GradAutomaton

P. Baillehache

March 22, 2020

Contents

Introduction

GradAutomaton is a C library providing structures and functions to manipulate cellular automaton based on Grad structures.

It currently implements the following cellular automaton:

- GradAutomatonWolframOriginal: Cellular automaton described page 53 of "A new kind of science" by S. Wolfram
- GradAutomatonNeuraNet: Cellular Automaton on GradSquare and GradHexa where the automaton function is a NeuraNet

It uses the `PBErr`, `Grad`, `NeuraNet` libraries.

1 Definitions

2 Interface

```
// ============ GRADAUTOMATON.H ================

#ifndef GRADAUTOMATON_H
#define GRADAUTOMATON_H

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

#include <stdlib.h>
#include <stdio.h>
#include <math.h>
#include <string.h>
#include <stdbool.h>
#include "pberr.h"
#include "pbmath.h"
#include "gset.h"
#include "grad.h"
#include "neuranet.h"

// -------------- GrACell

// ================= Define ==================

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

typedef struct GrACell {

  // Index of the current status of the cell
  unsigned char curStatus;

  // Pointer toward the supporting GradCell
  GradCell* gradCell;

} GrACell;

typedef struct GrACellShort {

  // Parent GrACell
  GrACell gradAutomatonCell;

  // Double buffered status of the cell
  VecShort* status[2];

} GrACellShort;

typedef struct GrACellFloat {

  // Parent GrACell
  GrACell gradAutomatonCell;

  // Double buffered status of the cell
  VecFloat* status[2];

} GrACellFloat;

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

```
// Create a new static GradAutomatonCell
GrACell GradAutomatonCellCreateStatic(
  GradCell* const gradCell);

// Create a new GrACellShort with a status vector of dimension 'dim'
// for the GradCell 'gradCell'
GrACellShort* GrACellCreateShort(
       const long dim,
  GradCell* const gradCell);

// Create a new GrACellFloat with a status vector of dimension 'dim'
// for the GradCell 'gradCell'
GrACellFloat* GrACellCreateFloat(
       const long dim,
  GradCell* const gradCell);

// Free the memory used by the GrACellShort 'that'
void _GrACellShortFree(GrACellShort** that);

// Free the memory used by the GrACellFloat 'that'
void _GrACellFloatFree(GrACellFloat** that);

// Switch the current status of the GrACell 'that'
#if BUILDMODE != 0
static inline
#endif
void _GrACellSwitchStatus(GrACell* const that);

// Return the current status of the GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
VecShort* _GrACellShortCurStatus(const GrACellShort* const that);

// Return the current status of the GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
VecFloat* _GrACellFloatCurStatus(const GrACellFloat* const that);

// Return the previous status of the GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
VecShort* _GrACellShortPrevStatus(const GrACellShort* const that);

// Return the previous status of the GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
VecFloat* _GrACellFloatPrevStatus(const GrACellFloat* const that);

// Return the 'iVal'-th value of the previous status of the
// GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
short _GrACellShortGetPrevStatus(
  const GrACellShort* const that,
        const unsigned long iVal);

// Return the 'iVal'-th value of the previous status of the
```

```
// GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
float _GrACellFloatGetPrevStatus(
  const GrACellFloat* const that,
        const unsigned long iVal);

// Set the 'iVal'-th value of the previous status of the
// GrACellShort 'that' to 'val'
#if BUILDMODE != 0
static inline
#endif
void _GrACellShortSetPrevStatus(
  const GrACellShort* const that,
        const unsigned long iVal,
                const short val);

// Set the 'iVal'-th value of the previous status of the
// GrACellFloat 'that' to 'val'
#if BUILDMODE != 0
static inline
#endif
void _GrACellFloatSetPrevStatus(
  const GrACellFloat* const that,
        const unsigned long iVal,
                const float val);

// Return the 'iVal'-th value of the current status of the
// GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
short _GrACellShortGetCurStatus(
  const GrACellShort* const that,
        const unsigned long iVal);

// Return the 'iVal'-th value of the current status of the
// GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
float _GrACellFloatGetCurStatus(
  const GrACellFloat* const that,
        const unsigned long iVal);

// Set the 'iVal'-th value of the current status of the
// GrACellShort 'that' to 'val'
#if BUILDMODE != 0
static inline
#endif
void _GrACellShortSetCurStatus(
  const GrACellShort* const that,
        const unsigned long iVal,
                const short val);

// Set the 'iVal'-th value of the current status of the
// GrACellFloat 'that' to 'val'
#if BUILDMODE != 0
static inline
#endif
void _GrACellFloatSetCurStatus(
```

```
  const GrACellFloat* const that,
        const unsigned long iVal,
                const float val);

// Return the GradCell of the GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
GradCell* _GrACellShortGradCell(const GrACellShort* const that);

// Return the GradCell of the GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
GradCell* _GrACellFloatGradCell(const GrACellFloat* const that);

// ================= Polymorphism ==================

#define GrACellFree(G) _Generic(G, \
  GrACellShort**: _GrACellShortFree, \
  GrACellFloat**: _GrACellFloatFree, \
  default: PBErrInvalidPolymorphism)(G)

#define GrACellSwitchStatus(G) _Generic(G, \
  GrACell*: _GrACellSwitchStatus, \
  GrACellShort*: _GrACellSwitchStatus, \
  GrACellFloat*: _GrACellSwitchStatus, \
  default: PBErrInvalidPolymorphism)((GrACell*)(G))

#define GrACellCurStatus(G) _Generic(G, \
  GrACellShort*: _GrACellShortCurStatus, \
  const GrACellShort*: _GrACellShortCurStatus, \
  GrACellFloat*: _GrACellFloatCurStatus, \
  const GrACellFloat*: _GrACellFloatCurStatus, \
  default: PBErrInvalidPolymorphism)(G)

#define GrACellPrevStatus(G) _Generic(G, \
  GrACellShort*: _GrACellShortPrevStatus, \
  const GrACellShort*: _GrACellShortPrevStatus, \
  GrACellFloat*: _GrACellFloatPrevStatus, \
  const GrACellFloat*: _GrACellFloatPrevStatus, \
  default: PBErrInvalidPolymorphism)(G)

#define GrACellGetCurStatus(G, I) _Generic(G, \
  GrACellShort*: _GrACellShortGetCurStatus, \
  const GrACellShort*: _GrACellShortGetCurStatus, \
  GrACellFloat*: _GrACellFloatGetCurStatus, \
  const GrACellFloat*: _GrACellFloatGetCurStatus, \
  default: PBErrInvalidPolymorphism)(G, I)

#define GrACellGetPrevStatus(G, I) _Generic(G, \
  GrACellShort*: _GrACellShortGetPrevStatus, \
  const GrACellShort*: _GrACellShortGetPrevStatus, \
  GrACellFloat*: _GrACellFloatGetPrevStatus, \
  const GrACellFloat*: _GrACellFloatGetPrevStatus, \
  default: PBErrInvalidPolymorphism)(G, I)

#define GrACellSetCurStatus(G, I, V) _Generic(G, \
  GrACellShort*: _GrACellShortSetCurStatus, \
  GrACellFloat*: _GrACellFloatSetCurStatus, \
  default: PBErrInvalidPolymorphism)(G, I, V)
```

```
#define GrACellSetPrevStatus(G, I, V) _Generic(G, \
  GrACellShort*: _GrACellShortSetPrevStatus, \
  GrACellFloat*: _GrACellFloatSetPrevStatus, \
  default: PBErrInvalidPolymorphism)(G, I, V)

#define GrACellGradCell(G) _Generic(G, \
  GrACellShort*: _GrACellShortGradCell, \
  const GrACellShort*: _GrACellShortGradCell, \
  GrACellFloat*: _GrACellFloatGradCell, \
  const GrACellFloat*: _GrACellFloatGradCell, \
  default: PBErrInvalidPolymorphism)(G)

// -------------- GrAFun

// ================= Define ==================

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

typedef enum GrAFunType {

  GrAFunTypeDummy,
  GrAFunTypeWolframOriginal,
  GrAFunTypeNeuraNet

} GrAFunType;

typedef struct GrAFun {

  // Type of GrAFun
  GrAFunType type;

} GrAFun;

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

// Create a static GrAFun with type 'type'
GrAFun GrAFunCreateStatic(const GrAFunType type);

// Free the memory used by the GrAFun 'that'
void _GrAFunFreeStatic(GrAFun* that);

// Return the type of the GrAFun 'that'
#if BUILDMODE != 0
static inline
#endif
GrAFunType _GrAFunGetType(const GrAFun* const that);

// -------------- GrAFunDummy

// ================= Define ==================

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

typedef struct GrAFunDummy {

  // GrAFun
  GrAFun grAFun;

} GrAFunDummy;

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

```
// Create a new GrAFunDummy
GrAFunDummy* GrAFunCreateDummy(void);

// Free the memory used by the GrAFunDummy 'that'
void _GrAFunDummyFree(GrAFunDummy** that);

// -------------- GrAFunWolframOriginal

// ================= Define ==================

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

typedef struct GrAFunWolframOriginal {

  // GrAFun
  GrAFun grAFun;

  // Rule, cf "A new kind of science" p.53
  unsigned char rule;

} GrAFunWolframOriginal;

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

// Create a new GrAFunWolframOriginal
GrAFunWolframOriginal* GrAFunCreateWolframOriginal(
  const unsigned char rule);

// Free the memory used by the GrAFunWolframOriginal 'that'
void _GrAFunWolframOriginalFree(GrAFunWolframOriginal** that);

// Return the rule of the GrAFunWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
unsigned char GrAFunWolframOriginalGetRule(
  GrAFunWolframOriginal* const that);

// Apply the step function for the GrAFunWolframOriginal 'that'
// to the GrACellShort 'cell' in the GradSquare 'grad'
void _GrAFunWolframOriginalApply(
  GrAFunWolframOriginal* const that,
            GradSquare* const grad,
          GrACellShort* const cell);

// -------------- GrAFunNeuraNet

// ================= Define ==================

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

typedef struct GrAFunNeuraNet {

  // GrAFun
  GrAFun grAFun;

  // NeuraNet applied to the cells
  NeuraNet* nn;

} GrAFunNeuraNet;

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

```
// Create a new GrAFunNeuraNet
GrAFunNeuraNet* GrAFunCreateNeuraNet(
  NeuraNet* const nn);

// Free the memory used by the GrAFunNeuraNet 'that'
void _GrAFunNeuraNetFree(GrAFunNeuraNet** that);

// Return the NeuraNet of the GrAFunNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
NeuraNet* GrAFunNeuraNetNN(
  GrAFunNeuraNet* const that);

// Apply the step function for the GrAFunNeuraNet 'that'
// to the GrACellShort 'cell' in the GradSquare 'grad'
void _GrAFunNeuraNetApply(
  GrAFunNeuraNet* const that,
            Grad* const grad,
    GrACellFloat* const cell);

// ================= Polymorphism ==================

#define GrAFunFree(G) _Generic(G, \
  GrAFun*: _GrAFunFreeStatic, \
  GrAFunDummy**: _GrAFunDummyFree, \
  GrAFunWolframOriginal**: _GrAFunWolframOriginalFree, \
  GrAFunNeuraNet**: _GrAFunNeuraNetFree, \
  default: PBErrInvalidPolymorphism)(G)

#define GrAFunGetType(G) _Generic(G, \
  GrAFun*: _GrAFunGetType, \
  const GrAFun*: _GrAFunGetType, \
  GrAFunDummy*: _GrAFunGetType, \
  const GrAFunDummy*: _GrAFunGetType, \
  GrAFunWolframOriginal*: _GrAFunGetType, \
  const GrAFunWolframOriginal*: _GrAFunGetType, \
  GrAFunNeuraNet*: _GrAFunGetType, \
  const GrAFunNeuraNet*: _GrAFunGetType, \
  default: PBErrInvalidPolymorphism)((const GrAFun*)(G))

#define GrAFunApply(F, G, C) _Generic(F, \
  GrAFunWolframOriginal*: _GrAFunWolframOriginalApply, \
  GrAFunNeuraNet*: _GrAFunNeuraNetApply, \
  default: PBErrInvalidPolymorphism)(F, G, C)

// -------------- GradAutomaton

// ================= Define ==================

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

typedef enum GradAutomatonType {

  GradAutomatonTypeDummy,
  GradAutomatonTypeWolframOriginal,
  GradAutomatonTypeNeuraNet

} GradAutomatonType;

typedef struct GradAutomaton {
```

```
  // Type of the GradAutomaton
  GradAutomatonType type;

  // Dimension of the status vector of each cell
  long dim;

  // Grad
  Grad* grad;

  // GrAFun
  GrAFun* fun;

} GradAutomaton;

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

// Create a new static GradAutomaton
GradAutomaton GradAutomatonCreateStatic(
  const GradAutomatonType type,
              Grad* const grad,
            GrAFun* const fun);

// Return the Grad of the GradAutomaton 'that'
#if BUILDMODE != 0
static inline
#endif
Grad* _GradAutomatonGrad(GradAutomaton* const that);

// Return the GrACellShort at position 'pos' for the
// GradAutomaton 'that'
#if BUILDMODE != 0
static inline
#endif
GrACell* _GradAutomatonCellPos(
     GradAutomaton* const that,
  const VecShort2D* const pos);

// Return the GrACellShort at index 'iCell' for the GradAutomaton 'that'
#if BUILDMODE != 0
static inline
#endif
GrACell* _GradAutomatonCellIndex(
  GradAutomaton* const that,
            const long iCell);

// Switch the status of all the cells of the GradAutomaton 'that'
void _GradAutomatonSwitchAllStatus(GradAutomaton* const that);

// -------------- GradAutomatonDummy

// ================= Define ==================

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

// GradSquare (2x2, no diag), GraFunDummy, GrACellShort dimension 1
typedef struct GradAutomatonDummy {

  // Parent GradAutomaton
  GradAutomaton gradAutomaton;

} GradAutomatonDummy;
```

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

// Create a new static GradAutomaton
GradAutomaton GradAutomatonCreateStatic(
  const GradAutomatonType type,
              Grad* const grad,
            GrAFun* const fun);

// Create a new GradAutomatonDummy
GradAutomatonDummy* GradAutomatonCreateDummy();

// Free the memory used by the GradAutomatonDummy 'that'
void GradAutomatonDummyFree(GradAutomatonDummy** that);

// Step the GradAutomatonDummy
void _GradAutomatonDummyStep(GradAutomatonDummy* const that);

// Return the Grad of the GradAutomatonDummy 'that'
#if BUILDMODE != 0
static inline
#endif
GradSquare* _GradAutomatonDummyGrad(GradAutomatonDummy* const that);

// Return the GrAFun of the GradAutomatonDummy 'that'
#if BUILDMODE != 0
static inline
#endif
GrAFunDummy* _GradAutomatonDummyFun(GradAutomatonDummy* const that);

// Return the GrACellShort at position 'pos' for the
// GradAutomatonDummy 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellShort* _GradAutomatonDummyCellPos(
  GradAutomatonDummy* const that,
    const VecShort2D* const pos);

// Return the GrACellShort at index 'iCell' for the GradAutomatonDummy 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellShort* _GradAutomatonDummyCellIndex(
  GradAutomatonDummy* const that,
                const long iCell);

// -------------- GradAutomatonWorlframOriginal

// ================= Define ==================

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

// GradSquare (Nx1, no diag), GraFunWolframOriginal, GrACellShort dimension 1
typedef struct GradAutomatonWolframOriginal {

  // Parent GradAutomaton
  GradAutomaton gradAutomaton;

} GradAutomatonWolframOriginal;

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

```
// Create a new GradAutomatonWolframOriginal
GradAutomatonWolframOriginal* GradAutomatonCreateWolframOriginal(
  const unsigned char rule,
          const long size);

// Free the memory used by the GradAutomatonWolframOriginal 'that'
void GradAutomatonWolframOriginalFree(
  GradAutomatonWolframOriginal** that);

// Step the GradAutomatonWolframOriginal
void _GradAutomatonWolframOriginalStep(
  GradAutomatonWolframOriginal* const that);

// Return the Grad of the GradAutomatonWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
GradSquare* _GradAutomatonWolframOriginalGrad(
  GradAutomatonWolframOriginal* const that);

// Return the GrAFun of the GradAutomatonWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
GrAFunWolframOriginal* _GradAutomatonWolframOriginalFun(
  GradAutomatonWolframOriginal* const that);

// Return the GrACellShort at position 'pos' for the
// GradAutomatonWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellShort* _GradAutomatonWolframOriginalCellPos(
  GradAutomatonWolframOriginal* const that,
              const VecShort2D* const pos);

// Return the GrACellShort at index 'iCell' for the
// GradAutomatonWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellShort* _GradAutomatonWolframOriginalCellIndex(
  GradAutomatonWolframOriginal* const that,
                           const long iCell);

// Print the GradAutomatonWolframOriginal 'that' on the FILE 'stream'
void _GradAutomatonWolframOriginalPrintln(
  GradAutomatonWolframOriginal* const that,
                                FILE* stream);

// -------------- GradAutomatonNeuraNet

// ================= Define ==================

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

// GradSquare/GradHexa, GraFunNeuraNet, GrACellFloat
typedef struct GradAutomatonNeuraNet {

  // Parent GradAutomaton
  GradAutomaton gradAutomaton;
```

```
} GradAutomatonNeuraNet;

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

// Create a new GradAutomatonNeuraNet with a GradSquare
GradAutomatonNeuraNet* GradAutomatonCreateNeuraNetSquare(
               const long dimStatus,
  const VecShort2D* const dimGrad,
               const bool diagLink,
         NeuraNet* const nn);

// Create a new GradAutomatonNeuraNet with a GradHexa
GradAutomatonNeuraNet* GradAutomatonCreateNeuraNetHexa(
               const long dimStatus,
  const VecShort2D* const dimGrad,
       const GradHexaType gradType,
         NeuraNet* const nn);

// Free the memory used by the GradAutomatonNeuraNet 'that'
void GradAutomatonNeuraNetFree(
  GradAutomatonNeuraNet** that);

// Step the GradAutomatonNeuraNet
void _GradAutomatonNeuraNetStep(GradAutomatonNeuraNet* const that);

// Return the Grad of the GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
Grad* _GradAutomatonNeuraNetGrad(GradAutomatonNeuraNet* const that);

// Return the type of Grad of the GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
GradType GradAutomatonNeuraNetGetGradType(
  GradAutomatonNeuraNet* const that);

// Return the GrAFun of the GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
GrAFunNeuraNet* _GradAutomatonNeuraNetFun(
  GradAutomatonNeuraNet* const that);

// Return the GrACellFloat at position 'pos' for the
// GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellFloat* _GradAutomatonNeuraNetCellPos(
  GradAutomatonNeuraNet* const that,
       const VecShort2D* const pos);

// Return the GrACellFloat at index 'iCell' for the
// GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellFloat* _GradAutomatonNeuraNetCellIndex(
  GradAutomatonNeuraNet* const that,
```

```
                    const long iCell);

// ================ Polymorphism ==================

#define GradAutomatonSwitchAllStatus(G) _Generic(G, \
  GradAutomaton* : _GradAutomatonSwitchAllStatus, \
  GradAutomatonDummy* : _GradAutomatonSwitchAllStatus, \
  GradAutomatonWolframOriginal* : _GradAutomatonSwitchAllStatus, \
  GradAutomatonNeuraNet* : _GradAutomatonSwitchAllStatus, \
  default: PBErrInvalidPolymorphism)((GradAutomaton*)(G))

#define GradAutomatonStep(G) _Generic(G, \
  GradAutomatonDummy* : _GradAutomatonDummyStep, \
  GradAutomatonWolframOriginal* : _GradAutomatonWolframOriginalStep, \
  GradAutomatonNeuraNet* : _GradAutomatonNeuraNetStep, \
  default: PBErrInvalidPolymorphism)(G)

#define GradAutomatonGrad(G) _Generic(G, \
  GradAutomaton* : _GradAutomatonGrad, \
  GradAutomatonDummy* : _GradAutomatonDummyGrad, \
  GradAutomatonWolframOriginal* : _GradAutomatonWolframOriginalGrad, \
  GradAutomatonNeuraNet* : _GradAutomatonNeuraNetGrad, \
  default: PBErrInvalidPolymorphism)(G)

#define GradAutomatonFun(G) _Generic(G, \
  GradAutomatonDummy* : _GradAutomatonDummyFun, \
  GradAutomatonWolframOriginal* : _GradAutomatonWolframOriginalFun, \
  GradAutomatonNeuraNet* : _GradAutomatonNeuraNetFun, \
  default: PBErrInvalidPolymorphism)(G)

#define GradAutomatonCell(G, P) _Generic(G, \
  GradAutomaton* : _Generic(P, \
    VecShort2D*: _GradAutomatonCellPos, \
    const VecShort2D*: _GradAutomatonCellPos, \
    long: _GradAutomatonCellIndex, \
    const long: _GradAutomatonCellIndex, \
    default: PBErrInvalidPolymorphism), \
  GradAutomatonDummy* : _Generic(P, \
    VecShort2D*: _GradAutomatonDummyCellPos, \
    const VecShort2D*: _GradAutomatonDummyCellPos, \
    long: _GradAutomatonDummyCellIndex, \
    const long: _GradAutomatonDummyCellIndex, \
    default: PBErrInvalidPolymorphism), \
  GradAutomatonWolframOriginal* : _Generic(P, \
    VecShort2D*: _GradAutomatonWolframOriginalCellPos, \
    const VecShort2D*: _GradAutomatonWolframOriginalCellPos, \
    long: _GradAutomatonWolframOriginalCellIndex, \
    const long: _GradAutomatonWolframOriginalCellIndex, \
    default: PBErrInvalidPolymorphism), \
  GradAutomatonNeuraNet* : _Generic(P, \
    VecShort2D*: _GradAutomatonNeuraNetCellPos, \
    const VecShort2D*: _GradAutomatonNeuraNetCellPos, \
    long: _GradAutomatonNeuraNetCellIndex, \
    const long: _GradAutomatonNeuraNetCellIndex, \
    default: PBErrInvalidPolymorphism), \
  default: PBErrInvalidPolymorphism)(G, P)

#define GradAutomatonPrintln(G, S) _Generic(G, \
  GradAutomatonWolframOriginal* : \
    _GradAutomatonWolframOriginalPrintln, \
  const GradAutomatonWolframOriginal* :\
    _GradAutomatonWolframOriginalPrintln, \
```

```
  default: PBErrInvalidPolymorphism)(G, S)

// ================ static inliner ====================

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

#endif
```

3 Code

3.1 gradautomaton.c

```
// ============ GRADAUTOMATON.C ================

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

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

// -------------- GrACell

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

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

// Create a new static GrACell
GrACell GradAutomatonCellCreateStatic(
  GradCell* const gradCell) {

  // Create the new GradAutomatonCell
  GrACell cell;

  // Set the properties
  cell.curStatus = 0;
  cell.gradCell = gradCell;

  // Return the new GradAutomatonCell
  return cell;

}

// Create a new GrACellShort with a status vector of dimension 'dim'
// for the GradCell 'gradCell'
GrACellShort* GrACellCreateShort(
       const long dim,
  GradCell* const gradCell) {

  // Allocate memory
  GrACellShort* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GrACellShort));

  // Initialise properties
```

```
  that->status[0] = VecShortCreate(dim);
  that->status[1] = VecShortCreate(dim);
  that->gradAutomatonCell = GradAutomatonCellCreateStatic(gradCell);

  // Return the new GrACellShort
  return that;

}

// Create a new GrACellFloat with a status vector of dimension 'dim'
// for the GradCell 'gradCell'
GrACellFloat* GrACellCreateFloat(
       const long dim,
  GradCell* const gradCell) {

  // Allocate memory
  GrACellFloat* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GrACellFloat));

  // Initialise properties
  that->status[0] = VecFloatCreate(dim);
  that->status[1] = VecFloatCreate(dim);
  that->gradAutomatonCell = GradAutomatonCellCreateStatic(gradCell);

  // Return the new GrACellFloat
  return that;

}

// Free the memory used by the GrACellShort 'that'
void _GrACellShortFree(GrACellShort** that) {

  // If that is null
  if (that == NULL || *that == NULL) {

    // Do nothing
    return;

  }

  // Free memory
  VecFree(&((*that)->status[0]));
  VecFree(&((*that)->status[1]));
  free(*that);
  *that = NULL;

}

// Free the memory used by the GrACellFloat 'that'
void _GrACellFloatFree(GrACellFloat** that) {

  // If that is null
  if (that == NULL || *that == NULL) {

    // Do nothing
    return;

  }

  // Free memory
```

```
  VecFree(&((*that)->status[0]));
  VecFree(&((*that)->status[1]));
  free(*that);
  *that = NULL;

}

// -------------- GrAFun

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

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

// Create a static GrAFun with type 'type'
GrAFun GrAFunCreateStatic(const GrAFunType type) {

  // Declare the new GrAFun
  GrAFun that;

  // Set properties
  that.type = type;

  // Return the new GrAFun
  return that;

}

// Free the memory used by the GrAFun 'that'
void _GrAFunFreeStatic(GrAFun* that) {

  // If that is null
  if (that == NULL) {

    // Do nothing
    return;

  }

}

// -------------- GrAFunDummy

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

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

// Create a new GrAFunDummy
GrAFunDummy* GrAFunCreateDummy(void) {

  // Declare the new GrAFun
  GrAFunDummy* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GrAFunDummy));

  // Set properties
  that->grAFun = GrAFunCreateStatic(GrAFunTypeDummy);

  // Return the new GrAFun
  return that;

}
```

```
// Free the memory used by the GrAFunDummy 'that'
void _GrAFunDummyFree(GrAFunDummy** that) {

  // If that is null
  if (that == NULL || *that == NULL) {

    // Do nothing
    return;

  }

  // Free memory
  _GrAFunFreeStatic((GrAFun*)(*that));
  free(*that);
  *that = NULL;

}

// -------------- GrAFunWolframOriginal

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

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

// Create a new GrAFunWolframOriginal
GrAFunWolframOriginal* GrAFunCreateWolframOriginal(
  const unsigned char rule) {

  // Declare the new GrAFun
  GrAFunWolframOriginal* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GrAFunWolframOriginal));

  // Set properties
  that->grAFun = GrAFunCreateStatic(GrAFunTypeWolframOriginal);
  that->rule = rule;

  // Return the new GrAFun
  return that;

}

// Free the memory used by the GrAFunWolframOriginal 'that'
void _GrAFunWolframOriginalFree(GrAFunWolframOriginal** that) {

  // If that is null
  if (that == NULL || *that == NULL) {

    // Do nothing
    return;

  }

  // Free memory
  _GrAFunFreeStatic((GrAFun*)(*that));
  free(*that);
  *that = NULL;

}
```

```
// Apply the step function for the GrAFunWolframOriginal 'that'
// to the GrACellShort 'cell' in the GradSquare 'grad'
void _GrAFunWolframOriginalApply(
  GrAFunWolframOriginal* const that,
             GradSquare* const grad,
           GrACellShort* const cell) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (grad == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'grad' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (cell == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'cell' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Declare a variable to memorize the current status of the
  // cell and its neighbour
  short status[3] = {0, 0, 0};

  // Get the current status of the left cell
  long leftLink =
    GradCellGetLink(
      GrACellGradCell(cell),
      GradSquareDirW);
  if (leftLink != -1) {

    GradCell* leftNeighbour =
      GradCellNeighbour(
        grad,
        GrACellGradCell(cell),
        GradSquareDirW);
    GrACellShort* leftCell =
      (GrACellShort*)GradCellData(leftNeighbour);
    status[0] =
      VecGet(
        GrACellCurStatus(leftCell),
        0);
```

```
  }

  // Get the current status of the cell
  status[1] =
    VecGet(
      GrACellCurStatus(cell),
      0);

  // Get the current status of the right cell
  long rightLink =
    GradCellGetLink(
      GrACellGradCell(cell),
      GradSquareDirE);
  if (rightLink != -1) {

    GradCell* rightNeighbour =
      GradCellNeighbour(
        grad,
        GrACellGradCell(cell),
        GradSquareDirE);
    GrACellShort* rightCell =
      (GrACellShort*)GradCellData(rightNeighbour);
    status[2] =
      VecGet(
        GrACellCurStatus(rightCell),
        0);

  }

  // Get the corresponding mask in the rule
  unsigned char mask =
    powi(
      2,
      ((status[0] * 2) + status[1]) * 2 + status[2]);

  // Get the new status of the cell
  short newStatus = 0;
  if (GrAFunWolframOriginalGetRule(that) & mask) {

    newStatus = 1;

  }

  // Update the previous status with the new status
  // (it will be switch later)
  GrACellSetPrevStatus(
    cell,
    0,
    newStatus);

}

// -------------- GrAFunNeuraNet

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

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

// Create a new GrAFunNeuraNet
GrAFunNeuraNet* GrAFunCreateNeuraNet(
  NeuraNet* const nn) {
```

```
  // Declare the new GrAFun
  GrAFunNeuraNet* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GrAFunNeuraNet));

  // Set properties
  that->grAFun = GrAFunCreateStatic(GrAFunTypeNeuraNet);
  that->nn = nn;

  // Return the new GrAFun
  return that;

}

// Free the memory used by the GrAFunNeuraNet 'that'
void _GrAFunNeuraNetFree(GrAFunNeuraNet** that) {

  // If that is null
  if (that == NULL || *that == NULL) {

    // Do nothing
    return;

  }

  // Free memory
  _GrAFunFreeStatic((GrAFun*)(*that));
  free(*that);
  *that = NULL;

}

// Apply the step function for the GrAFunNeuraNet 'that'
// to the GrACellShort 'cell' in the GradSquare 'grad'
void _GrAFunNeuraNetApply(
  GrAFunNeuraNet* const that,
            Grad* const grad,
    GrACellFloat* const cell) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (grad == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'grad' is null");
    PBErrCatch(GradAutomatonErr);

  }
```

```
  if (cell == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'cell' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the number of links of the cell
  int nbLinks = GradCellGetNbLink(GrACellGradCell(cell));

  // Get the dimension of the input vector for the NeuraNet
  long dimInput = (nbLinks + 1) * VecGetDim(GrACellCurStatus(cell));

  // Declare a variable to memorize the input of the NeuraNet
  VecFloat* input = VecFloatCreate(dimInput);

  // Declare a variable to memorize the output of the NeuraNet
  VecFloat* output = VecFloatCreate(VecGetDim(GrACellCurStatus(cell)));

  // Set the current status of the cell in the input vector
  for (
    long iDim = VecGetDim(output);
    iDim--;) {

    float val =
      GrACellGetCurStatus(
        cell,
        iDim);

    VecSet(
      input,
      iDim,
      val);

  }

  // Loop on the links toward neighbour cells
  for (
    long iLink = nbLinks;
    iLink--;) {

    // Get the link
    long link =
      GradCellGetLink(
        GrACellGradCell(cell),
        iLink);

    // If the link is active
    if (link != -1) {

      // Get the neighbour cell and its status
      GradCell* neighbour =
        GradCellNeighbour(
          grad,
          GrACellGradCell(cell),
          iLink);
      GrACellFloat* neighbourCell =
```

```
        (GrACellFloat*)GradCellData(neighbour);

      // Set the current status of the neighbour cell in the
      // input vector
      for (
        long iDim = VecGetDim(output);
        iDim--;) {

        float val =
          GrACellGetCurStatus(
            neighbourCell,
            iDim);

        VecSet(
          input,
          (link + 1) * VecGetDim(output) + iDim,
          val);

      }

    }

  }

  // Apply the NeuraNet
  NNEval(
    GrAFunNeuraNetNN(that),
    input,
    output);

  // Update the previous status with the output of the NeuraNet
  // (it will be switch later)
  for (
    long iDim = VecGetDim(output);
    iDim--;) {

    float val =
      VecGet(
        output,
        iDim);

    GrACellSetPrevStatus(
      cell,
      iDim,
      val);

  }

  // Free memory
  VecFree(&input);
  VecFree(&output);

}

// ------------- GradAutomaton

// Create a new static GradAutomaton
GradAutomaton GradAutomatonCreateStatic(
  const GradAutomatonType type,
              Grad* const grad,
            GrAFun* const fun) {
```

```
#if BUILDMODE == 0
  if (grad == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'grad' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (fun == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'fun' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Declare the new GradAutomaton
  GradAutomaton that;

  // Set the properties
  that.type = type;
  that.grad = grad;
  that.fun = fun;

  // Return the new GradAutomaton
  return that;

}

// Switch the status of all the cells of the GradAutomaton 'that'
void _GradAutomatonSwitchAllStatus(GradAutomaton* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the number of cells in the grad
  long nbCell = GradGetArea(GradAutomatonGrad(that));

  // Loop on the cell
  for (
    long iCell = nbCell;
    iCell--;) {

    // Get the cell
    GrACell* cell =
```

```
      GradAutomatonCell(
        that,
        iCell);

    // Switch the status of the cell
    GrACellSwitchStatus(cell);

  }

}

// ------------- GradAutomatonDummy

// Create a new GradAutomatonDummy
GradAutomatonDummy* GradAutomatonCreateDummy() {

  // Allocate memory for the new GradAutomatonDummy
  GradAutomatonDummy* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GradAutomatonDummy));

  // Create the associated Grad and GrAFun
  bool diagLink = false;
  VecShort2D dim = VecShortCreateStatic2D();
  VecSet(
    &dim,
    0,
    2);
  VecSet(
    &dim,
    1,
    2);
  Grad* grad =
    (Grad*)GradSquareCreate(
      &dim,
      diagLink);
  GrAFun* fun = (GrAFun*)GrAFunCreateDummy();

  // Initialize the properties
  that->gradAutomaton =
    GradAutomatonCreateStatic(
      GradAutomatonTypeDummy,
      grad,
      fun);

  // Add a GrACell to each cell of the Grad
  VecShort2D pos = VecShortCreateStatic2D();
  bool flag = true;
  do {

    GradCell* cell =
      GradCellAt(
        grad,
        &pos);

    long dimStatus = 1;
    GrACellShort* cellStatus =
      GrACellCreateShort(
        dimStatus,
        cell);
```

```
    GradCellSetData(
      cell,
      cellStatus);

    flag =
      VecStep(
        &pos,
        &dim);

  } while(flag);

  // Return the new GradAutomatonDummy
  return that;

}

// Free the memory used by the GradAutomatonDummy 'that'
void GradAutomatonDummyFree(GradAutomatonDummy** that) {

  // If that is null
  if (that == NULL || *that == NULL) {

    // Do nothing
    return;

  }

  // Free the GrACell attached to the cells of the Grad
  VecShort2D pos = VecShortCreateStatic2D();
  bool flag = true;
  do {

    GradCell* cell =
      GradCellAt(
        GradAutomatonGrad(*that),
        &pos);

    GrACellShort* cellStatus = GradCellData(cell);

    GrACellFree(&cellStatus);

    flag =
      VecStep(
        &pos,
        GradDim(GradAutomatonGrad(*that)));

  } while(flag);

  // Free memory
  GradSquareFree((GradSquare**)&((*that)->gradAutomaton.grad));
  _GrAFunDummyFree((GrAFunDummy**)&((*that)->gradAutomaton.fun));
  free(*that);
  *that = NULL;

}

// Step the GradAutomatonDummyStep
void _GradAutomatonDummyStep(GradAutomatonDummy* const that) {

#if BUILDMODE == 0
  if (that == NULL) {
```

```
    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  (void)that;

}

// ------------- GradAutomatonWolframOriginal

// Create a new GradAutomatonWolframOriginal
GradAutomatonWolframOriginal* GradAutomatonCreateWolframOriginal(
  const unsigned char rule,
           const long size) {

  // Allocate memory for the new GradAutomatonWolframOriginal
  GradAutomatonWolframOriginal* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GradAutomatonWolframOriginal));

  // Create the associated Grad and GrAFun
  bool diagLink = false;
  VecShort2D dim = VecShortCreateStatic2D();
  VecSet(
    &dim,
    0,
    size);
  VecSet(
    &dim,
    1,
    1);
  Grad* grad =
    (Grad*)GradSquareCreate(
      &dim,
      diagLink);
  GrAFun* fun = (GrAFun*)GrAFunCreateWolframOriginal(rule);

  // Initialize the properties
  that->gradAutomaton =
    GradAutomatonCreateStatic(
      GradAutomatonTypeWolframOriginal,
      grad,
      fun);

  // Get the index of the cell in th center of the Grad
  long iCellCenter = size / 2;

  // Add a GrACell to each cell of the Grad
  for (
    long iCell = size;
    iCell--;) {

    GradCell* cell =
      GradCellAt(
        grad,
```

```
        iCell);

    long dimStatus = 1;
    GrACellShort* cellStatus =
      GrACellCreateShort(
        dimStatus,
        cell);

    // If it's the cell in the center of the Grad
    if (iCell == iCellCenter) {

      // Initialise the cell value to 1
      long iStatus = 0;
      short val = 1;
      GrACellSetPrevStatus(
        cellStatus,
        iStatus,
        val);
      GrACellSetCurStatus(
        cellStatus,
        iStatus,
        val);

    }

    GradCellSetData(
      cell,
      cellStatus);

  };

  // Return the new GradAutomatonWolframOriginal
  return that;

}

// Free the memory used by the GradAutomatonWolframOriginal 'that'
void GradAutomatonWolframOriginalFree(
  GradAutomatonWolframOriginal** that) {

  // If that is null
  if (that == NULL || *that == NULL) {

    // Do nothing
    return;

  }

  // Get the number of cells in the grad
  long nbCell = GradGetArea(GradAutomatonGrad(*that));

  // Free the GrACell attached to the cells of the Grad
  for (
    long iCell = nbCell;
    iCell--;) {

    GradCell* cell =
      GradCellAt(
        GradAutomatonGrad(*that),
        iCell);

    GrACellShort* cellStatus = GradCellData(cell);
```

```
    GrACellFree(&cellStatus);

  }

  // Free memory
  GradSquareFree((GradSquare**)&((*that)->gradAutomaton.grad));
  _GrAFunWolframOriginalFree(
    (GrAFunWolframOriginal**)&((*that)->gradAutomaton.fun));
  free(*that);
  *that = NULL;

}

// Step the GradAutomatonWolframOriginalStep
void _GradAutomatonWolframOriginalStep(
  GradAutomatonWolframOriginal* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the number of cells in the grad
  long nbCell = GradGetArea(GradAutomatonGrad(that));

  // Loop on the cell
  for (
    long iCell = nbCell;
    iCell--;) {

    // Get the cell
    GrACellShort* cell =
      GradAutomatonCell(
        that,
        iCell);

    // Apply the step function to the cell
    GrAFunApply(
      GradAutomatonFun(that),
      GradAutomatonGrad(that),
      cell);

  }

  // Switch all the cells
  GradAutomatonSwitchAllStatus(that);

}

// Print the GradAutomatonWolframOriginal 'that' on the FILE 'stream'
void _GradAutomatonWolframOriginalPrintln(
  GradAutomatonWolframOriginal* const that,
                                FILE* stream) {
```

```
#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (stream == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'stream' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the number of cells in the grad
  long nbCell = GradGetArea(GradAutomatonGrad(that));

  fprintf(
    stream,
    "[");

  // Loop on the cell
  for (
    long iCell = 0;
    iCell < nbCell;
    ++iCell) {

    // Get the cell
    GrACellShort* cell =
      GradAutomatonCell(
        that,
        iCell);

    // Get the current status of the cell
    short status =
      VecGet(
        GrACellCurStatus(cell),
        0);

    // Print the status
    if (status == 0) {

      fprintf(
        stream,
        " ");

    } else {

      fprintf(
        stream,
        "*");
```

```
    }

  }

  fprintf(
    stream,
    "]\n");

}

// ------------- GradAutomatonNeuraNet

// Create a new GradAutomatonNeuraNet with a GradSquare
GradAutomatonNeuraNet* GradAutomatonCreateNeuraNetSquare(
               const long dimStatus,
  const VecShort2D* const dimGrad,
               const bool diagLink,
         NeuraNet* const nn) {

  // Allocate memory for the new GradAutomatonNeuraNet
  GradAutomatonNeuraNet* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GradAutomatonNeuraNet));

  // Create the associated Grad and GrAFun
  Grad* grad =
    (Grad*)GradSquareCreate(
      dimGrad,
      diagLink);
  GrAFun* fun = (GrAFun*)GrAFunCreateNeuraNet(nn);

  // Initialize the properties
  that->gradAutomaton =
    GradAutomatonCreateStatic(
      GradAutomatonTypeNeuraNet,
      grad,
      fun);

  // Add a GrACell to each cell of the Grad
  long area = GradGetArea(GradAutomatonGrad(that));
  for (
    long iCell = area;
    iCell--;) {

    GradCell* cell =
      GradCellAt(
        grad,
        iCell);

    GrACellFloat* cellStatus =
      GrACellCreateFloat(
        dimStatus,
        cell);

    GradCellSetData(
      cell,
      cellStatus);

  }

  // Return the new GradAutomatonNeuraNet
```

```
  return that;

}

// Create a new GradAutomatonNeuraNet with a GradHexa
GradAutomatonNeuraNet* GradAutomatonCreateNeuraNetHexa(
               const long dimStatus,
  const VecShort2D* const dimGrad,
       const GradHexaType gradType,
          NeuraNet* const nn) {

  // Allocate memory for the new GradAutomatonNeuraNet
  GradAutomatonNeuraNet* that =
    PBErrMalloc(
      GradAutomatonErr,
      sizeof(GradAutomatonNeuraNet));

  // Create the associated Grad and GrAFun
  Grad* grad = NULL;
  switch (gradType) {

    case GradHexaTypeEvenQ:
      grad = (Grad*)GradHexaCreateEvenQ(
        dimGrad);
      break;
    case GradHexaTypeEvenR:
      grad = (Grad*)GradHexaCreateEvenR(
        dimGrad);
      break;
    case GradHexaTypeOddQ:
      grad = (Grad*)GradHexaCreateOddQ(
        dimGrad);
      break;
    case GradHexaTypeOddR:
      grad = (Grad*)GradHexaCreateOddR(
        dimGrad);
      break;
    default:
      break;

  }

  GrAFun* fun = (GrAFun*)GrAFunCreateNeuraNet(nn);

  // Initialize the properties
  that->gradAutomaton =
    GradAutomatonCreateStatic(
      GradAutomatonTypeNeuraNet,
      grad,
      fun);

  // Add a GrACell to each cell of the Grad
  long area = GradGetArea(GradAutomatonGrad(that));
  for (
    long iCell = area;
    iCell--;) {

    GradCell* cell =
      GradCellAt(
        grad,
        iCell);
```

```
    GrACellFloat* cellStatus =
      GrACellCreateFloat(
        dimStatus,
        cell);

    GradCellSetData(
      cell,
      cellStatus);

  }

  // Return the new GradAutomatonNeuraNet
  return that;

}

// Free the memory used by the GradAutomatonNeuraNet 'that'
void GradAutomatonNeuraNetFree(
  GradAutomatonNeuraNet** that) {

  // If that is null
  if (that == NULL || *that == NULL) {

    // Do nothing
    return;

  }

  // Free the GrACell attached to the cells of the Grad
  long area = GradGetArea(GradAutomatonGrad(*that));
  for (
    long iCell = area;
    iCell--;) {

    GradCell* cell =
      GradCellAt(
        GradAutomatonGrad(*that),
        iCell);

    GrACellFloat* cellStatus = GradCellData(cell);

    GrACellFree(&cellStatus);

  }

  // Free memory
  GradSquareFree((GradSquare**)&((*that)->gradAutomaton.grad));
  _GrAFunNeuraNetFree((GrAFunNeuraNet**)&((*that)->gradAutomaton.fun));
  free(*that);
  *that = NULL;

}

// Step the GradAutomatonNeuraNetStep
void _GradAutomatonNeuraNetStep(GradAutomatonNeuraNet* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
```

```
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the number of cells in the grad
  long nbCell = GradGetArea(GradAutomatonGrad(that));

  // Loop on the cell
  for (
    long iCell = nbCell;
    iCell--;) {

    // Get the cell
    GrACellFloat* cell =
      GradAutomatonCell(
        that,
        iCell);

    // Apply the step function to the cell
    GrAFunApply(
      GradAutomatonFun(that),
      GradAutomatonGrad(that),
      cell);

  }

  // Switch all the cells
  GradAutomatonSwitchAllStatus(that);

}
```

3.2 gradautomaton-inline.c

```
// ============ GRADAUTOMATON_INLINE.C ================

// -------------- GrACell

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

// Switch the current status of the GrACell 'that'
#if BUILDMODE != 0
static inline
#endif
void _GrACellSwitchStatus(GrACell* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif
```

```
  that->curStatus = 1 - that->curStatus;

}

// Return the current status of the GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
VecShort* _GrACellShortCurStatus(const GrACellShort* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->status[that->gradAutomatonCell.curStatus];

}

// Return the current status of the GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
VecFloat* _GrACellFloatCurStatus(const GrACellFloat* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->status[that->gradAutomatonCell.curStatus];

}

// Return the previous status of the GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
VecShort* _GrACellShortPrevStatus(const GrACellShort* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
```

```
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->status[1 - that->gradAutomatonCell.curStatus];

}

// Return the previous status of the GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
VecFloat* _GrACellFloatPrevStatus(const GrACellFloat* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->status[1 - that->gradAutomatonCell.curStatus];

}

// Return the 'iVal'-th value of the previous status of the
// GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
short _GrACellShortGetPrevStatus(
  const GrACellShort* const that,
        const unsigned long iVal) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return VecGet(
    GrACellPrevStatus(that),
    iVal);

}
```

```
// Return the 'iVal'-th value of the previous status of the
// GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
float _GrACellFloatGetPrevStatus(
  const GrACellFloat* const that,
        const unsigned long iVal) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return VecGet(
    GrACellPrevStatus(that),
    iVal);

}

// Set the 'iVal'-th value of the previous status of the
// GrACellShort 'that' to 'val'
#if BUILDMODE != 0
static inline
#endif
void _GrACellShortSetPrevStatus(
  const GrACellShort* const that,
        const unsigned long iVal,
                const short val) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  VecSet(
    GrACellPrevStatus(that),
    iVal,
    val);

}

// Set the 'iVal'-th value of the previous status of the
// GrACellFloat 'that' to 'val'
#if BUILDMODE != 0
```

```
static inline
#endif
void _GrACellFloatSetPrevStatus(
  const GrACellFloat* const that,
        const unsigned long iVal,
                const float val) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  VecSet(
    GrACellPrevStatus(that),
    iVal,
    val);

}

// Return the 'iVal'-th value of the current status of the
// GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
short _GrACellShortGetCurStatus(
  const GrACellShort* const that,
        const unsigned long iVal) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return VecGet(
    GrACellCurStatus(that),
    iVal);

}

// Return the 'iVal'-th value of the current status of the
// GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
float _GrACellFloatGetCurStatus(
  const GrACellFloat* const that,
```

```
        const unsigned long iVal) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return VecGet(
    GrACellCurStatus(that),
    iVal);

}

// Set the 'iVal'-th value of the current status of the
// GrACellShort 'that' to 'val'
#if BUILDMODE != 0
static inline
#endif
void _GrACellShortSetCurStatus(
  const GrACellShort* const that,
        const unsigned long iVal,
                const short val) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  VecSet(
    GrACellCurStatus(that),
    iVal,
    val);

}

// Set the 'iVal'-th value of the current status of the
// GrACellFloat 'that' to 'val'
#if BUILDMODE != 0
static inline
#endif
void _GrACellFloatSetCurStatus(
  const GrACellFloat* const that,
        const unsigned long iVal,
                const float val) {

#if BUILDMODE == 0
```

```
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  VecSet(
    GrACellCurStatus(that),
    iVal,
    val);

}

// Return the GradCell of the GrACellShort 'that'
#if BUILDMODE != 0
static inline
#endif
GradCell* _GrACellShortGradCell(const GrACellShort* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->gradAutomatonCell.gradCell;

}

// Return the GradCell of the GrACellFloat 'that'
#if BUILDMODE != 0
static inline
#endif
GradCell* _GrACellFloatGradCell(const GrACellFloat* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->gradAutomatonCell.gradCell;
```

```
}

// -------------- GrAFun

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

// Return the type of the GrAFun 'that'
#if BUILDMODE != 0
static inline
#endif
GrAFunType _GrAFunGetType(const GrAFun* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->type;

}

// -------------- GrAFunWolframOriginal

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

// Return the rule of the GrAFunWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
unsigned char GrAFunWolframOriginalGetRule(
  GrAFunWolframOriginal* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->rule;

}

// -------------- GrAFunNeuraNet

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

```
// Return the NeuraNet of the GrAFunNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
NeuraNet* GrAFunNeuraNetNN(
  GrAFunNeuraNet* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  return that->nn;

}

// -------------- GradAutomaton

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

// Return the Grad of the GradAutomaton 'that'
#if BUILDMODE != 0
static inline
#endif
Grad* _GradAutomatonGrad(GradAutomaton* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Return the Grad
  return that->grad;

}

// Return the GrACellShort at position 'pos' for the
// GradAutomaton 'that'
#if BUILDMODE != 0
static inline
#endif
GrACell* _GradAutomatonCellPos(
     GradAutomaton* const that,
  const VecShort2D* const pos) {

#if BUILDMODE == 0
```

```
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (pos == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'pos' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the GradCell at the requested position
  GradCell* cell =
    GradCellAt(
      GradAutomatonGrad(that),
      pos);

  // Return the GrACellShort associated to the cell
  return (GrACell*)GradCellData(cell);

}

// Return the GrACellShort at index 'iCell' for the GradAutomaton 'that'
#if BUILDMODE != 0
static inline
#endif
GrACell* _GradAutomatonCellIndex(
  GradAutomaton* const that,
            const long iCell) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the GradCell at the requested position
  GradCell* cell =
    GradCellAt(
      GradAutomatonGrad(that),
      iCell);

  // Return the GrACellShort associated to the cell
  return (GrACell*)GradCellData(cell);
```

```
}

// -------------- GradAutomatonDummy

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

// Return the Grad of the GradAutomatonDummy 'that'
#if BUILDMODE != 0
static inline
#endif
GradSquare* _GradAutomatonDummyGrad(GradAutomatonDummy* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Return the Grad
  return (GradSquare*)(((GradAutomaton*)that)->grad);

}

// Return the GrAFun of the GradAutomatonDummy 'that'
#if BUILDMODE != 0
static inline
#endif
GrAFunDummy* _GradAutomatonDummyFun(GradAutomatonDummy* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Return the GrAFun
  return (GrAFunDummy*)(((GradAutomaton*)that)->fun);

}

// Return the GrACellShort at position 'pos' for the
// GradAutomatonDummy 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellShort* _GradAutomatonDummyCellPos(
  GradAutomatonDummy* const that,
```

```
    const VecShort2D* const pos) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (pos == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'pos' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the GradCell at the requested position
  GradCell* cell =
    GradCellAt(
      GradAutomatonGrad(that),
      pos);

  // Return the GrACellShort associated to the cell
  return (GrACellShort*)GradCellData(cell);

}

// Return the GrACellShort at index 'iCell' for the
// GradAutomatonDummy 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellShort* _GradAutomatonDummyCellIndex(
  GradAutomatonDummy* const that,
                const long iCell) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the GradCell at the requested position
  GradCell* cell =
    GradCellAt(
      GradAutomatonGrad(that),
```

```
      iCell);

  // Return the GrACellShort associated to the cell
  return (GrACellShort*)GradCellData(cell);

}

// -------------- GradAutomatonWolframOriginal

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

// Return the Grad of the GradAutomatonWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
GradSquare* _GradAutomatonWolframOriginalGrad(
  GradAutomatonWolframOriginal* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Return the Grad
  return (GradSquare*)(((GradAutomaton*)that)->grad);

}

// Return the GrAFun of the GradAutomatonWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
GrAFunWolframOriginal* _GradAutomatonWolframOriginalFun(
  GradAutomatonWolframOriginal* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Return the GrAFun
  return (GrAFunWolframOriginal*)(((GradAutomaton*)that)->fun);

}

// Return the GrACellShort at position 'pos' for the
```

```
// GradAutomatonWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellShort* _GradAutomatonWolframOriginalCellPos(
  GradAutomatonWolframOriginal* const that,
              const VecShort2D* const pos) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (pos == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'pos' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the GradCell at the requested position
  GradCell* cell =
    GradCellAt(
      GradAutomatonGrad(that),
      pos);

  // Return the GrACellShort associated to the cell
  return (GrACellShort*)GradCellData(cell);

}

// Return the GrACellShort at index 'iCell' for the
// GradAutomatonWolframOriginal 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellShort* _GradAutomatonWolframOriginalCellIndex(
  GradAutomatonWolframOriginal* const that,
                           const long iCell) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }
```

```
#endif

  // Get the GradCell at the requested position
  GradCell* cell =
    GradCellAt(
      GradAutomatonGrad(that),
      iCell);

  // Return the GrACellShort associated to the cell
  return (GrACellShort*)GradCellData(cell);

}

// -------------- GradAutomatonNeuraNet

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

// Return the Grad of the GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
Grad* _GradAutomatonNeuraNetGrad(GradAutomatonNeuraNet* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Return the Grad
  return ((GradAutomaton*)that)->grad;

}

// Return the type of Grad of the GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
GradType GradAutomatonNeuraNetGetGradType(
  GradAutomatonNeuraNet* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Return the type of the Grad
```

```
  return GradGetType(((GradAutomaton*)that)->grad);

}

// Return the GrAFun of the GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
GrAFunNeuraNet* _GradAutomatonNeuraNetFun(
  GradAutomatonNeuraNet* const that) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Return the GrAFun
  return (GrAFunNeuraNet*)(((GradAutomaton*)that)->fun);

}

// Return the GrACellFloat at position 'pos' for the
// GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellFloat* _GradAutomatonNeuraNetCellPos(
  GradAutomatonNeuraNet* const that,
       const VecShort2D* const pos) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

  if (pos == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'pos' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the GradCell at the requested position
```

```
  GradCell* cell =
    GradCellAt(
      GradAutomatonGrad(that),
      pos);

  // Return the GrACellFloat associated to the cell
  return (GrACellFloat*)GradCellData(cell);

}

// Return the GrACellFloat at index 'iCell' for the
// GradAutomatonNeuraNet 'that'
#if BUILDMODE != 0
static inline
#endif
GrACellFloat* _GradAutomatonNeuraNetCellIndex(
  GradAutomatonNeuraNet* const that,
                    const long iCell) {

#if BUILDMODE == 0
  if (that == NULL) {

    GradAutomatonErr->_type = PBErrTypeNullPointer;
    sprintf(
      GradAutomatonErr->_msg,
      "'that' is null");
    PBErrCatch(GradAutomatonErr);

  }

#endif

  // Get the GradCell at the requested position
  GradCell* cell =
    GradCellAt(
      GradAutomatonGrad(that),
      iCell);

  // Return the GrACellFloat associated to the cell
  return (GrACellFloat*)GradCellData(cell);

}
```

4 Makefile

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

all: pbmake_wget main

# Automatic installation of the repository PBMake in the parent folder
pbmake_wget:
if [ ! -d ../PBMake ]; then wget https://github.com/BayashiPascal/PBMake/archive/master.zip; unzip master.zip; rm -f

# Makefile definitions
MAKEFILE_INC=../PBMake/Makefile.inc
```

```
include $(MAKEFILE_INC)

# Rules to make the executable
repo=gradautomaton
$($(repo)_EXENAME): \
$($(repo)_EXENAME).o \
$($(repo)_EXE_DEP) \
$($(repo)_DEP)
$(COMPILER) `echo "$($(repo)_EXE_DEP) $($(repo)_EXENAME).o" | tr ' ' '\n' | sort -u` $(LINK_ARG) $($(repo)_LINK_ARG)

$($(repo)_EXENAME).o: \
$($(repo)_DIR)/$($(repo)_EXENAME).c \
$($(repo)_INC_H_EXE) \
$($(repo)_EXE_DEP)
$(COMPILER) $(BUILD_ARG) $($(repo)_BUILD_ARG) `echo "$($(repo)_INC_DIR)" | tr ' ' '\n' | sort -u` -c $($(repo)_DIR)/$
```

5 Unit tests

```
#include <stdlib.h>
#include <stdio.h>
#include <time.h>
#include <string.h>
#include <time.h>
#include <unistd.h>
#include <sys/time.h>
#include "pberr.h"
#include "gradautomaton.h"

#define RANDOMSEED 0

void UnitTestGrACellCreateFree(void) {

  int dim = 2;
  GradCell gradCell;
  GrACellShort* cellShort =
    GrACellCreateShort(
      dim,
      &gradCell);
  if (
    cellShort == NULL ||
    VecGetDim(cellShort->status[0]) != dim ||
    VecGetDim(cellShort->status[1]) != dim ||
    cellShort->gradAutomatonCell.curStatus != 0 ||
    cellShort->gradAutomatonCell.gradCell != &gradCell) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellCreateShort failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellFree(&cellShort);
  if (cellShort != NULL) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
```

```
      GradAutomatonErr->_msg,
      "GrACellShortFree failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellFloat* cellFloat =
    GrACellCreateFloat(
      dim,
      &gradCell);
  if (
    cellFloat == NULL ||
    VecGetDim(cellFloat->status[0]) != dim ||
    VecGetDim(cellFloat->status[1]) != dim ||
    cellFloat->gradAutomatonCell.curStatus != 0 ||
    cellFloat->gradAutomatonCell.gradCell != &gradCell) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellCreateFloat failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellFree(&cellFloat);
  if (cellFloat != NULL) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellFloatFree failed");
    PBErrCatch(GradAutomatonErr);

  }

  printf("UnitTestGrACellCreateFree OK\n");

}

void UnitTestGrACellSwitchStatus(void) {

  int dim = 2;
  GrACellShort* cellShort =
    GrACellCreateShort(
      dim,
      NULL);
  GrACellSwitchStatus(cellShort);
  if (cellShort->gradAutomatonCell.curStatus != 1) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellShortSwitchStatus failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellSwitchStatus(cellShort);
  if (cellShort->gradAutomatonCell.curStatus != 0) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
```

```
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellShortSwitchStatus failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellFree(&cellShort);

  GrACellFloat* cellFloat =
    GrACellCreateFloat(
      dim,
      NULL);
  GrACellSwitchStatus(cellFloat);
  if (cellFloat->gradAutomatonCell.curStatus != 1) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellFloatSwitchStatus failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellSwitchStatus(cellFloat);
  if (cellFloat->gradAutomatonCell.curStatus != 0) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellFloatSwitchStatus failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellFree(&cellFloat);

  printf("UnitTestGrACellSwitchStatus OK\n");

}

void UnitTestGrACellCurPrevStatus(void) {

  int dim = 2;
  GrACellShort* cellShort =
    GrACellCreateShort(
      dim,
      NULL);
  if (cellShort->status[0] != GrACellCurStatus(cellShort)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellShortCurStatus failed");
    PBErrCatch(GradAutomatonErr);

  }

  if (cellShort->status[1] != GrACellPrevStatus(cellShort)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
```

```
      GradAutomatonErr->_msg,
      "GrACellShortCurStatus failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellFree(&cellShort);

  GrACellFloat* cellFloat =
    GrACellCreateFloat(
      dim,
      NULL);
  if (cellFloat->status[0] != GrACellCurStatus(cellFloat)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellFloatCurStatus failed");
    PBErrCatch(GradAutomatonErr);

  }

  if (cellFloat->status[1] != GrACellPrevStatus(cellFloat)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellFloatCurStatus failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellFree(&cellFloat);

  printf("UnitTestGrACellCurPrevStatus OK\n");

}

void UnitTestGrACellGetSet(void) {

  int dim = 1;
  GradCell gradCell;
  GrACellShort* cellShort =
    GrACellCreateShort(
      dim,
      &gradCell);
  GrACellSetCurStatus(
    cellShort,
    0,
    1);
  short curStatusS =
    VecGet(
      GrACellCurStatus(cellShort),
      0);
  if (curStatusS != 1) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellShortSetCurStatus failed");
    PBErrCatch(GradAutomatonErr);
```

```
}

curStatusS =
  GrACellGetCurStatus(
    cellShort,
    0);
if (curStatusS != 1) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GrACellShortGetCurStatus failed");
  PBErrCatch(GradAutomatonErr);

}

GrACellSetPrevStatus(
  cellShort,
  0,
  1);
short prevStatusS =
  VecGet(
    GrACellPrevStatus(cellShort),
    0);
if (prevStatusS != 1) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GrACellShortSetPrevStatus failed");
  PBErrCatch(GradAutomatonErr);

}

prevStatusS =
  GrACellGetPrevStatus(
    cellShort,
    0);
if (prevStatusS != 1) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GrACellShortGetPrevStatus failed");
  PBErrCatch(GradAutomatonErr);

}

if (GrACellGradCell(cellShort) != &gradCell) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GrACellShortGradCell failed");
  PBErrCatch(GradAutomatonErr);

}

GrACellFree(&cellShort);

GrACellFloat* cellFloat =
  GrACellCreateFloat(
```

```
    dim,
    &gradCell);
GrACellSetCurStatus(
  cellFloat,
  0,
  1);
float curStatusF =
  VecGet(
    GrACellCurStatus(cellFloat),
    0);
if (curStatusF != 1) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GrACellFloatSetCurStatus failed");
  PBErrCatch(GradAutomatonErr);

}

curStatusF =
  GrACellGetCurStatus(
    cellFloat,
    0);
if (curStatusF != 1) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GrACellFloatGetCurStatus failed");
  PBErrCatch(GradAutomatonErr);

}

GrACellSetPrevStatus(
  cellFloat,
  0,
  1);
float prevStatusF =
  VecGet(
    GrACellPrevStatus(cellFloat),
    0);
if (prevStatusF != 1) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GrACellFloatSetPrevStatus failed");
  PBErrCatch(GradAutomatonErr);

}

prevStatusF =
  GrACellGetPrevStatus(
    cellFloat,
    0);
if (prevStatusF != 1) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GrACellFloatGetPrevStatus failed");
```

```
    PBErrCatch(GradAutomatonErr);

  }

  if (GrACellGradCell(cellFloat) != &gradCell) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrACellFloatGradCell failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrACellFree(&cellFloat);

  printf("UnitTestGrACellCurGetSet OK\n");

}

void UnitTestGrACell(void) {

  UnitTestGrACellCreateFree();
  UnitTestGrACellSwitchStatus();
  UnitTestGrACellCurPrevStatus();
  UnitTestGrACellGetSet();
  printf("UnitTestGrACell OK\n");

}

void UnitTestGrAFunDummyCreateFree(void) {

  GrAFunDummy* fun = GrAFunCreateDummy();
  if (
    fun == NULL ||
    fun->grAFun.type != GrAFunTypeDummy) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunCreateDummy failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrAFunFree(&fun);
  if (fun != NULL) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunFree failed");
    PBErrCatch(GradAutomatonErr);

  }

  printf("UnitTestGrAFunDummyCreateFree OK\n");

}

void UnitTestGrAFunDummyGetType(void) {
```

```
  GrAFunDummy* fun = GrAFunCreateDummy();
  if (GrAFunGetType(fun) != GrAFunTypeDummy) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunDummyGetType failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrAFunFree(&fun);

  printf("UnitTestGrAFunDummyGetType OK\n");

}

void UnitTestGrAFunDummy(void) {

  UnitTestGrAFunDummyCreateFree();
  UnitTestGrAFunDummyGetType();
  printf("UnitTestGrAFunDummy OK\n");

}

void UnitTestGrAFunWolframOriginalCreateFree(void) {

  unsigned char rule = 42;
  GrAFunWolframOriginal* fun = GrAFunCreateWolframOriginal(rule);
  if (
    fun == NULL ||
    fun->grAFun.type != GrAFunTypeWolframOriginal ||
    fun->rule != rule) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunCreateWolframOriginal failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrAFunFree(&fun);
  if (fun != NULL) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunFree failed");
    PBErrCatch(GradAutomatonErr);

  }

  printf("UnitTestGrAFunWolframOriginalCreateFree OK\n");

}

void UnitTestGrAFunWolframOriginalGetType(void) {

  unsigned char rule = 42;
  GrAFunWolframOriginal* fun = GrAFunCreateWolframOriginal(rule);
  if (GrAFunGetType(fun) != GrAFunTypeWolframOriginal) {
```

```
    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunWolframOriginalGetType failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrAFunFree(&fun);

  printf("UnitTestGrAFunWolframOriginalGetType OK\n");

}

void UnitTestGrAFunWolframOriginalGetRule(void) {

  unsigned char rule = 42;
  GrAFunWolframOriginal* fun = GrAFunCreateWolframOriginal(rule);
  if (GrAFunWolframOriginalGetRule(fun) != rule) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunWolframOriginalGetRule failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrAFunFree(&fun);

  printf("UnitTestGrAFunWolframOriginalGetRule OK\n");

}

void UnitTestGrAFunWolframOriginal(void) {

  UnitTestGrAFunWolframOriginalCreateFree();
  UnitTestGrAFunWolframOriginalGetType();
  UnitTestGrAFunWolframOriginalGetRule();
  printf("UnitTestGrAFunWolframOriginal OK\n");

}

void UnitTestGrAFunNeuraNetCreateFree(void) {

  int nbIn = 1;
  int nbOut = 1;
  VecLong* hiddenLayers = VecLongCreate(1);
  VecSet(
    hiddenLayers,
    0,
    1);
  NeuraNet* nn =
    NeuraNetCreateFullyConnected(
      nbIn,
      nbOut,
      hiddenLayers);
  GrAFunNeuraNet* fun = GrAFunCreateNeuraNet(nn);
  if (
    fun == NULL ||
    fun->grAFun.type != GrAFunTypeNeuraNet ||
```

```
    fun->nn != nn) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunCreateNeuraNet failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrAFunFree(&fun);
  if (fun != NULL) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunFree failed");
    PBErrCatch(GradAutomatonErr);

  }

  NeuraNetFree(&nn);
  VecFree(&hiddenLayers);

  printf("UnitTestGrAFunNeuraNetCreateFree OK\n");

}

void UnitTestGrAFunNeuraNetGetType(void) {

  int nbIn = 1;
  int nbOut = 1;
  VecLong* hiddenLayers = VecLongCreate(1);
  VecSet(
    hiddenLayers,
    0,
    1);
  NeuraNet* nn =
    NeuraNetCreateFullyConnected(
      nbIn,
      nbOut,
      hiddenLayers);
  GrAFunNeuraNet* fun = GrAFunCreateNeuraNet(nn);
  if (GrAFunGetType(fun) != GrAFunTypeNeuraNet) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunNeuraNetGetType failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrAFunFree(&fun);
  NeuraNetFree(&nn);
  VecFree(&hiddenLayers);

  printf("UnitTestGrAFunNeuraNetGetType OK\n");

}

void UnitTestGrAFunNeuraNetNN(void) {
```

```
  int nbIn = 1;
  int nbOut = 1;
  VecLong* hiddenLayers = VecLongCreate(1);
  VecSet(
    hiddenLayers,
    0,
    1);
  NeuraNet* nn =
    NeuraNetCreateFullyConnected(
      nbIn,
      nbOut,
      hiddenLayers);
  GrAFunNeuraNet* fun = GrAFunCreateNeuraNet(nn);
  if (GrAFunNeuraNetNN(fun) != nn) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GrAFunNeuraNetNN failed");
    PBErrCatch(GradAutomatonErr);

  }

  GrAFunFree(&fun);
  NeuraNetFree(&nn);
  VecFree(&hiddenLayers);

  printf("UnitTestGrAFunNeuraNetNN OK\n");

}

void UnitTestGrAFunNeuraNet(void) {

  UnitTestGrAFunNeuraNetCreateFree();
  UnitTestGrAFunNeuraNetGetType();
  UnitTestGrAFunNeuraNetNN();
  printf("UnitTestGrAFunNeuraNet OK\n");

}

void UnitTestGrAFun(void) {

  UnitTestGrAFunDummy();
  UnitTestGrAFunWolframOriginal();
  UnitTestGrAFunNeuraNet();
  printf("UnitTestGrAFun OK\n");

}

void UnitTestGradAutomatonDummyCreateFree(void) {

  GradAutomatonDummy* ga = GradAutomatonCreateDummy();
  if (
    ga == NULL ||
    ga->gradAutomaton.grad == NULL ||
    ga->gradAutomaton.fun == NULL ||
    ga->gradAutomaton.type != GradAutomatonTypeDummy) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
```

```
      "GradAutomatonCreateDummy failed");
    PBErrCatch(GradAutomatonErr);

  }

  GradAutomatonDummyFree(&ga);
  if (ga != NULL) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonDummyFree failed");
    PBErrCatch(GradAutomatonErr);

  }

  printf("UnitTestGradAutomatonDummyCreateFree OK\n");

}

void UnitTestGradAutomatonDummyGet(void) {

  GradAutomatonDummy* ga = GradAutomatonCreateDummy();
  if (GradAutomatonGrad(ga) != (GradSquare*)(ga->gradAutomaton.grad)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonDummyGrad failed");
    PBErrCatch(GradAutomatonErr);

  }

  if (GradAutomatonFun(ga) != (GrAFunDummy*)(ga->gradAutomaton.fun)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonDummyFun failed");
    PBErrCatch(GradAutomatonErr);

  }

  for (
    long i = 0;
    i < 4;
    ++i) {

    void* cellA =
      GradAutomatonCell(
        ga,
        i);
    void* cellB =
      GradCellAt(
        ga->gradAutomaton.grad,
        i);
    if (cellA != GradCellData(cellB)) {

      GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
      sprintf(
        GradAutomatonErr->_msg,
        "GradAutomatonDummyCellIndex failed");
```

```
      PBErrCatch(GradAutomatonErr);

    }

  }

  VecShort2D dim = VecShortCreateStatic2D(2);
  VecSet(
    &dim,
    0,
    2);
  VecSet(
    &dim,
    1,
    2);
  VecShort2D pos = VecShortCreateStatic2D(2);
  bool flag = true;
  do {

    void* cellA =
      GradAutomatonCell(
        ga,
        &pos);
    void* cellB =
      GradCellAt(
        ga->gradAutomaton.grad,
        &pos);
    if (cellA != GradCellData(cellB)) {

      GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
      sprintf(
        GradAutomatonErr->_msg,
        "GradAutomatonDummyCellPos failed");
      PBErrCatch(GradAutomatonErr);

    }

    flag =
      VecStep(
        &pos,
        &dim);

  } while(flag);

  GradAutomatonDummyFree(&ga);

  printf("UnitTestGradAutomatonDummyGet OK\n");

}

void UnitTestGradAutomatonDummyStep(void) {

  GradAutomatonDummy* ga = GradAutomatonCreateDummy();

  GradAutomatonStep(ga);

  GradAutomatonDummyFree(&ga);

  printf("UnitTestGradAutomatonDummyStep OK\n");

}
```

```
void UnitTestGradAutomatonDummy(void) {

  UnitTestGradAutomatonDummyCreateFree();
  UnitTestGradAutomatonDummyGet();
  UnitTestGradAutomatonDummyStep();
  printf("UnitTestGradAutomatonDummy OK\n");

}

void UnitTestGradAutomatonWolframOriginalCreateFree(void) {

  unsigned char rule = 42;
  long size = 20;
  GradAutomatonWolframOriginal* ga =
    GradAutomatonCreateWolframOriginal(
      rule,
      size);
  if (
    ga == NULL ||
    ga->gradAutomaton.grad == NULL ||
    ga->gradAutomaton.fun == NULL ||
    ga->gradAutomaton.type != GradAutomatonTypeWolframOriginal ||
    ((GrAFunWolframOriginal*)(ga->gradAutomaton.fun))->rule != rule ||
    ga->gradAutomaton.grad->_dim._val[0] != size ||
    ga->gradAutomaton.grad->_dim._val[1] != 1) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonCreateWolframOriginal failed");
    PBErrCatch(GradAutomatonErr);

  }

  GradAutomatonWolframOriginalFree(&ga);
  if (ga != NULL) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonWolframOriginalFree failed");
    PBErrCatch(GradAutomatonErr);

  }

  printf("UnitTestGradAutomatonWolframOriginalCreateFree OK\n");

}

void UnitTestGradAutomatonWolframOriginalGet(void) {

  unsigned char rule = 42;
  long size = 20;
  GradAutomatonWolframOriginal* ga =
    GradAutomatonCreateWolframOriginal(
      rule,
      size);
  if (GradAutomatonGrad(ga) != (GradSquare*)(ga->gradAutomaton.grad)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
```

```
    "GradAutomatonWolframOriginalGrad failed");
  PBErrCatch(GradAutomatonErr);

}

if ((void*)GradAutomatonFun(ga) != ga->gradAutomaton.fun) {

  GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
  sprintf(
    GradAutomatonErr->_msg,
    "GradAutomatonWolframOriginalFun failed");
  PBErrCatch(GradAutomatonErr);

}

for (
  long i = 0;
  i < 4;
  ++i) {

  void* cellA =
    GradAutomatonCell(
      ga,
      i);
  void* cellB =
    GradCellAt(
      ga->gradAutomaton.grad,
      i);
  if (cellA != GradCellData(cellB)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonWolframOriginalCellIndex failed");
    PBErrCatch(GradAutomatonErr);

  }

}

VecShort2D dim = VecShortCreateStatic2D(2);
VecSet(
  &dim,
  0,
  size);
VecSet(
  &dim,
  1,
  1);
VecShort2D pos = VecShortCreateStatic2D(2);
bool flag = true;
do {

  void* cellA =
    GradAutomatonCell(
      ga,
      &pos);
  void* cellB =
    GradCellAt(
      ga->gradAutomaton.grad,
      &pos);
  if (cellA != GradCellData(cellB)) {
```

```
      GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
      sprintf(
        GradAutomatonErr->_msg,
        "GradAutomatonWolframOriginalCellPos failed");
      PBErrCatch(GradAutomatonErr);

    }

    flag =
      VecStep(
        &pos,
        &dim);

  } while(flag);

  GradAutomatonWolframOriginalFree(&ga);

  printf("UnitTestGradAutomatonWolframOriginalGet OK\n");

}

void UnitTestGradAutomatonWolframOriginalStepPrintln(void) {

  unsigned char rule = 30;
  long size = 100;
  GradAutomatonWolframOriginal* ga =
    GradAutomatonCreateWolframOriginal(
      rule,
      size);

  GradAutomatonPrintln(
    ga,
    stdout);

  for (
    long iStep = 0;
    iStep < size;
    ++iStep) {

    GradAutomatonStep(ga);

    GradAutomatonPrintln(
      ga,
      stdout);

  }

  GradAutomatonWolframOriginalFree(&ga);

  printf("UnitTestGradAutomatonWolframOriginalStepPrintln OK\n");

}

void UnitTestGradAutomatonWolframOriginal(void) {

  UnitTestGradAutomatonWolframOriginalCreateFree();
  UnitTestGradAutomatonWolframOriginalGet();
  UnitTestGradAutomatonWolframOriginalStepPrintln();
  printf("UnitTestGradAutomatonWolframOriginal OK\n");

}
```

```
void UnitTestGradAutomatonNeuraNetCreateFree(void) {

  long dimStatus = 3;
  VecShort2D dimGrad = VecShortCreateStatic2D();
  VecSet(
    &dimGrad,
    0,
    2);
  VecSet(
    &dimGrad,
    1,
    2);
  bool diagLink = true;
  int nbIn = dimStatus * 9;
  int nbOut = dimStatus;
  VecLong* hiddenLayers = VecLongCreate(1);
  VecSet(
    hiddenLayers,
    0,
    1);
  NeuraNet* nn =
    NeuraNetCreateFullyConnected(
      nbIn,
      nbOut,
      hiddenLayers);
  GradAutomatonNeuraNet* ga =
    GradAutomatonCreateNeuraNetSquare(
      dimStatus,
      &dimGrad,
      diagLink,
      nn);
  if (
    ga == NULL ||
    ga->gradAutomaton.grad == NULL ||
    ga->gradAutomaton.fun == NULL ||
    ga->gradAutomaton.type != GradAutomatonTypeNeuraNet ||
    ga->gradAutomaton.grad->_type != GradTypeSquare ||
    ga->gradAutomaton.grad->_dim._val[0] != 2 ||
    ga->gradAutomaton.grad->_dim._val[1] != 2) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonCreateNeuraNetSquare failed");
    PBErrCatch(GradAutomatonErr);

  }

  GradAutomatonNeuraNetFree(&ga);
  if (ga != NULL) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonNeuraNetFree failed");
    PBErrCatch(GradAutomatonErr);

  }

  NeuraNetFree(&nn);
  VecFree(&hiddenLayers);
```

```
  printf("UnitTestGradAutomatonNeuraNetCreateFree OK\n");

}

void UnitTestGradAutomatonNeuraNetGet(void) {

  long dimStatus = 3;
  VecShort2D dimGrad = VecShortCreateStatic2D();
  VecSet(
    &dimGrad,
    0,
    2);
  VecSet(
    &dimGrad,
    1,
    2);
  bool diagLink = true;
  int nbIn = dimStatus * 9;
  int nbOut = dimStatus;
  VecLong* hiddenLayers = VecLongCreate(1);
  VecSet(
    hiddenLayers,
    0,
    1);
  NeuraNet* nn =
    NeuraNetCreateFullyConnected(
      nbIn,
      nbOut,
      hiddenLayers);
  GradAutomatonNeuraNet* ga =
    GradAutomatonCreateNeuraNetSquare(
      dimStatus,
      &dimGrad,
      diagLink,
      nn);
  if (GradAutomatonGrad(ga) != ga->gradAutomaton.grad) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonNeuraNetGrad failed");
    PBErrCatch(GradAutomatonErr);

  }

  if (GradAutomatonNeuraNetGetGradType(ga) != GradTypeSquare) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonNeuraNetGradType failed");
    PBErrCatch(GradAutomatonErr);

  }

  if ((void*)GradAutomatonFun(ga) != ga->gradAutomaton.fun) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonNeuraNetFun failed");
```

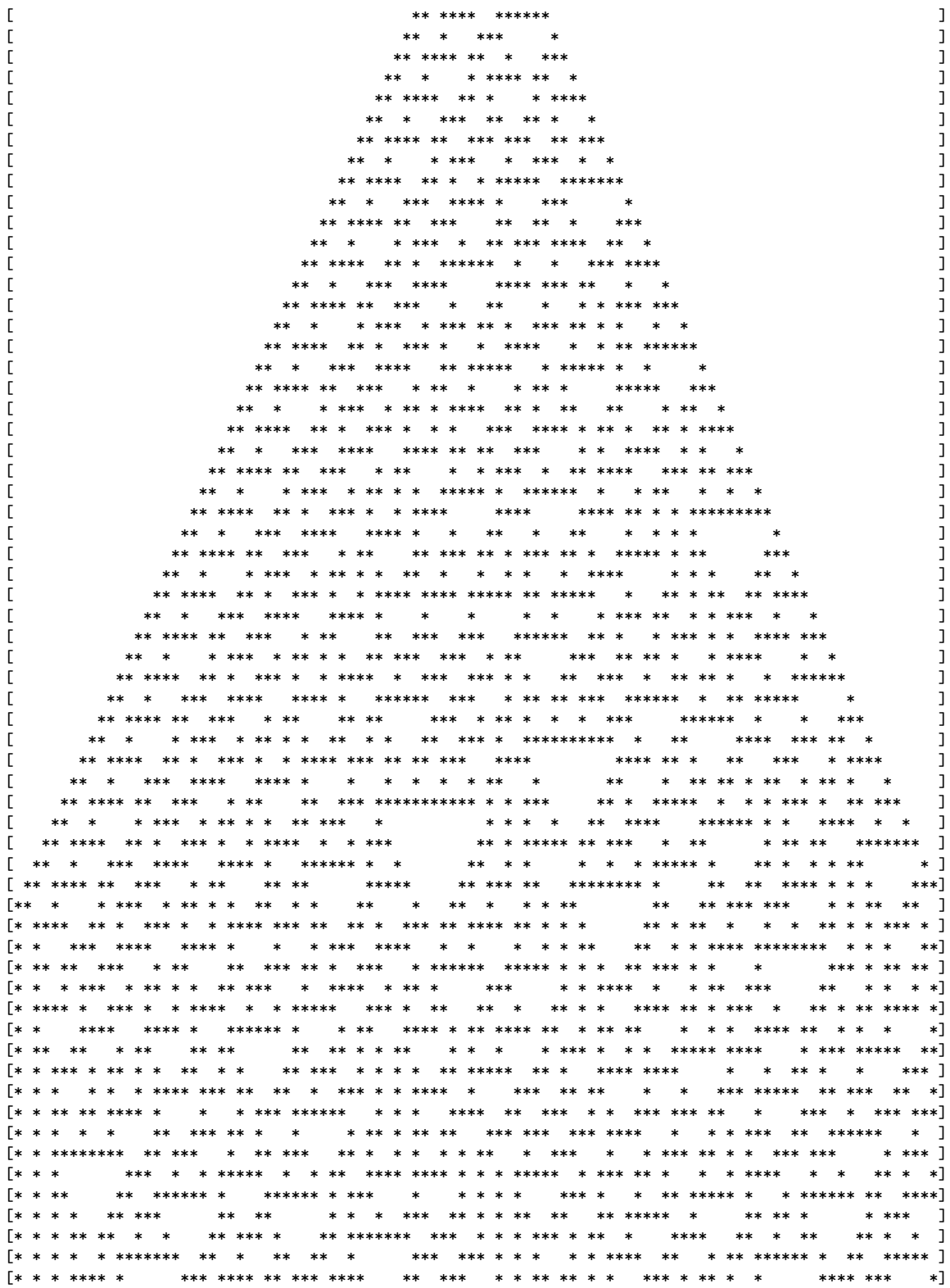
```
  PBErrCatch(GradAutomatonErr);

}

for (
  long i = 0;
  i < 4;
  ++i) {

  void* cellA =
    GradAutomatonCell(
      ga,
      i);
  void* cellB =
    GradCellAt(
      ga->gradAutomaton.grad,
      i);
  if (cellA != GradCellData(cellB)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonNeuraNetCellIndex failed");
    PBErrCatch(GradAutomatonErr);

  }

}

VecShort2D pos = VecShortCreateStatic2D(2);
bool flag = true;
do {

  void* cellA =
    GradAutomatonCell(
      ga,
      &pos);
  void* cellB =
    GradCellAt(
      ga->gradAutomaton.grad,
      &pos);
  if (cellA != GradCellData(cellB)) {

    GradAutomatonErr->_type = PBErrTypeUnitTestFailed;
    sprintf(
      GradAutomatonErr->_msg,
      "GradAutomatonNeuraNetCellPos failed");
    PBErrCatch(GradAutomatonErr);

  }

  flag =
    VecStep(
      &pos,
      &dimGrad);

} while(flag);

GradAutomatonNeuraNetFree(&ga);
NeuraNetFree(&nn);
VecFree(&hiddenLayers);
```

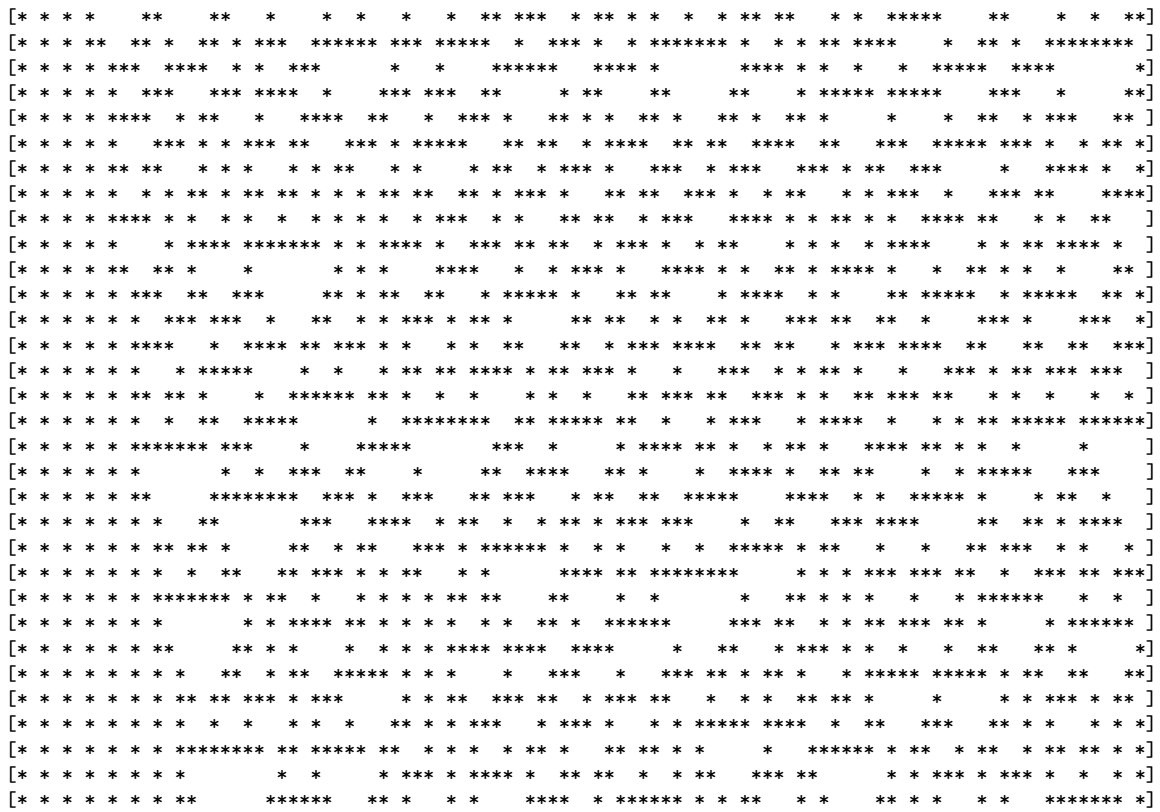
```
  printf("UnitTestGradAutomatonNeuraNetGet OK\n");

}

void UnitTestGradAutomatonNeuraNetStep(void) {

  long dimStatus = 3;
  VecShort2D dimGrad = VecShortCreateStatic2D();
  VecSet(
    &dimGrad,
    0,
    2);
  VecSet(
    &dimGrad,
    1,
    2);
  bool diagLink = true;
  int nbIn = dimStatus * 9;
  int nbOut = dimStatus;
  VecLong* hiddenLayers = VecLongCreate(1);
  VecSet(
    hiddenLayers,
    0,
    1);
  NeuraNet* nn =
    NeuraNetCreateFullyConnected(
      nbIn,
      nbOut,
      hiddenLayers);
  GradAutomatonNeuraNet* ga =
    GradAutomatonCreateNeuraNetSquare(
      dimStatus,
      &dimGrad,
      diagLink,
      nn);

  for (
    long iStep = 0;
    iStep < 2;
    ++iStep) {

    GradAutomatonStep(ga);

  }

  GradAutomatonNeuraNetFree(&ga);
  NeuraNetFree(&nn);
  VecFree(&hiddenLayers);

  printf("UnitTestGradAutomatonNeuraNetStep OK\n");

}

void UnitTestGradAutomatonNeuraNet(void) {

  UnitTestGradAutomatonNeuraNetCreateFree();
  UnitTestGradAutomatonNeuraNetGet();
  UnitTestGradAutomatonNeuraNetStep();
  printf("UnitTestGradAutomatonNeuraNet OK\n");

}
```

```
void UnitTestGradAutomaton(void) {

  UnitTestGradAutomatonDummy();
  UnitTestGradAutomatonWolframOriginal();
  UnitTestGradAutomatonNeuraNet();
  printf("UnitTestGradAutomaton OK\n");

}

void UnitTestAll(void) {

  UnitTestGrACell();
  UnitTestGrAFun();
  UnitTestGradAutomaton();
  printf("UnitTestAll OK\n");

}

int main(void) {

  UnitTestAll();

  // Return success code
  return 0;

}
```

6 Unit tests output

```
UnitTestGrACellCreateFree OK
UnitTestGrACellSwitchStatus OK
UnitTestGrACellCurPrevStatus OK
UnitTestGrACellCurGetSet OK
UnitTestGrACell OK
UnitTestGrAFunDummyCreateFree OK
UnitTestGrAFunDummyGetType OK
UnitTestGrAFunDummy OK
UnitTestGrAFunWolframOriginalCreateFree OK
UnitTestGrAFunWolframOriginalGetType OK
UnitTestGrAFunWolframOriginalGetRule OK
UnitTestGrAFunWolframOriginal OK
UnitTestGrAFunNeuraNetCreateFree OK
UnitTestGrAFunNeuraNetGetType OK
UnitTestGrAFunNeuraNetNN OK
UnitTestGrAFunNeuraNet OK
UnitTestGrAFun OK
UnitTestGradAutomatonDummyCreateFree OK
UnitTestGradAutomatonDummyGet OK
UnitTestGradAutomatonDummyStep OK
UnitTestGradAutomatonDummy OK
UnitTestGradAutomatonWolframOriginalCreateFree OK
UnitTestGradAutomatonWolframOriginalGet OK
[                                                *                                                ]
[                                               ***                                               ]
[                                              **  *                                             ]
[                                             ** ****                                           ]
[                                            **  *   *                                          ]
[                                           ** **** ***                                         ]
[                                          **  *    *  *                                        ]
```





```
UnitTestGradAutomatonWolframOriginalStepPrintln OK
UnitTestGradAutomatonWolframOriginal OK
UnitTestGradAutomatonNeuraNetCreateFree OK
UnitTestGradAutomatonNeuraNetGet OK
UnitTestGradAutomatonNeuraNetStep OK
UnitTestGradAutomatonNeuraNet OK
UnitTestGradAutomaton OK
UnitTestAll OK
```