

# Program Analysis with ML

ML, Coding Companions, The Future

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Lecture #10 out of 10

80 minutes

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How Machine Learning Works?

AI Coding Companions

What's Next?

Chapter #1:

# How Machine Learning Works?

[ [Determinism](#) Training Embedding Tasks ]

## Deterministic Algorithm

A *deterministic* algorithm means that given a particular input, the algorithm will always produce the same output:

```
String sayHello(int hours, int minutes) {  
    if (hours > 4 && hours < 12) {  
        return "Good morning!";  
    } else if (hours > 12 && hours < 18) {  
        return "Good afternoon!";  
    } else if (hours > 18 && hours < 22) {  
        return "Good evening!";  
    }  
    return "Good night!";  
}
```

The behavior of the `sayHello()` function is defined upfront by its creator.

[ Determinism [Training](#) Embedding Tasks ]

## Training a Model

“The process of training an *ML model* involves providing a *learning algorithm* with *training data*. The algorithm finds patterns in the training data that map the *input data attributes* to the *target attributes*, and it outputs an ML model that captures these patterns.” (c) Amazon

```
8:35  Good morning!
8:40  Good morning!
10:00  How are you?
11:55  Good afternoon!
13:18  Good day!
14:50  Good afternoon!
15:22  Good afternoon, Sir!
17:14  Good evening!
...
22:34  Evening!
23:50  Good night!
```

$$f : H \times M \rightarrow G$$

$$H = \{0, 1, 2, \dots, 23\}$$

$$M = \{0, 1, 2, \dots, 59\}$$

$$G = \{\text{"Good morning!"}, \\ \text{"Good afternoon!"}, \\ \text{"Good evening!"}, \\ \text{"Good night!"}\}$$

[ Determinism Training [Embedding](#) Tasks ]

## Embedding

“An *embedding* is a relatively low-dimensional space into which you can translate high-dimensional vectors.” (c) Google

Features:	Embeddings:	Vectors:
8:35 Good morning!	(8, 30, "morning")	(8, 30, 0)
8:40 Good morning!	(8, 45, "morning")	(8, 45, 0)
10:00 How are you?	NIL	
11:55 Good afternoon!	(12, 00, "morning")	(12, 00, 0)
13:18 Good day!	NIL	
14:50 Good afternoon!	(14, 45, "afternoon")	(14, 45, 1)
15:22 Good afternoon, Sir!	(15, 30, "afternoon")	(15, 30, 1)
17:14 Good evening!	(17, 00, "evening")	(17, 00, 2)
...	...	...
22:34 Evening!	(22, 30, "evening")	(22, 30, 2)
23:50 Good night!	(23, 45, "night")	(23, 45, 3)

[ Determinism Training Embedding Tasks ]

## Data Science

There are five tasks to complete *repeatedly*:

1. Collect and clean a dataset
2. Define features + embeddings
3. Choose and tune an algorithm
4. Train a Model
5. Validate the Model

Chapter #2:

## AI Coding Companions



[ [Complete](#) PR Review Risks Explain Safurai Repeat Tests Refactor LLM ]

## Auto Code Completion

This is how Copilot by GitHub is suggesting code completion in our own programming language, which he definitely hasn't seen before:

```
81 # Converts this to hash
82 [] > as-hash
83 reduced. > @
84 list
85   bytes-as-array ^
86   1
87   [a b]
88   plus. > @
89   times.
90   31
91   a
92   as-int.
93   (0.as-bytes.and b).right 54
```

```
81 # Converts this to hash
82 [] > as-hash
83 reduced. > @
84 list
85   bytes-as-array ^
86   1
87   [x y] > +
88     ^,left
89     ^,right
```

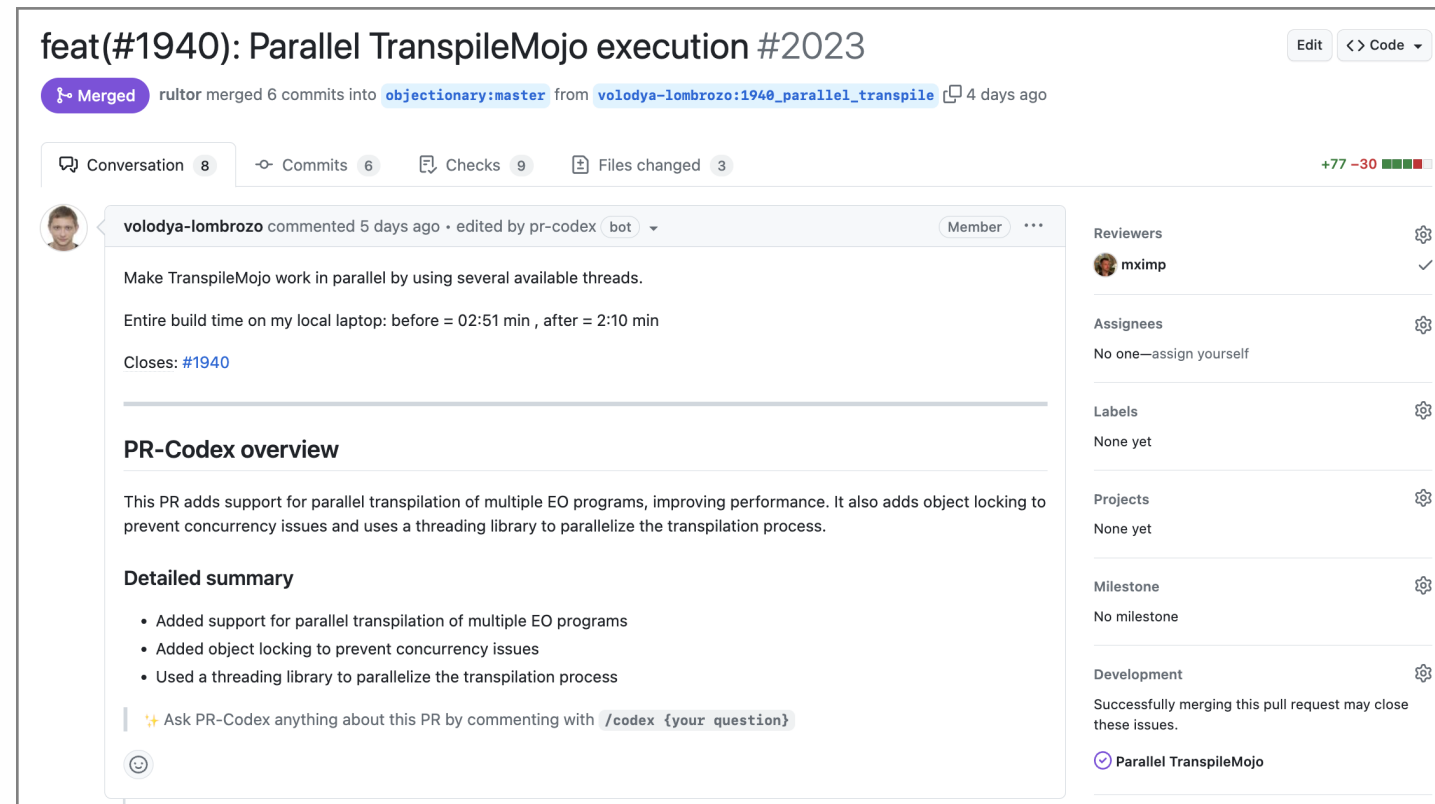
```
# Converts this to hash
[] > as-hash
reduced. > @
list
  bytes-as-array ^
  1
  [a b]
  |^,or (a.xor b) > @
```

```
81 # Converts this to hash
82 [] > as-hash
83 reduced. > @
84 list
85   bytes-as-array ^
86   1
87   [a b]
88   plus. > @
89     list
90     a
91     b
```

Read also about AWS CodeWhisperer at Werner Vogels' blog. Also, about TabNine (used to be Codota).

[ Complete [PR](#) Review Risks Explain Safurai Repeat Tests Refactor LLM ]

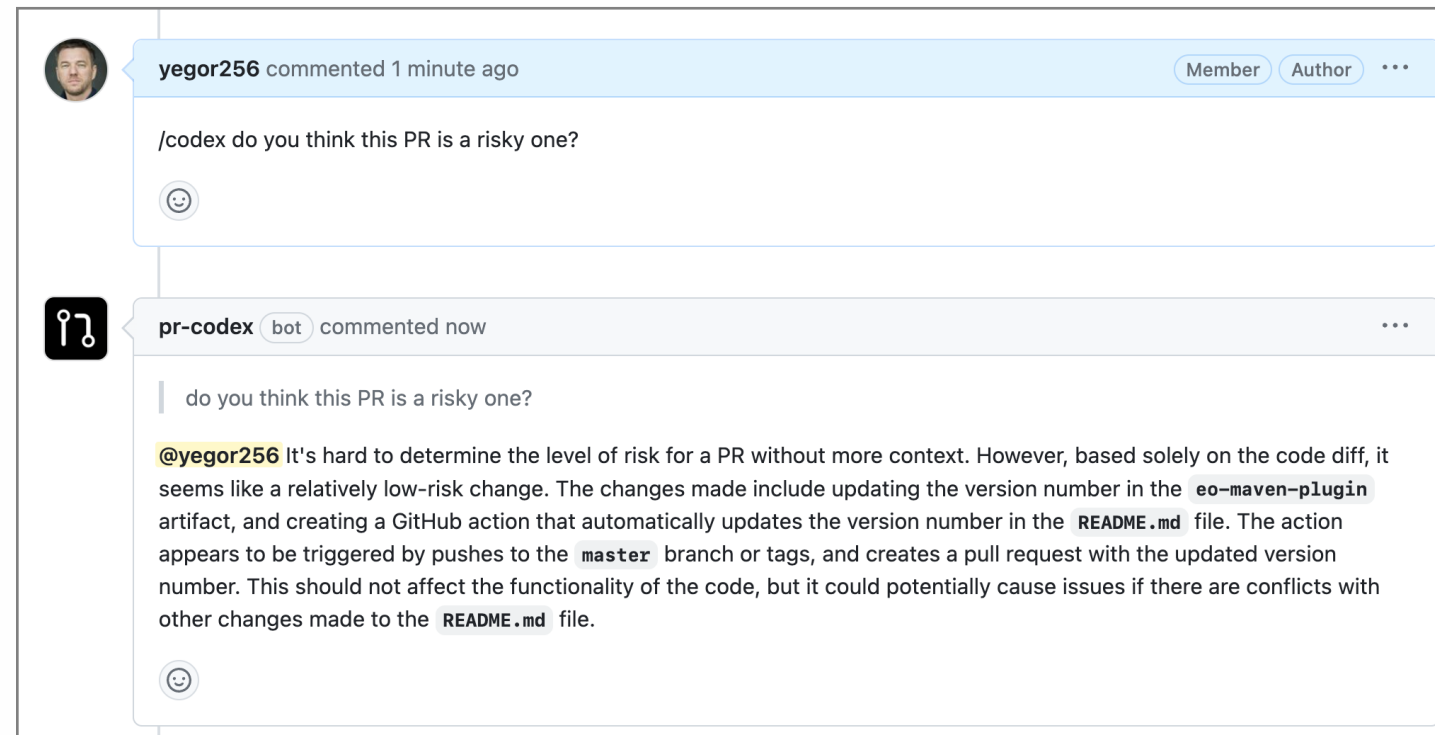
## Pull Request Explanation



PR-Codex plugin for GitHub by dlabs

[ Complete PR [Review](#) Risks Explain Safurai Repeat Tests Refactor LLM ]

## Reviewing Changes



The discussion happened in this GitHub issue: [objectionary/eo:2034](#)

[ Complete PR Review [Risks](#) Explain Safurai Repeat Tests Refactor LLM ]

# Pull Request Risk Analysis

Filters

is:pr is:open

Labels 15

Milestones 0

New pull request

☐

🔗

21 Open

✓

913 Closed

Author

Label

Projects

Milestones

Reviews

Assignee

Sort

☐

🔗

New version in README

✓

#2053 opened 16 hours ago by github-actions (bot)

☐

🔗

#1915 Enable IT tests

✗

codeball:approved

#2051 opened 2 days ago by mximp

1

2

☐

🔗

feat(#2046): Specify javadoc sources explicitly

✓

codeball:needs-careful-review

#2049 opened 2 days ago by volodya-lombrozo

1

7

☐

🔗

feat(#2017): Enable BinarizeMojoTest run in parallel

✓

codeball:needs-careful-review

#2045 opened 3 days ago by volodya-lombrozo

1

9

☐

🔗

added a test to solve the missing attribute problem

✓

#2042 opened 3 days ago by Graur

1

1

☐

🔗

feat(#2015): Fix concurrency problem with LogFormatTest

✓

#2040 opened 4 days ago by volodya-lombrozo

1

9

☐

🔗

2011 rusr name loc2code csv

✗

#2028 opened last week by levBagryansky • Draft

☐

🔗

2011 rust name by location

✓

codeball:needs-careful-review

#2027 opened last week by levBagryansky

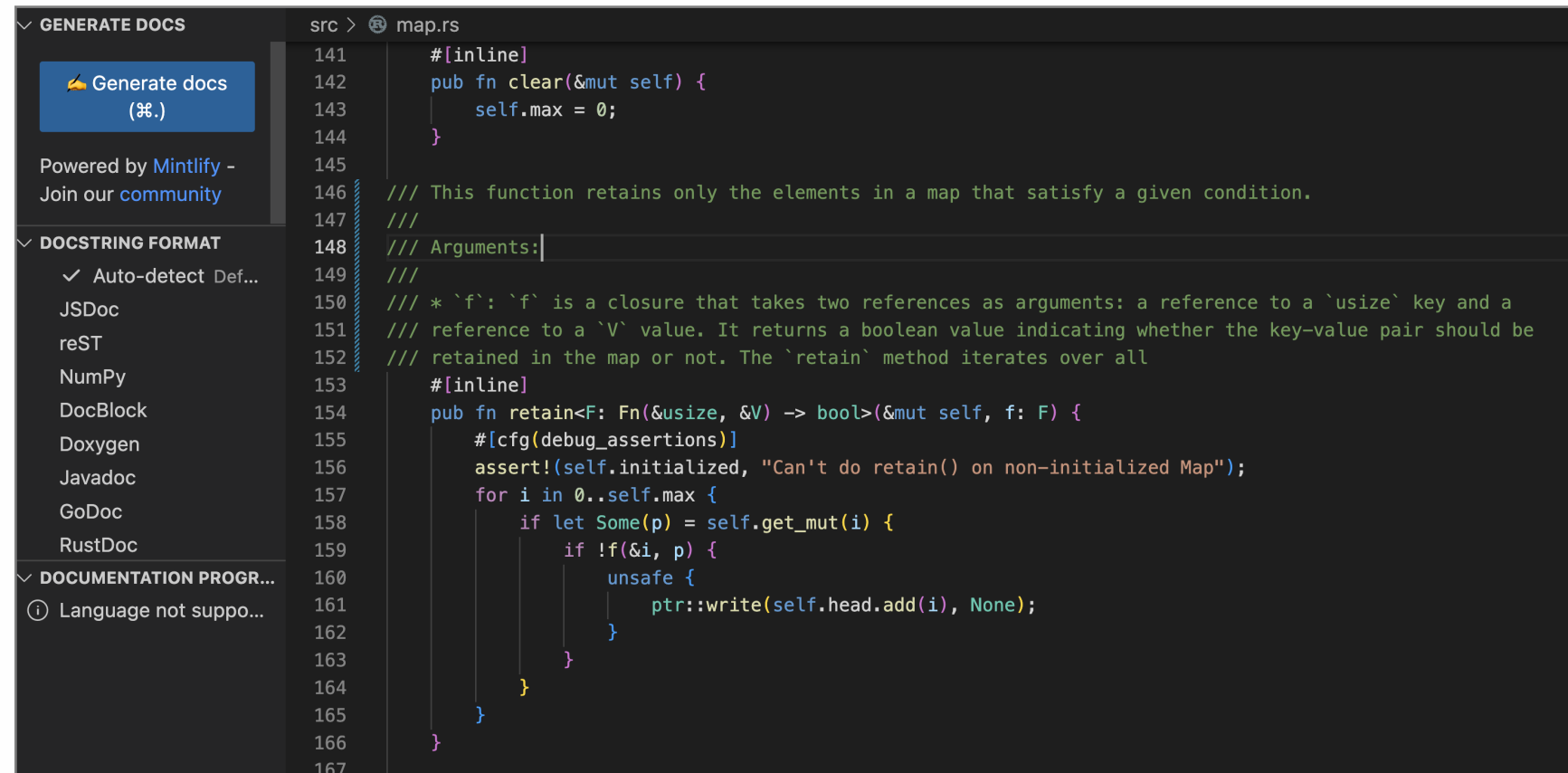
1

73

## Codeball plugin for GitHub

[ Complete PR Review Risks [Explain](#) Safurai Repeat Tests Refactor LLM ]

Explain This to Me!



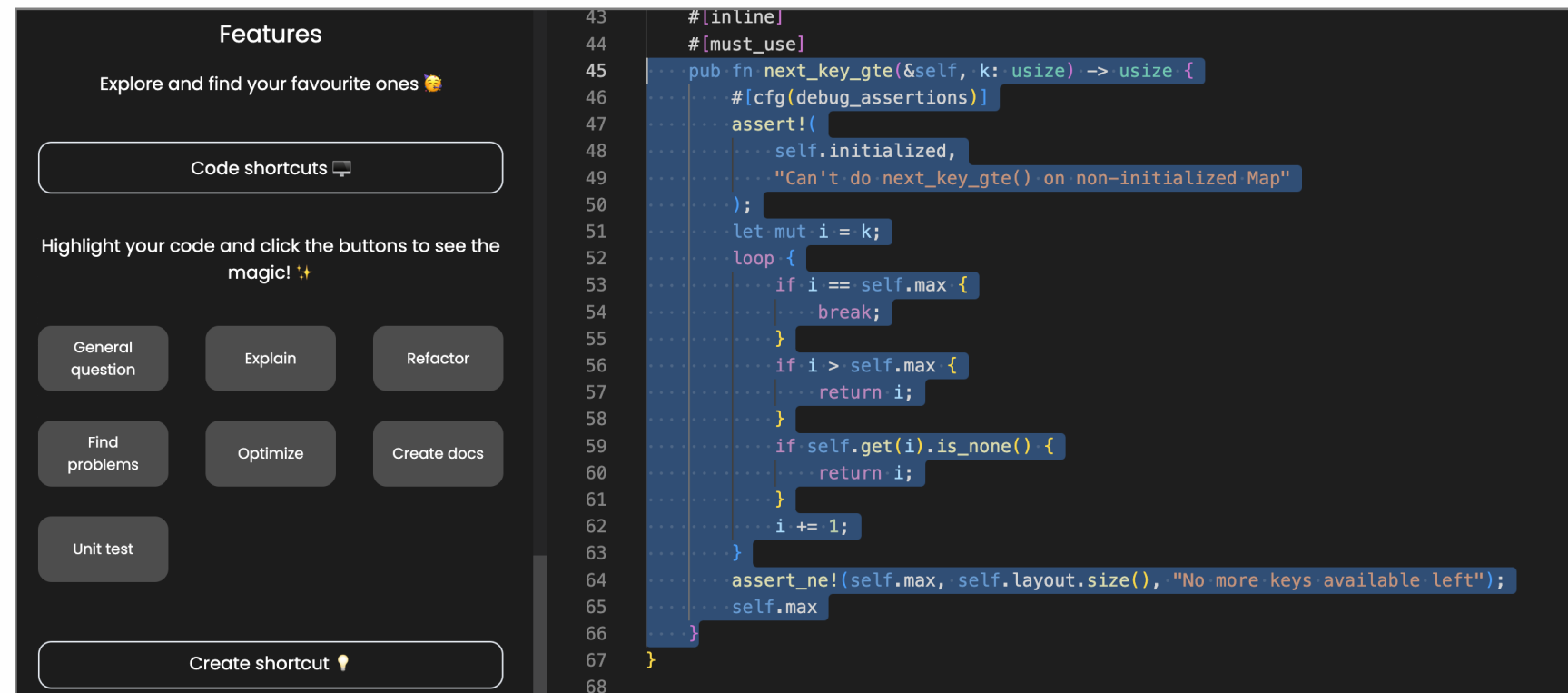
The screenshot shows the VS Code interface with the Mintlify documentation generator plugin. On the left, the 'GENERATE DOCS' sidebar is open, showing a 'Generate docs (%.)' button and a list of documentation formats: JSDoc, reST, NumPy, DocBlock, Doxygen, Javadoc, GoDoc, and RustDoc. Below this, there's a 'DOCUMENTATION PROGR...' section with a note 'Language not suppo...'. The main editor area displays a Rust file named 'map.rs' with the following code:

```
src > map.rs
141  #[inline]
142  pub fn clear(&mut self) {
143      self.max = 0;
144  }
145
146  /// This function retains only the elements in a map that satisfy a given condition.
147  ///
148  /// Arguments:
149  ///
150  /// * `f`: `f` is a closure that takes two references as arguments: a reference to a `usize` key and a
151  /// reference to a `V` value. It returns a boolean value indicating whether the key-value pair should be
152  /// retained in the map or not. The `retain` method iterates over all
153  #[inline]
154  pub fn retain<F: Fn(&usize, &V) -> bool>(&mut self, f: F) {
155      #[cfg(debug_assertions)]
156      assert!(self.initialized, "Can't do retain() on non-initialized Map");
157      for i in 0..self.max {
158          if let Some(p) = self.get_mut(i) {
159              if !f(&i, p) {
160                  unsafe {
161                      ptr::write(self.head.add(i), None);
162                  }
163              }
164          }
165      }
166  }
167
```

Writer plugin for VS-Code by Mintlify

[ Complete PR Review Risks Explain [Safurai](#) Repeat Tests Refactor LLM ]

## All in One Package



Plugin for VS-Code by [Safurai](#)

[ Complete PR Review Risks Explain Safurai [Repeat](#) Tests Refactor LLM ]

## Repeat After Me!

Read about “making repeated edits easier with IntelliCode suggestions”,  
by Peter Groenewegen.

[ Complete PR Review Risks Explain Safurai Repeat [Tests](#) Refactor LLM ]

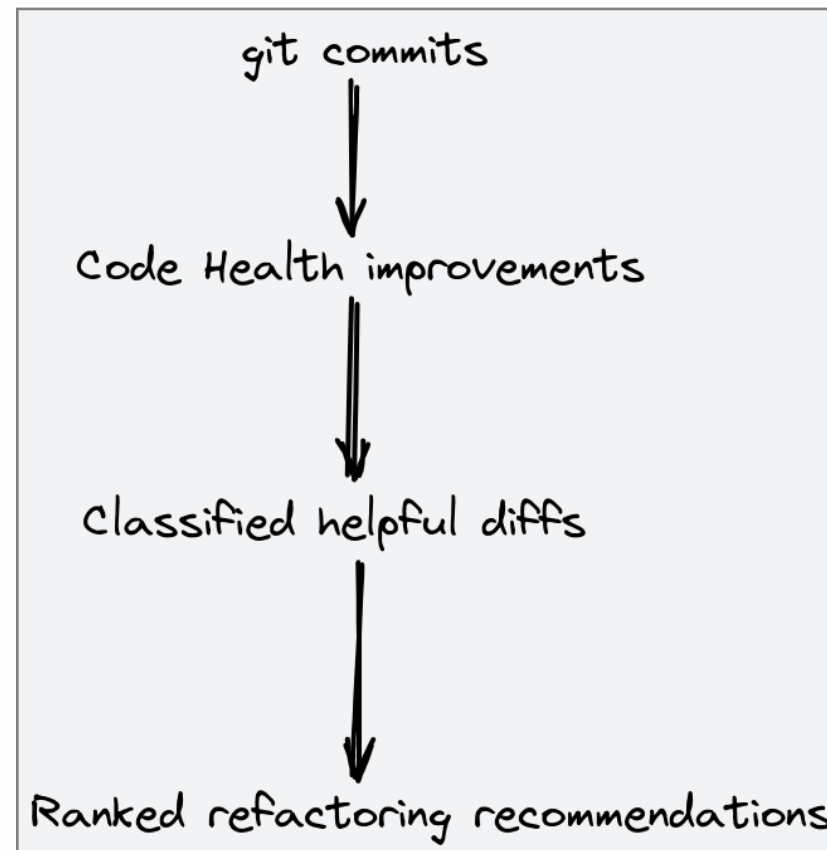
## Test Case Generation

Ponicode was alive in 2022, now it's ~~dead~~ acquired by CircleCI.



[ Complete PR Review Risks Explain Safurai Repeat Tests [Refactor](#) LLM ]

## Automated Refactoring



I found this picture in the [CodeScene website](#).

[ Complete PR Review Risks Explain Safurai Repeat Tests Refactor [LLM](#) ]

## Large Language Models (LLM)



Look at this code (it is written in our own object-oriented programming language called EOLANG) and suggest your opinion about the quality of it in terms of readability. Also, if you see any issues, suggest refactoring:

```
...  
[x] > f  
if. > @  
  x.lt 2  
  x.plus 25  
  x.plus 25  
...
```

Based on the code snippet provided, it seems to define a function called `f` that takes an argument `x`, and applies some logic to it based on a conditional statement.

In terms of readability, there are some aspects of the code that could be improved:

1. The use of `>` to indicate the start of the function definition may be confusing to someone who is not familiar with EOLANG. It might be better to use a more descriptive keyword like `function` instead.
2. The use of `if.` and `@` may be confusing to someone not familiar with EOLANG. It's not immediately clear what these symbols mean.
3. The lack of indentation makes it harder to see which statements are part of the conditional block and which are not.
4. The repeated use of `x.plus 25` could be simplified by combining them into a single statement.

Here is a refactored version of the code that addresses these issues:

javascript

Copy code

```
function f(x)  
  if x.lt(2) {  
    x.plus(50)  
  }  
  x
```

In this version, I have used the `function` keyword to define the function, and `if` to define the conditional statement. I have also used curly braces to indicate the start and end of the conditional block, which makes it easier to see which statements are part of the block. Finally, I have combined the two `x.plus(25)` statements into a single `x.plus(50)` statement.

Chapter #3:

**What's Next?**

[ [Neural](#) EEG ]

## Neural Software Analysis

### “Neural Software Analysis”

By Michael Pradel, Satish Chandra

*Communications of the ACM*, January 2022, Vol. 65 No. 1, Pages 86–96

Watch it.

## Electroencephalography (EEG)

### **“Understanding Programming Expertise: An Empirical Study of Phasic Brain Wave Changes”**

By Igor Crk, Timothy Kluthe, Andreas Stefik

*ACM Transactions on Computer-Human Interaction*, Volume 23, Issue 1,  
Article No. 2, Pages 1–29



Programmers are parts of programs

# Bibliography