Untitled: A DirectX Game

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3.1 Noise

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[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.[1]

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 α 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 ω_n denote the string generated by applying the production rules n times, it follows that

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

While the above defintions 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.

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...

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

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

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

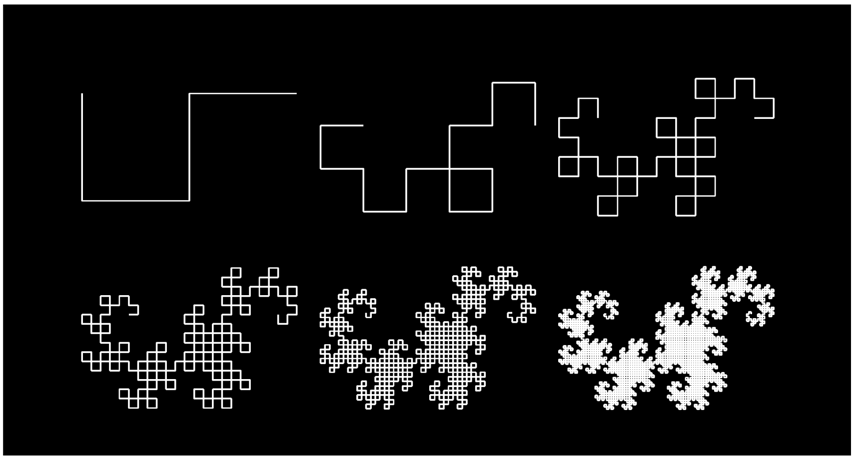

Figure 1: Dragon curves, generated by strings $\omega_2, \omega_4, \cdots, \omega_{12}$.

Furthermore, the branches diverge from their parent at angles

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

$$\begin{array}{lcl} \mathbf{C} & \mapsto & \mathbf{X}[+\mathbf{C}]-\mathbf{C} \\ \mathbf{X} & \mapsto & \mathbf{XX} \end{array}$$

$$\begin{array}{l} \mathbf{C}, \\ \mathbf{X}[+\mathbf{C}]-\mathbf{C}, \\ \mathbf{XX}[+\mathbf{X}[+\mathbf{C}]-\mathbf{C}]-\mathbf{X}[+\mathbf{C}]-\mathbf{C}, \\ \mathbf{XXXX}[+\mathbf{XX}[+\mathbf{X}[+\mathbf{C}]-\mathbf{C}]-\mathbf{X}[+\mathbf{C}]-\mathbf{C}]-\mathbf{XX}[+\mathbf{X}[+\mathbf{C}]-\mathbf{C}]-\mathbf{X}[+\mathbf{C}]-\mathbf{C}, \quad \cdots \end{array}$$

$$\begin{array}{lcl} \mathbf{C}(l,w,\theta) & \underset{0.4}{\longmapsto} & \mathbf{X}(l,w,\theta)[\mathbf{C}(l_M,w_M,\theta+\theta_M)]\mathbf{C}(l_m,w_m,\theta-\theta_m) \\ \mathbf{C}(l,w,\theta) & \underset{0.4}{\longmapsto} & \mathbf{X}(l,w,\theta)[\mathbf{C}(l_m,w_m,\theta+\theta_m)]\mathbf{C}(l_M,w_M,\theta-\theta_M) \\ \mathbf{C}(l,w,\theta) & \underset{0.2}{\longmapsto} & \mathbf{X}(l,w,\theta)\mathbf{C}(l,w,\theta) \end{array}$$

$$\begin{array}{lcl} \mathbf{C}(l,w,\theta) & \underset{0.4}{\longmapsto} & \mathbf{X}(l,w,\theta)[\mathbf{L}(l_M,w_M,\theta+\theta_M)]\mathbf{R}(l_m,w_m,\theta-\theta_m) \\ \mathbf{C}(l,w,\theta) & \underset{0.4}{\longmapsto} & \mathbf{X}(l,w,\theta)[\mathbf{L}(l_m,w_m,\theta+\theta_m)]\mathbf{R}(l_M,w_M,\theta-\theta_M) \\ \mathbf{C}(l,w,\theta) & \underset{0.2}{\longmapsto} & \mathbf{X}(l,w,\theta)\mathbf{C}(l,w,\theta) \end{array}$$

$$\mathbf{L}(l,w,\theta) \underset{1.0}{\longmapsto} \mathbf{X}(l,w,\theta)\mathbf{C}(l_M,w_M,\theta-\theta_M)$$

$$\mathbf{R}(l,w,\theta) \underset{1.0}{\longmapsto} \mathbf{X}(l,w,\theta)\mathbf{C}(l_M,w_M,\theta+\theta_M)$$

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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