

Towards Quality Assurance of SPLs with Adversarial Configurations

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Configurable systems



Linux Kernel: **15,000** options

Configurable systems



Linux Kernel: **15,000** options

$2^{15,000} \approx 10^{3,250} \gg 10^{1,000} \gg$ estimated # of particles



Sébastien Mosser @petitroll · 25 févr.

...

"the number of atoms in the visible universe is 10^{80} . There are 2^{15000} different versions of the Linux kernel. So astrophysicists works with things way simpler than software engineers". @jmjezequel



JHipster: **50** options

- Generate web app
- Micro-services

Halin et al., <https://doi.org/10.1007/s10664-018-9635-4>

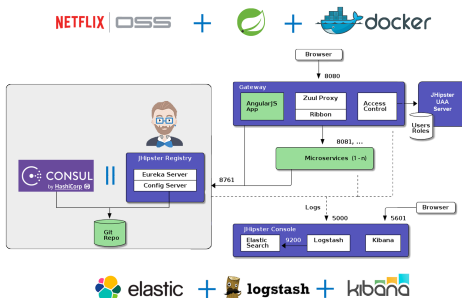
<https://www.jhipster.tech/microservices-architecture>

JHipster



JHipster: **50** options

- Generate web app
- Micro-services
- 26,000+ configurations



Halin et al., <https://doi.org/10.1007/s10664-018-9635-4>

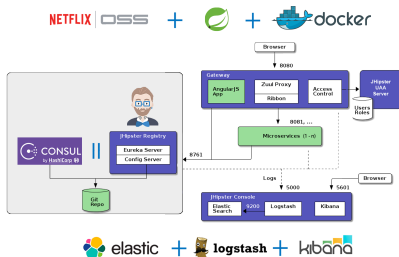
<https://www.jhipster.tech/microservices-architecture>

JHipster



JHipster: **50** options

- Generate web app
- 26,000+ configurations



Problem:

- Which variants can be build under X seconds?
- Which variants can run with limited resources? (less than Y Watts)

Reducing configuration space with ML

JHipster → **26,000+** configurations

- **Exploring** all configurations is **impossible**
- **Measuring** performances is **costly**
- **Few** configurations are **acceptable** (meet performances)

→ How to find the few interesting one?

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Performance predictions

- Assumption: similar configuration → similar performances
- **Train** a model on **few** configurations
- **Predict** on **all** the others

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Performance predictions

- Assumption: similar configuration → similar performances
- **Train** a model on **few** configurations
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→ **Filter** to retrieve the interesting ones

Reducing configuration space with ML

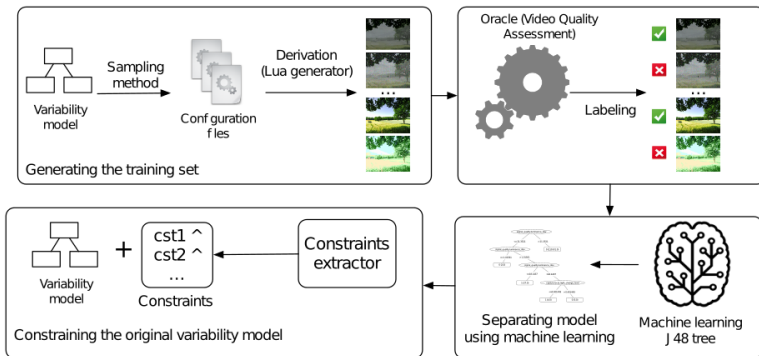
Scope the configuration space

- User: "I want technology X and Y but the system should run under S seconds"
- Learn which configurations are ok with that

Reducing configuration space with ML

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- Learn which configurations are ok with that



Temple *et al.*, Using machine learning to infer constraints for product lines, SPLC'16

Improving the classification of software configurations

Impacts

Machine Learning is based on statistics → errors

- Over-constraining
- Under-constraining

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Over-constraining

- Forbid more configurations than necessary
- Lack of flexibility

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Impacts

Machine Learning is based on statistics → errors

- Over-constraining
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Over-constraining

- Forbid more configurations than necessary
- Lack of flexibility

Under-constraining

- Allow more configurations than necessary
- Waste of resources

Improve the quality of the classifier

Robustifying the model

- Show new configurations
- Configurations with **high risk** of misclassification

Goodfellow *et al.*, <https://arxiv.org/pdf/1412.6572.pdf>

Elsayed *et al.*, <https://proceedings.neurips.cc/paper/2018/file/8562ae5e286544710b2e7ebe9858833b-Paper.pdf>

Sharif *et al.*, <https://dl.acm.org/doi/pdf/10.1145/2976749.2978392>

YT: <https://www.youtube.com/watch?v=6Xh1vuwnVhU>

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Robustifying the model

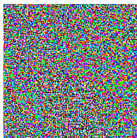
- Show new configurations
- Configurations with **high risk** of misclassification



“panda”

57.7% confidence

+ .007 ×



noise

=



“gibbon”

99.3% confidence

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Robustifying the model

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- Configurations with **high risk** of misclassification



“panda”

57.7% confidence



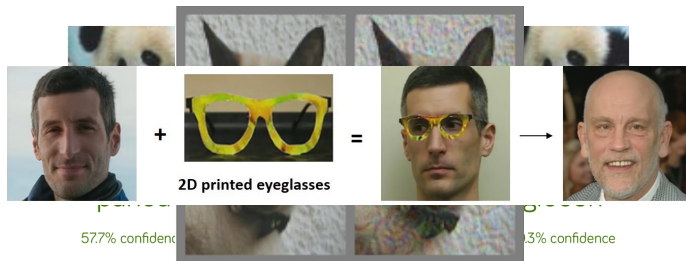
“gibbon”

3% confidence

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Robustifying the model

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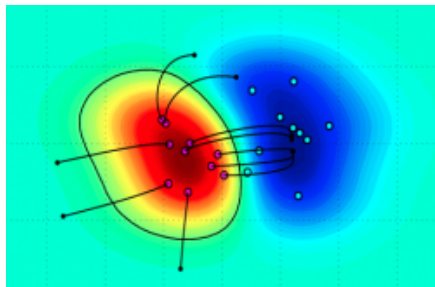
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Improve the quality of the classifier

Adv. configurations, how does it work?

- Configurations of a system = **vector of (Binary) options**
- Model is trained on few configurations
- Choose a (known) configuration
- Apply gradient descent → **modifications** on the values of options
- **Repeat** gradient descent until happy



Adv ML allows for:

- Automatic generation of new configurations → iterative modifications
- prediction error mitigation → adversarial retraining
- enhanced design space coverage → adversarial configurations

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Future works

- Need for better support for domain constraints
- Integration with constraint solvers
- Can adv ML be used as a new sampling strategy?

Sum-up

- Introduce adv ML to variability
- ML models useful to deal with configurable design spaces
- Generate configurations with high risk of misclassification
- Open directions for new sampling strategies?
- Need for better constraint support

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