

Data Analysis using R

Version Control

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16.09.2024

Introduction

- Data analysis projects are typically conducted by a team of analysts
- Through team work in courses you may be used to storing your group work independently on your PCs and (when a group member finishes a task) send updated files to each other
- Especially when files are often revised, it becomes harder and harder to trace which file reflects the current state of your work
- The larger the group, the more work this kind of workflow means for each group member
- Version control systems such as Git help trace changes made to your files

What is Git?

Git is a version control system used in particular in software development to **trace changes to the source code**. This way of working has been adopted by scientists in order to keep track of the countless changes to the multitude of files that exist within a project.

- Manages the evolution of a set of files in a so-called **repository** (or "repo")
- Data analysis projects are made up of a many files (data, scripts, figures, reports, ...)
 - Often subject to incremental changes
 - Using Git allows to track changes (and in the worst case undo mistakes like accidentally deleting a file)
- Allows for distributed development
 - Each collaborator has a local copy of the repository
 - Able to develop locally without an internet connection



Greatly simplifies collaboration within projects and communication of results and source code!

Installing Git

Step 1: Register a GitHub Account

- Register a free GitHub account on <https://github.com/>
- Remarks on your username (in case you want to use your GitHub account for e. g. your resume):
 1. Use some variant of your actual name
 2. Do not include your current organization/employer
 3. Keep it short
 4. Use lower case only
 5. Use a hyphen – for word separation

Step 2a: Install Git for Windows

- Git for Windows (msysgit or "Git Bash") can be downloaded from <https://gitforwindows.org/>
 - Contains Git and other useful tools such as the Bash shell
- Install Git
 - When asked about "Adjusting your PATH environment", select "Git from the command line and also from 3rd-party software"
 - Otherwise accept the defaults

Step 2b: Install Git for macOS

Option 1

- Install Xcode command line tools
- Go to the shell and enter one of these commands to elicit an offer to install developer command line tools:

```
git --version  
git config
```

- Accept the offer and “Install”

Option 2

Install Git from <http://git-scm.com/downloads>

Step 3: Connect your GitHub account to Git

Start RStudio and connect your previously registered GitHub account to Git using the `usethis` package:

```
# If you do not have the package installed, run:  
# install.packages("usethis")  
  
# Replace user name and email with your GitHub user name and the  
# email address you registered your account with!  
  
library(usethis)  
use_git_config(user.name = "YOUR_NAME",  
               user.email = "YOUR_MAIL@ruhr-uni-bochum.de")
```

Step 4: Set up your GitHub credentials

- In order to interact with GitHub (e. g. pull a repository or push some changes), we have to provide credentials
- For communication with the server, we can choose between two protocols, HTTPS and SSH
- For ease of use, we set up our credentials using HTTPS which requires a **personal access token (PAT)**
- We can do this easily in R

Step 4: Set up your GitHub credentials

- Use the `usethis` package to generate a PAT:
- Click "Generate token", copy the generated PAT and store the PAT where you can easily find it
- Next time you are asked for your password, give this PAT

```
usethis::create_github_token()
```

Step 4: Set up your GitHub credentials



You can store your PAT using the `gitcreds` package. `gitcreds_set()` will open a prompt, where you can paste your PAT:

```
gitcreds::gitcreds_set()
```

Creating a New Repository

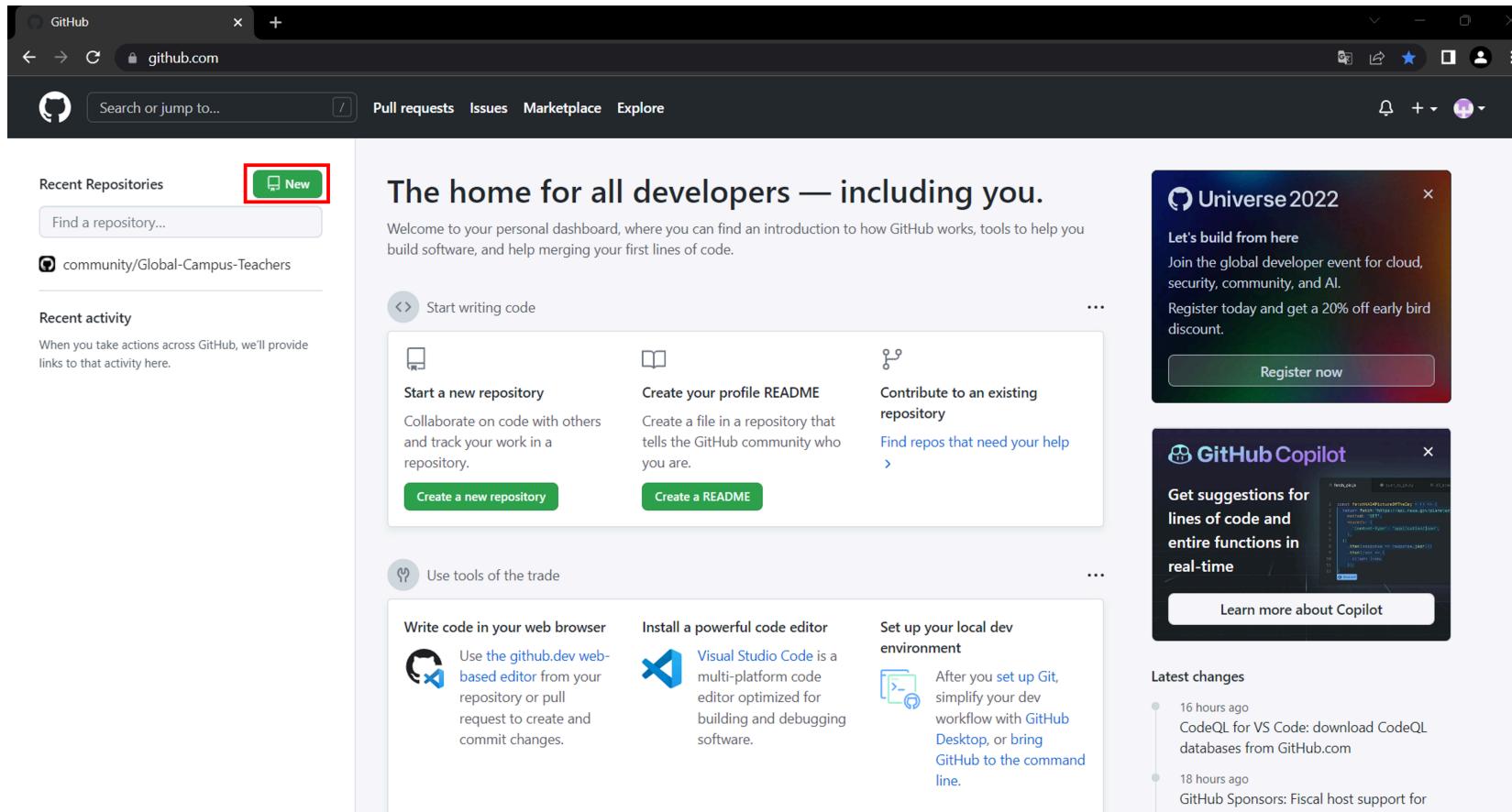
Initializing a Repository

- There are different ways to set up a repository
 - Using Git from the shell
 - Using the `usethis` package
 - Via RStudio IDE
- The easiest way is to create a GitHub repository first, then an R project with version control via the RStudio IDE

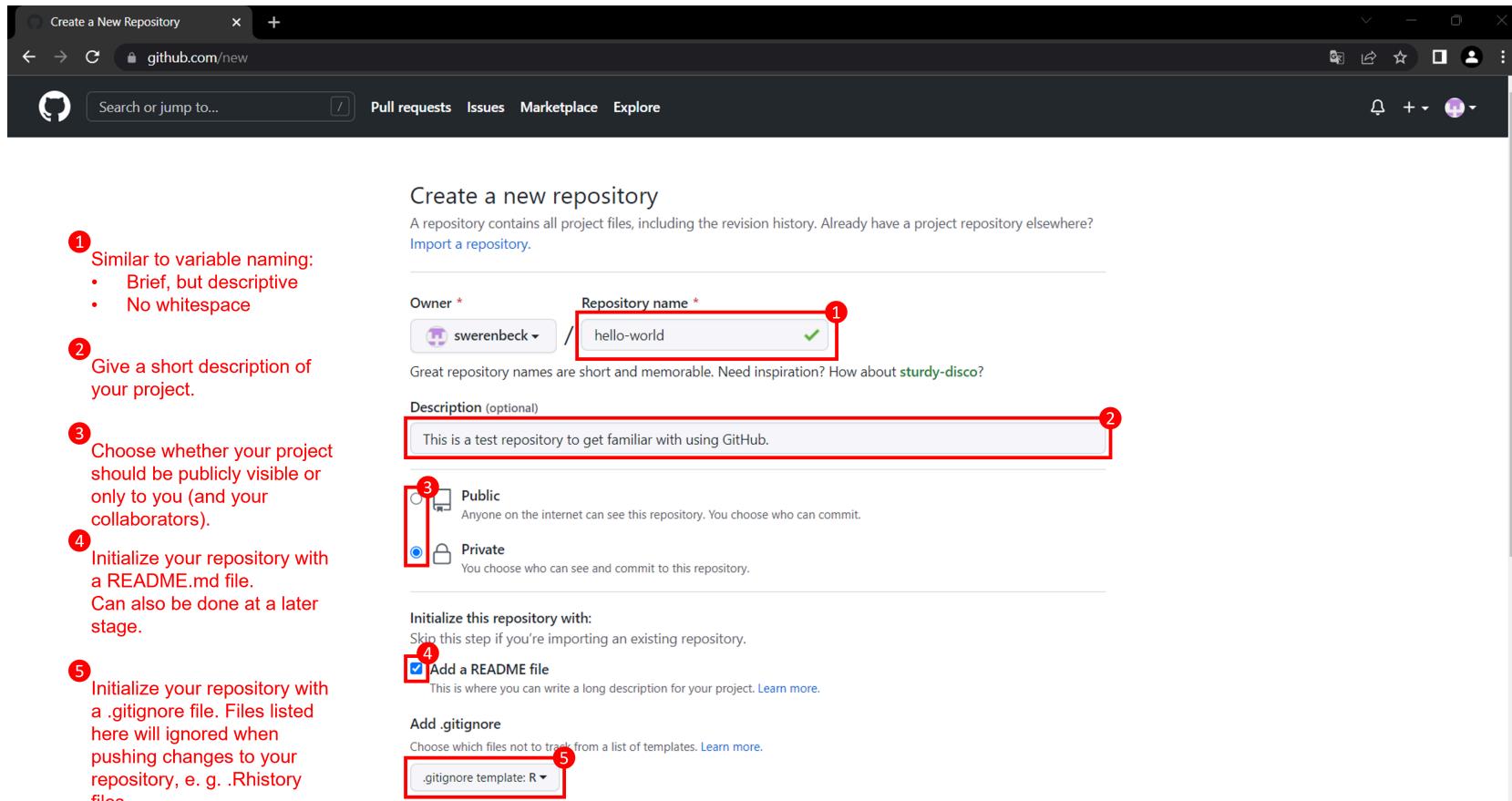


If you are interested in the other approaches, check out chapters 15 to 17 of [Bryan \(2022\)](#)!

Step 1: Create a new GitHub repository



Step 1: Create a new GitHub repository



The screenshot shows the GitHub 'Create a new repository' interface. A sidebar on the left lists steps 1 through 5, each with a red circle and a number. Step 1 is 'Similar to variable naming: Brief, but descriptive No whitespace'. Step 2 is 'Give a short description of your project'. Step 3 is 'Choose whether your project should be publicly visible or only to you (and your collaborators)'. Step 4 is 'Initialize your repository with a README.md file. Can also be done at a later stage'. Step 5 is 'Initialize your repository with a .gitignore file. Files listed here will be ignored when pushing changes to your repository, e. g. .Rhistory files'. The 'Repository name' field (containing 'hello-world') is highlighted with a red box and a red circle with the number 1. The 'Description (optional)' text area (containing 'This is a test repository to get familiar with using GitHub.') is highlighted with a red box and a red circle with the number 2. The 'Private' radio button is selected and highlighted with a red box and a red circle with the number 3. The 'Add a README file' checkbox is checked and highlighted with a red box and a red circle with the number 4. The '.gitignore template' dropdown (set to 'R') is highlighted with a red box and a red circle with the number 5.

1 Similar to variable naming:
• Brief, but descriptive
• No whitespace

2 Give a short description of your project.

3 Choose whether your project should be publicly visible or only to you (and your collaborators).

4 Initialize your repository with a README.md file.
Can also be done at a later stage.

5 Initialize your repository with a .gitignore file. Files listed here will be ignored when pushing changes to your repository, e. g. .Rhistory files.

Create a new repository

A repository contains all project files, including the revision history. Already have a project repository elsewhere? Import a repository.

Owner * swerenbeck Repository name * 1 / hello-world

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

Description (optional) 2

This is a test repository to get familiar with using GitHub.

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

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

Initialize this repository with: Skip this step if you're importing an existing repository.

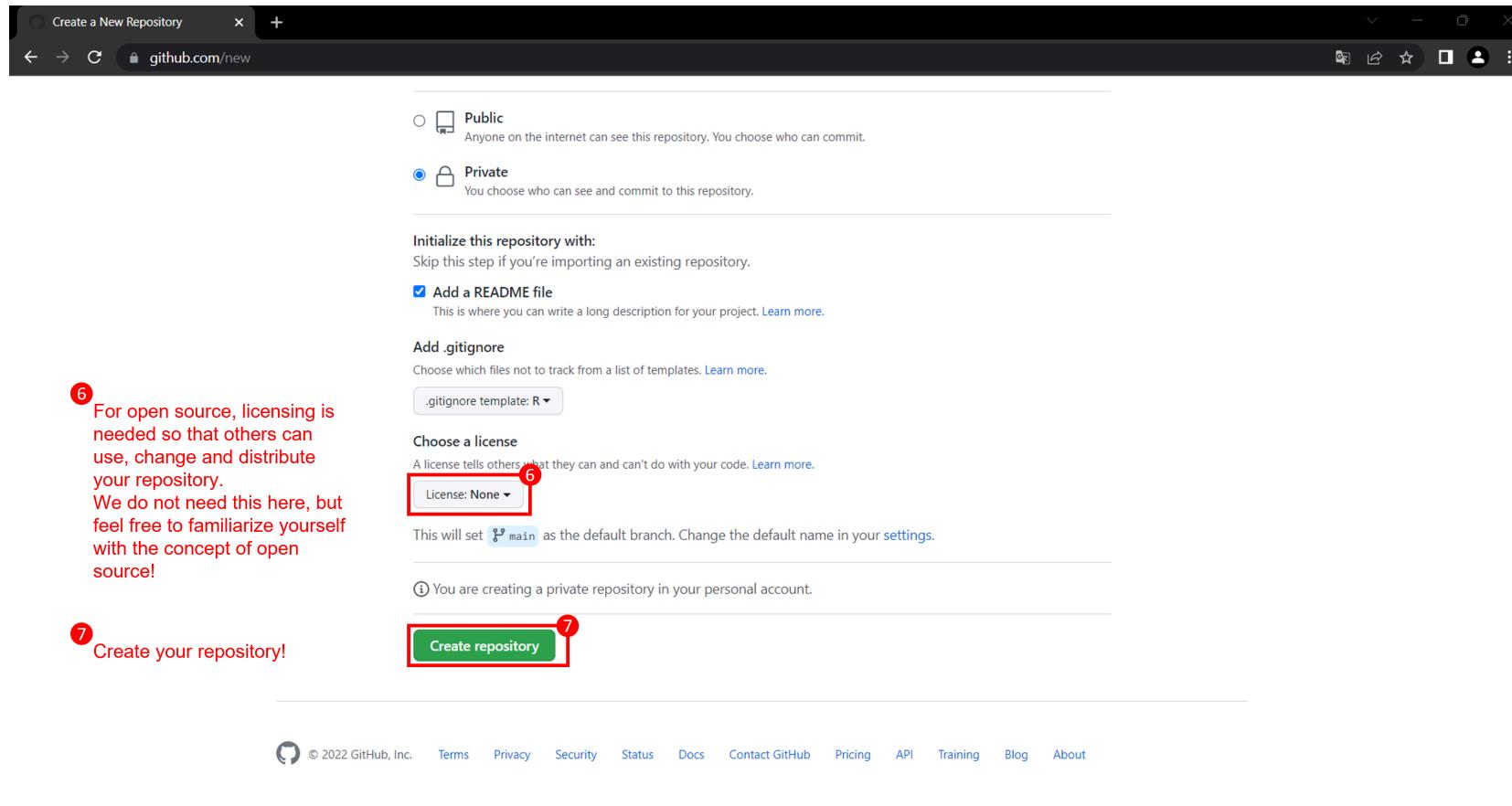
4 Add a README file This is where you can write a long description for your project. [Learn more](#).

Add .gitignore

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

.gitignore template: 5 R

Step 1: Create a new GitHub repository



6 For open source, licensing is needed so that others can use, change and distribute your repository. We do not need this here, but feel free to familiarize yourself with the concept of open source!

7 Create your repository!

6

7

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:

Skip this step if you're importing an existing repository.

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

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

.gitignore template: R ▾

Choose a license
A license tells others what they can and can't do with your code. [Learn more](#).

License: None ▾ 6

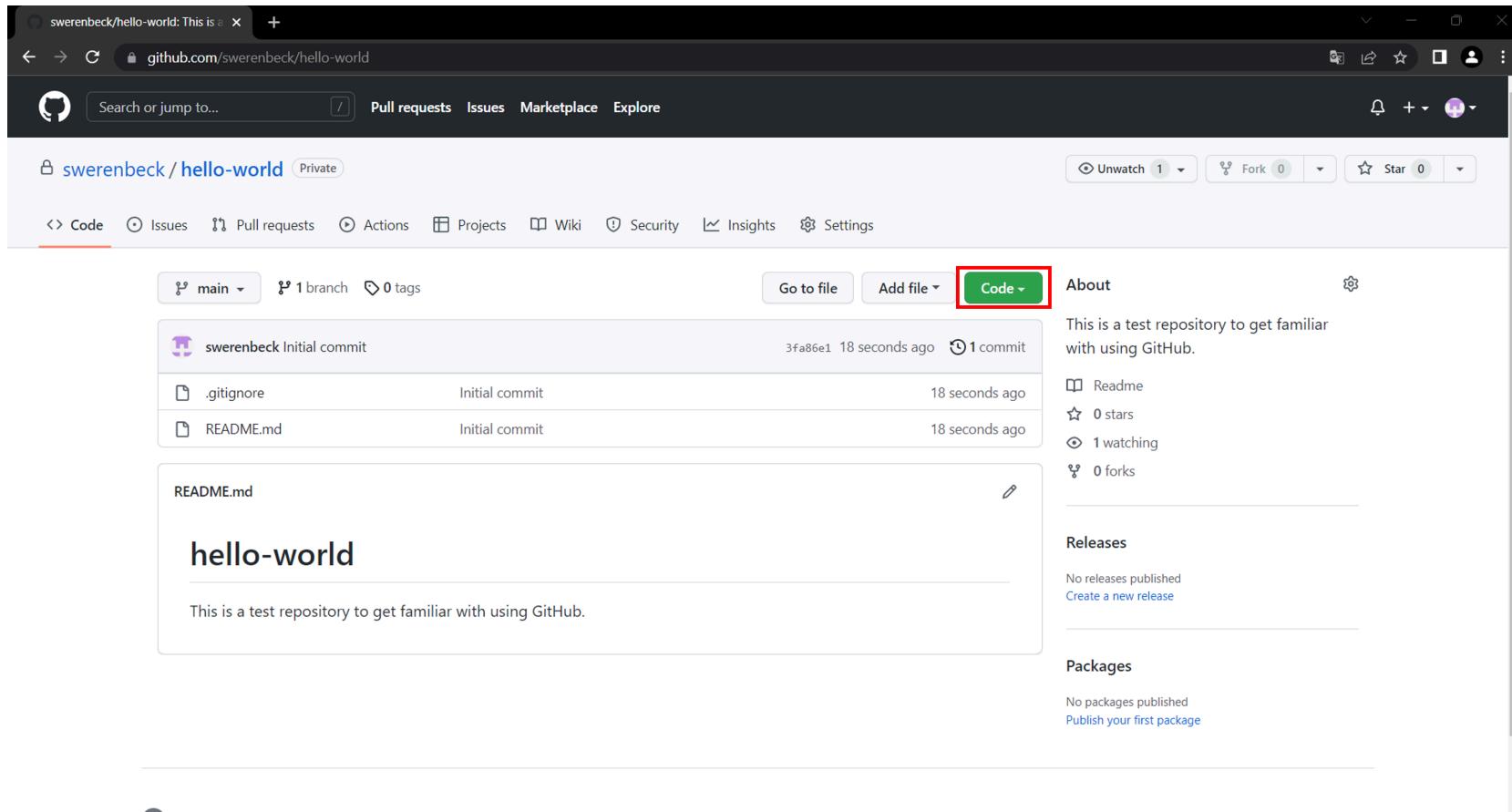
This will set `main` as the default branch. Change the default name in your [settings](#).

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

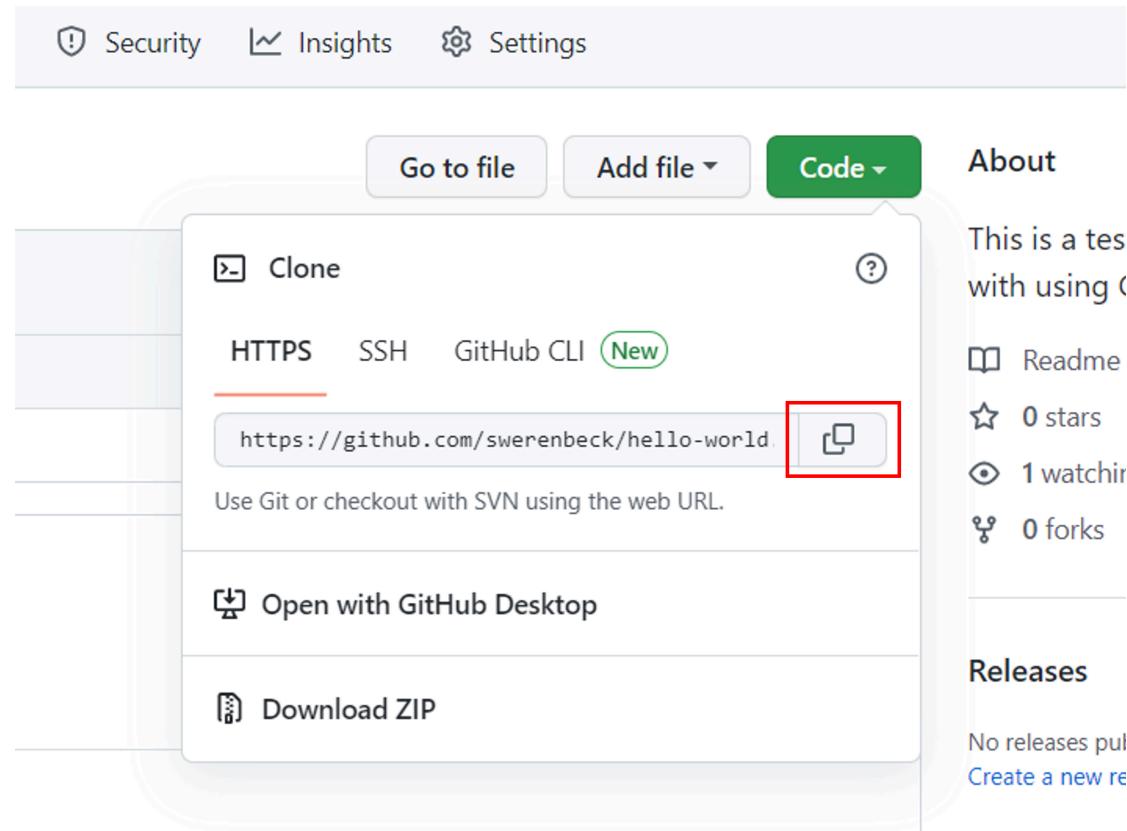
Create repository 7

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Step 2: Inspect your repo and copy its link

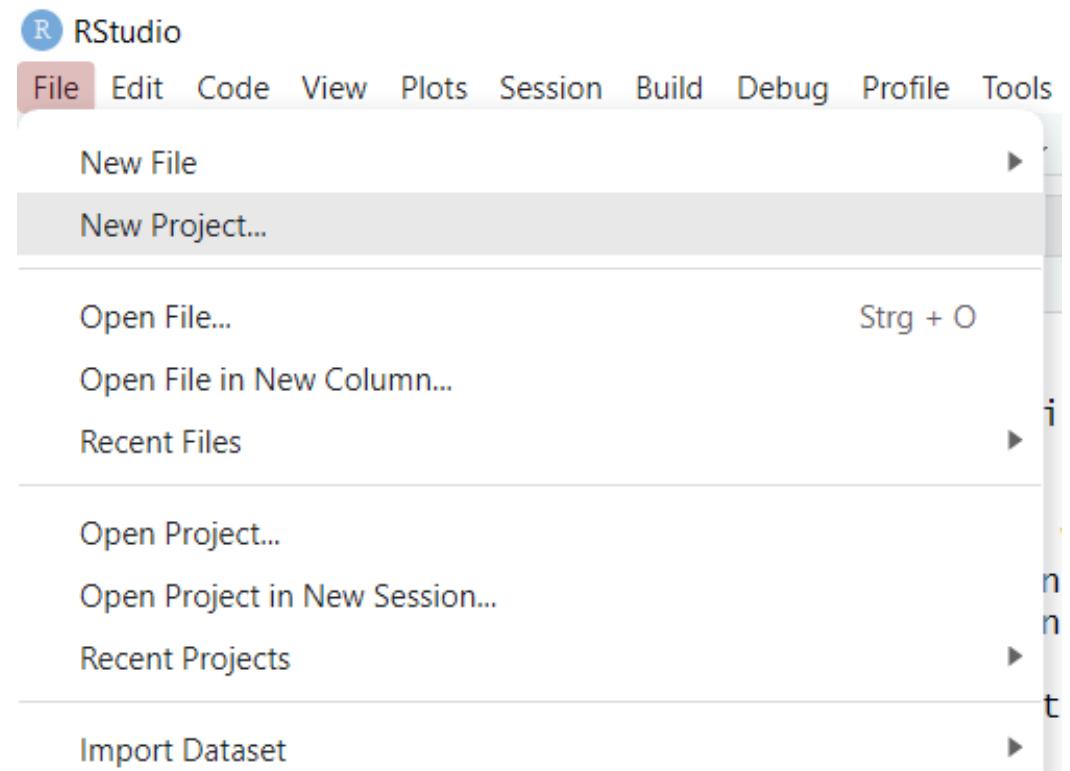


Step 2: Inspect your repo and copy its link



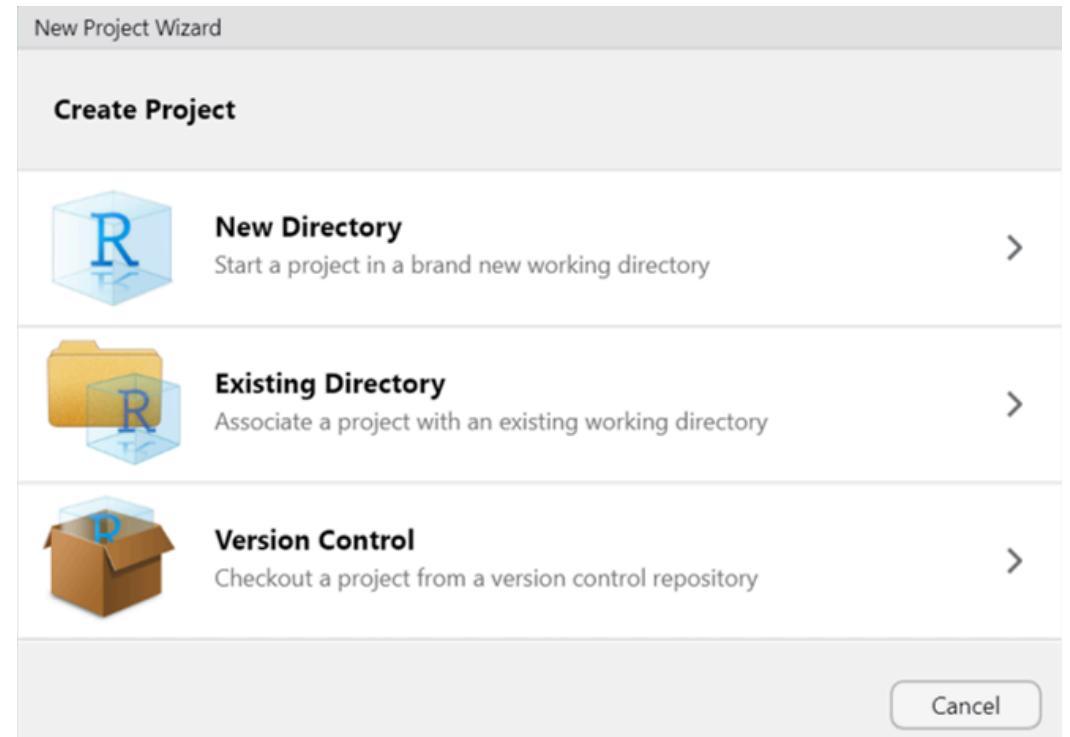
Step 3: Create an R project in RStudio

In RStudio, create a new project by clicking on **File > New Project...**



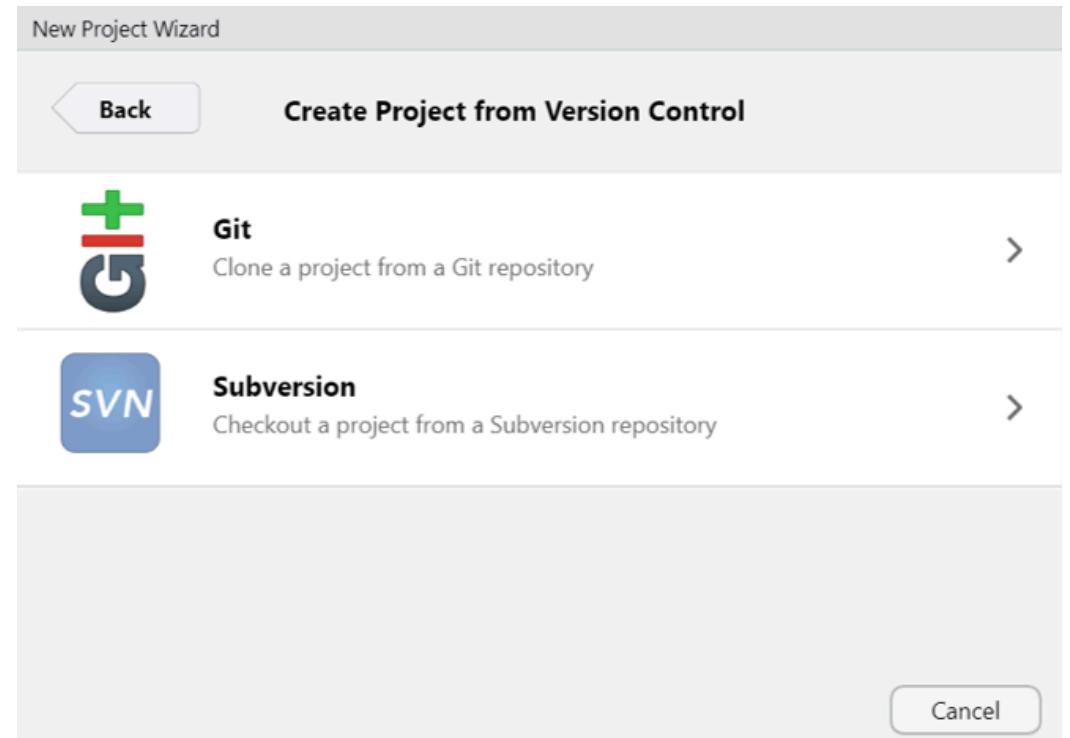
Step 3: Create an R project in RStudio

Select "Version Control"



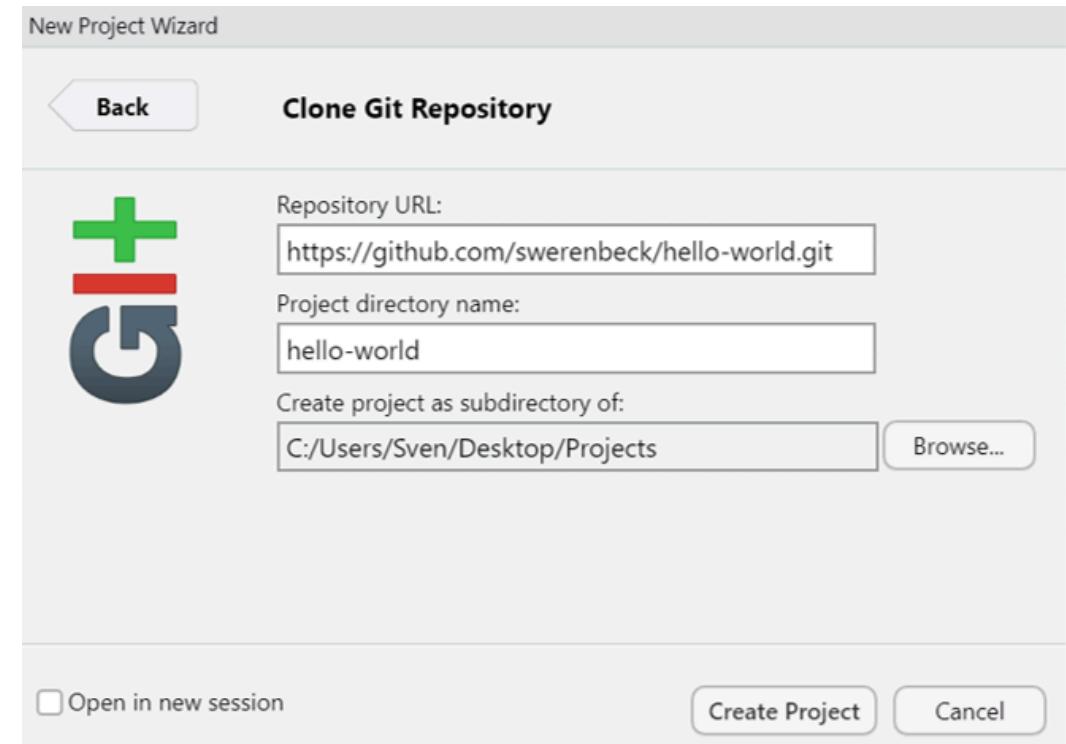
Step 3: Create an R project in RStudio

Select "Git"



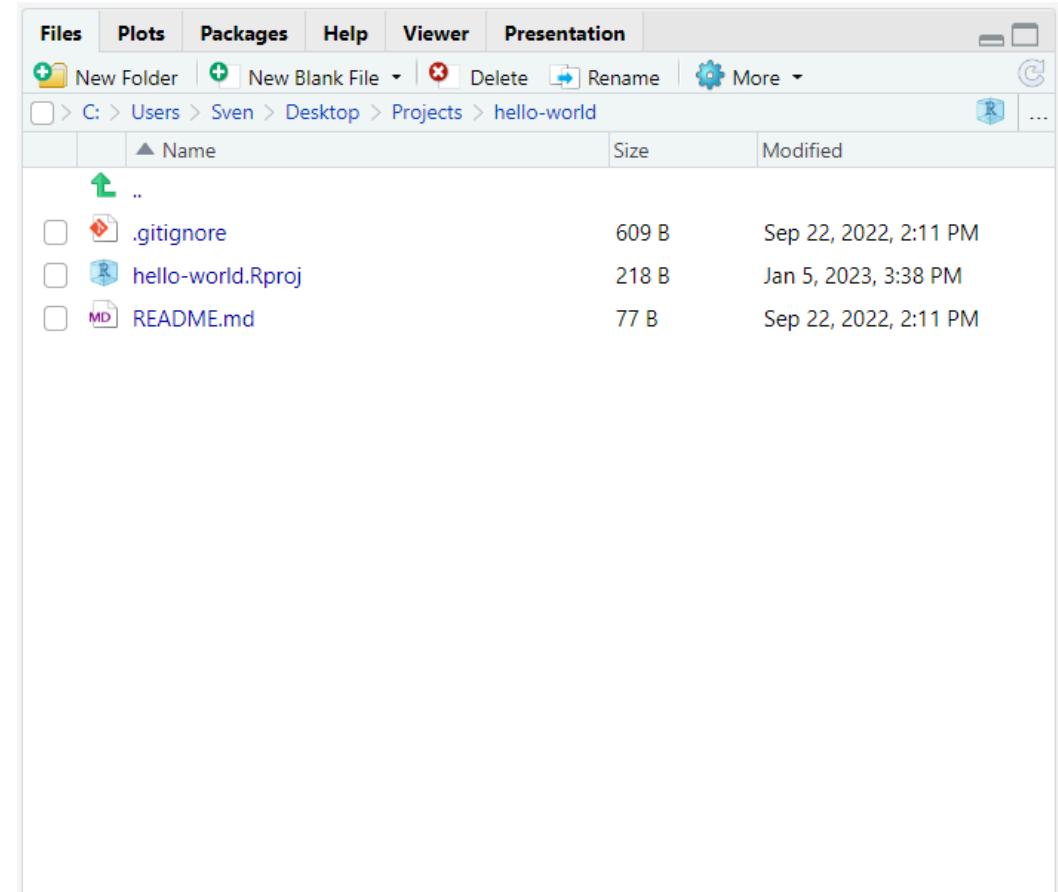
Step 3: Create an R project in RStudio

Paste the previous copied repository link into "Repository URL" and click on "Create Project"



Step 3: Create an R project in RStudio

An RStudio Project in a local directory on your computer was created and linked that directory as a Git repository to your remote GitHub repository



Creating Commits

Make Changes to Your Repository

- Your repository is now set up and running. Time to fill it with content!
- Let's do some regression analysis on the `mtcars` data set included in R:

1. Create a new folder `analyses` inside your project directory
2. Create an `.R` file with some content, e. g. regressing the gas consumption of cars (`mpg`) on the logarithm of their horsepower (`hp`) and the number of their cylinders (`cyl`)
3. Save the content of the code on the right to an R file `regression_analysis.R` inside the `analyses` folder
4. Commit your changes to your Git repository

```
# Create a linear regression model
model <- lm(mpg ~ log(hp) + cyl,
            data = mtcars)

# Print a model summary for "model"
summary(model)
```

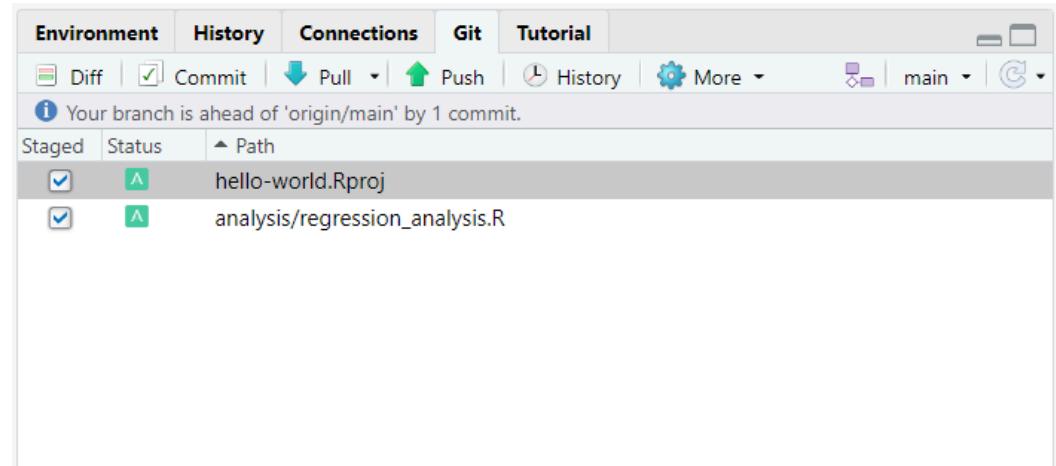
What is a commit?

- A commit can be thought of as saving changes to your git repository
- Takes a snapshot of all modified files in the repository at the moment
- The difference in files between two commits is called a "diff"
- Each commit contains a commit message
 - Looking at the commit history makes it possible to track changes
- Commits are initially only local changes
 - To make commits available to collaborators, commits have to be "pushed" to the GitHub repository

Creating a Commit

RStudio's Git pane shows files that were modified, added or deleted. To save these changes to your repository, follow these steps:

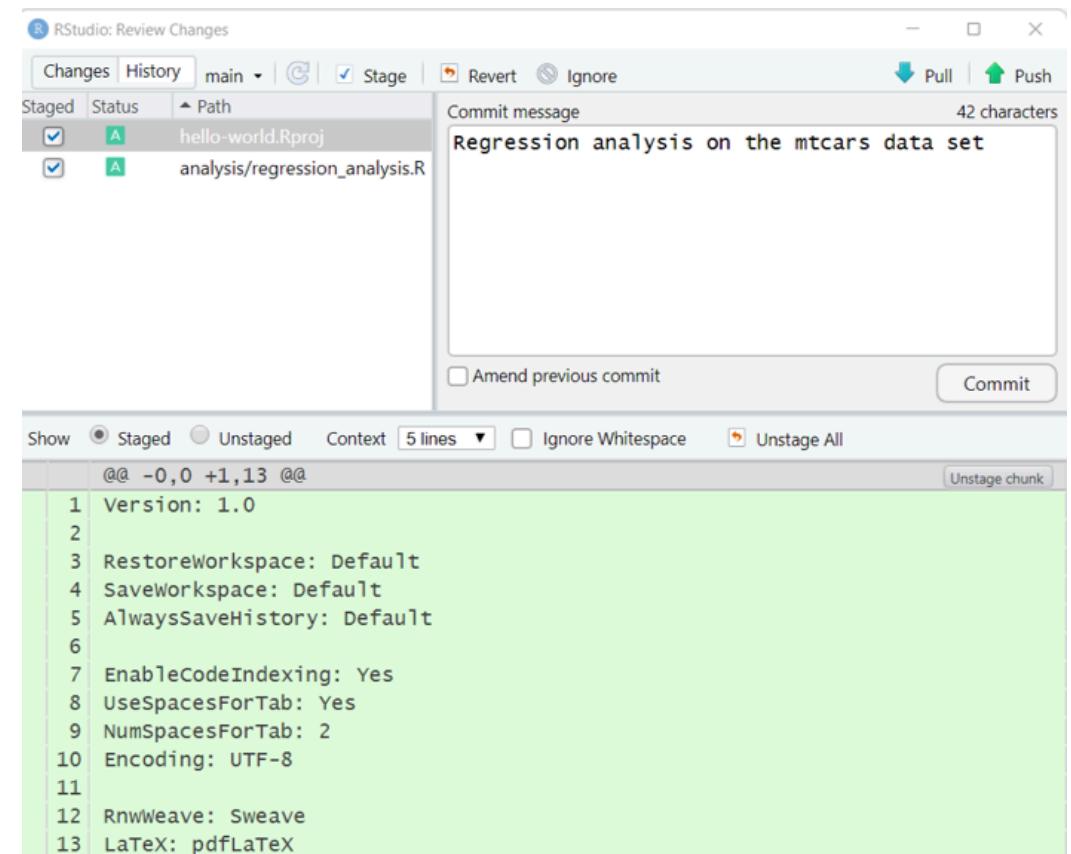
- Select files to commit



Creating a Commit

RStudio's Git pane shows files that were modified, added or deleted. To save these changes to your repository, follow these steps:

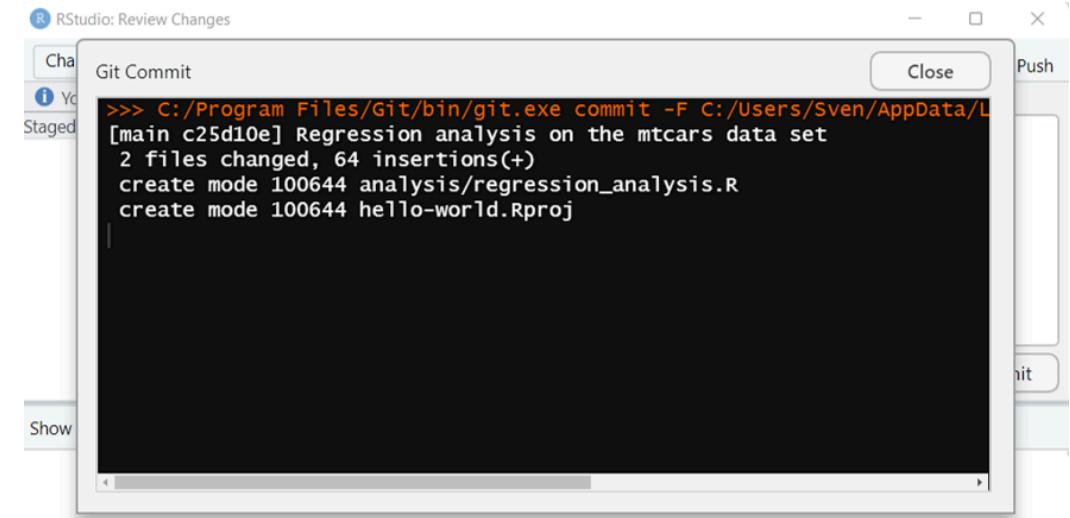
- Click on "Commit" in the Git pane



Creating a Commit

RStudio's Git pane shows files that were modified, added or deleted. To save these changes to your repository, follow these steps:

- Type a brief commit message and click on "Commit"



Commit Messages

- In software development, a commit is often done when finishing a unit of work (e. g. writing a function that lets you retrieve some data)
- Not feasible for data analysis projects
 - What would a unit of work be in a data analysis?
- Best to think of commit messages as logging work done
 - Does not have to be finished
 - It helps to log work-in-progress (e. g. when finishing for today)

Best Practices

There is no "one way" of writing commit messages but they have to be **consistent** and **informative**!

1. Separate subject from body with a blank line
2. Keep the subject line as short as possible
3. Do not end the subject line with a period
4. Use imperatives for the subject line
5. Use the body to explain *what* and *why* vs. *how*

Examples



Bad

Regression analysis on the mtcars data set



Good

Build linear model for gas consumption

Done:

- A linear regression model was built to analyze the effect of cyl and hp on mpg

Not done:

- Run further model specifications for robustness check.

Pushing Commits

We have changed our local directory by adding files and made a commit to our Git repository. Let's share our code by pushing our commit to the GitHub repository!

Pushing Commits

We have changed our local directory by adding files and made a commit to our Git repository. Let's share our code by pushing our commit to the GitHub repository!

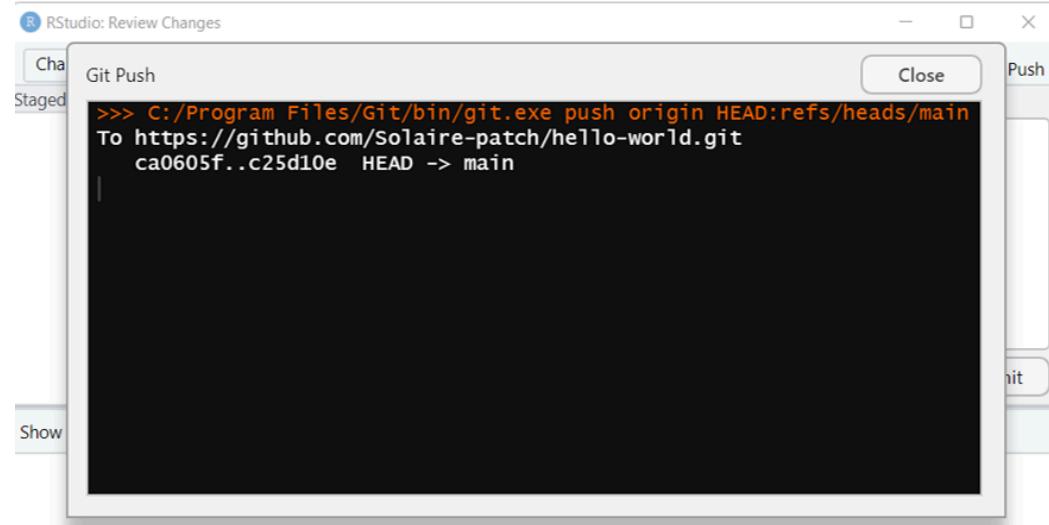
- "Pull" to check whether the local repository is up to date
- While you were working on problem X, your collaborators might have already pushed their solution to problem Y

The screenshot shows a RStudio interface with a "Review Changes" window open. A modal dialog box titled "Git Pull" is displayed. The dialog contains the command line output: >>> C:/Program Files/Git/bin/git.exe pull and the message "Already up to date.".

Pushing Commits

We have changed our local directory by adding files and made a commit to our Git repository. Let's share our code by pushing our commit to the GitHub repository!

- "Push" your commit(s) to the remote GitHub repository

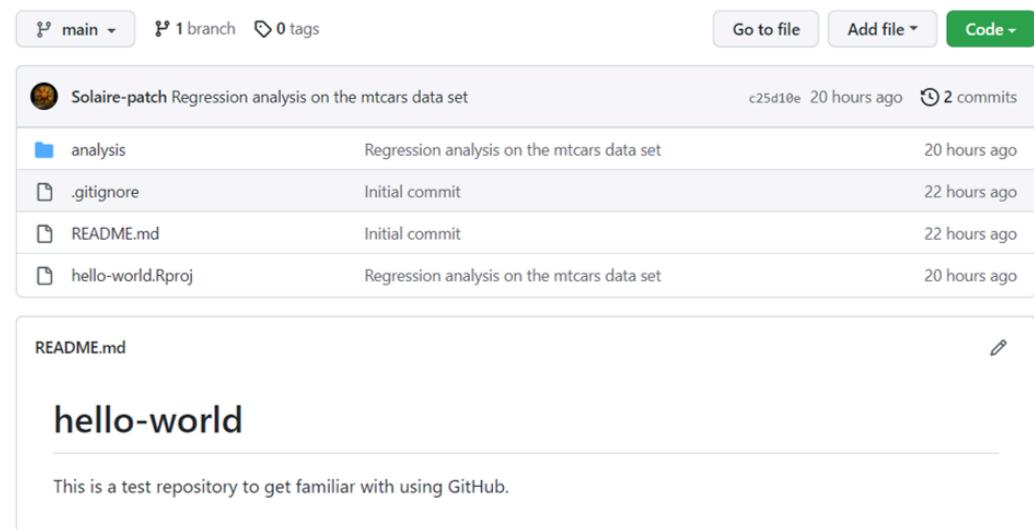


```
>>> C:/Program Files/Git/bin/git.exe push origin HEAD:refs/heads/main
To https://github.com/Solaire-patch/hello-world.git
  ca0605f..c25d10e  HEAD -> main
```

Pushing Commits

We have changed our local directory by adding files and made a commit to our Git repository. Let's share our code by pushing our commit to the GitHub repository!

- Go to your GitHub repository
- The new files should now be visible



The screenshot shows a GitHub repository interface. At the top, there are buttons for 'main' (with a dropdown arrow), '1 branch', '0 tags', 'Go to file', 'Add file', and a green 'Code' button. Below this is a list of commits:

Commit	Message	Time	Commits
 Solaire-patch	Regression analysis on the mtcars data set	c25d10e 20 hours ago	2 commits
 analysis	Regression analysis on the mtcars data set	20 hours ago	
 .gitignore	Initial commit	22 hours ago	
 README.md	Initial commit	22 hours ago	
 hello-world.Rproj	Regression analysis on the mtcars data set	20 hours ago	

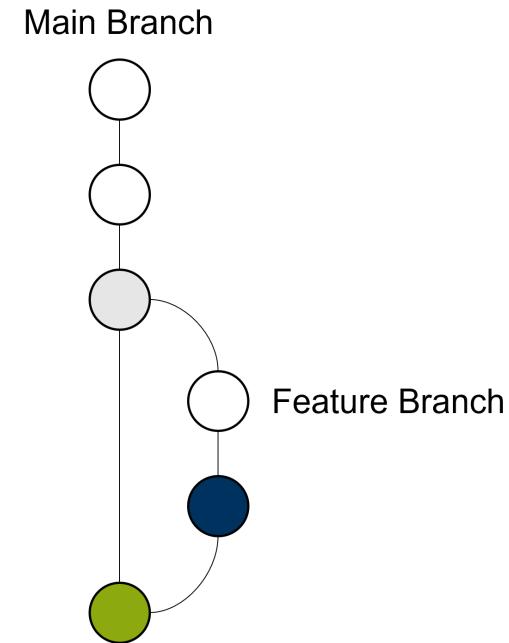
Below the commits is the 'README.md' file content:

```
hello-world
This is a test repository to get familiar with using GitHub.
```

Working with Feature Branches

Branches

- Creating a branch means detouring from the main development branch and working on feature without changing the state of the main stream
 - Allows for **parallel development** streams because collaborators don't overwrite each other's code
 - Useful for single-authored repositories to experiment with different problem solving strategies
- Working directly on the main branch is generally considered bad practice
 - Would require to constantly incorporate code changes by your collaborators
 - Leads to conflicting code when working on the same branch



Issues

- The scope of development on a feature branch should always be outlined beforehand (and maybe adjusted later on)
 - Think about *what, why* and (to some extent) *how* you want to achieve something before writing your code
 - Don't develop something for the sake of writing code
- GitHub offers an easy to use feature for documenting the scope of a feature branch: Issues
- Issues are shown in the "Issues" tab of your repository and can be assigned to GitHub projects

Estimate gas consumption using different specifications #1

Open 2 tasks Solaire-patch opened this issue 1 minute ago · 0 comments

Solaire-patch commented 1 minute ago · edited

Check different specifications for the estimation of gas consumption using the "mtcars" data set to check for robustness of the results. The outcome variable in each specification is mileage per gallons of gas (mpg).

The first specification includes horsepower (hp) and number of cylinders (cyl) as explanatory variables

The second specification includes the logarithm of hp and cyl as explanatory variables

Solaire-patch self-assigned this 1 minute ago

Assignees Solaire-patch

Labels None yet

Projects None yet

Milestone No milestone

Development Create a branch for this issue or link a pull request.

Notifications Customize

GitHub Projects

- Another great feature of GitHub is the project management tool
- You can organize and manage your repository using GitHub projects
- Create a project for your repository in the "Projects" tabs
- Give your project a concise and descriptive name
- The "Team backlog" template is best suited for your needs

Select a template

Start from scratch

Table

Board

Project templates

Team backlog

Feature

Team backlog

Project name

Hello world!

Team backlog template

Backlog | By priority | By size | New view

Filter by keyword or by field

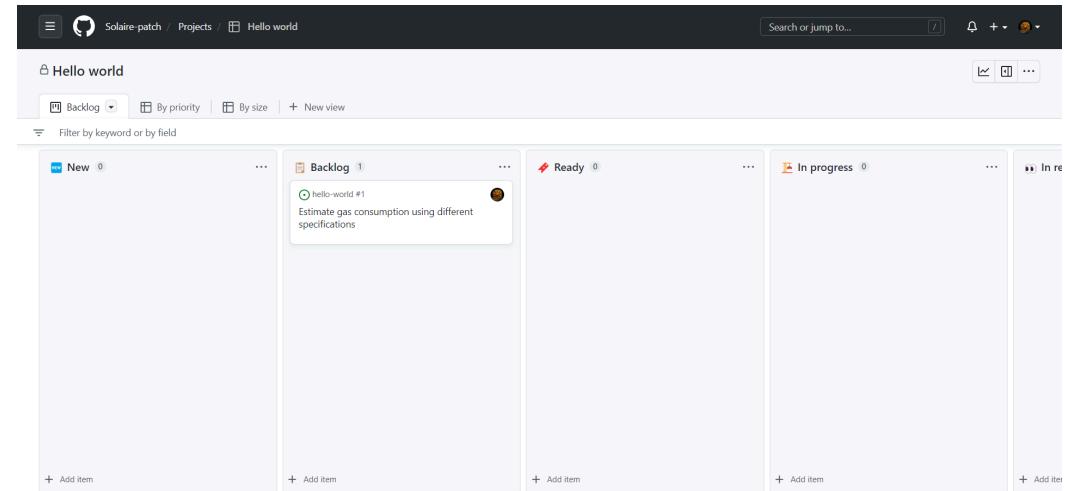
Category	Item	Priority	Size
Backlog	planning-tracking-demo #808	Low	Small
	Upsell / Growth experience	Medium	Medium
	planning-tracking-demo #824	Low	Medium
	Beta signup page	Medium	Medium
	planning-tracking-demo #816	High	Small
Ready	planning-tracking-demo #101	Medium	Medium
	Integrate new payments system	High	Medium
	planning-tracking-demo #809	High	Large
	Integrate with backend systems	Medium	Large
	planning-tracking-demo #223	High	Small
In progress	planning-tracking-demo #1012	High	Large
	Hero site - Development	Medium	Medium
	planning-tracking-demo #1011	High	Large
	Score and game reset logic	Medium	Large
	planning-tracking-demo #1010	Low	Small
Planned	planning-tracking-demo #934	Medium	Medium
	Design new launch screen	Low	Small
	planning-tracking-demo #932	Medium	Medium
	Hero site - Development	Medium	Medium
	planning-tracking-demo #931	Medium	Medium

Define and plan your team's backlog using a task board and custom fields for item priority and size.

Create

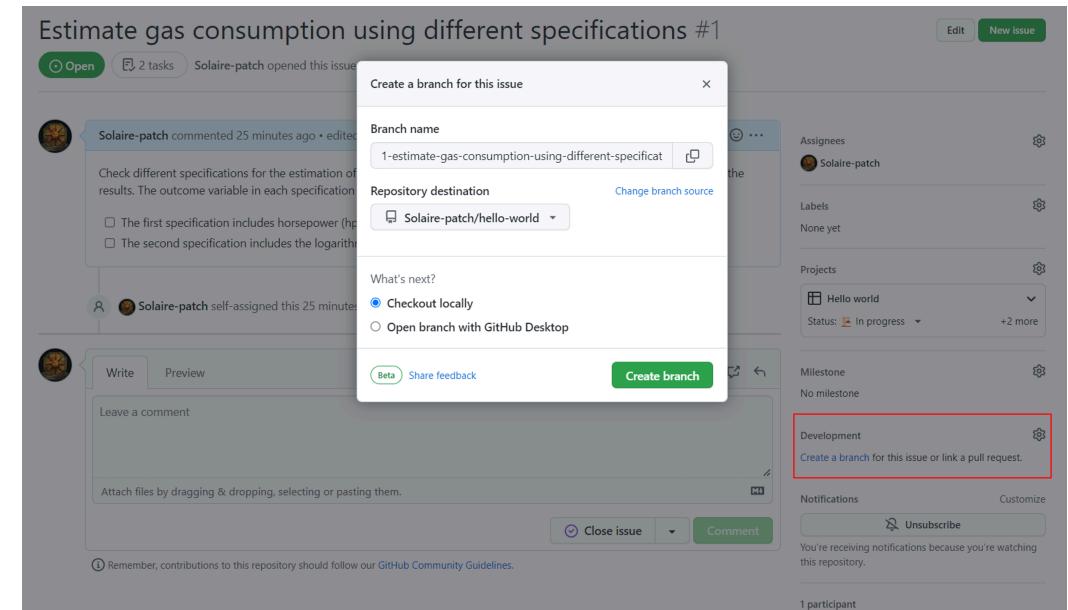
Managing Your Project

- The default team backlog has the following cards representing different statuses:
 1. **New:** Shows all newly created issues in your project
 2. **Backlog:** Collect all your issues that are not yet ready for development in the backlog
 3. **Ready:** Drag issues that are ready to develop from "Backlog" to "Ready"
 4. **In progress:** When you begin the development of a feature described in an issue, drag the corresponding issue to the "In progress" card
 5. **In review:** When you are done developing the feature, it is good practice to let others review your code
 6. **Done:** Feature that have gone through the review process are set to the status "Done"



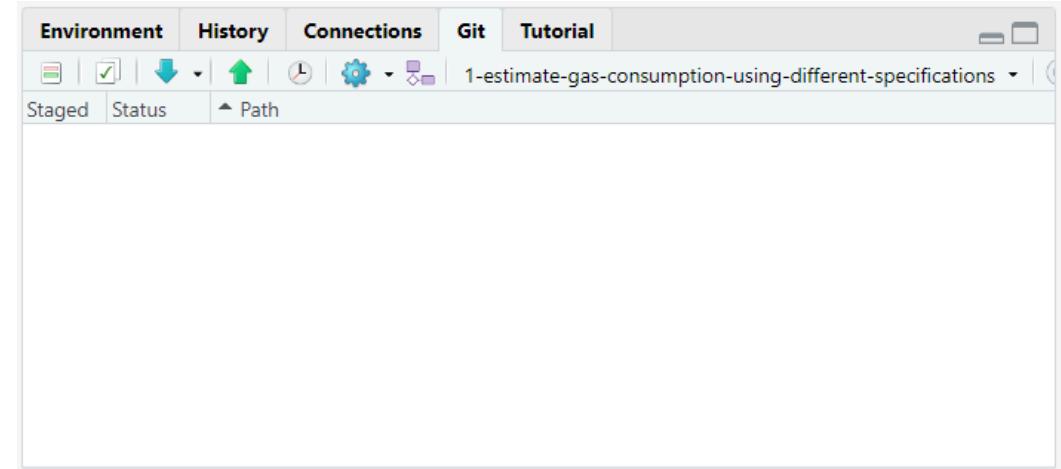
Linking Feature Branches and Issues

- Issues can be linked to feature branches by creating a branch on the issue page
- Branches can also be created directly in RStudio by clicking on the purple symbol on the right of the Git pane
- Linking issues to branches is the better approach when you are already documenting the scope of a feature branch in issues and use GitHub projects to manage your repository



Checkout Branches

- To change the branch you are working on in RStudio, click on the dropdown right to the symbol for creating a new branch in the Git pane
- You have to pull (blue arrow) the remote repository before the newly created feature branch appears in RStudio



Commit and Push

- Let's implement what we outlined in the issue and estimate two specifications of our linear regression model:

- $mpg = \alpha + \beta_1 hp + \beta_2 cyl + \varepsilon$
- $mpg = \alpha + \beta_1 \log hp + \beta_2 cyl + \varepsilon$

- Commit your changes and push the commit to the repository

```
# Create list of specifications
formulas <- list(
  model_1 = formula(mpg ~ hp + cyl),
  model_2 = formula(mpg ~ log(hp) + cyl)
)

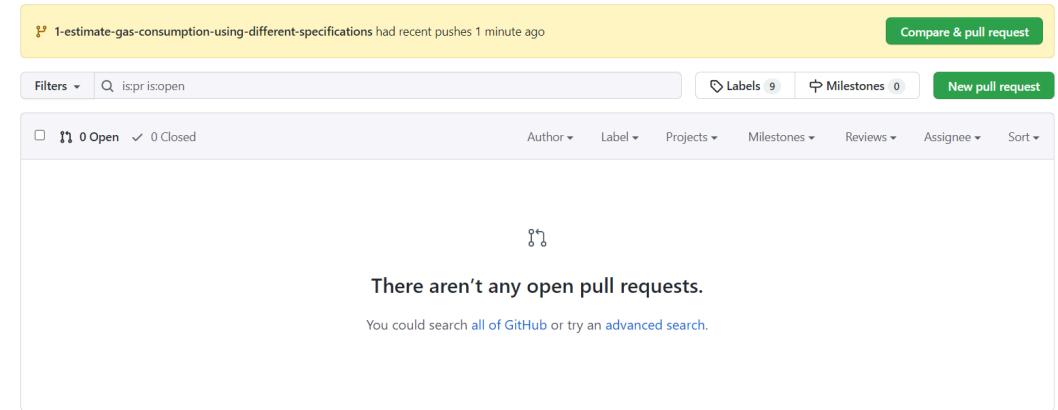
# Estimate each formula in formulas
models <- lapply(formulas,
  lm,
  data = mtcars)

# Print model summaries
lapply(models, summary)
```

Pull Requests

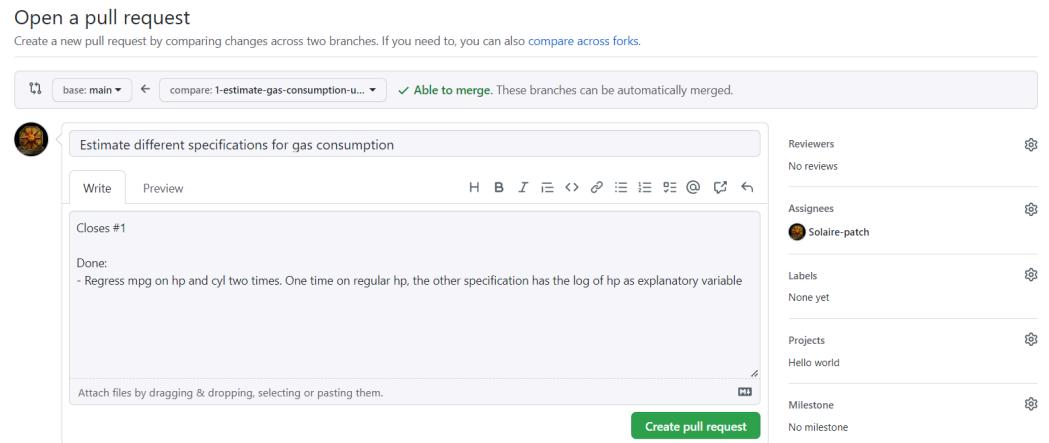
Creating a Pull Request

- The process of merging the feature branch into the main branch is called **pull request**
- After pushing your commit to the repository, GitHub conveniently asks whether you want to create a pull request



Creating a Pull Request

- Open a pull request and assign it to you
- Assign a reviewer and specify the project
- If there is only one commit on the feature branch, GitHub automatically fills subject line and body for you
 - Otherwise give a concise but descriptive subject line and note what was done
 - Use closing keywords to automatically close the issue when the branch is merged (e. g. "Closes #1" for issue number 1)
- Don't forget to change the issue status to "In review"

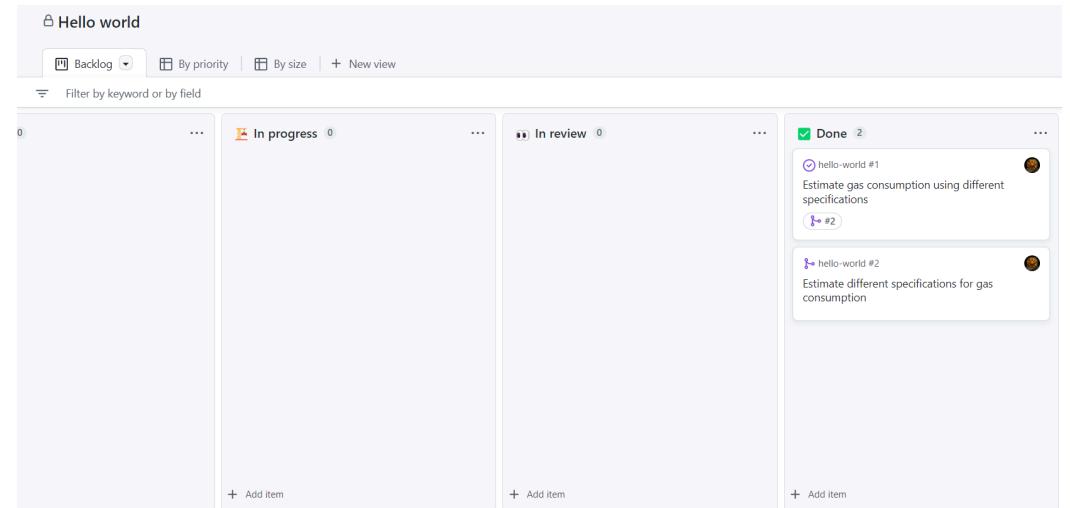


Inspect Pull Requests

- Once the pull request was created, it will be displayed in the "Pull requests" tab of your repository until the feature branch was successfully merged into the main branch
- Creating a pull request automatically creates a task in your project that you can track
- Your reviewers can inspect your commits and write comments as well as make suggestions for code changes
- If all requirements for the feature were met, the reviewer can approve the pull request
- The feature branch can then be merged into the main branch by clicking on "Merge pull request"

Setting Issues on "Done"

- After merging the feature branch into the main branch, the feature branch can be safely deleted
- Because closing keywords were used, both, the issue and the pull request, were automatically set to "Done" in your repository after merging the feature



Resolving Merge Conflicts

Merge Conflicts

- Sometimes, Git identifies competing code lines, e. g. when two persons edit the same line on two different branches
- Merge conflicts are often a hassle but (if you know what to do) are fairly easy to resolve



Just keep a cool head and do not start doing anything in hope of magically resolving the merge conflict!

Resolving Merge Conflicts Using the Terminal

1. Navigate to the terminal in RStudio (the tab next to the console)
2. Get a list of files responsible for the merge conflict by running `git status` in the terminal
3. Open the files listed as "both modified". Conflicting lines are marked by <<<<< and separated by =====.
 - The base branch is marked as <<<<< HEAD
 - The code line on the other branch is followed by >>>>> BRANCH-NAME
 - Adjust the code according to your needs. This may involve combining both code chunks.
4. Add your changes to the commit by running `git add .` in the terminal
5. Commit your changes with a comment:

```
git commit -m "Resolved merge conflict by deleting base code."
```



For more information, see the GitHub documentation on [how to resolve merge conflicts!](#)

References

Bryan, J. (2022). *Happy Git and GitHub for the useR*. <http://www.happygitwithr.com/>, Last accessed on 2022-09-21.