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# CS 639A Project Proposal

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Figure 1: Is my code bloated ?

## Part 1 : The Problem

**Software bloating** is quite a common problem in any real world software project where the code base is plagued with LOCs that are not useful in while the program runs in a given execution context, a common example being exposing too many **redundant APIs**, **default configurations** for each context or many **command line options** that are not used or never invoked in general but are still in the codebase. One primary reason for this is that it isn't possible to structure the codebase before hand or to choose a strict design pattern for all components that we write. Many times code needs to be written on demand or ad-hoc basis per se and that becomes the potential root cause for **software bloating**. **Software bloating** can lead to bugs, slower code execution and even expose vulnerabilities in the code base. The current techniques used are **manually thought** clever **metrics & heuristics** for identifying such **bloat sites** and refactoring the code to remove them.

## Part 2 : The Proposal

We propose to debloat a piece of **C & C++ Code** using **Policy Based Reinforcement Learning** using techniques and approaches as shared in the two research papers we have selected for accomplishing the task. Both the papers have demonstrated novel techniques for finding potential sites in the codebase for a given **C & C++ Software** using **Policy Based Reinforcement Learning**, the first paper mentioned does this by **Learning-Guided Delta Debugging** while the second paper does this by **Guided Function Specialization** technique. In our project, we model the debloating problem as **reinforcement learning** where action would be to specialize a program or not. The state of the model will be a **vector** containing all the required details about the **specialized code**. The **reward** will be a **reduction** of the number of **instructions or code size** in the program after the program is debloated. As the model keeps learning, we expect the rewards to be improved with more inputs.

## Part 3 : Tools and Procedure

We will initially focus on the implementation, analysis and comparison of both the techniques as mentioned above and then move on to finding new sites for debloating or in figuring a better policy for the **RL model** we will build. The tentative procedure for our project submission is as outlined below (**RL** means **Reinforcement Learning** henceforth):

### Stage 1 : Pre RL Stage :: Week 1 & 2

- Start with **LLVM IR** of the code and use **Inst2Vec** as outlined in **Paper 2** to extract feature information as outlined in the paper before **RL stage**
- Start with **LLVM IR** of the code and come up with a specification for **debloating** for **Paper 1**
- Finding more sites other than the ones listed for **Program Specialization** in **Paper 2**.
- Understanding **Chisel & Trimmer** Tool as implemented in **Paper 1**.
- Finish setting up all the tools and frameworks needed for developing rest of our tool.
- Collect and prepare bloated code samples for analysis, this is the input to our tool infrastructure.

### Stage 2 : RL Implement Stage :: Week 3 & 4

- Implementing **DeepOCCAM** tool from **OCCAM** Tool and run or analysis.
- Exploring the use of other off-the-shelf decision tree based model other than **FastDT** in **Chisel Tool**
- Compare performance with **Chisel** tool of **Paper 1** based on the metrics we choose before hand in **Stage 1**.
- Seeing if the metrics we choose for **Program Specialization** in **Stage 1** are good w.r.t to **Chisel Tool**.

### Stage 3 : Analysis & Wrap Up :: Week 5

- We produce the results of our analysis in a systematic way and show it using a web-based interface that connects to our tool communicating over **gRPC** or as a **REST API**
- Finish writing the report and presentation for the **Final Review**.
- We demonstrate a **run** of our tool to report **new sites** for better debloating.
- Report the new **heuristics** and **approaches** we adopted to accomplish the same.

### Deliverable

- A complete **comparison report & project report**.
- **Final Slides** for **review & presentation** purpose.
- **Code Repository** of our tool. (Would add a docker image for ad-hoc running).
- **Sample code** files on which we ran out tools for testing and implementation purpose.
- Report on new **heuristics, approaches** and **sites** for software debloating.
- **Extra Task** : Explore the use of other **machine learning** techniques or approaches for better software debloat.
- **Extra Task** : Run an LLVM pass which would do **debloating** using our tool. We wont commit it or share with LLVM repository but just integrate and run our implementation as an LLVM Pass

## Paper 1

- Kihong Heo, Woosuk Lee, Pardis Pashakhanloo, and Mayur Naik. 2018. Effective Program Debloating via Reinforcement Learning. In 2018 ACM SIGSAC Conference on Computer and Communications Security (CCS '18), October 15–19, 2018, Toronto, ON, Canada. ACM, New York, NY, USA, 15 pages. Link : <https://dl.acm.org/doi/10.1145/3243734.3243838>

## Paper 2

- Le Van, Nham, Ashish Gehani, Arie Gurfinkel, Susmit Jha, and Jorge A. Navas. "Reinforcement Learning Guided Software Debloating.", NIPS 2019. Link : <http://www.csl.sri.com/users/gehani/papers/MLSys-2019.DeepOCCAM.pdf>

## Tools (We may add a few tools later on)

- Chisel Tool : <https://github.com/aspire-project/chisel>
- OCCAM Tool : <https://github.com/SRI-CSL/OCCAM>
- PyTorch : <https://pytorch.org/>
- Inst2Vec : NCC Tool <https://github.com/lahiri-phdworks/ncc>
- LLVM : <https://github.com/lahiri-phdworks/llvm-project>
- OpenAI Gym : <https://github.com/lahiri-phdworks/gym>
- gRPC-go Tool : <https://github.com/codersguild/grpc-go>
- Kibana Dashboard : <https://www.elastic.co/downloads/kibana>

## Preliminaries

We have already done a preliminary analysis of the task at hand and also of both papers we shared here in the proposal.

## Terms

Our best efforts would be to deliver all the things listed but we may get stuck at stages where we can't proceed further or trace back to change the proposal here. Any appropriate action on your part can be exercised in such scenarios. Instances where we sought help from your side on implementation or further guidance will be appropriately mentioned in the report as well. Thanking you for giving us the opportunity to do this project.

## References & Study

- What is Software Bloat? : [https://en.wikipedia.org/wiki/Software\\_bloat](https://en.wikipedia.org/wiki/Software_bloat)
- Chisel ACM Presentation : <https://www.youtube.com/watch?v=8eRZKoLFakw>
- IR 2 VEC : <https://arxiv.org/pdf/1909.06228.pdf>
- Neural Code Comprehension : [http://www.cs.columbia.edu/~suman/gabe\\_slides.pdf](http://www.cs.columbia.edu/~suman/gabe_slides.pdf)
- Neural Code Comprehension: A Learnable Representation of Code Semantics <https://www.youtube.com/watch?v=8aXl53pGfIU>
- How LLVM Optimizes a Function : <https://blog.regehr.org/archives/1603>
- On Software Disenchantment : <https://tonsky.me/blog/disenchantment/>