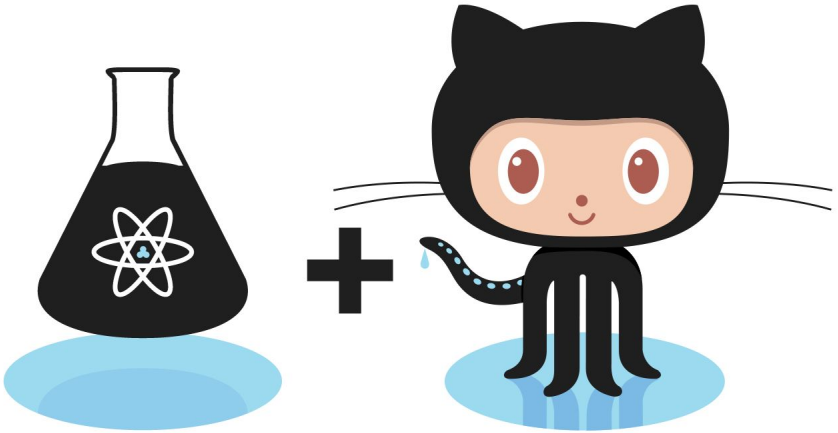
Lukas Snoek
22 Feb 2018

git + GitHub

version control for scientists

Why ‘for scientists’?

- Originally a tool for software developers
- Used (slightly) differently in science

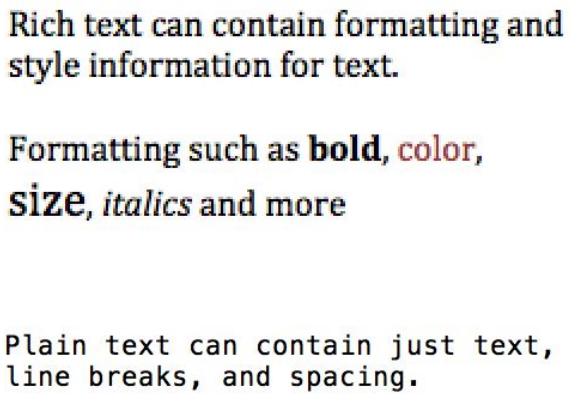


Contents/goals

- What is version control?
- Why version control?
- Git basics/terminology
- Tutorial 1: initialize git repo + connect to Github
- Tutorial 2: collaborating

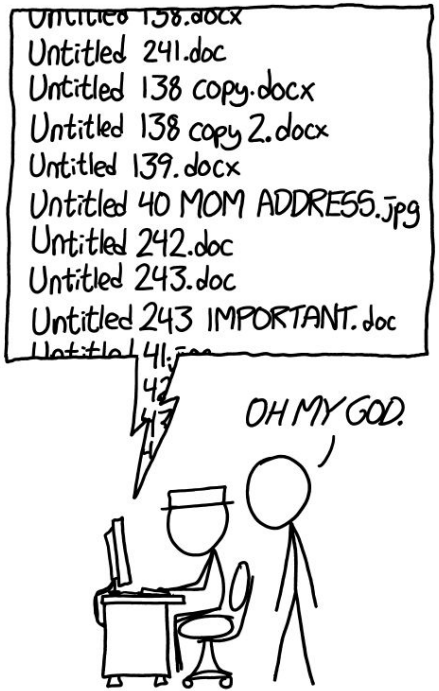
What is version control?

- A way to manage changes to documents
  - Meant for **plain text files**, not data or "rich text" (e.g., Word docx)



What is version control?

- A way to manage changes to documents
- Update versions & revert back to old versions
  - All using the same file, e.g., analysis.m
  - No more analysis_final_version2 _really_final_with_plots_nocomments_ _updated4.m

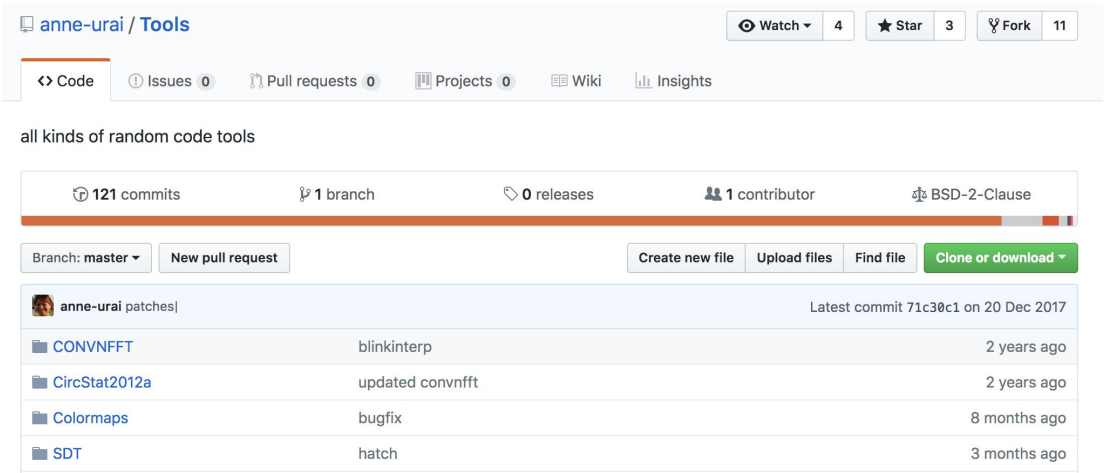


Why version control?

- Avoid versions across files!
- “Relatively” easy to revert to old versions
- Great for collaboration
- A *must* for software development
- Nice way to make your research more transparent, reproducible, and replicable

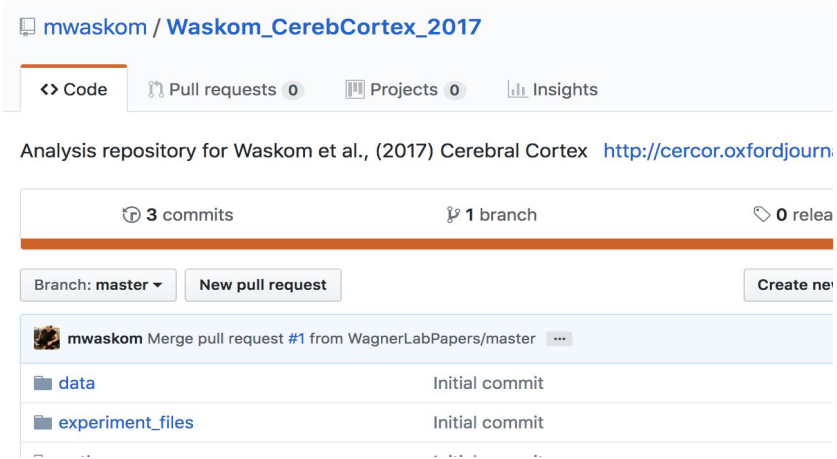
Ways to use it in science

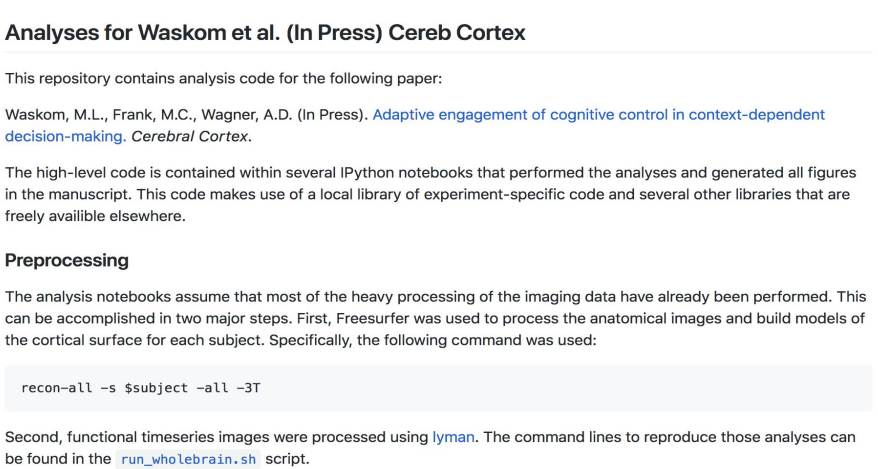
- Storage for your code/tools (cf. Dropbox)
  - Might be useful for others!



Ways to use it in science

- Publish code along with article
  - Transparency, reproducibility, replicability





Analyses for Waskom et al. (In Press) Cereb Cortex

This repository contains analysis code for the following paper:

Waskom, M.L., Frank, M.C., Wagner, A.D. (In Press). Adaptive engagement of cognitive control in context-dependent decision-making. *Cerebral Cortex*.

The high-level code is contained within several IPython notebooks that performed the analyses and generated all figures in the manuscript. This code makes use of a local library of experiment-specific code and several other libraries that are freely availible elsewhere.

Preprocessing

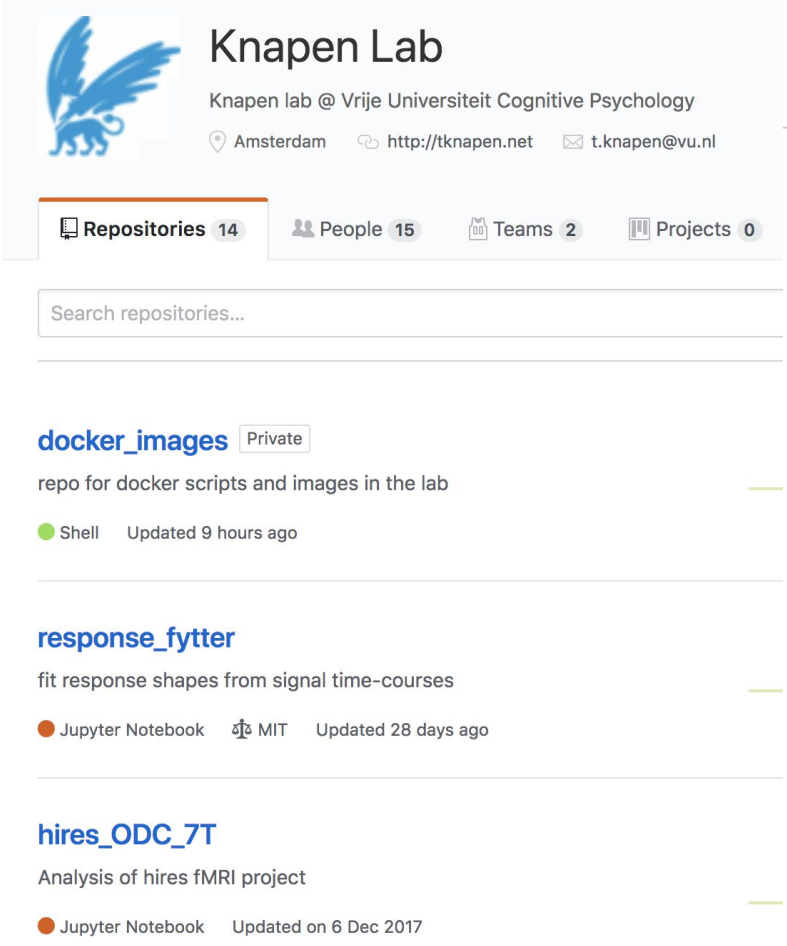
The analysis notebooks assume that most of the heavy processing of the imaging data have already been performed. This can be accomplished in two major steps. First, Freesurfer was used to process the anatomical images and build models of the cortical surface for each subject. Specifically, the following command was used:

```
recon-all -s $subject -all -3T
```

Second, functional timeseries images were processed using lyman. The command lines to reproduce those analyses can be found in the `run_wholebrain.sh` script.

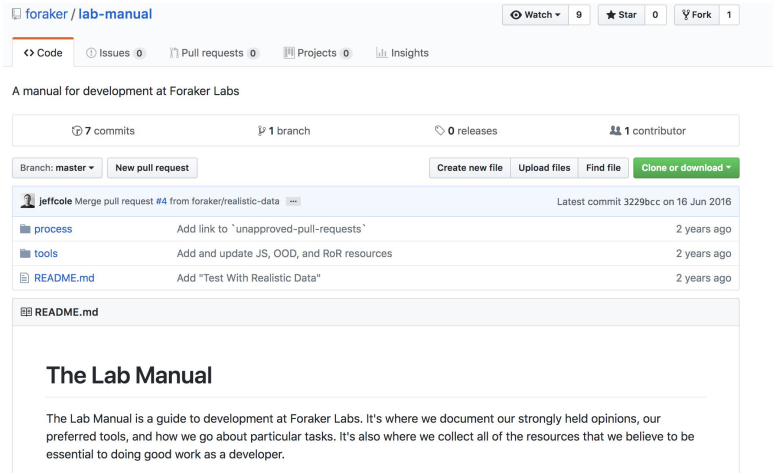
Ways to use it in science

- Storage for lab's code
  - Common tools (code)
  - Publications
  - Guidelines



Ways to use it in science

- Storage for lab's code
  - Common tools (code)
  - Publications
  - Guidelines



Git(hub) basics

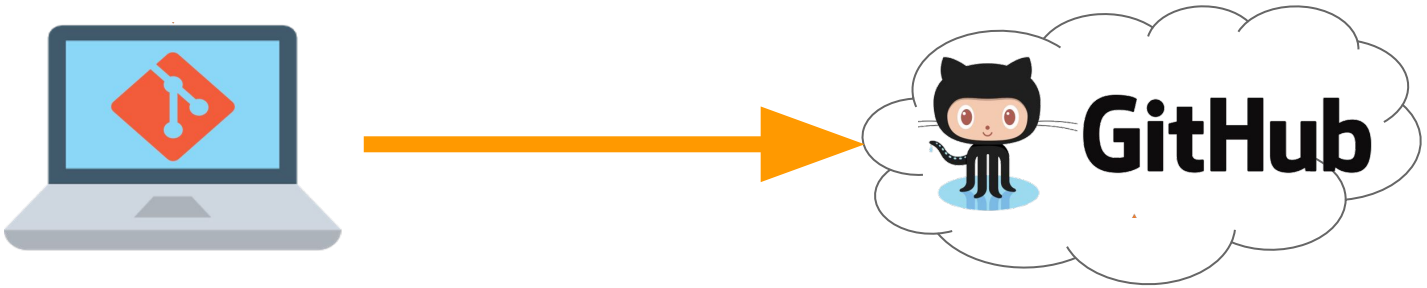
Git vs. Github

- Git is a version control **system** (software)
- Github is a place to **host** your projects that use git

Git vs. Github

In other words ...

- Git is software (used **locally**), while Github is "**hosting service**" (a "remote" service)
  - Github ≈ Dropbox (for code)



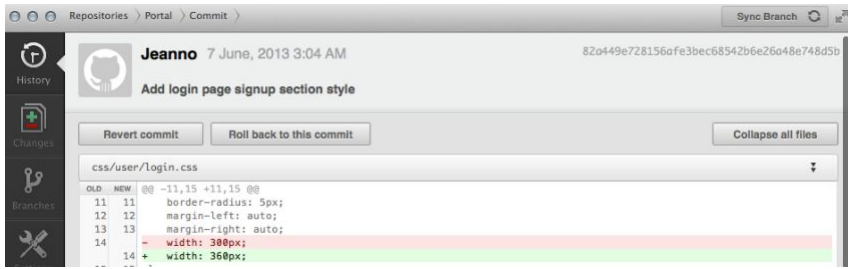
Git CLI

- Git is **software**
  - Nerd fun fact: developed by Linus Torvalds (creator of Linux!)
- Here, explained from its **command line interface**

```
lukas@Lukass-MacBook-Pro: ~
$ git
usage: git [--version] [--help] [-C <path>] [-c name=value]
           [--exec-path[=<path>]] [--html-path] [--man-path] [--info-path]
           [-p | --paginate | --no-pager] [--no-replace-objects] [--bare]
           [--git-dir=<path>] [--work-tree=<path>] [--namespace=<name>]
           <command> [<args>]
```

Git CLI

- Git is **software**
  - Nerd fun fact: developed by Linus Torvalds (creator of Linux!)
- Here, explained from its **command line interface**
- (You also have a Github GUI!)

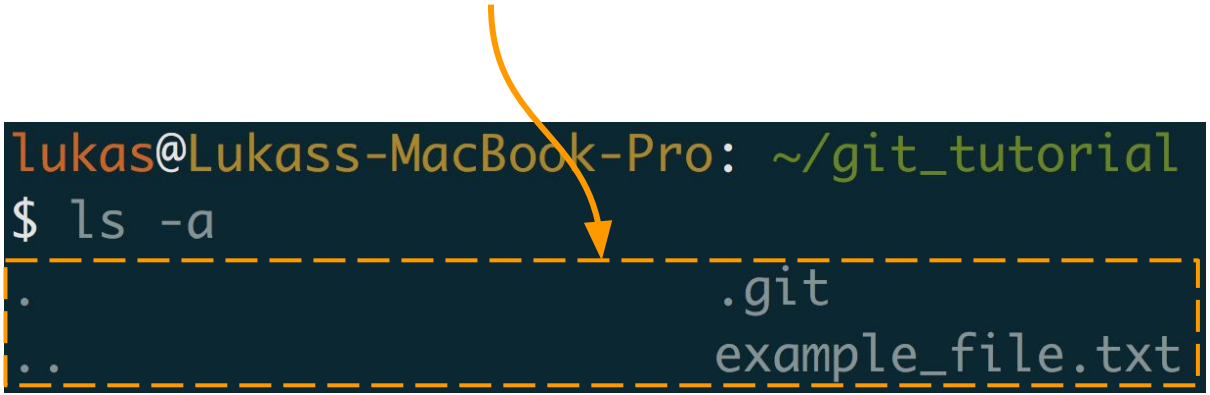


Git repositories

- Git works with "**repositories**"
  - A hidden folder called ".git"

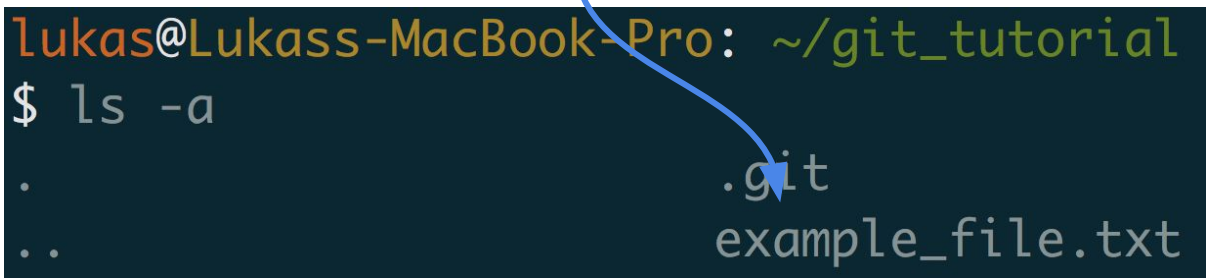
Git repositories

- Git works with “**repositories**”
- The folder containing the “.git” directory is called the **working directory**



Git repositories

- Git works with “**repositories**”
- The folder containing the “.git” directory is called the **working directory**
  - Git will keep track of **any file** in the working directory



Ready to go?

- Git installed?
- Do you have a Github account?

Tutorial 1: Git basics

Git repositories

- To create a .git directory (and thus create a “repo”) ...
  - Navigate to the folder you want to place under git control (best to create a new, empty one)
  - Type: `git init`

```
lukas@Lukass-MacBook-Pro: ~
$ mkdir git_tutorial
lukas@Lukass-MacBook-Pro: ~
$ cd git_tutorial/
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git init
Initialized empty Git repository in /Users/lukas/git_tutorial/.git/
```

Git repositories

- Now, we can use other `git` commands
- The most important one: `git status`

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git status
On branch master

No commits yet

nothing to commit (create/copy files and use "git add" to track)
```

Git repositories

- Now, add a file (e.g., a new MATLAB file, text-file, markdown file ...)

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ cat normalize.py
import numpy as np

def demean(arr):
    """Demeans an array (i.e., subtracts the mean
    from each value in the array)."""

    arr_demeaned = arr - np.mean(arr)
    return arr_demeaned
```

Git repositories

- Now, add a file (e.g., a new MATLAB file, text-file, markdown file ...)
- Run `git status` again!

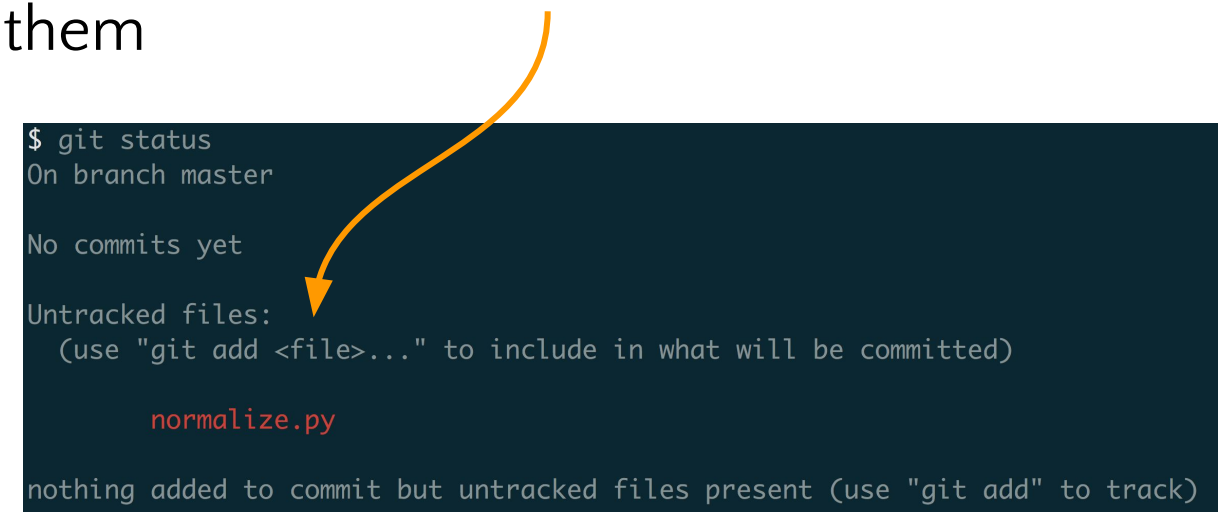
```
$ git status
On branch master

No commits yet

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

        normalize.py

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

Git commits

- Git's major functionality is to create "checkpoints"/"snapshots", which are called **commits** in git terminology
- These commits reflect "versions" of your code

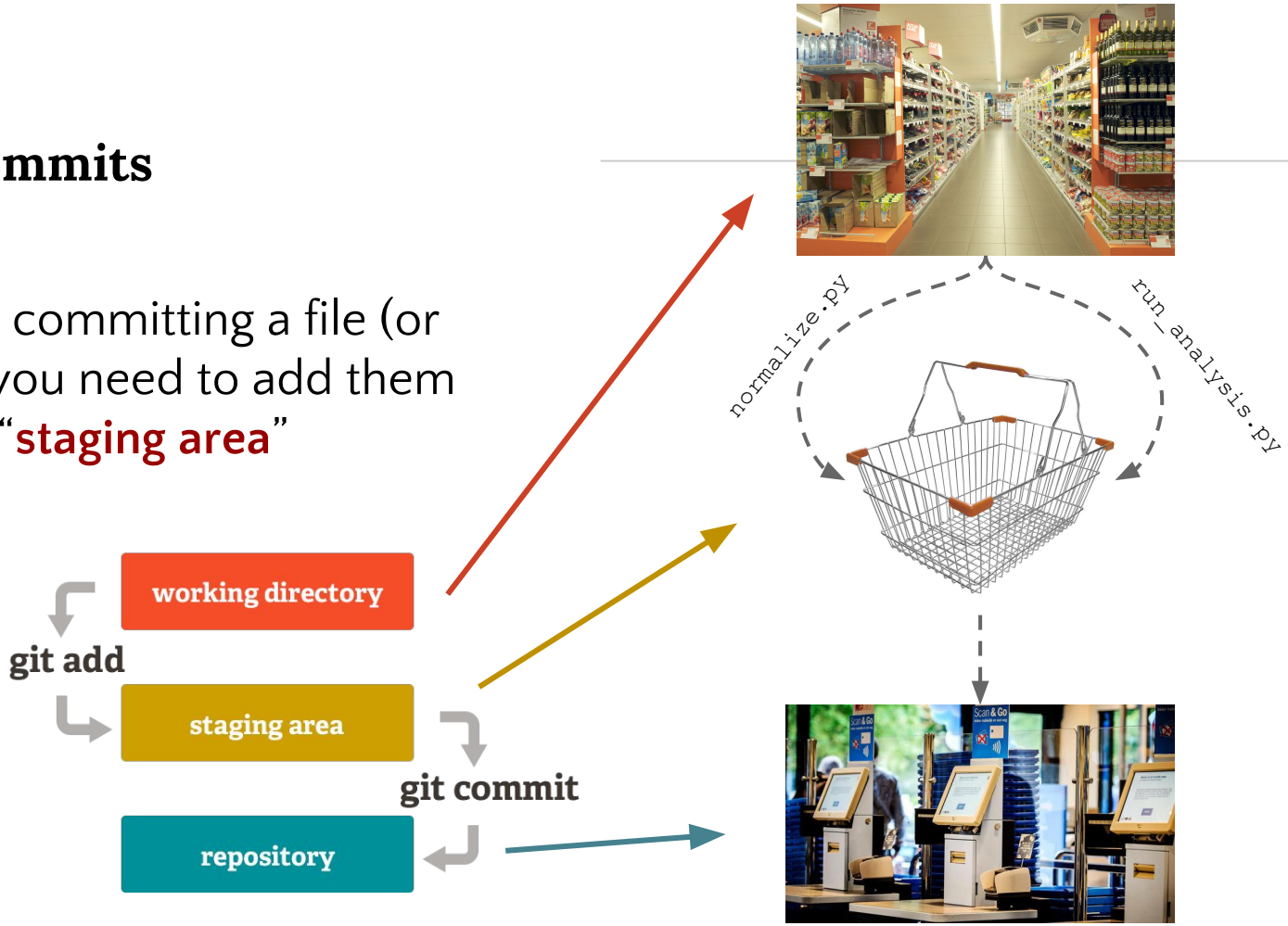
Git add & git commit

- Git tells us to *first* `add` files before `committing` them



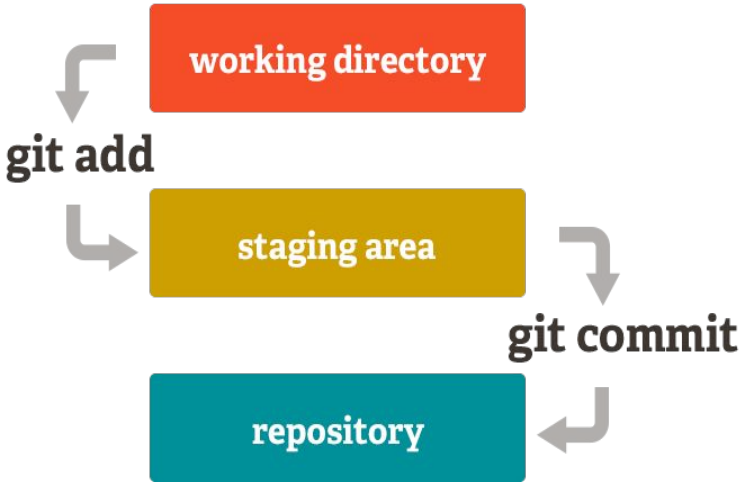
Git commits

Before committing a file (or files), you need to add them to the "**staging area**"



Git commits

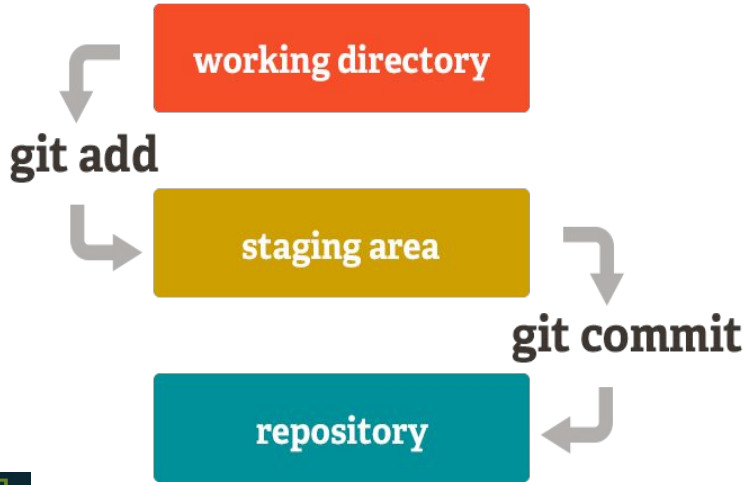
- Importantly, *one* commit may contain *multiple* files!
- A commit should reflect a coherent “change”
- For example websites: an update is usually reflected as a change in two files (.html + .css)



Git commits

- Often, though, a commit contains one file
- Let's try it! We'll add normalize.py (or your own file) to the staging area:

```
git add {your_file}
```

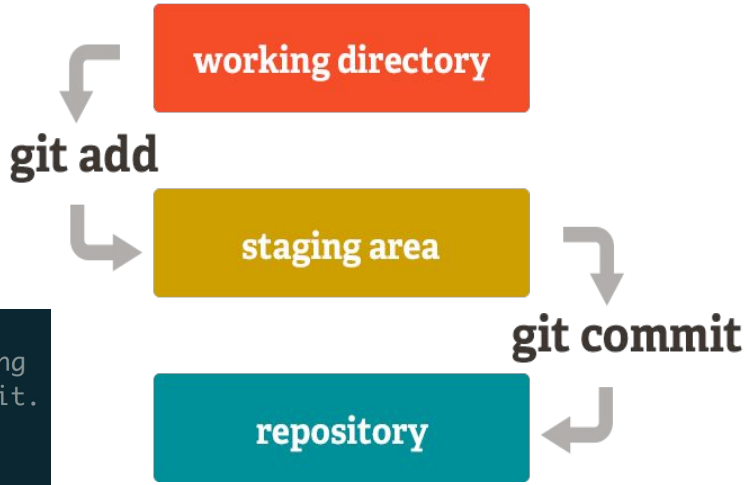



```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git add normalize.py
```

Git commits

- Now, to *commit* your file(s), type: `git commit`
- This will open your system's default editor to add a "commit message"

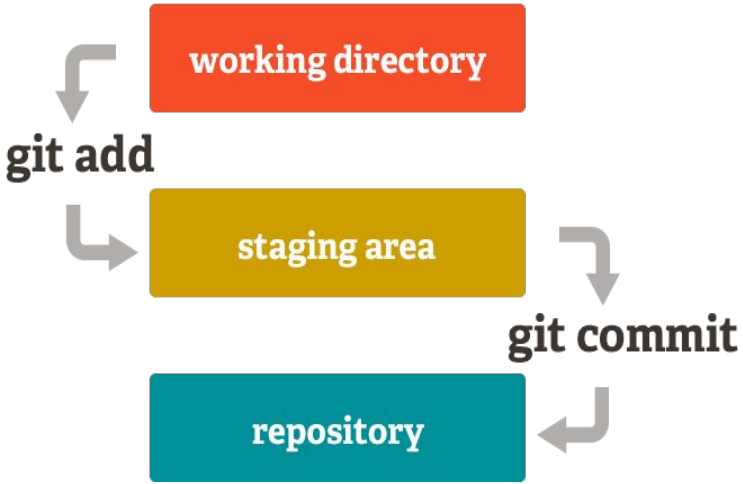
```
Initial commit
# Please enter the commit message for your changes. Lines starting
# with '#' will be ignored, and an empty message aborts the commit.
#
# On branch master
# Changes to be committed:
#       modified:   normalize.py
#
```



Git commits

- Use `git commit -m "Your commit message"` as a shortcut

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git commit -m "Initial commit"
[master 8fd4baf] Initial commit
 1 file changed, 9 insertions(+)
 create mode 100644 normalize.py
```

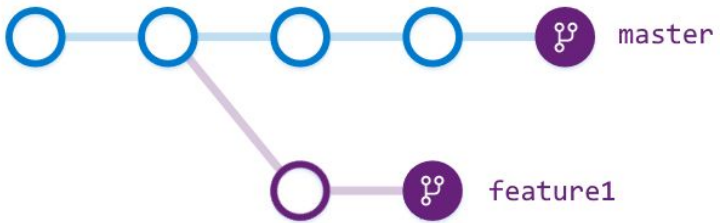


Git branches

- Suppose you want to **change** something about your code …
  - E.g. new functionality/feature
  - Complete rewrite/restructure (“refactor”)
- … but you want to keep a **working version** of the original file
  - For example, because others depend on it

Git branches

- Git supports this by “branches”
  - “Copies” of the original branch (the **master** branch)
- You can switch ‘versions’ by switching branches



Git branches

- Let's check this out. Type `git branch` to get the name of the current branch you're on

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git branch
* master
```

Git branches

- To create a new branch, type:

```
git branch {name_of_new_branch}
```

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git branch new_branch
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git branch
* master
  new_branch
```

Git branches

- Importantly, you're not actually switched to the new branch after calling

  ```
  git branch {name}
  ```

- To switch to (or to "check out") your new branch, call:

  ```
  git checkout {name}
  ```

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git checkout new_branch
Switched to branch 'new_branch'
```

Git branches

- A shortcut to create and immediately check out a new branch, call:

```
git checkout -b {new_branch_name}
```

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git checkout -b new_branch
Switched to a new branch 'new_branch'
```

Git branches

- Example: I want to extend my demean function to operate on 2D arrays
- I'll create a branch named `vectorize`
- (But feel free to use your own example!)

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git checkout -b vectorize
Switched to a new branch 'vectorize'
```

Git branches

- After implementing this feature, the file looks like this:

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ cat normalize.py
import numpy as np

def demean(arr, dim):
    """Demeans an array (i.e., subtracts the mean
    from each value) for across rows (dim=0)
    or columns (dim=1)."""

    arr_demeaned = arr - np.mean(arr, axis=dim, keepdims=True)
    return arr_demeaned
```

Git branches

- Now, let's commit this change

```
git add normalize.py
git commit normalize.py -m “Extend to 2D arrays”
```

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git add normalize.py
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git commit normalize.py -m "Extend to 2D arrays"
[vectorize 37a6b80] Extend to 2D arrays
 1 file changed, 4 insertions(+), 3 deletions(-)
```

Git diff

- Want to know exactly how your files differ across branches?

  Use `git diff`!

```
git diff <ref branch> <current branch>
```

```
$ git diff master vectorize
diff --git a/normalize.py b/normalize.py
index 8c4c335..2c8df97 100644
--- a/normalize.py
+++ b/normalize.py
@@ -1,9 +1,10 @@
 import numpy as np

-def demean(arr):
+def demean(arr, dim):
     """Demeans an array (i.e., subtracts the mean
-    from each value in the array)."""
+    from each value) for across rows (dim=0)
+    or columns (dim=1)."""

-    arr_demeaned = arr - np.mean(arr)
+    arr_demeaned = arr - np.mean(arr, axis=dim, keepdims=True)
     return arr_demeaned
```

Git branches

- Alright, let's switch back to our `master` branch:

  ```
  git checkout master
  ```

- And verify that it contains the original file!

Git branches

Check out the file on your file system:

the file itself is really different!

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git checkout master
Switched to branch 'master'
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ cat normalize.py
import numpy as np

def demean(arr):
    """Demeans an array (i.e., subtracts the mean
    from each value in the array)."""

    arr_demeaned = arr - np.mean(arr)
    return arr_demeaned
```

Git merge

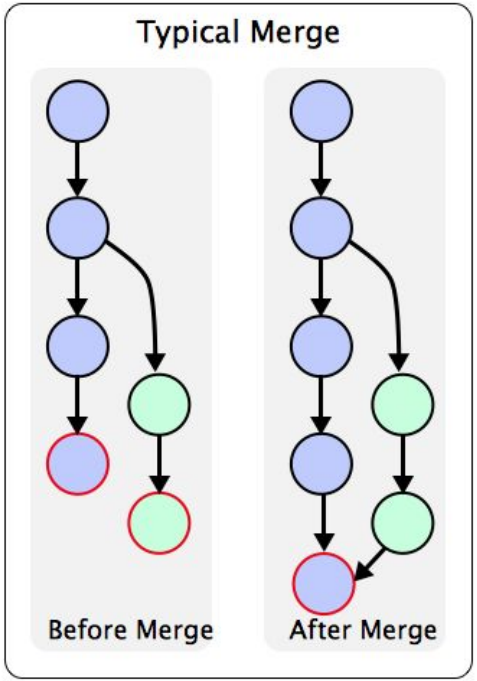
- Suppose we're happy with our new feature on our `vectorize` branch – how do we get it back in our `master` branch?
- `git merge`!
  - Smart merging of the same file across branches

Git merge

- To merge a branch:

```
git merge {branche_to_merge_in}
```

- Importantly, you do this *from the reference branch* (usually `master`)

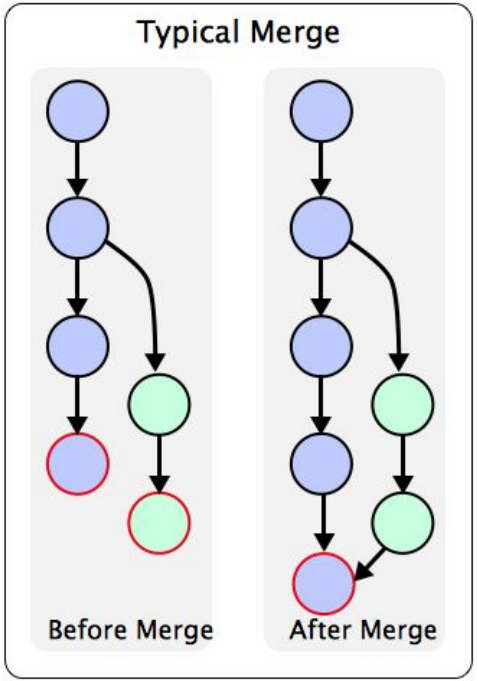


Git merge

- Example:

```
git checkout master
git merge vectorize
```

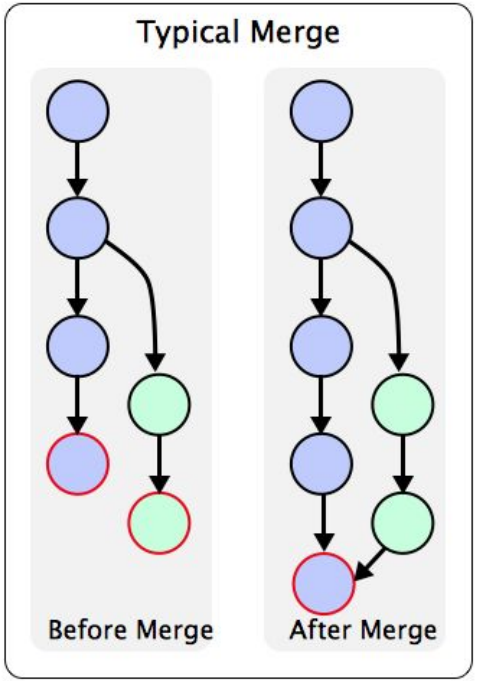
```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git checkout master
Switched to branch 'master'
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git merge vectorize
Updating 8fd4baf..37a6b80
Fast-forward
 normalize.py | 7 ++++---
 1 file changed, 4 insertions(+), 3 deletions(-)
```



Git merge

- It worked!

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git branch
* master
  vectorize
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ cat normalize.py
import numpy as np

def demean(arr, dim):
    """Demeans an array (i.e., subtracts the mean
    from each value) for across rows (dim=0)
    or columns (dim=1)."""

    arr_demeaned = arr - np.mean(arr, axis=dim, keepdims=True)
    return arr_demeaned
```



Adding a remote

- So far, we've only worked **locally** with git
- Usually, we want to "sync" it to a **remote**
- A "remote" can be any (web)server/host!
  - I'll show how to use **Github**, but other host services exist (Gitlab, Bitbucket)
  - Even an (SSH-accessible) **server** would work, like the TUX-servers at the UvA, or your home PC

Adding a remote

- Note that Github is a commercial service!
  - But free for academic use (i.e., if you have a @uva or any other academic email address)

Github

- Apply for a free academic account!
- Link

Applying for a free Developer plan for your personal account

1. Go to GitHub's Education page and click **Request a discount**.

2. Select **Researcher**.

3. To apply this discount to your personal account, select **Individual account** and click **Next**.

4. Type your name.

5. Verify your academic status.
   - If you have a school-issued email address, use the drop-down menu and click the desired email address.
   - If you don't have a school-issued email-address, use the drop-down menu and click **I don't have a school-issued email address**. Next, upload an image of your school or faculty ID, employment verification letter, academic transcript, or other proof of affiliation that shows at least one date to prove your current academic status.

6. Enter the school name.

7. Describe how you plan to use GitHub in your research group.

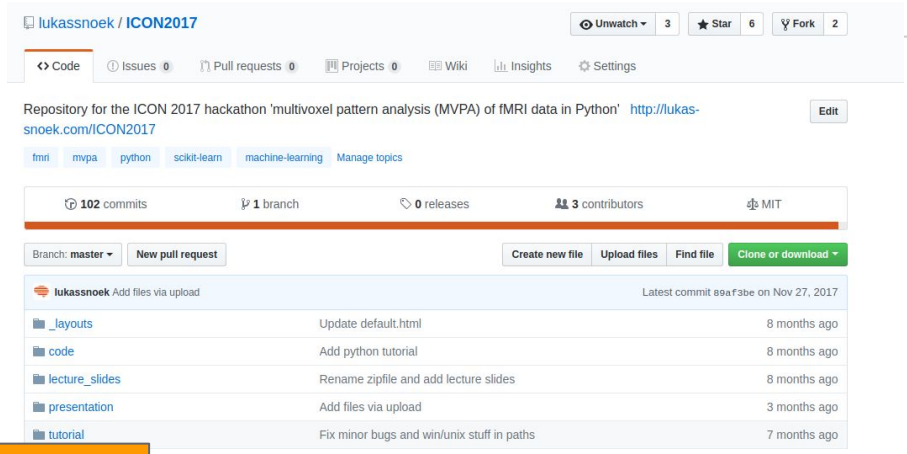
8. Verify your application details, then click **Submit Request**.

If your application is approved, you'll receive a confirmation email. Applications are usually processed within a few days, but it may take longer during peak times, such as during the start of a new semester.

Adding a remote

- Note that Github is a commercial service!
  - But free for academic use (i.e., if you have a @uva or any other academic email address)
- I use it because it offers all kinds of cool features/integrations
  - Automatic testing and documentation generation
  - Create and host websites with a single click

Adding a remote



Hi there!

This is the website for the **multivoxel pattern analysis (MVPA) of fMRI data in Python** workshop which was originally given at ICON 2017. The materials and data will remain online so that everyone who's interested can follow the workshop. Also, all the material is *fully open-source*, so feel free the re-use and modify this workshop's materials to fit your own educational activities! If you find mistakes or have suggestions for improvements of this workshop, please let me know by email (see Github) or, even better, submit a "Pull Request" (PR) to this workshop's Github repository - this is greatly appreciated! That said, on this website, you'll find some general info about the workshop, how to prepare for it (in terms of Python prerequisites and environment), and the slides/notebooks/data that will be used during the workshop.

Also, check out the slides from the introductory lecture below:

Hi there!

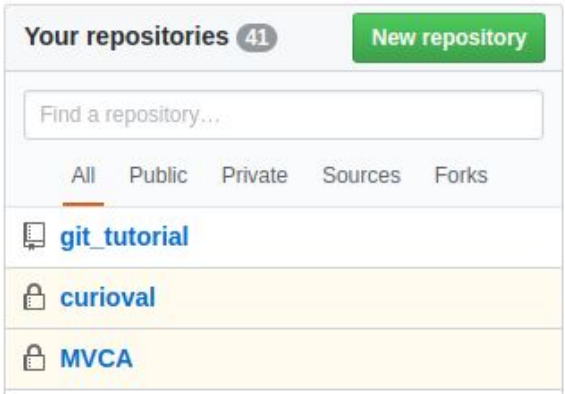
This is the website for the **multivoxel pattern analysis (MVPA) of fMRI data in Python** workshop which was originally given at ICON 2017. The materials and data will remain online so that everyone who's interested can follow the workshop. Also, all the material is *fully open-source*, so feel free the re-use and modify this workshop's materials to fit your own educational activities! If you find mistakes or have suggestions for improvements of this workshop, please let me know by email (see Github) or, even better, submit a "Pull Request" (PR) to this workshop's Github repository - this is greatly appreciated! That said, on this website, you'll find some general info about the workshop, how to prepare for it (in terms of Python prerequisites and environment), and the slides/notebooks/data that will be used during the workshop.

Also, check out the slides from the introductory lecture below:

<style> .responsive-wrap iframe{ max-width: 100%;} </style>
<iframe src="https://docs.google.com/presentation/d/1bgK1sv-VmnvAR_HgTiWsU0vQkyjz6oO1zQ5ly4laPkw/embed?start=false&loop=false&delayms=3000" frameborder="0" width="900" height="569" allowfullscreen="true" mozallowfullscreen="true" webkitallowfullscreen="true"></iframe>

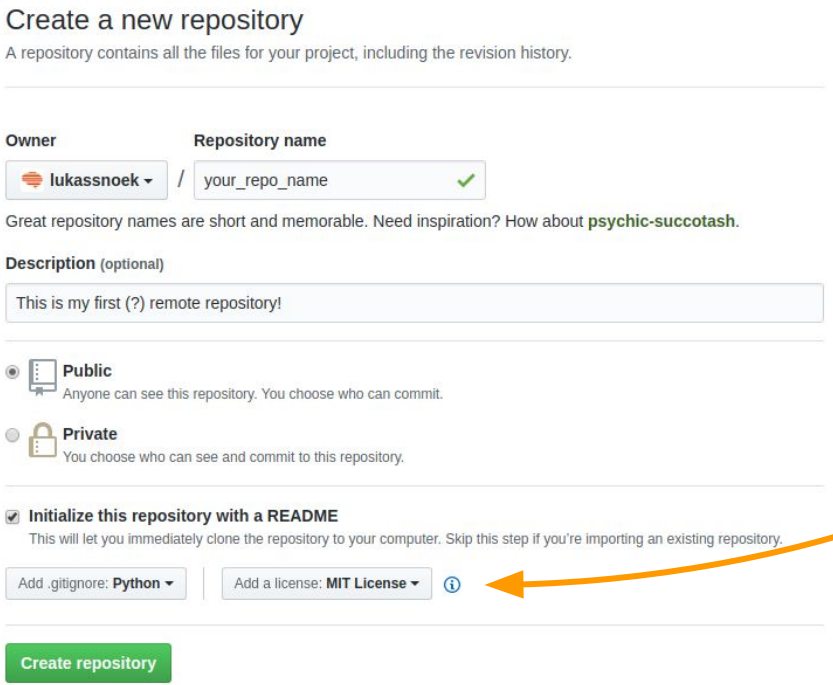
Adding a remote

- To add a “remote” to our local git repo, we need to create one first!
- Go to Github and click “New repository”



Adding a remote

A .gitignore is a “config file” in which you can indicate which files git should ignore (e.g. *.mat files)



A license indicates if (and to what extent) people can re(use) and modify your code

Adding a remote

- Now, we have a **local repository** (on your laptop) and a **remote repository** (on Github)
- We link them using the command:

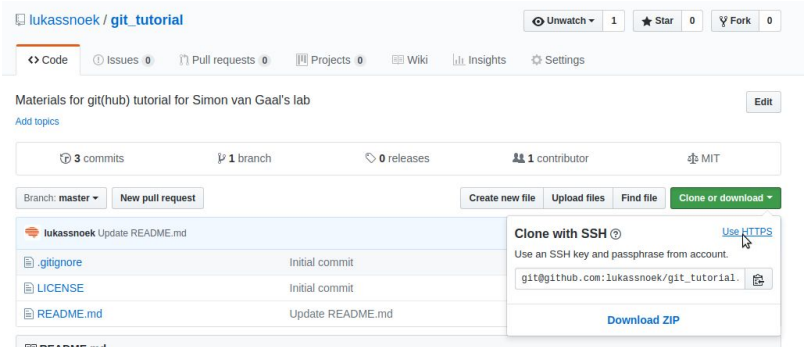
```
git remote add
```

```
usage: git remote add [<options>] <name> <url>

    -f, --fetch           fetch the remote branches
    --tags                import all tags and associated objects when fetching
                          or do not fetch any tag at all (--no-tags)
    -t, --track <branch>  branch(es) to track
    -m, --master <branch>
                          master branch
    --mirror[=<push|fetch>]
                          set up remote as a mirror to push to or fetch from
```

```
usage: git remote add [<options>] <name> <url>

    -f, --fetch           fetch the remote branches
    --tags                import all tags and associated objects when fetching
                          or do not fetch any tag at all (--no-tags)
```

Adding a remote

- It's common practice to name your remote "origin"
- To get the url of your remote, click the "Clone or download" button
- You can download the material using SSH-authentication or via HTTPS



```
usage: git remote add [<options>] <name> <url>

    -f, --fetch           fetch the remote branches
    --tags                import all tags and associated objects when fetching
                          or do not fetch any tag at all (--no-tags)
```

Adding a remote

- Copy the link (either SSH or HTTPS-based) and call:

```
git remote add origin git@github.com:lukassnoek/git_tutorial.git
```

Prints out the currently connected remote

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git remote add origin git@github.com:lukassnoek/git_tutorial.git
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git remote -v
origin  git@github.com:lukassnoek/git_tutorial.git (fetch)
origin  git@github.com:lukassnoek/git_tutorial.git (push)
```

Syncing a local repo & remote

- Now, we can push our local repository to Github using the command:

```
git push -u [remote name] [local branch name]
git push -u origin master
```

Syncing a local repo & remote

- But it fails! Why?

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git push -u origin master
To github.com:lukassnoek/git_tutorial.git
 ! [rejected]        master -> master (fetch first)
error: failed to push some refs to 'git@github.com:lukassnoek/git_tutorial.git'
hint: Updates were rejected because the remote contains work that you do
hint: not have locally. This is usually caused by another repository pushing
hint: to the same ref. You may want to first integrate the remote changes
hint: (e.g., 'git pull ...') before pushing again.
hint: See the 'Note about fast-forwards' in 'git push --help' for details.
```

Syncing a local repo & remote

- If the remote contains new/modified files, you need to `pull` the remote first:
  - `git pull [remote name] [remote branch name] --allow-unrelated-histories`
  - `git pull origin master --allow-unrelated-histories`
- The `git pull` will trigger a `merge` between the remote files and the local files

Syncing a local repo & remote

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git pull origin master --allow-unrelated-histories
```

```
Merge branch 'master' of github.com:lukassnoek/git_tutorial

# Please enter a commit message to explain why this merge is necessary,
# especially if it merges an updated upstream into a topic branch.
#
# Lines startir                                                    ge aborts
# the commit.
```

```
From github.com:lukassnoek/git_tutorial
 * branch            master     -> FETCH_HEAD
Merge made by the 'recursive' strategy.
 .gitignore | 101 ++++++++++++++++++++++++++++++++++++++++++++++++++++
 LICENSE    |  21 +++++++++++++++
 README.md  |   5 ++++
 3 files changed, 127 insertions(+)
 create mode 100644 .gitignore
 create mode 100644 LICENSE
 create mode 100644 README.md
```

Syncing a local repo & remote

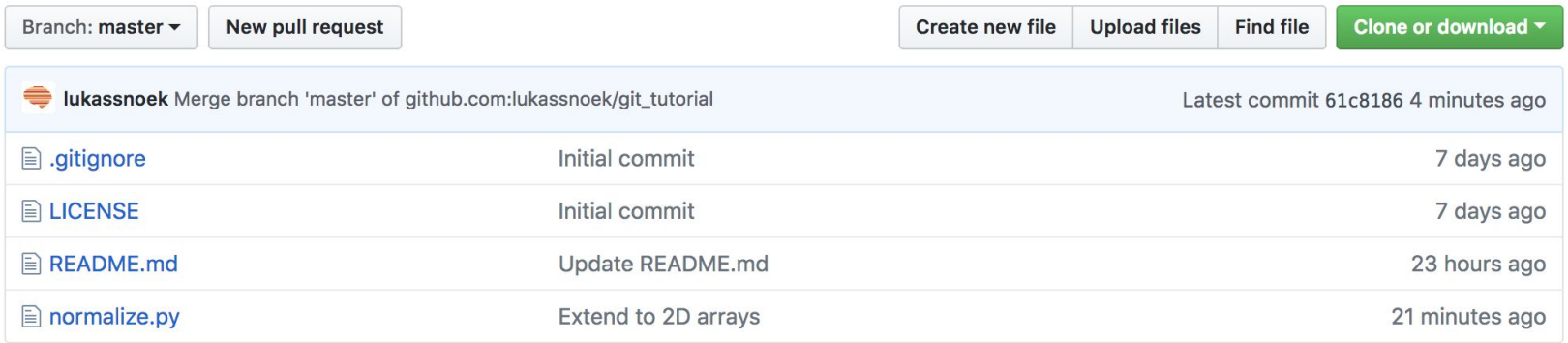
- Now, we're really ready to push to our remote:

```
git push -u origin master
```

```
lukas@Lukass-MacBook-Pro: ~/git_tutorial
$ git push -u origin master
Counting objects: 14, done.
Delta compression using up to 4 threads.
Compressing objects: 100% (10/10), done.
Writing objects: 100% (14/14), 1.37 KiB | 704.00 KiB/s, done.
Total 14 (delta 4), reused 0 (delta 0)
remote: Resolving deltas: 100% (4/4), completed with 1 local object.
To github.com:lukassnoek/git_tutorial.git
   2d2f11d..61c8186  master -> master
Branch master set up to track remote branch master from origin.
```

Syncing a local repo & remote

- Check out your Github repo! Are your new files/changes there?



Initializing a git repo

- An **alternative** (better) **method** to initializing a git repo:
  - *first* create a remote (Github) repo
  - “Clone” (fancy word for download) your remote repo to your laptop:

```
git clone git@github.com:lukassnoek/git_tutorial.git
```

Initializing a git repo

- Best when you have no local files to start with (e.g., completely new projects)
- Avoids the ‘unrelated histories’ error in `git push`

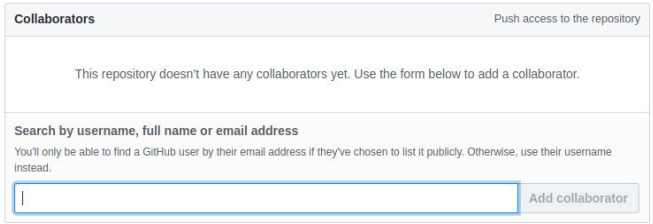
Questions?

Questions so far?

Tutorial 2: collaborating

Collaborating

- Pair up with someone else!
- Pick one repo to work on together
- The owner of the repo adds the other person to the repo as collaborator
  - Settings → Collaborators



Collaborating

- Exercise:
  - The collaborator (i.e., not owner) clones the repo to his/her laptop: `git clone <owner's repo url>`
  - Make a new branch (`git branch <new name>`) and switch to branch
  - Modify/add stuff; commit changes
  - Push branch to remote (`git push -u origin <new name>`)
  - Owner pulls new branch (`git pull -u origin <new name>`)
  - Owner merges new branch into master (`git merge <new name>`)

Don't forget ...

- Git is *hard*

Katie Cunningham @kcunning · Feb 16
I am an experienced developer.

I am also googling "How to roll back a git commit" for the millionth time.

234 1.9K 9.2K

Don’t forget …

- Git is *hard*
- But it is ***useful***
- Takes a while to get used to
  - But a great skill to have (also outside academia!)
- Best way to learn is by *doing* it
- Good luck!