Accelerate Functional Coverage Closure Using Machine-Learning-Based Test Selection

Jakub Pluciński, Łukasz Bielecki, Robert Synoczek (Nokia)
Emelie Andersson, Antii Löytynoja, Cristian Macario (MathWorks)
Premise

• Constrained random verification.
• Some coverage points are being hit extremely frequently.
• **Solution**: reliably producing stressful tests with most stimuli variety.
• Use of autoencoders to reduce the number of simulations.
Co-simulation flow (1)

- Environment based on co-simulation flow
- Matlab was used as DUT input/output generator
Co-simulation flow (2)
Test selector

• Dissimilar tests tend to hit dissimilar functional coverage events
Method evaluation (1)

• Multiple machine learning methods tested.
• Supervised and unsupervised.
• Supervised:
  • Support Vector Machine (SVM)
  • Decision Trees
  • Random Forest
  • Simple Neural Networks
  • Long-Short Term Memory (LSTM) networks
Method evaluation (2)

• Unsupervised:
  • Factorial Analysis of Mixed Data (FAMD)
  • T-distributed Stochastic Neighbour Embedding (t-SNE)
  • Uniform Manifold Approximation and Projection (UMAP)

• The problem was later redefined as an anomaly detection problem
Autoencoder (1)

• Simple fully connected autoencoder
• Layer size based on number of inputs
• Inputs normalized
  • Continuous – 0-1 min/max scaling
  • Discrete – one-hot encoding
• MSE loss for training
• Processing in batches
• Transfer learning is utilized
Autoencoder (2)
Autoencoder (3)
Thresholding

- Two thresholding methods proposed: Fixed and MMSE
- Fixed keeps given percentage of tests
- Moving Mean Square Error (MMSE) based on previous training MSE
- MMSE changes with each batch of tests
Evaluation

- **DUT:** Physical Uplink Shared Channel (PUSCH) IP estimation block
- **Thresholds:** Fixed 25%, Fixed 50% and MMSE
- **Batches:** 25, 50, 75, 100
- Coverage goal set to 67% due to testbench limitations
Results (1)
Results (2)
Conclusions and next steps

• First ML and co-simulation flow tested on commercial IP
• Generic and applicable in software and hardware
• Improvement in numer of simulations for each threshold
• Full flow needs to be improved
• Deeper autoencoder architectures should be tested
• The system will be tested on bigger IPs.
Questions