

Bug linking techniques in software repositories

Advanced topics in Software Engineering

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1. Introduction
2. Problems
3. Linking techniques
4. Comparison

Introduction

- What is a version control system?
- What is a bug tracking system?
- How do they interact?

VERSION CONTROL

A category of software tools that help a software team manage changes to source code over time by tracking modifications on a special kind of database.

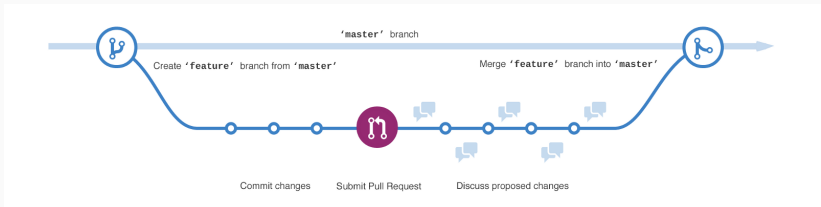


Figure 1: VCS Workflow example [1]



- Decentralized (despite GitHub, Bitbucket)
- Created by Linus Torvalds in 2005
- Very popular in OSS communities





- Centralized
- Created by Apache in 2000
- Mainly used inside companies

BUG TRACKING

Enter A Bug

Product: **Firefox:** ([Change](#))

 If you are new to Firefox or Bugzilla, please consider checking [Firefox Help](#) instead of creating a bug.

 [Firefox is poorly translated into my native language.](#)

Please summarise your issue or request in one sentence:

[Find similar issues](#)[My issue is not listed](#)

Bug ID	Summary	Component	Status	
245418	menus and contextual menus open on wrong screen when using two/dual/multiple screens/monitors/displays	XUL	RESOLVED FIXED	
292852	Dropdown menu not scrollable; full dropdown not displayed	General	RESOLVED EXPIRED	
400082	[10.5] Unable to access dropdown list on this site, works on Tiger	Widget: Mac	VERIFIED FIXED	
552180	Right Clicks menus, drop menus and the top level menus frequently stops to display	Menus	RESOLVED INCOMPLETE	
600381	[Windows] Context and dropdown menus displayed on a secondary monitor flicker rapidly	Graphics	NEW	Follow bug
613790	Most Drop down menus/boxes do not appear with hardware acceleration.	Graphics	VERIFIED FIXED	
649324	after installing Firefox 4 all the text labels in menus sub menus and context menus is replaced with weird characters	General	RESOLVED INCOMPLETE	
940307	Australis panel does not properly support type="menu-button" style buttons	Theme	VERIFIED FIXED	

Figure 2: Bugzilla

SoF The Council Regathers lua map generator error #3737 New Issue

Closed Pentastagon opened this issue 12 days ago · 1 comment

Pentastagon commented 12 days ago Member

After saving the replay for 'The Council Regathers in SoF', the scenario exits to the main menu with the error:

```

error general: Map generator error: Error when running lua_map_generator create_map.
The generator was: lua C:\demo\generator
Lua Error:
When executing: lua runtime error: lua\helper.lua:249) attempt to index a nil value (f)
stack traceback:
  lua\helper.lua:249: in main chunk
  [C]: in field 'doFile'
  lua\engine.lua:131: in field 'require'
  lua\cave_map_generator.lua:1: in main chunk
  [C]: in field 'doFile'
  lua\engine.lua:131: in field 'require'
  [string ""]:1: in main chunk

```

Assignees
CelticMistral

Labels
Bug
Lua API

Projects
None yet

Milestone
No milestone

Participants

Pentastagon added Bug Lua API labels 12 days ago

lyrkive commented 12 days ago Member

Looks like a regression from Lua API reorganization.

lyrkive assigned **CelticMistral** 12 days ago

CelticMistral closed this in [8f377a](#) 12 days ago

Figure 3: Issue tracker

Lua API: Fix some deprecations of game-only functions Browse files

Fixes #3737

master
CelticMistral committed 12 days ago Verified 3 parent: d7646f8 commit: 8f377a9d5f404a2d8ff417a1f1320ff0d

Showing 1 changed file with 2 additions and 2 deletions. Unified Split

4 + - data/lua/helper.lua View file

```

228 228 @@ -226,25 +226,25 @@ if wesnoth-kernel_type == "Game Lua Kernel" then
229 229     helper.set_variable_array = wesnoth.deprecate_api('helper.set_variable_array', 'wml.array_access.set', 1, nil, w
230 230     helper.get_variable_array = wesnoth.deprecate_api('helper.get_variable_array', 'wml.array_access.get
231 231     helper.wml_error = wesnoth.deprecate_api('helper.wml_error', 'wml.error', 1, nil, wml.error)
232 232     helper.move_unit_fake = wesnoth.deprecate_api('helper.move_unit_fake', 'wesnoth.interface.move_unit_fake', 1, ni
233 233     helper.modify_unit = wesnoth.deprecate_api('helper.modify_unit', 'wesnoth.units.modify', 1, nil, wesnoth.units.m
234 234 end
235 235 helper.literal = wesnoth.deprecate_api('helper.literal', 'wml.literal', 1, nil, wml.literal)
236 236 helper.parsed = wesnoth.deprecate_api('helper.parsed', 'wml.parsed', 1, nil, wml.parsed)
237 237 helper.shallow_literal = wesnoth.deprecate_api('helper.shallow_literal', 'wml.shallow_literal', 1, nil, wml.shallow_li
238 238 helper.shallow_parsed = wesnoth.deprecate_api('helper.shallow_parsed', 'wml.shallow_parsed', 1, nil, wml.shallow_parse
239 239 helper.set_wml_var_mutable = wesnoth.deprecate_api('helper.set_wml_var_mutable', 'wml.variable.proxy', 2, nil, hel
240 240 helper.set_wml_tag_mutable = wesnoth.deprecate_api('helper.set_wml_tag_mutable', 'wml.tag', 2, nil, helper.set_wml
241 241 -- helper.move_unit_fake = wesnoth.deprecate_api('helper.move_unit_fake', 'wesnoth.interface.move_unit_fake', 1, nil, wes
242 242 helper.get_user_choice = wesnoth.deprecate_api('helper.get_user_choice', 'gui.get_user_choice', 1, nil, gui.get_user_c
243 243 -- helper.modify_unit = wesnoth.deprecate_api('helper.modify_unit', 'wesnoth.units.modify', 1, nil, wesnoth.units.modify)
244 244 return helper

```

0 comments on commit [8f377a](#)

Figure 4: Bug fixing commit

Problems



	COMMENT	DATE
○	CREATED MAIN LOOP & TIMING CONTROL	14 HOURS AGO
○	ENABLED CONFIG FILE PARSING	9 HOURS AGO
○	MISC BUGFIXES	5 HOURS AGO
○	CODE ADDITIONS/EDITS	4 HOURS AGO
○	MORE CODE	4 HOURS AGO
○	HERE HAVE CODE	4 HOURS AGO
○	AAAAAAA	3 HOURS AGO
○	ADKFJSLKDFJSDKLFJ	3 HOURS AGO
○	MY HANDS ARE TYPING WORDS	2 HOURS AGO
○	HAAAAAAAAANDS	2 HOURS AGO

AS A PROJECT DRAGS ON, MY GIT COMMIT MESSAGES GET LESS AND LESS INFORMATIVE.

Figure 5: Obligatory xkcd comic [5]

This introduces a number of problems:

- Makes release notes **uninformative**
- Slows down the **reviewing** process
- Makes software hard to **maintain**
- Loss of valuable production **insights**

Just write better commit descriptions

- Hard to enforce in decentralized environments
- Inconsistencies between different developers
- Development timeline discrepancies

Or we can resort to **bug-linking** methods

Linking techniques

Research on linking methods

- When Do Changes Induce Fixes?, 2005 - J. Sliwerski et al. [9]
- RELINK, 2011 - R. Wu, H. Zhang, S. Kim, and S.-C. Cheung [11]
- MLINK, 2012 - A. T. Nguyen, T. T. Nguyen, H. A. Nguyen [7]
- BFLINKS, 2014 - L. Prechelt and A. Pepper [8]
- RCLINK, 2015 - B. Le, M. Linares, D. Lo, and D. Poshyvanyk [6]
- FRLINK, 2016 - Y. Sun, Q. Wang, and Y. Yang [10]

WHEN DO CHANGES INDUCE FIXES?

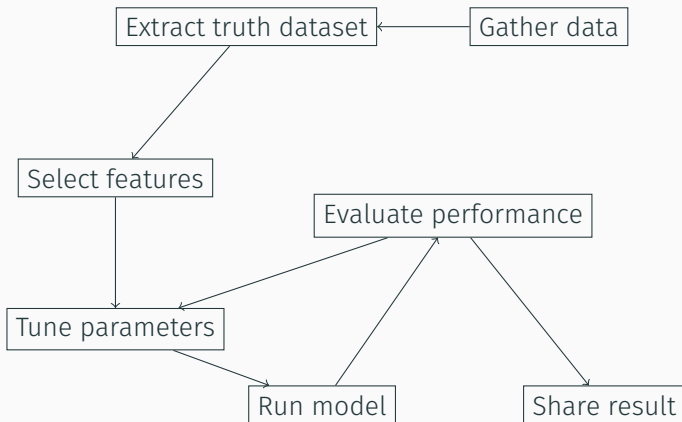
Syntactic analysis:

- strings containing **bug**, **fix**, **pr**, etc.
- plain numbers: **345933**
- alphanumeric strings: **a4d015b2**

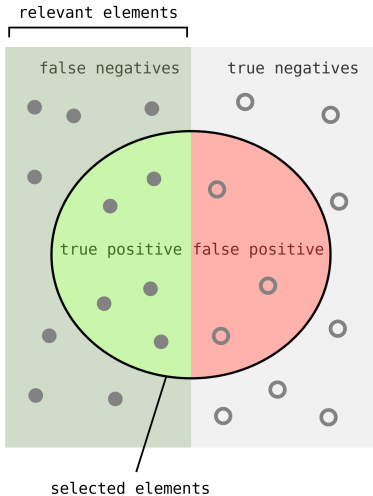
Semantic analysis:

- bug is flagged as **FIXED** in the bug tracker
- the author of the fixing commit has been assigned to the bug
- the bug report contains a description of the commit

Outcome: Don't program on **fridays**



PERFORMANCE METRICS



How many selected
items are relevant?

$$\text{Precision} = \frac{\text{true positive}}{\text{true positive} + \text{false positive}}$$

How many relevant
items are selected?

$$\text{Recall} = \frac{\text{true positive}}{\text{true positive} + \text{false negative}}$$

$$F_1 = \left(\frac{\text{recall}^{-1} + \text{precision}^{-1}}{2} \right)^{-1}$$

Figure 6: F-score measure [4]

```
input : TL: Training links
        ITR: Input training recall
output: LThres: Learned threshold
1 begin
2   ThresVal= 0.0 , Step= 0.01, LThres= 0.0, F= 0.0, RMax= ITR
3   foreach ThresVal do
4     Select all links in TL with similarities  $\geq$  ThresVal
5     Calculate the F-measure and Recall at ThresVal
6     if Recall  $\geq$  ITR then
7       if
8         (F-measure > F)  $\vee$  (F-measure = F  $\wedge$  Recall > RMax)
9         then
10          LThres = ThresVal
11          RMax = Recall
12          F = F-measure
11     ThresVal = ThresVal + Step
12 return LThres
```

Figure 7: Basic threshold learning algorithm [10]

ReLink is the first formalized feature-based approach to bug linking, demonstrating major improvements over regex-based methods.

Datasets

Apache, ZXing, OpenIntents

Average scores

PRECISION	–
RECALL	–
F-SCORE	–

Features

- Referential causality
- Bug owner and fixer
- Bug-commit descriptions similarity

TERM FREQUENCY-INVERSE DOCUMENT FREQUENCY

DC-9 WITH 55 ABOARD CRASHES; AT LEAST 16 DEAD

CHARLOTTE, NC, (Reuter)

A USAir DC-9 with 55 people on board crashed and burst into flames during a thunderstorm after missing an approach to Charlotte's international airport Saturday, killing at least 16 people. The flight, which originated in Columbia, South Carolina and was on its final approach, hit a house near the airport runway and caught fire, said Jerry Orr, aviation director at Charlotte-Douglas International Airport. Orr said 16 people were dead, six were missing and presumed dead and 33 were taken to local hospitals. USAir reported 18 dead. Rescue teams fought to save lives inside the wreckage of the plane, which split into three sections on impact at about 6:50 p.m. EDT as the plane was trying to land at Charlotte during heavy storms.

top 15 terms ranked by

frequency	highest idf	tf * idf
32 the	1.00 tdt000077	3.20 orr
16 were	1.00 picknickers	2.81 charlotte
14 said	0.93 screaming	2.65 payne
12 and	0.93 timmy	2.48 dc
12 to	0.86 6thld	2.24 usair
11 a	0.80 orr	2.00 plane
10 of	0.78 1016	1.93 crash
9 at	0.76 bergen	1.74 bones
9 was	0.75 dripping	1.63 survivors
7 in	0.73 abrams	1.50 dripping
6 on	0.72 0419	1.49 wreckage
6 they	0.69 fuselage	1.35 dead
6 people	0.66 nc	1.29 hospitals
6 had	0.66 thunderstorm	1.27 airport
6 plane	0.66 payne	1.23 55

Figure 8: The weight of a term in a document increases with its frequency in the specific document and decreases with its frequency in the others [3]

How do you measure **distance** between reports and fixes?

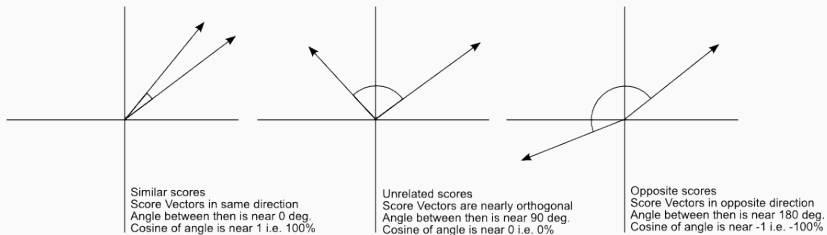


Figure 9: Document similarity as TF-IDF vectors distance

MLink improves over Relink by also taking into account entities with relationships crossing the source-description barrier.

Datasets

Apache, ZXing, OpenIntents

Average scores

PRECISION	0.56
RECALL	0.18
F-SCORE	0.27

Features

- Code metrics
- Entity names
- Term-entity association

Bflinks improves on the previous approaches with more specific time and frequency-based assumptions. Unidirectional links are discarded when taking into account dataset composition.

Datasets

Infopark

Average scores

PRECISION	0.93
RECALL	0.65
F-SCORE	0.76

Features

- ID candidates frequency
- Time intervals
- Bidirectional linking

RCLinker is a more "machine learning" oriented approach, employing random forests as classifier. Commit descriptions are algorithmically enriched, providing the model with further contextual metadata.

Datasets

CLI, CC, CSV, IO, Lang, Math

Average scores

PRECISION	0.74
RECALL	0.85
F-SCORE	0.79

Features

- 20+ features based on multiple text, timing and priority metrics

RANDOM FORESTS

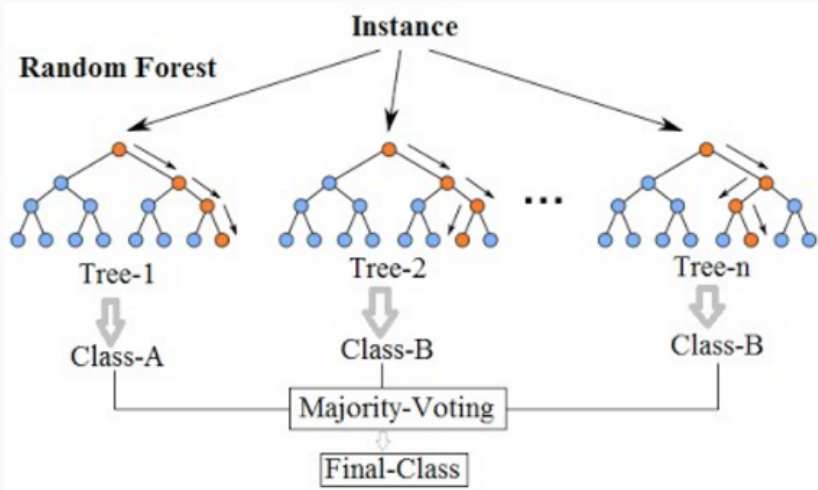


Figure 10: Multiple randomized trees prevent overfitting [2]

FRLink improves dataset composition by extracting additional data from non-source code and by filtering out textually irrelevant candidates by the source files pool.

Datasets

CLI, CC, CSV, IO, Lang, Math

Average scores

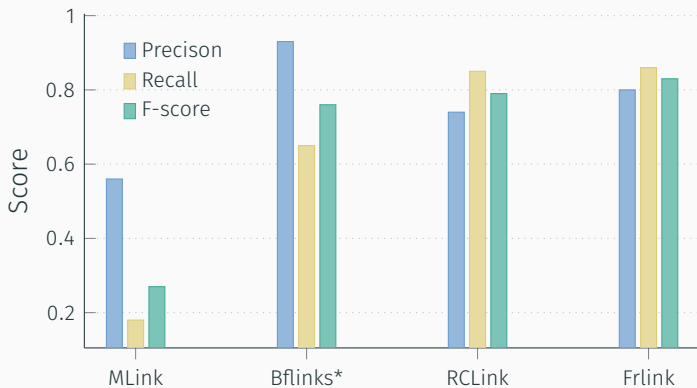
PRECISION	0.8
RECALL	0.86
F-SCORE	0.83

Features

- Comparable to the previous ones

Comparison

PERFORMANCE



* Infopark dataset

Thank you!

Get the source of this theme and the demo presentation from






`github.com/matze/mtheme`

The theme *itself* is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.



Questions?

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