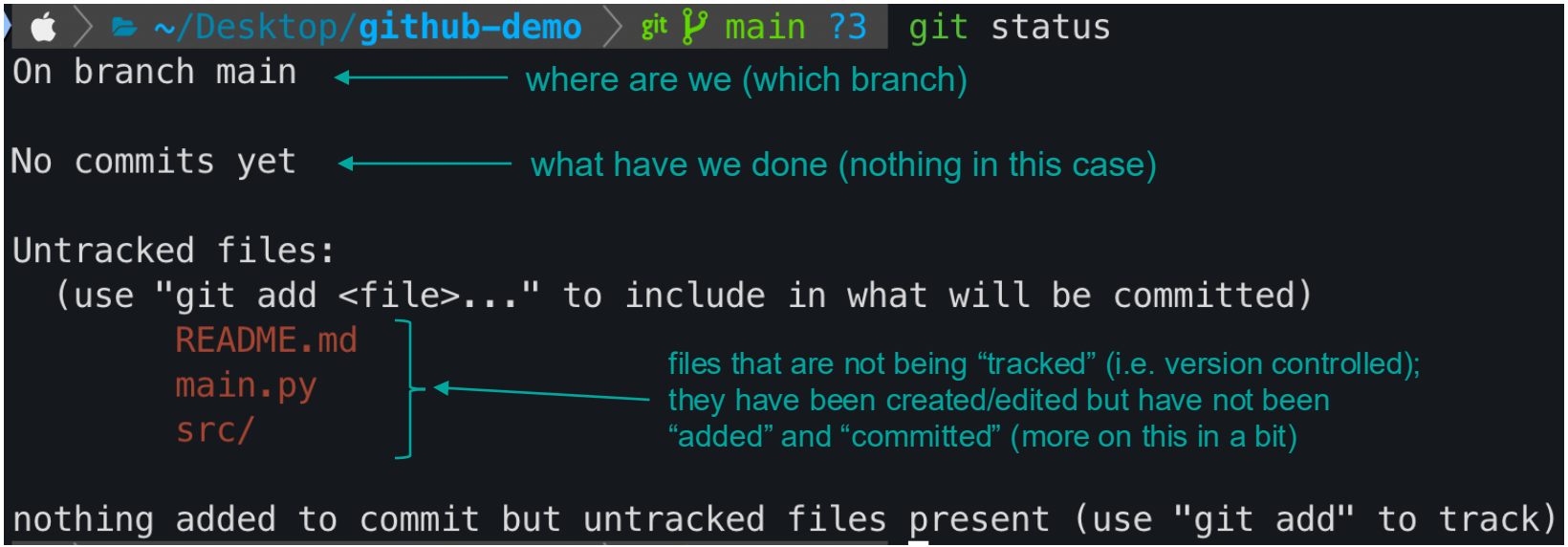
```
git status
git clone
git init
```

git status

Provides general info on the current repository (e.g files modified, current branch, etc). ALWAYS, carefully **read** its output



git status

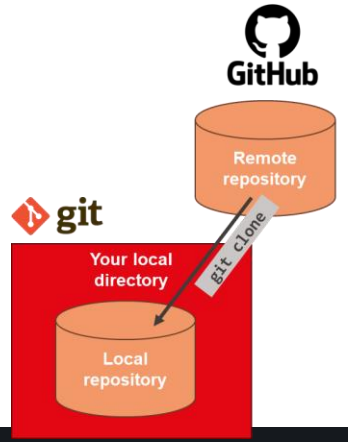


In case of doubt: `git status`

git clone

Used to ”**download**” (clone) a **remote** repository to the **current folder**.

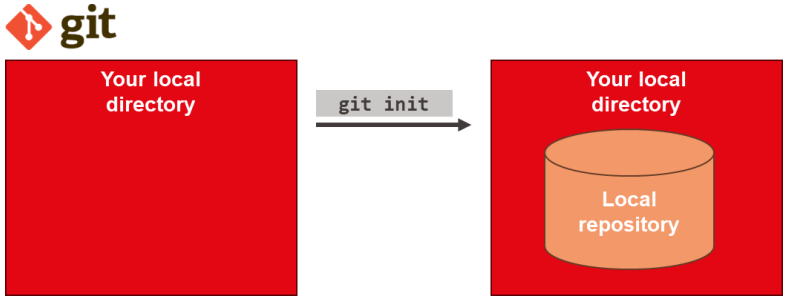
```
~/Desktop git clone https://github.com/dmg99/github-demo
Cloning into 'github-demo'...
warning: You appear to have cloned an empty repository.
```



If it is a **private** repo, you need to have been granted **access**, otherwise you will get a **“not found” error**:

```
Cloning into 'github-demo2'...
remote: Repository not found.
fatal: repository 'https://github.com/dmg99/github-demo2/' not found
```

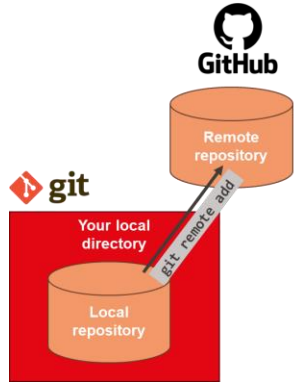
git init + git remote



Alternative to “`git clone`”. Instead of downloading a repository, it **initializes** one in the **current folder** (it is a bit more messy).

```
~/Desktop/github-demo2  git init
Initialized empty Git repository in /Users/molinuev/Desktop/github-demo2/.git/
```

git init + git remote



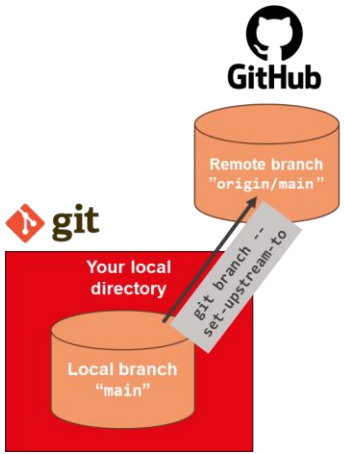
Alternative to “`git clone`”. Instead of downloading a repository, it **initializes** one in the **current folder** (it is a bit more messy).

```
~/Desktop/github-demo2 git init
Initialized empty Git repository in /Users/molinuev/Desktop/github-demo2/.git/
```

Need to **link local repository to remote repository** using ”`git remote add`”

```
~/Desktop/github-demo2 git main git remote add origin https://github.com/dmg99/github-demo
```

git init + git remote



Alternative to “`git clone`”. Instead of downloading a repository, it **initializes** one in the **current folder** (it is a bit more messy).

```
~/Desktop/github-demo2 git init
Initialized empty Git repository in /Users/molinuev/Desktop/github-demo2/.git/
```

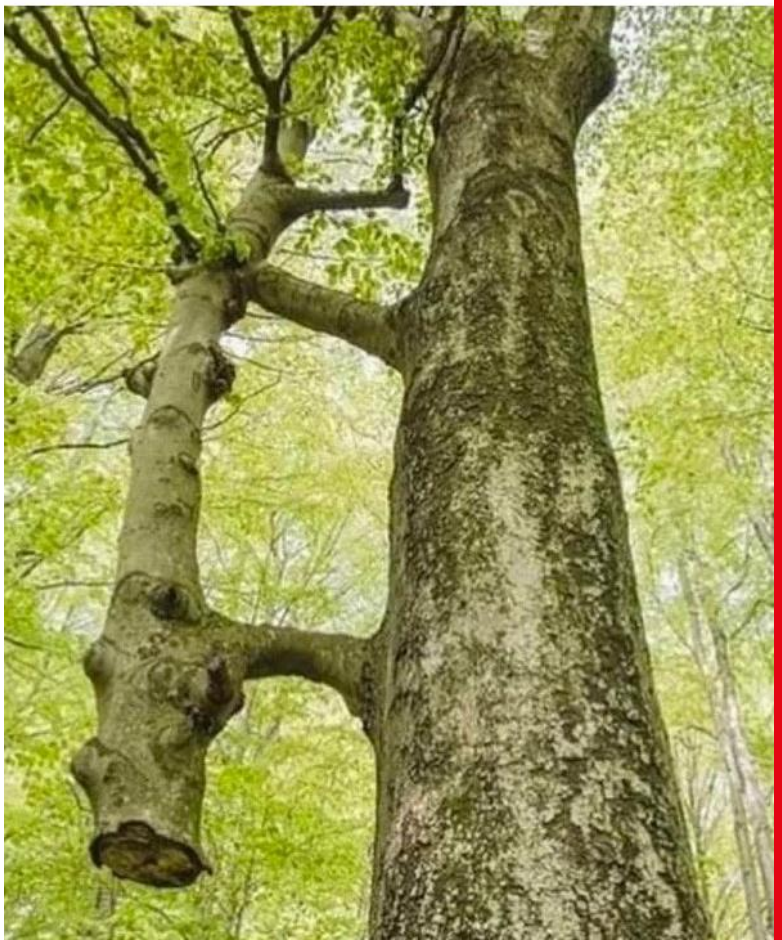
Need to **link local repository to remote repository** using ”`git remote add`”

```
~/Desktop/github-demo2 git main git remote add origin https://github.com/dmg99/github-demo
```

Need to link the **current branch** to a **remote one**

```
git branch --set-upstream-to=origin/main main
```

```
> git checkout -b new_branch
> git merge new_branch
```



Branches

Local vs remote

`git branch`

`git checkout`

Local and remote

When speaking of branches, we need to distinguish:

- **Remote branches**: they exist in the **“remote” repository** (e.g on GitHub)

- **Local branches:** they exist in the **current folder** we are working on (e.g our PC).

A local branch **can be set to track** a remote branch. This means that it will **pull and push** to that one. *Note that this means that **local branches can exist without a remote counterpart.***

If we try to push/pull in a local branch without remote:

```
~/De/github-demo  git my_local_branch !1  git pull
There is no tracking information for the current branch.
Please specify which branch you want to merge with.
See git-pull(1) for details.

    git pull <remote> <branch>

If you wish to set tracking information for this branch you can do so with:

    git branch --set-upstream-to=origin/<branch> my_local_branch
```

get more help

we need to know from which:
(1) repository and (2) branch

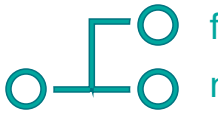
we just did this in the previous slide!

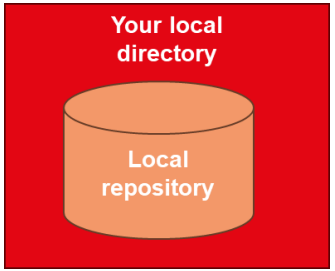
git branch

Lists existing **local** branches

```
~/De/github-demo  featureA !1  git branch
```

```
* featureA
  main
(END)
```

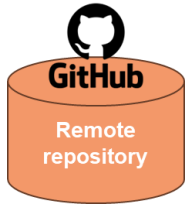




Flag `--remote` allows to list also **remote** branches

```
git branch --remote
```

```
  origin/featureA
  origin/featureB
  origin/main
(END)
```



git checkout

Changes current working branch.

If branch does not exist locally but there is a remote with that name (*need to run `git fetch` first*) it will **create a new one and track it**.

```
~/Desktop/github-demo  main !1  git checkout featureA
branch 'featureA' set up to track 'origin/featureA'.
Switched to a new branch 'featureA'
```

create new local branch; note: it tracks "origin/main"

switch to the newly created branch

If it exists locally, it will simply **switch branch**

```
~/De/github-demo  featureA !1  git checkout main
Switched to branch 'main'
Your branch is up to date with 'origin/main'.
```

switch to the local branch

branch status

Note: to checkout branch, you need to commit/stash your current changes

git checkout – create branch

When using the `-b` flag, checkout will create **a new local branch** that **forks from the current one**

```
~/Desktop/github-demo  main !1  git checkout -b new_branch
Switched to a new branch 'new_branch'
```

If a **remote one does not exist**, when **pushing for the first time** you need to run the following:

```
~/De/github-demo  new_branch !1  git branch -u origin/featureA new_branch
branch 'new_branch' set up to track 'origin/featureA'.
```

This would **pair** the **local branch "`new_branch`"** with the **remote branch "`featureA`"**.

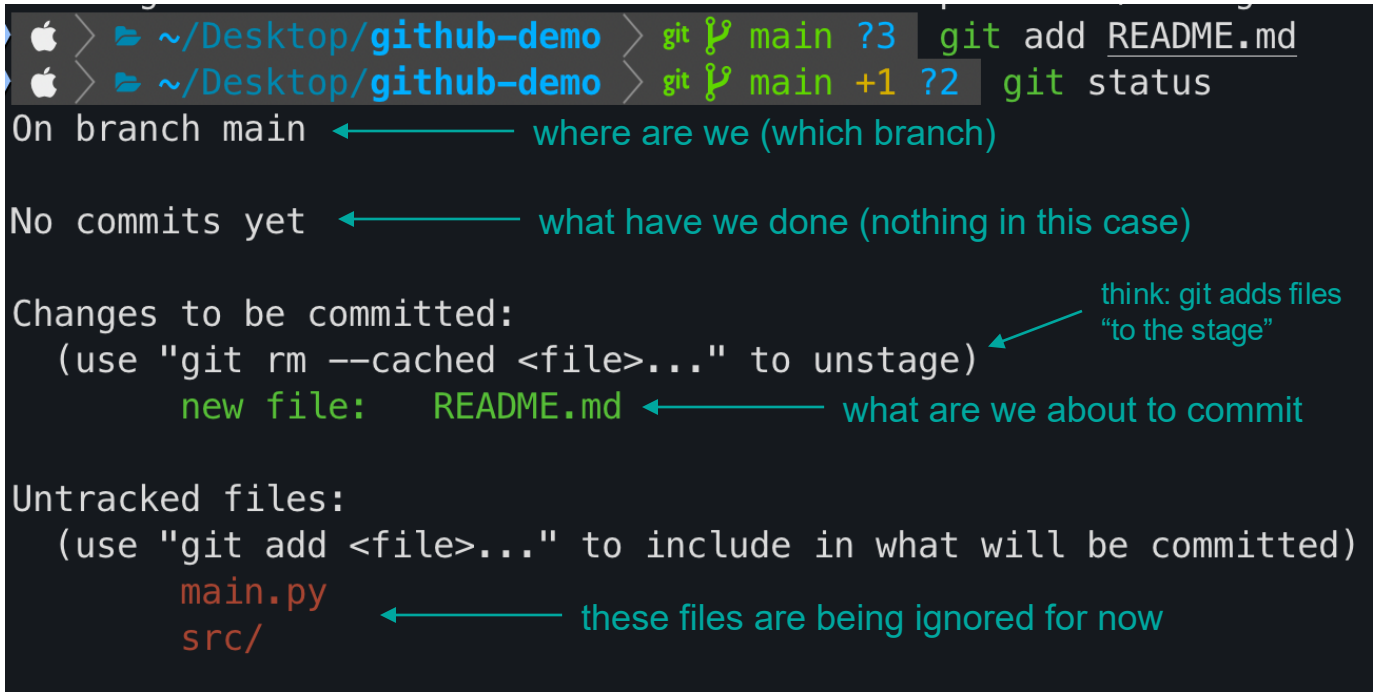
Commiting changes

```
git add
git rm
git commit
git push
```

git add

Used to prepare a “commit”.

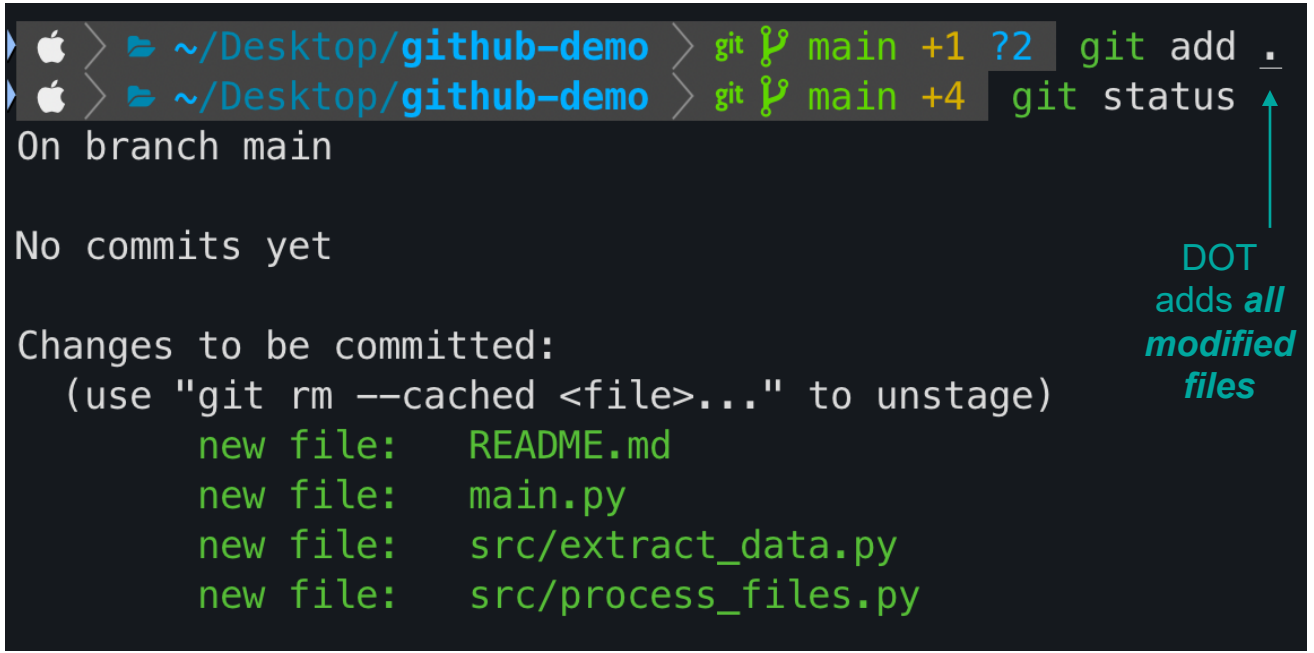
By using “`git add`” we **specify which files** we would like to commit



git add

To add **all modified files**, you can use "`git add .`"

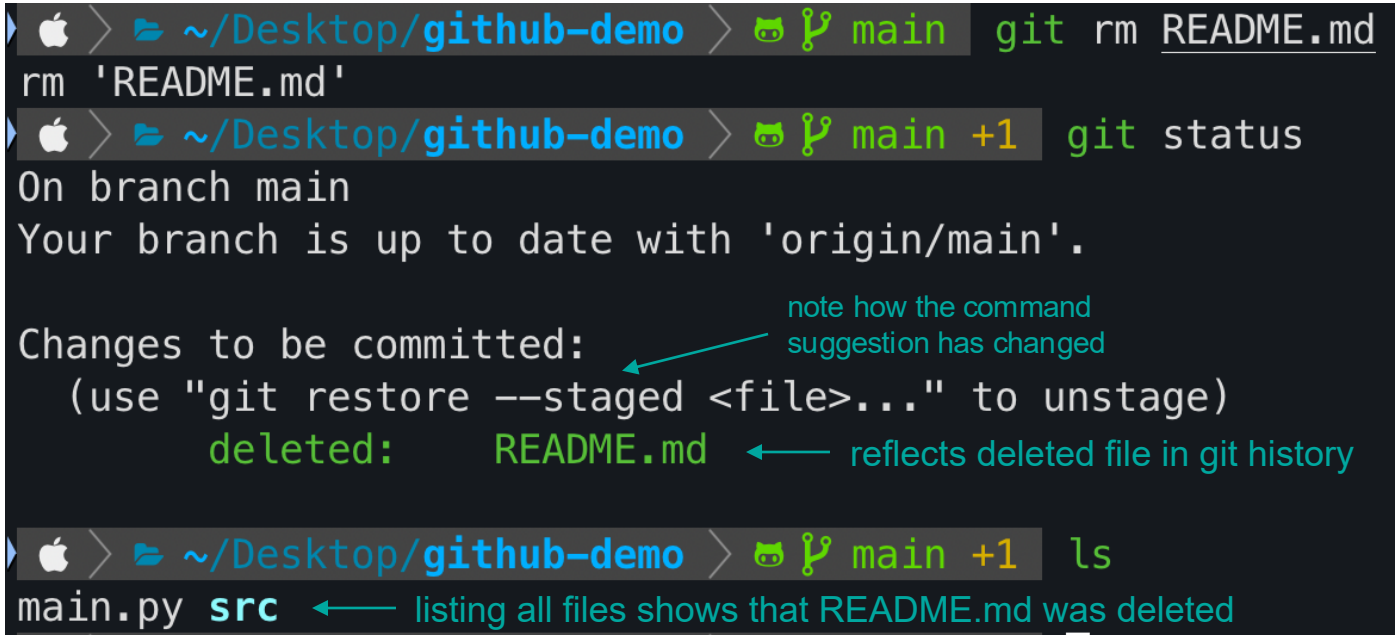
Be **CAREFUL** when doing this and **always check** with "`git status`" which files have been included.



git rm

You can use it to remove files that are in remote.

Careful, running "`git rm`" will also **delete the actual file!**



git commit

Commiting is one of the main actions in git.

It consists of **taking a set of changes already specified** via "`git add`" and "`git rm`" and **putting them together**.

```
~/Desktop/github-demo  main +1  git commit -m "Added description to README.md"
[main 848a973] Added description to README.md
 1 file changed, 3 insertions(+)
~/Desktop/github-demo  main ↑1  git status
On branch main
Your branch is ahead of 'origin/main' by 1 commit.
  (use "git push" to publish your local commits)

nothing to commit, working tree clean
```

-m for message and the message is in ""

what have we done ***locally***

any uncommitted changes?

PSA: write **MEANINGFUL** commit messages **CONSISTENTLY**

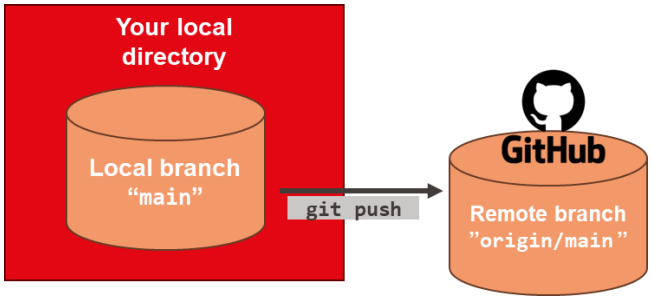
Cartoon credits: https://xkcd.com/1296/

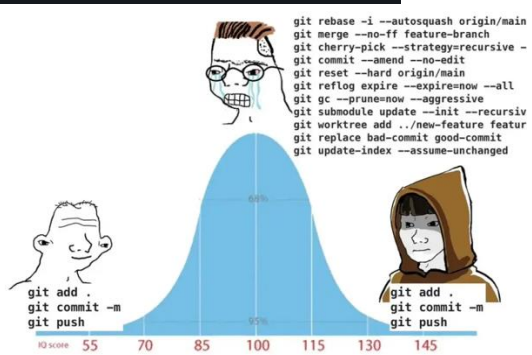
git push

Used to **sync the local changes** (commits) with the **remote**.

Note that it **will only push commited changes**!

```
~/Desktop/github-demo  main ↑1  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), 405 bytes | 405.00 KiB/s, done.
Total 3 (delta 0), reused 0 (delta 0), pack-reused 0
To https://github.com/dmg99/github-demo
   544708e..848a973  main -> main
```

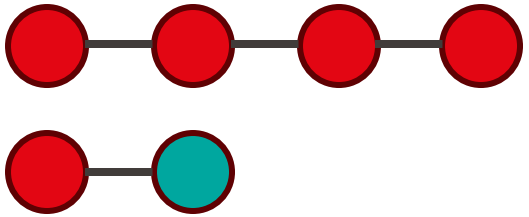




git push

In order to push, the ***current branch has to be synced with the remote!***

```
~/Desktop/github-demo2  main ↓2↑1  git push
To https://github.com/dmg99/github-demo
 ! [rejected]        main -> main (non-fast-forward)   ← divergence error
error: failed to push some refs to 'https://github.com/dmg99/github-demo'
hint: Updates were rejected because the tip of your current branch is behind
hint: its remote counterpart. Integrate the remote changes (e.g.
hint: 'git pull ...') before pushing again.   ← sync branches
hint: See the 'Note about fast-forwards' in 'git push --help' for details.
```



remote branch

local branch
missing commits from remote
and has a different commit

Once you **push to remote**, all your changes **will be saved!**

Syncing remote changes to local

```
git pull
git pull --rebase
git fetch
```

git pull

Used to **update** the changes (commits) **from the remote branch to the local branch**. After running it, mainly 4 things can happen:

1. **Up to date:** No new changes in the remote branch

```
~/Desktop/github-demo  main !1  git pull
Already up to date.
```

2. **Successful pull:** There are changes and local branch can be easily updated

```
~/Desktop/github-demo  main ⇣1 !1  git pull
Updating 848a973..9740ded
Fast-forward
 main.py | 2 ++
 1 file changed, 2 insertions(+)
```

git pull

Used to **update** the changes (commits) **from the remote branch to the local branch**. After running it, mainly 4 things can happen:

3. Merge conflict: both you and the remote **have modified the same file**.

Two options to fix this: (1) `git stash` or (2) `git commit` + `git pull --rebase`

```
~/De/github-demo  main !2  git pull
remote: Enumerating objects: 5, done.
remote: Counting objects: 100% (5/5), done.
remote: Compressing objects: 100% (3/3), done.
remote: Total 3 (delta 0), reused 3 (delta 0), pack-reused 0 (from 0)
Unpacking objects: 100% (3/3), 356 bytes | 118.00 KiB/s, done.
From https://github.com/dmg99/github-demo
   9740ded..6241bec  main       -> origin/main
Updating 9740ded..6241bec
error: Your local changes to the following files would be overwritten by merge:
        main.py
Please commit your changes or stash them before you merge.
Aborting
```

remote branch

local branch with *uncommitted changes*

main.py was out **of sync with main** AND **modified in a conflicting way**

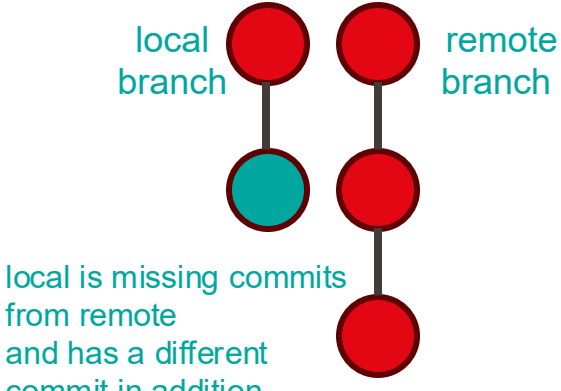
`git commit` + `git pull --rebase`

stash = “put on hold until you sort out pulling”

git pull

4. Diverged branches: you have **local commits not present in remote** and **remote has commits not present in local**.

Fix: Try `git pull --rebase`. If it does not work, probably both **the local and remote changes modified the same files**. Then you need to ***merge conflicts*** (big mess up, ask TA/SA)




```
~/Desktop/github-demo  main ↓1↑1  git status
On branch main
Your branch and 'origin/main' have diverged,
and have 1 and 1 different commits each, respectively.
  (use "git pull" to merge the remote branch into yours)

nothing to commit, working tree clean
~/Desktop/github-demo  main ↓1↑1  git pull

hint: You have divergent branches and need to specify how to reconcile them.
hint: You can do so by running one of the following commands sometime before
hint: your next pull:
hint:
hint:   git config pull.rebase false  # merge
hint:   git config pull.rebase true   # rebase
hint:   git config pull.ff only       # fast-forward only
hint:
hint: You can replace "git config" with "git config --global" to set a default
hint: preference for all repositories. You can also pass --rebase, --no-rebase,
hint: or --ff-only on the command line to override the configured default per
hint: invocation.
fatal: Need to specify how to reconcile divergent branches.
```

divergence warning

note that `git pull` ***merges changes*** from the remote branch into the local one by default

help message: configure default behaviour

pass `--rebase` to `git pull` aka suggests running `git pull --rebase`

git pull --rebase

In case the local branch and remote branch **have diverged** but their commits **modify different files** (or **different parts** of the **same file**), **rebasing** will **stack** the local **commits** on top of the remote ones.

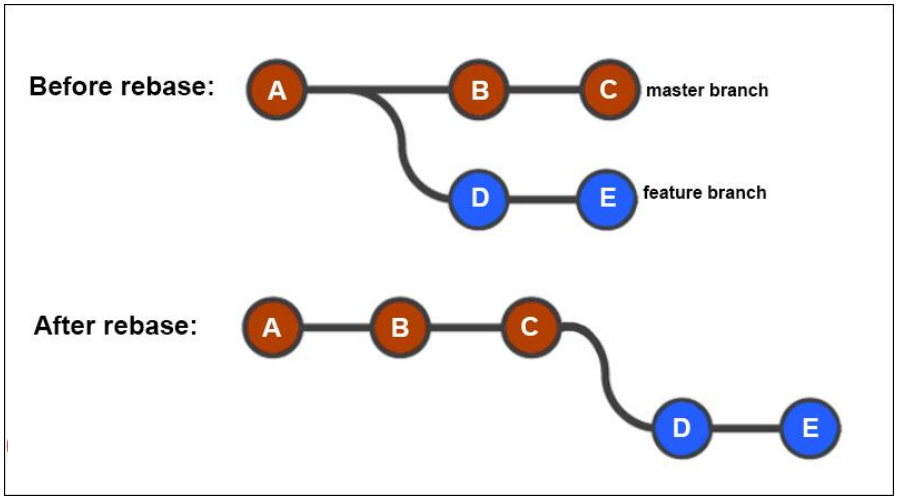
```
~/Desktop/github-demo main ↓1↑1 git status
On branch main
Your branch and 'origin/main' have diverged,
and have 1 and 1 different commits each, respectively.
  (use "git pull" to merge the remote branch into yours)

nothing to commit, working tree clean
~/Desktop/github-demo main ↓1↑1 git pull --rebase
Successfully rebased and updated refs/heads/main.
~/Desktop/github-demo main ↑1 git status
On branch main
Your branch is ahead of 'origin/main' by 1 commit.
  (use "git push" to publish your local commits)

nothing to commit, working tree clean
```

divergence warning

rebase worked and needs to be pushed to be visible on the remote repo

git pull --rebase

Rebasing can be represented as the following operations on the chain of commits.



We would say that:

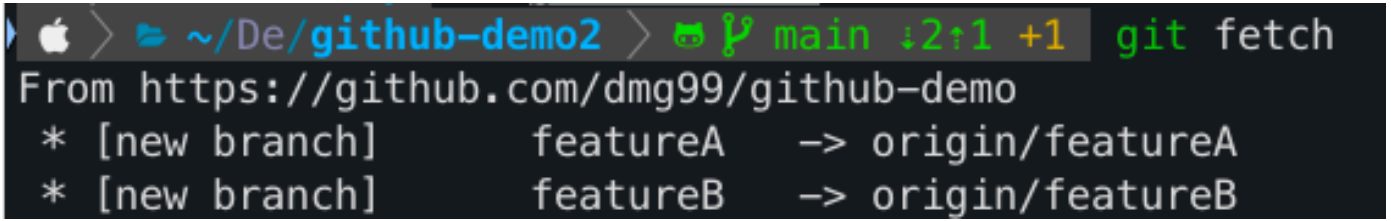
Branch “feature” has been **rebased to** branch “master”

https://phoenixnap.com/kb/git-rebase-vs-merge

git fetch

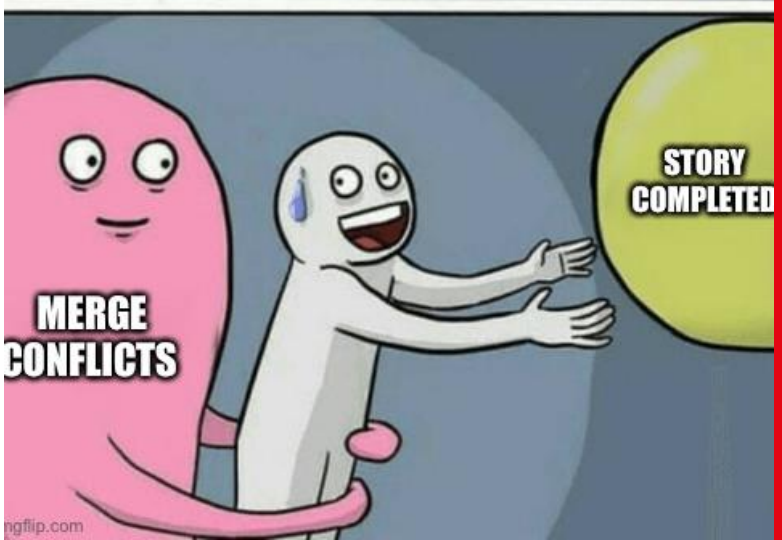
Allows to **check for changes** in remote. It looks for **new branches** and **whether there are changes** in the existing ones.

Unlike `git pull`, it ***does not update local files***.



Note: git will have **no clue** of what is happening **in remote** if you do not run `git fetch`.

If for example you run “`git status`” and you get “up to date with remote” this will only make sense if you have run “`git fetch`” first. Otherwise there might be changes that git is not ”seeing”.



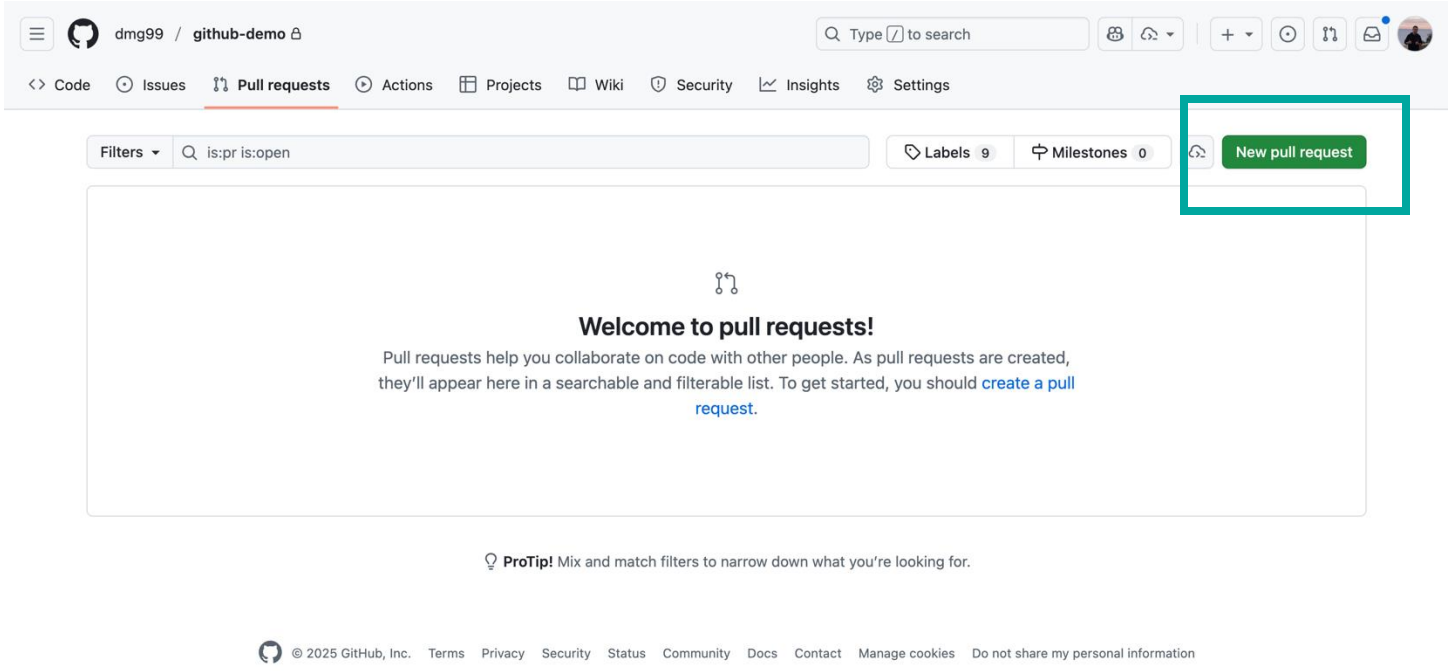
Merging branches Pull requests

Merge – Pull request

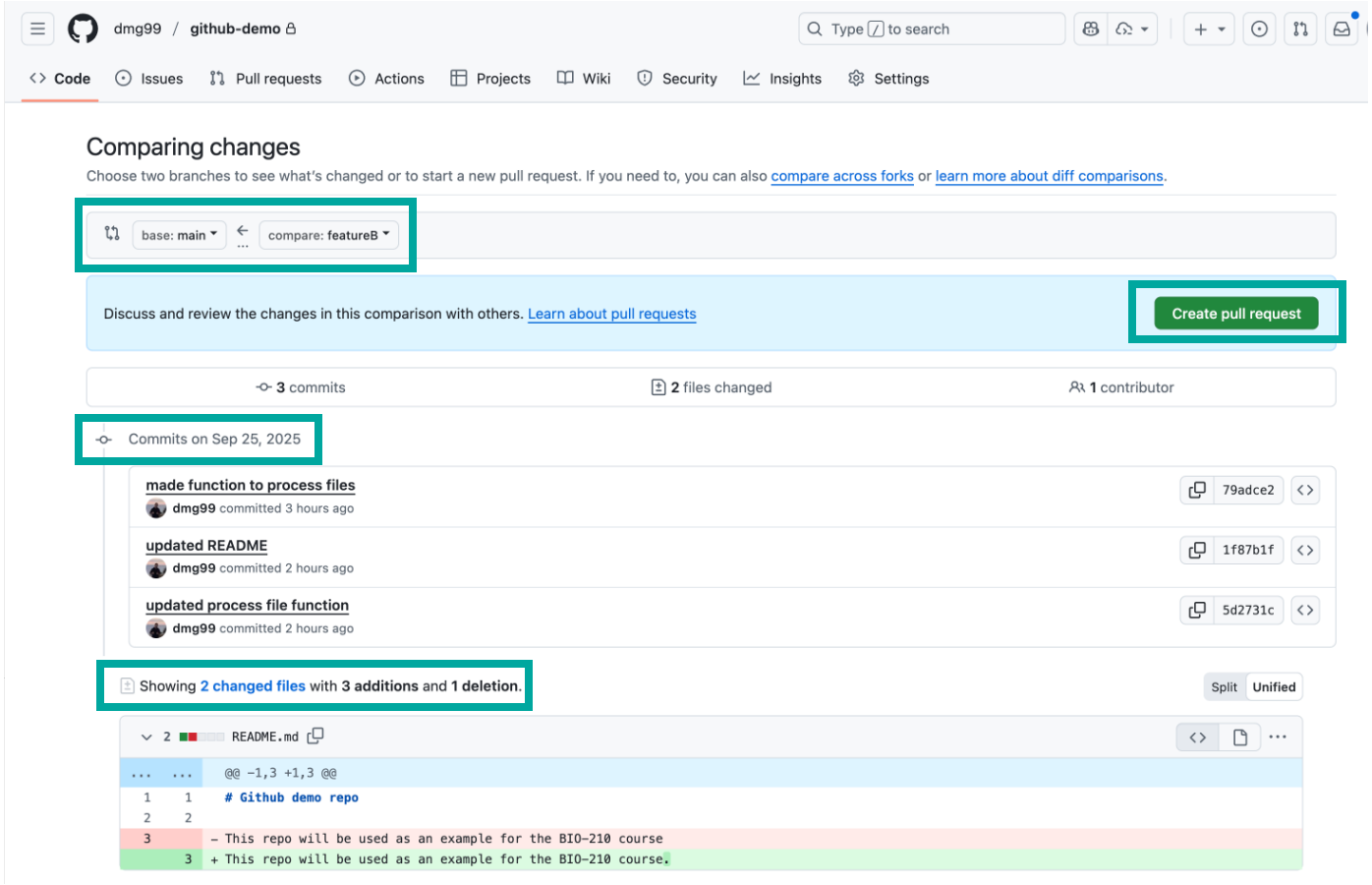
`git rebase`

Merging branches – Pull requests

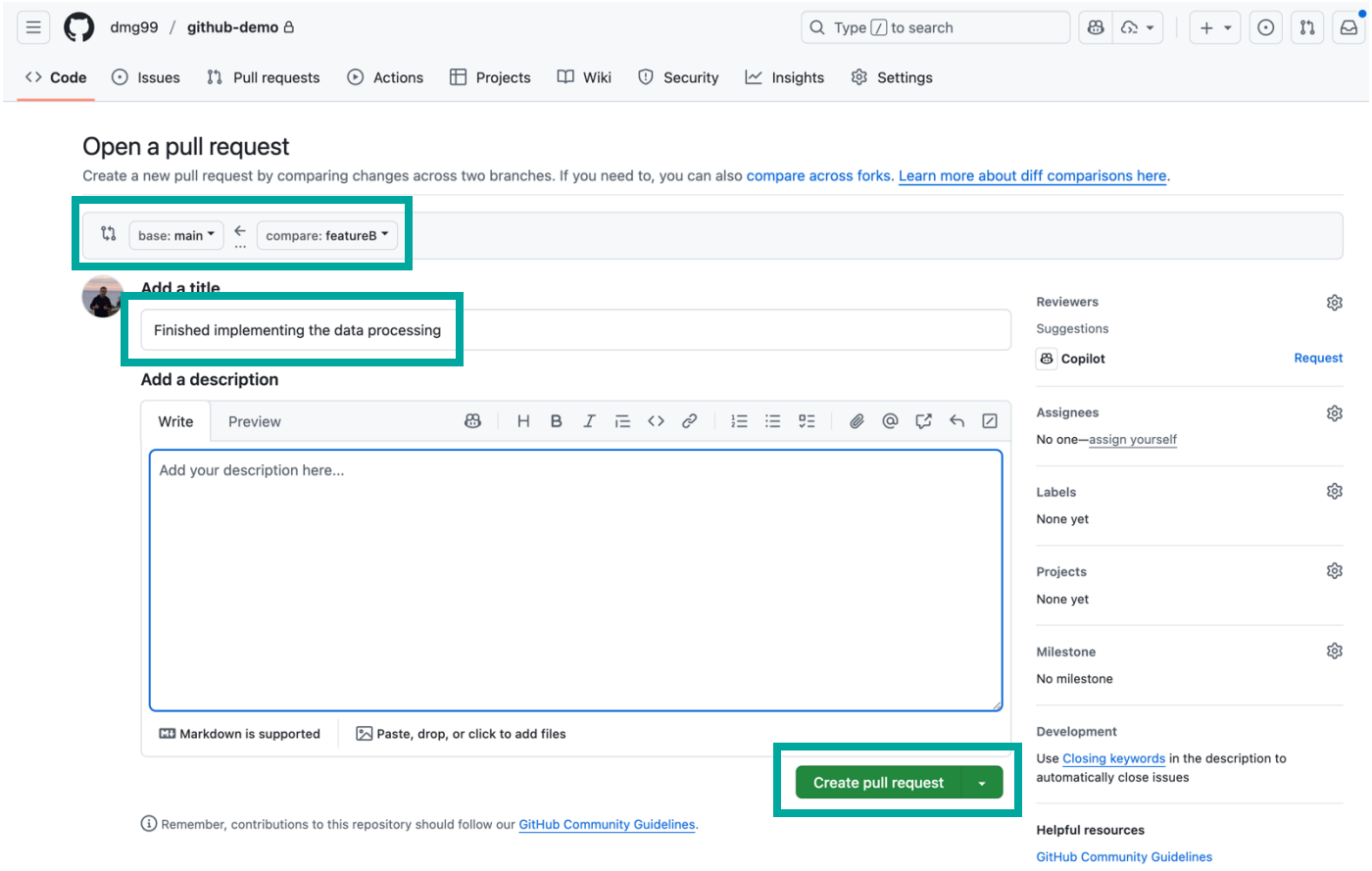
When you are **done working on a branch** (e.g featureA branch) and you want to **merge it to main**, the best way is to **create a pull request** on GitHub.



Merging branches – Pull requests



Merging branches – Pull requests



Merging branches – Pull requests

dmg99 / github-demo

Type / to search

Code | Issues | Pull requests 1 | Actions | Projects | Wiki | Security | Insights | Settings

Finished implementing the data processing #1

Edit | Code

Open dmg99 wants to merge 3 commits into `main` from `featureB`

Conversation 0 | Commits 3 | Checks 0 | Files changed 2 +3 −1

dmg99 commented now

No description provided.

dmg99 added 3 commits 3 hours ago

- `made function to process files` 79adce2
- `updated README` 1f87b1f
- `updated process file function` 5d2731c

No conflicts with base branch
Merging can be performed automatically.

Merge pull request | You can also merge this with the command line. View command line instructions.

Add a comment

Write | Preview

Reviewers
Suggestions
Copilot Request
Still in progress? Convert to draft

Assignees
No one—assign yourself

Labels
None yet

Projects
None yet

Milestone
No milestone

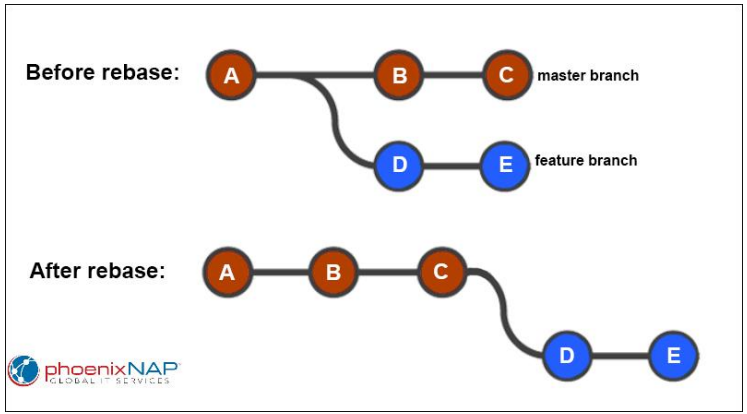
Development
Successfully merging this pull request may close these issues.
None yet

git rebase

If you have two **local** branches and you want to rebase one onto another, you can use "`git rebase`".

For example, if I am working on `featureB` branch and I want to update it with some changes made to `main`, I can run:

```
~/Desktop/github-demo  featureB  git rebase main featureB
Successfully rebased and updated refs/heads/featureB.
```



This would "rebase featureB onto main".

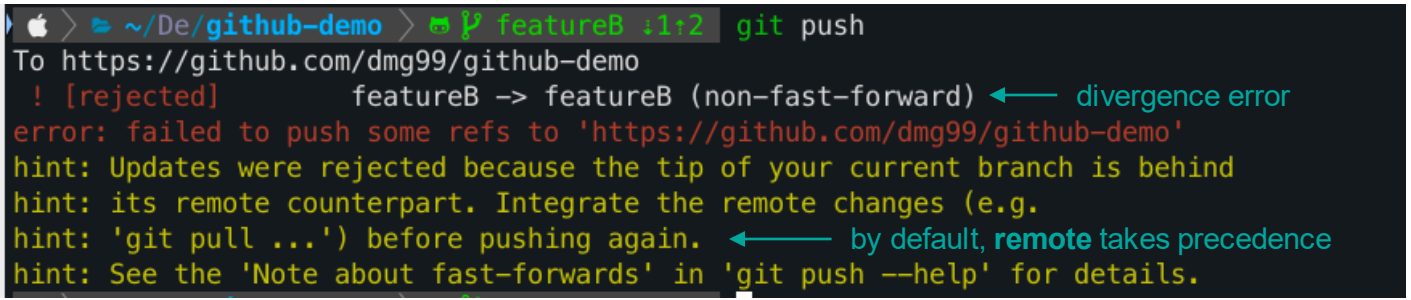
https://phoenixnap.com/kb/git-rebase-vs-merge

git push --force

In general, you should **never** have to use this command.

The only case were you should find the need for this is if you have **rebased a local branch** (*e.g.* `featureB`) onto another (*e.g.* `main`) and you wanto to **push this change to the remote `featureB`**.

If you try to push normally, you might get:



git push --force

What the `--force` flag does is **overwriting previous history of the remote chain** (potentially very dangerous!).

If you have **previously rebased** it makes sense to do so, because when rebasing you **have overwritten past commits** in the chain.

```
~/De/github-demo  featureB ↓1↑2  git push --force
Enumerating objects: 11, done.
Counting objects: 100% (11/11), done.
Delta compression using up to 8 threads
Compressing objects: 100% (6/6), done.
Writing objects: 100% (7/7), 686 bytes | 686.00 KiB/s, done.
Total 7 (delta 2), reused 0 (delta 0), pack-reused 0
remote: Resolving deltas: 100% (2/2), completed with 1 local object.
To https://github.com/dmg99/github-demo
 + 5198987...5d2731c featureB -> featureB (forced update)
```

Note: ONLY USE `--force` IN THIS USE CASE.

If you are in another situation and think that `--force` is the solution to your problem, you are probably wrong, ask a TA/SA!

Other useful commands

```
git reset
git restore
.gitignore
```

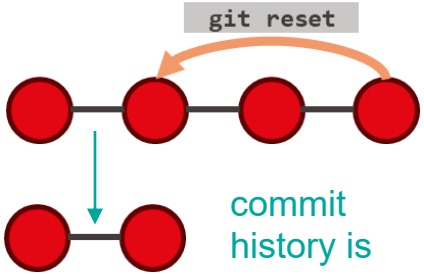
git reset

`git reset` can be used to **go backwards** in the commit chain (**locally!**).

Example 1: remove local changes made to **tracked** files.

```
~/Desktop/github-demo  featureB !1  git status
On branch featureB
Your branch is up to date with 'origin/featureB'.

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")
~/Desktop/github-demo  featureB !1  git reset --hard
HEAD is now at 5d2731c updated process file function
~/Desktop/github-demo  featureB  git status
On branch featureB
Your branch is up to date with 'origin/featureB'.

nothing to commit, working tree clean
```

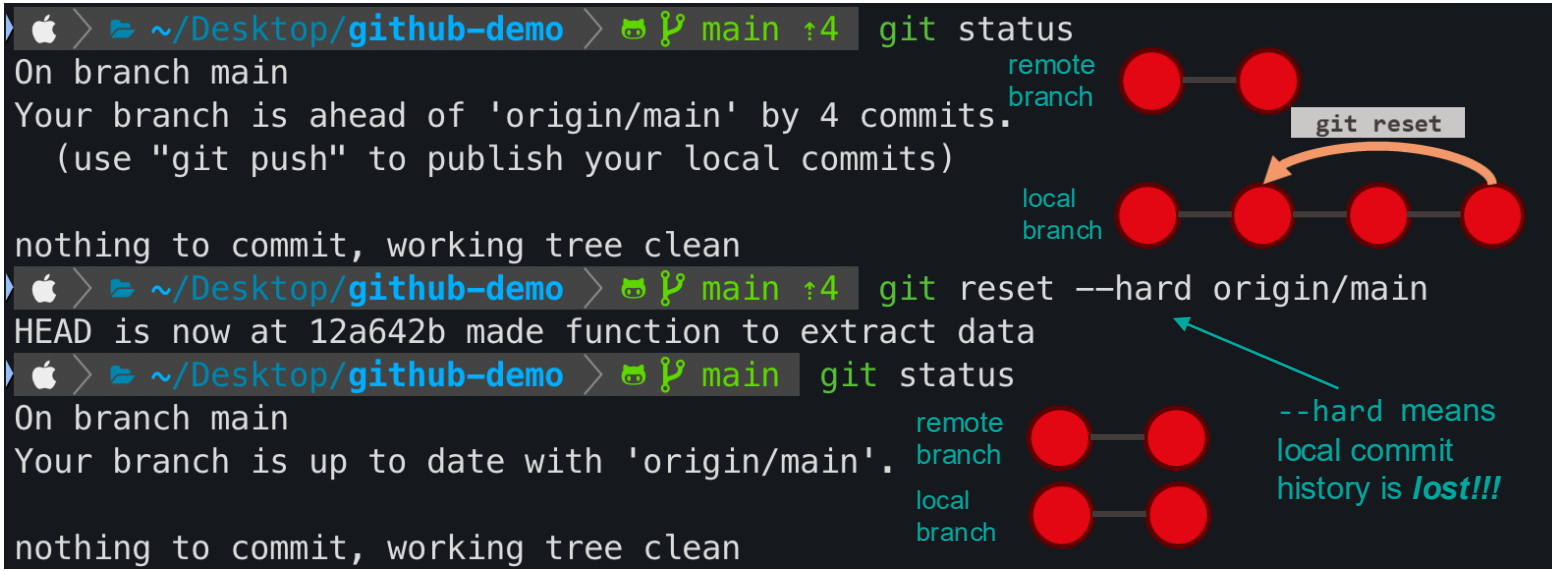
`--hard` means all commit history is ***lost locally!!!***



commit history is ***lost locally!!!***

git reset

Example 2: remove local commit(s) and **reset head to the origin commit**.



Note: be careful with this command. It is suprisingly easy to “get lost” in the chain. ***Moreover the changes are lost for good!***

git reset - advanced

The main flags used with `git reset` are

- Soft (`--soft`): if you have staged changes, it will **keep** them.
- Hard (`--hard`): if you have staged changes, it will **discard** them.
- Mixed (`--mixed`): if you have staged changes, it will **unstage** them but **keep the files**.

Choosing “where” to go can be done as follows:

- **Commit hash:** will go to a specific commit (*e.g.* `git reset 12a642b`)
- **Head of a branch:** *e.g.* `git reset origin/main` will reset to the head of the remote main
- **Backwards by n commits:** you can use “`git reset HEAD~n`”, *e.g.* to go back two commits you can do ”`git reset HEAD~2`”

git log --oneline

Useful to check the **commit history**, good combo with reset.

```
12a642b (HEAD -> main, origin/main, origin/HEAD) made function to extract data
6241bec added main.py function!
9740ded added imports in main.py
848a973 (origin/featureA) Added description to README.md
544708e Initializing repo with basic files
(END)
```

commit hashes

commit messages

git restore

`git restore` can be used with the staged flagged in case you have **added a file to commit by mistake**. Note: this can be used **before** committing.

```
~/Desktop/github-demo  featureB +1  git status
On branch featureB
Your branch is up to date with 'origin/featureB'.

Changes to be committed:
  (use "git restore --staged <file>..." to unstage)
        new file:   src/extra_file.py

~/Desktop/github-demo  featureB +1  git restore --staged src/extra_file.py
~/Desktop/github-demo  featureB ?1  git status
On branch featureB
Your branch is up to date with 'origin/featureB'.

Untracked files:
  (use "git add <file>..." to include in what will be committed)
        src/extra_file.py

nothing added to commit but untracked files present (use "git add" to track)
```

accidentally added this file to the stage

file is no longer staged but remains in local directory

git stash

This is used ”save apart” **some unstaged/uncommitted changes** so that they can **later be retrieved and committed**. Its use is:

```
 ~/De/github-demo  main !1  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   <-- file is modified but not committed

no changes added to commit (use "git add" and/or "git commit -a")
 ~/Desktop/github-demo  main !1  git stash
Saved working directory and index state WIP on main: 12a642b made function to extract data
 ~/Desktop/github-demo  main *1  git status
On branch main
Your branch is up to date with 'origin/main'.   <-- post stash, no changes are visible

nothing to commit, working tree clean
```

git stash list

Stashes are **similar to commits**, since they contain **changes** and have a specific **ID**. You can list the local stashes by using “`git stash list`”:

```
stash@{0}: WIP on main: 12a642b made function to extract data
(END)
```

git stash pop

Used to **recover the last stash**. Note that it ***could lead to merge conflicts*** if the stash modifies a file already modified in your local branch.

```
~/De/github-demo  main *1  git stash pop
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")
Dropped refs/stash@{0} (3f5394a4f7320ef55f966806a9817c48fc2fad2b)
```

changes are retrieved but still need to be staged (“added”) and committed

Note: this will **bring back the changes** and then **delete** the stash!

Note2: if you have multiple you can choose to “pop” a specific stash with “`git stash pop stash@\{n\}`” where “n” has to be replaced.

.gitignore file

This is a file that you can create in your repo so that git **completely ignores some files** in the repo. It looks something like this:

```
1   # Ignore data outputs
2   *.csv
3   *.tsv
4
5   # Ignore log files
6   *.log
7
8   # Ignore large datasets folder
9   /data/
10
11  # Ignore OS or editor files
12  .DS_Store
13  *.swp
14
```

ignore a pattern

ignore a directory and its contents

can add comments using #

For the specific syntax, go to:

https://git-scm.com/docs/gitignore

This file is usually **created at the beggining of a project** and then **updated when necessary**.