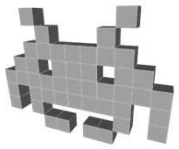
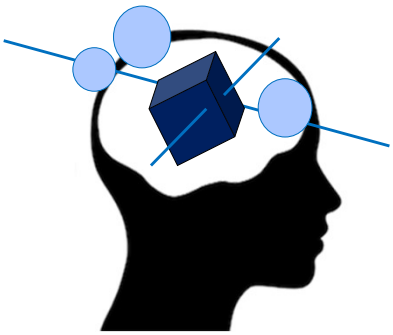
3D VideoGames - UniMi

Points, Vectors, Versors: (final notes on programming)





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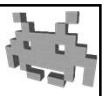
Points, Vectors, Versors: Internal representation



- *n*-tuple of scalar values (*n* is the dimension)
  - for us (usually): *n* = 3 (at times, 2 or 4)
  - they are the Cartesian coordinates of the point/vector
- e.g.:

```
class Vector3 {
  // fields:
  float coords[3];

  // methods:
  …
}
```

or:

```
class Vector3 {
  // fields:
  float x, y, z;

  // methods:
  …
}
```

- note: the same structure is often used to represent points, vectors, and versors

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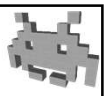
Caveat (about coding): one type, multiple semantics



- Many libraries/engines/languages opt to use the same data type for 3D points, 3D vectors, 3D versors, (plus, sometimes: colors, and more)
  - alternatively, a library can use different types, e.g. Vector, Point, Versor
- Still, they should not be considered the same thing
  - that's nothing new: likewise, we use the same scalar data types ("float", "doubles") with widely different semantics (e.g. "weight", "volume", "temperature"…).
- It is up to the coder to *operate* on them accordingly
  - e.g.: not ok to sum a *temperature* with a *surface area*
  - e.g.: it's ok to divide a *weight* by a *volume* (and get a *specific weight*)
- which operations do make sense on points, vectors, versors?
  - the ones we have seen in their *algebra* !

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Points, Vectors, Versors: Internal representation

- same class for points, vectors, and versors
- this is done in many libs & languages, e.g.:

class Vector3
https://docs.unity3d.com/ScriptReference/Vector3.html

class FVector
http://api.unrealengine.com/INT/API/Runtime/Core/Math/FVector/

- and also: GLSL, HLSL, GLM, Eigen, VcgLib , three.js, …

vec3 (GLSL, HLSL, GLM) — shader languages
Vector3d (Eigen) — C++ libraries
Point3d (VcgLib) — C++ libraries
Vector3 (three.js) — JavaScript library

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Classes for Points / Vectors / Versors
A few examples in C++ libraries

- GLM library (*Graphics*) : class `vec3`
- UNREAL ENGINE library (*Videogames*) : class `VectorF`
- Eigen lib (*Linear Algebra*) : class `Vector3d`
- VCG-Lib (*Geometry processing*) : class `Point3f`
- Point Cloud Lib (*Geometry Processing*) : class `ON_3dVector`
- openMesh for (*Geometry processing*) : class `VectorT`
- cgall for (*Geometry Processing*) : class `Vector3`
- CinoLib (*Geometry Processing*) : class `vec3d`
- OpenCV for (*Computer Vision*) : class `Point3f`
- bullet for (*Physical Simulation*) : class `btVector3`
- ODE for (*Physical Simulation*) : class `dVector3`

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Classes for Points / Vectors / Versors:
Other examples in C++ like languages

- GLSL shader language from Chronos : type `vec3`
- HLSL shader language from DirectX : type `float3`
- unity , C# *(videogames)*: class `Vector3`
- three.js , JavaScript *(graphics)* : class `Vector3`

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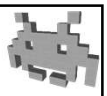
Programming with vector algebra: the code looks like the expressions



- Concept ("on paper"): $\mathbf{p} = \mathbf{p} + k\,\hat{\mathbf{d}}$
- Code:
  - Data types:

```
Point3D dragonPos = …;
Versor3D dir = …;
float k = …;
```

  - Beginner's style code:

```
dragonPos.x = dragonPos.x + dir.x * k ;
dragonPos.y = dragonPos.y + dir.y * k ;
dragonPos.z = dragonPos.z + dir.z * k ;
```

  - What you should do:

```
dragonPos.add( dir.scale(k) );
```

or (depending on the language)

```
dragonPos += dir * k ;
```

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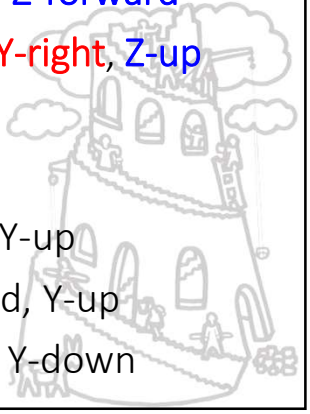
Semantics associated to X,Y,Z: still no standards for 3D games

personal opinion: the most standard one, among 3D modellers too

- Unity: left-handed: X-right, Y-up, Z-forward
- Unreal: left-handed: X-forward, Y-right, Z-up
- 3ds-Max: right-handed, Z-up
- Blender: left-handed, Z-up
- most VR systems: right-handed, Y-up
- OpenGL: (clip space) right-handed, Y-up
- DirectX: (clip space) left-handed, Y-down



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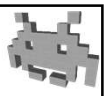
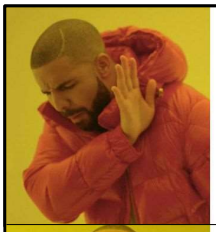
Pro-tip: try making your code assumption free!



E.g.: to move a pos 2.5 units “to the right”:



```
Vector3 pos = new Vector3 ( … );

pos.x = pos.x + 2.5;   // maybe ??
pos.y = pos.y + 2.5;   // hmm…??
```

```
Vector3 pos = new Vector3 ( … );

pos += Vector3.right * 2.5;
```

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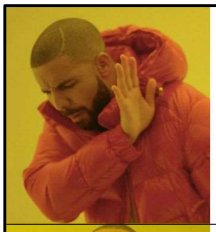
Pro-tip: try making your code assumption free!

E.g.: to move a pos 2.5 units “to the right”:



```
FVector pos = FVector( … );

pos.X += 2.5f;   // maybe ??
pos.Y += 2.5f;   // hmm…??
```

```
FVector pos ( … );

pos += FVector::RightVector * 2.5f;
```

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