

Programming Proverbs

- 13. “Do not recompute constants within a loop.”
- Henry F. Ledgard, “Programming Proverbs: Principles of Good Programming with Numerous Examples to Improve Programming Style and Proficiency”, (Hayden Computer Programming Series), Hayden Book Company, 1st edition, ISBN-13: 978-0810455221, December 1975.

PGE Predictive Game Engine

- purpose
- to provide a simple reference model for predictive collision detection between simple 2D objects
- as an educational experiment

Overview

- a game engine will simulate a 2D environment which understands and polygons, circles
- each circle and polygon can be fixed or unfixed
- each object may be given a mass, velocity and acceleration

Overview

- PGE predicts the time of the next collision
- and draws the world for each frame
- the game engine is a discrete event simulator
 - so an event is either a collision event or a draw frame event

Limitations

- the game engine does not model rotation of objects

- collision response has a fixed inelastic property
 - no provision to have a per object inelastic or elastic property
 - easy to do, just not done yet

- contact resolution code could be improved

Points of note

- designed to be easy to debug
- version 1 used a `macroObject` module which allows more complex objects to be created
- the 2D world is populated via `macroObjects`
- uses a fractional data type for the render and `macroObjects`
 - allows for much easier debugging

Structure



Snooker (or other game application)		
macroObjects	popWorld	Matrix3D
twoDsim		Fractions Transform3D
deviceGroff		Roots

Fractions

- pge is currently 20244 lines of code
 - `Fractions` accounts for 2973 lines of code
- nevertheless it provides good visual clues when debugging
 - much easier to spot $1/80$ than 0.0125
- also knows about certain symbolic values: π , $\sqrt{2}$, $\sqrt{3}$, $\sqrt{6}$
 - symbolic numbers are only resolved once required, thus they might disappear if used together

Example of a debugging session with GDB and PGE

- let us assume there is a bug somewhere in the `macroObject_rotate` function
- an obvious way to solve this is to use `gdb` and single step the function, printing out the variable contents as they are created

Example of a debugging session with GDB and PGE

pge/c/macroObjects.c

```
macroObjects_Macro macroObjects_rotate (macroObjects_Macro m,  
                                         Points_Point p, Fractions_Fract r)  
{  
    PolyMatrix3D_Matrix a;  
    PolyMatrix3D_Matrix b;  
    PolyMatrix3D_Matrix c;  
    PolyMatrix3D_Matrix d;  
    macroObjects_Macro n;  
    /* a: translate point, p, to the origin. */  
    a = Transform3D_translate (Points_negatePoint (Points_dupPoint (p)));  
    b = Transform3D_rotate (r); /* b: rotate, r, radians. */  
    c = Transform3D_translate (p); /* c: translate from origin to point, p. */  
    d = PolyMatrix3D_mult3 (a, b, c); /* d: combine a, b and c transforms. */  
    n = macroObjects_initMacro ();  
    n = foreachObject (n, m, d); /* n: for every object in m transform using, d. */  
    return n;  
}
```

Example of a debugging session with GDB and PGE

```
$ make npn
$ gdb a.out
(gdb) break macroObjects_rotate
(gdb) run
Breakpoint 24, macroObjects_rotate (m=0x6797f0, p=..., r=0x697ef0)
at macroObjects.mod:562
(gdb) next
(gdb) print dmat(a)
+-
| 1  0  0
| 0  1  0
| -.1/4  -.1/4  1
+- 1 = void
(gdb) next
```

Example of a debugging session with GDB and PGE

```
(gdb) print dmat(b)
+-
| cos((pi/2))  -1  0
| sin((pi/2))  cos((pi/2))  0
| 0  0  1
+- 2 = void
(gdb) next
(gdb) print dmat(c)
+-
| 1  0  0
| 0  1  0
| .1/4  .1/4  1
+- 3 = void
```

Example of a debugging session with GDB and PGE

```
(gdb) next
(gdb) print dmat(d)
+-
| ((1*((cos((pi/2))*1)+0))+((0*((sin((pi/2))*1)+((cos((pi/2))*0)+0))+0)) \
| ((1*((cos((pi/2))*0)+-1))+((0*((sin((pi/2))*0)+((cos((pi/2))*1)+0))+0)) \
| ((1*((cos((pi/2))*0)+0))+((0*((sin((pi/2))*0)+((cos((pi/2))*0)+0))+0)) \
| ((0*((cos((pi/2))*1)+0))+((1*((sin((pi/2))*1)+((cos((pi/2))*0)+0))+0)) \
| ((0*((cos((pi/2))*0)+-1))+((1*((sin((pi/2))*0)+((cos((pi/2))*1)+0))+0)) \
| ((0*((cos((pi/2))*0)+0))+((1*((sin((pi/2))*0)+((cos((pi/2))*0)+0))+0)) \
| ((-.1/4*((cos((pi/2))*1)+0))+((-.1/4*((sin((pi/2))*1)+((cos((pi/2))*0)+0))+.1/4)) \
| ((-.1/4*((cos((pi/2))*0)+-1))+((-.1/4*((sin((pi/2))*0)+((cos((pi/2))*1)+0))+.1/4)) \
| ((-.1/4*((cos((pi/2))*0)+0))+((-.1/4*((sin((pi/2))*0)+((cos((pi/2))*0)+0))+1))
+- 4 = void
```

Example of a debugging session with GDB and PGE

```
(gdb) print PolyMatrix3D_eval(d)
4 = (POINTER TO RECORD ... END ) 0x6876e0
(gdb) print dmat(d)
+-
| 0  -1  0
| 1  0  0
| 0  .1/2  1
+- 15 = void
```

Performance testing of a game engine

- let us build and run snooker

- ```
$ make snooker
gm2 -pg -g -fiso -fextended-opaque -fonlylink snooker.mod
$./a.out
```

- notice the `-pg` flag to `gm2` (the same applies to `gcc`)

# Performance testing of a game engine

- this flag turns on runtime profiling

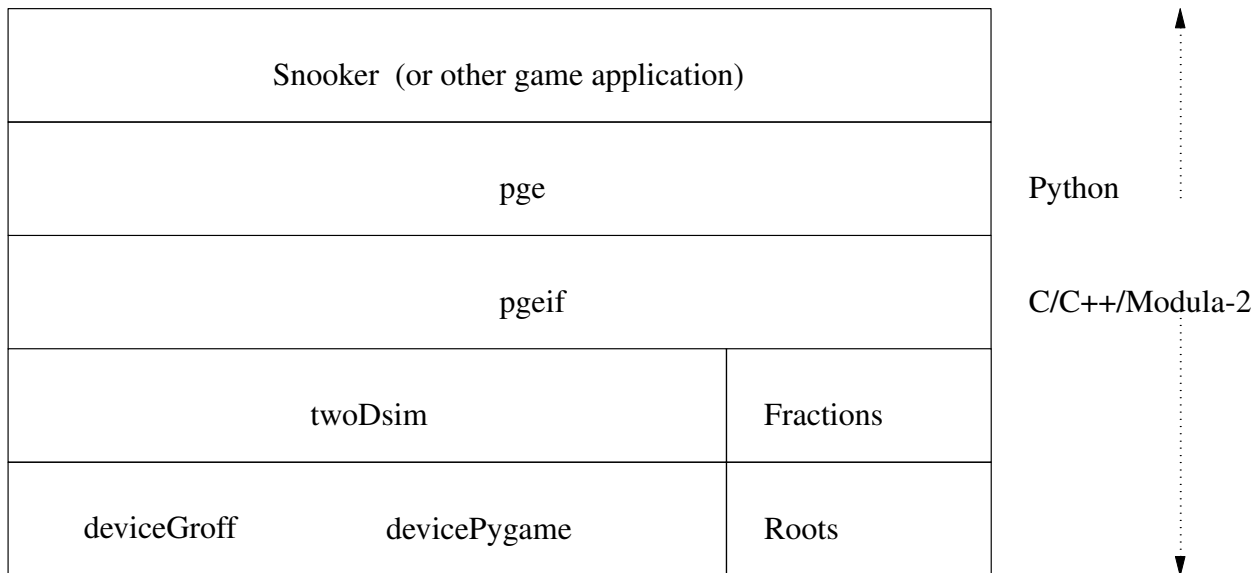
- ```
$ gprof a.out
Flat profile:

Each sample counts as 0.01 seconds.
%   cumulative   self           self         total
time  seconds    seconds   calls   s/call   s/call   name
34.22      2.06      2.06    99486    0.00    0.00  initEntity
30.15      3.88      1.82 132186249    0.00    0.00  Indexing_InBounds
29.49      5.65      1.78 132183929    0.00    0.00  Indexing_GetIndices
 1.41      5.74      0.09                Indexing_DebugIndex
 1.08      5.80      0.07    2320    0.00    0.00  Indexing_PutIndices
 0.50      5.83      0.03 236365    0.00    0.00  unMarkEntity
```


Useful to profile version 1 of PGE

- version 1 was completely implemented in a 3rd generation language (Modula-2)
- we can profile all this code and optimize the hotspots
- as above the InBounds was optimized (removed) and this gave a 30% performance improvement
- version 1 did not link up to Pygame and the game had to be written in Modula-2 as well
- version 2 interacts with Pygame and has a Python interface

Structure of version 2 PGE



Conclusion to the construction of version 2 of PGE

- implemented in Modula-2, C, C++ and Python
- the Modula-2 code is translated into C or C++ code
 - the translated code conforms to GNU coding standards and is very neatly formatted
- the [Python interface documentation](http://floppsie.comp.glam.ac.uk/Southwales/gaius/pge/homepage.html) (`http://floppsie.comp.glam.ac.uk/Southwales/gaius/pge/homepage.html`) is available on line

Obtaining and building pge for the coursework

- you can either obtain pge from the debian package - or from the git repository
 - I'd advise the git repository as it will contain very minor incremental improvements

```
$ cd  
$ mkdir -p Sandpit  
$ cd Sandpit  
$ git clone https://github.com/gaiusm/pge
```

Building PGE

- you can build a local copy by:

```
$ cd
$ mkdir -p Sandpit
$ cd Sandpit
$ rm -rf build-pge
$ mkdir build-pge
$ cd build-pge
$ ../pge/configure --prefix=$HOME/opt --enable-langc
$ make
```

Testing your local copy of PGE



```
$ cd  
$ cd Sandpit/build-pge  
$ ./localrun.sh ../pge/examples/breakout/breakout.py
```