

Bioinformatics session

A two-day workshop for
bioinformaticians and molecular
biologists with focus on the TSO500
pipeline in InPreD



Overview

1. Setup
2. Development & Collaboration
3. Nextflow
4. tso500_nxf_workflow
5. Python

1. Setup

Create a GitHub account

- go to <https://github.com/> and click on `Sign up`



Create a GitHub account

- enter your email

Welcome to GitHub!

Let's begin the adventure

Enter your email*

→ coder@inpred.no

Continue

Create a GitHub account

- set a password

Welcome to GitHub!

Let's begin the adventure

Enter your email*

✓ coder@inpred.no

Create a password*

→ ••••••••



Continue

Create a GitHub account

- choose a username

Welcome to GitHub!

Let's begin the adventure

Enter your email*

✓ coder@inpred.no

Create a password*

✓ ••••••••••

Enter a username*

→ inpredder

Continue

Create a GitHub account

- choose email preferences

Email preferences

☐ Receive occasional product updates and announcements.

Continue

Create a GitHub account

- solve the puzzle



Create a GitHub account

- create your account



Create a GitHub account

- find the activation code in the email you received



Here's your GitHub launch code, @inpredder!



Continue signing up for GitHub by entering the code below:

40619601

Open GitHub

Create a GitHub account

- select the desired options

This will help us guide you to the tools that are best suited for your projects.

How many team members will be working with you?

☒ Just me

☐ 2-5

☐ 5-10

☐ 10-20

☐ 20-50

☐ 50+

Are you a student or teacher?

☒ N/A

☐ Student

☐ Teacher

Continue

What specific features are you interested in using?

Select all that apply so we can point you to the right GitHub plan.



Collaborative coding

Codespaces, Pull requests, Notifications, Code review, Code review assignments, Code owners, Draft pull requests, Protected branches, and more.



Automation and CI/CD

Actions, Packages, APIs, GitHub Pages, GitHub Marketplace, Webhooks, Hosted runners, Self-hosted runners, Secrets management, and more.



Security

Private repos, 2FA, Required reviews, Required status checks, Code scanning, Secret scanning, Dependency graph, Dependabot alerts, and more.

Create a GitHub account

- choose the free plan

Free

- > Unlimited public/private repositories
- > 2,000 CI/CD minutes/month
Free for public repositories
- > 500MB of Packages storage
Free for public repositories
- > 120 core-hours of Codespaces compute
- > 15GB of Codespaces storage
- > Community support

Continue for free

1. Setup

Be added to InPreD organisation at GitHub

1. Resources

- [Getting started with your GitHub account](#)

2. Development & Collaboration

Short `git` introduction

- distributed version control system
- tracks history of changes committed by different contributors
- every developer has full copy of project and its history

Short `git` introduction

Basic `git` commands

`git init` : initialises new git repository

`git clone <repository url>` : creates local copy of remote repository

`git add <file/s>` : stage new or changed files (anything that should be committed to the repository)

`git commit -m "feat: my new feature"` : commit changes to the repository

Basic `git` commands

commit message conventions

`<type>[optional scope]: <description>`

- `feat` : new feature
- `fix` : patching bug
- `refactor` : code change that neither is neither feat nor fix
- `build` : build system related changes
- `perf` : improving performance

commit message conventions

`<type>[optional scope]: <description>`

- `chore` : code unrelated changes, e.g. dependencies
- `style` : code change that does not change meaning
- `test` : changes to tests
- `docs` : adding/updating documentation
- `ci` : continuous integration, e.g. github actions

Basic `git` commands

`git status` : overview over untracked, modified and staged changes

`git branch` : show local branches

`git merge` : merge branches

`git pull` : load changes from remote counterpart

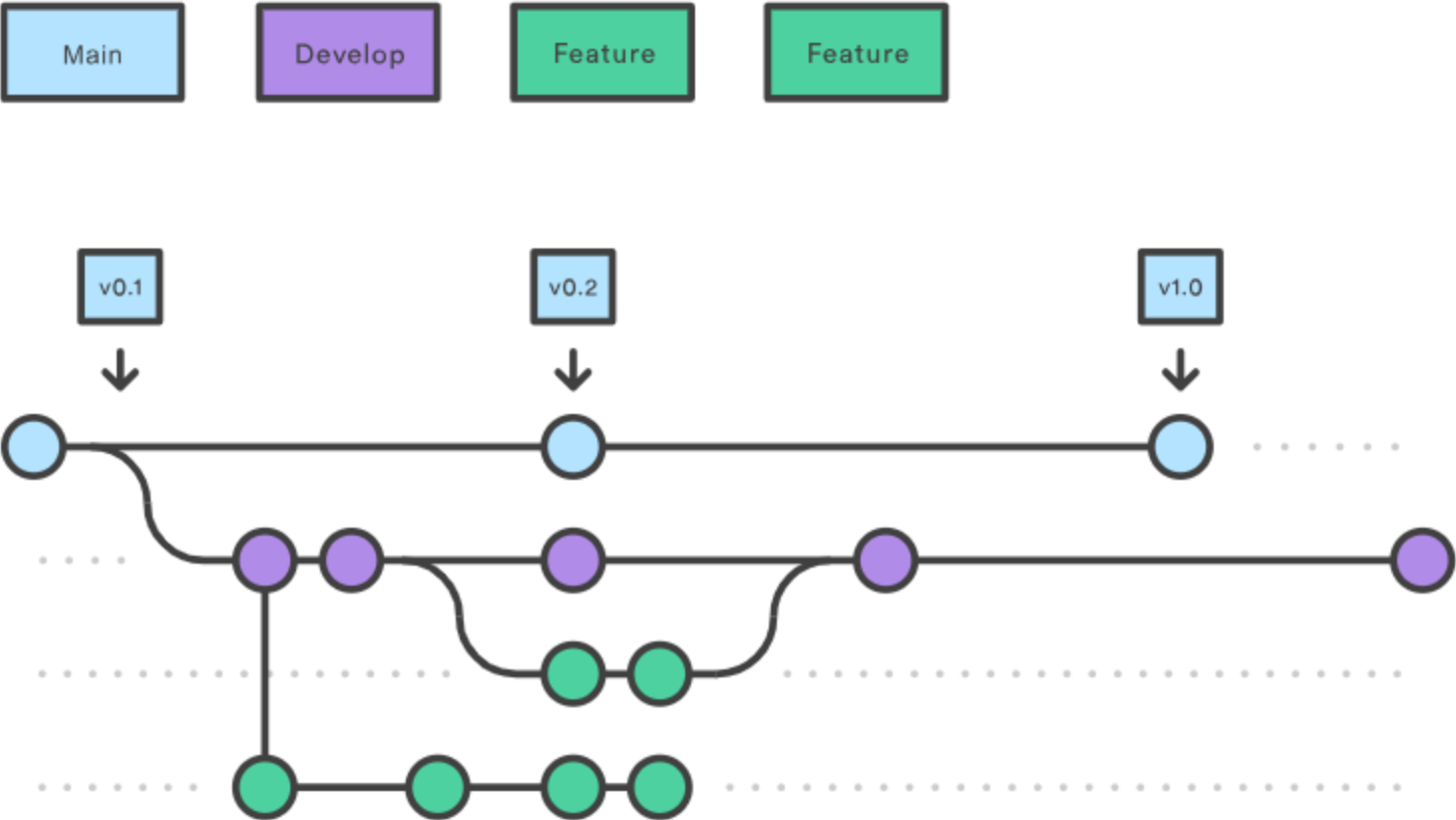
`git push` : upload changes to remote counterpart

2. Development & Collaboration

Branching model: simplified Gitflow workflow

- start with two branches to record project history: `main` and `develop`
- each new feature resides in its own branch (feature branch)
- feature branch is generally created off latest `develop` commit
- upon feature completion, feature branch is merged into `develop`

Branching model: simplified Gitflow workflow



2. Development & Collaboration

GitHub Actions

- continuous integration (CI) and continuous deployment (CD)
- building, testing and deploying directly from GitHub
- set up by adding yaml instructions to `.github/workflows`

```
name: GitHub Actions Demo
on: [push]
jobs:
  Explore-GitHub-Actions:
    runs-on: ubuntu-latest
    steps:
      - run: echo "Hello world!"
```

GitHub Actions

```
name: Docker Build
on:
  push:
    branches:
      - main
      - develop
    tags:
      - '!*.*.*'

jobs:
  test:
    name: Run unit tests
    runs-on: ubuntu-latest
    steps:
      -
        name: Check out the repo
        uses: actions/checkout@v4
      -
        name: Unit testing
        uses: fylein/python-pytest-github-action@v2
        with:
          args: pip3 install -r requirements.txt && pytest
    ...
```


GitHub Actions

```
...
  build:
    name: Build Image
    runs-on: ubuntu-latest
    needs: test
    steps:
      -
        name: Check out the repo
        uses: actions/checkout@v4

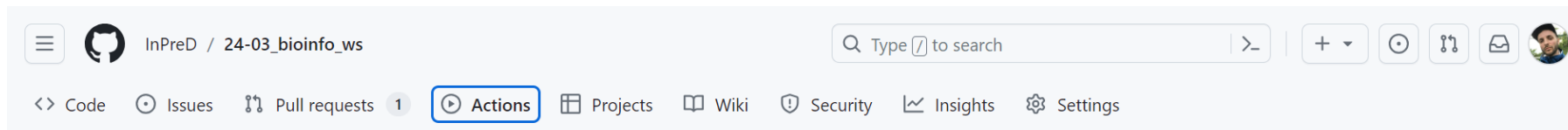
      -
        name: Lint Dockerfile
        uses: hadolint/hadolint-action@v3.1.0

      -
        name: Docker Meta
        id: meta
        uses: docker/metadata-action@v5
        with:
          images: |
            inpred/local_app_prepper
          tags: |
            latest
            type=semver,pattern={{version}}
            type=semver,pattern={{major}}.{{minor}}
            type=semver,pattern={{major}}

      -
        name: Login to Dockerhub
        uses: docker/login-action@v3
        with:
          username: ${{ secrets.DOCKERHUB_USERNAME }}
          password: ${{ secrets.DOCKERHUB_TOKEN }}

      -
        name: Build and push image to Docker Hub
        uses: docker/build-push-action@v5
        with:
          push: true
          tags: ${{ steps.meta.outputs.tags }}
          labels: ${{ steps.meta.outputs.labels }}
```

GitHub Actions



Actions

New workflow

All workflows

Workflows

marp-to-pages

pages-build-deployment

Management

Caches

Deployments

Runners

All workflows

Showing runs from all workflows

Filter workflow runs

36 workflow runs

Event Status Branch Actor

✓	pages build and deployment pages-build-deployment #19: by github-pages (bot)	11 minutes ago 41s	...
✓	docs: add github actions marp-to-pages #17: Commit 34d473e pushed by marrip	12 minutes ago 47s	...
✓	pages build and deployment pages-build-deployment #18: by github-pages (bot)	46 minutes ago 47s	...

GitHub Actions

InPreD / 24-03_bioinfo_ws

Q Type / to search

>_

+ ▾

⌚

🔗

✉

<> Code ⌚ Issues 🔗 Pull requests 1 ⌚ Actions 📁 Projects 📖 Wiki 🛡 Security 📈 Insights ⚙ Settings

← marp-to-pages

docs: add images for github actions #18

Cancel workflow

⋮

🏠 Summary

Jobs

build

Run details

🕒 Usage

📄 Workflow file

Triggered via push now

marrip pushed 698fa73 develop

Status

In progress

Total duration

—

Artifacts

—

main.yml

on: push

build16s

🗨

—

+

GitHub Actions

InPreD / 24-03_bioinfo_ws

Q

Type / to search

>_


+

▼

⌂

🔗

✉



<>

Code

⌚

Issues

🔗

Pull requests

1

▶

Actions

📁

Projects

📖

Wiki

🛡

Security

📈

Insights

⚙

Settings

←

marp-to-pages

✓ docs: add images for github actions #18

Re-run all jobs

⋮

🏠

Summary

Jobs

✓ build

Run details

🕒

Usage

📄

Workflow file

build

Beta

Give feedback

Q

Search logs

🔄

⚙

>

✓

Set up job

1s

>

✓

Pull marpteam/marp-cli:v3.0.2

13s

>

✓

Checkout code

0s

>

✓

Ensure build dir exists

0s

>

✓

Copy images directory (if exists)

0s

>

✓

Marp Build (README)

2s

>

✓

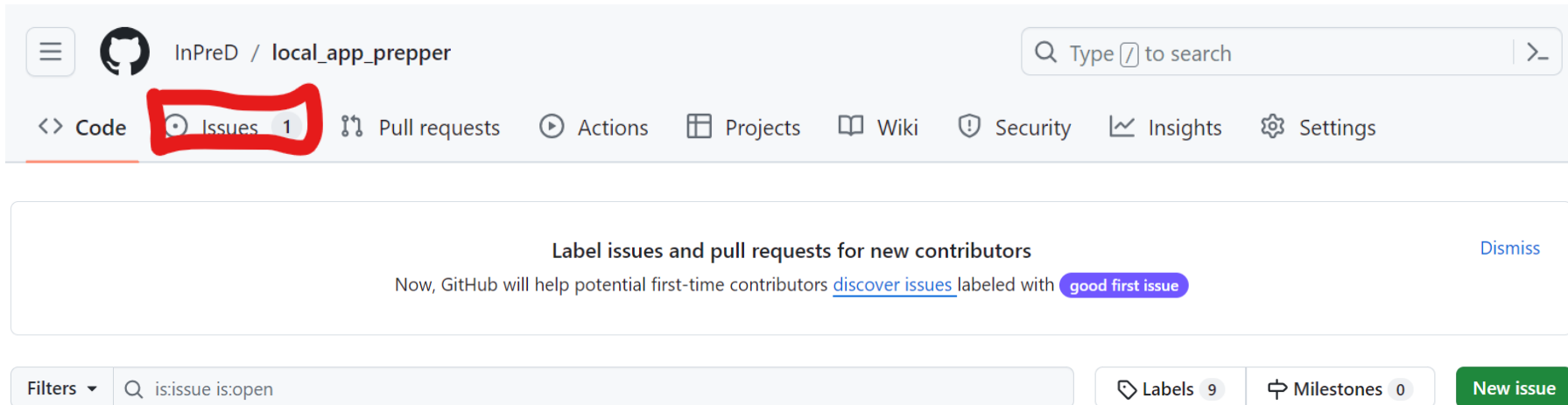
Marp Build (README.pdf)

3s

2. Development & Collaboration

GitHub workflow

- go to issues and create a **New issue**



GitHub workflow

- give the issue a descriptive title and a description and **Submit new issue**



Add a title

new fancy feature

Add a description

Write

Preview

H B I ≡ <> 🔗 | ☰ ☷ ⚙️ | 📎 @ 🗨️ ↩️ 📌

Add your description here...

📖 Markdown is supported

🖼️ Paste, drop, or click to add files

Assignees



No one—[assign yourself](#)

Labels



None yet

Projects



None yet

Milestone



No milestone

Development

Shows branches and pull requests linked to this issue.

Helpful resources

[GitHub Community Guidelines](#)

Submit new issue

GitHub workflow

- if you decide to work on the issue (own repository), **Create a branch** via the issue

The screenshot displays a GitHub issue interface. At the top, a comment by user 'marrip' is shown with the text 'No description provided.' Below this, 'marrip' is shown as having self-assigned the issue. The 'Add a comment' section is active, featuring a rich text editor with a toolbar containing icons for bold, italic, code, link, and other formatting options. A red rectangular box highlights the text 'Create a branch' in the 'Development' section, which is part of a message that says 'Create a branch for this issue or link a pull request.' To the right of the main content area, there are sections for 'Assignees' (listing 'marrip'), 'Labels' (showing 'None yet'), 'Projects' (showing 'None yet'), 'Milestone' (showing 'No milestone'), and 'Development' (with the highlighted 'Create a branch' link). At the bottom right, there is a 'Notifications' section with an 'Unsubscribe' button and a note stating 'You're receiving notifications because you were assigned.'

marrip commented now

Member

No description provided.

marrip self-assigned this now

Add a comment

Write Preview

H B I

Add your comment here...

Markdown is supported Paste, drop, or click to add files

Close issue

Comment

Assignees

marrip

Labels

None yet

Projects

None yet

Milestone

No milestone

Development

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

Notifications Customize

Unsubscribe

You're receiving notifications because you were assigned.

GitHub workflow

- Change branch source to develop and Create branch

Create a branch for this issue ×

Branch name
4-new-fancy-feature 📋

Repository destination
📁 InPreD/local_app_prepper ▾

What's next?
☐ Open in codespace
☒ Checkout locally
☐ Open branch with GitHub Desktop

Beta [Share feedback](#) Create branch

Change branch source

Create a branch for this issue ×

Branch name
4-new-fancy-feature 📋

Repository destination
📁 InPreD/local_app_prepper ▾

Branch source
🔗 develop ▾

What's next?
☐ Open in codespace
☒ Checkout locally
☐ Open branch with GitHub Desktop

Beta [Share feedback](#) Create branch

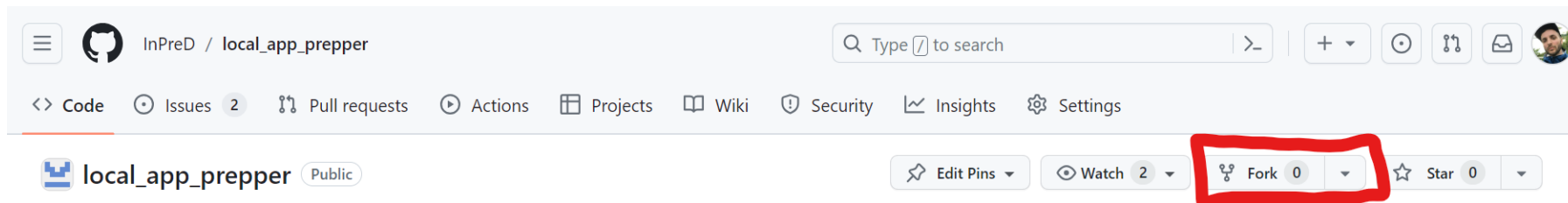
GitHub workflow

- load the new branch to your local repository, check it out and start working
- push your changes back to the remote

```
$ git pull
$ git checkout 4-new-fancy-feature
$ git add README.md
$ git commit -m "docs: updating docs"
$ git push
```

GitHub workflow

- for repositories you don't have access to, create a fork




GitHub workflow

Create a new fork

A *fork* is a copy of a repository. Forking a repository allows you to freely experiment with changes without affecting the original project.

Required fields are marked with an asterisk ().*

Owner * Repository name *


 marrip / local_app_prepper

✔ local_app_prepper is available.


By default, forks are named the same as their upstream repository. You can customize the name to distinguish it further.

Description (optional)

creates inputs.json files to be used with the LocalApp

 Copy the **main** branch only

Contribute back to InPreD/local_app_prepper by adding your own branch. [Learn more.](#)

 You are creating a fork in your personal account.

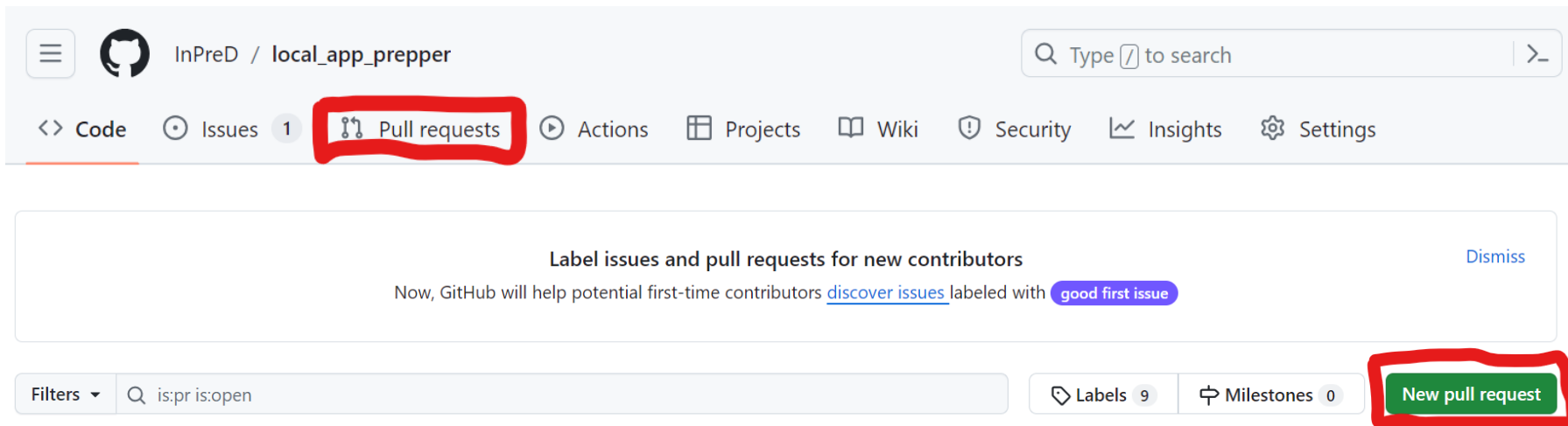
Create fork

GitHub workflow

- once you have a fork, `git clone` your forked repository
- create a new branch and work on that
- `git push` your changes back to the forked remote

GitHub workflow

- when you are done, go to pull requests and create a **New pull request**

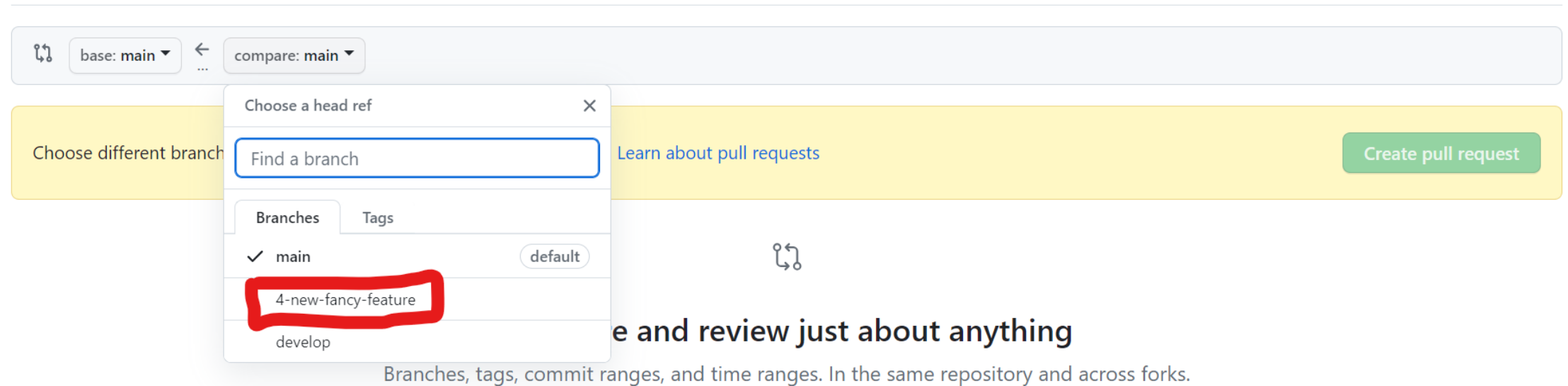


GitHub workflow

- choose `develop` as `base` and your new feature branch for `compare`

Compare changes

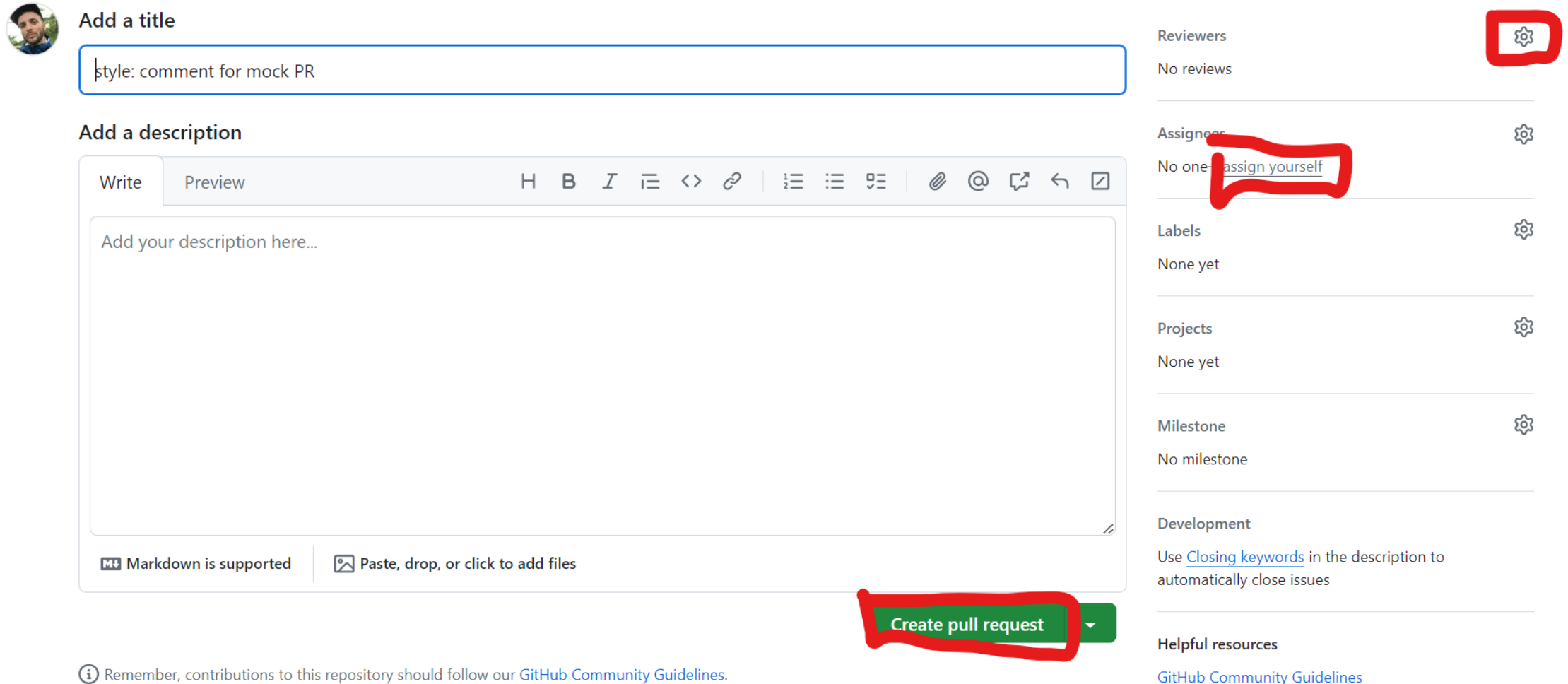
Compare changes across branches, commits, tags, and more below. If you need to, you can also [compare across forks](#).



The screenshot shows the GitHub 'Compare changes' interface. At the top, there are dropdowns for 'base: main' and 'compare: main'. Below these, a yellow banner contains the text 'Choose different branch', a search bar with 'Find a branch', a link 'Learn about pull requests', and a green button 'Create pull request'. A dropdown menu titled 'Choose a head ref' is open, showing a list of branches: 'main' (checked and marked 'default'), '4-new-fancy-feature' (highlighted with a red rectangle), and 'develop'. Below the dropdown, the text 'e and review just about anything' is visible, followed by a link 'Branches, tags, commit ranges, and time ranges. In the same repository and across forks.'

GitHub workflow

- assign yourself, add at least one reviewer (cog icon), provide some context and Create pull request



The screenshot shows the GitHub 'Create pull request' form. A red box highlights the 'Add a title' section, which contains the text 'style: comment for mock PR'. Another red box highlights the 'Add a description' section, which is empty. A third red box highlights the 'Assignees' section, where 'No one' is selected and 'assign yourself' is highlighted. A fourth red box highlights the 'Create pull request' button at the bottom right. On the right sidebar, a red box highlights the 'Reviewers' section, which shows 'No reviews' and a cog icon. Below the 'Assignees' section, the 'Labels' section shows 'None yet' and a cog icon. The 'Projects' section shows 'None yet' and a cog icon. The 'Milestone' section shows 'No milestone' and a cog icon. The 'Development' section shows 'Use [Closing keywords](#) in the description to automatically close issues'. At the bottom, a note says 'Remember, contributions to this repository should follow our [GitHub Community Guidelines](#)'.

Add a title

style: comment for mock PR

Add a description

Write Preview

Add your description here...

Markdown is supported Paste, drop, or click to add files

Reviewers

No reviews

Assignees

No one assign yourself

Labels

None yet

Projects

None yet

Milestone

No milestone

Development

Use [Closing keywords](#) in the description to automatically close issues

Helpful resources

[GitHub Community Guidelines](#)

Create pull request

Remember, contributions to this repository should follow our [GitHub Community Guidelines](#).

GitHub workflow

- if you still want to work on the pull request, you can **Convert to draft** to let the reviewers know that it is not done yet
- otherwise you can just wait for them to review your changes

style: comment for mock PR #5

Edit <> Code

Open marrip wants to merge 1 commit into main from 4-new-fancy-feature

Conversation 0 Commits 1 Checks 0 Files changed 1

+3 -1



marrip commented now

Member

No description provided.



style: comment for mock PR

Verified

35908ea



marrip requested a review from gertrudeln now



marrip self-assigned this now



marrip linked an issue now that may be closed by this pull request

new fancy feature #4

Open

Reviewers

gertrudeln

Still in progress

Convert to draft

Assignees

marrip

Labels

None yet

Projects

None yet

Milestone

No milestone

GitHub workflow


- as a reviewer, make your you check your email notifications to see if there is pull requests waiting for you
- open the pull request and start the review in the **Files changed** tab

style: comment for mock PR #5


Edit <> Code ▾

 Open marrip wants to merge 1 commit into `main` from `4-new-fancy-feature` 

 Conversation 0

 Commits 1

 Checks 0

 **Files changed 1**

+3 -1 



marrip commented now

Member ...

No description provided.



style: comment for mock PR

Verified

35908ea



marrip requested a review from gertrudeln now



marrip self-assigned this now




marrip linked an issue [now](#) that may be closed by this pull request

[new fancy feature #4](#)

 Open

Reviewers

 gertrudeln

Still in progress? [Convert to draft](#)

Assignees

 marrip

Labels

None yet


Projects

None yet

Milestone

No milestone

GitHub workflow

- you can leave comments and suggestions in the code by hovering over the line with the changes and clicking on 


style: comment for mock PR #5

Edit


<> Code ▾

 Open marrip wants to merge 1 commit into `main` from `4-new-fancy-feature` 

 Conversation 0

 Commits 1

 Checks 0

 Files changed 1



+3 -1 

Changes from all commits ▾ File filter ▾ Conversations ▾ Jump to ▾ 

0 / 1 files viewed

Review in codespace

Review changes ▾

4  local_app_prepper.py 

☐ Viewed

 ...

... @@ -1,6 +1,8 @@

1 1 #!/usr/local/bin/python

2



just a comment

3 5 from prepper.cli import main

4 6

5 7 if __name__ == "__main__":

6 - main()



8 + main()
















GitHub workflow

- you can type your comment


3 + # just a comment


Write

Preview

 |       |    |     

Leave a comment

 Markdown is supported

 Paste, drop, or click to add files

Cancel












Add single comment

Start a review



GitHub workflow

- or you leave a suggestion, ideally you click **Start a review** to initialise the reviewing process












3 + # just a comment

Write Preview  H B I        @   



Leave a comment

 Markdown is supported  Paste, drop, or click to add files

Cancel Add single comment **Start a review**

Write Preview  H B I        @   

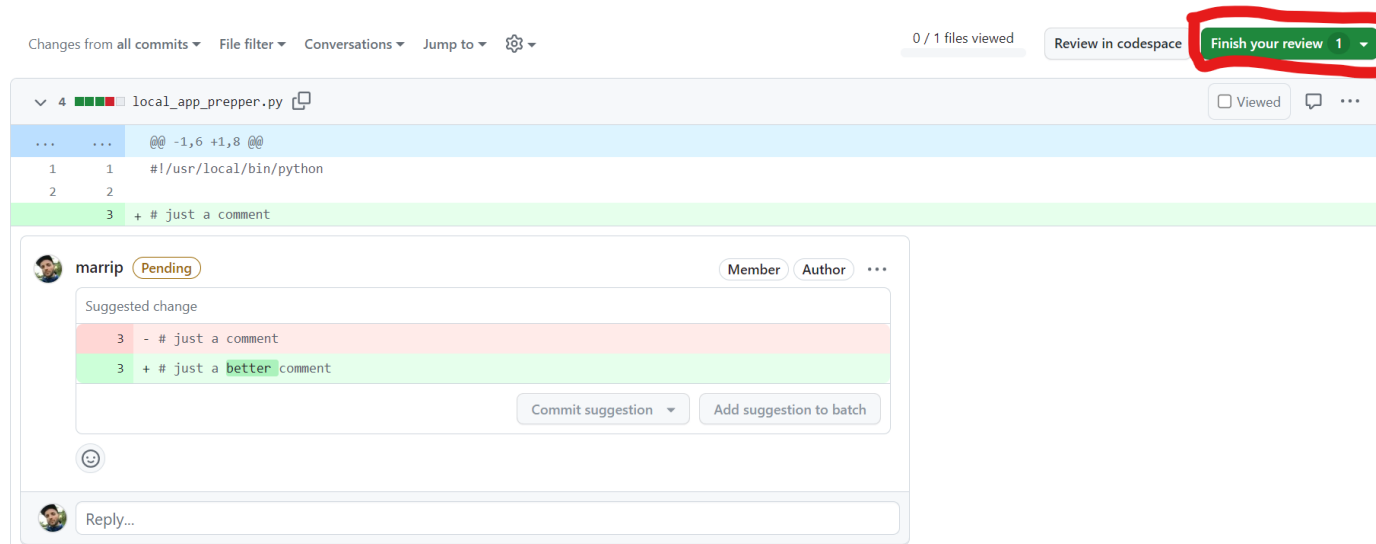
````suggestion`  
`# just a better comment`  
`````

 Markdown is supported  Paste, drop, or click to add files

Cancel Add single comment **Start a review**

GitHub workflow

- when you are done with reviewing, Finish your review



GitHub workflow

- again, leave a comment if you like, and choose if you just want to **Comment**, **Approve** or **Request changes**

Finish your review



Write Preview **H** **B** *I* | | @

Leave a comment

Markdown is supported | Paste, drop, or click to add files

- ☒ **Comment**
Submit general feedback without explicit approval.
- ☐ **Approve**
Submit feedback and approve merging these changes.
- ☐ **Request changes**
Submit feedback that must be addressed before merging.

Submit review

GitHub workflow

- you can add a general comment to the pull request under Conversation



Add a comment


Write


Preview

H B I ≡ <> 🔗 ⋮ ≡ ⋮ ⋮ 📎 @ ↗ ↶ 🗒

LGTM 👍 |

M+ Markdown is supported

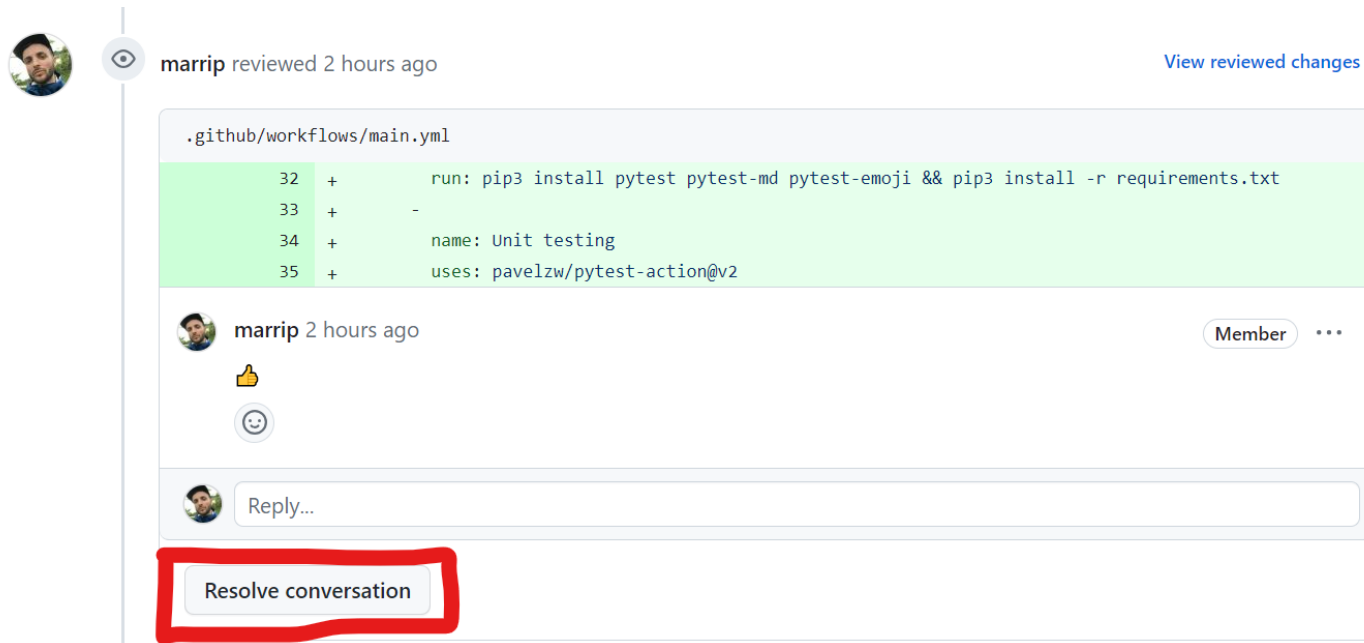
 Paste, drop, or click to add files

 Close with comment

Comment

GitHub workflow

- after the reviewer left their comments and suggestions, you can address them one by one by replying or applying the suggested changes
- whenever a certain comment/suggestion is handled (discussion comes to conclusion, suggestion was applied), you can resolve it



The screenshot shows a GitHub pull request review interface. At the top, a user profile icon for 'marrip' is shown next to the text 'marrip reviewed 2 hours ago'. To the right of this is a link 'View reviewed changes'. Below this is a code diff for the file '.github/workflows/main.yml'. The diff shows lines 32 to 35, all with '+' indicating additions. The code is: line 32: 'run: pip3 install pytest pytest-md pytest-emoji && pip3 install -r requirements.txt', line 33: a hyphen '-', line 34: 'name: Unit testing', and line 35: 'uses: pavelzw/pytest-action@v2'. Below the code diff is a comment by 'marrip' from '2 hours ago'. The comment contains a thumbs-up emoji and a smiley face emoji. To the right of the comment is a 'Member' badge and a three-dot menu. Below the comment is a 'Reply...' input field. At the bottom of the comment box is a button labeled 'Resolve conversation', which is highlighted with a red rectangular border.

marrip reviewed 2 hours ago [View reviewed changes](#)

```
.github/workflows/main.yml
32 + run: pip3 install pytest pytest-md pytest-emoji && pip3 install -r requirements.txt
33 + -
34 + name: Unit testing
35 + uses: pavelzw/pytest-action@v2
```

marrip 2 hours ago Member ...



👍 😊

Reply...

Resolve conversation

GitHub workflow


- as soon as the reviewers gave you an approval, you can finally **Merge pull request**




gertrudeln approved these changes 1 minute ago


[View reviewed changes](#)


Add more commits by pushing to the 4-new-fancy-feature branch on InPreD/local_app_prepper.





Require approval from specific reviewers before merging
[Rulesets](#) ensure specific people approve pull requests before they're merged.

[Add rule](#) 



This branch has no conflicts with the base branch
Merging can be performed automatically.

Merge pull request

You can also [open this in GitHub Desktop](#) or view [command line instructions](#).


2. Development & Collaboration

Release

- releases should be from `main` branch
- good practice is to open a pull request for `develop` into `main` when you are done with the desired features


Release










- whenever you are ready for a new release, **create a new release**

 **local_app_prepper** Public

Edit Pins Watch 2 Fork 0 Star 0








main 3 Branches 1 Tags Add file <> Code About

 **marrip** Merge pull request [#1](#) from InPreD/develop ... ✓ f6930c1 · last week 🕒 31 Commits

| | | |
|---|--|--------------|
|  .devcontainer | chore: update devcontainer with testing devs | 3 months ago |
|  .github/workflows | ci: split testing and building into 2 jobs | last month |
|  prepper | tests: use parametrized pytest unit testing and check excep... | last week |
|  templates | fix: rm unused stanza from gather json | 3 months ago |
|  test | tests: use parametrized pytest unit testing and check excep... | last week |
|  .dockerignore | ci: add Dockerfile | 3 months ago |
|  .gitignore | feat: produce inputs.json for demultiplexing, one per sampl... | 3 months ago |
|  Dockerfile | ci: add procps to docker image | 3 months ago |
|  LICENSE | Initial commit | 3 months ago |


About

creates inputs.json files to be used with the LocalApp

-  Readme
-  GPL-3.0 license
-  Activity
-  Custom properties
-  0 stars
-  2 watching
-  0 forks

[Report repository](#)

Releases

 1 tags


[Create a new release](#)


Release

- add a title and a description for your release and **Choose a tag**

Releases

Tags

 Choose a tag ▼

 Target: main ▼







Generate release notes

Choose an existing tag, or create a new tag when you publish this release.



Release title

Write

Preview

H B I ≡ <>      @  ↩

Describe this release

 Markdown is supported  Paste, drop, or click to add files

Tagging suggestions

It's common practice to prefix your version names with the letter v. Some good tag names might be v1.0.0 or v2.3.4.

If the tag isn't meant for production use, add a pre-release version after the version name. Some good pre-release versions might be v0.2.0-alpha or v5.9-beta.3.

Semantic versioning

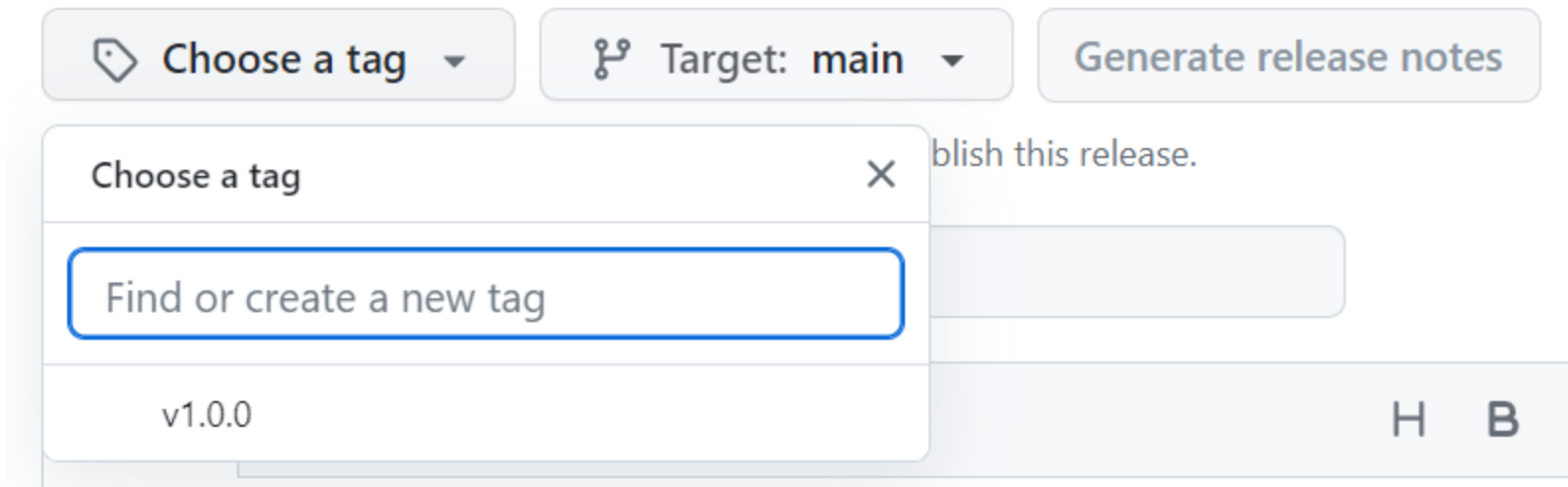
If you're new to releasing software, we highly recommend to [learn more about semantic versioning](#).

A newly published release will automatically be labeled as the latest release for this repository.

If 'Set as the latest release' is unchecked, the latest release will be determined by higher semantic version and creation date. [Learn more about release settings](#).

Release

- ideally, you choose a tag according to semantic versioning



The image shows a user interface for creating a release. At the top, there are three buttons: 'Choose a tag' with a tag icon, 'Target: main' with a branch icon, and 'Generate release notes'. Below the 'Choose a tag' button, a dropdown menu is open. The menu has a title bar 'Choose a tag' with a close button (X). Inside the menu, there is a text input field with the placeholder 'Find or create a new tag'. Below the input field, the tag 'v1.0.0' is listed. To the right of the dropdown, the text 'Publish this release.' is visible. Below the dropdown, there are two buttons labeled 'H' and 'B'.

Release

Semantic versioning

- version tag should be **MAJOR.MINOR.PATCH**
- you increment one of the three depending on the change
 - **MAJOR**: version when you make incompatible API changes
 - **MINOR**: version when you add functionality in a backward compatible manner
 - **PATCH**: version when you make backward compatible bug fixes

Release

- when you are satisfied with your release, **Publish release**

Write

Preview

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Describe this release

Markdown is supported Paste, drop, or click to add files

↓ Attach binaries by dropping them here or selecting them.

☐ Set as a pre-release

This release will be labeled as non-production ready

Publish release

Save draft

2. Development & Collaboration

Licensing

- let's discuss



I need to work in a community.

Use the **license preferred by the community** you're contributing to or depending on. Your project will fit right in.

If you have a dependency that doesn't have a license, ask its maintainers to **add a license**.



I want it simple and permissive.

The **MIT License** is short and to the point. It lets people do almost anything they want with your project, like making and distributing closed source versions.

Babel, **.NET**, and **Rails** use the MIT License.



I care about sharing improvements.

The **GNU GPLv3** also lets people do almost anything they want with your project, *except* distributing closed source versions.

Ansible, **Bash**, and **GIMP** use the GNU GPLv3.

2. Resources

- [About Git](#)
- [Gitflow workflow](#)
- [GitHub Actions](#)
- [Semantic versioning](#)
- [Licensing](#)

3. Nextflow

Short introduction

- workflow manager that enables scalable and reproducible scientific workflows using software containers
- an extension of groovy which is object-oriented programming language for the Java platform
- **nf-core**: project/community that develops framework for nextflow including guidelines, tools, modules, subworkflows, pipelines and test data

3. Nextflow

Requirements

- POSIX compatible system (e.g. Linux, Os X)
- Bash
- Java ≥ 11 / ≤ 21
- Docker/Singularity

3. Nextflow

Installation

```
$ curl -s https://get.nextflow.io | bash  
$ chmod +x nextflow
```

or

```
$ wget -O nextflow https://github.com/nextflow-io/nextflow/releases/download/v23.10.1/nextflow-23.10.1-all
```

or via browser at <https://github.com/nextflow-io/nextflow/releases>

3. Nextflow

Best practice

- containerized processes

3. Resources

- nf-core template
- stubbing
- nextflow.io
- nf-co.re
- [nf-core github](https://github.com/nf-core)

4. `tso500_nxf_workflow`

- status
- demonstration

5. Python

- general (best practice, cli)
- unit testing (pytest)

Resources

- [nf-core](#)
- [pytest unittesting](#)