L-Germs: L-System Based Plant Modeling and Music Score Generation through Scientific Pitch Notation

ChenKim Lim, KianLam Tan, Vicknesh Suppramaniam, HweiTeeng Chong

Abstract—The mission for photo-realism plants modeling areas yet open test. Within the L-System, non-regular and complex plant turn out to be all more numerically sensible. In any case, some control parameters should be adjusted again and to get the correct L-System axioms and productions protocols so as produce the good plants modeling. In this paper, an cross-compiling l-Systems stage are created for developing plant models from squiggly structures of computer graphics application to genuine numerically based representations. The determinations are worked using enabling the standards JSON IDE (Java Script Object Notation Integrated Development Environment) within primitive custom-made to L-Systems algorithms. Besides, from plant modeled, a music score based on scientific pitch notation is generated. Toward the finish of this paper, various outlined programming precedentis gives through graphic interpretations on L-System.

Index Terms—l-System, Plants modeling, L-System Fractal, Turtles Graphic, Scientific Pitch Notation.

I. INTRODUCTION

Usually, there are 2famous strategies in creating fractal which is Iterated Function System (IFS) and Lindenmayer System (L-System). Practically each fractals figure may be produced utilizing an L-Systems idea[1]. L-Systems are a scientific based-algorithm to explaining the conduct of plant cell also to show development procedures of plant improvement. After the fuse of geometric highlights, sensible perception of L-Systems based-plant modeling turned out to being increasingly point by point in technically [2]. In any cases, an application that are run-able in various stages so L-System is utilized to produce plant with-in or with-out inflorescences, cells development, geometric examples and tiling were generally unexplored. The illustrations architect more often than not needs to find in reverse to figure the creation rules. It is in reality exceptionally hard to structure the proper L-Systems to getting an ideal visual model on plant. Some arrangement may have revising and running the contents in the compilers(i.e.) equipped for making implementable coding of different stages. The improvements of bi-nary code are then achievable to keep running with an existing content that are composed on a committed stage at first. This could create the plants modeling having capacity for consolidate with other plants modeling flexibly dependent on L-System algorithm.

II. LITERATURE REVIEW

A review of different written works uncovers the advancement of fractals and practical demonstrating of plant utilizing the L-System technique. Beginning [3], to presented the easiest classes of L-System known DOL-System (Deterministics and O-context or context-free) on Fibonacci series. Context-free implies have a generation protocols consider account just in a single symbol/image and not of what their neighbor are [4]. This study proceeded on presenting a graphics interpretations of string dependent of turtles geometric[5]. As referenced in [6][7][8], the enthusiasm for L-Systems keeps to sprawling for represented to chart/graphic-theory tree and back geometry understanding by string with bracket. Processing on the elements that had extraordinary effects on the development of plant, the Genetic Algorithm (GA) within its wellness work is utilized with L-Systems [9] [10].Afterward, context-sensitive L-System is likewise presented when the generation protocol is possibly substituting

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For a specific image just where certain neighbor images existing or on privilege or left [11]. Additionally, sto-chastic L-Systemis likewise broadly considering an specific creations just occurred with specific probabilities [12]. [13]Then presented to combine a context-sensitive and stochastic L-Systems into visual programs. Another different strategy had been presented to produce plant by L-System, it have been appeared nothing is focusing of executing then on a cross stages way. The basic reviews in the subjective of crossing stage for L-Systems applications had been create to comprehend it's applications of structuring an progressively route of interpreting the L-System protocol. In these unique circumstances, we presented the complete cross-arranging/compiling stage known as L-Germs explicitly for L-System. L-Germs supporting the visual originators to had full coding generations have demonstrates plant use abusing the cross-gathering stage.

III. SYSTEM METHODOLOGY

L-System are fundamentally the same as the organic procedures where in the Chomsky sentence structures, creations are connected successively in L-system, there is connected in a parallel way (supplanting at the same time all letters in the words). In this paper, the 3stage framework systems are appeared in Figure 1. AL-System comprises for (1) The alphabets (letter) set of symbol may be utilized to create string, (2) An accumulation on creation decides to grow every symbols into other bigger strings of symbol, (3) A underlying first axioms strings begin to start development and (4) A component on making an interpretation of the produced string into geometric structure are outlined in the L-Systems scripting phases. J-SON, the crossing stage IDE that enables a content to run-able of various stage is outlined onstage assurance phases. Depend upon stage, an content is run at the terminals, 3yield records of the creation rules, plant picture and music note dependent on scientific pitch notation are produced as delineated in the yield record stage. A totally unique plant model can be build by a fundamentally the same as recursive method through numerous stages or iterations.

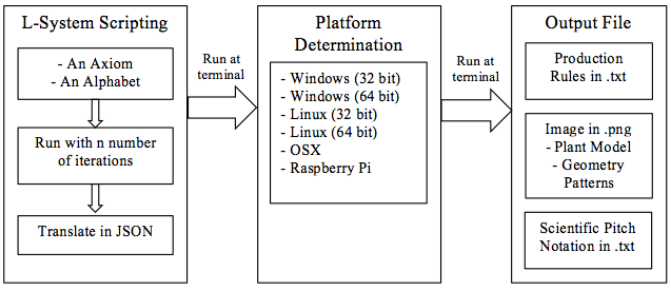

Fig. 1 System Methodology of LGerms

IV. DEVELOPMENT

There is some existing L-Systems devices; example of MAC versions, LMUSe (Java 8), Tree-Sketch 3.0 and Open-Alea 1.2. In any case, this apparatuses aren't run-able in multi-platform and consequently, that are hard for create an ideal plants demonstrates on the photo-realistic point of view or common place mechanized representations. In L-GERM's, the guidelines for cross ordering L-Systems to the various stage has per the following:

1. **For Windows (64-bits)**:
env GOOS=windows GOARCH=amd64 go build
2. **For Windows (32-bits)**:
env GOOS=windows GOARCH=386 go build
3. **For Linux (64-bits)**:
env GOOS=linux GOARCH=amd64 go build
4. **For Linux (32-bits)**:
env GOOS=linux GOARCH=386 go build
5. **For OSX**:
env GOOS=darwin GOARCH=amd64 go build
6. **For Raspberry Pi**:
env GOOS=linux GOARCH=arm go build

Figure 2 demonstrates to summarize of the parameter define so as to run-able a binary document in the terminals in a cross-aggregations. For make protocols and defining, an alternative to "activity" is as appeared in Figure 3.

</path/to/lsystem.json> - documents contained a principle and definitions of the L-Systems. They gave L-system.json are an example set.
<start string> -initial pattern set.
<iterations> - no.of.iterationsto run.
<output_file> - output files. They contains3 documentshavecreated;outcomes recordon the generation rules in .text, an image record there ends in a .png. that is more a music score that closes in .txt.

Fig. 2 Defining of Parameter to run the binary Files.

push - To Save x,y coordinate and angles of stacks.
pop – To Load x,y coordinate and angles from stacks.
rotate N –To Changes the direction of next drawing operations use N degree.
Move N - Move by N-pixels without drawings.
Draw C W L –to Draw a line with color C (in #rrggbbaa notation), Width W and long L pixel

Fig. 3 Operation to make Own Rules and Definitions.

In order to generate music score, the instructions to run the "lsystem" binary on the following Operating Systems and the definition of the parameters are as follows according to the different operating systems:

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Windows

lsystem.exe</path/to/lsystem.json><start string><iterations><output_file>

Linux

chmod 755 lsystem./lsystem</path/to/lsystem.json><start string><iterations><output_file>

Osx

chmod 755 lsystem.osx./lsystem.osx</path/to/lsystem.json><start string><iterations><output_file>

An example of the command of OSX operating system would be ./system.osx ./Lsystem.json "Ff" 8 output. To the text-file, they are better opening with Sub-lime Texts 3 and content composed within json (a cross-platform IDE), they very well have been approved within jsonlint.com. A content composed within json are appeared in Figure 4. Figure 5 demonstrates an order keep running in the terminals for producing the plants record for the example direction written in lsystem.json within axioms of "Ff" and 8iteration.Using similar parameter, Figure 6demonstrates the order keep running at the terminal to create the music score dependent on scientific pitch notation.

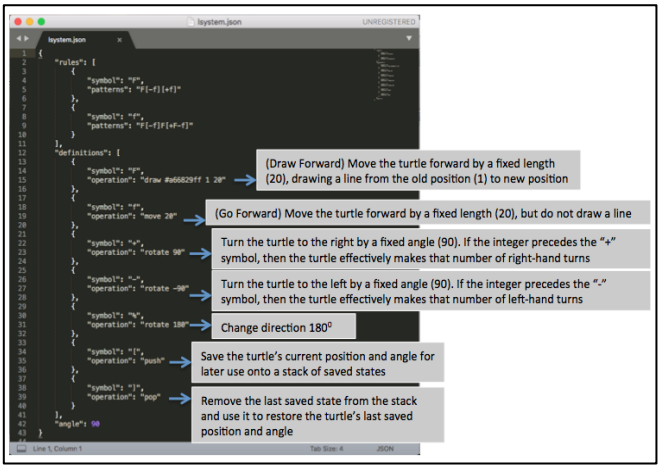


Fig. 4 Scripted Notion on L-Systems Grammar of.json File

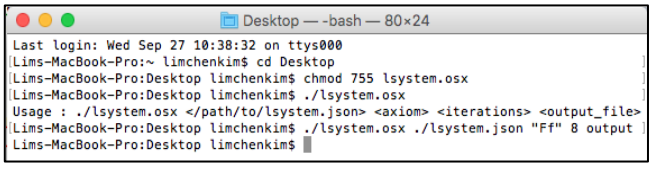


Fig. 5 Generation of Plant Models from Terminal.

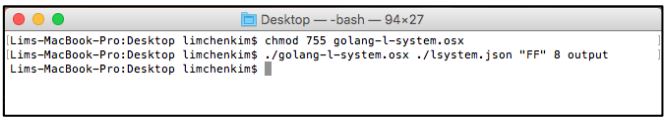
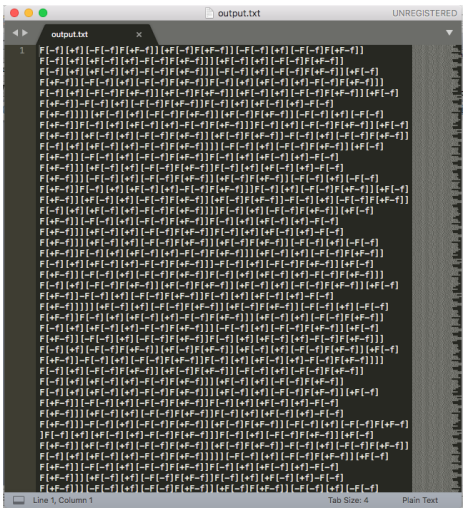
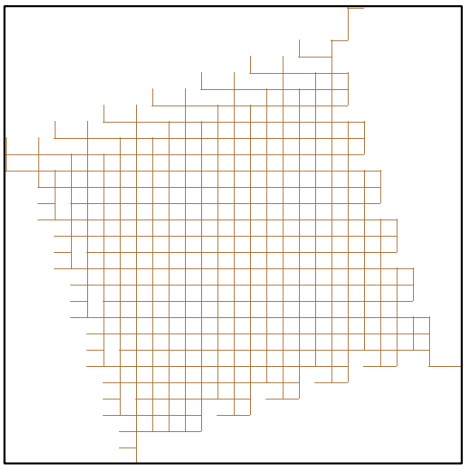


Fig. 6 Generation of the Music Score and Sound from the Terminals.

In the wake of, running this directions of terminal, an output.txt are appeared in Figure 7(a) and the fractal image records .png are appeared in Figure 7(b) is produced.



(a)



(b)

Fig. 7 (a) Output File Generated from Production Strings and (b) Geometry Patterns Generated from the Interpretation on Production Strings.

In this research we are only concentrating in the note of E, G, B, D, F, A, C, E with the pitch level of '1'. Besides, there is no actual music score generated instead L-System Grammar is converted to music note in term of Scientific Pitch Notation. The Scientific Pitch Notation has ten levels as shown in Figure 8.

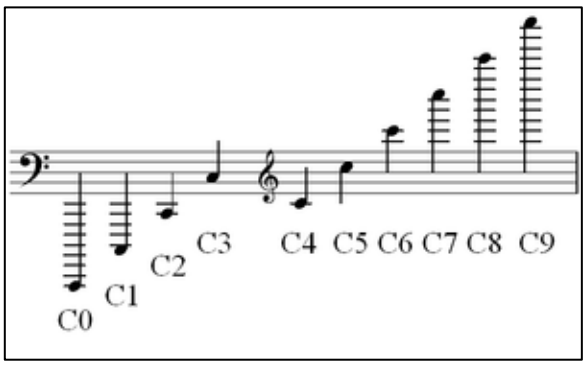


Fig. 8 Original Representation of Scientific Pitch Notation with Ten Levels.

Figure 9 shows the class "music" written in json for the comparability of the L-System grammar to the Scientific Pitch Notation while Figure 10 shows the output file of the music score based on Scientific Pitch Notation in .txt.

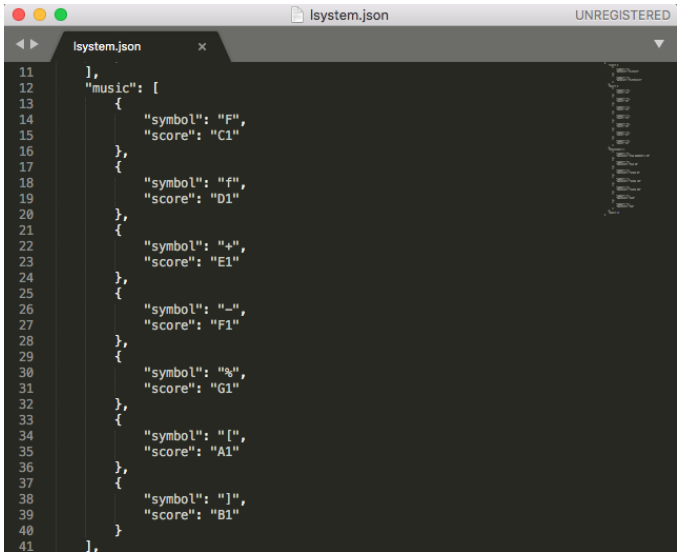
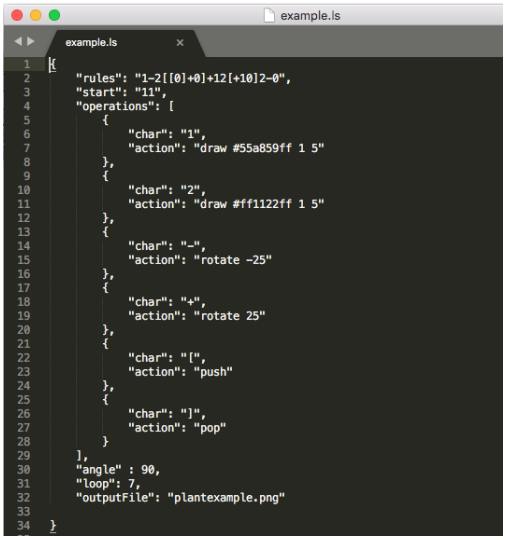


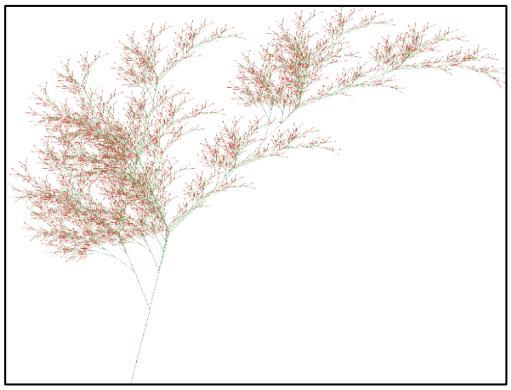
Fig .9 Equivalence of the L-Systems Grammar to the Scientific Pitch Notation.

Fig. 10 The Output File of Music Score Based on Scientific Pitch Notation.

The similar procedure repeating with other example content writting in .json are appeared in Figure 11(a) the yield for plants are appeared in Figure 11(b).



(a)



(b)

Fig. 11 (a) Another Samples Scripts Re-defining an Equivalence of L-Systems and (b) Plants Output

V. PROOF OF CONCEPT

In order to proof the concept of the workability of the proposed multi-compiler, several L-System based applications are tested running together with LGERMs. All the backend engine working on LGERMs are from public sources. Figure 12 shows the most relevant application to our proposed work which in LMUSe. It is written in Java and is designed to run the "LS" filed that Laurens Lapre' LParser program uses.

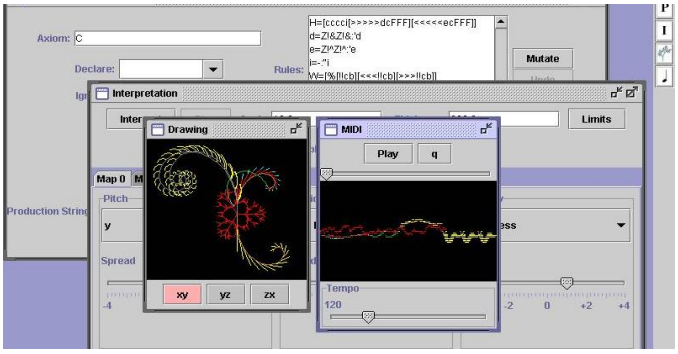


Fig. 12 LMUSe: Laurens Lapre's Multi-User Simulation Environment

Another L-Systems application named L-Systems Turtle Graphics Renderer based on the literature is also tested (http://www.kevs3d.co.uk/dev/lsystems/). Then the same rules are put in LMUSe and L-Systems Turtle Graphics Renderer to compare the correctness as shown in Figure 13. The results of the plant modelling of both LMUSe and L-Systems Turtle Graphics Renderer are similar through three iterations but they are running on LGERMs as the front end application as appeared in Figure 14.

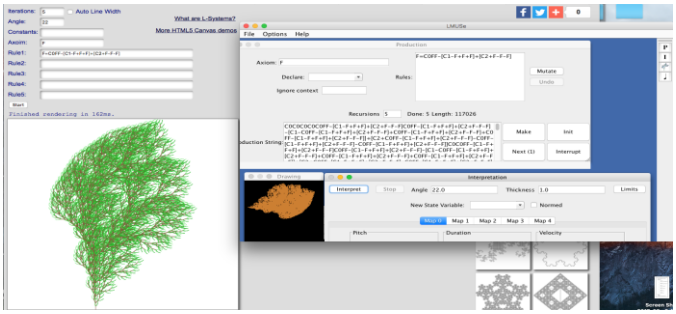


Fig. 13 LMUSe equivalent rules with L-Systems Turtle Graphics Renderer.

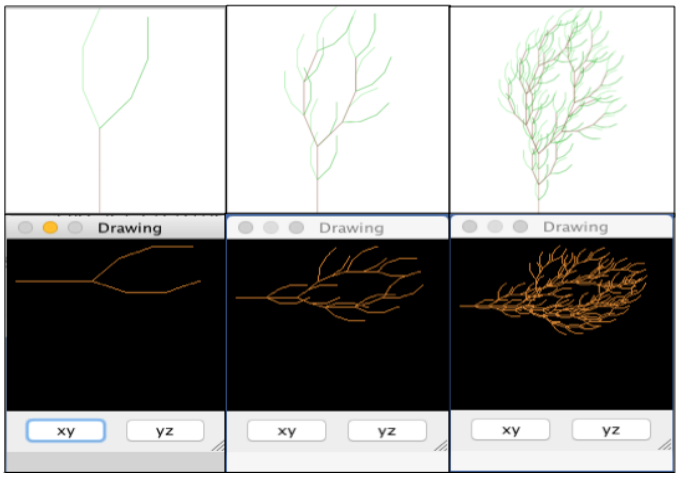


Fig. 14 Results of Plant Modelling through Three Iterations: From upper Left to Right is iteration 1, 2 and 3 using L-Systems Turtle Graphics Renderer while from bottom Left to Right is iteration 1, 2 and 3 using LMUSe.

Another L-System Generator developed by Michael Norris in 2006 (http://www.michaelnorris.info/musictheory/l-system-generator) is also the primary source of understanding the syntax of L-Systems themselves, which concerned also the decay system of the plant model. The simple application gave idea on how one substituting another and those who do not have another substitution, it will go through decay stage and eliminated in the next generation. The system input and output interfaces are as shown in Figure 15.

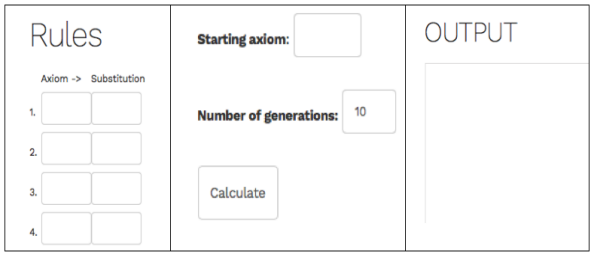


Fig. 15 Interface of the L-System Generator.

The same process repeated by changing the rules randomly using LGERMs regardless of what sample rules used from other L-Systems equivalent system, and the new generatedoutputs are as shown in Figure 16, Figure 17 and Figure 18 respectively.

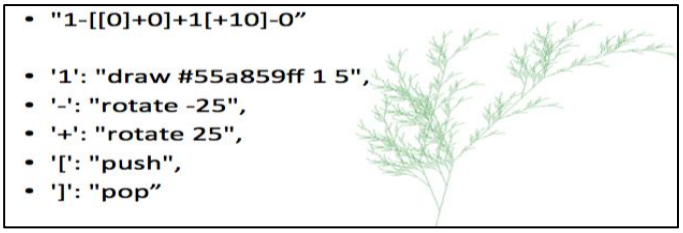


Fig. 16 Sample plant output with the initial rules "1-[[0]+0]+1[+10]-0"

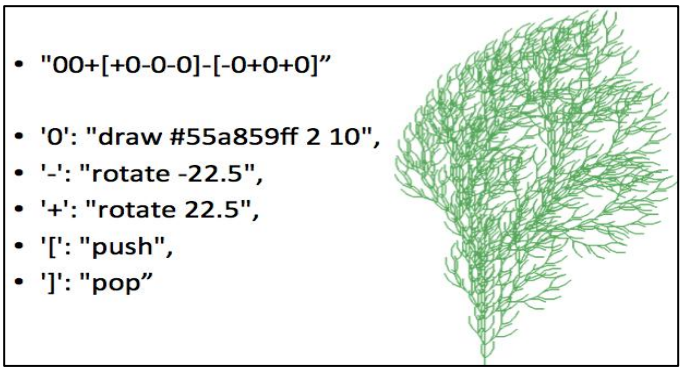


Fig. 17 Sample plant output with the initial rules "00+[+0-0-0]-[-0+0+0]"

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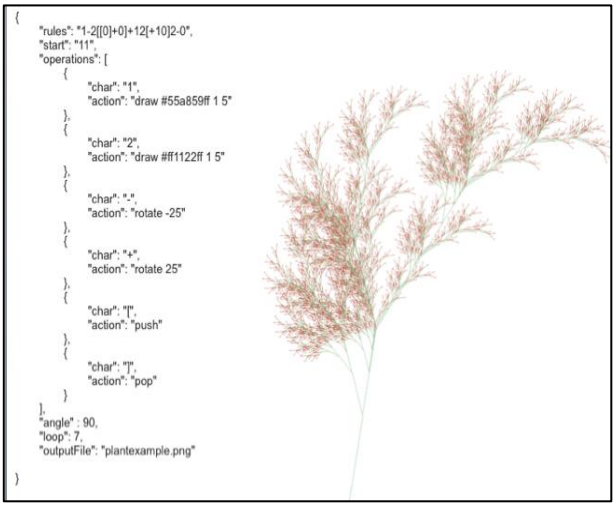


Fig. 18 Sample plant output with the initial rules "1-2[[0]+0]+12[+10]2-0"

VI. EVALUATION

By utilizing L-Germs, the visual/ graphic plants may create has about precise are conceivable for sketches to plants. The visual correlation of modeling within genuine structures are ideal of approval reason. Fractals geometric are particularly an graphic ideas and in this way graphic instinct and translation are critical for the approval to these analyze. Table 1 demonstrates an image drawing on the visual planner (left) and modeling exhibited by L-System geometric computations (right) joined by set of program precedents. The created plant demonstrate an solid likeness of the genuine plant the visual planner are proposed on impersonate, in spite of that there were no really may be naturally accurate. This comparison is genuinely self-explanation and all things considered won't be talked about in any more subtleties here.

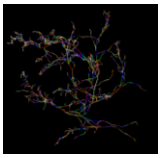
Table. 1 Images are drawn by computer (a-d), Images modeling use computer based on L-systems geometric calculations (f-h) and program example.

2D Sketch	LGERM's	Example of L-Systems Code

 (a)	 (e)	LGERM's{ axioms = X;
		num_recursive= 5;
		angle = 339;
		thickness = 300;
		Y=(0.7071)>A>B>A>B>A}[A>B<(2)^(45)FA];
		X='\CF{mFCB/CB>B>&(45);
		A=[m(1)F{+(45)FCA}[-(45)FCA]];
		B=A>B<>A>B>A>B>A>B>A{A}{Y}>B;
		C=X<>X;
		}

 (b)	 (f)	LGERM's{ axioms: &(90)+(90)FB-C;
		num_recursive = 5;
		angle = 50;
		thickness = 10;
		F=FX;
		X=A>B>A>B>A>B>A>B>A>B>A>B>A>B>A>B>A>B;
		A=[-(45)X>X;
		B=[F{c(i2)m(2)^(45){A}FCB}[&(45)FCc(i1)B]];
		C='(0.7071);
		}

 (c)	 (g)	LGERM;s{ axioms = F;
		num_recursive = 4;
		angle = 150;
		thickness = 10;
		F=Fc(8)F++[F-F+F-F]--[F-F+F-F];
		}

 (d)	 (h)	LGERM's{ axioms: A
		num_recursive = 15;
		angle = 104;
		thickness = 170;
		A=~(30)?(.9)"(.9)Fc[~(40)?(.25)"(.25)B]c~(30)?(.9)"
		(.9)Fc[~(40)?(.50)"(.50)B]c~(30)?(.9)"(.9)Fc[~(40)? (.75)"(.75)B]cA;
		B=~(30)?(.9)"(.9)Fc[~(40)?(.33)"(.33)C]c~(30)?(.9)"
		(.9)Fc[~(40)?(.66)"(.66)C]cB;
		C=~(30)?(.9)"(.9)FcC;
		}

VII. CONCLUSION AND FUTURE WORKS

L-Systems algorithms empowers anybody with an essential program information have produce complex plant demonstrate by again and again applying some easy sentence structures and activities. By L-System techniques, one may reproduce at-least each fractals images idea such as plants. In this paper, we are effectively executed a cross-arranging L-System stage to building plant. Have appeared on the outcomes, plants may be effectively demonstrated and also determined in the visual architect may translate lot of program decides(i.e.) 'compilable' of different L-System stages. Be that as it may, the level

of authenticity on these models on assessment lies' intensely on the hand of visual fashioners. The limitations of these explorations are that the cross-incorporating stage must be utilized for producing deterministic fractal (mathematical and geometrical). Some of things for come work is to grow this cross compiling stage to have the capacity to create the non-deterministic fractals (stochastic). Another direction is structure the cross incorporating stages within an intelligent graphic manager and graphic programs. Furthermore, from the generated scientific pitch notation, this work can be extended to MIDI to generating an equivalent music file.

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