

Garbage Collection,  
Program  
Comprehension and  
Machine Learning

Jeremy Singer,  
Gavin Brown,  
Mikel Lujan,  
Ian Watson

Program  
Comprehension  
Jikes RVM Visualization  
Appealing Visualization

Intelligent  
Pretuning  
Garbage Collector

Perceptron  
Pretuning  
Perceptrons  
Preliminary Study

Wrap Up  
Future Work  
Conclusions

# Garbage Collection, Program Comprehension and Machine Learning

Jeremy Singer    Gavin Brown  
Mikel Lujan    Ian Watson

School of Computer Science, University of Manchester

# Outline

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# Jikes RVM

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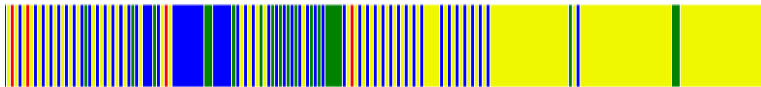
Future Work  
Conclusions

- Research Virtual Machine (RVM)
- from IBM Research, now open-source on sourceforge.net
- easy-to-modify adaptive compilation environment for/in Java
- has research respectability—100's of papers use it
- good platform for GC research

Jikes RVM 

# Visualizing Adaptive Subsystems

- monitor activity due to compilation/gc/other
- dynamic concept assignment techniques



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# Feedback from ACM Symposium

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- your visual metaphors are ...
  - unappealing
  - non-intuitive

# Better Visualization

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- interactivity
- familiar objects as metaphor for unfamiliar
- 3-d

# Visualizing Garbage Collection

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- mutator
- objects
- spaces (generations)
- collection
- promotion

# Metaphor for Garbage Collection

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- mutator: *juggler*
- objects: *jugglable artefacts*
- spaces (generations): *labelled boxes*
- collection: *tidying boxes*
- promotion: *moving between boxes*

# Metaphor Applications

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- EPSRC CS Writing competition
- illustrate idea of *intelligent pretenuring*

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# Avoid live objects during collection

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- processing live objects is wasted time
- so long-lived objects should not start in nursery
- pretenuring—put them in mature space immediately

# Predicting Object Lifetimes

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- heuristics to detect long-lived objects
- based on allocation site
- based on object connectivity
- can be adaptive heuristics

# Automatic Heuristic Generation

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- use *Machine Learning*
- select an algorithm (there are plenty!)
- select some inputs (tricky!)
- train the algorithm on the inputs
- at last, a heuristic emerges!

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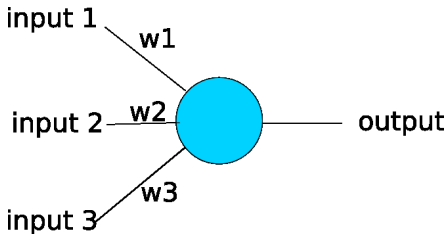
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# Perceptrons

- a number of inputs  $x_1, x_2, \dots, x_n$
- weight per input  $w_1, w_2, \dots, w_n$
- compute  $\sum_i w_i x_i$
- if sum  $>$  threshold then output 1, else output 0



# Inputs

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- obtain info about objects at allocation
- instrument Jikes RVM and MMTk
- dump data to file, for postprocessing
- typical inputs
  - object size
  - number of fields/methods
  - depth in inheritance tree
  - in package `java.*` or `com.ibm.jikesrvm.*`

# Output

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- keep record of every nursery-allocated object
- track object promotions to mature space
- at end, dump out object attributes and ...
- whether or not object was promoted

# Experiments

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- use some benchmarks from SPECjvm98
- for each benchmark
  - train perceptron on first 50% of allocations
  - test perceptron on second 50%

# Prediction Types

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- positive means predict mature, negative immature
- prediction either true or false

	<i>true</i>	<i>false</i>
<i>positive</i>	good	terrible!
<i>negative</i>	good	acceptable

# Results

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benchmark	200check	201compress
allocs	87768	100749
mispreds	19748	19785
tps	14733	14892
fps	75	828
tns	53287	66072
fns	19673	18957

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# More Results

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benchmark	205raytrace
allocs	4.3m
mispreds	1306
tps	95
fps	295
tns	4.3m
fns	1011

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# Future Work—better experiments

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- train on one benchmark, test on another
- use DaCapo instead of SPEC

# Future Work—better predictors

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**Future Work**  
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- change perceptron threshold
- different inputs?
- vote between perceptron ensemble
- multilayer perceptrons

# Future Work—use predictions online

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- incorporate learning technique into RVM
- either static or adaptive heuristic
- pretenure objects
- measure performance improvement

# Conclusions

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- GC is like *juggling*
- ML enables *intelligent* pretenuring
- watch this space!