

# Untitled: A DirectX Game

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## 1 Summary

## 2 User Controls

## 3 Features

### 3.1 Noise

### 3.2 Procedural Terrain

[Starting point: the problem of concavity!]

Introduce marching cubes as the central tenet of the modelling process...

Definitive... Paul Bourke's *Polygonising a scalar field* (1994)...

### 3.2.1 Case Study: Hexes

### 3.2.2 Case Study: Landmarks

## 3.3 Procedural Screen Textures

[*Untitled* uses screen textures, based on l-systems...].

In formal languages, a grammar is a tuple  $G = (N, \Sigma, P, \omega_0)$ . This contains two disjoint sets of symbols: nonterminals  $A, B, \dots \in N$ , and terminals  $a, b, \dots \in \Sigma$ . The production rules in  $P$  map nonterminals to strings  $\alpha, \beta, \dots \in (N \cup \Sigma)^*$ ; applied recursively to the axiom  $\omega_0 \in (N \cup \Sigma)^*$ , these rules can produce increasingly complex strings of terminals and/or nonterminals.<sup>1</sup>

The Chomsky hierarchy (Chomsky 1956) classifies grammars by their production rules:

*Type-3. Regular grammars* map  $A \mapsto a$  or  $A \mapsto aB$ .

*Type-2. Context-free grammars* map  $A \mapsto \alpha$ .

*Type-1. Context-sensitive grammars*  $\alpha A \beta \mapsto \alpha \gamma \beta$ .

*Type-0. Unrestricted grammars* map  $\alpha \mapsto \beta$ , where  $\alpha$  is non-empty.

Note that all Type-3 grammars are also Type-2, all Type-2 grammars also Type-1, and so on.

Suppose, for example, that  $N = \{F, G\}$ ,  $\Sigma = \{+, -\}$ ,  $P = \{F \mapsto F + G, G \mapsto F - G\}$ ,  $\omega_0 = F$ . Letting  $\omega_n$  denote the string generated by applying the production rules  $n$  times, it follows that

$$\begin{aligned}\omega_1 &= F + G, \\ \omega_2 &= F + G + F - G, \\ \omega_3 &= F + G + F - G + F + G - F - G, \\ \omega_4 &= F + G + F - G + F + G - F - G + F + G + F - G - F + G - F - G, \dots\end{aligned}$$

While the above definitions are rather abstract, they come with a surprising practical application. Lindenmayer (1968) introduces the L-system, ... [Introduce basics of L-systems, include the angles used for dragon curves...] produces the dragon curves in Figure 1.

Quick test!

### 3.3.1 Case Study: Runes

Parametric L-systems (Hanan 1992) exist as a generalisation of the above... [theory].

[Move into code... what parameters will we consider?]

[Example: various geometric runes!].

### 3.3.2 Case Study: Blood Vessels

Zamir (2001) uses parametric L-systems... equations for bifurcation...

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<sup>1</sup>In mathematical literature,  $\omega_0 \in N$  (Hopcroft, Motwani & Ullman 2000), but this paper takes an informal approach.

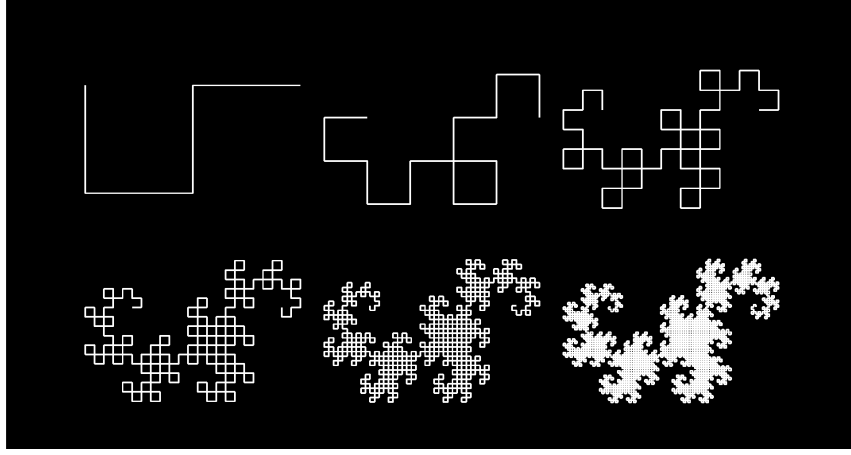


Figure 1: Dragon curves, generated by strings  $\omega_2, \omega_4, \dots, \omega_{12}$ .

Suppose a branch with length  $l$ , width  $w$  bifurcates into two branches  $M$  and  $m$ , such that  $l_M \geq l_m$ . Defining the *asymmetry ratio*  $\alpha = l_m/l_M$ , it follows that

$$l_M = \frac{l}{(1 + \alpha^3)^{1/3}}, \quad l_m = \frac{\alpha \cdot l}{(1 + \alpha^3)^{1/3}}, \quad w_M = \frac{w}{(1 + \alpha^3)^{1/3}}, \quad w_m = \frac{\alpha \cdot w}{(1 + \alpha^3)^{1/3}}.$$

Furthermore, the branches diverge from their parent at angles

$$\theta_M = \arccos \left( \frac{(1 + \alpha^3)^{4/3} + 1 - \alpha^4}{2(1 + \alpha^3)^{2/3}} \right), \quad \theta_m = \arccos \left( \frac{(1 + \alpha^3)^{4/3} + \alpha^4 - 1}{2\alpha^2(1 + \alpha^3)^{2/3}} \right).$$

$$\begin{aligned} \mathbf{C} &\mapsto \mathbf{X}[\mathbf{C}]\mathbf{C} \\ \mathbf{X} &\mapsto \mathbf{X}\mathbf{X} \end{aligned}$$

$$\mathbf{C} \mapsto \mathbf{X}[\mathbf{C}]\mathbf{C}$$

$$\mathbf{C}(l, w, \theta) \xrightarrow[0.4]{} \mathbf{X}(l, w, \theta)[\mathbf{C}(l_M, w_M, \theta + \theta_M)]\mathbf{C}(l_m, w_m, \theta - \theta_m)$$

$$\mathbf{C}(l, w, \theta) \xrightarrow[0.4]{} \mathbf{X}(l, w, \theta)[\mathbf{C}(l_m, w_m, \theta + \theta_m)]\mathbf{C}(l_M, w_M, \theta - \theta_M)$$

$$\mathbf{C}(l, w, \theta) \xrightarrow[0.2]{} \mathbf{X}(l, w, \theta)\mathbf{C}(l, w, \theta)$$

$$\mathbf{C}(l, w, \theta) \xrightarrow[0.4]{} \mathbf{X}(l, w, \theta)[\mathbf{L}(l_M, w_M, \theta + \theta_M)]\mathbf{R}(l_m, w_m, \theta - \theta_m)$$

$$\mathbf{C}(l, w, \theta) \xrightarrow[0.4]{} \mathbf{X}(l, w, \theta)[\mathbf{L}(l_m, w_m, \theta + \theta_m)]\mathbf{R}(l_M, w_M, \theta - \theta_M)$$

$$\mathbf{C}(l, w, \theta) \xrightarrow[0.2]{} \mathbf{X}(l, w, \theta)\mathbf{C}(l, w, \theta)$$

$$\mathbf{L}(l, w, \theta) \xrightarrow[1.0]{} \mathbf{X}(l, w, \theta)\mathbf{C}(l_M, w_M, \theta - \theta_M)$$

$$\mathbf{R}(l, w, \theta) \xrightarrow[1.0]{} \mathbf{X}(l, w, \theta)\mathbf{C}(l_M, w_M, \theta + \theta_M)$$

Liu et al. (2010) further introduce a stochastic component...

### 3.4 Procedural Narrative

## 4 Code Organisation

### 4.1 Post-Processing

### 4.2 GUI

[Include HDRR/bloom here...]

## 5 Evaluation

### 5.1 Features

### 5.2 Code Organisation

## 6 Conclusions

## References

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