Evolving a Classification Tool

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Evolving an automatic defect classification tool

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Background

- Applied Materials Inc.
  - Production of Semiconductors (fabs)
  - 80% market share (several billion $)

Wafer

Fab: Customer’s wafer fabrication facility
Background

- AMIL – Applied Materials Israeli Division
  - PDC – Process Diagnostic & Control
  - SEMVision product holds 70% share of Defect Review market (~0.5 billion $)
  - Benchmark: SEMVision ADC tool
  - Current product based on RBFN Classifier
Automatic Defect Classification (ADC)

1. Feature Extraction
2. Classification
3. Class (Defect Type)
4. Pattern Defect
ADC (cont’d)

ADC is a key step in the identification of the root cause of manufacturing problems.

Examples of defects:
- Chrome Spot
- Chrome Extension
- Chrome Bridging
- Pin Hole
- Clear Extension
- Clear Break
Guidelines

- Maximize classification rate
- Anytime algorithm
- Generic model
- Reduce Complexity
- Robust solution: Remove human from loop
The ADC Challenge

- Overcome problem of sparse data
- Explore new and obsolete defects
- Automated process, no human intervention

(/interference...)
Baseline (Human)

87.0% accuracy with 498 prototypical samples
We developed two GAs:

Basic & Enhanced
Basic GA

- Single GA, replacing limited human capability
- Automatically select optimal prototypical samples
Enhanced GA

- Anytime algorithm, remove human from loop
- Two GAs working in tandem, with a time delay between them
Enhanced GA (cont’d)

• Far better than human:
  90.1% accuracy with 213 prototypical samples
  (cf. human: 87%, 498)

• Faster convergence (than basic GA or human)

• Anytime optimization

• High accuracy

• Low complexity

• Automated process

• Ability to identify obsolete and relevant samples
Result is Human Competitive

(A) Patented / Patentable

(D) Publishable as new scientific result

(E) Equal/better than human-created solution to long-standing problem

(F) Equal/better than previously considered achievement

(G) Solves problem of indisputable difficulty
Why is Result Best?

- Automatic Defect Classification (ADC) is a well-developed technology, using heavily patented technology (criterion A)
- Goal simple to state, though arduous to attain: given a wafer image, classify the defects (criterion G)
- Problem compounded by poor data + deceptive environment in fab (problem changes constantly)
- Changing environment (new and obsolescent defect types) requires constant human intervention, limiting technology's effectiveness
Why is Result Best? (cont’d)

• Real “real-world” problem (work carried out in large, multinational company to improve multimillion $ product)

• Our evolutionary tool replaces manual bottleneck and limited human-optimization capabilities

• Major breakthrough: Our GA able to autonomously adapt to changing environment in fab

• Direct competition with humans (previous system)

• Silicon not only for semiconductors, also for solar energy
Why is Result Best? (cont’d)

• Our GA better in many respects than humans (criteria D, E, F):
  ▪ Significantly higher classification rate
  ▪ Increased throughput
  ▪ Better generalization
  ▪ Reduced complexity

• By replacing human bottleneck, we meet the industry's growing demand for robustness and stability in the production process

• No extant automated process equivalent to our model in any other product in the industry, worldwide
Why is Result Best? (cont’d)

In a nutshell:

1. Real-world problem
2. Beats current leading product
3. Much better than previous human-based product
4. Can replace humans
5. Novel GA algorithm to boot…