

# FracNoise

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## Contents

<b>1</b>	<b>Definitions</b>	<b>2</b>
1.1	Perlin noise . . . . .	2
1.2	FracNoise . . . . .	2
<b>2</b>	<b>Interface</b>	<b>5</b>
<b>3</b>	<b>Code</b>	<b>11</b>
3.1	fracnoise.c . . . . .	11
3.2	fracnoise-inline.c . . . . .	23
<b>4</b>	<b>Makefile</b>	<b>32</b>
<b>5</b>	<b>Unit tests</b>	<b>33</b>
<b>6</b>	<b>Unit tests output</b>	<b>41</b>
<b>7</b>	<b>Examples</b>	<b>43</b>
7.1	Terrain . . . . .	43
7.2	Cloud . . . . .	47
7.3	Rock . . . . .	52

## Introduction

FracNoise is a C library providing structures and functions to generate noise based on the Perlin noise.

The library provides the structure `PerlinNoise` and its functions to generate noise as described by Prof. Ken Perlin.

It also provides the structure `FracNoise` and its functions, which extends the `PerlinNoise`. A `FracNoise` is made of a composition of one or several `PerlinNoise`. Each of the composed `PerlinNoise` can be individually controlled over its input/output values scale and shift; be attached to a boundary (`Shapoid`) outside of which the `PerlinNoise` is inactive, and inside of which it becomes smoothly active across a border width defined by the user; support a recursive definition with user defined depth and strength; have a 'smooth' parameter to set the aspect (round or spiky) of the `PerlinNoise`; have a user defined seed; return output as a vector of any dimension; take input as a vector of 1, 2 or 3 dimensions, however the limit of 3 can somehow be extended up to 6 by using the 3 components of the seed as input values too.

The `FracNoise` structure also provides an export function toward ".df3" density file to be used in computer graphics software like POV-Ray.

It uses the `PBErr`, the `GSet`, the `Shapoid` and the `PBMath` library.

## 1 Definitions

### 1.1 Perlin noise

For details about the Perlin noise, please refer to the paper of, and its reference implementation by, Prof. Ken Perlin:

<http://mrl.nyu.edu/~perlin/paper445.pdf>

<http://mrl.nyu.edu/~perlin/noise/>

The implementation of the Perlin noise in the `FracNoise` library is a port from the JAVA Reference Implementation of Prof. Perlin toward C language with only modification a mapping of the output value to  $[0.0, 1.0]$ .

### 1.2 FracNoise

In the `FracNoise` structure, each instance of a `PerlinNoise` is called a `PerlinNoisePod`. A `PerlinNoisePod` contains a `PerlinNoise` and the associated

parameters. These parameters are described below:

- **seed**: a 3D vector of float values.  
The value returned by the PerlinNoise is defined by the permutations used to init the structure. Then a given input will always generates the same output, which is not very useful. Different output values would require to generate different permutations. FracNoise offers another solution: Each PerlinNoise is associated to a seed which is used to transform the input values. The transformation is a rotation of the input vector around the axis defined by the seed vector. The seed vector is a 3D vector, and the input is extended internally to a 3D vector if necessary (missing components equal 0.0). The angle of the rotation for the  $i$ -th component of the output value is defined as  $2\pi(i+1)/(n+1)$  where  $n$  is the dimension of output. Then, we can generate as many different noises as needed, and we solve at the same time the problem of generating output of dimension higher than 1. Also, the seed components can be used as extra components to the input when one needs more than 3D input. As the transformation is a 3D rotation of the input, continuity and derivability of the output are conserved over seed values.
- **scaleIn**: a vector of float values of dimension equals to the dimension of the input.  
This scale is applied to the input, component by component.
- **fractalLvl**: an integer greater than or equal to 0.  
The fractal level controls the number of recursive call of the PerlinNoise on itself. If it's equal to 0, the output is the standard output. If it's equal to 1 the output is equal to the standard output added to the output of the same PerlinNoise multiplied by the fractal coefficient (see below) for input divided by the fractal coefficient. And so on (there is no limit to the fractal level). Recursive call are made before applying the scaling and shifting on output. As the output at each level sum up, the final output value might get out of the range  $[0.0, 1.0]$ , but it is automatically rescaled to ensure the values stay in the correct range whatever the fractal level. Recursive call occurs before smoothing, scaling and shifting.
- **fractalCoeff**: a float value (typically in  $]0.0, 1.0[$  but one may experiments with values out of this range).  
The output value is multiplied by the fractal coefficient at each fractal

level, and the input value is divided by the fractal coefficient at each level. the output value is rescaled to ensure it stays inside  $[0.0,1.0]$ . So for example, for a PerlinNoise with a fractal level of 2, a fractal coefficient of 0.1, an input value of 0.5, the output value will be equal to  $(\text{PerlinNoise}(0.5)*0.9+0.1*\text{PerlinNoise}(5.0))*0.9+0.01*\text{PerlinNoise}(50.0)$

- smooth: a float value greater than 0.0.  
The smooth is applied after fractal and before scaling. Output values are raise to the power of smooth component by component. This can be used to control the general aspect of the distribution of the output values (more bumpy for value below 1.0, more thorny for value above).
- bound: a Shapoid.  
The PerlinNoise is defined over  $\mathbb{R}$ , however one can want to restrain it to some subdomain. This can be done by attaching a Shapoid with proper position and axis of dimension equal to the input dimension. Then, the PerlinNoise will output 0.0 for input (original one, not the scaleIn-ed one) outside of the subdomain defined by the outside of the Shapoid, and its normal value for the subdomain defined by the inside of the Shapoid.
- border: a float value between 0.0 and 1.0 representing the border of the boundary.  
If the PerlinNoise is attached to a boundary, one may want a smooth transition between the outside and inside of the boundary. The depth in the Shapoid defining the boundary of the input position is compared to the border, if the depth is greater than the border then the normal output is returned. If the depth is between 0.0 and the border, the normal output is multiplied by  $\text{SmootherStep}(\text{depth}/\text{border})$ .
- scaleOut: a vector of float values of dimension equals to the dimension of the output.  
This scale is applied to the output, component by component.
- shiftOut: a vector of float values of dimension equals to the dimension of the output.  
This shift is added to the output after scaling.

The value of a FracNoise for a given input is equal to the sum of the values of its PerlinNoisePod for this input and can be expressed as follow:

$$FracNoise(\vec{p}) = \sum_{pod} \left( \left( In(\vec{p}) \cdot \left( \sum_{f=0}^l c^f \left[ PN \left( Rot_{\vec{e}} \left( \vec{p} \odot \vec{s}_i, \frac{2\pi(i+1)}{n+1} \right) \cdot \frac{1.0}{c^f} \right)^s \right]_{i \in [0, n-1]} \odot \vec{s}_o + \vec{t} \right) \right) \right) \quad (1)$$

where

- $\vec{p}$  is the input (redimensioned to a 3D vector if it's of different dimension).
- $pod$  is the set of PerlinNoisePod.
- $In(\vec{p})$  is the insideness of  $\vec{p}$ , equals to 1.0 if the PerlinNoisePod has no boundary, or if it has a boundary: 0.0 if  $\vec{p}$  is out of boundary; 1.0 if  $depth(\vec{p})$  is greater than the *border* of the PerlinNoisePod;  $SmootherStep(depth(\vec{p})/border)$  else. We remind that  $SmootherStep(x) = ((6x - 15)x + 10)x^3$ .
- $l$  is the fractalLvl.
- $c$  is the fractalCoeff.
- $PN()$  is the PerlinNoise function.
- $\vec{e}$  is the seed.
- $Rot_{\vec{e}}(\vec{p}, \theta)$  is the rotation of  $\vec{p}$  around the axis  $\vec{e}$  by angle  $\theta$ .
- $\vec{s}_i$  is the scaleIn.
- $\vec{s}_o$  is the scaleOut.
- $\vec{t}$  is the shiftOut.
- $n$  is the number of dimensions of output.

## 2 Interface

```
// ===== FRACNOISE.H =====

#ifndef FRACNOISE_H
#define FRACNOISE_H

// ===== Include =====
```

```

#include <stdlib.h>
#include <stdio.h>
#include <math.h>
#include <string.h>
#include <stdbool.h>
#include "pbmath.h"
#include "gset.h"
#include "shapoid.h"

// ----- PerlinNoise
// http://mrl.nyu.edu/~perlin/noise/

// ===== Data structure =====

typedef struct PerlinNoise {
    // Parameters
    int _p[512];
} PerlinNoise;

// ===== Functions declaration =====

// Return a new PerlinNoise
PerlinNoise* PerlinNoiseCreate(void);

// Return a new static PerlinNoise
PerlinNoise PerlinNoiseCreateStatic(void);

// Free the memory used by the PerlinNoise 'that'
void PerlinNoiseFree(PerlinNoise** that);

// Return the value of the PerlinNoise 'that' at position 'u'
// 'u' can be of dimension 1 to 3, 'u' values in R, the Perlin noise
// has interpolation on unit, so u in [0.0, 1.0] will be interpolated
// between 2 values, u in [0.0, 2.0] will be interpolated between
// 3 values, and the noise always equal 0.5 at unit values, so
// noise(0.0) == noise(1.0) == noise(2.0) == ... == 0.5
// Return a value in [0.0, 1.0]
float _PerlinNoiseGet(PerlinNoise* noise, VecFloat* u);
float _PerlinNoiseGet1D(PerlinNoise* noise, float u);
float _PerlinNoiseGet2D(PerlinNoise* noise, VecFloat2D* u);
float _PerlinNoiseGet3D(PerlinNoise* noise, VecFloat3D* u);

// Set the permutations of the PerlinNoise 'that' to 'permut'
// 'permut' is an array of 256 int
void PerlinNoiseSetPermut(PerlinNoise* that, int* permut);

// ----- PerlinNoisePod

typedef struct PerlinNoisePod {
    // Perlin noise
    PerlinNoise _noise;
    // Seed
    VecFloat3D _seed;
    // Boundary
    Shapoid* _bound;
    // Boundary border
    float _border;
    // Scale inputs
    VecFloat* _scaleIn;
    // Scale outputs
    VecFloat* _scaleOut;
    // Shift outputs

```

```

    VecFloat* _shiftOut;
    // Fractal level
    int _fractalLvl;
    // Fractal coefficient
    float _fractalCoeff;
    // Smoothness
    float _smooth;
} PerlinNoisePod;

// ===== Functions declaration =====

// Return a new PerlinNoisePod with dimension 'dim' and seed
// 'seed'
// If the seed is the vector null replace it by (1,1,1)
// Default values:
// bound = NULL, border = 0.1, scaleIn/Out = 1.0
// fractalLvl = 0, fractalCoeff = 0.1, smooth = 1.0
PerlinNoisePod* PerlinNoisePodCreate(VecShort2D* dim, VecFloat3D* seed);

// Free memory used by the PerlinNoisePod 'that'
void PerlinNoisePodFree(PerlinNoisePod** that);

// Get the Perlin noise of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
PerlinNoise* PerlinNoisePodNoise(PerlinNoisePod* that);

// Get the seed of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
VecFloat3D* PerlinNoisePodSeed(PerlinNoisePod* that);

// Get the bound of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
Shapoid* PerlinNoisePodBound(PerlinNoisePod* that);

// Get the scale of inputs of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
VecFloat* PerlinNoisePodScaleIn(PerlinNoisePod* that);

// Get the scale of outputs of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
VecFloat* PerlinNoisePodScaleOut(PerlinNoisePod* that);

// Get the shift of outputs of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
VecFloat* PerlinNoisePodShiftOut(PerlinNoisePod* that);

// Get the fractal level of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif

```

```

int PerlinNoisePodGetFractLvl(PerlinNoisePod* that);

// Get the fractal coefficient of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
float PerlinNoisePodGetFractCoeff(PerlinNoisePod* that);

// Get the border coefficient of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
float PerlinNoisePodGetBorder(PerlinNoisePod* that);

// Get the smoothness of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
float PerlinNoisePodGetSmooth(PerlinNoisePod* that);

// Set the seed of the PerlinNoisePod 'that' to a copy of 'seed'
// If 'seed' is the vector null the seed is left unchanged
#if BUILDMODE != 0
inline
#endif
void PerlinNoisePodSetSeed(PerlinNoisePod* that, VecFloat3D* seed);

// Set the bound of the PerlinNoisePod 'that' to 'bound'
// The Shapoid 'bound' must have same dimensions as the input dimension
// of the PerlinNoisePod.
#if BUILDMODE != 0
inline
#endif
void _PerlinNoisePodSetBound(PerlinNoisePod* that, Shapoid* bound);

// Set the scale of inputs of the PerlinNoisePod 'that' to a
// copy of 'scale'
// 'scale' must have same dimension as the input dimension
// of the PerlinNoisePod.
#if BUILDMODE != 0
inline
#endif
void _PerlinNoisePodSetScaleIn(PerlinNoisePod* that, VecFloat* scale);

// Set the scale of outputs of the PerlinNoisePod 'that' to a copy
// of 'scale'
// 'scale' must have same dimension as the output dimension
// of the PerlinNoisePod.
#if BUILDMODE != 0
inline
#endif
void _PerlinNoisePodSetScaleOut(PerlinNoisePod* that, VecFloat* scale);

// Set the shift of outputs of the PerlinNoisePod 'that' to a copy
// of 'shift'
// 'shift' must have same dimension as the output dimension
// of the PerlinNoisePod.
#if BUILDMODE != 0
inline
#endif
void _PerlinNoisePodSetShiftOut(PerlinNoisePod* that, VecFloat* shift);

```



```

// Set the fractal level of the PerlinNoisePod 'that' to 'lvl'
// 'lvl' must be greater than or equal to 0
#if BUILDMODE != 0
inline
#endif
void PerlinNoisePodSetFractLvl(PerlinNoisePod* that, int lvl);

// Set the fractal coefficient of the PerlinNoisePod 'that' to 'coeff'
// 'coeff' must be greater than 0.0, if it's negative its absolute
// value is used
#if BUILDMODE != 0
inline
#endif
void PerlinNoisePodSetFractCoeff(PerlinNoisePod* that, float coeff);

// Set the border coefficient of the PerlinNoisePod 'that' to 'border'
#if BUILDMODE != 0
inline
#endif
void PerlinNoisePodSetBorder(PerlinNoisePod* that, float border);

// Set the smoothness of the PerlinNoisePod 'that' to 'smooth'
// 'smooth' must be greater than 0.0
// Below 1.0 gives a bumpy aspect, above 1.0 gives a thorny aspect,
// 1.0 is the smoothest
#if BUILDMODE != 0
inline
#endif
void PerlinNoisePodSetSmooth(PerlinNoisePod* that, float smooth);

// Get the insideness in boundary of the PerlinNoisePod 'that' at
// position 'pos'
// If there is no bounday it's always 1.0
// If there is boundary, it's 0.0 outside of boundary and else it's
// the position depth in the Shapoid corrected with the border as follow:
// if depth > border the depth is set to 1.0, else the depth is
// SmootherStep from (0.0, border) to (0.0, 1.0)
// 'pos' 's dimension must be equal to the Shapoid's dimension
float PerlinNoisePodGetInsideness(PerlinNoisePod* that, VecFloat* pos);

// ----- FracNoise

typedef struct FracNoise {
    // Dimensions (input, output)
    VecShort2D _dim;
    // Set of PerlinNoisePod
    GSet _noises;
} FracNoise;

// ===== Functions declaration =====

// Return a new FracNoise of dimensions 'dim' and 'seed'
// The number of input must be between 1 and 3
// The number of output can be any value greater or equal to 1
// If seed is null it is replaced by a default seed
// Return null if the number of dimensions are invalid
FracNoise* FracNoiseCreate(VecShort2D* dim, VecFloat3D* seed);

// Free the memory used by the FracNoise 'that'
void FracNoiseFree(FracNoise** that);

// Get the dimensions of the noise 'that'

```

```

#if BUILDMODE != 0
inline
#endif
VecShort2D* FracNoiseDim(FracNoise* that);

// Get the pods of the noise 'that'
#if BUILDMODE != 0
inline
#endif
GSet* FracNoisePods(FracNoise* that);

// Get the 'iNoise'-th noise of the FracNoise 'that'
// Return null if 'iNoise' is invalid
#if BUILDMODE != 0
inline
#endif
PerlinNoisePod* FracNoiseGetNoise(FracNoise* that, int iNoise);

// Add a new noise with seed 'seed' to the FracNoise 'that'
// If seed is null it is replaced by a default seed
// Return the new noise
#if BUILDMODE != 0
inline
#endif
PerlinNoisePod* FracNoiseAddNoise(FracNoise* that, VecFloat3D* seed);

// Remove the PerlinNoisePod 'pod' from the FracNoise 'that'
#if BUILDMODE != 0
inline
#endif
void FracNoiseRemoveNoise(FracNoise* that, PerlinNoisePod* pod);

// Get the noise value of the FracNoise 'that' at 'input'
VecFloat* _FracNoiseGet(FracNoise* that, VecFloat* input);

// Export the FracNoise 'that' to a POV-Ray .df3 file located at
// 'filename'. The input range goes from 0.0 to 'range'. The number of
// samples per axis is given by 'nbSample'. The resolution in bit is
// given by 'res' (must be 8, 16 or 32).
// If 'rescale' equals true, the values are scaled to [0,1] else they
// are clipped
// The FracNoise's dimensions must be 3D->1D
// The output values are automatically scaled
// If the arguments are invalid, the df3 file is not generated.
// Return true if the df3 has been succesfully created, false else.
bool FracNoiseExportDF3(FracNoise* that, VecFloat3D* range,
    VecShort3D* nbSample, int res, bool rescale, char* fileName);

// ===== Polymorphism =====
#define PerlinNoiseGet(Noise, U) _Generic(U, \
    VecFloat*: _PerlinNoiseGet, \
    float: _PerlinNoiseGet1D, \
    VecFloat2D*: _PerlinNoiseGet2D, \
    VecFloat3D*: _PerlinNoiseGet3D, \
    default: PBErrInvalidPolymorphism) (Noise, U)

#define PerlinNoisePodSetBound(Pod, Bound) _Generic(Bound, \
    Shapoid*: _PerlinNoisePodSetBound, \
    Facoid*: _PerlinNoisePodSetBound, \
    Pyramidoid*: _PerlinNoisePodSetBound, \
    Spheroid*: _PerlinNoisePodSetBound, \
    default: PBErrInvalidPolymorphism) (Pod, (Shapoid*)Bound)

```

```

#define PerlinNoisePodSetScaleIn(Pod, Scale) _Generic(Scale, \
    VecFloat*: _PerlinNoisePodSetScaleIn, \
    VecFloat2D*: _PerlinNoisePodSetScaleIn, \
    VecFloat3D*: _PerlinNoisePodSetScaleIn, \
    default:PBErrInvalidPolymorphism) (Pod, (VecFloat*)(Scale))

#define PerlinNoisePodSetScaleOut(Pod, Scale) _Generic(Scale, \
    VecFloat*: _PerlinNoisePodSetScaleOut, \
    VecFloat2D*: _PerlinNoisePodSetScaleOut, \
    VecFloat3D*: _PerlinNoisePodSetScaleOut, \
    default:PBErrInvalidPolymorphism) (Pod, (VecFloat*)(Scale))

#define PerlinNoisePodSetShiftOut(Pod, Shift) _Generic(Shift, \
    VecFloat*: _PerlinNoisePodSetShiftOut, \
    VecFloat2D*: _PerlinNoisePodSetShiftOut, \
    VecFloat3D*: _PerlinNoisePodSetShiftOut, \
    default:PBErrInvalidPolymorphism) (Pod, (VecFloat*)(Shift))

#define FracNoiseGet(Noise, U) _Generic(U, \
    VecFloat*: _FracNoiseGet, \
    VecFloat2D*: _FracNoiseGet, \
    VecFloat3D*: _FracNoiseGet, \
    default:PBErrInvalidPolymorphism) (Noise, (VecFloat*)(U))

// ===== Inliner =====

#if BUILDMODE != 0
#include "fracnoise-inline.c"
#endif

#endif

```

## 3 Code

### 3.1 fracnoise.c

```

// ===== FRACNOISE.C =====

// ===== Include =====

#include "fracnoise.h"
#if BUILDMODE == 0
    #include "fracnoise-inline.c"
#endif

// ----- PerlinNoise

// Declare the permutations for the Perlin noise
int PerlinNoisePermutation[256] = {
    151,160,137,91,90,15,131,13,201,95,96,53,194,233,7,225,140,36,
    103,30,69,142,8,99,37,240,21,10,23,190,6,148,247,120,234,75,0,
    26,197,62,94,252,219,203,117,35,11,32,57,177,33,88,237,149,56,87,
    174,20,125,136,171,168,68,175,74,165,71,134,139,48,27,166,77,
    146,158,231,83,111,229,122,60,211,133,230,220,105,92,41,55,46,245,
    40,244,102,143,54,65,25,63,161,1,216,80,73,209,76,132,187,208,89,
    18,169,200,196,135,130,116,188,159,86,164,100,109,198,173,186,
    3,64,52,217,226,250,124,123,5,202,38,147,118,126,255,82,85,212,

```

```

207,206,59,227,47,16,58,17,182,189,28,42,223,183,170,213,119,248,
152,2,44,154,163,70,221,153,101,155,167,43,172,9,129,22,39,253,19,
98,108,110,79,113,224,232,178,185,112,104,218,246,97,228,251,34,
242,193,238,210,144,12,191,179,162,241,81,51,145,235,249,14,239,
107,49,192,214,31,181,199,106,157,184,84,204,176,115,121,50,45,
127,4,150,254,138,236,205,93,222,114,67,29,24,72,243,141,128,195,
78,66,215,61,156,180
};

// ===== Functions definition =====

inline float fade(float t);
inline float lerp(float t, float a, float b);
inline float grad(int hash, float x, float y, float z);

// ===== Functions implementation =====

// Return a new PerlinNoise
PerlinNoise* PerlinNoiseCreate(void) {
    // Allocate memory
    PerlinNoise *noise = PBErrMalloc(FracNoiseErr,
        sizeof(PerlinNoise));
    // Initialize the permutations
    PerlinNoiseSetPermut(noise, PerlinNoisePermutation);
    // Return the new PerlinNoise
    return noise;
}

// Return a new static PerlinNoise
PerlinNoise PerlinNoiseCreateStatic(void) {
    // Declare the noise
    PerlinNoise noise;
    // Initialize the permutations
    PerlinNoiseSetPermut(&noise, PerlinNoisePermutation);
    // Return the noise
    return noise;
}

// Set the permutations of the PerlinNoise 'that' to 'permut'
// 'permut' is an array of 256 int
void PerlinNoiseSetPermut(PerlinNoise* that, int* permut) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (permut == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'permut' is null");
        PBErrCatch(FracNoiseErr);
    }
}
#endif
    // Set the permutations
    for (int i = 256; i--;)
        that->_p[256 + i] = that->_p[i] = permut[i];
}

// Free the memory used by the PerlinNoise 'that'
void PerlinNoiseFree(PerlinNoise** that) {
    // Check arguments
    if (that == NULL || *that == NULL)

```

```

    return;
    // Free memory
    free(*that);
    *that = NULL;
}

// Return the value of the PerlinNoise 'that' at position 'u'
// 'u' can be of dimension 1 to 3, 'u' values in R, the Perlin noise
// has interpolation on unit, so u in [0.0, 1.0] will be interpolated
// between 2 values, u in [0.0, 2.0] will be interpolated between
// 3 values, and the noise always equal 0.5 at unit values, so
// noise(0.0) == noise(1.0) == noise(2.0) == ... == 0.5
// Return a value in [0.0, 1.0]
float _PerlinNoiseGet(PerlinNoise* that, VecFloat* p) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (p == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'p' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (VecGetDim(p) > 3) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg, "'p' 's dimension is invalid (%d<4)",
            VecGetDim(p));
        PBErrCatch(FracNoiseErr);
    }
#endif
    if (VecGetDim(p) == 1)
        return _PerlinNoiseGet1D(that, VecGet(p, 0));
    else if (VecGetDim(p) == 2)
        return _PerlinNoiseGet2D(that, (VecFloat2D*)p);
    else if (VecGetDim(p) == 3)
        return _PerlinNoiseGet3D(that, (VecFloat3D*)p);
    else if (VecGetDim(p) > 3) {
        VecFloat* p3 = VecGetNewDim(p, 3);
        float ret = _PerlinNoiseGet3D(that, (VecFloat3D*)p3);
        VecFree(&p3);
        return ret;
    } else
        return 0.0;
}

float _PerlinNoiseGet1D(PerlinNoise* that, float p) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    int pInt;
    float q = 0.0;
    float u = 0.0;
    // Get the Unit cube that contains the point
    pInt = (int)floor(p) & 255;
    // Get the relative coordinates of the point in the cube
    q = p - floor(p);

```

```

// Fade input for smooth transition
u = SmootherStep(q);
// Hash coordinates of the segment extremities
int A = that->_p[pInt];
int AA = that->_p[A];
int B = that->_p[pInt + 1];
int BA = that->_p[B];
// Blend the value of the 8 cube corners according to relative
// position in the cube
float res = lerp(u, grad(that->_p[AA], q, 0.0, 0.0),
    grad(that->_p[BA], q - 1.0, 0.0, 0.0));
// Return the result mapped to [0.0, 1.0]
res = res * 0.5 + 0.5;
return res;
}

float _PerlinNoiseGet2D(PerlinNoise* that, VecFloat2D* p) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (p == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'p' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (VecGetDim(p) != 2) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg, "'p' 's dimension is invalid (%d==2)",
            VecGetDim(p));
        PBErrCatch(FracNoiseErr);
    }
#endif
    int pInt[2];
    VecFloat2D q = VecFloatCreateStatic2D();
    VecFloat2D u = VecFloatCreateStatic2D();
    for (int i = 2; i--;) {
        // Get the Unit cube that contains the point
        pInt[i] = (int)floor(VecGet(p, i)) & 255;
        // Get the relative coordinates of the point in the cube
        VecSet(&q, i, VecGet(p, i) - floor(VecGet(p, i)));
        // Fade input for smooth transition
        VecSet(&u, i, SmootherStep(VecGet(&q, i)));
    }
    // Hash coordinates of the 8 cube corners
    int A = that->_p[pInt[0]] + pInt[1];
    int AA = that->_p[A];
    int AB = that->_p[A + 1];
    int B = that->_p[pInt[0] + 1] + pInt[1];
    int BA = that->_p[B];
    int BB = that->_p[B + 1];
    // Blend the value of the 8 cube corners according to relative
    // position in the cube
    float res =
        lerp(0.0,
            lerp(VecGet(&u, 1),
                lerp(VecGet(&u, 0),
                    grad(that->_p[AA],
                        VecGet(&q, 0), VecGet(&q, 1), 0.0),
                    grad(that->_p[BA],

```

```

        VecGet(&q, 0) - 1.0, VecGet(&q, 1), 0.0)),
    lerp(VecGet(&u, 0),
        grad(that->p[AB],
            VecGet(&q, 0), VecGet(&q, 1) - 1.0, 0.0),
        grad(that->p[BB],
            VecGet(&q, 0) - 1.0, VecGet(&q, 1) - 1.0, 0.0))),
    lerp(VecGet(&u, 1),
        lerp(VecGet(&u, 0),
            grad(that->p[AA + 1],
                VecGet(&q, 0), VecGet(&q, 1), -1.0),
            grad(that->p[BA + 1],
                VecGet(&q, 0) - 1.0, VecGet(&q, 1), -1.0)),
        lerp(VecGet(&u, 0),
            grad(that->p[AB + 1],
                VecGet(&q, 0), VecGet(&q, 1) - 1.0, -1.0),
            grad(that->p[BB + 1],
                VecGet(&q, 0) - 1.0, VecGet(&q, 1) - 1.0, -1.0))));
// Return the result mapped to [0.0, 1.0]
res = res * 0.5 + 0.5;
return res;
}

float _PerlinNoiseGet3D(PerlinNoise* that, VecFloat3D* p) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (p == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'p' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (VecGetDim(p) != 3) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg, "'p' 's dimension is invalid (%d==3)",
            VecGetDim(p));
        PBErrCatch(FracNoiseErr);
    }
#endif
    int pInt[3];
    VecFloat3D q = VecFloatCreateStatic3D();
    VecFloat3D u = VecFloatCreateStatic3D();
    for (int i = 3; i--;) {
        // Get the Unit cube that contains the point
        pInt[i] = (int)floor(VecGet(p, i)) & 255;
        // Get the relative coordinates of the point in the cube
        VecSet(&q, i, VecGet(p, i) - floor(VecGet(p, i)));
        // Fade input for smooth transition
        VecSet(&u, i, SmootherStep(VecGet(&q, i)));
    }
    // Hash coordinates of the 8 cube corners
    int A = that->p[pInt[0]] + pInt[1];
    int AA = that->p[A] + pInt[2];
    int AB = that->p[A + 1] + pInt[2];
    int B = that->p[pInt[0] + 1] + pInt[1];
    int BA = that->p[B] + pInt[2];
    int BB = that->p[B + 1] + pInt[2];
    // Blend the value of the 8 cube corners according to relative
    // position in the cube
    float res =

```

```

lerp(VecGet(&u, 2),
    lerp(VecGet(&u, 1),
        lerp(VecGet(&u, 0),
            grad(that->p[AA],
                VecGet(&q, 0), VecGet(&q, 1), VecGet(&q, 2)),
            grad(that->p[BA],
                VecGet(&q, 0) - 1.0, VecGet(&q, 1), VecGet(&q, 2))),
        lerp(VecGet(&u, 0),
            grad(that->p[AB],
                VecGet(&q, 0), VecGet(&q, 1) - 1.0, VecGet(&q, 2)),
            grad(that->p[BB],
                VecGet(&q, 0) - 1.0, VecGet(&q, 1) - 1.0, VecGet(&q, 2))))),
    lerp(VecGet(&u, 1),
        lerp(VecGet(&u, 0),
            grad(that->p[AA + 1],
                VecGet(&q, 0), VecGet(&q, 1), VecGet(&q, 2) - 1.0),
            grad(that->p[BA + 1],
                VecGet(&q, 0) - 1.0, VecGet(&q, 1), VecGet(&q, 2) - 1.0)),
        lerp(VecGet(&u, 0),
            grad(that->p[AB + 1],
                VecGet(&q, 0), VecGet(&q, 1) - 1.0, VecGet(&q, 2) - 1.0),
            grad(that->p[BB + 1],
                VecGet(&q, 0) - 1.0, VecGet(&q, 1) - 1.0,
                VecGet(&q, 2) - 1.0))));
// Return the result mapped to [0.0, 1.0]
res = res * 0.5 + 0.5;
return res;
}

inline float fade(float t) {
    float ret = t * t * t * (t * (t * 6.0 - 15.0) + 10.0);
    return ret;
}

inline float lerp(float t, float a, float b) {
    float ret = a + t * (b - a);
    return ret;
}

float grad(int hash, float x, float y, float z) {
    int h = hash & 15;
    float u = h < 8 ? x : y;
    float v = h < 4 ? y : h == 12 || h == 14 ? x : z;
    return ((h & 1) == 0 ? u : -u) + ((h & 2) == 0 ? v : -v);
}

// ----- PerlinNoisePod

// ===== Functions implementation =====

// Return a new PerlinNoisePod with output dimension 'dimOut' and seed
// 'seed'
// If the seed is the vector null replace it by (1,1,1)
// Default values:
// bound = NULL, border = 0.1, scaleIn/Out = 1.0
// fractalLvl = 0, fractalCoeff = 0.1, smooth = 1.0
PerlinNoisePod* PerlinNoisePodCreate(VecShort2D* dim, VecFloat3D* seed) {
#ifdef BUILDMODE == 0
    if (VecGet(dim, 0) < 1 || VecGet(dim, 0) > 3 ||
        VecGet(dim, 1) < 1) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg, "'dim' is invalid (0<%d<4,0<%d)",

```



```

        VecGet(dim, 0), VecGet(dim, 1));
    PBErrCatch(FracNoiseErr);
}
#endif
// Declare the new PerlinNoisePod
PerlinNoisePod* pod = PBErrMalloc(FracNoiseErr,
    sizeof(PerlinNoisePod));
// Set properties
pod->_noise = PerlinNoiseCreateStatic();
// If the seed is not given or is the vector null replace it by (1,1,1)
if (seed == NULL || VecNorm(seed) < PBMath_EPSILON) {
    pod->_seed = VecFloatCreateStatic3D();
    for (int i = 3; i--;)
        VecSet(&(pod->_seed), i, 1.0);
// Else, copy the seed in argument
} else {
    pod->_seed = *seed;
}
// Ensure the seed is normalized
VecNormalise(&(pod->_seed));
pod->_bound = NULL;
pod->_border = 0.1;
pod->_smooth = 1.0;
pod->_scaleIn = VecFloatCreate(VecGet(dim, 0));
for (int i = VecGet(dim, 0); i--;)
    VecSet(pod->_scaleIn, i, 1.0);
pod->_scaleOut = VecFloatCreate(VecGet(dim, 1));
for (int i = VecGet(dim, 1); i--;)
    VecSet(pod->_scaleOut, i, 1.0);
pod->_shiftOut = VecFloatCreate(VecGet(dim, 1));
pod->_fractalLvl = 0;
pod->_fractalCoeff = 0.1;
// Return the new pod
return pod;
}

// Free memory used by the PerlinNoisePod 'that'
void PerlinNoisePodFree(PerlinNoisePod** that) {
    // Check argument
    if (that == NULL || *that == NULL)
        // Nothing to do
        return;
    // Free memory
    VecFree(&((*that)->_scaleIn));
    VecFree(&((*that)->_scaleOut));
    VecFree(&((*that)->_shiftOut));
    free(*that);
    *that = NULL;
}

// Get the insideness in boundary of the PerlinNoisePod 'that' at
// position 'pos'
// If there is no bounday it's always 1.0
// If there is boundary, it's 0.0 outside of boundary and else it's
// the position depth in the Shapoid corrected with the border as follow:
// if depth > border the depth is set to 1.0, else the depth is
// SmootherStep from (0.0, border) to (0.0, 1.0)
// 'pos' 's dimension must be equal to the Shapoid's dimension
float PerlinNoisePodGetInsideness(PerlinNoisePod* that, VecFloat* pos) {
    #if BUILDMODE == 0
        if (that == NULL) {
            FracNoiseErr->_type = PBErrTypeNullPointer;

```

```

        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErriCatch(FracNoiseErr);
    }
    if (pos == NULL) {
        FracNoiseErr->_type = PBErriTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'pos' is null");
        PBErriCatch(FracNoiseErr);
    }
    if (that->_bound != NULL &&
        VecGetDim(pos) != ShapoidGetDim(that->_bound)) {
        FracNoiseErr->_type = PBErriTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'pos' 's dimension is invalid (%d=%d)",
            VecGetDim(pos), ShapoidGetDim(that->_bound));
        PBErriCatch(FracNoiseErr);
    }
}
#endif
// Declare a variable to memorize the insideness in boundary
float inside = 1.0;
// If there is a boundary
if (PerlinNoisePodBound(that) != NULL) {
    // Get the insideness of the input
    inside = ShapoidGetPosDepth(PerlinNoisePodBound(that), pos);
    // If there is a border
    float border = PerlinNoisePodGetBorder(that);
    if (border > PBMATH_EPSILON) {
        // Correct insideness with border: inside the border apply a
        // smotherstep transition and outside set to 1.0
        if (inside < border)
            inside = SmotherStep(inside / border);
        else
            inside = 1.0;
    }
}
// Return the insideness
return inside;
}

// ----- FracNoise

// ===== Functions implementation =====

// Return a new FracNoise of dimensions 'dim' and seed 'seed'
// The number of input must be between 1 and 3
// The number of output can be any value greater or equal to 1
// If seed is null it is replaced by a default seed
// Return null if the number of dimensions are invalid
FracNoise* FracNoiseCreate(VecShort2D* dim, VecFloat3D* seed) {
#ifdef BUILDMODE == 0
    if (dim == NULL) {
        FracNoiseErr->_type = PBErriTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'dim' is null");
        PBErriCatch(FracNoiseErr);
    }
    if (VecGet(dim, 0) < 1 || VecGet(dim, 0) > 3 ||
        VecGet(dim, 1) < 1) {
        FracNoiseErr->_type = PBErriTypeInvalidArg;
        sprintf(FracNoiseErr->_msg, "'dim' is invalid (0<%d<4,0<%d)",
            VecGet(dim, 0), VecGet(dim, 1));
        PBErriCatch(FracNoiseErr);
    }
}
#endif

```

```

// Check the dimensions
if (VecGet(dim, 0) < 1 || VecGet(dim, 0) > 3 ||
    VecGet(dim, 1) < 1)
    return NULL;
// Declare the new FracNoise
FracNoise* noise = PBErrMalloc(FracNoiseErr, sizeof(FracNoise));
// Set properties
noise->_dim = VecShortCreateStatic2D();
noise->_dim = *dim;
noise->_noises = GSetCreateStatic();
// Add a PerlinNoise
PerlinNoisePod* pod = PerlinNoisePodCreate(dim, seed);
GSetAppend(&(noise->_noises), pod);
// Return the new FracNoise
return noise;
}

// Free the memory used by the FracNoise 'that'
void FracNoiseFree(FracNoise** that) {
    // Check argument
    if (that == NULL || *that == NULL)
        // Nothing to do
        return;
    // Free memory
    while (GSetNbElem(&((*that)->_noises)) > 0) {
        PerlinNoisePod* pod = GSetPop(&((*that)->_noises));
        PerlinNoisePodFree(&pod);
    }
    free(*that);
    *that = NULL;
}

// Get the noise value of the FracNoise 'that' at 'pos'
VecFloat* _FracNoiseGet(FracNoise* that, VecFloat* pos) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (pos == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'pos' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (VecGetDim(pos) != VecGet(&(that->_dim), 0)) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'pos' 's dimension is invalid (%d==%d)",
            VecGetDim(pos), VecGet(&(that->_dim), 0));
        PBErrCatch(FracNoiseErr);
    }
#endif
    // Create the result
    VecFloat* res = VecFloatCreate(VecGet(FracNoiseDim(that), 1));
    // Loop on noises
    GSetIterForward iter =
        GSetIterForwardCreateStatic(FracNoisePods(that));
    do {
        // Get the current pod
        PerlinNoisePod* pod = GSetIterGet(&iter);
        // Get the insideness

```

```

float inside = PerlinNoisePodGetInsideness(pod, pos);
// If we are inside the boundary
if (inside > PBMath_EPSILON) {
    // Internally FracNoise always considers the input position as 3D,
    // declare a 3D version of it
    VecFloat3D* p = (VecFloat3D*)VecGetNewDim(pos, 3);
    // Scale the input
    for (int i = MIN(3, VecGetDim(pos)); i--;)
        VecSet(p, i,
            VecGet(p, i) * VecGet(PerlinNoisePodScaleIn(pod), i));
    // Declare a variable to memorize the rotated version of the input
    VecFloat3D pRot = VecFloatCreateStatic3D();
    // Declare a variable to memorize the result for this pod
    VecFloat* resPod = VecFloatCreate(VecGet(FracNoiseDim(that), 1));
    // Declare a variable to memorize the current fractal coefficient
    float fractCoeff = 1.0;
    // Declare a variable to memorize the fractal coeff
    float fc = PerlinNoisePodGetFractCoeff(pod);
    // Get the angle for rotation of input vector over dimensions
    float theta =
        PBMath_TWOPI / (float)(VecGet(FracNoiseDim(that), 1) + 1);
    // Loop on fractal levels
    for (int iFract = PerlinNoisePodGetFractLvl(pod) + 1; iFract--;) {
        // If we are not at the first fractal level
        if (iFract != PerlinNoisePodGetFractLvl(pod))
            // Rescale to ensure the values stay in [0.0, 1.0] as addition
            // over fractal levels may bring the value outside this range
            VecScale(resPod, 1.0 / (1.0 + fractCoeff));
        // Loop on output dimension
        VecCopy(&pRot, p);
        for (int iDim = VecGet(FracNoiseDim(that), 1); iDim--;) {
            // Apply the seed
            VecRotAxis(&pRot, PerlinNoisePodSeed(pod), theta);
            // Get the Perlin noise value
            float val = _PerlinNoiseGet3D(PerlinNoisePodNoise(pod), &pRot);
            // Add the value for the current dimension at the current
            // fractal level
            VecSet(resPod, iDim, VecGet(resPod, iDim) + val * fractCoeff);
        }
        // Update the fractal coefficient
        fractCoeff *= fc;
        // Update the input position at this level
        VecScale(p, 1.0 / fc);
    }
    // Apply the insideness and smoothness
    for (int i = VecGetDim(resPod); i--;)
        VecSet(resPod, i,
            pow(VecGet(resPod, i) * inside, PerlinNoisePodGetSmooth(pod)));
    // Scale the output
    for (int i = VecGetDim(resPod); i--;)
        VecSet(resPod, i,
            VecGet(resPod, i) * VecGet(PerlinNoisePodScaleOut(pod), i));
    // Shift the output
    VecOp(resPod, 1.0, PerlinNoisePodShiftOut(pod), 1.0);
    // Add the result for this pod
    VecOp(res, 1.0, resPod, 1.0);
    // Free memory
    VecFree(&resPod);
    VecFree((VecFloat**)&p);
}
} while (GSetIterStep(&iter));
// Return the result

```

```

    return res;
}

// Export the FracNoise 'that' to a POV-Ray .df3 file located at
// 'filename'. The input range goes from 0.0 to 'range'. The number of
// samples per axis is given by 'nbSample'. The resolution in bit is
// given by 'res' (must be 8, 16 or 32).
// If 'rescale' equals true, the values are scaled to [0,1] else they
// are clipped
// The FracNoise's dimensions must be 3D->1D
// The output values are automatically scaled
// If the arguments are invalid, the df3 file is not generated.
// Return true if the df3 has been successfully created, false else.
bool FracNoiseExportDF3(FracNoise* that, VecFloat3D* range,
    VecShort3D* nbSample, int res, bool rescale, char* fileName) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (range == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'range' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (nbSample == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'nbSample' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (fileName == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'fileName' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (VecGet(FracNoiseDim(that), 0) != 3) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'that' 's input dimension is invalid (%d==3)",
            VecGet(FracNoiseDim(that), 0));
        PBErrCatch(FracNoiseErr);
    }
    if (VecGet(FracNoiseDim(that), 1) != 1) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'that' 's output dimension is invalid (%d==1)",
            VecGet(FracNoiseDim(that), 1));
        PBErrCatch(FracNoiseErr);
    }
    if (VecGet(nbSample, 0) <= 0 ||
        VecGet(nbSample, 1) <= 0 ||
        VecGet(nbSample, 2) <= 0) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'nbSample' is invalid (<%d,%d,%d> > <0,0,0>)",
            VecGet(nbSample, 0), VecGet(nbSample, 1), VecGet(nbSample, 2));
        PBErrCatch(FracNoiseErr);
    }
    if (res != 8 && res != 16 && res != 32) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,

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```

        "'res' is invalid (%d=={8,16,32})", res);
    PBErrCatch(FracNoiseErr);
}
if (GSetNbElem(&(that->_noises)) == 0) {
    FracNoiseErr->_type = PBErrTypeInvalidArg;
    sprintf(FracNoiseErr->_msg, "'that' is empty");
    PBErrCatch(FracNoiseErr);
}
if (sizeof(unsigned char) != 1 ||
    sizeof(unsigned short) != 2 ||
    sizeof(unsigned int) != 4) {
    FracNoiseErr->_type = PBErrTypeInvalidArg;
    sprintf(FracNoiseErr->_msg,
        "types' size mismatched (%d==1,%d==2,%d==4)",
        sizeof(unsigned char), sizeof(unsigned short),
        sizeof(unsigned int));
    PBErrCatch(FracNoiseErr);
}
#endif
// Check arguments
if (VecGet(FracNoiseDim(that), 0) != 3 ||
    VecGet(FracNoiseDim(that), 1) != 1 ||
    VecGet(nbSample, 0) <= 0 ||
    VecGet(nbSample, 1) <= 0 ||
    VecGet(nbSample, 2) <= 0 ||
    (res != 8 && res != 16 && res != 32) ||
    GSetNbElem(&(that->_noises)) == 0)
    return false;
// Get the min and max values of the noise for automatic rescaling
float min = 0.0;
float max = 1.0;
if (rescale) {
    PerlinNoisePod* pod = FracNoiseGetNoise(that, 0);
    if (VecGet(PerlinNoisePodScaleOut(pod), 0) > 0.0) {
        min = VecGet(PerlinNoisePodShiftOut(pod), 0);
        max = min + VecGet(PerlinNoisePodScaleOut(pod), 0);
    } else {
        max = VecGet(PerlinNoisePodShiftOut(pod), 0);
        min = max + VecGet(PerlinNoisePodScaleOut(pod), 0);
    }
    for (int iNoise = 1; iNoise < GSetNbElem(&(that->_noises));
        ++iNoise) {
        pod = FracNoiseGetNoise(that, iNoise);
        float minP = 0.0;
        float maxP = 1.0;
        if (VecGet(PerlinNoisePodScaleOut(pod), 0) > 0.0) {
            minP = VecGet(PerlinNoisePodShiftOut(pod), 0);
            maxP = minP + VecGet(PerlinNoisePodScaleOut(pod), 0);
        } else {
            maxP = VecGet(PerlinNoisePodShiftOut(pod), 0);
            minP = maxP + VecGet(PerlinNoisePodScaleOut(pod), 0);
        }
        if (minP < 0.0)
            min += minP;
        if (maxP > 0.0)
            max += maxP;
    }
}
// Open the file
FILE* file = fopen(fileName, "wb");
// If we couldn't open the file
if (file == NULL)

```

```

        // Stop here
        return false;
    // Write the header
    for (int i = 0; i < 3; ++i) {
        unsigned short v = VecGet(nbSample, i);
        // Big-endian !
        char* ptr = (char*)&v;
        for (int ip = sizeof(unsigned short); ip--;)
            fwrite(ptr + ip, 1, 1, file);
    }
    // Write the body
    // Loop on position
    VecShort3D pos = VecShortCreateStatic3D();
    do {
        // Get the equivalent input
        VecFloat3D u = VecFloatCreateStatic3D();
        for (int i = 3; i--;)
            VecSet(&u, i,
                (float)VecGet(&pos, i) / (float)VecGet(nbSample, i) *
                VecGet(range, i));
        // Get the noise value
        VecFloat* out = FracNoiseGet(that, &u);
        float val = VecGet(out, 0);
        VecFree(&out);
        // Scale or clip the output value
        if (rescale)
            val = (val - min) / (max - min);
        if (val < 0.0)
            val = 0.0;
        else if (val > 1.0)
            val = 1.0;
        // Write the value according to resolution
        if (res == 8) {
            unsigned char vChar = (unsigned char)round(val * 255.0);
            fwrite(&vChar, sizeof(unsigned char), 1, file);
        } else if (res == 16) {
            unsigned short vShort = (unsigned short)round(val * 65535.0);
            // Big-endian !
            char* ptr = (char*)&vShort;
            for (int ip = sizeof(unsigned short); ip--;)
                fwrite(ptr + ip, 1, 1, file);
        } else if (res == 32) {
            unsigned int vInt = (unsigned int)round(val * 4294967296.0);
            // Big-endian !
            char* ptr = (char*)&vInt;
            for (int ip = sizeof(unsigned int); ip--;)
                fwrite(ptr + ip, 1, 1, file);
        }
    }
    // The data in df3 are stored as z,y,x -> PStep
    } while (VecPStep(&pos, nbSample));
    // Close the file
    fclose(file);
    // Return the success code
    return true;
}

```

## 3.2 fracnoise-inline.c

```
// ===== FRACNOISE-INLINE.C =====
```

```

// ----- PerlinNoisePod

// ===== Functions implementation =====

// Get the Perlin noise of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
PerlinNoise* PerlinNoisePodNoise(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PErrCatch(FracNoiseErr);
    }
#endif
    return &(that->_noise);
}

// Get the seed of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
VecFloat3D* PerlinNoisePodSeed(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PErrCatch(FracNoiseErr);
    }
#endif
    return &(that->_seed);
}

// Get the bound of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
Shapoid* PerlinNoisePodBound(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PErrCatch(FracNoiseErr);
    }
#endif
    return that->_bound;
}

// Get the scale of inputs of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
VecFloat* PerlinNoisePodScaleIn(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PErrCatch(FracNoiseErr);
    }
#endif
}

```



```

    return that->_scaleIn;
}

// Get the scale of outputs of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
VecFloat* PerlinNoisePodScaleOut(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    return that->_scaleOut;
}

// Get the shift of outputs of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
VecFloat* PerlinNoisePodShiftOut(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    return that->_shiftOut;
}

// Get the fractal level of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
int PerlinNoisePodGetFractLvl(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    return that->_fractalLvl;
}

// Get the fractal coefficient of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
float PerlinNoisePodGetFractCoeff(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    return that->_fractalCoeff;
}

```

```

// Get the border coefficient of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
float PerlinNoisePodGetBorder(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    return that->_border;
}

// Get the smoothness of the PerlinNoisePod 'that'
#if BUILDMODE != 0
inline
#endif
float PerlinNoisePodGetSmooth(PerlinNoisePod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    return that->_smooth;
}

// Set the seed of the PerlinNoisePod 'that' to a copy of 'seed'
// If 'seed' is the vector null the seed is left unchanged
#if BUILDMODE != 0
inline
#endif
void PerlinNoisePodSetSeed(PerlinNoisePod* that, VecFloat3D* seed) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (seed == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'seed' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    // Check if the seed is the vector null
    if (VecNorm(seed) < PBMATH_EPSILON)
        return;
    // Set the new seed
    that->_seed = *seed;
    // Make sure the seed is normalised
    VecNormalise(&(that->_seed));
}

// Set the bound of the PerlinNoisePod 'that' to 'bound'
// The Shapoid 'bound' must have same dimensions as the input dimension
// of the PerlinNoisePod.
#if BUILDMODE != 0

```

```

inline
#endif
void _PerlinNoisePodSetBound(PerlinNoisePod* that, Shapoid* bound) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PErrCatch(FracNoiseErr);
    }
    if (bound == NULL) {
        FracNoiseErr->_type = PErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'bound' is null");
        PErrCatch(FracNoiseErr);
    }
    if (ShapoidGetDim(bound) != VecGetDim(that->_scaleIn)) {
        FracNoiseErr->_type = PErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'bound' 's dimension is invalid (%d=%d)",
            ShapoidGetDim(bound), VecGetDim(that->_scaleIn));
        PErrCatch(FracNoiseErr);
    }
}
#endif
// Set the new bound
that->_bound = bound;
}

// Set the scale of inputs of the PerlinNoisePod 'that' to a
// copy of 'scale'
// 'scale' must have same dimension as the input dimension
// of the PerlinNoisePod.
#if BUILDMODE != 0
inline
#endif
void _PerlinNoisePodSetScaleIn(PerlinNoisePod* that, VecFloat* scale) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PErrCatch(FracNoiseErr);
    }
    if (scale == NULL) {
        FracNoiseErr->_type = PErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'scale' is null");
        PErrCatch(FracNoiseErr);
    }
    if (VecGetDim(scale) != VecGetDim(that->_scaleIn)) {
        FracNoiseErr->_type = PErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'scale' 's dimension is invalid (%d=%d)",
            VecGetDim(scale), VecGetDim(that->_scaleIn));
        PErrCatch(FracNoiseErr);
    }
}
#endif
// Set the new scale
VecCopy(that->_scaleIn, scale);
}

// Set the scale of outputs of the PerlinNoisePod 'that' to a copy
// of 'scale'
// 'scale' must have same dimension as the output dimension
// of the PerlinNoisePod.
#if BUILDMODE != 0

```

```

inline
#endif
void _PerlinNoisePodSetScaleOut(PerlinNoisePod* that, VecFloat* scale) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (scale == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'scale' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (VecGetDim(scale) != VecGetDim(that->_scaleOut)) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'scale' 's dimension is invalid (%d=%d)",
            VecGetDim(scale), VecGetDim(that->_scaleOut));
        PBErrCatch(FracNoiseErr);
    }
}
#endif
    // Set the new scale
    VecCopy(that->_scaleOut, scale);
}

// Set the shift of outputs of the PerlinNoisePod 'that' to a copy
// of 'shift'
// 'shift' must have same dimension as the output dimension
// of the PerlinNoisePod.
#if BUILDMODE != 0
inline
#endif
void _PerlinNoisePodSetShiftOut(PerlinNoisePod* that, VecFloat* shift) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (shift == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'shift' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (VecGetDim(shift) != VecGetDim(that->_shiftOut)) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg,
            "'shift' 's dimension is invalid (%d=%d)",
            VecGetDim(shift), VecGetDim(that->_shiftOut));
        PBErrCatch(FracNoiseErr);
    }
}
#endif
    // Set the new shift
    VecCopy(that->_shiftOut, shift);
}

// Set the fractal level of the PerlinNoisePod 'that' to 'lvl'
// 'lvl' must be greater than or equal to 0
#if BUILDMODE != 0
inline
#endif

```

```

void PerlinNoisePodSetFractLvl(PerlinNoisePod* that, int lvl) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (lvl < 0) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg, "'lvl' is invalid (%d>=0)", lvl);
        PBErrCatch(FracNoiseErr);
    }
#endif
    // Set the new level
    that->_fractalLvl = lvl;
}

// Set the fractal coefficient of the PerlinNoisePod 'that' to 'coeff'
// 'coeff' must be greater than 0.0, if it's negative its absolute
// value is used
#ifdef BUILDMODE != 0
inline
#endif
void PerlinNoisePodSetFractCoeff(PerlinNoisePod* that, float coeff) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (fabs(coeff) < PBMath_EPSILON) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg, "'coeff' is equal to 0.0");
        PBErrCatch(FracNoiseErr);
    }
#endif
    // Set the new coefficient
    that->_fractalCoeff = fabs(coeff);
}

// Set the fractal coefficient of the PerlinNoisePod 'that' to 'border'
#ifdef BUILDMODE != 0
inline
#endif
void PerlinNoisePodSetBorder(PerlinNoisePod* that, float border) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    // Set the new coefficient
    that->_border = border;
}

// Set the smoothness of the PerlinNoisePod 'that' to 'smooth'
// 'smooth' must be greater than 0.0
// Below 1.0 gives a bumpy aspect, above 1.0 gives a spiky aspect,
// 1.0 is the smoothest
#ifdef BUILDMODE != 0
inline

```

```

#endif
void PerlinNoisePodSetSmooth(PerlinNoisePod* that, float smooth) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
    if (smooth < PBMath_EPSILON) {
        FracNoiseErr->_type = PBErrTypeInvalidArg;
        sprintf(FracNoiseErr->_msg, "'smooth' is invalid (%f>0)", smooth);
        PBErrCatch(FracNoiseErr);
    }
#endif
    // Set the new coefficient
    that->_smooth = smooth;
}

// ----- FracNoise

// ===== Functions implementation =====

// Get the dimensions of the noise 'that'
#if BUILDMODE != 0
inline
#endif
VecShort2D* FracNoiseDim(FracNoise* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    return &(that->_dim);
}

// Get the pods of the noise 'that'
#if BUILDMODE != 0
inline
#endif
GSet* FracNoisePods(FracNoise* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    return &(that->_noises);
}

// Get the 'iNoise'-th noise of the FracNoise 'that'
// Return null if 'iNoise' is invalid
#if BUILDMODE != 0
inline
#endif
PerlinNoisePod* FracNoiseGetNoise(FracNoise* that, int iNoise) {
#if BUILDMODE == 0
    if (that == NULL) {

```

```

    FracNoiseErr->_type = PBErrTypeNullPointer;
    sprintf(FracNoiseErr->_msg, "'that' is null");
    PBErrCatch(FracNoiseErr);
}
#endif
if (iNoise < 0 || iNoise >= GSetNbElem(&(that->_noises)))
    return NULL;
return (PerlinNoisePod*)GSetGet(&(that->_noises), iNoise);
}

// Add a new noise with seed 'seed' to the FracNoise 'that'
// If seed is null it is replaced by a default seed
// Return the new noise
#if BUILDMODE != 0
inline
#endif
PerlinNoisePod* FracNoiseAddNoise(FracNoise* that, VecFloat3D* seed) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    // Create a new pod
    PerlinNoisePod* pod = PerlinNoisePodCreate(FracNoiseDim(that), seed);
    // Add the pod to the set of noises
    GSetAppend(&(that->_noises), pod);
    // Return the new pod
    return pod;
}

// Remove the PerlinNoisePod 'pod' from the FracNoise 'that'
#if BUILDMODE != 0
inline
#endif
void FracNoiseRemoveNoise(FracNoise* that, PerlinNoisePod* pod) {
#if BUILDMODE == 0
    if (that == NULL) {
        FracNoiseErr->_type = PBErrTypeNullPointer;
        sprintf(FracNoiseErr->_msg, "'that' is null");
        PBErrCatch(FracNoiseErr);
    }
#endif
    // Loop on the set of noises
    GSetIterForward iter = GSetIterForwardCreateStatic(&(that->_noises));
    bool flag = true;
    do {
        // Get the current pod
        PerlinNoisePod* p = GSetIterGet(&iter);
        // If it's the searched pod
        if (p == pod) {
            // Remove from the set
            GSetIterRemoveElem(&iter);
            // Free memory
            PerlinNoisePodFree(&p);
            // End the loop on the set
            flag = false;
        }
    } while (flag && GSetIterStep(&iter));
}

```

## 4 Makefile

```
#directory
PBERRDIR=../PBErr
PBMATHDIR=../PBMath
GENBRUSHDIR=../GenBrush
GSETDIR=../GSet
SHAPOIDDIR=../Shapoid
BCURVEDIR=../BCurve

# Build mode
# 0: development (max safety, no optimisation)
# 1: release (min safety, optimisation)
# 2: fast and furious (no safety, optimisation)
BUILDMODE=0

# 0: monolith version, the GBSurface is rendered toward a TGA image
# 1: GTK version, the GBSurface is rendered toward a TGA image or
#    a GtkWidget
BUILDWITHGRAPHICLIB=0

include $(PBERRDIR)/Makefile.inc

INCPATH=-I./ -I$(PBERRDIR)/ -I$(PBMATHDIR)/ -I$(GENBRUSHDIR)/ -I$(SHAPOIDDIR)/ -I$(BCURVEDIR)/ -I$(GSETDIR)/
BUILDOPTIONS=$(BUILDPARAM) $(INCPATH) -gdb

# compiler
COMPILER=gcc

#rules
all : main

main: main.o pberr.o bcurve.o shapoid.o pbmath.o gset.o genbrush.o fracnoise.o Makefile
$(COMPILER) main.o pberr.o bcurve.o shapoid.o pbmath.o gset.o genbrush.o fracnoise.o $(LINKOPTIONS) -o main $(GTKLIBS)

main.o : main.c $(PBERRDIR)/pberr.h $(SHAPOIDDIR)/shapoid.h $(SHAPOIDDIR)/shapoid-inline.c $(PBMATHDIR)/pbmath.h $(PBERRDIR)/pberr.h
$(COMPILER) $(BUILDOPTIONS) -c main.c

fracnoise.o: fracnoise.h fracnoise.c fracnoise-inline.c $(PBMATHDIR)/pbmath.h Makefile
$(COMPILER) $(BUILDOPTIONS) -c fracnoise.c

genbrush.o : $(GENBRUSHDIR)/genbrush.c $(GENBRUSHDIR)/genbrush.h $(GENBRUSHDIR)/genbrush-inline.c $(BCURVEDIR)/bcurve.h
$(COMPILER) $(BUILDOPTIONS) -c $(GENBRUSHDIR)/genbrush.c

bcurve.o : $(BCURVEDIR)/bcurve.c $(BCURVEDIR)/bcurve-inline.c $(BCURVEDIR)/bcurve.h $(SHAPOIDDIR)/shapoid.h $(SHAPOIDDIR)/shapoid-inline.c
$(COMPILER) $(BUILDOPTIONS) -c $(BCURVEDIR)/bcurve.c

shapoid.o : $(SHAPOIDDIR)/shapoid.c $(SHAPOIDDIR)/shapoid.h $(SHAPOIDDIR)/shapoid-inline.c $(PBMATHDIR)/pbmath.h $(PBERRDIR)/pberr.h
$(COMPILER) $(BUILDOPTIONS) -c $(SHAPOIDDIR)/shapoid.c

pberr.o : $(PBERRDIR)/pberr.c $(PBERRDIR)/pberr.h Makefile
$(COMPILER) $(BUILDOPTIONS) -c $(PBERRDIR)/pberr.c

pbmath.o : $(PBMATHDIR)/pbmath.c $(PBMATHDIR)/pbmath-inline.c $(PBMATHDIR)/pbmath.h Makefile $(PBERRDIR)/pberr.h
$(COMPILER) $(BUILDOPTIONS) -c $(PBMATHDIR)/pbmath.c

gset.o : $(GSETDIR)/gset.c $(GSETDIR)/gset-inline.c $(GSETDIR)/gset.h Makefile $(PBERRDIR)/pberr.h
```



```

$(COMPILER) $(BUILDOPTIONS) -c $(GSETDIR)/gset.c

clean :
rm -rf *.o main

valgrind :
valgrind -v --track-origins=yes --leak-check=full --gen-suppressions=yes --show-leak-kinds=all ./main

unitTest :
main > unitTest.txt; diff unitTest.txt unitTestRef.txt

HF:
povray +FT -W500 -H300 -D -P -Q9 +A +UA -IHF.pov

DF3:
povray +FT -W500 -H300 -D -P -Q9 +A -IDF3.pov

```

## 5 Unit tests

```

#include <stdlib.h>
#include <stdio.h>
#include <time.h>
#include <string.h>
#include "fracnoise.h"
#include "genbrush.h"

#define RANDOMSEED 0

void UnitTestPerlinNoise() {
    // Create a PerlinNoise
    PerlinNoise* noise = PerlinNoiseCreate();
    PerlinNoise noiseStatic = PerlinNoiseCreateStatic();
    // Create a GB to render the image
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 512); VecSet(&dim, 1, 512);
    GenBrush* gb = GBCreateImage(&dim);
    // Draw the Image
    VecShort2D pos = VecShortCreateStatic2D();
    VecFloat3D p = VecFloatCreateStatic3D();
    VecSet(&p, 2, 0.4);
    GBPixel pix = GBColorBlack;
    do {
        for (int i = 2; i--;)
            VecSet(&p, i, (float)VecGet(&pos, i) / 64.0);
        float pn = PerlinNoiseGet(noise, &p);
        float pnStatic = PerlinNoiseGet(&noiseStatic, &p);
        if (ISEQUALF(pn, pnStatic) == false) {
            FracNoiseErr->_type = PBErrTypeUnitTestFailed;
            sprintf(FracNoiseErr->_msg, "PerlinNoiseStatic NOK");
            PBErrCatch(FracNoiseErr);
        }
        unsigned char n = (unsigned char)floor(255.0 * pn);
        pix._rgba[GBPixelRed] = n;
        pix._rgba[GBPixelGreen] = n;
        pix._rgba[GBPixelBlue] = n;
        GBSetFinalPixel(gb, &pos, &pix);
    } while (VecStep(&pos, &dim));
    // Compare to reference
    GenBrush* gbRef = GBCreateFromFile("./UnitTestPerlinNoise3DRef.tga");
}

```

```

if (gbRef == NULL) {
    FracNoiseErr->_type = PBErrTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg,
        "Couldn't load UnitTestPerlinNoise3DRef.tga");
    PBErrCatch(FracNoiseErr);
}
if (GBIsSameAs(gb, gbRef) == false) {
    FracNoiseErr->_type = PBErrTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoiseGet3D NOK");
    PBErrCatch(FracNoiseErr);
}
VecFloat2D p2 = VecFloatCreateStatic2D();
do {
    for (int i = 2; i--;)
        VecSet(&p2, i, (float)VecGet(&pos, i) / 64.0);
    float pn = PerlinNoiseGet(noise, &p2);
    unsigned char n = (unsigned char)floor(255.0 * pn);
    pix._rgba[GBPixelRed] = n;
    pix._rgba[GBPixelGreen] = n;
    pix._rgba[GBPixelBlue] = n;
    GBSetFinalPixel(gb, &pos, &pix);
} while (VecStep(&pos, &dim));
// Compare to reference
GBFree(&gbRef);
gbRef = GBCreateFromFile("./UnitTestPerlinNoise2DRef.tga");
if (gbRef == NULL) {
    FracNoiseErr->_type = PBErrTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg,
        "Couldn't load UnitTestPerlinNoise2DRef.tga");
    PBErrCatch(FracNoiseErr);
}
if (GBIsSameAs(gb, gbRef) == false) {
    FracNoiseErr->_type = PBErrTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoiseGet2D NOK");
    PBErrCatch(FracNoiseErr);
}
float p1 = 0.0;
int i = 0;
float check[64] = {
    0.500000,0.507794,0.515479,0.522958,0.530141,0.536949,0.543313,
    0.549172,0.554474,0.559176,0.563242,0.566646,0.569366,0.571388,
    0.572708,0.573324,0.573242,0.572474,0.571037,0.568952,0.566247,
    0.562952,0.559102,0.554736,0.549896,0.544627,0.538977,0.532996,
    0.526736,0.520251,0.513596,0.506826,0.500000,0.493174,0.486404,
    0.479749,0.473264,0.467004,0.461023,0.455373,0.450104,0.445264,
    0.440898,0.437048,0.433753,0.431048,0.428963,0.427526,0.426758,
    0.426676,0.427292,0.428612,0.430634,0.433354,0.436758,0.440824,
    0.445526,0.450828,0.456687,0.463051,0.469859,0.477042,0.484521,
    0.492206};
do {
    float pn = PerlinNoiseGet(noise, p1);
    if (ISEQUALF(pn, check[i]) == false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoiseGet1D NOK");
        PBErrCatch(FracNoiseErr);
    }
    p1 += 1.0 / 64.0;
    ++i;
} while (p1 < 1.0);
int permut[256] = {};
for (int i = 256; i--;)
    permut[i] = i;

```

```

PerlinNoiseSetPermut(noise, permut);
for (int i = 256; i--;)
    if (noise->p[i] != permut[i] ||
        noise->p[256 + i] != permut[i]) {
        FracNoiseErr->_type = PErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoiseSetPermut NOK");
        PErrCatch(FracNoiseErr);
    }
// Free memory
GBFree(&gb);
GBFree(&gbRef);
PerlinNoiseFree(&noise);
printf("UnitTestPerlinNoise OK\n");
}

void UnitTestPerlinNoisePodCreateFree() {
    VecFloat3D seed = VecFloatCreateStatic3D();
    VecSet(&seed, 0, 1.0); VecSet(&seed, 1, 2.0); VecSet(&seed, 2, 3.0);
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 3); VecSet(&dim, 1, 2);
    PerlinNoisePod* pod = PerlinNoisePodCreate(&dim, &seed);
    if (pod->_bound != NULL ||
        ISEQUALF(pod->_border, 0.1) == false ||
        ISEQUALF(VecGet(pod->_scaleIn, 0), 1.0) == false ||
        ISEQUALF(VecGet(pod->_scaleIn, 1), 1.0) == false ||
        ISEQUALF(VecGet(pod->_scaleIn, 2), 1.0) == false ||
        VecGetDim(pod->_scaleOut) != 2 ||
        ISEQUALF(VecGet(pod->_scaleOut, 0), 1.0) == false ||
        ISEQUALF(VecGet(pod->_scaleOut, 1), 1.0) == false ||
        pod->_fractalLvl != 0 ||
        ISEQUALF(pod->_fractalCoeff, 0.1) == false) {
        FracNoiseErr->_type = PErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodCreate NOK");
        PErrCatch(FracNoiseErr);
    }
    VecNormalise(&seed);
    if (VecIsEqual(&(pod->_seed), &seed) == false) {
        FracNoiseErr->_type = PErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodCreate NOK");
        PErrCatch(FracNoiseErr);
    }
    PerlinNoisePodFree(&pod);
    if (pod != NULL) {
        FracNoiseErr->_type = PErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodFree NOK");
        PErrCatch(FracNoiseErr);
    }
    printf("UnitTestPerlinNoisePodCreateFree OK\n");
}

void UnitTestPerlinNoisePodSetGet() {
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 2); VecSet(&dim, 1, 3);
    PerlinNoisePod* pod = PerlinNoisePodCreate(&dim, NULL);
    if (PerlinNoisePodNoise(pod) != &(pod->_noise)) {
        FracNoiseErr->_type = PErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodNoise NOK");
        PErrCatch(FracNoiseErr);
    }
    if (PerlinNoisePodSeed(pod) != &(pod->_seed)) {
        FracNoiseErr->_type = PErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodSeed NOK");
    }
}

```

```

    PBErriCatch(FracNoiseErr);
}
VecFloat3D seed = VecFloatCreateStatic3D();
VecSet(&seed, 0, 1.0); VecSet(&seed, 1, 2.0); VecSet(&seed, 2, 3.0);
PerlinNoisePodSetSeed(pod, &seed);
VecNormalise(&seed);
if (VecIsEqual(PerlinNoisePodSeed(pod), &seed) == false) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetSeed NOK");
    PBErriCatch(FracNoiseErr);
}
if (PerlinNoisePodBound(pod) != pod->_bound) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodBound NOK");
    PBErriCatch(FracNoiseErr);
}
Facoid* shap = FacoidCreate(2);
PerlinNoisePodSetBound(pod, shap);
if (ShapoidIsEqual(PerlinNoisePodBound(pod), shap) == false) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetBound NOK");
    PBErriCatch(FracNoiseErr);
}
ShapoidFree(&shap);
if (PerlinNoisePodScaleIn(pod) != pod->_scaleIn) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodScaleIn NOK");
    PBErriCatch(FracNoiseErr);
}
VecFloat2D in = VecFloatCreateStatic2D();
VecSet(&in, 0, 2.0); VecSet(&in, 1, 3.0);
PerlinNoisePodSetScaleIn(pod, (VecFloat*)&in);
if (VecIsEqual(PerlinNoisePodScaleIn(pod), &in) == false) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetScaleIn NOK");
    PBErriCatch(FracNoiseErr);
}
if (PerlinNoisePodScaleOut(pod) != pod->_scaleOut) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodScaleOut NOK");
    PBErriCatch(FracNoiseErr);
}
VecFloat3D out = VecFloatCreateStatic3D();
VecSet(&out, 0, 2.0); VecSet(&out, 1, 3.0); VecSet(&out, 2, 4.0);
PerlinNoisePodSetScaleOut(pod, (VecFloat*)&out);
if (VecIsEqual(PerlinNoisePodScaleOut(pod), &out) == false) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetScaleOut NOK");
    PBErriCatch(FracNoiseErr);
}
if (PerlinNoisePodShiftOut(pod) != pod->_shiftOut) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodShiftOut NOK");
    PBErriCatch(FracNoiseErr);
}
VecFloat3D shift = VecFloatCreateStatic3D();
VecSet(&shift, 0, 2.0); VecSet(&shift, 1, 3.0); VecSet(&shift, 2, 4.0);
PerlinNoisePodSetShiftOut(pod, (VecFloat*)&shift);
if (VecIsEqual(PerlinNoisePodShiftOut(pod), &shift) == false) {
    FracNoiseErr->_type = PBErriTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetShiftOut NOK");
    PBErriCatch(FracNoiseErr);
}

```

```

    }
    if (PerlinNoisePodGetFractLvl(pod) != pod->_fractalLvl) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodGetFractLvl NOK");
        PBErrCatch(FracNoiseErr);
    }
    PerlinNoisePodSetFractLvl(pod, 2);
    if (PerlinNoisePodGetFractLvl(pod) != 2) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetFractLvl NOK");
        PBErrCatch(FracNoiseErr);
    }
    if (ISEQUALF(PerlinNoisePodGetFractCoeff(pod), pod->_fractalCoeff) ==
        false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodGetFractCoeff NOK");
        PBErrCatch(FracNoiseErr);
    }
    PerlinNoisePodSetFractCoeff(pod, 0.5);
    if (ISEQUALF(PerlinNoisePodGetFractCoeff(pod), 0.5) == false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetFractCoeff NOK");
        PBErrCatch(FracNoiseErr);
    }
    if (ISEQUALF(PerlinNoisePodGetBorder(pod), pod->_border) ==
        false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodGetBorder NOK");
        PBErrCatch(FracNoiseErr);
    }
    PerlinNoisePodSetBorder(pod, 0.25);
    if (ISEQUALF(PerlinNoisePodGetBorder(pod), 0.25) == false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetBorder NOK");
        PBErrCatch(FracNoiseErr);
    }
    if (ISEQUALF(PerlinNoisePodGetSmooth(pod), pod->_smooth) ==
        false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodGetSmooth NOK");
        PBErrCatch(FracNoiseErr);
    }
    PerlinNoisePodSetSmooth(pod, 0.25);
    if (ISEQUALF(PerlinNoisePodGetSmooth(pod), 0.25) == false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodSetSmooth NOK");
        PBErrCatch(FracNoiseErr);
    }
    PerlinNoisePodFree(&pod);
    printf("UnitTestPerlinNoisePodSetGet OK\n");
}

void UnitTestPerlinNoisePodGetInsideness() {
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 2); VecSet(&dim, 1, 3);
    PerlinNoisePod* pod = PerlinNoisePodCreate(&dim, NULL);
    Facoid* shap = FacoidCreate(2);
    PerlinNoisePodSetBound(pod, shap);
    PerlinNoisePodSetBorder(pod, 0.5);
    VecFloat2D pos = VecFloatCreateStatic2D();
    float check[25] = {
        0.000000,0.000000,0.000000,0.003368,0.113456,0.537834,0.955768,

```

```

1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,
1.000000,1.000000,1.000000,1.000000,0.955768,0.537834,0.113456,
0.003368,0.000000,0.000000,0.000000};
for (int i = 0; i <= 24; ++i) {
    float x = -0.1 + 0.05 * (float)i;
    VecSet(&pos, 0, x); VecSet(&pos, 1, x);
    float in = PerlinNoisePodGetInsideness(pod, (VecFloat*)&pos);
    if (ISEQUALF(in, check[i]) == false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "PerlinNoisePodGetInsideness NOK");
        PBErrCatch(FracNoiseErr);
    }
}
ShapoidFree(&shap);
PerlinNoisePodFree(&pod);
printf("UnitTestPerlinNoisePodGetInsideness OK\n");
}

void UnitTestPerlinNoisePod() {
    UnitTestPerlinNoisePodCreateFree();
    UnitTestPerlinNoisePodSetGet();
    UnitTestPerlinNoisePodGetInsideness();

    printf("UnitTestPerlinNoisePod OK\n");
}

void UnitTestFracNoiseCreateFree() {
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 2); VecSet(&dim, 1, 3);
    FracNoise* noise = FracNoiseCreate(&dim, NULL);
    if (VecIsEqual(&(noise->_dim), &dim) != true) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "FracNoiseCreate NOK");
        PBErrCatch(FracNoiseErr);
    }
    FracNoiseFree(&noise);
    if (noise != NULL) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "FracNoiseFree NOK");
        PBErrCatch(FracNoiseErr);
    }
    printf("UnitTestFracNoiseCreateFree OK\n");
}

void UnitTestFracNoiseSetGet() {
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 2); VecSet(&dim, 1, 3);
    FracNoise* noise = FracNoiseCreate(&dim, NULL);
    if (VecIsEqual(FracNoiseDim(noise), &dim) != true) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "FracNoiseDim NOK");
        PBErrCatch(FracNoiseErr);
    }
    if (FracNoisePods(noise) != &(noise->_noises)) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "FracNoisePods NOK");
        PBErrCatch(FracNoiseErr);
    }
    if (FracNoiseGetNoise(noise, 0) !=
        (PerlinNoisePod*)(noise->_noises._head->_data)) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "FracNoiseGetNoise NOK");
    }
}

```

```

        PBErCatch(FracNoiseErr);
    }
    FracNoiseFree(&noise);
    printf("UnitTestFracNoiseSetGet OK\n");
}

void UnitTestFracNoiseAddRemoveNoise() {
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 2); VecSet(&dim, 1, 3);
    FracNoise* noise = FracNoiseCreate(&dim, NULL);
    PerlinNoisePod* pod = FracNoiseAddNoise(noise, NULL);
    if (GSetNbElem(FracNoisePods(noise)) != 2 ||
        pod != FracNoiseGetNoise(noise, 1)) {
        FracNoiseErr->_type = PBErTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "FracNoiseAddNoise NOK");
        PBErCatch(FracNoiseErr);
    }
    FracNoiseRemoveNoise(noise, pod);
    if (GSetNbElem(FracNoisePods(noise)) != 1 ||
        pod == FracNoiseGetNoise(noise, 0)) {
        FracNoiseErr->_type = PBErTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "FracNoiseRemoveNoise NOK");
        PBErCatch(FracNoiseErr);
    }
    FracNoiseFree(&noise);
    printf("UnitTestFracNoiseAddRemoveNoise OK\n");
}

void UnitTestFracNoiseGet() {
    // Create a FracNoise
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 2); VecSet(&dim, 1, 3);
    FracNoise* noise = FracNoiseCreate(&dim, NULL);
    // Set properties of the FracNoise
    PerlinNoisePod* podA = FracNoiseGetNoise(noise, 0);
    VecFloat2D scaleIn = VecFloatCreateStatic2D();
    VecSet(&scaleIn, 0, 1.0); VecSet(&scaleIn, 1, 0.5);
    PerlinNoisePodSetScaleIn(podA, (VecFloat*)&scaleIn);
    VecFloat3D scaleOut = VecFloatCreateStatic3D();
    VecSet(&scaleOut, 0, 1.0); VecSet(&scaleOut, 1, 0.2);
    VecSet(&scaleOut, 2, 1.0);
    PerlinNoisePodSetScaleOut(podA, (VecFloat*)&scaleOut);
    PerlinNoisePodSetFractLvl(podA, 1);
    VecFloat3D seed = VecFloatCreateStatic3D();
    VecSet(&seed, 0, -1.0); VecSet(&seed, 1, 0.5);
    VecSet(&seed, 2, 1.0);
    PerlinNoisePod* podB = FracNoiseAddNoise(noise, &seed);
    VecSet(&scaleOut, 0, 0.0); VecSet(&scaleOut, 1, 0.7);
    VecSet(&scaleOut, 2, 0.0);
    PerlinNoisePodSetScaleOut(podB, (VecFloat*)&scaleOut);
    VecFloat3D shiftOut = VecFloatCreateStatic3D();
    VecSet(&shiftOut, 0, 0.0); VecSet(&shiftOut, 1, 0.1);
    VecSet(&shiftOut, 2, 0.0);
    Spheroid* bound = SpheroidCreate(2);
    ShapoidScale(bound, (float)(200.0 / 64.0));
    VecFloat2D v = VecFloatCreateStatic2D();
    VecSet(&v, 0, 250.0 / 64.0); VecSet(&v, 1, 250.0 / 64.0);
    ShapoidTranslate(bound, &v);
    PerlinNoisePodSetBound(podB, bound);
    PerlinNoisePodSetBorder(podB, 0.5);
    PerlinNoisePodSetSmooth(podA, 3.0);
    // Create a GB to render the image

```

```

VecSet(&dim, 0, 512); VecSet(&dim, 1, 512);
GenBrush* gb = GBCreateImage(&dim);
// Draw the Image
VecShort2D pos = VecShortCreateStatic2D();
VecFloat2D p = VecFloatCreateStatic2D();
GBPixel pix = GBColorBlack;
do {
    for (int i = 2; i--;)
        VecSet(&p, i, (float)VecGet(&pos, i) / 64.0);
    VecFloat* pn = FracNoiseGet(noise, &p);
    pix._rgba[GBPixelRed] = (unsigned char)floor(255.0 * VecGet(pn, 0));
    pix._rgba[GBPixelGreen] =
        (unsigned char)floor(255.0 * VecGet(pn, 1));
    pix._rgba[GBPixelBlue] = (unsigned char)floor(255.0 * VecGet(pn, 2));
    GBSetFinalPixel(gb, &pos, &pix);
    VecFree(&pn);
} while (VecStep(&pos, &dim));
// Compare to reference (two versions because changes in compilation
// options trigger small variations when casting from float to int)
#if BUILDMODE == 0
    GenBrush* gbRef = GBCreateFromFile("./UnitTestFracNoiseGetRef0.tga");
#else
    GenBrush* gbRef = GBCreateFromFile("./UnitTestFracNoiseGetRef1.tga");
#endif
if (gbRef == NULL) {
    FracNoiseErr->_type = PBErrTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg,
        "Couln't load UnitTestPerlinNoise3DRef.tga");
    PBErrCatch(FracNoiseErr);
}
if (GBIsSameAs(gb, gbRef) == false) {
    FracNoiseErr->_type = PBErrTypeUnitTestFailed;
    sprintf(FracNoiseErr->_msg, "FracNoiseGet NOK");
    PBErrCatch(FracNoiseErr);
}
// Free memory
ShapoidFree(&bound);
GBFree(&gb);
GBFree(&gbRef);
FracNoiseFree(&noise);

printf("UnitTestFracNoiseGet OK\n");
}

void UnitTestFracNoiseExport() {
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 3); VecSet(&dim, 1, 1);
    FracNoise* noise = FracNoiseCreate(&dim, NULL);
    VecFloat3D range = VecFloatCreateStatic3D();
    VecSet(&range, 0, 10.0); VecSet(&range, 1, 10.0);
    VecSet(&range, 2, 10.0);
    VecShort3D nbSample = VecShortCreateStatic3D();
    VecSet(&nbSample, 0, 30); VecSet(&nbSample, 1, 30);
    VecSet(&nbSample, 2, 30);
    int res = 8;
    char* fileName = "./UnitTestFracNoiseExport.df3";
    if (FracNoiseExportDF3(noise, &range, &nbSample, res, true,
        fileName) == false) {
        FracNoiseErr->_type = PBErrTypeUnitTestFailed;
        sprintf(FracNoiseErr->_msg, "FracNoiseExportDF3 NOK");
        PBErrCatch(FracNoiseErr);
    }
}

```



```

    FracNoiseFree(&noise);
    printf("UnitTestFracNoiseExport OK\n");
}

void UnitTestFracNoise() {
    UnitTestFracNoiseCreateFree();
    UnitTestFracNoiseSetGet();
    UnitTestFracNoiseAddRemoveNoise();
    UnitTestFracNoiseGet();
    UnitTestFracNoiseExport();

    printf("UnitTestFracNoise OK\n");
}

void UnitTestAll() {
    UnitTestPerlinNoise();
    UnitTestPerlinNoisePod();
    UnitTestFracNoise();
    printf("UnitTestAll OK\n");
}

int main() {
    UnitTestAll();

    // Return success code
    return 0;
}

```

## 6 Unit tests output

```

UnitTestPerlinNoise OK
UnitTestPerlinNoisePodCreateFree OK
UnitTestPerlinNoisePodSetGet OK
UnitTestPerlinNoisePodGetInsideness OK
UnitTestPerlinNoisePod OK
UnitTestFracNoiseCreateFree OK
UnitTestFracNoiseSetGet OK
UnitTestFracNoiseAddRemoveNoise OK
UnitTestFracNoiseGet OK
UnitTestFracNoiseExport OK
UnitTestFracNoise OK
UnitTestAll OK

```

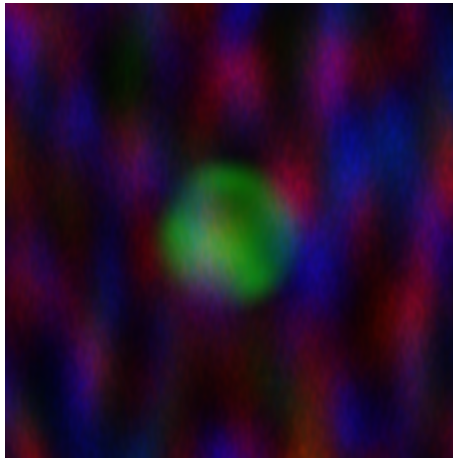
UnitTestPerlinNoise2DRef.png:



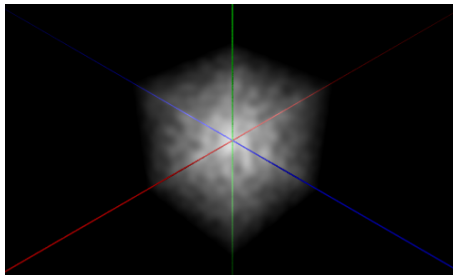
UnitTestPerlinNoise3DRef.png:



UnitTestFracNoiseGetRef.png:



UnitTestFracNoiseExportRef.df3 (rendered in POV-Ray in a unit cube):



## 7 Examples

### 7.1 Terrain

main.c:

```
#include <stdlib.h>
#include <stdio.h>
#include <time.h>
#include <string.h>
#include "fracnoise.h"
#include "genbrush.h"

#define RANDOMSEED 1

int main() {
```

```

srandom(RANDOMSEED);
// HF dimension
int HFDim = 512;
// Create a FracNoise
VecShort2D dim = VecShortCreateStatic2D();
VecSet(&dim, 0, 2); VecSet(&dim, 1, 1);
VecFloat3D seed = VecFloatCreateStatic3D();
for (int i = 3; i--;)
    VecSet(&seed, i, rnd());
FracNoise* terrain = FracNoiseCreate(&dim, &seed);
// --- main ground
PerlinNoisePod* ground = FracNoiseGetNoise(terrain, 0);
// scaleIn
VecFloat2D scaleIn = VecFloatCreateStatic2D();
float sIn = 1.0 / (float)HFDim;
for (int i = 2; i--;)
    VecSet(&scaleIn, i, sIn);
PerlinNoisePodSetScaleIn(ground, &scaleIn);
// scaleOut
float sOut = 200.0;
VecFloat* scaleOut = VecFloatCreate(1);
VecSet(scaleOut, 0, sOut);
PerlinNoisePodSetScaleOut(ground, scaleOut);
// fractal
PerlinNoisePodSetFractLvl(ground, 2);
PerlinNoisePodSetFractCoeff(ground, 0.3);
// --- mountains
PerlinNoisePod* mount = FracNoiseAddNoise(terrain, &seed);
// scaleIn
sIn = 5.0 / (float)HFDim;
for (int i = 2; i--;)
    VecSet(&scaleIn, i, sIn);
PerlinNoisePodSetScaleIn(mount, &scaleIn);
// scaleOut
sOut = 500.0;
VecSet(scaleOut, 0, sOut);
PerlinNoisePodSetScaleOut(mount, scaleOut);
// boundary
Spheroid* boundMount = SpheroidCreate(2);
PerlinNoisePodSetBound(mount, boundMount);
VecFloat2D scaleBound = VecFloatCreateStatic2D();
VecSet(&scaleBound, 0, 350.0); VecSet(&scaleBound, 1, 750.0);
ShapoidScale(boundMount, (VecFloat*)&scaleBound);
ShapoidRotCenter(boundMount, PBMath_QUARTERPI * 0.5);
VecFloat2D shiftBound = VecFloatCreateStatic2D();
VecSet(&shiftBound, 0, 150.0); VecSet(&shiftBound, 1, 275.0);
ShapoidTranslate(boundMount, &shiftBound);
PerlinNoisePodSetBorder(mount, 1.0);
// fractal
PerlinNoisePodSetFractLvl(mount, 2);
PerlinNoisePodSetFractCoeff(mount, 0.4);
// Create a GB to render the height field
VecSet(&dim, 0, HFDim); VecSet(&dim, 1, HFDim);
GenBrush* gb = GBCreateImage(&dim);
// Draw the image
VecShort2D pos = VecShortCreateStatic2D();
VecFloat2D p = VecFloatCreateStatic2D();
GBPixel pix = GBColorBlack;
// search the min and max values ot renormalize over the height field
float min = 255.0;
float max = 0.0;
do {

```

```

    for (int i = 2; i--;)
        VecSet(&p, i, (float)VecGet(&pos, i));
    VecFloat* pn = FracNoiseGet(terrain, &p);
    if (VecGet(pn, 0) > max)
        max = VecGet(pn, 0);
    if (VecGet(pn, 0) < min)
        min = VecGet(pn, 0);
    VecFree(&pn);
} while (VecStep(&pos, &dim));
VecSetNull(&pos);
do {
    for (int i = 2; i--;)
        VecSet(&p, i, (float)VecGet(&pos, i));
    VecFloat* pn = FracNoiseGet(terrain, &p);
    unsigned char rgb = (unsigned char)floor(255.0 *
        (VecGet(pn, 0) - min) / (max - min));
    // Avoid hole in the height field due to water_level in POV
    if (rgb == 0) rgb = 1;
    pix._rgba[GBPixelRed] = rgb;
    pix._rgba[GBPixelGreen] = rgb;
    pix._rgba[GBPixelBlue] = rgb;
    GBSetFinalPixel(gb, &pos, &pix);
    VecFree(&pn);
} while (VecStep(&pos, &dim));
// Save the image
GBSetFileName(gb, "./HF.tga");
GBRender(gb);
// Free memory
GBFree(&gb);
FracNoiseFree(&terrain);
VecFree(&scaleOut);
ShapoidFree(&boundMount);

// Return success code
return 0;
}

```

terrain.pov:

```

#include "colors.inc"

#declare _texNeutral = texture {
    pigment { color rgb <0.75, 0.75, 0.75> }
    finish { ambient 0.1 diffuse 0.6 phong 0.0}
}

#declare _tex = texture {
    pigment { color White }
}

#declare RndSeed = seed(30);
#declare _posCamera = <0.0,1.0,2.0>;
#declare _lookAt = <0.0,0.0,0.5>;

camera {
    location    _posCamera
    look_at    _lookAt
    right x
    up y * 3/5
}

```

```

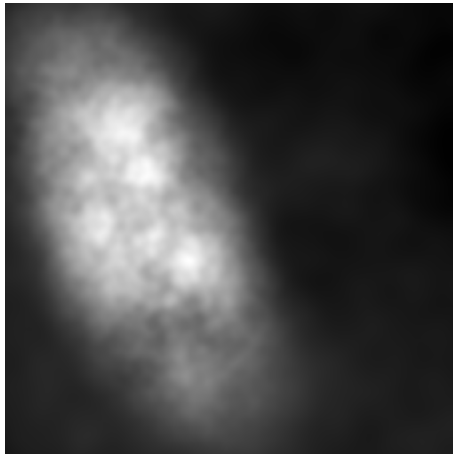
light_source {
  <1.0, 2.0, 0.0>
  color rgb 1.0
  area_light <-0.1, 0, -0.1>, <0.1, 0, 0.1>, 3, 3
  adaptive 1
  jitter
}

background { color rgbft <1.0, 1.0, 1.0, 1.0, 1.0> }

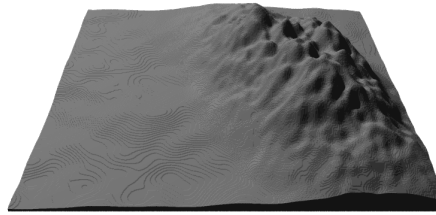
intersection {
  height_field {
    tga
    "HF.tga"
  }
  box {
    <0.0001,0.0001,0.0001>
    <0.9999,1.0,0.9999>
  }
  translate -0.5 * x
  scale <1.0, 0.25, 1.0>
  texture { _texNeutral }
}

```

HF.png:



terrain.png:



## 7.2 Cloud

main.c:

```
#include <stdlib.h>
#include <stdio.h>
#include <time.h>
#include <string.h>
#include "fracnoise.h"
#include "genbrush.h"

#define RANDOMSEED 2

// I have no idea if the names match, you'd be warned !!
typedef enum {
    cumulusA, cumulusB, stratusA, stratusB, stratusC
} typeCloud;

void MakeCloud(typeCloud type, int rndSeed, char* fileName) {
    srandom(rndSeed);
    // Set parameters according to type
    float smoothness = 1.0;
    float nbPodMin = 50.0;
    float nbPodMax = 100.0;
    float sizeCompMin = 0.1;
    float sizeCompMax = 0.3;
    float scaleInY = 1.0;
    float borderMin = 0.1;
    float borderMax = 0.5;
    if (type == cumulusA) {
        smoothness = 0.1;
        nbPodMin = 50.0;
        nbPodMax = 100.0;
        sizeCompMin = 0.1;
        sizeCompMax = 0.3;
        scaleInY = 1.0;
    } else if (type == cumulusB) {
        smoothness = 0.1;
        nbPodMin = 100.0;
        nbPodMax = 150.0;
        sizeCompMin = 0.1;
        sizeCompMax = 0.3;
        scaleInY = 1.0;
        borderMin = 0.0;
        borderMax = 0.0;
    } else if (type == stratusA) {
        smoothness = 1.0;
    }
}
```

```

    nbPodMin = 100.0;
    nbPodMax = 200.0;
    sizeCompMin = 0.05;
    sizeCompMax = 0.15;
    scaleInY = 1.0;
} else if (type == stratusB) {
    smoothness = 0.1;
    nbPodMin = 100.0;
    nbPodMax = 200.0;
    sizeCompMin = 0.05;
    sizeCompMax = 0.15;
    scaleInY = 1.0;
} else if (type == stratusC) {
    smoothness = 1.0;
    nbPodMin = 20.0;
    nbPodMax = 50.0;
    sizeCompMin = 0.1;
    sizeCompMax = 0.8;
    scaleInY = 0.2;
}
// Create the noise
VecShort2D dim = VecShortCreateStatic2D();
VecSet(&dim, 0, 3); VecSet(&dim, 1, 1);
FracNoise* cloud = FracNoiseCreate(&dim, NULL);
// Create the cloud components
int nbPod = (int)floor(nbPodMin + rnd() * (nbPodMax - nbPodMin));
VecFloat3D seed = VecFloatCreateStatic3D();
Spheroid** bounds = malloc(nbPod * sizeof(Spheroid*));
VecFloat3D scaleIn = VecFloatCreateStatic3D();
VecFloat3D scaleBound = VecFloatCreateStatic3D();
PerlinNoisePod* pod = NULL;
for (int iPod = nbPod; iPod--;) {
    if (iPod == 0)
        pod = FracNoiseGetNoise(cloud, 0);
    else {
        for (int i = 3; i--;)
            VecSet(&seed, i, rnd());
        pod = FracNoiseAddNoise(cloud, &seed);
    }
    bounds[iPod] = SpheroidCreate(3);
    PerlinNoisePodSetBound(pod, bounds[iPod]);
    float border = borderMin + (borderMax - borderMin) * rnd();
    PerlinNoisePodSetBorder(pod, border);
    float s = sizeCompMin + (sizeCompMax - sizeCompMin) * rnd();
    for (int i = 3; i--;)
        VecSet(&scaleBound, i, s * (i == 1 ? scaleInY : 1.0));
    ShapoidScale(bounds[iPod], (VecFloat*)&scaleBound);
    for (int i = 3; i--;) {
        float x = s + (1.0 - 2.0 * s) * rnd();
        if (type != cumulusB && i == 1 && x < 0.5)
            x = 0.5 - pow(0.5 - x, 2.0);
        VecSet(ShapoidPos(bounds[iPod]), i, x);
    }
    float sIn = 20.0 + 40.0 * rnd();
    for (int i = 3; i--;)
        VecSet(&scaleIn, i, sIn);
    PerlinNoisePodSetScaleIn(pod, &scaleIn);
    PerlinNoisePodSetSmooth(pod, smoothness);
}
// Export to the df3 file
VecFloat3D range = VecFloatCreateStatic3D();
VecSet(&range, 0, 1.0); VecSet(&range, 1, 1.0);

```



```

VecSet(&range, 2, 1.0);
VecShort3D nbSample = VecShortCreateStatic3D();
VecSet(&nbSample, 0, 50); VecSet(&nbSample, 1, 50);
VecSet(&nbSample, 2, 50);
int res = 16;
if (FracNoiseExportDF3(cloud, &range, &nbSample, res, false,
    fileName) == false) {
    fprintf(stderr, "export to df3 failed\n");
}
// Free memory
FracNoiseFree(&cloud);
for (int iPod = nbPod; iPod--;)
    ShapoidFree(bounds + iPod);
free(bounds);
}

int main() {
    char* fileName = "./cloud.df3";

    MakeCloud(cumulusB, RANDOMSEED, fileName);

    system("make DF3");

    // Return success code
    return 0;
}

```

cloud.pov:

```

#include "colors.inc"

#declare _posCamera = <2.5,0.0,2.5>;
#declare _lookAt = <0.0,0.1,0.0>;

camera {
    location      _posCamera
    look_at      _lookAt
    right x
    up y * 3/5
}

light_source {
    <10.0, 10.0, 20.5>
    color rgb 1.0
}

background { color rgb <0.0, 0.0, 0.0> }

#declare boxinterior = interior {
    media {
        method 3
        samples 10,10
        emission <0.9, 0.9, 1>
        //emission <1.25, 1.25, 1.25> // cumulusB
        absorption <1.0, 1.0, 1.0>*2
        scattering {1, <1, 1, 1>*1 extinction 1.0 }
        density {
            density_file df3 "./cloud.df3"
            interpolate 1

```

```

    }
  }
}

#declare boxtexture = texture {
  pigment {
    rgbf 1
  }
}

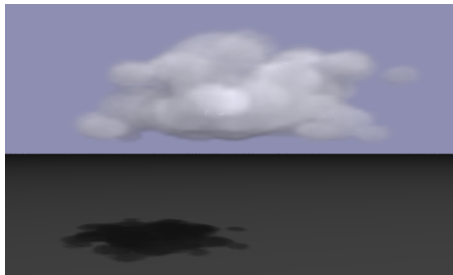
box {
  <0,0,0>, <1,1,1>
  texture { boxtexture }
  interior { boxinterior }
  hollow
  scale <2,1,2>
  translate <-0.5,-0.25,-0.5>
}

plane {
  y, -1.0
  pigment { color rgb 0.7 }
}

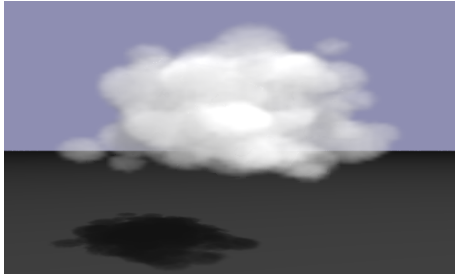
sphere {
  <0.0,0.0,0.0>, 1000.0
  pigment {color <0.8,0.8,1.0>}
  hollow
}

```

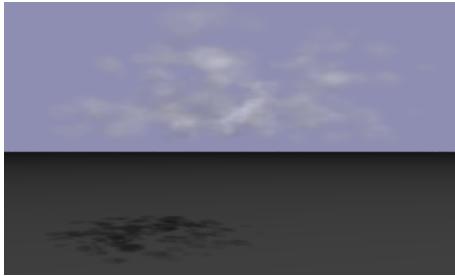
cumulusA.png:



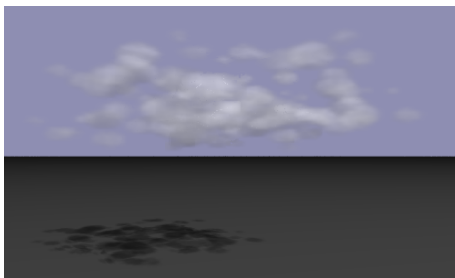
cumulusB.png:



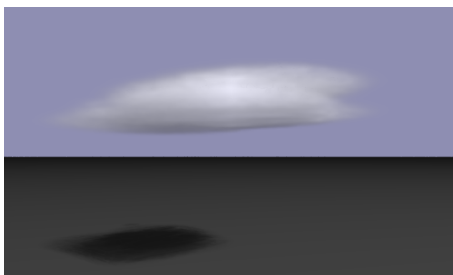
stratusA.png:



stratusB.png:



stratusC.png:



## 7.3 Rock

main.c:

```
#include <stdlib.h>
#include <stdio.h>
#include <time.h>
#include <string.h>
#include "fracnoise.h"
#include "genbrush.h"

#define RANDOMSEED 30

typedef enum {
    rockA
} typeRock;

void MakeRock(typeRock type, int rndSeed, char* fileName,
    VecFloat3D* radiusRock) {
    srand(rndSeed);
    // Parameters
    float fractCoeff = 0.1;
    float smooth = 0.5;
    float scaleInXZ = 3.0;
    float scaleInY = 5.0;
    float scaleOut = 0.3;
    if (type == rockA) {
        fractCoeff = 0.05 + 0.15 * rnd();
        smooth = 0.1 + 1.9 * rnd();
        scaleInXZ = 1.0 + 4.0 * rnd();
        scaleInY = 1.0 + 4.0 * rnd();
        scaleOut = 0.1 + 0.2 * rnd();
    }
    // Create the FracNoise for the rock
    VecShort2D dim = VecShortCreateStatic2D();
    VecSet(&dim, 0, 3); VecSet(&dim, 1, 3);
    VecFloat3D seed = VecFloatCreateStatic3D();
    for (int i = 3; i--;)
        VecSet(&seed, i, rnd());
    FracNoise* rock = FracNoiseCreate(&dim, &seed);
    PerlinNoisePod* pod = FracNoiseGetNoise(rock, 0);
    VecFloat3D scaleIn = VecFloatCreateStatic3D();
    for (int i = 3; i--;)
        VecSet(&scaleIn, i, (i == 1 ? scaleInY : scaleInXZ));
    PerlinNoisePodSetScaleIn(pod, &scaleIn);
}
```

```

VecFloat3D sOut = VecFloatCreateStatic3D();
for (int i = 3; i--;)
    VecSet(&sOut, i, scaleOut);
PerlinNoisePodSetScaleOut(pod, &sOut);
for (int i = 3; i--;)
    VecSet(&sOut, i, -0.5 * scaleOut);
PerlinNoisePodSetShiftOut(pod, &sOut);
PerlinNoisePodSetFractLvl(pod, 1);
PerlinNoisePodSetFractCoeff(pod, fractCoeff);
PerlinNoisePodSetSmooth(pod, smooth);
// Open the file to save the rock mesh
FILE* fileRock = fopen(fileName, "w");
// Print the head of the mesh
fprintf(fileRock, "#declare rock = mesh {\n");
// Loop on the polar coordinates
float theta = 0.0;
float phi = 0.0;
float delta = PBMMATH_TWOPI_DIV_360 * 1.0;
VecFloat3D pos = VecFloatCreateStatic3D();
float vtheta[4];
float vphi[4];
bool flagRow = true;
for (phi = 0.0; phi < PBMMATH_TWOPI; phi += delta) {
    for (theta = 0.0; theta < PBMMATH_PI; theta += delta) {
        // Calculate the polar coordinates of vertices
        if (flagRow) {
            vtheta[0] = theta - delta * 0.5;
            vtheta[1] = theta;
            vtheta[2] = theta + delta * 0.5;
            vtheta[3] = theta + delta;
        } else {
            vtheta[0] = theta;
            vtheta[1] = theta - delta * 0.5;
            vtheta[2] = theta + delta;
            vtheta[3] = theta + delta * 0.5;
        }
        vphi[0] = phi + delta;
        vphi[1] = phi;
        vphi[2] = phi + delta;
        vphi[3] = phi;
        // Calculate the coordinates of vertices and write the 2 triangles
        fprintf(fileRock, "triangle {");
        for (int iv = 3; iv--;) {
            VecSet(&pos, 0,
                VecGet(radiusRock, 0) * sin(vtheta[iv]) * cos(vphi[iv]));
            VecSet(&pos, 1,
                VecGet(radiusRock, 1) * cos(vtheta[iv]));
            VecSet(&pos, 2,
                VecGet(radiusRock, 2) * sin(vtheta[iv]) * sin(vphi[iv]));
            VecFloat* vert = FracNoiseGet(rock, &pos);
            VecOp(vert, 1.0, (VecFloat*)&pos, 1.0);
            VecFloatPrint(vert, fileRock, 5);
            if (iv != 0)
                fprintf(fileRock, ",");
            VecFree(&vert);
        }
        fprintf(fileRock, "}\n");
        fprintf(fileRock, "triangle {");
        for (int iv = 1; iv < 4; ++iv) {
            VecSet(&pos, 0,
                VecGet(radiusRock, 0) * sin(vtheta[iv]) * cos(vphi[iv]));
            VecSet(&pos, 1,

```

```

        VecGet(radiusRock, 1) * cos(vtheta[iv]));
    VecSet(&pos, 2,
        VecGet(radiusRock, 2) * sin(vtheta[iv]) * sin(vphi[iv]));
    VecFloat* vert = FracNoiseGet(rock, &pos);
    VecOp(vert, 1.0, (VecFloat*)&pos, 1.0);
    VecFloatPrint(vert, fileRock, 5);
    if (iv != 3)
        fprintf(fileRock, ",");
    VecFree(&vert);
}
fprintf(fileRock, "}\n");
}
flagRow = (flagRow ? false : true);
}
// Print the tail of the mesh
fprintf(fileRock, "};\n");
fclose(fileRock);
}

int main() {
    char* fileName = "./rock.inc";

    VecFloat3D radiusRock = VecFloatCreateStatic3D();
    VecSet(&radiusRock, 0, 1.0);
    VecSet(&radiusRock, 1, 0.5);
    VecSet(&radiusRock, 2, 1.0);
    MakeRock(rockA, RANDOMSEED, fileName, &radiusRock);

    system("make rock");

    // Return success code
    return 0;
}

```

rock.pov:

```

#include "colors.inc"
#include "rock.inc"

#declare _texNeutral = texture {
    pigment { color rgb <0.75, 0.75, 0.75> }
    finish { ambient 0.1 diffuse 0.6 phong 0.0}
}

#declare _posCamera = <3.0,0.0,3.0>;
#declare _lookAt = <0.0,0.0,0.0>;

camera {
    location      _posCamera
    look_at      _lookAt
    right x
    up y * 3/5
}

light_source {
    <10.0, 10.0, 20.5>
    color rgb 1.0
}

background { color rgb <1.0, 1.0, 1.0> }

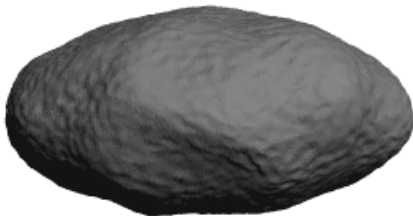
```

```
object {  
  rock  
  texture {_texNeutral}  
}
```

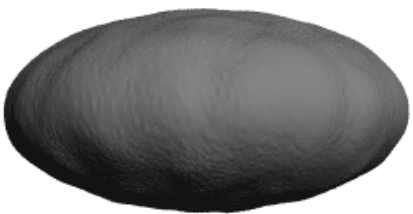
rock01.png:



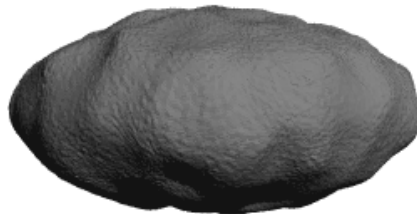
rock03.png:



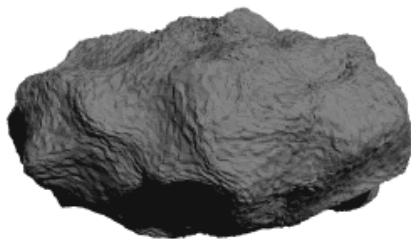
rock05.png:



rock06.png:



rock30.png:



rock50.png:

