Data structures used in PGE

- in this lecture we will examine the key data structures used in PGE
- at the end of the lecture you should understand how these data structures are used to represent the world of polygons, circles and colours in the game engine
- before we examine the data structures we will examine the API layering in a little more detail

API layering

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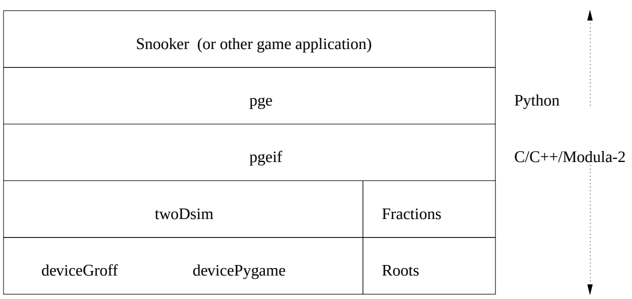


API layering

- recall
  - `python/pge.py` is written in Python
  - `c/pgeif.c` is written in C and its external Python functions are defined in `i/pgeif.i`
  - `swig` generates the wrapping code
- the file `c/pgeif.c` contains the implementation of all the publically accessible Python methods
- it also ensures that all publically created objects in the Physics game engine are remembered and stored in this file

API layering

- this allows colours, polygons, circles to be mapped onto their high level Python counterparts in `python/pge.py`
- it also allows the implementation of `python/pge.py` to be cleaner as it will always obtain any object from `c/pgeif.c`
- examine the implementation for `box` inside `c/pgeif.c`
- we see that much of `c/pgeif.c` just calls upon the services of the lower layer `c/twoDsim.c`
  - after performing extensive checking of parameter types

Implementation of box

- **c/pgeif.c**

```
/*
   box - place a box in the world at (x0,y0),(x0+i,y0+j)
*/

unsigned int box (double x0, double y0,
                  double i, double j, unsigned int c)
{
  double k;

  x0 = check_range (x0, (char *) "box", 3, (char *) "x0",
  y0 = check_range (y0, (char *) "box", 3, (char *) "y0",
  k = check_range (x0+i, (char *) "box", 3, (char *) "x0+
  k = check_range (y0+j, (char *) "box", 3, (char *) "y0+
  return trace (addDef ((TypeOfDef) object,
                        twoDsim_box (x0, y0, i, j,
                        (deviceIf_Colour) lookupDef ((Typ
                (char *) "box", 3);
}
```


Implementation of box

- we see that it creates a box (using `twoDsim_box`)
  - it saves this box in its local definitions `addDef`
  - it is saved as an `object` and not a `colour`
- also note that the 5th parameter to `twoDsim_box` is a colour id, `c`, which is looked up using `lookupDef`

The data structures inside c/twoDsim.c

- **c/twoDsim.c**

```
typedef enum {polygonOb, circleOb, springOb} ObjectType;

typedef enum {frameKind, functionKind, collisionKind} eve

typedef enum {frameEvent, circlesEvent, circlePolygonEven
              polygonPolygonEvent, functionEvent} eventTy
```

- `ObjectType` defines the different kinds of object (ignore spring object)
- `eventKind` defines the three major classification of events

The data structures inside c/twoDsim.c

- `eventType` further subclassifies the event kind with the collision event info
  - we distinguish between a circle/polygon collision and a circle/circle collision and a polygon/polygon collision

object

- c/twoDsim.c

```
typedef struct _T2_r {
       unsigned int id;           /* the id of the object.
       unsigned int deleted;      /* has it been deleted?
       unsigned int fixed;        /* is it fixed to be worl
       unsigned int stationary;   /* is it stationary?  */
       double vx;                 /* velocity along x-axis.
       double vy;                 /* velocity along y-axis.
       double ax;                 /* acceleration along x-a
       double ay;                 /* acceleration along y-a
       double inertia;            /* a constant for the lif
       double angleOrientation;   /* the current rotation a
       double angularVelocity;    /* the rate of rotation.
       double angularMomentum;    /* used to hold the curre
       unsigned int interpen;     /* a count of the times t
       ObjectType object;  /* case tag */
       union {
               Polygon p;  /* object is either a polygon,
               Circle c;
               Spring s;
             };
     };
```


object

- c/twoDsim.c

```
typedef struct _T2_r _T2;
typedef _T2 *Object;
```

- notice you can ignore the `inertia`, `angleOrientation`, `angularVelocity` and `angularMomentum` as these are used to implement rotation

Circle

- c/twoDsim.c

```
typedef struct Circle_r Circle;

struct Circle_r {
       coord_Coord pos;   /* center of the circle in the w
       double r;              /* radius of circle.  */
       double mass;           /* mass of the circle.  */
       deviceIf_Colour col;   /* colour of circle.  */
};
```

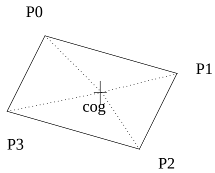
Polygon

- c/twoDsim.c

```
typedef struct Polygon_r Polygon;
struct _T3_a { polar_Polar array[MaxPolygonPoints+1]; };
struct Polygon_r {
                   unsigned int nPoints;
                   _T3 points;
                   double mass;
                   deviceIf_Colour col;
                   coord_Coord cOfG;
                 };
typedef struct _T3_a _T3;
```


Polygon

- the polygon has an array which is used to contain each corner
    - a corner is a polar coordinate from the centre of gravity
-



Polar coordinates

- remember that a polar coordinate has a magnitude and an angle
    - an angle of 0 radians is along the x-axis
    - magnitude of, r and an angle of ω
- so we can convert a polar to cartesian coordinate by:
- $x = \cos(\omega) \times r$
- $y = \sin(\omega) \times r$

Polar coordinates

- in our diagram
- $P0 = (p0, 135/360 \times 2\pi)$
- $P1 = (p1, 45/360 \times 2\pi)$
- $P2 = (p2, 315/360 \times 2\pi)$
- $P3 = (p3, 225/360 \times 2\pi)$
- where p1, p2, p3, p4 are the lengths of the line from the CofG to the corner
    - dotted lines in our diagram

Polar coordinates

- the angle values in the polar coordinates for our polygon are the offset of the angle for the particular corner
  - the angularVelocity is used to determine the rotation of the polygon, this is added to each corner to find out the corner position at any time
- this allows rotation of the polygon to be modelled at a later date

Polar coordinates

- at any time in the future, t we can determine the polygons corner, i by:
- $\Omega = angleOrientation + angularVelocity \times t$
- $x_i = cofg_x + r_i \times \cos(\omega_i + \Omega)$
- $y_i = cofg_y + r_i \times \sin(\omega_i + \Omega)$

Polar coordinates

- we can see how this data structure represents a polygon by following the `dumpPolygon` function

Polar coordinates

- see how each corner is defined by following through the function `box`
  - into `poly4`
- how it calculates the box CofG
- how it defines each corner relative to the CofG and as a polar coordinate
  - each corner is orbiting the CofG

dumpPolygon

- c/twoDsim.c

```
static void dumpPolygon (Object o)
{
  unsigned int i;
  coord_Coord c0;

  libc_printf ((char *) "polygon mass %g colour %d\\n", 2
               o->p.mass, o->p.col);
  libc_printf ((char *) "  c of g  (%g,%g)\\n", 19,
               o->p.cOfG.x, o->p.cOfG.y);
  for (i=0; i<=o->p.nPoints-1; i++)
    {
      c0 = coord_addCoord (o->p.cOfG,
           polar_polarToCoord (polar_rotatePolar
           ((polar_Polar) o->p.points.array[i], o->angleO
      libc_printf ((char *) "  point at (%g,%g)\\n", 20,
    }
}
```


dumpPolygon

- follow through the function `doDrawFrame` and see how the corners of a polygon are updated dependant upon the `angularVelocity`, `angleOrientation` and the acceleration and velocity components
- examine `newPositionRotationCoord`, `newPositionRotationSinScalar` and `newPositionRotationCosScalar`

Acceleration and Conclusion

- examine the function `getAccelCoord` and see if you can think how you might modify PGE to allow per object gravity