Automatic Formative Feedback Generation for Programming Tasks Using Program Repair Techniques

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Project Goal and Scope

Main Goal

Build a machine learning model for automatically generating formative feedback for programming task using a state-of-the-art code repair technique.

Scope

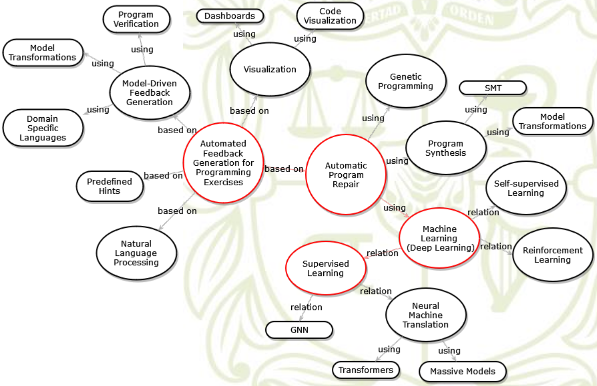
This project is limited to adapting a state-of-the-art repair model for use in generating formative feedback focused on basic python programming tasks.

Main Concepts

- **Formative Feedback:** aimed at helping students to improve their work, is an important factor in learning. [1]
- **Automatic Program Repair:** consists of automatically finding a solution to software bugs without human intervention. [2]

Context

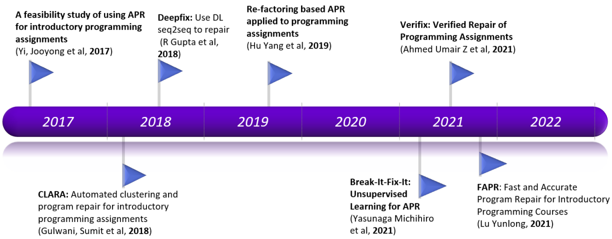
Figura: Relationship between formative feedback and program repair and its most relevant approaches.



Fonte: Based on: [2] [1]

Timeline

Figura: Some interesting approaches using program repair to give formative feedback in the last 5 years.



A feasibility study of using APR for introductory programming assignments (Yi, Jooyong et al, **2017**)

Deepfix: Use DL seq2seq to repair (R Gupta et al, **2018**)

Re-factoring based APR applied to programming assignments (Hu Yang et al, **2019**)

Verifix: Verified Repair of Programming Assignments (Ahmed Umair Z et al, **2021**)

CLARA: Automated clustering and program repair for introductory programming assignments (Gulwani, Sumit et al, **2018**)

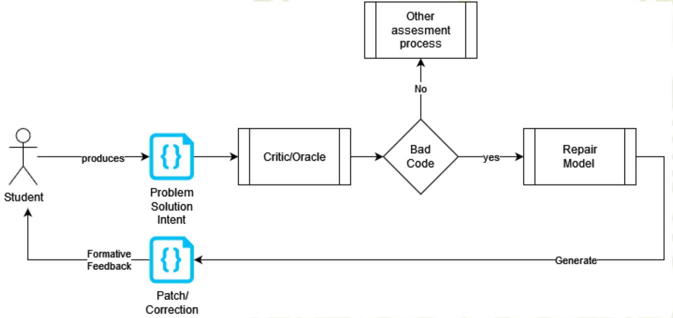
Break-It-Fix-It: Unsupervised Learning for APR (Yasunaga Michihiro et al, **2021**)

FAPR: Fast and Accurate Program Repair for Introductory Programming Courses (Lu Yunlong, **2021**)

Fonte: Based on: [3] [4] [5] [6] [7] [8] [9]

Formative Feedback using Automatic Program Repair

Figura: Simple scheme of the use of automatic repair programs to generate formative feedback.



Typical approach to the program repair task

A common approach to perform learning-based repair tasks is to use neural translation techniques, in which pairs are needed (Buggy Code, Correct Code). To build that kind of data set, there are two options:

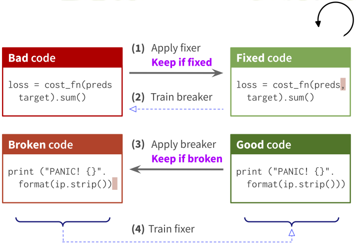
1. Mine repositories and manually identify which commit introduced a bug and which commit resolved it.
2. Create training data consisting of (bad, good) pairs by corrupting good examples using heuristics.

Break-It-Fix-It Approach

Fixers trained on this synthetically-generated data **do not extrapolate well** to the real distribution of bad inputs. BIFI propose:

1. Use the **critic** to check a fixer's output on real bad inputs and add good (fixed) outputs to the training data.
2. Train a **breaker** to generate realistic bad code from good code

Figura: Example of BIFI approach.



```
loss = cost_fn(preds
  target).sum()
```

```
loss = cost_fn(preds,
  target).sum()
```

```
print ("PANIC! {}".
  format(ip.strip())
```

```
print ("PANIC! {}".
  format(ip.strip()))
```

Fonte: Taken from: [7]

Datasets

Identified data sets useful to achieve the objective of this proposal.

Name	Description	Purpose in this project
CodeXBlue [9]	It includes models (based on CodeBERT and GPT) and data sets for diverse task (including program repair)	Benchmark for repair task
MBPP [10]	It consists of around 1,000 crowd-sourced Python programming problems, designed to be solvable by entry level programmers. Each problem consists of a task description, code solution and 3 automated test cases.	Benchmark for feedback generation
BIFI [7]	3 million Python3 snippets from GitHub, divided in two groups: Bad code, Correct code.	Dataset for training/validate models

Propose

This proposal then consists of:

1. Replicating the BIFI work.
2. Using BIFI with the MBPP dataset to evaluate its performance (accuracy, precision, etc.), repairing assignments of basic programming problems.

Outcome

A baseline useful for other Introductory programming assignments repair models.

References I

[1] Hieke Keuning, Johan Jeuring e Bastiaan Heeren. “A Systematic Literature Review of Automated Feedback Generation for Programming Exercises”. Em: **ACM Transactions on Computing Education** 19 (1 jan. de 2019), pp. 1–43. ISSN: 1946-6226. DOI: 10.1145/3231711. URL: https://dl.acm.org/doi/10.1145/3231711.

[2] Martin Monperrus. “Automatic software repair: A Bibliography”. Em: **Proceedings - International Conference on Software Engineering** Part F1371 (1 2018), p. 1219. ISSN: 02705257. DOI: 10.1145/3180155.3182526.

[3] Jooyong Yi et al. “A feasibility study of using automated program repair for introductory programming assignments”. Em: vol. Part F130154. Association for Computing Machinery, ago. de 2017, pp. 740–751. ISBN: 9781450351058. DOI: 10.1145/3106237.3106262.

References II

[4] Sumit Gulwani, Ivan Radiček e Florian Zuleger. "Automated clustering and program repair for introductory programming assignments". Em: **ACM SIGPLAN Notices** 53 (4 jun. de 2018), pp. 465–480. ISSN: 15232867. DOI: 10.1145/3192366.3192387.

[5] Yang Hu et al. **Re-factoring based Program Repair applied to Programming Assignments**. 2019. URL: https://github.com/githubhuyang/refactory.

[6] Rahul Gupta et al. "DeepFix: Fixing Common Programming Errors by Deep Learning". Em: **Proceedings of the AAAI Conference on Artificial Intelligence** 1 (Traver 2017), pp. 1345–1351.

[7] Michihiro Yasunaga e Percy Liang. "Break-It-Fix-It: Unsupervised Learning for Program Repair". Em: (2021). URL: http://arxiv.org/abs/2106.06600.

References III

[8] Umair Z. Ahmed et al. “Verifix: Verified Repair of Programming Assignments”. Em: (jun. de 2021). URL: http://arxiv.org/abs/2106.16199.

[9] Shuai Lu et al. “CodeXGLUE: A Machine Learning Benchmark Dataset for Code Understanding and Generation”. Em: (2021). URL: http://arxiv.org/abs/2102.04664.

[10] Jacob Austin et al. “Program Synthesis with Large Language Models”. Em: (ago. de 2021). URL: http://arxiv.org/abs/2108.07732.

Thanks for your attention

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