

Haskell + Deep Learning Informatics in the Context of Designing Image Processing R&D Algorithms– A Simple Suggestion & Short Technical Communication.

[Exploring – HIT]

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[I] Abstract :

A Deep Learning(DL) Framework Using JIT Compiler with Haskell & LLVM in the Context of Medical Image Processing/Electron Microscopy(EM) Image Processing/Satellite Imagery Software R&D Using Mandelbrot Algorithms is suggested.Exploring Functional Programming+Deep Learning for designing Advanced Image Processing Algorithms R&D-is it the right choice ? – Keep going on with Haskell+Grenade,to refine the image processing tasks based on Deep Learning(DL) concepts.Haskell is a good choice for Image Processing R&D using Deep Learning.

[index words/keywords] : JIT Compilers/Haskell/LLVM/Grenade/Mafia/Deep Learning-DL/IoT/HPC/Functional Programming(FP)-Haskell/Image Processing Algorithms/Medical Images/Electron Microscopy Images/Satellite Imagery/Fractals.

[II] Inspiration+Introduction :

<http://book.realworldhaskell.org/read/why-functional-programming-why-haskell.html> - Excellent Information. [Real World Haskell](#) by Bryan O'Sullivan, Don Stewart, and John Goerzen.

Recently, researchers at Google's **Deep Mind** have developed a simple algorithm to handle significant challenges in reasoning and it has already beaten humans at a **Complex Image Comprehension Test**.

[a] Functional Programming-Haskell :

<https://www.ibm.com/developerworks/linux/tutorials/l-hask/index.html>

[b] LLVM -Framework/Tools :

The LLVM Project is a collection of modular and reusable compiler and tool chain technologies. Despite its name, LLVM has little to do with traditional virtual... [<https://llvm.org>]

[c] Haskell-LLVM-JIT Compiler :

[Implementing a JIT Compiler with Haskell and LLVM ...](#) Dec 25, 2013 -With Haskell and LLVM in place, you can use either Stack or Cabal to install the necessary Haskell bindings and compile the source code from..... [www.stephendiehl.com > llvm/ sdiehl/kaleidoscope: Haskell LLVM JIT Compiler ... - GitHub/](http://www.stephendiehl.com/llvm/sdiehl/kaleidoscope:HaskellLLVMJITCompiler...-GitHub/)

[d] Mandelbrot Mathematics/Data Sets/Algorithms :

The Mandelbrot Set In TensorFlow- What is the Mandelbrot set and how can we compute it in Tensor Flow? by Rinu Gour · Feb. 19, 19 · AI Zone · Tutorial.[**Main source of my inspiration**].

[e] Medical Image Processing+Electron Microscopy Image Processing :

Please See our Vixra.org based Publications. Already, there are a number of publications so we are not mentioning the details here. [e.g. <http://vixra.org/pdf/2001.0218v2.pdf>]

[f] Deep Learning/ Haskell-Grenade/Other Related Haskell Software :

grenade: Practical Deep Learning in Haskell - "Grenade is a composable, dependently typed, practical, and fast recurrent neural network library for precise specifications and complex deep neural networks in Haskell. Grenade provides an API for composing layers of a neural network into a sequence parallel graph in a type safe manner; running networks with reverse automatic differentiation to calculate their gradients; and applying gradient descent for learning." Grenade is most easily built with the mafia script that is located in the.....

[i] [<https://github.com/HuwCampbell/grenade.>] / [ii] [<https://github.com/ambiata/mafia>]

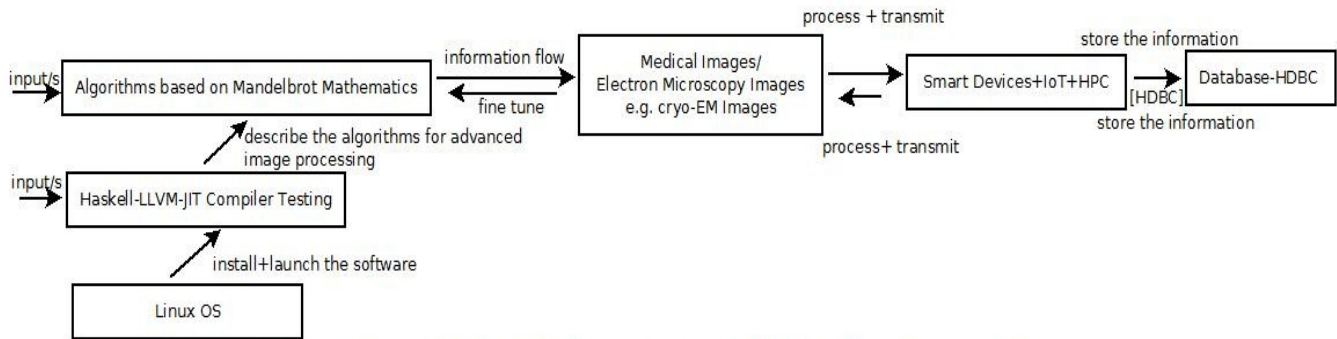
Mafia - Provides protection against cabal swindling, robbing, injuring or sabotaging people with chopsticks. Overview. **Mafia** is a light weight but opinionated wrapper around Cabal that makes working on Haskell projects fun and easy. [iii] <https://github.com/haskell-mafia/mafia> [IV] <https://haskell.libhunt.com/grenade-alternatives>

[g] "In [computing](#), just-in-time (JIT) compilation (also dynamic translation or run-time compilations) [1] is a way of executing [computer code](#) that involves [compilation](#) during execution of a program - at [run time](#) - rather than before execution. [2] ." [https://en.wikipedia.org/wiki/Just-in-time_compilation]

[h] Haskell-Neo4j-Graph Database System : [hackage.haskell.org > package > hypher > docs > Database-Neo4j...../hackage.haskell.org > package > haskell-neo4j-client > docs > Databas.../neo4j.com > developer > haskell.....](http://hackage.haskell.org/package/hypher/docs/Database-Neo4j)

[III] R&D Informatics Framework Involving the Above Mentioned Software Tools/Mathematics :

Description of our Simple Suggestion Involving the Required Mathematics+Software Used



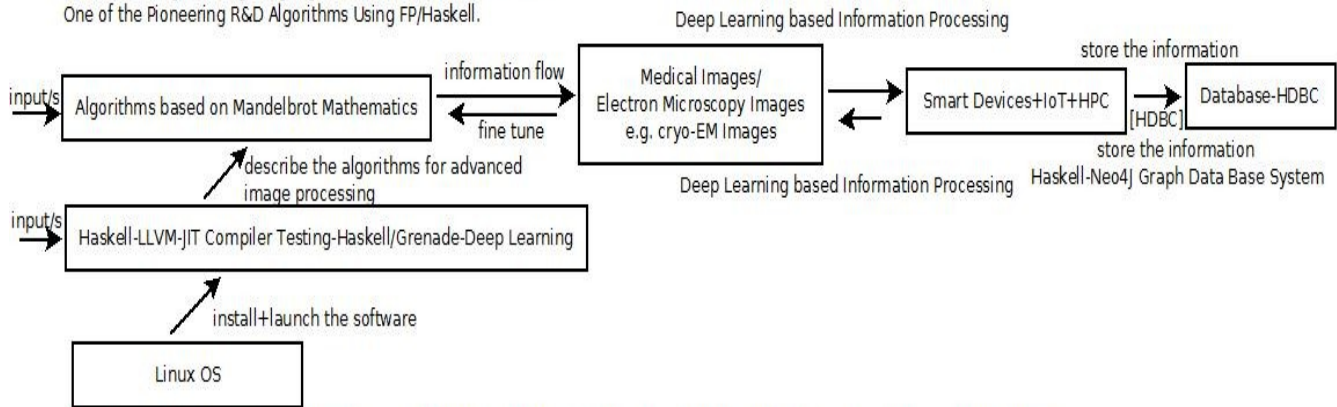
Algorithm I - R&D Informatics Framework based on Haskell+LLVM+JIT Compiler Techniques for Advanced Image Processing Platform
 Approximate Algorithm Only. Testing in Progress with some Promising Results
 Simple Conclusions - Functional Programming is always useful in demanding Science & Technology Domains
 like Medical Imaging/cryo-EM Imaging.
 Actual Implementations will certainly vary. Please Check the literature.
 Thanks - Dr.Nirmal

[Source <http://vixra.org/pdf/2001.0218v2.pdf>]

[Figure I – Algorithm I – R&D Informatics Framework for Advanced Image Processing]

Description of our Simple Suggestion Involving the Required Mathematics+Software Used

Functional Programming Languages suit AI Related Domains Well.
 One of the Pioneering R&D Algorithms Using FP/Haskell.

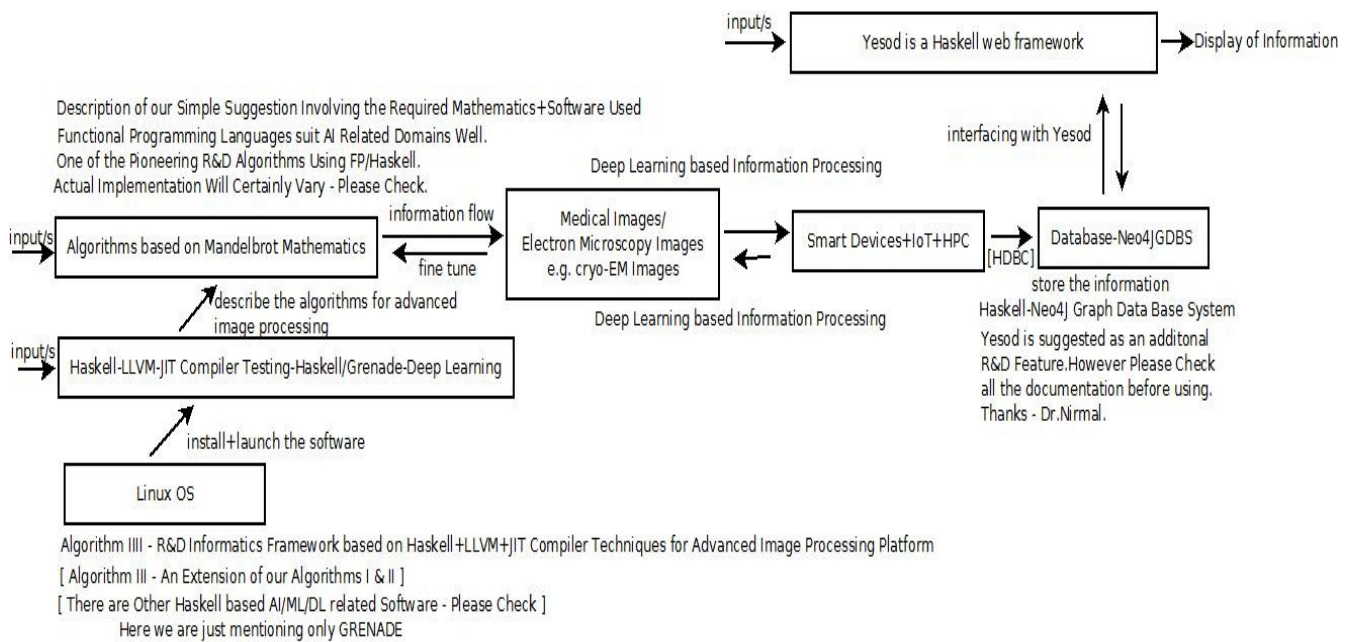


Algorithm I - R&D Informatics Framework based on Haskell+LLVM+JIT Compiler Techniques for Advanced Image Processing Platform
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 Simple Conclusions - Functional Programming is always useful in demanding Science & Technology Domains
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 Thanks - Dr.Nirmal

[Algorithm II - An Extension of our Algorithm I]

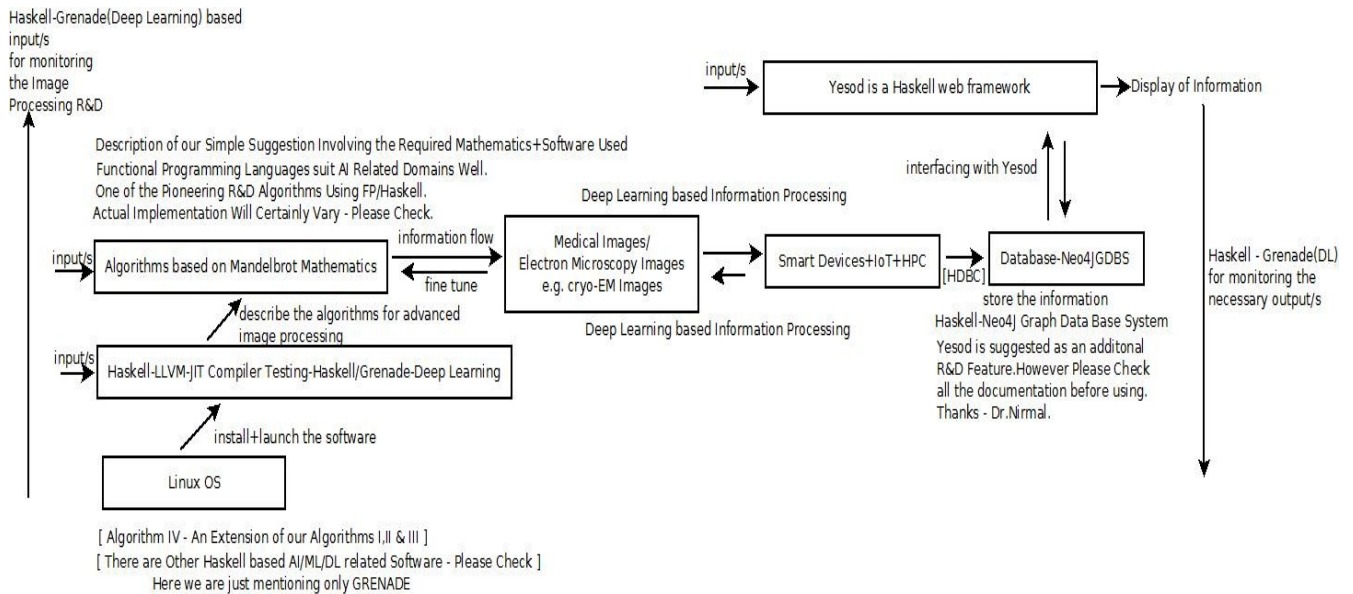
[Figure II – Algorithm II – R&D Informatics Framework for Advanced Image Processing]
 [Based on Extension of our Algorithm I]

We are “Testing” all the Algorithms presented .Encouraging or inspiring others in Image Processing Domains using FP is my intention.Functional Programming(FP) is worth learning.It is advantageous.Fractals are interesting images created from complex numbers.Fractals are produced using an iteration process. Is there a use for any of this?



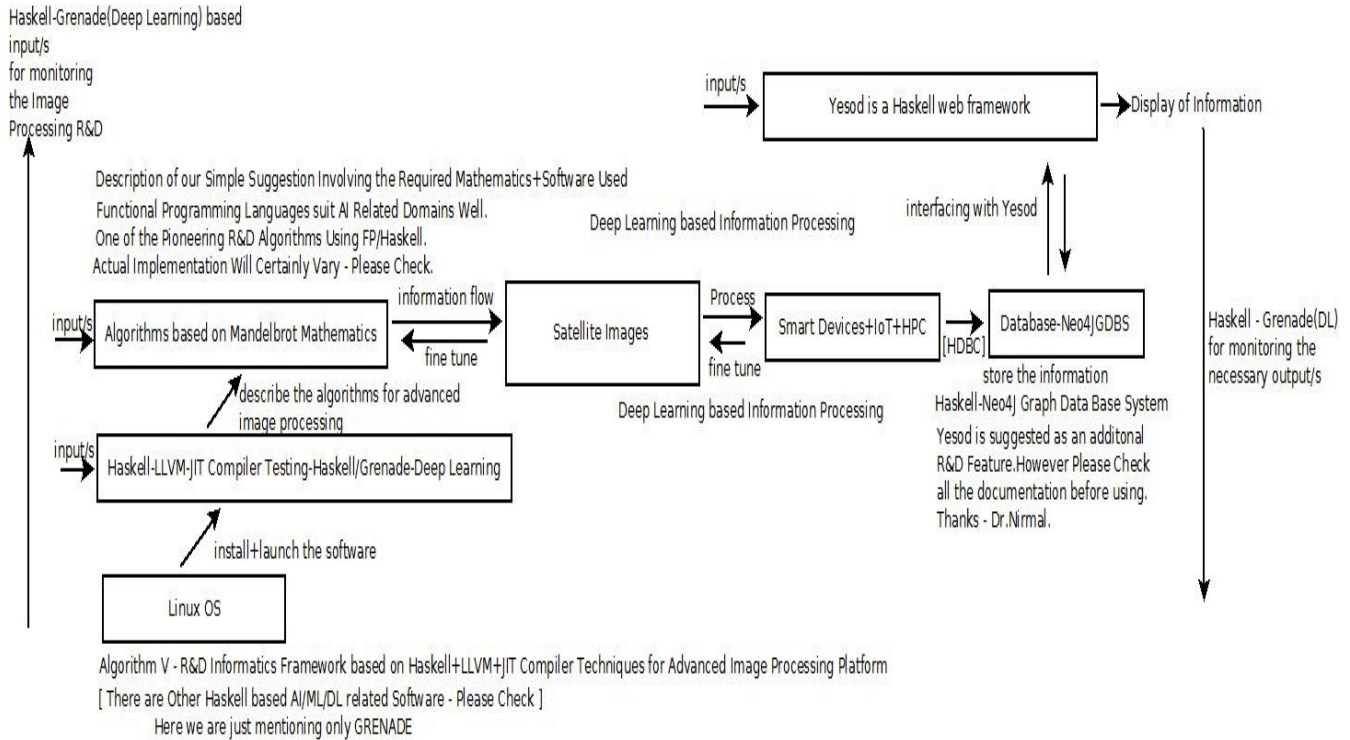
[Figure III – Algorithm III – R&D Informatics Framework for Advanced Image Processing]
{ Based on Extension of our Algorithms I & II }

[*** Check different Databases for compatibility with **Yesod – Web Development Framework**.We have mentioned Neo4) as an example for the sake of our discussion using Haskell ***]



[Figure IV – Algorithm IV – R&D Informatics Framework for Advanced Image Processing]
{ Based on Extension of our Algorithms I ,II & III }
{ Total Overview of our Main Idea }

*** <https://www.leadtools.com/sdk/image-processing/web-services> – My own experience with LEADTOOLS/SDK made me think about Yesod Web Framework +Image Processing integration.



[Figure V – Algorithm V – R&D Informatics Framework for Advanced Image Processing]
[“Solving Complex Societal Problems via Innovative uses of AI + Emerging Space Technologies.”]
[Haskell–Grenade based Satellite Imagery Software R&D Applications]

“Satellite imagery (also Earth observation imagery or spaceborne photography) are images of Earth or other planets collected by imaging satellites operated by governments and businesses around the world. Satellite imaging companies sell images by licensing them to governments and businesses such as Apple Maps and Google Maps.”

[Source – <https://gisgeography.com/free-satelli>]

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

[Source – <https://zoom.earth>]

[Source – <https://sciencing.com/difference-satellite-imagery-aerial-photography-8621214.html>]

[Source – <https://www.nesdis.noaa.gov/content/imagery-and-data>]

[Source – <http://pythonimage.blogspot.com/2009/09/image-processing-web-application.html>]

[Source – <http://iopscience.iop.org/article/10.1088/1742-6596/1087/5/052024/pdf>]

What an inspiration !!! : -----> must read----->

AI Moonshot Challenge will combine AI + Emerging Space Technologies to combat Climate Change –

[Source – <https://unbabel.com/news/50ok-ai-moonshot-challenge-will-combine-ai-with-emerging-space-technologies-to-combat-climate-change/>] – **Space Challenge – Analysis – BIG DATA – AI – HPC.*******

[IV] Useful Information & Reading Materials on Mathematics+Software Used/Useful :

[a] book.realworldhaskell.org > read > using-databases

[b] <https://wiki.haskell.org> > Web > Databases_and_Persistence

[c] <https://caiorss.github.io> > haskell > DatabaseHDBC

[d] <https://en.wikipedia.org> > wiki > Mandelbrot_set

[e] math.hws.edu > eck > mandelbrot

[f] mathworld.wolfram.com > MandelbrotSet

[g] www.math.utah.edu > ~alfeld > math > mandelbrot > mandelbrot

[h] <https://blogs.scientificamerican.com> > roots-of-unity > a-few-of-my-favorit..

[i] <https://dzone.com/articles/mandelbrot-set-in-tensorflow> *****

[j] <https://github.com/OlafenwaMoses/ImageAI/blob/master/imageai/Detection/YOLOv3/models.py>

[k] YOLO – You only look once, real time object detection explained by **Manish Chablani** /
[Source – Towards Data Science] [Very much an inspiration]

[l] **Original paper** – (CVPR 2016. OpenCV People’s Choice Award) : [i] &[ii]→

[i] <https://arxiv.org/pdf/1506.02640v5.pdf> / [ii] YOLOv2: <https://arxiv.org/pdf/1612.08242v1.pdf>

[m] **Complex numbers** have **applications** in many scientific areas, including signal processing, control theory, electromagnetism, fluid dynamics, quantum mechanics, cartography, and vibration analysis.
en.wikipedia.org > wiki > [Complex_number](http://en.wikipedia.org/wiki/Complex_number) / [Complex number – Wikipedia](http://en.wikipedia.org/wiki/Complex_number) .

[n] [Some Geometrical Applications of Complex Numbers – jstor](http://www.jstor.org/stable/2341111) – by LL Small – 1929.

[o] [A Short History of Complex Numbers – URI Math Department](http://www.math.uri.edu/~merino/spring06/mth562/ShortHistoryComplexNumbers2006.pdf) – by O Merino – 2006.
[<https://www.math.uri.edu/~merino/spring06/mth562/ShortHistoryComplexNumbers2006.pdf>]

[p] [henrikmidtiby.github.io > downloads > 2015-05-28ComplexNumbers...](https://henrikmidtiby.github.io/downloads/2015-05-28ComplexNumbers.../) / [Complex numbers and image analysis](https://henrikmidtiby.github.io/downloads/2015-05-28ComplexNumbers.../)

[q] <https://arxiv.org/pdf/1811.12351> – [Evaluation of Complex-Valued Neural Networks on Real ...](https://arxiv.org/pdf/1811.12351) by N Mönning – 2018.

[r] https://wiki.haskell.org/Applications_and_libraries/Theorem_provers – **Useful for probing ideas.**
[**Tools for Formal Reasoning in Haskell for Advanced R&D**] ***

[We are testing with Haskabelle/Agda to design/implement/test our ideas. There could be other options as well.
We are giving here some guidelines only – Please Check & Satisfy Yourselves.
Thanks.]

[V] Additional Information on Functional Programming/Haskell/Yesod/LLVM/AI/ML/DL :

[a] <http://www.stephendiehl.com/llvm/#why-is-this-a-hard-problem> - Implementing a JIT Compiler with Haskell and LLVM (Stephen Diehl)

[b] [The LLVM Compiler Infrastructure Project](https://llvm.org) - <https://llvm.org>

[c] [Haskell Language](https://www.haskell.org) - <https://www.haskell.org> - The Haskell purely functional programming language home page.

[d] [<http://hackage.haskell.org/package/grenade>]

[e] <https://mmhaskell.com/machine-learning>

[f] https://mafiadoc.com/scripting-com-components-in-haskell-microsoft_59a.. - **Important Notes.**

[g]  wiki.haskell.org > [Learning_Haskell](#)

[h]  Yesodweb.com - **Yesod Web Framework in Haskell.**

[i] hackage.haskell.org > packages > tag > database

[VI] Importance of Complex Numbers/Mandelbrot Sets/BIG DATA :

[a] A complex number is a number that can be expressed in the form $a + bi$, where a and b are real numbers, and i is a solution of the equation $x^2 = -1$. Because no real number satisfies this equation, i is called an imaginary number. - [Wikipedia](#) - [Complex Numbers](#).

[b] The **Mandelbrot set** is the set of complex numbers c for which the function $f_c \dots$ The cover article of the August 1985 Scientific American introduced a **wide** audience to the algorithm for computing the **Mandelbrot set**. The cover... - [Mandelbrot set - Wikipedia](#)

[c] [Do we need a new definition of fractals for big data? Or must ...](#) / www.researchgate.net > post > Do_we_need_a_new_definition_of_fra.

[d] [Why Is Fractal Geometry the Right Paradigm for Big Data ...](#) Why is **Mandelbrot set** fractal or beautiful? 7 ... **BIGDATA**: Geo-spatial analysis of **big data** based on fractal geometry and power law statistics. - www.researchgate.net > [publication](#) > [276276557-Why_Is_Fractal_G.](#) -

[e] [Mandelbrot Set In TensorFlow - Compute Quickly - DataFlair](#) / [data-flair.training](#) > [DataFlair](#) > [Tensorflow Tutorials](#) - Useful Notes.

[f] [Mandelbrot set - Rosetta Code](#) - rosettacode.org > wiki > Mandelbrot_set

[g] [FRACTALS, INTERNET, BIG DATA AND CYBERSECURITY . - fernandojimenezmotte.com](#) > [fractals-internet-big-data-and-cybersecu...](#) - Below is a script written in Matlab to generate a fractal or **Mandelbrot set** ... Big Data is likely to display fractals because of the underlying heterogeneity and.....

[h] blogs.scientificamerican.com > [roots-of-unity](#) > [a-few-of-my-favorite-..](#) - / The **Mandelbrot set**, possibly the world's most famous fractal.....

An Important Observation : "The Mandelbrot set has become popular outside mathematics both for its aesthetic appeal and as an example of a complex structure arising from the application of simple rules. It is one of the best-known examples of mathematical visualization and mathematical beauty." - [Source - https://en.wikipedia.org/wiki/Mandelbrot_set]

[VII] Other Information ((via)) Vixra.org :

- [a] http://www.vixra.org/author/d_n_t_kumar
- [b] http://www.vixra.org/author/n_t_kumar
- [c] <http://www.vixra.org/author/nirmal>
- [d] http://www.vixra.org/author/nirmal_tej_kumar
- [e] vixra.org/pdf/1805.0380v1.pdf. **** --- from the Author.
- [f] vixra.org/pdf/1911.0447v1.pdf **** --- from the Author.
- [g] <https://www.semanticscholar.org/author/Nirmal-Kumar/12354503/suggest>

[VIII] Encouraging Information on Haskell – Functional Programming Language :

“Haskell is an advanced purely-functional programming language. An open-source product of more than twenty years of cutting-edge research, it allows rapid development of robust, concise, correct software. With strong support for integration with other languages, built-in concurrency and parallelism, debuggers, profilers, rich libraries and an active community, Haskell makes it easier to produce flexible, maintainable, high-quality software.”

[Source – <https://wiki.haskell.org/Haskell>]

[IX] Why Functional Programming(FP) is useful in the Context of AI/ML/DL/HOL ?

“**Functional programming** is all about composing chains of higher-order functions to operate over simple data structures. Neural nets are designed the same way, chaining together **function** transformations from one layer to the next to operate over a simple matrix of input data.” –

[[towardsdatascience.com > functional-programming-for-deep-learning-b...](https://towardsdatascience.com/functional-programming-for-deep-learning-b...)]

“In computer science, **functional programming** is a **programming** paradigm that treats computation as the evaluation of mathematical functions and avoids changing state and mutable data. It is a **programming** pattern that is closer to mathematical thinking. **Deep learning models are essentially mathematical models.**”

[[www.welcometothejungle.com > btc-deep-learning-clojure-haskell](http://www.welcometothejungle.com/btc-deep-learning-clojure-haskell)]

[<https://hub.packtpub.com/what-makes-functional-programming-a-viable-choice-for-artificial-intelligence-projects/>]

[<https://www.researchgate.net/post/-Why-is-functional-programming-advantageous-in-Artificial-Intelligence>]

[[www.infoq.com > presentations > ai-ml-functional-programming](http://www.infoq.com/presentations/ai-ml-functional-programming)]

[[www.quora.com > Why-is-functional-programming-a-good-paradigm-f...](http://www.quora.com/Why-is-functional-programming-a-good-paradigm-f...)]

[[hackernoon.com > the-future-is-functional-haskell-and-the-ai-native-...](http://hackernoon.com/the-future-is-functional-haskell-and-the-ai-native-...)] – [The Future is Functional: Haskell and the AI Native World.....](#)

[[link.springer.com > article](http://link.springer.com/article) – [AI and the Origins of the Functional Programming Language ...](#)]

by M Priestley – 2017.

[www.math.univ-toulouse.fr > ~cheritat > wiki-draw > index.php > Ma...](http://www.math.univ-toulouse.fr/~cheritat/wiki-draw/index.php/Ma...) -

Mandelbrot set - Techniques for computer generated pictures ...

[phys.org > Other Sciences > Mathematics](http://phys.org/Other_Sciences/Mathematics) - Beautiful math of fractals - Phys.org

[<https://pdfs.semanticscholar.org/e892/bad93aabc40d1c725e936387136f369a81b3.pdf>] - [A Functional Programming Approach to AI Search Algorithms.](#)

[[www.dfki.de > ~neumann > publications > new-ps > ai-pgr](http://www.dfki.de/~neumann/publications/new-ps/ai-pgr)] - [Programming Languages in Artificial Intelligence - DFKI](#) by G Neumann .

https://wiki.haskell.org/Haskell_in_industry /

https://wiki.haskell.org/Haskell_in_research /

https://wiki.haskell.org/Haskell_in_education .

https://wiki.haskell.org/Development_Libraries_and_Tools - **Convert Haskell Programs to Isabelle Theories.*******

<http://www.cl.cam.ac.uk/research/hvg/Isabelle/haskabelle.html>*****

[X] Acknowledgment/s :

Special Thanks to all my **Mentors+Friends+Collaborators**. Non-Profit R&D. **Receiving Excellent +ve Feedback.**

[XI] Conclusion/s With Future Perspectives :

An important idea based on Mandelbrot Algorithms is suggested and presented in the Context of Medical Imaging/ Electron Microscopy Imaging/Satellite Imagery Software R&D Applications Using →

[Smart Devices/IoT/HPC/Haskell-LLVM-DL/Grenade/Neo4J Graph DB System/Yesod -Web Development Framework in Haskell] in Heterogeneous Environments. Algorithms II,III,IV & V are presented by extending our Algorithm I using simple diagrams as a Short Communication.AI/ML/DL can improve health care by analyzing Medical Informatics Data/Other Scientific Data from apps, Smartphones & Wearable Technology in the context of IoT. Designing,implementing and testing a **Novel Image Processing R&D Framework** based on Haskell is worth pursuing.

[THE END]