CMSC 691
High Performance Distributed Systems

GPUs for Evolutionary Computation
Random Number Generation

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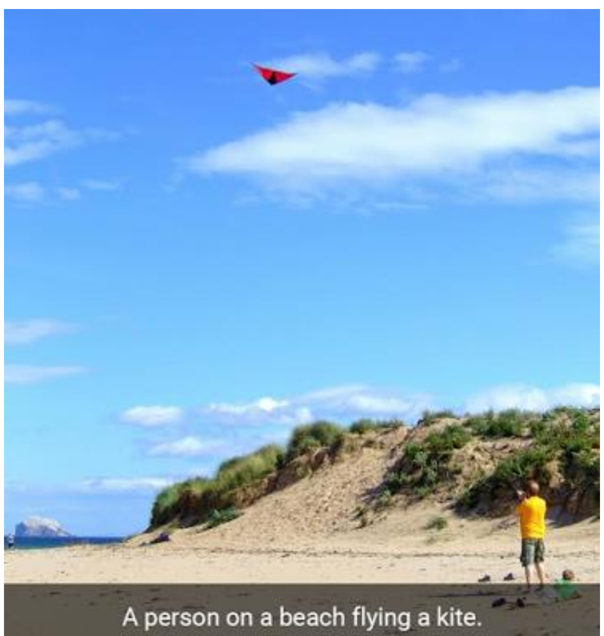
Massively parallel evolutionary computation on GPUs

- In Lecture #4 we introduced Evolutionary Algorithms and their parallelization using threads and RMI
- CPU-based parallelization is limited even when distributing workload in a cluster of compute nodes
- GPU computing provides a massively parallel solution!!!
- Advantages:
  - Afford many more resources for better accuracy
  - Reduce runtime for a given problem
  - Address much bigger dimensionalities
  - Deep learning, Computer Vision, NLP frameworks publicly available

Open source frameworks!

- Google Brain team & TensorFlow released last 09/22/2016

  Show and Tell: A Neural Image Caption Generator
- 2 weeks training phase using NVIDIA Tesla K20m GPU, datasets with millions of images, 93.9% accuracy



Random number generation in the GPU

- Stochastic methods such as evolutionary algorithms require high quality pseudorandom number generator (PRNG) or quasirandom number generator (QRNG)
- GPU threads cannot call host functions then *rand()* is not available
- cuRAND for fast random generation in host and device API
- Host API: a number of random numbers are generated and stored for alter use in a kernel
- Device API: random numbers are generated and immediately used in real time on an as-need basis
- Compile linking the library: -lcurand

cuRAND host API

1. Create a new generator with *curandCreateGenerator()*
2. Set the generator options, e.g. set the seed using *curandSetPseudoRandomGeneratorSeed()*
3. Allocate memory for the random numbers with *cudaMalloc()*
4. Generate random numbers with on or more calls to *curandGenerate()* or another generation function
5. Clean up the generator with *curandDestroyGenerator()*
6. Clean up everything else with *free()* and *cudaFree()*

Random number generator types

- Pseudorandom number generators
  - CURAND_RNG_PSEUDO_XORWOW
  - CURAND_RNG_PSEUDO_MRG32K3A
  - CURAND_RNG_PSEUDO_MTGP32
  - CURAND_RNG_PSEUDO_PHILOX4_32_10
  - CURAND_RNG_PSEUDO_MT19937
- Quasi-random number generators
  - CURAND_RNG_QUASI_SOBOL32
  - CURAND_RNG_QUASI_SOBOL64
  - CURAND_RNG_QUASI_SCRAMBLED_SOBOL32
  - CURAND_RNG_QUASI_SCRAMBLED_SOBOL64

Generator functions

- ***curandGenerate**(curandGenerator_t generator, unsigned int *outputPtr, size_t num)*
- ***curandGenerateUniform**(curandGenerator_t generator, float *outputPtr, size_t num)*
- ***curandGenerateNormal**(curandGenerator_t generator, float *outputPtr, size_t n, float mean, float stddev)*
- ***curandGenerateLogNormal**(curandGenerator_t generator, float *outputPtr, size_t n, float mean, float stddev)*
- ***curandGeneratePoisson**(curandGenerator_t generator, unsigned int *outputPtr, size_t n, double lambda)*

cuRAND device API

- *curandState_t* to keep track of the state of the random sequence
- Kernel threads call *curand_init(curandState_t *state)* to initialize the state of the random number generator
- Call *curand()* or one of its wrapper functions to generate pseudorandom or quasi random numbers as needed

Device distributions:

- *curand_uniform (curandState_t *state)*
- *curand_normal (curandState_t *state)*
- *curand_log_normal (curandState_t *state, float mean, float stddev)*
- *curand_poisson (curandState_t *state, double lambda)*

Evolutionary algorithms

- Individual representation using arrays
- Initialization of the population
  - Random initialization of each gene for each individual
- Genetic operators
  - Crossover and mutation, recombination of the genotypes
- #threads = #individuals x #dimensionality
- Fully coalesced memory access pattern
- Maximum GPU occupancy
- Next we'll see an application study to LSGO using distributed GPUs

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