The Kyzis 3D Engine 2.0

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Introduction

The **Kyzis 3D Engine 2.0** rests on a fundamental idea: a three-dimensional world should not necessarily be built by imposing the same fixed dimensions on every object. Each object has its own geometry, its own frame of reference, its own surfaces and its own possibilities of movement.

In this view, dimensions are therefore not used only to position an object in a global space. They take a direct part in its construction, its measurement, its movements, its deformations and its interactions.

A balloon provides a simple example.

The balloon has a volumetric frame of reference that defines its spherical shape. Its surface also has its own frame of reference made up of two curved, finite dimensions. An element located on this surface can follow these dimensions directly, without having to be treated as an independent element that is constantly repositioned in the general frame of reference of the scene.

This approach had already been introduced in the first design of the engine, in which textures were treated as dimensions belonging to the objects, and position had to follow their frame of reference.

Potential Dimensions

The Kyzis 3D Engine 2.0 also introduces the notion of **potential dimensions applied to geometry**.

Here, potential dimensions are the dimensions that may be needed to build, measure, traverse or transform an object at a given resolution.

A pentagon can be described as a two-dimensional surface. But its construction reveals several calculable geometric directions: its five sides, the directions connecting its center to its five vertices and, if its geometry is broken down further, the new directions resulting from that decomposition.

The number of potential dimensions is therefore not absolute. It depends on the geometry described and on the chosen resolution.

The more complex and precisely defined the geometry, the more potential dimensions it can reveal.

The Surface as a Flexible Structure

In the Kyzis 3D Engine 2.0, a texture is not conceived as a simple image pasted onto an object.

It is a **flexible dimensional surface**.

A surface with two dimensions can be curved. This curvature allows it to produce a three-dimensional shape. A texture can thus be compared to a flexible sheet that is curved around a balloon and can then be deformed again in a particular region.

This property becomes fundamental for collisions.

When two objects come into contact, their surfaces locally create a **frame of reference for collision and curvature**. The direction of movement, the angle of arrival, the local orientations of the surfaces and their properties determine how the curvature evolves.

The collision then becomes a geometric transformation:

contact → curvature → deformation → limit → restitution → push → rebound

A rigid surface keeps its geometry. A flexible surface, on the other hand, can locally adapt its curvature to the surface it meets.

Collision Belongs to Surfaces

A balloon hitting the ground illustrates this logic.

At the initial point of contact, a local region of the balloon's surface begins to curve relative to the geometry of the ground. The speed of arrival helps determine the extent of this deformation.

Flexibility is expressed as a percentage.

At **100% curvature**, in this definition, the surface can reach the curvature determined by the surface it meets and by the conditions of the impact. This value therefore does not represent infinite curvature. It represents the full attainment of the reference curvature determined by the collision.

When the limit is reached, the surface seeks to recover its geometry. The reversal of this deformation then exerts a push on the opposing surface and contributes to the movement or rebound of the object.

Thus, a collision is no longer merely the observation that two volumes intersect.

It becomes a temporary interaction between the own dimensions of two surfaces.

A Living Geometry

This is ultimately the central idea of the Kyzis 3D Engine 2.0.

An object is not merely a shape drawn in a fixed three-dimensional space. It is a structure that has: - its own frame of reference; - its own geometry; - surface dimensions; - potential dimensions; - movement dimensions; - local curvature properties; - rigidity and flexibility properties; - dimensional interactions with other objects.

The setting therefore does not need to impose its geometry on every object. **Each object carries its own geometry and interacts with that of the others.**

The Kyzis 3D Engine 2.0 can thus be summed up in one principle:

Geometry does not merely serve to represent the object. It becomes the mechanism by which the object exists, moves, deforms and interacts.

Chapter 1 — Potential Dimensions

The **Kyzis 3D Engine 2.0** is based on a particular conception of dimensions: the dimensions of an object are not limited to the three fixed axes of a global space. They depend on the geometry of the object, its frame of reference, its surfaces and the degree of precision with which this geometry must be built, measured or traversed.

In this approach, a **potential dimension** is a calculable geometric direction that may become necessary to define an object or to allow movement within its structure.

1.1 — From the Fixed Axis to the Calculable Direction

An object can be located in a scene using three general coordinates. However, these coordinates do not necessarily describe its entire structure.

Take a pentagon.

It can be represented on a surface with two dimensions. Yet its construction brings out several geometric directions: - five segments form its outline; - five directions can connect its center to its five vertices.

At this level of description, the pentagon therefore has ten directly calculable directions.

In the Kyzis 3D Engine 2.0, these directions can be considered **potential dimensions**, because they contribute to the geometric definition of the object.

This does not mean that the pentagon becomes an absolute ten-dimensional space. The word potential is essential: it indicates that these dimensions appear according to the needs of construction, measurement and movement, and according to the chosen geometric resolution.

1.2 — Dimensional Resolution

The quantity of potential dimensions depends directly on the level of detail with which an object is described.

The pentagon can, for example, be broken down into five triangles. Each of these triangles can then be analyzed separately. New geometric directions then become calculable.

If this subdivision continues, the description can become more and more complex and gradually approach a fractal logic.

There is therefore not necessarily an absolute number of potential dimensions permanently associated with a shape.

The principle is rather:

The more complex the geometry of an object and the more precisely its structure is defined, the more potential dimensions the object can reveal.

The chosen resolution determines how far this decomposition must go.

For a simple simulation, only a few dimensions may be needed. For an extremely precise simulation, a much larger quantity of potential dimensions may become relevant.

1.3 — Dimensions Specific to the Surface

Surfaces also have their own dimensional frame of reference.

A balloon helps illustrate this principle.

The surface of the balloon can be traversed along two dimensions specific to that surface. However, these two dimensions are not flat. They are **curved and closed around the object**.

The balloon also has a frame of reference that defines its volumetric geometry.

A distinction must therefore be made between:

the frame of reference of the object, which defines its overall structure,

and

the frame of reference of its surface, which defines how an element can travel across that surface.

This separation becomes fundamental in the engine.

An element attached to the surface of the balloon does not need to be considered only as an independent position in global space. Its position can be defined relative to the curved dimensions of the balloon's surface.

When the balloon moves or rotates, the element follows its frame of reference.

1.4 — Curvature as a Dimensional Transformation

Two surface dimensions can also curve.

This property is central to the Kyzis 3D Engine 2.0.

A sheet of paper provides an intuitive picture. It has a surface that can be considered along two directions. When the sheet is curved around a balloon, its surface directions do not disappear. They gradually change orientation and produce a geometry that extends in depth.

In the engine's model:

flexible 2D surface + curvature = 3D geometry

Depth therefore does not necessarily have to be imposed on each portion of surface as an independent fixed third axis. It can emerge from the curvature of the surface's own dimensions.

This property then makes it possible to define local deformations. A small region of the texture can change its curvature while the rest of the surface keeps its geometry.

1.5 — Potential Dimensions and Movement Dimensions

A potential dimension can become a **movement dimension** when it actually provides a path that an element can travel.

This dimension can be straight, curved, closed, folded or cyclic.

It does not necessarily need to be infinite.

A dimension can contain a finite number of positions while still allowing continuous movement when its end joins its origin.

Thus:

finite does not necessarily mean ending at a boundary.

A finite dimension can close back on itself.

This property allows the engine to represent movements in which the element directly follows the geometry of the object, rather than constantly depending on a uniform global space.

1.6 — The Object as a Set of Dimensional Frames of Reference

A complex object therefore does not necessarily have a single dimensional frame of reference.

It can have, simultaneously: - a global frame of reference specific to the object; - frames of reference associated with its different surfaces; - movement dimensions; - potential dimensions revealed by its geometry; - local dimensions appearing during a deformation; - temporary frames of reference created during interactions with other objects.

An arm, a balloon, a wheel, a rugged surface or an articulated object do not necessarily need to be described in the same way.

Geometry determines the dimensions needed to describe itself.

1.7 — Fundamental Principle

The Kyzis 3D Engine 2.0 can therefore establish its first principle:

A potential dimension is a calculable geometric direction that may be needed to build, measure, traverse, deform or transform an object. The number of potential dimensions is not absolute: it depends on the geometry of the object and on the resolution with which that geometry is defined.

This definition profoundly changes the way the engine can consider an object.

The object is no longer simply placed in three dimensions to which it must entirely conform.

The object has its geometry. Its geometry defines its dimensions. Its dimensions define its possibilities of movement and transformation.

Chapter 2 — The Dimensional Frame of Reference

The **Kyzis 3D Engine 2.0** holds that an object must not be defined solely by its position in a general three-axis system. Each object has its own frame of reference, determined by its geometry, its orientation, its surface dimensions and its possibilities of movement.

The frame of reference thus becomes the link between the shape of an object and its behavior in the simulation.

2.1 — Each Object Has Its Own Frame of Reference

An object does not exist only through its position in the setting. It has an internal geometric organization that belongs to it.

A balloon, for example, has a center, a spherical volume and a curved surface. These elements remain linked to one another when the balloon rolls, spins, bounces or deforms.

The principle of the engine therefore consists of considering that the elements belonging to the balloon **follow its frame of reference**.

When an element is attached to its surface, its position can be defined relative to the dimensions of that surface. If the balloon spins, the element does not need to be thought of as an independent entity whose position would be redefined from scratch. It follows the transformations of the frame of reference to which it belongs.

The principle can be summarized as follows:

An element belongs first to the frame of reference of the object that carries it. Its position in the world then results from the position and transformation of that frame of reference.

2.2 — Frames of Reference Can Be Nested

A single object can have several levels of frames of reference.

For the balloon, we can distinguish at least:

The frame of reference of the object

It represents the general structure of the balloon, its center, its shape and its orientation.

The frame of reference of the surface

It contains the two curved dimensions that allow the surface to be traversed.

Local frames of reference

A small region of the surface can temporarily have a different geometry when the balloon deforms.

These frames of reference are not independent. They are nested.

A change to the main frame of reference carries the surface with it. A local change to the surface transforms only the region concerned while remaining attached to the whole object.

We thus obtain a hierarchy:

object → surface → local region → element

Each level follows the one to which it belongs.

2.3 — The Surface Frame of Reference

The surface frame of reference is particularly important.

A surface is not merely a visual envelope. It is a space in which movements can take place.

On a balloon, the two surface dimensions are curved. An element moving across this surface follows this curvature.

This is the case of a fly walking over a balloon: the relevant movement is the one made **on the surface**, not an arbitrary succession of movements imposed along three external axes.

The engine can therefore directly treat the surface's own dimensions as a space of movement.

This approach preserves a natural relationship between:

local position → surface geometry → frame of reference of the object → environment

2.4 — The Frame of Reference Is Dynamic

The frame of reference of an object is not necessarily fixed.

If the balloon rolls, its frame of reference rotates.

If it bounces, the frame of reference moves.

If it deforms, certain parts of its surface frame of reference change curvature.

If it collides with another object, a new local frame of reference can temporarily appear between the surfaces.

The engine therefore does not consider geometry as an immobile structure.

The frame of reference is a **dynamic structure carrying the dimensions of the object**.

The dimensions belonging to the balloon naturally follow its transformations.

2.5 — The Two Curved Dimensions of the Surface

A fundamental characteristic of the engine is that a flexible surface keeps its dimensions when it curves.

Take a sheet of paper.

When it is flat, its surface can be described along two dimensions. If this sheet is curved around the balloon, these dimensions continue to exist, but their directions vary gradually along the surface.

Curvature then transforms the geometry produced by these two dimensions.

In the model:

2 surface dimensions + curvature → three-dimensional shape

The third geometric component therefore does not necessarily need to be imposed locally as an additional fixed axis. It can appear through the curvature of the surface dimensions.

This property becomes particularly important during deformations.

2.6 — The Local Frame of Reference for Curvature

When a flexible region deforms, the engine can establish around that region a **local frame of reference for curvature**.

It describes the temporary transformation of the surface.

Take a balloon hitting a rigid floor.

At first, the two surfaces meet in a very small region. The geometry of the floor, the orientation of the balloon, the speed of arrival and the properties of the surfaces determine how this region must evolve.

The surface dimensions of the balloon then begin to curve locally.

The rest of the balloon keeps its general frame of reference while the contact region temporarily has an additional transformation.

The engine therefore does not need to treat deformation as an arbitrary modification of the whole object.

The deformation belongs to the region concerned and to its local frame of reference.

2.7 — Interaction Between Two Frames of Reference

A collision then becomes the meeting of two dimensional frames of reference.

Each surface contributes: - its local directions; - its orientation; - its current curvature; - its capacity for curvature; - its texture properties; - its movement.

The angle of arrival also determines how the two geometries meet.

The local directions can be combined to determine the relevant orientation of the collision. Cross products can notably provide perpendicular directions useful for calculating the local frame of reference of the contact.

The collision then becomes a geometric interaction:

frame of reference A + frame of reference B + relative motion → local collision frame of reference

This frame of reference did not necessarily exist before the contact.

It appears because the two surfaces interact.

2.8 — A Temporary Frame of Reference

The collision frame of reference has a particular characteristic: it can be temporary.

It appears at contact.

It evolves during the deformation.

It changes when the surface reaches its maximum curvature.

It then accompanies the restitution of the surface.

Finally, when the objects separate, this frame of reference is no longer needed.

We thus obtain:

contact → creation of the frame of reference → curvature → restitution → separation → disappearance of the frame of reference

The geometry of the engine thus becomes capable of creating and deleting frames of reference according to interactions.

2.9 — The Object No Longer Depends Entirely on the World

In this architecture, the general system of the scene can still be used to determine where the different objects are relative to one another.

But it must no longer describe their entire internal geometry on its own.

A balloon knows its surface.

A surface knows its dimensions.

A region knows its curvature.

An element attached to this region knows its position relative to it.

The world therefore does not need to be **the sole frame of reference for all geometric properties**.

It is the object that first possesses its dimensional structure.

2.10 — Principle of the Dimensional Frame of Reference

The second fundamental principle of the Kyzis 3D Engine 2.0 can therefore be formulated as follows:

Every object has its own dimensional frame of reference to which its geometry, its surfaces and its elements are attached. Local frames of reference can appear or be transformed when the geometry of the object curves, deforms or interacts with that of another object.

This architecture directly links the first two principles of the engine:

potential dimensions determine the available geometric directions;

the dimensional frame of reference organizes these directions and allows elements to follow them.

Thus, the engine no longer describes only **where an object is**.

It describes **the own space in which this object exists and can transform itself**.

It is this own space that will accompany the object in its movement.

Chapter 3 — The Mechanics of Collisions

In the **Kyzis 3D Engine 2.0**, a collision is not defined solely as the meeting of two volumes. It is considered a **dynamic interaction between the dimensional frames of reference of two surfaces**.

Each surface has its geometry, its local dimensions, its orientation, its capacity for curvature and its physical properties. When two surfaces meet, these properties determine how the contact zone evolves.

The collision thus becomes a dynamic geometric phenomenon in which the surfaces can curve, transmit their movement, reach their deformation limits and then restore this deformation in the form of movement or rebound.

3.1 — The Meeting of Two Surfaces

Every collision begins with the meeting of two surfaces.

Before contact, each object moves in its own frame of reference. Its surface dimensions follow its geometry and its movement.

At the moment of contact, the two local geometries meet.

The engine then has several pieces of information: - the local geometry of each surface; - the directions followed by their dimensions; - the orientation of the surfaces; - the relative speed of the objects; - their angle of arrival; - their capacity for curvature; - their rigidity or flexibility properties.

This information makes it possible to build a **local collision frame of reference**.

This frame of reference belongs to the interaction itself. It is not necessarily permanent in the structure of the two objects.

3.2 — The Point of Contact as a Dimensional Space

In the engine, the point of contact must not be considered only as a mathematical point with no extent.

It is the origin of a contact region with its own surface dimensions.

At the beginning of the collision, this region can be extremely small. As the deformation increases, the region gradually extends over the surfaces concerned.

It then becomes possible to consider this region as a **local two-dimensional space capable of curving**.

This curvature naturally produces a local three-dimensional geometry:

2D surface → curvature → local 3D shape

The three-dimensional behavior of the collision can thus emerge from the transformation of the surfaces' own dimensions.

3.3 — The Angle of Arrival

The collision depends directly on the way the objects meet.

A direct impact does not have the same geometry as an oblique impact.

The relative speed gives a direction of movement, while the local orientation of the surfaces indicates how this movement meets their dimensions.

The angle of arrival therefore helps determine: - the direction of the deformation; - the distribution of the curvature; - the evolution of the contact zone; - the direction of the restitution; - the trajectory resulting from the collision.

Thus, the collision is not calculated solely from the position of the objects' centers. **The real geometry of the surfaces at the point of meeting directly contributes to the result.**

3.4 — Cross Products and the Orientation of the Contact

The local directions of the surfaces also provide the information needed to determine the orientation of the collision frame of reference.

If two local directions are represented by the vectors $\vec{u}$ and $\vec{v}$, their cross product gives a perpendicular direction:

$$\vec{n} = \vec{u} \times \vec{v}$$

This direction can help define the local orientation of the contact.

The engine can therefore use the geometric properties of the surfaces themselves to determine the relevant directions of the collision.

The collision frame of reference is not arbitrarily imposed by the general axes of the world. **It is built from the directions actually present in the local geometry of the objects.**

3.5 — Curvature Caused by the Impact

Take the example of a balloon hitting a rigid floor.

The surface of the balloon has two curved and flexible dimensions. The floor also has its own surface geometry, but its rigidity prevents this geometry from deforming significantly.

At contact, the geometry of the floor therefore becomes a constraint for the flexible surface of the balloon.

The speed of arrival, the angle of impact and the properties of the texture progressively determine the degree of curvature applied to the contact zone.

The texture of the balloon then begins to modify its dimensions locally.

The balloon does not lose its main frame of reference. It is **a region of its surface that temporarily adopts a new frame of reference for curvature**.

3.6 — The Curvature Percentage

Deformation can be represented by a percentage.

This percentage expresses the degree to which the flexible surface can reach the curvature determined by the surface it meets under the current conditions of the impact.

Thus:

0% corresponds to the state in which the surface keeps its initial geometry.

An intermediate value corresponds to a partial adaptation of its curvature.

100% represents the full attainment of the curvature defined by the interaction with the surface met.

The 100% therefore does not represent infinite curvature.

It is **the curvature limit determined for this particular interaction**.

This limit depends notably on the speed of arrival and on the properties of the textures that come into contact.

3.7 — Two Flexible Surfaces

When two flexible surfaces collide, neither is necessarily an absolute rigid reference.

Both surfaces take part in forming the collision frame of reference.

Their local directions, their orientation, their respective capacity for curvature and their movement determine the temporary geometry created between them.

The deformation then becomes **mutual**.

One surface can curve in one direction while the other transforms in the complementary direction. The geometry of the contact results from this interaction.

The engine therefore does not simply ask:

“Which object hits which object?”

It rather asks:

“How can the two surface frames of reference geometrically respond to this meeting?”

3.8 — The Curvature Limit

A flexible surface does not necessarily keep curving indefinitely.

The deformation evolves until it reaches the limit defined by the conditions of the collision and the properties of the surface.

This limit is an essential moment.

Before this limit, the impact mainly causes the curvature to progress.

At the limit, the surface reaches its state of maximum deformation for this interaction.

After this limit, the **restitution** begins.

The surface seeks to recover its geometry.

3.9 — Restitution and Rebound

The rebound appears when the curved surface returns toward its shape.

The zone that had absorbed the deformation then changes behavior: instead of continuing to yield to the impact, it returns in the opposite direction.

This return exerts a push on the other surface.

The cycle can be described as follows:

contact → curvature → geometric compression → curvature limit → restitution → push → separation

The rebound thus becomes the consequence of the transformation and then the restitution of the local geometry.

A balloon can momentarily flatten against the floor, reach its curvature limit and then restore this deformation. The surface then pushes the floor away, while the resulting reaction contributes to the movement of the balloon in the opposite direction.

3.10 — The Collision Zone Is Dynamic

The contact region does not need to keep the same size throughout the collision.

It can start almost as a point, then grow as the surfaces deform.

During restitution, this region can then gradually shrink until it disappears when the objects separate.

We thus obtain a geometric evolution:

initial point → contact region → maximum curvature → shrinking of the region → separation

The collision frame of reference follows this evolution.

It is born with the contact, evolves with the curvature and disappears when the interaction ends.

3.11 — Texture as a Mechanical Element

In this architecture, a texture is no longer only a visual property.

It takes part in the behavior of the surface.

A texture can notably define: - its capacity to curve; - its deformation limit; - its reaction to another texture; - its behavior during restitution; - its capacity to keep or locally modify its geometry.

The texture thus becomes a **dimensional and mechanical structure**.

Two objects with exactly the same shape can therefore react differently because their surfaces do not have the same properties.

3.12 — A Locally Resolved Collision

One of the important consequences of this architecture is that the collision can be studied mainly where it occurs.

The whole object does not necessarily have to undergo the same geometric transformation.

The region concerned creates its local collision frame of reference, while this region remains connected to the surface frame of reference, itself connected to the general frame of reference of the object.

The hierarchy becomes:

object → surface → collision zone → local curvature

The transformation can then propagate if the properties of the object require it.

Thus, a local collision first produces a local response before passing its consequences on to the rest of the object.

3.13 — Collision Principle of the Kyzis 3D Engine 2.0

The third fundamental principle can therefore be formulated as follows:

A collision is a temporary interaction between the dimensional frames of reference of two surfaces. The local geometry, the angle of arrival, the speed and the properties of the textures determine a frame of reference for curvature in which the surfaces can deform, reach their limit and then restore this deformation in the form of push and movement.

The collision is therefore no longer simply an event indicating that two objects momentarily occupy a common region.

It becomes a **calculable geometric transformation between two surfaces**.

In the Kyzis 3D Engine 2.0, the surface is not only the place where the collision occurs.

The surface becomes the very mechanism of the collision.

Chapter 4 — The Equations

The **Kyzis 3D Engine 2.0** must translate its dimensional principles into calculable relationships. The equations proposed in this chapter are a first formalization of the model: they describe the object's own frame of reference, surface dimensions, movement, curvature and the local mechanics of collisions.

The goal is not to impose three fixed axes on the whole scene, but to allow each object to calculate its behavior from **its own dimensions and its interactions with the dimensions of other objects**.

4.1 — Local Position and Global Position

Let there be an object O with its own frame of reference R_O.

An element belonging to this object has a local position:

$$p_L$$

The transformation from the object's frame of reference to the scene is represented by:

$$T_O(t)$$

The observable position of the element becomes:

$$p_G(t) = T_O(t)\, p_L$$

The fundamental idea is that p_L remains attached to the object's frame of reference. When the object rotates or moves, its elements follow the transformation T_O.

The engine can thus distinguish **the position within the object** from **the position of the object in the world**.

4.2 — Dimensions of a Surface

A flexible surface can be described locally by two dimensions:

$$S(u, v)$$

where u and v represent the two dimensions specific to the surface.

The local directions are then:

$$e_u = \frac{\partial S}{\partial u}$$

and

$$e_v = \frac{\partial S}{\partial v}$$

These two directions are not necessarily straight across the whole object. They can evolve with the geometry of the surface.

The surface thus becomes a traversable space whose directions are determined locally.

4.3 — Perpendicular Direction of the Surface

From the two local directions of the surface, the cross product makes it possible to construct a perpendicular direction:

$$n = \frac{e_u \times e_v}{\|e_u \times e_v\|}$$

This direction n provides a local orientation that can be used during a collision or a deformation.

The engine thus has three local geometric pieces of information:

$$(e_u, e_v, n)$$

The first two belong to the surface. The third results directly from their geometric relationship.

4.4 — Movement Along the Object's Own Dimensions

An element located on the surface can move along u and v.

Its local displacement can be represented by:

$$\Delta p_S = \Delta u\, e_u + \Delta v\, e_v$$

The direction actually obtained therefore depends on the local geometry.

On a curved surface, e_u and e_v evolve during the movement. The element thus follows **the surface itself**, rather than a set of fixed world directions.

4.5 — Finite and Folded Dimensions

Some movement dimensions can be finite and close back on themselves.

For a dimension with N positions:

$$q' = (q + \Delta q) \bmod N$$

In a cyclic canvas of dimensions N_x, N_y, N_z:

$$x' = (x + \Delta x) \bmod N_x$$

$$y' = (y + \Delta y) \bmod N_y$$

$$z' = (z + \Delta z) \bmod N_z$$

Going past the last position then produces a return to the first.

The dimension has a finite size, but **movement can continue without meeting a terminal boundary**.

4.6 — Relative Speed During a Collision

Let there be two surfaces A and B with the speeds:

$$v_A$$

and

$$v_B$$

Their relative speed is:

$$v_{rel} = v_A - v_B$$

Its magnitude is:

$$v_{rel} = \|v_{rel}\|$$

This quantity indicates the kinematic intensity of their relative approach.

4.7 — Angle of Arrival

Speed alone is not enough. Its relationship with the local orientation of the contact must also be known.

If n represents the local reference direction of the contact:

$$\theta = \cos^{-1}\left(\frac{v_{rel} \cdot n}{\|v_{rel}\|}\right)$$

The angle θ makes it possible to distinguish an impact arriving mainly against the surface from a movement oriented more along it.

The relative speed can also be split into two components.

Normal component:

$$v_n = (v_{rel} \cdot n)n$$

Tangential component:

$$v_t = v_{rel} - v_n$$

The collision frame of reference thus directly has the information needed to determine **how the impact arrives on the surface**.

4.8 — Curvature Percentage

In the Kyzis model, the deformation of the surface can be expressed as a percentage:

$$C \in [0,1]$$

with:

$$C = 0$$

for the initial state of the region considered, and:

$$C = 1$$

for **100% of the curvature allowed by this interaction**.

If $S_0(u, v)$ represents the initial surface and $S_C(u, v)$ the target geometry determined by the contact, a first geometric interpolation can be written:

$$S(u, v, C) = (1 - C)\, S_0(u, v) + C\, S_C(u, v)$$

At 0%:

$$S(u, v, 0) = S_0(u, v)$$

At 100%:

$$S(u, v, 1) = S_C(u, v)$$

This equation directly formalizes the principle that **100% means the surface reaches the curvature determined by the collision**, and not infinite curvature.

4.9 — Dynamic Curvature

The curvature percentage must evolve over time.

Its evolution can be represented by:

$$C(t + \Delta t) = \text{clamp}(C(t) + \Delta C,\ 0,\ 1)$$

where ΔC depends notably on the speed of arrival, the angle of contact and the properties of the surfaces.

As a general structure of the model, we can write:

$$\Delta C = F(v_{rel}, \theta, E_A, E_B, \Delta t)$$

where: - E_A represents the flexibility properties of surface A; - E_B those of surface B; - v_{rel} represents the relative speed; - θ represents the angle of arrival; - F is the engine's curvature function.

The exact form of F can be determined during implementation and experimentation.

4.10 — Distribution Between Two Flexible Surfaces

When both surfaces are flexible, the total deformation can be distributed between them.

Two coefficients can be introduced:

$$\alpha_A + \alpha_B = 1$$

and the transformation distributed:

$$C_A = \alpha_A C$$

$$C_B = \alpha_B C$$

For a practically rigid surface:

$$\alpha_A \approx 0$$

Most of the transformation is then applied to the other surface.

When both surfaces can deform, α_A and α_B determine their respective participation in the shared frame of reference for curvature.

4.11 — Restitution of the Surface

When the maximum curvature defined for the impact is reached, the system enters its restitution phase.

During this phase:

$$\frac{dC}{dt} < 0$$

The surface gradually approaches its initial state:

$$C \to 0$$

The direction of restitution depends on the local collision frame of reference and on the geometric state reached during compression.

The complete cycle becomes:

$$0 \to C_{\max} \to 0$$

When:

$$C_{\max} = 1$$

the surface has reached 100% of the curvature allowed by this interaction.

4.12 — Transmission of Movement

Geometric restitution produces a change in the movement of the objects.

In a first general model, the change in speed can be expressed as a function:

$$\Delta v = G(C_{\max}, n, v_{rel}, E_A, E_B)$$

The new speed becomes:

$$v' = v + \Delta v$$

This deliberately general formulation separates two problems:

geometry determines how the surface deforms;

mechanics determines how this deformation modifies movement.

The engine can then specify G according to the physical properties assigned to the objects.

4.13 — Potential Dimensions

The number of potential dimensions of an object depends on its geometry and on the resolution used to define it.

We can therefore write:

$$D_{pot} = D(G, R)$$

where: - G represents the geometric structure of the object; - R represents the chosen resolution; - D_{pot} represents the set or number of calculable directions retained at this resolution.

When the resolution increases:

$$R_2 > R_1$$

the description can reveal more geometric structures and therefore potentially:

$$D_{pot}(G, R_2) \geq D_{pot}(G, R_1)$$

The engine therefore does not require every object to have exactly the same number of relevant dimensions.

4.14 — Effective Dimensions

Not all the potential dimensions of an object are necessarily used simultaneously.

We can define:

$$D_{eff} \subseteq D_{pot}$$

The effective dimensions then correspond to the dimensions needed for the operation currently being performed.

When moving across a surface, two curved dimensions may be enough.

During a collision, the directions of the contact, the curvature and the movement also become relevant.

During a complex deformation, a larger set of potential dimensions can be activated locally.

The engine then calculates only **the dimensions needed for the current state of the object**.

4.15 — Conceptual Equation of the Kyzis 3D Engine 2.0

The whole system can finally be summed up in a conceptual relationship:

$$\boxed{\text{Future state} = F\left(\text{frame of reference}, \text{geometry}, D_{eff}, \text{movement}, \text{interaction}\right)}$$

The Kyzis 3D Engine 2.0 therefore does not seek only to determine a new position in three coordinates.

It seeks to determine **how an object's own frame of reference evolves when its dimensions interact with those of its environment**.

The equations are no longer only a way of moving an object.

They become the language that allows its geometry to transform itself.