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

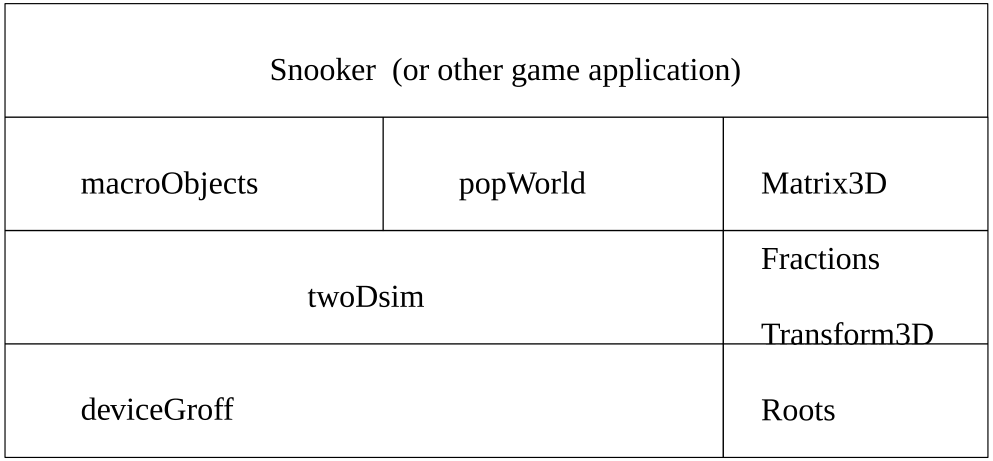
Limitations

- 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

```
$ 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

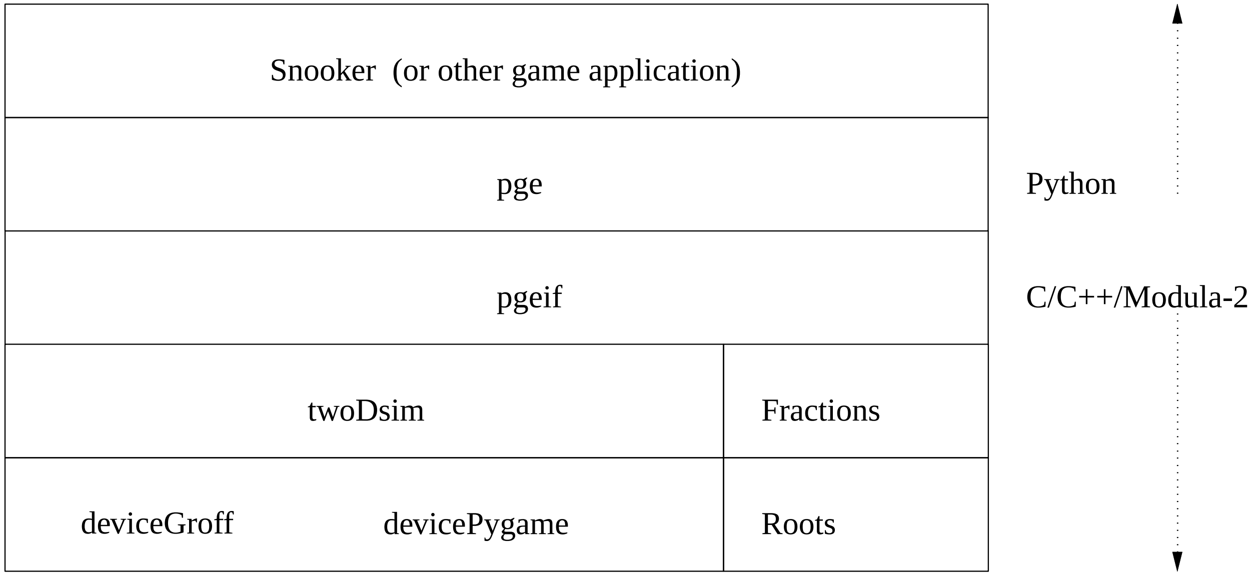
-
  ```
  $ gprof a.out
  Flat profile:

  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_GetIndice
    1.41      5.74     0.09                             Indexing_DebugIndex
    1.08      5.80     0.07     2320     0.00     0.00  Indexing_PutIndice
    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

-



Snooker (or other game application)

pge

pgeif

twoDsim

Fractions

deviceGroff

devicePygame

Roots

Python

C/C++/Modula-2

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`⟩ 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
```