A Short Communication on Exploring – [MRI Scans With Sparse Tensors based on Mir–Library/D Language/IoT/HPC Heterogeneous Environments]

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Abstract :

An Interesting Suggestion+Review on Using Sparse Tensors as Information Processing Tools in the Context of Probing Mathematical Algorithms for Next Generation Medical Image Processing R&D based on [D lang/Mir–Library Modules/IoT/HPC/LLVM/LDC] – High Performance Computing in Heterogeneous [Linux/Windows/Other OS] Environments.

Keywords : MRI Scans/D Lang/Mir–Library/LLVM/IoT/HPC/Sparse Tensors/AI

[I] Introduction+Inspiration :

@inproceedings{Kumar2019DlangRagelSM, title={[Dlang+Ragel State Machine Compiler+Colm] Based Design of Embedded Systems & Bio-informatics in the Context of IoT/HPC for Hi-end Computational Environment/s – An Insight into Probing Intelligent Embedded Systems and Intelligent Bio-informatics Framework}, author={Nirmal Tej Kumar}, year={2019} }

[**Source** – [Dlang+Ragel State Machine Compiler+Colm] Based Design of Embedded Systems & Bio-informatics in the Context of IoT/HPC for Hi-end Computational Environment/s – An Insight into Probing Intelligent Embedded Systems and Intelligent Bio-informatics Framework – Nirmal Tej Kumar Published 2019.]

MRI – **"Magnetic resonance imaging** (**MRI**) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body. MRI scanners use strong magnetic fields, magnetic field gradients, and radio waves to generate images of the organs in the body. MRI does not involve X-rays or the use of ionizing radiation, which distinguishes it from CT or CAT scans and PET scans. Magnetic resonance imaging is a medical application of nuclear magnetic resonance (NMR). NMR can also be used for *imaging* in other NMR applications such as NMR spectroscopy."

[**Source** – **https://en.wikipedia.org/wiki/Magnetic_resonance_imaging**]

https://www.ndcn.ox.ac.uk/research#research-groups – **Excellent & Useful Information**.
https://www.ndcn.ox.ac.uk/research/computational-neuroscience-group

http://www.cneuro.cu/general/9-best-models/64-tensor-analysis-and-fusion-of-multimodal-brain-images
– **"**These are the Matlab codes and examples for the algorithms depicted in the paper titled Tensor Analysis and Fusion of Multimodal Brain Images with authors Esin Karahan, Pedro A. Rojas-Lopez, Maria L. Bringas-Vega, Pedro A. Valdes-Hernandez and Pedro A. Valdes-Sosa, publication pending. A detailed exposition about these methods can be found in each folder."

"Estos son los códigos de Matlab y ejemplos para los algoritmos descritos en el artículo titulado Tensor Analysis and Fusion of Multimodal Brain Images de los autores Esin Karahan, Pedro A. Rojas-Lopez, Maria L. Bringas-Vega, Pedro A. Valdes-Hernandez y Pedro A. Valdes-Sosa, pendiente a publicación. Una descripción detallada de estos métodos puede ser encontrada en cada archivo."[Spanish]

"The Cuban Neurosciences Center, CNEURO, began as one of the first groups in the world that used computers for the analysis of the brain electrical activity. It is today one of the institutions dedicated to basic and applied research, as well as the development of high technology for the diagnosis and intervention of problems related to mental health".

http://www.cneuro.cu/general/9-best-models/63-parallel-searchlight-classification-toolbox –

"The **Parallel Searchlight** MVPA Toolbox contains **Matlab** functions for classification and regression designed for parallelizing the computations of searchlight classifiers across the brain. This **toolbox** uses operations with sparse matrices with the purpose of reducing the computational time (CPU time). It avoids the sequential calculus of searchlight classifiers across voxels.The maximum gain of computational speed is achieved for Gaussian Naive Bayes (GNB), since it is based on the assumption of independence between voxels."

"Nevertheless not all the algorithms improves the CPU time when compared with the sequential approach. This strategy produces a significant gain for those classifiers that requires iterative minimization of the cost function as: SVM and Logistic Regression (LR). The implementations of SVM and Logistic Regression uses MEX compiled C code. The windows mex compiled functions are included in the **toolbox**.For other OS and the cpp files were also included."

Authors: "This **toolbox** has been developed by Marlis Ontivero-Ortega, Agustin Lage-Castellanos, and Mitchell Valdés-Sosa from the **Cuban Center for Neuroscience** in collaboration with Giancarlo Valente and Rainer Goebel from the Cognitive **Neuroscience** Department at the Maastricht University."

http://blog.mir.dlang.io/ – **Mir Library Blog – Some interesting Points**.

" **Mir** – **Generic Numerical Library for Science and Machine Learning**.

Separated Mir Projects
- Mir Algorithm – Multidimensional arrays (ndslice), iterators, algorithms.
- Mir Random – Professional Random Number Generators
- Mir GLAS – Linear Algebra Library (Experimental, not supported for now)
- Mir BLAS – Bindings to libraries with CBLAS API like OpenBLAS and Intel MKL.
- Mir LAPACK – Bindings to libraries with LAPACK API like OpenBLAS and Intel MKL.
- Mir Runtime – Mir Runtime (experimental).
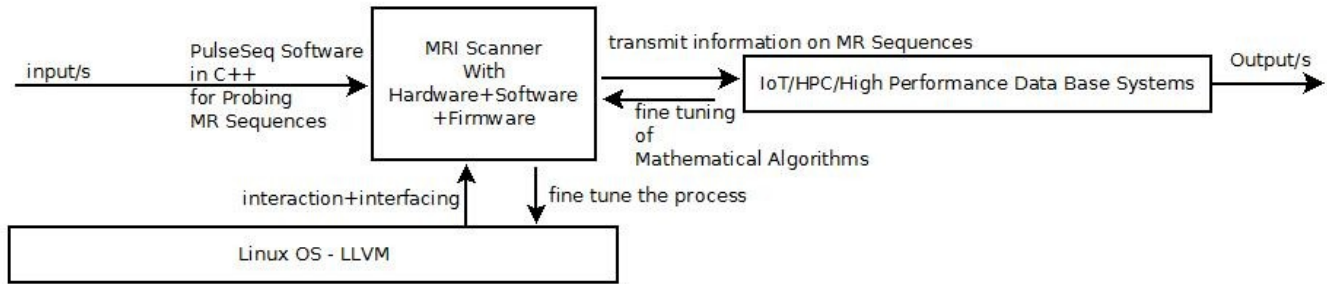- Mir CPUID – CPU Identification routines (less buggy then Phobos).

Contents
- mir.glas – Generic Linear Algebra Subroutines
- mir.sparse Sparse Tensors
- Sparse – DOK format
- Different ranges for COO format
- CompressedTensor – CSR/CSC formats
- mir.sparse.blas – Sparse BLAS for CompressedTensor
- mir.model.lda.hoffman – Online variational Bayes for latent Dirichlet allocation (Online VB LDA) for sparse documents. LDA is used for topic modeling.
- mir.combinatorics Combinations, combinations with repeats, cartesian power, permutations."

[Source – https://github.com/libmir/mir **]**

[II] R&D Informatics Framework Implementation Using D Lang+Related Tools :

Simple Suggestion to Understand MR Sequences Using PulseSeq Open Source Software
Not all details are covered here - it is a Short Technical Communication

input/s → PulseSeq Software in C++ for Probing MR Sequences → MRI Scanner With Hardware+Software +Firmware → transmit information on MR Sequences → IoT/HPC/High Performance Data Base Systems → Output/s

fine tuning of Mathematical Algorithms

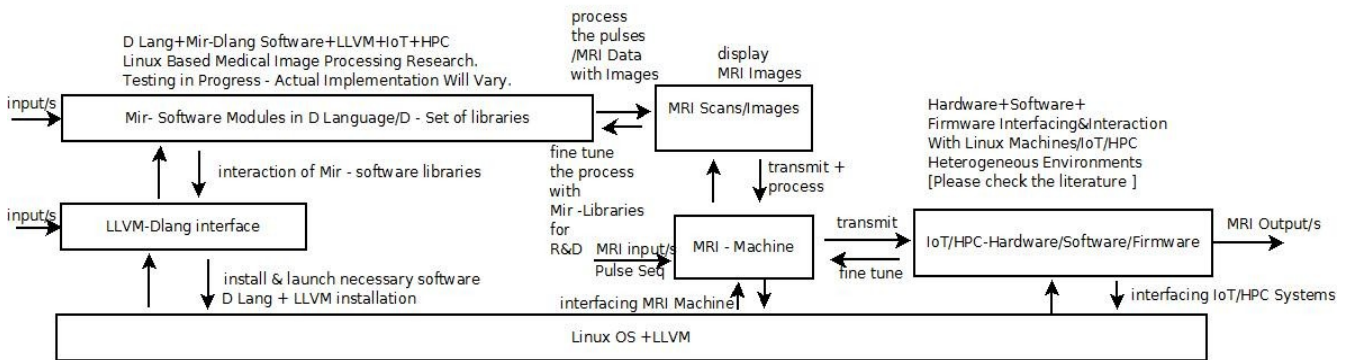interaction+interfacing — fine tune the process

Linux OS - LLVM

Simple Algorithm I - To Understand Basics of MR Sequences Using Standard Hardware Available.
Please Check & Satisfy Yourselves
Thanks - Dr.Nirmal.
We consider - " Testing" our Algorithms on Siemens/Bosch XDK - IoT Devices in the context of
HPC/Heterogeneous Linux OS Environments
(there could be other options as well)

[Figure I – Algorithm I – Simple Representation to Probe PulseSeq/MR Sequences]
[Simple +Basic Understanding of Algorithm I]

D Lang Features – "Write Fast –D allows writing large code fragments without redundantly specifying types, like dynamic languages do. On the other hand, static inference deduces types and other code properties, giving the best of both the static and the dynamic worlds".Read Fast –"The best paradigm is to not impose something at the expense of others. D offers classic polymorphism, value semantics, functional style, generics, generative programming, contract programming, and more—all harmoniously integrated." Run Fast – "D compiles naturally to efficient native code.D is designed such that most "obvious" code is fast *and* safe."
[**Source** – https://dlang.org/]

APPROXIMATE MEDICAL IMAGING FRAMEWORK FOR ADVANCED IoT/HPC -HETEROGENEOUS ENVIRONMENTS
INVOLVING SPARSE TENSORS USING D-Language.

D Lang+Mir-Dlang Software+LLVM+IoT+HPC
Linux Based Medical Image Processing Research.
Testing in Progress - Actual Implementation Will Vary.

input/s → Mir- Software Modules in D Language/D - Set of libraries

process the pulses /MRI Data with Images → MRI Scans/Images

display MRI Images

Hardware+Software+ Firmware Interfacing&Interaction With Linux Machines/IoT/HPC Heterogeneous Environments [Please check the literature]

interaction of Mir - software libraries

fine tune the process with Mir -Libraries for R&D

transmit + process

input/s → LLVM-Dlang interface

MRI input/s Pulse Seq → MRI - Machine → transmit → IoT/HPC-Hardware/Software/Firmware → MRI Output/s

fine tune

install & launch necessary software D Lang + LLVM installation

interfacing MRI Machine

interfacing IoT/HPC Systems

Linux OS +LLVM

We could focus on Sparse Tensors to Probe MRI DATA Using Mir-DLang/LLVM Informatics Framework

An MRI pulse sequence is a programmed set of changing magnetic gradients.
Each sequence will have a number of parameters, and multiple sequences are grouped together into an MRI protocol.

Algorithm II - Probing MRI Data & Informatics Framework in the context of IoT/HPC Environments.
Sparse Tensors are an important class of Mathematical Tools for
Next Generation Medical Image Processing R&D.
Please Check & Satify Yourselves.
Thanks - Dr.Nirmal.

[Figure II – Algorithm II – D Language Based Medical Images Processing IoT/HPC Informatics Framework]
[Advanced Investigation Using Algorithm II]
** Please Make a Note – Figure I & Figure II should follow each other in a sequence.All the References/Reading Materials mentioned were used in preparing this Short Communication.

[III] Related R&D Information on Mathematics+Software Used :

[a] https://www.semanticscholar.org/author/Nirmal-Tej-Kumar/12354503/suggest

[b] *www.vixra.org/author/nirmal_tej_kumar*

[c] http://www.vixra.org/pdf/1803.0124v1.pdf

[d] http://www.vixra.org/author/n_t_kumar

[e] *www.vixra.org/author/d_n_t_kumar*

[f] Notes/Publications Focusing on MRI + Related Issues :

https://mathigon.org/applications/mri
https://www.utas.edu.au/maths-physics/research/mathematics-research/Applied...

https://iopscience.iop.org/chapter/978-1-6817-4068-3/bk978-1-6817-4068-3ch1.pdf
https://plus.maths.org/content/saving-lives-mathematics-tomography

https://www.whitman.edu/Documents/Academics/Mathematics/SeniorProject...·
https://radiology.medschl.cam.ac.uk/blog/new-book-physics-mathematics-mri
https://www.webmd.com/a-to-z-guides/what-is-a-mri
https://www.math.wisc.edu/~angenent/preprints/medicalBAMS.pdf· PDF file

https://*www.hindawi.com/*journals/cmmm/2015/450341
https://my-ms.org/mri_planes.htm
https://www.quora.com/How-is-calculus-used-in-an-MRI-scan

[IV] Acknowledgment/s :

Special Thanks to ALL WHO made this happen in my LIFE – Non Profit R&D.

[V] Conclusion/s With Future Perspectives :

Sparse Tensors were investigated as promising mathematics-research tools to develop advanced algorithms to probe the frontiers of MRI Scans in the Context of IoT/HPC Environments.To the best of our knowledge,this is one of the pioneering communications.

[VI] Reference/s :

[1] https://www.sciencedirect.com/science/article/abs/pii/S0307904X19300290 – MRI denoising via sparse tensors with reweighted regularization

[2] https://dlang.org/ – **D Language Website** – **D** is a general-purpose programming language with static typing, systems-level access, and C-like syntax. With the **D Programming Language**, write fast, read fast, and run fast. Fast code, fast.

[3] https://github.com/libmir/mir – **Mir – Software Libraries** – Mir –**Generic Numerical Library for Science and Machine Learning**.

[4] https://aosabook.org/en/llvm.html – "LLVM is now used as a common infrastructure to implement a broad variety of statically and runtime compiled languages (e.g., the family of languages supported by GCC, Java, .NET, Python, Ruby, Scheme, Haskell, D, as well as countless lesser known languages)."

"LLVM was designed as a set of reusable libraries with well-defined interfaces.LLVM provides some unique capabilities, and is known for some of its great tools (e.g., the Clang compiler2, a C/C++/Objective-C compiler which provides a number of benefits over the GCC compiler), the main thing that sets LLVM apart from other compilers is its internal architecture."

[5] https://github.com/ldc-developers/ldc#installation / The LLVM-based D Compiler. – **Very Useful**.

[6] http://wiki.dlang.org/LDC /https://dlang.org/articles/cpptod.html#recursivetemplates.

[7] https://www.mr-tip.com/serv1.php?type=db1&dbs=Pulse%20Sequence

[8] https://radiopaedia.org/articles/mri-pulse-sequences-1

[9] https://en.wikipedia.org/wiki/MRI_sequence – **MRI Sequences – Basics**

[10] *https://www.princeton.edu/~nmr/apseq/apsExamples.pdf*

[11] *www.xrayphysics.com/sequences.html*

[12] https://pulseq.github.io/ – Open-source pulse sequences /Easily create and execute MR sequences.

[13] https://github.com/pulseq/pulseq – **Source Code**.
[*Pulseq* is an open source framework for the development, representation and execution of magnetic resonance (MR) sequences. A central contribution of this project is an **open file format** to compactly describe MR sequences suitable for execution on an MRI scanner or NMR spectrometer.]

[14] *https://par.nsf.gov/servlets/purl/10073356 – A Sparse Tensor Decomposition with Multi-DictionaryLearning Applied to Diffusion Brain Imaging*

[15] https://www.siemens-healthineers.com/magnetic-resonance-imaging

[16] https://xdk.bosch-connectivity.com/overview

[THE END]