KMeans Clustering Algorithm Parallelization With CUDA Task 4

Presentation of Report:

From our implementation so far, it is pretty obvious that clustering is a search method that reveals hidden patterns that exist in datasets. A process of grouping data objects into disjoint clusters so that the data in each cluster are similar, yet different to the other clusters. In k-means, a data point consists of several values, called features. By dividing a cluster of data objects into k sub-clusters, k -means represents all the data objects by the mean values or centroids of their respective sub-clusters. Since the complexity and time taken by the sequential compiler is high, we proposed the use of GPU for parallelization to the maximum extent possible.

The objective of the project is to implement a parallel version of k-means clustering algorithm using CUDA parallel programming language. The project also aims to compare the efficiency between serial C++ and Cuda parallel versions of K-means clustering algorithm.

Implemented Planned Actions

Task I: **Problem Analysis and Design of Solution**

Project execution schedule and outline of its objectives. To study and understand the k-means clustering algorithm and the mathematical model.

Task II: Presentation of Solution with required Scenarios

Centroid approach to k-means algorithm. Validation of the Mathematical model. Implementation of the K-means Algorithm with Cuda programming.

Task III: Presenting a Working Solution for Various Devices: An Implementation of K-Means Algorithm using a Sequential C++ as a benchmark for comparing the speedup of the Cuda version. An implementation of parallel k-means using **global memory** and **shared memory** to optimize the speed of the algorithm. Comparing the results timing with serial and parallel algorithms. Execution of both the sequential code and the parallel code comparing different data sets.

Task IV: Reporting

Comparison of Execution Time vs Input Data size : *Putting simple **time.time()** calculations immediately around the function invocations, I get* *the following results for a dataset of* ***n∈100,100000 points, T=300 iterations and k = 3 clusters, using the average time of 5 runs:***

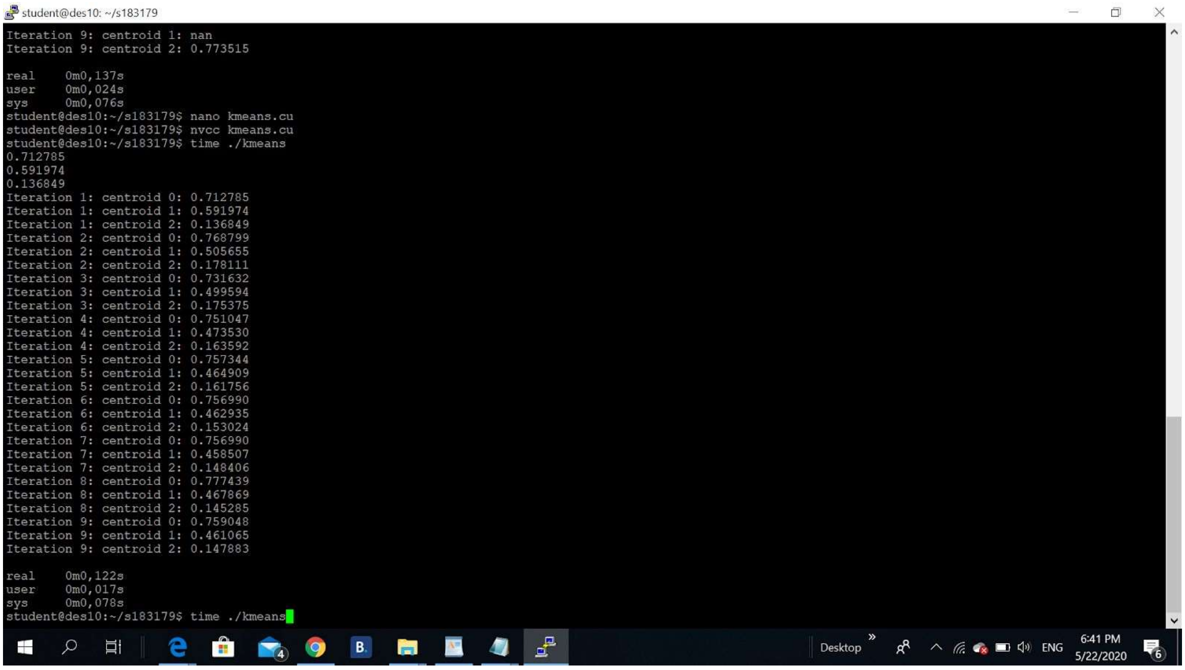
Size of Data (N)	No. of Clusters (K)	Serial Time (C++)	Parallel Time (Cuda)
100	**3**	**0.00054s**	0.00956s
100000	3	**0.26804s**	**0.0752s**

Optimization of Code by fixing global memory load

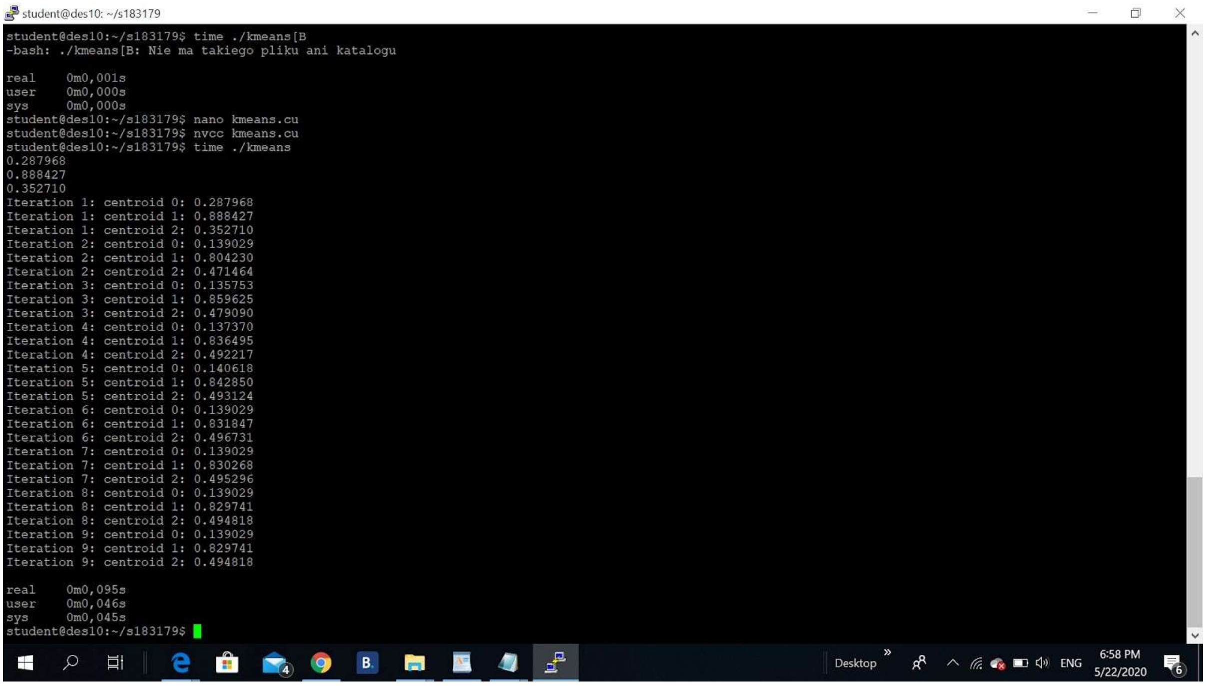
The simple fix for the global memory loads is to place the means into shared memory and have the threads load them from there. Here is the noticeable improvement in the speedup.

Size of Data (N)	No. of Clusters (K)	Serial Time (C++)	Parallel Time (Cuda)	Parallel Time after optimization
100	**3**	**0.00054s**	0.00956s	0.00878s
100000	3	**0.26804s**	**0.0752s**	**0.0611s**

Performed the assignment and block-wise reduction in the same kernel to further obtain a speed up of 0.00822s for N = 100 and 0.0171s for N = 100,000. ***Now, that's fast! Our CUDA implementation is nearly 16 times faster than plain c++.***

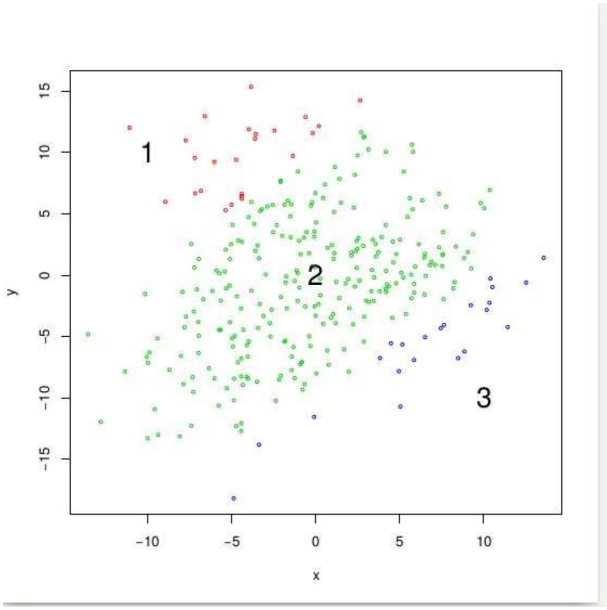


Data size: 100

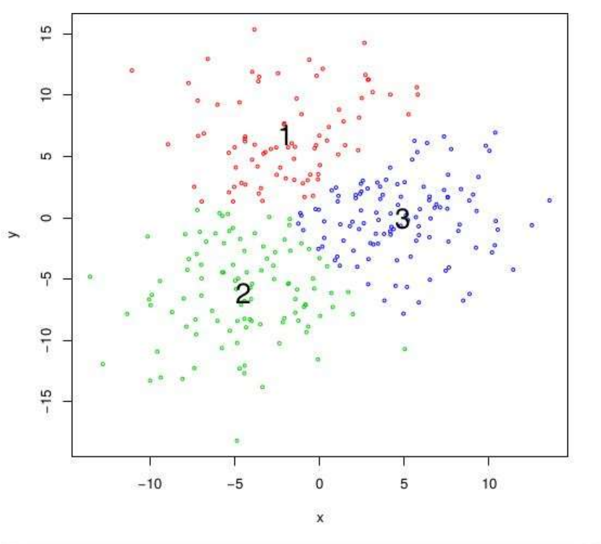


Datasize: 100,000

Visual Representation of ***Points before algorithm***



Visual Representation of ***Points after algorithm***



Objectives Achieved

Following is the list of objectives achieved during the course of the project:

- Implementation of sequential k-means clustering algorithm.
- An Implementation of K-Means Algorithm using a Sequential c++ as a benchmark for comparing the speedup of the Cuda version.
- An implementation of parallel k-means using global memory and shared memory to optimize the speed of the algorithm. Also performed the assignment and block-wise reduction in the same kernel for more optimization.

In Conclusion:

This algorithm can be used in the variety of application like grouping of same colors based on the RGB value in image, It can handle numeric weather forecast as well as abnormal climate event identification, the Parallelism used reduces the execution time and so other application like wireless network, sensor based application and search engine can equally use it.