Big Data Approach to fMRI Data Analysis with Intel DAAL and Full Correlation Matrix Analysis

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fMRI data analysis deals with data in tera bytes and operations on large scale matrices, which breeds an ideal scenario for the use of Big Data framework such as Apache Spark.
biananees - Spark Nifti Reader Library

Read Nifti(.nii) to RowMatrix RDD

resilient distributed data set
Supposedly, rows in RowMatrix will be represented as vectors(rows) in NumericTable.
PCA Performance Boost Using Intel® DAAL vs. Spark* MLLib

<table>
<thead>
<tr>
<th>Table Size</th>
<th>Speedup</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M x 200</td>
<td>4X</td>
</tr>
<tr>
<td>1M x 400</td>
<td>6X</td>
</tr>
<tr>
<td>1M x 600</td>
<td>6X</td>
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<tr>
<td>1M x 800</td>
<td>7X</td>
</tr>
<tr>
<td>1M x 1000</td>
<td>7X</td>
</tr>
</tbody>
</table>

Configuration Info - Versions: Intel® Data Analytics Acceleration Library 2016, CDH v5.3.1, Apache Spark* v1.2.0; Hardware: Intel® Xeon® Processor E5-2699 v3, 2 Eighteen-core CPUs (45MB LLC, 2.3GHz), 128GB of RAM per node; Operating System: CentOS 6.6 x86_64. PCA normalized input.

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. * Other brands and names are the property of their respective owners. Benchmark Source: Intel Corporation

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Incorporate with Intel DAAL

Theoretical performance boost
1. Intel Math Kernel Library is optimised for Intel processors
2. Set up overhead reduced in Apache Spark
Benchmarking

1. Volumes in image data are scaled up according to the number of nodes.
2. 1 volume contains a column of 480115 elements.
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2. 1 volume contains a column of 480115 elements.
Benchmarking Remarks

1. The above results do not give conclusive comparison between DAAL and MLlib. As the size of test data is small (~1MB), overhead for preliminary set up of the algorithms overwhelms the actual computation time.

2. Transformation of rows in RowMatrix from MLlib to vectors in NumericTable from DAAL has failed. Instead, the above results are compared under transformation in which rows in RowMatrix are represented by columns in NumericTable.

3. Computation attempts on Principal Component Analysis and Covariance were taken but failed to draw comparison as with input matrix size larger than 65535, these computations in MLlib are not supported.
Full Correlation Matrix Analysis

Traditional approach to fMRI analysis

pair-wise correlation, univariate analysis
Full Correlation Matrix Analysis

activity 1

activity 2

multivariate pattern analysis
implementation pipeline with parallel computing speeds up computation for more than 50 times

Full Correlation Matrix Analysis

1. Correlation computation
   Pearson Correlation reduced to MM multiplication

2. Normalisation of correlation results
   Fisher Transformation to normally distribute data

3. Support Vector Machine
   Classifier to validate results via cross validation
Full Correlation Matrix Analysis

1. Correlation computation

Since the use of MKL is encapsulated in DAAL, direct call of Matrix-Matrix multiplication is not supported.

Resolution is to adapt to Covariance computation, which is currently an ongoing process with the need to review and refine the representation of data transformed in NumericTable.
Reference

1. rboubela, https://github.com/rboubela/biananes
4. Yida Wang et al., Full correlation matrix analysis of fmri data, technical report
Acknowledgements

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