CS 45, Lecture 10
Version Control II

Spring 2023
Akshay Srivatsan, Ayelet Drazen, Jonathan Kula
Outline

1. Review
2. Merge Conflicts
3. Commit Etiquette
4. GitHub
1. Review

2. Merge Conflicts

3. Commit Etiquette

4. GitHub
Overview

Last lecture, we saw:

- How to keep track of linear (ordered) histories of files
- How to turn non-linear version history into pseudo-linear history
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• How to keep track of linear (ordered) histories of files
• How to turn non-linear version history into pseudo-linear history

In this lecture, we will see:

• How to resolve merge (or rebase) conflicts
• How to collaborate on files with others over the internet
• How to back up your files and their history on the internet
Git is Confusing

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• Ask as many questions as you need, and don't let me move on if you don't yet understand something.
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- Ask as many questions as you need, and don't let me move on if you don't yet understand something.

```plaintext
commit c8f3dcbfb0e87d4aa334f6bcdd541db78135881 (origin/master, origin/HEAD)
Merge: 480cbe2 2a7f97b
Author: engler <ddd.rrr.eee@gmail.com>
Date: Thu Feb 13 14:27:50 2020 -0800

git. sucks.

Merge branch 'master' of github.com:dddrrreee/cs140e-20win
```
**Terminology**

- **HEAD** is the branch you're currently looking at
- **a branch** is a named version of a repository
- **fast-forwarding** means moving an old branch “forward” to add new commits from a more recent branch
- **merging** is a way of combining branches by creating a single “merge commit”
- **cherry-picking** is a way of moving commits from one branch to another
- **rebasing** is a way of moving an *entire branch* to have a different “base”
Rebasing

When you rebase a branch onto a new "base commit":

A → B → C
When you rebase a branch onto a new “base commit”:
Rebasing

When you rebase a branch onto a new "base commit":

```
A → B → C
  ↓
  X → Y
```

- `main` branch
- `feature` branch
When you rebase a branch onto a new “base commit”: 

Rebasing

A → B → C → D → E

X → Y

main

feature
Rebasing

When you rebase a branch onto a new “base commit”:

```
A -> B -> C -> D -> E
```

```
X -> Y
```

- **main**
- **feature**
Rebasing

When you rebase a branch onto a new “base commit”: 

```
A → B → C → D → E

X → Y → X'
```

- **A** → **B** → **C** → **D** → **E** (main)
- **X** → **Y** → **X'** (feature)
Rebasing

When you rebase a branch onto a new "base commit":

```
A -> B -> C -> D -> E

X -> Y -> X' -> Y'
```

- `main`
- `feature`
Rebasing

When you rebase a branch onto a new "base commit":

```
A -> B -> C -> D -> E

X ---- X' -> Y ---- Y'

main

feature
```
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## Merge Conflicts

### Definition (merge conflict)

A merge conflict is what happens when you try to combine two contradictory branches. Git can’t always figure out how to resolve the contradiction, so it’ll ask the user (you).
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Merge Conflicts

Git will tell you which files conflicted, and tell you to resolve the commits and commit the results:

Auto-merging hello.txt
CONFLICT (content): Merge conflict in hello.txt
Automatic merge failed; fix conflicts and then commit the result.
Merge Conflicts

Conflict Markers

Git will also add conflict markers to the files:

Hello, my name is Akshay Srivatsan.
<<<<<<< HEAD
I'm doing my PhD in the Stanford CS department.
=======
I am a PhD student studying CS at Stanford.
>>>>>>> add-major
I'm currently co-teaching CS45 and doing research.

This might look scary, but it's not that bad!
Hello, my name is Akshay Srivatsan.

<<<<<<< HEAD
I'm doing my PhD in the Stanford CS department.
=======
I am a PhD student studying CS at Stanford.
>>>>>>> add-major

I'm currently co-teaching CS45 and doing research.
Merge Conflicts

Conflict Markers: The Incoming Branch

The top part (labeled with a branch name or commit message) are the changes in the incoming branch (the one you're merging):

Hello, my name is Akshay Srivatsan.
<<<<<<<<< HEAD
I'm doing my PhD in the Stanford CS department.
=========
I am a PhD student studying CS at Stanford.
>>>>>> add-major
I'm currently co-teaching CS45 and doing research.
Resolving a Conflict

Pick how you want to resolve the conflict (i.e., decide what the “correct” result of the merge is), and make the file look that way!

Hello, my name is Akshay Srivatsan.
I'm a PhD student in the Stanford CS department.
I'm currently co-teaching CS45 and doing research.

In this case, I mixed together both versions. The “correct” answer often depends on what exactly you're doing, which is why Git can't figure it out for you.
Merge Conflicts

Commiting the Merge

Resolve all the conflicts in all the files however you want, then:

1. `git add` your changes to track them
2. `git commit` the changes (with no message)

Git will auto-generate a message, and open your `$EDITOR` to have you confirm it:

```
Merge branch 'add-major'
```

Save the file in your editor and close it (`:wq` in Vim), and Git will save the merge commit. That's it—the merge conflict is gone!
Merge Conflicts

Rebase Conflicts

Resolve all the conflicts in all the files however you want, then:

1. `git add` your changes to tell Git you fixed them
2. `git rebase --continue`

Since rebasing doesn't create a merge commit, you don't run `git commit`; use `git rebase --continue` instead!

Remember, rebasing happens *backwards*; the base branch (the one onto which you're rebasing) becomes HEAD, and the “feature” branch becomes the incoming branch.
Resolving Merge Conflicts

To resolve a merge conflict:

1. Don't panic!
2. Look at the files in conflict (run git status to see what's going on).
3. Fix each conflict, one-by-one.
4. When you're done, git add all the fixed files and git commit.

Let's practice!

Merge conflicts usually happen in shared repos, so let's clone one of my repos onto your computer:

```
git clone https://github.com/Akshay-Srivatsan/cs45-23win-demo-repo.git
```
Resolving Merge Conflicts

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```
git clone https://github.com/Akshay-Srivatsan/cs45-23win-demo-repo.git
```
Pulling Changes

You might have seen references to the `git pull` command before. This is a combination of two commands, but the exact two depends on your Git version and configuration:

- `git pull --ff-only`: `git fetch` and `git merge --ff-only` (Default)
- `git pull --no-rebase`: `git fetch` and `git merge` (Old Default)
- `git pull --rebase`: `git fetch` and `git rebase`

Depending on your preferences, you can configure `git pull` to do any of these.
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Commit Messages

Git only saves work that we've committed, so we want to commit as often as possible, but...

• Other people will also look at your commit history to see what you did.
• Your commit messages in the history should be short and specific, but descriptive enough that someone new can understand what they do.
• Similarly, each of your commits should do a single thing, so a single message can describe it easily.
• Good commits are *bisectable*; you should be able to checkout any commit in main and get a valid (e.g., compilable) state of your repo.

Writing good commit messages is part of being a good programmer!
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Squashing Commits

We can commit often locally but still have meaningful commits in the end by SQUASHING commits together with INTERACTIVE REBASE.
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Editing History

Interactive rebasing edits history! Don't do this on a branch you share with other people (like main). In general, only do this on commits you have not pushed. Otherwise, you'll have to FORCE-PUSH (git push --force) your changes, which will destroy everyone else's changes.
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You can start an interactive rebase using the command git rebase --interactive <base>; for example, git rebase --interactive main will let you edit every commit that's in your branch but not in main.
Interactive Rebasing

Git will open $EDITOR with a list of actions (which you can edit!).

```
pick 0cd3296 start working on new file
pick 594a80c continue working
pick 162392b almost done
pick bf45520 done
pick c545ae9 oops, had a bug
pick 9b3d056 fix the bug for real this time
```

Each line represents one commit. The first word is a “command”; `pick` cherry-picks (i.e., includes) the commit in the new history, `reword` lets you edit the commit message, `edit` lets you change the commit contents, `squash` and `fixup` both squash the commit into the previous one, and `drop` removes the commit.
Squash and Fixup Commits

Squash commits let you specify that two commits are closely related, so they should be combined into a single commit with both messages.

Fixup commits let you specify that a particular commit just “fixes” a previous one, and therefore should be absorbed into the previous commit.

```
  reword 0cd3296 start working on new file
  squash 594a80c continue working
  squash 162392b almost done
  squash bf45520 done
  squash c545ae9 oops, had a bug
  squash 9b3d056 fix the bug for real this time
```
Rewording Commits

When you want to reword a commit, Git will open $EDITOR and ask you for a new commit message. Enter the message you want, save, and quit.

Add a file providing more information about the project

# Please enter the commit message for your changes. Lines starting
# with '#' will be ignored, and an empty message aborts the commit.
#
# Date: Fri Feb 3 22:34:02 2023 -0800
Amending Commits

If you want to edit the most recent commit you made (i.e., HEAD), you can skip the rebase and just AMEND it, using `git commit --amend`.

This will also let you edit the commit message of the last commit.
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If you want to add to an earlier commit but don’t want to do the full interactive rebase yet, you can use `git commit --fixup <hash>` to mark a commit as being a fixup commit of an earlier commit.

You can then use `git rebase --interactive --autosquash <base>` to automatically absorb your fixup commits into the original commits.
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Again, only do this if no one else is using your branch.
Good Commit Messages

- b68f706 Add training trick for handling missing notes
- 7c0afae Fix audio issue in metronome
- fa18a3d Add a metronome for beat tracking
- 739aa0a Add test for per-millisecond prediction on MIDI files
- dc4693a Use last eight piano roll columns to predict next
- eb327b4 Fix timing bug in MIDI file parser
- b46c6f6 Add MIDI training demo program
- a624b32 Switch to cross-entropy loss for MIDI classifier
- db3c6f3 Fix bug in MIDI parser
- 5b0f299 Return effective learning rate from training wrapper
- 726886d Print more relevant training info from full-piano predictor
Bad Commit Messages

a527839  minor
adaf72e  minor
c9c6193  minor
d64a6ef  minor
ff2636e  minor
4a988f2  minor
cb901d5  minor
8d4e80a  minor
53b5e84  minor
0321f79  minor
4126899  minor
f1d7231  minor
cefba82  minor
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<thead>
<tr>
<th>Commit Hash</th>
<th>Change Type</th>
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<tbody>
<tr>
<td>a527839</td>
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<tr>
<td>adaf72e</td>
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<tr>
<td>c9c6193</td>
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<tr>
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<td>f492a3f</td>
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<td>Commit</td>
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<td>minor</td>
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<td>0543316</td>
<td>minor</td>
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<tr>
<td>40b48f6</td>
<td>minor</td>
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<tr>
<td>fb0ec84</td>
<td>minor</td>
</tr>
<tr>
<td>3a124af</td>
<td>added basic files.</td>
</tr>
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</table>
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• You MERGE or REBASE your local main into/onto origin/main.

• You PUSH your new main back to the remote, which updates its main and your origin/main.
Let's create a new repository on GitHub!

You'll need the git command and the GitHub CLI (gh).

1. Go to https://github.com/new and pick a name.
2. Click “Create repository” to continue.
3. Run git clone with the URL of your new repo.
4. Run gh auth login from inside your new clone. Tell gh that you want to use it to authenticate with git.
5. Make some changes (add a file), and run git push to upload them!
Let's start collaborating!

1. On the GitHub website for your repo, go to “Settings” and click on “Collaborators”.

2. Add the person sitting next to you as a collaborator!

3. Make a clone of their repo, make some changes, then commit and push them. Use `git fetch` or `git pull` to download their changes to your repo.

4. What happens if you both try to edit the same file at the same time?

5. Can you push a new branch to your partner's repo?¹

¹Hint: you might have to use the `--set-upstream` flag; Git will tell you exactly what to do.
Pull Requests

- It's dangerous to give access to the main branch on your repo to everyone; someone might start messing with it!

- In “Settings/Branches”, you can enable BRANCH PROTECTION for main. Specifically, you can enable “Require a pull request before merging”.

- A PULL REQUEST\(^2\) is a way to review a change before merging it. You (the repo owner/maintainer) can choose whether to approve or reject the request.

- To create a pull request: create a new branch, make your changes, push your new branch, then run `gh pr create`.

\(^2\)This is misleadingly named, it’s really a “merge request”
When to use Git

- When you want to look at past versions of a folder.
- When you want to be safe from accidentally overwriting your work.
- When you want to collaborate with other people asynchronously (use GitHub!).
- When you want to keep a backup copy of a folder with full history (use GitHub!).
- You want to “fork” a project already using Git/GitHub and contribute back to it.