```
(env311) PS F:\test> & F:/test/env311/Scripts/python.exe f:/test/net/ultimate_zero_copy_breakthrough.py
INFO:__main__:🔥 启动终极零拷贝性能突破引擎!
INFO:__main__:🚀 初始化终极零拷贝性能引擎...
INFO:__main__:✅ SVM已启用
INFO:__main__:✅ OpenCL环境: 8 队列
INFO:__main__:🔍 检测硬件终极能力...
INFO:__main__:   计算单元: 18
INFO:__main__:   最大工作组: 256
INFO:__main__:   向量宽度: 1
INFO:__main__:🌊 初始化多层内存系统...
INFO:__main__:✅ 多层内存系统初始化完成
INFO:__main__:⚡ 预编译终极优化kernels...
F:\test\env311\Lib\site-packages\pyopencl\cache.py:496: CompilerWarning: Non-empty compiler output
encountered. Set the environment variable PYOPENCL_COMPILER_OUTPUT=1 to see more.
  _create_built_program_from_source_cached(
INFO:__main__:✅ 预编译完成: 6 个kernels
INFO:__main__:✅ 终极引擎初始化完成
INFO:__main__:🚀 开始终极零拷贝性能突破测试
INFO:__main__:
📊 终极测试计划: 17 个测试用例
INFO:__main__:🎯 目标: <200μs延迟, >95%计算占比, >200 MOPS吞吐量
INFO:__main__:
🔬 16元素纳秒挑战 (大小: 16 元素)
INFO:__main__:     13854.2μs (13.85ms)
INFO:__main__:     计算占比: 99.9%
INFO:__main__:     吞吐量: 0.0 MOPS
INFO:__main__:     效率评分: 0.302
INFO:__main__:     最优策略: NANO_OPTIMIZED
INFO:__main__:
🔬 32元素微秒突破 (大小: 32 元素)
f:\test\net\ultimate_zero_copy_breakthrough.py:968: RepeatedKernelRetrieval: Kernel 'nano_direct_compute'
has been retrieved more than once. Each retrieval creates a new, independent kernel, at possibly
considerable expense. To avoid the expense, reuse the retrieved kernel instance. To avoid this warning,
use cl.Kernel(prg, name).
  kernel = program.nano_direct_compute
INFO:__main__:     20945.7μs (20.95ms)
INFO:__main__:     计算占比: 99.9%
INFO:__main__:     吞吐量: 0.0 MOPS
INFO:__main__:     效率评分: 0.301
INFO:__main__:     最优策略: NANO_OPTIMIZED
INFO:__main__:
🔬 64元素亚毫秒巅峰 (大小: 64 元素)
INFO:__main__:     14882.3μs (14.88ms)
INFO:__main__:     计算占比: 99.9%
INFO:__main__:     吞吐量: 0.0 MOPS
INFO:__main__:     效率评分: 0.302
INFO:__main__:     最优策略: NANO_OPTIMIZED
INFO:__main__:
🔬 128元素极速优化 (大小: 128 元素)
INFO:__main__:     17089.6μs (17.09ms)
INFO:__main__:     计算占比: 99.9%
INFO:__main__:     吞吐量: 0.0 MOPS
INFO:__main__:     效率评分: 0.302
INFO:__main__:     最优策略: NANO_OPTIMIZED
INFO:__main__:
🔬 256元素寄存器极限 (大小: 256 元素)
f:\test\net\ultimate_zero_copy_breakthrough.py:970: RepeatedKernelRetrieval: Kernel
'nano_optimized_compute' has been retrieved more than once. Each retrieval creates a new, independent
kernel, at possibly considerable expense. To avoid the expense, reuse the retrieved kernel instance. To
avoid this warning, use cl.Kernel(prg, name).
  kernel = program.nano_optimized_compute
INFO:__main__:     15009.0μs (15.01ms)
INFO:__main__:     计算占比: 99.9%
INFO:__main__:     吞吐量: 0.0 MOPS
INFO:__main__:     效率评分: 0.302
INFO:__main__:     最优策略: NANO_OPTIMIZED
INFO:__main__:
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🔬 挑战极限延迟 (大小: 512 元素)
INFO:__main__: 16676.2μs (16.68ms)
INFO:__main__: 计算占比: 99.3%
INFO:__main__: 吞吐量: 0.0 MOPS
INFO:__main__: 效率评分: 0.300
INFO:__main__: 最优策略: NANO_OPTIMIZED
INFO:__main__:
🔬 93.3%计算占比突破 (大小: 1024 元素)
INFO:__main__: 15886.9μs (15.89ms)
INFO:__main__: 计算占比: 99.8%
INFO:__main__: 吞吐量: 0.1 MOPS
INFO:__main__: 效率评分: 0.302
INFO:__main__: 最优策略: NANO_OPTIMIZED
INFO:__main__:
🔬 微优化巅峰 (大小: 2048 元素)
INFO:__main__: 14543.3μs (14.54ms)
INFO:__main__: 计算占比: 99.9%
INFO:__main__: 吞吐量: 0.1 MOPS
INFO:__main__: 效率评分: 0.302
INFO:__main__: 最优策略: NANO_OPTIMIZED
INFO:__main__:
🔬 寄存器级极限 (大小: 4096 元素)
INFO:__main__: 16188.8μs (16.19ms)
INFO:__main__: 计算占比: 99.9%
INFO:__main__: 吞吐量: 0.3 MOPS
INFO:__main__: 效率评分: 0.302
INFO:__main__: 最优策略: NANO_OPTIMIZED
INFO:__main__:
🔬 缓存对齐优化 (大小: 8192 元素)
INFO:__main__: 23479.4μs (23.48ms)
INFO:__main__: 计算占比: 65.0%
INFO:__main__: 吞吐量: 0.3 MOPS
INFO:__main__: 效率评分: 0.528
INFO:__main__: 最优策略: ADAPTIVE_HYBRID
INFO:__main__:
🔬 混合策略测试 (大小: 16384 元素)
f:\test\net\ultimate_zero_copy_breakthrough.py:1436: RepeatedKernelRetrieval: Kernel 'adaptive_hybrid_compute' has been retrieved more than once. Each retrieval creates a new, independent kernel, at possibly considerable expense. To avoid the expense, reuse the retrieved kernel instance. To avoid this warning, use cl.Kernel(prg, name).
  kernel = program.adaptive_hybrid_compute
INFO:__main__: 35751.5μs (35.75ms)
INFO:__main__: 计算占比: 50.9%
INFO:__main__: 吞吐量: 0.5 MOPS
INFO:__main__: 效率评分: 0.479
INFO:__main__: 最优策略: ADAPTIVE_HYBRID
INFO:__main__:
🔬 自适应调度 (大小: 32768 元素)
INFO:__main__: 34548.4μs (34.55ms)
INFO:__main__: 计算占比: 48.9%
INFO:__main__: 吞吐量: 0.9 MOPS
INFO:__main__: 效率评分: 0.474
INFO:__main__: 最优策略: ADAPTIVE_HYBRID
INFO:__main__:
🔬 流水线优化 (大小: 65536 元素)
INFO:__main__: 30588.8μs (30.59ms)
INFO:__main__: 计算占比: 50.2%
INFO:__main__: 吞吐量: 2.1 MOPS
INFO:__main__: 效率评分: 0.482
INFO:__main__: 最优策略: ADAPTIVE_HYBRID
INFO:__main__:
🔬 向量化加速 (大小: 131072 元素)
INFO:__main__: 34840.0μs (34.84ms)
INFO:__main__: 计算占比: 47.1%
INFO:__main__: 吞吐量: 3.8 MOPS
INFO:__main__: 效率评分: 0.398
INFO:__main__: 最优策略: PIPELINE_OPTIMIZED

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INFO:__main__:
🔬 并行吞吐量 (大小: 262144 元素)
INFO:__main__:     37693.2μs (37.69ms)
INFO:__main__:     计算占比: 45.4%
INFO:__main__:     吞吐量: 7.0 MOPS
INFO:__main__:     效率评分: 0.479
INFO:__main__:     最优策略: ADAPTIVE_HYBRID
INFO:__main__:
🔬 大规模融合 (大小: 524288 元素)
INFO:__main__:     36503.0μs (36.50ms)
INFO:__main__:     计算占比: 42.2%
INFO:__main__:     吞吐量: 14.4 MOPS
INFO:__main__:     效率评分: 0.489
INFO:__main__:     最优策略: ADAPTIVE_HYBRID
INFO:__main__:
🔬 终极挑战 (大小: 1048576 元素)
INFO:__main__:     40040.2μs (40.04ms)
INFO:__main__:     计算占比: 47.2%
INFO:__main__:     吞吐量: 26.2 MOPS
INFO:__main__:     效率评分: 0.541
INFO:__main__:     最优策略: ADAPTIVE_HYBRID
INFO:__main__:
================================================================================
INFO:__main__:🎯 终极零拷贝性能突破分析
INFO:__main__:================================================================================
INFO:__main__:
📊 终极性能分析表
INFO:__main__:数据大小          延迟(μs)       计算占比       吞吐量(MOPS)       效率评分                最优策略
INFO:__main__:--------------------------------------------------------------------------------
INFO:__main__:16              13854.2     99.9%            0.0       0.302      NANO_OPTIMIZED
INFO:__main__:32              20945.7     99.9%            0.0       0.301      NANO_OPTIMIZED
INFO:__main__:64              14882.3     99.9%            0.0       0.302      NANO_OPTIMIZED
INFO:__main__:128             17089.6     99.9%            0.0       0.302      NANO_OPTIMIZED
INFO:__main__:256             15009.0     99.9%            0.0       0.302      NANO_OPTIMIZED
INFO:__main__:512             16676.2     99.3%            0.0       0.300      NANO_OPTIMIZED
INFO:__main__:1024            15886.9     99.8%            0.1       0.302      NANO_OPTIMIZED
INFO:__main__:2048            14543.3     99.9%            0.1       0.302      NANO_OPTIMIZED
INFO:__main__:4096            16188.8     99.9%            0.3       0.302      NANO_OPTIMIZED
INFO:__main__:8192            23479.4     65.0%            0.3       0.528     ADAPTIVE_HYBRID
INFO:__main__:16384           35751.5     50.9%            0.5       0.479     ADAPTIVE_HYBRID
INFO:__main__:32768           34548.4     48.9%            0.9       0.474     ADAPTIVE_HYBRID
INFO:__main__:65536           30588.8     50.2%            2.1       0.482     ADAPTIVE_HYBRID
INFO:__main__:131072          34840.0     47.1%            3.8       0.398   PIPELINE_OPTIMIZED
INFO:__main__:262144          37693.2     45.4%            7.0       0.479     ADAPTIVE_HYBRID
INFO:__main__:524288          36503.0     42.2%           14.4       0.489     ADAPTIVE_HYBRID
INFO:__main__:1048576         40040.2     47.2%           26.2       0.541     ADAPTIVE_HYBRID
INFO:__main__:
🔥 突破统计分析:
INFO:__main__:📈 极限延迟(<200μs): 0/17 (0.0%)
INFO:__main__:📈 高计算占比(>90%): 9/17 (52.9%)
INFO:__main__:📈 高吞吐量(>150MOPS): 0/17 (0.0%)
INFO:__main__:
🏆 最佳成绩:
INFO:__main__:⚡ 最优数据大小: 1048576 元素
INFO:__main__:⚡ 极限延迟: 40040.2 μs
INFO:__main__:⚡ 计算占比: 47.2%
INFO:__main__:⚡ 峰值吞吐量: 26.2 MOPS
INFO:__main__:⚡ 效率评分: 0.541
INFO:__main__:⚡ 最优策略: ADAPTIVE_HYBRID
INFO:__main__:
🧠 分区间性能分析:
INFO:__main__:   EXTREME区间: 平均 16119.6μs, 计算占比 99.8%
INFO:__main__:   BALANCED区间: 计算占比 53.7%, 吞吐量 1.0 MOPS
INFO:__main__:   THROUGHPUT区间: 平均吞吐量 12.8 MOPS
INFO:__main__:
🎯 策略效果分析:
INFO:__main__:   NANO_OPTIMIZED: 平均效率 0.301, 最佳延迟 13854.2μs
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INFO:__main__:   ADAPTIVE_HYBRID: 平均效率 0.496, 最佳延迟 23479.4μs
INFO:__main__:   PIPELINE_OPTIMIZED: 平均效率 0.398, 最佳延迟 34840.0μs
INFO:__main__:
🎉 终极突破总结:
INFO:__main__:🚀 COMPUTE DOMINANCE! 实现>90%计算占比!
INFO:__main__:✅ 成功完成终极零拷贝挑战!
INFO:__main__:💡 终极融合: 微优化+寄存器级+流水线+自适应+智能调度 = APU巅峰!
INFO:__main__:
🎉 终极零拷贝挑战完成! APU性能巅峰达成!
```