Test Case Generation and Reduction by Automated Input-Output Analysis

Prachi Saraph, Mark Last, and Abraham Kandel

Introduction

- Black-Box Testing
  - Apply an Input
  - Observe the corresponding output
  - Compare Observed output with expected

- Large Number of Inputs

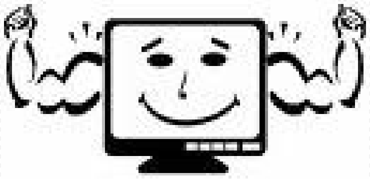
  → Huge number of Test Cases

Introduction

- Choose most important test cases and removing the redundant ones

- How?
  - Manual

  - Automatic



Input-Output Analysis

- Identifies the input attributes which affect the value of a particular output

- Concentrates on relationships between inputs and outputs

Machine Learning Approaches

- NN-based mechanism for identification of test cases that are likely to find faults

  C. Anderson et al., 1995

- NN is used to detect faults in mutated versions of software (Regression Testing)

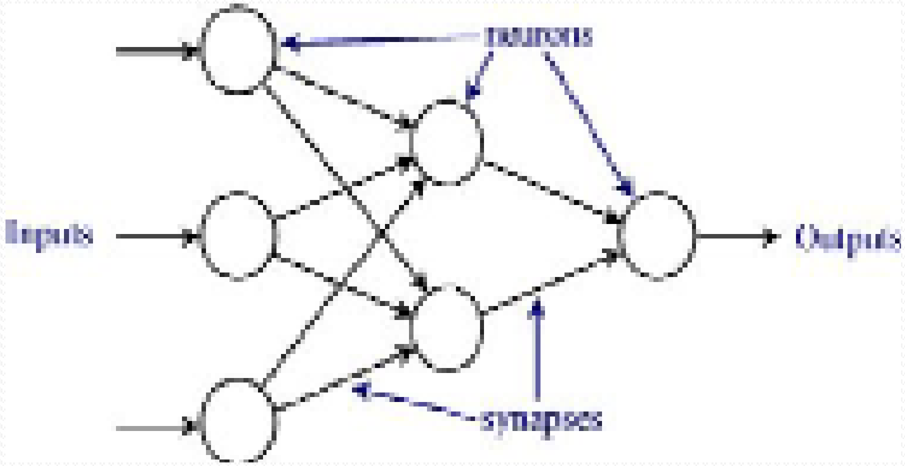
  M. Vanmali, 2002

- IFN is used to identify I-O relationships

  M. Last et al., 2003

Neural Networks – Background

- Supervised Learning



- Learn weights on each edge (Synapse) to get a general model of mapping between inputs and outputs based on training data

Neural Network based Testing

Phase I : NN Construction and Training

- 3-Layer Feed Forward Network using EBP

- Obtaining Training Set:
  - Randomize input values
  - Feed them into the original software
  - Storing output generated

NN Construction and Training

Phase II (a) : NN Pruning

- Less important connections

  ➔Lower Weights

- Pruning:
  - Remove edges with lower weights as long as the predictive accuracy after removing a link stays within the acceptable limits

Pruning and Feature Ranking

Phase II (b) : Feature Ranking

- Method 1 (Sorting):
  - Sort inputs according to the product
    *{weights from input layer to hidden layer * Corresponding weights from hidden layer to output layer}*
- Method 2 (Pruning):
  - Apply pruning method until all edges are removed
  - Note the order in which input nodes get all their nodes removed

Pruning and Feature Ranking

Phase III : Rule Extraction

- Express I-O relations pertained by pruning as if-then rules

- Use clustering to discretize hidden unit activation values

- Link Inputs to outputs through discretized hidden values

Phase IV : Test Case Generation

- After the completion of the pruning phase the possible data values of the attributes are used as equivalence classes to build test cases

Case Study: Employment Application Approval System

Attribute	Legend	Type
Application ID Number	UID	None
Degree	B.sc. / M.sc. / PhD	Input
Years of Experience	0 – 10	Input
Years out of College	0 – 10	Input
Certification	Yes / No	Input
Employment History	0 – 10	Input
Immigration Status	Citizen / Permanent Resident / Work Permit	Input
Number of References	0 – 3	Input
Employment Approval	Yes / No	Output
Full Time	Yes / No	Output
Part Time	Yes / No	Output

Case Study: Employment Application Approval System

- Random numbers were generated in the range of every input
- The inputs were fed to the application code, which produced the outputs
- The size of a training data set and a test data set was 1000 examples

Case Study: Employment Application Approval System

- The cycle of training, pruning and rule-extraction was run on a training data set at least ten times

- Two stopping criteria:
  - Upper limit on number of training epochs (1500)
  - Minimum accuracy on training data (set to 97%)

- The total number of test cases can be calculated by taking a Cartesian product of the corresponding data values. (58,080)

Results

- After Pruning Phase, The links retained in the network for output of *'Full Time'* corresponded to two inputs:
  - *years of experience*
  - *employment history*

- Number of test cases needed for this output =
  |years of experience| * |employment history| =
  11 * 10 = 110

- For the other two outputs, 120 test cases were needed

- Total Number = 230 vs 58,080 ➔ **Huge Reduction**

Rule Extraction Phase

- By clustering hidden unit activation levels and determining ranges of inputs that can generate each level, the following was found:
  - Values 4 – 10 for the input attribute '*years of experience*' resulted in activation value of **1** while the rest of the values resulted in activation value of **-1**

  - Values 6 – 10 for the input attribute '*Employment History*' generated activation value of 1 and the rest generated a value of -1

Results

- For this output '*Full Time*' the following rule is generated:

  If (years of experiencM) and (employment histop=6)

  Employment Hours: Full Time=Yes (1)

  Else

  Employment Hours: Full Time=No (0)

- By investigating the code, the accuracy of this rule turned out to be 100%

Test cases after rule-extraction phase

- By investigating previous extracted rules, We can build two equivalence classes for each of the two influential inputs
  - Years of experience 1 : [0-3]
  - Years of experience 2 : [4-10]
  - Employment history 1: [1-5]
  - Employment history 2: [6-10]

- Each equivalence class can be represented by one value

Yet More Test case Reduction

- Thus, to cover combinations of these two input attributes, we need 4 test cases for this output instead of previous 110
- By repeating the procedure for each of the other outputs, we get 10 test cases for the whole application
- Those 10 test cases carry some redundancies, so applying some minimization algorithm can further reduce them to 4 test cases!!

Drawbacks

- Generating and running random test cases to create the training set incurs some overhead that wasn’t addressed properly in the paper
- The method they propose for generating the training set implicitly assumes that you have a fault-free version of the program (which is not always the case)
- The authors didn’t actually give a basis or an experimental framework for choosing the NN learning or pruning parameters

Digging Deeper

- Although the authors didn't mention it explicitly, their approach is mainly useful in regression testing

- Another idea is to utilize this approach in Oracle generation out of the specifications of the program (By providing I-O pairs that are valid under specifications as he training set)

Questions

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Thank You