

Kyzis 3D Engine: A Geometry Based on Local Dimensions

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Introduction

A three-dimensional environment can be envisioned differently from a uniform space in which all objects are subject to the same fixed axes. A shape has its own geometry, its own surfaces and its own orientations. The Kyzis 3D engine starts from this principle: **the geometry of each object defines its dimensional frame of reference.**

Dimensions are therefore not merely global axes used to position objects. They can be associated directly with their shape. A surface thus constitutes a two-dimensional space that can be curved, closed or deformed. Its local directions evolve with its geometry and with the point under consideration.

A sphere provides a simple example. Its surface can be regarded as two dimensions folded around its volume. When an object moves across this surface, its motion can be determined relative to the local directions beneath it rather than solely relative to the general axes of the environment.

The same principle becomes particularly interesting with complex shapes. A human body, for example, has arms, legs, a torso, a head and joints whose orientations differ. The bones can serve as reference structures for the movement of the limbs, while the surface of the body has its own dimensional continuity.

A fly walking on a body naturally illustrates this approach. Moving from the forearm to the elbow, then to the arm and the shoulder, it follows a surface whose orientation changes continuously. Its frame of reference for movement can adapt to the local geometry it encounters. The notion of surface then becomes directly tied to movement and collision.

Collision textures can also be associated with this geometry, making it possible to define the physical properties of different regions of a single surface. The geometric shape is not limited to a primitive such as a cube or a sphere: it can represent any structure, however irregular and complex it may be.

The Kyzis 3D engine thus rests on a fundamental idea:

Geometry defines the local dimensions of the object, and interactions appear when the dimensional frames of reference of several geometries come into relation.

This approach opens the way to an engine in which surfaces, movements, joints and collisions are described from the objects' own geometry rather than from a single dimensional frame of reference imposed on the entire environment.

Chapter 1: The Dimensional Frame of Reference

The Kyzis 3D engine rests on a fundamental principle: **each object has its own dimensional frame of reference, determined by its geometry, its position and its orientation.**

The general axes of a 3D environment can be kept in order to locate objects relative to one another. However, they need not define the dimensions specific to each object. A sphere, an arm, a wheel or an irregular surface has a geometry that can be described from its own directions.

The frame of reference thus becomes a local property of the geometry.

1.1 The Frame of Reference Specific to Each Object

Two objects in the same environment can have completely different orientations. Their local dimensions are therefore not necessarily aligned.

An object thus has its own system for determining:

- its local directions;
- its orientation;
- its surfaces;
- its possibilities of rotation;
- its possibilities of movement;
- its relationships with surrounding objects.

The general frame of reference remains useful for knowing the object's position in the environment. However, the object's internal behavior can be defined relative to its own frame of reference.

This distinction leads to two levels:

General frame of reference → position of the object in the environment

Dimensional frame of reference → geometric organization specific to the object

1.2 Dimensions Depend on Geometry

A geometric shape does not necessarily have the same orientation at each of its points.

This property appears immediately when considering a curved surface.

The surface of a sphere can be regarded as a two-dimensional surface closed in on itself. A position at the top of this sphere and another on its side belong to the same surface, but their local orientations are different.

The dimensional frame of reference can therefore depend on the point considered.

We then obtain:

geometry → local position → local directions

Dimensions are no longer simply imposed from the outside. They follow the geometric shape of the object.

1.3 The Example of the Ball Rolling on the Ground

A ball rolling on the ground directly illustrates this principle.

The ball has its own spherical geometry. The ground also has its own surface and its own frame of reference.

When the ball touches the ground, a region of its surface comes into relation with the surface of the ground. As the ball moves forward, it turns. The point of the sphere that was in contact with the ground then moves away and a new point on the surface takes its place.

The sequence becomes:

surface of the ball → contact → rotation → change of position on the surface → new contact

The engine can then consider the local frame of reference of the ball's surface at the point of contact, as well as that of the ground.

The important phenomenon is therefore no longer solely the movement of the ball's center along three general axes. **The rotation continuously brings new regions of the ball's geometry into the contact zone.**

Contact becomes a relationship between two surfaces, each with its own local dimensional structure.

1.4 The Continuous Change of the Frame of Reference

On a curved surface, local directions can change gradually.

In the case of the ball, advancing along the surface also means following its curvature. Each new position has a slightly different orientation from the previous one.

It then becomes possible to represent a continuity:

$P_1 \rightarrow P_2 \rightarrow P_3 \rightarrow P_4 \rightarrow \dots$

Each position P corresponds to a local frame of reference associated with the geometry of the surface at that location.

The rotation of the ball is thus no longer considered only as the rotation of an object relative to the general axes. It can also be interpreted as **the successive displacement of the surface's local frames of reference in the contact region.**

1.5 The Frame of Reference of a Complex Shape

The same principle can be extended to a geometry far more complex than a sphere.

A human arm, for example, is not a uniform geometric primitive. Its volume changes, its surface curves and its orientation also depends on the position of the limb and its joints.

It can then have several levels of reference.

The bone provides a structural direction for the limb. The joint defines its possibilities of movement relative to the rest of the body. The surface, in parallel, has its own local directions.

The complete geometry can therefore be built from frames of reference linked to one another.

1.6 The Frame of Reference as a Relationship

When an object collides with another, their frames of reference should not be considered automatically aligned.

The engine must establish a relationship between them.

For the ball and the ground:

frame of the ball $\leftrightarrow$ contact surface $\leftrightarrow$ frame of the ground

For a foot placed on the ground:

frame of the foot $\leftrightarrow$ contact surface $\leftrightarrow$ frame of the terrain

For a hand grasping an object:

frame of the hand ↔ contact zones ↔ frame of the object

Each interaction thus becomes a local geometric relationship.

1.7 Principle of the Kyzis Dimensional Frame of Reference

The dimensional frame of reference can finally be summarized by one principle:

The dimensions of an object are defined relative to its own geometry. The general frame of reference locates the object in the environment, while the local frames of reference describe its shape, its surfaces, its orientation and its interactions.

The Kyzis 3D engine therefore does not necessarily eliminate general coordinates. It gives them a different role.

General coordinates indicate **where the object is**.

The dimensional frame of reference indicates **how the object exists geometrically at this position**.

In the example of the ball rolling on the ground, this distinction becomes essential: the ball can move forward through the environment while having a surface whose local frame of reference changes continuously as it rotates.

It is this relationship between **shape, surface, position, orientation and frame of reference** that forms the first foundation of the Kyzis 3D Engine.

Chapter 2: Potential Dimensions

The Kyzis 3D Engine introduces the notion of **potential dimension** in order to describe an object's geometry from its own directional possibilities. A dimension is no longer considered merely as a fixed X, Y or Z axis common to the whole environment. It can be defined locally, from a position and a direction belonging to the geometry itself.

This approach makes it possible to represent simple shapes as well as extremely complex ones without artificially imposing the same dimensional alignment on them.

2.1 The dimension as a directional possibility

A potential dimension represents a **direction accessible from a given position**.

It can be described conceptually by the association:

position + direction = potential dimension

If the position changes, the corresponding direction may also change.

The dimension therefore depends on the point under consideration.

On a straight line, successive directions can remain aligned. On a curved surface, by contrast, they can evolve progressively with the geometry.

A dimension is thus under no obligation to be rectilinear.

2.2 Potential dimensions and effective dimensions

Not all the possible directions of a geometry are necessarily used during an interaction.

A **potential dimension** represents a possibility of movement or orientation offered by the geometry.

An **effective dimension** corresponds to a possibility actually used during a movement, a rotation, a contact or a collision.

This distinction allows the engine to keep the complete geometric structure of an object while determining only the directions relevant to the action in progress.

2.3 The surface as a set of dimensions

A surface can be considered as a two-dimensional space whose directions follow its own shape.

In the case of a plane, this organization is relatively simple since the directions can remain aligned across the whole surface.

A curved surface presents a different situation.

On a sphere, the directions available at one position may have a different orientation from those available elsewhere. Yet they still belong to the same continuous surface.

The surface thus becomes an **organized set of local potential dimensions**.

2.4 The example of the ball

Let us consider once more a ball rolling on the ground.

The ball has a spherical surface. Each region of this surface has its own directional possibilities.

When part of the ball touches the ground, some potential dimensions of that region become particularly important for the interaction: those that describe the surface around the contact and its relationship with the ground.

When the ball rolls, the point of contact changes.

The region that previously touched the ground moves away, while a new region comes into contact with it.

We obtain a succession:

position A → position B → position C → position D

But each of these positions belongs to a curved surface. The corresponding local directions therefore evolve with the geometry of the ball.

The movement can thus be interpreted as a progression through the potential dimensions of its surface.

2.5 A shape is not limited to three straight lines

This conception becomes particularly important for complex shapes.

A human arm, for example, resembles neither a cube nor a perfect sphere. Its surface continuously changes in shape, orientation and curvature.

Using exclusively three fixed directions to define this geometry does not correspond to the principle of the Kyzis 3D Engine.

The arm instead has a dimensional structure tied to its own shape.

The bone can provide a dominant structural direction. The joint can define possibilities of rotation and movement. The surface simultaneously has a set of local potential dimensions corresponding to its geometry.

These different levels can coexist within the same object.

2.6 The example of the fly

A fly moving across a person's body helps us understand the function of these potential dimensions.

The fly can walk along the forearm, reach the elbow, continue along the upper arm and then move onto the shoulder.

The surface is never perfectly straight.

At each new position, the fly encounters a slightly different local orientation. Yet it simply keeps moving forward relative to the surface.

In the Kyzis 3D Engine, this movement could be interpreted as the successive passage between the directional possibilities offered by the surface:

position → potential directions → movement → new position → new potential directions

The fly therefore need not directly consider the whole body as an object aligned on three fixed axes. It interacts with the geometry immediately beneath it.

2.7 Potential dimensions in collisions

The same logic can be applied to collisions.

When two objects meet, their local potential dimensions are not necessarily aligned.

The engine must then determine the geometric relationship existing between the two surfaces at the point of contact.

For the ball and the ground:

potential dimensions of the ball ↔ contact ↔ potential dimensions of the ground

For a hand holding an object:

potential dimensions of the hand ↔ contact ↔ potential dimensions of the object

The collision is then no longer defined solely relative to the general environment. It becomes an interaction between the dimensional structures of the objects involved.

2.8 A geometry capable of taking any shape

One of the goals of this approach is precisely not to limit the engine to a collection of ideal shapes.

A geometry can be round, angular, curved, irregular, articulated or composed of several types of surfaces.

Potential dimensions make it possible to preserve this diversity, since the directions are associated with the real shape of the object and with the different points that make it up.

A rock therefore does not need to be conceptually reduced to a cube.

An arm does not need to be reduced to a cylinder.

A terrain does not need to be reduced to a plane.

Each shape can produce **its own dimensional organization**.

2.9 The Kyzis principle of potential dimensions

The Kyzis 3D Engine can finally establish the following principle:

A potential dimension is a directional possibility associated with a position in a geometry. When the position changes, the directional possibilities may change with it.

This definition makes it possible to consider a surface as a continuous dimensional structure rather than as a mere envelope placed in an external frame of reference.

The frame of reference discussed in the previous chapter thus indicates **how the geometry is organized**, while potential dimensions indicate **which directions this geometry makes accessible from its different positions**.

The engine can then begin to represent objects no longer solely as sets of coordinates, but as **geometric structures carrying directional possibilities**.