

**Technical University of Civil Engineering Bucharest**  
Faculty of Railways, Roads and Bridges

**University of Bucharest**  
Faculty of Mathematics and Computer Science

## **The International Conference Riemannian Geometry and Applications - Day 1**

**– RIGA 2021-**

**Bucharest, Romania, January 15 2021**

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Gözde ÖZKAN TÜKEL ...

Dr. Figula Ágota

Marian Ioan Munteanu (G...

Al-Abayechi Amer M...

Adela Mihai

Kadri Arslan (Konuk)



01:26:48



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A 4x3 grid of video feeds showing 11 participants. The participants are labeled as follows:

- Row 1: Cihan Özgür, Kadri Arslan (Konuk), Rakesh Kumar
- Row 2: Alfonso Carriazo, Veselina Tavkova (Guest), Ahmet YILDIZ (Konuk)
- Row 3: CENGİZHAN MURATHAN (Konuk), Mukut Mani Tripathi (Guest), VERONICA MARTIN MOLINA
- Row 4: +28, AH, GT, RM, SA, F, GM, LM, T, EP, (partially visible)

## Participants

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- IUC vranccken (Guest)
- Miroslava Antic (Guest)
- Muhittin Evren Aydin (Konuk)
- Mukut Mani Tripathi (Guest)
- Pablo Alegre (Invitado)
- Pablo Gómez (Invitado)
- Radu-loan Mihai (Guest)
- Rakesh Kumar  
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- Şaban Güvenç  
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- Sameer Annon Abbas (Guest)

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Introduction and Motivations

• Since both the null section and the screen distribution are fixed arbitrarily and independently therefore it is not clear how to choose them in order to have a reasonable coupling between the properties of the null hypersurface and the ambient space.

Rakesh Kumar Rigging technique on null hypersurfaces 4 / 38

RAKESH KUMAR (Guest)

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Ildefonso Castro (Invited Speaker)

Marian Munteanu (Guest)

Ion Mihai (Guest)

Ghiocel Groza

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## 2. FIRST NATURAL CONNECTION $D^1$

Let us consider an arbitrary almost paracontact almost paracomplex manifold  $(\mathcal{M}, \phi, \xi, \eta, g)$ .

**Definition 3.** A linear connection  $D$  is called a *natural connection* on the manifold  $(\mathcal{M}, \phi, \xi, \eta, g)$  if the almost paracontact structure  $(\phi, \xi, \eta)$  and the metric  $g$  are parallel with respect to  $D$ , i.e.  $D\phi = D\xi = D\eta = Dg = 0$ .

As a corollary, the associated metric  $\tilde{g}$  is also parallel with respect to a natural connection  $D$  on  $(\mathcal{M}, \phi, \xi, \eta, g)$ , i.e.  $D\tilde{g} = 0$ .

Therefore, an arbitrary natural connection  $D$  on  $(\mathcal{M}, \phi, \xi, \eta, g) \notin \mathcal{F}_0$  plays the same role like  $\nabla$  on  $(\mathcal{M}, \phi, \xi, \eta, g) \in \mathcal{F}_0$ . Obviously,  $D$  and  $\nabla$  coincide when  $(\mathcal{M}, \phi, \xi, \eta, g) \in \mathcal{F}_0$ .

Let  $Q$  be the potential of  $D$  regarding  $\nabla$ . Then we have

$$(2.1) \quad D_xy = \nabla_xy + Q(x, y).$$

Furthermore, we use the denotation  $Q(x, y, z) = g(Q(x, y), z)$ .

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In this report, we shall consider the case of the lowest dimension of the almost paracontact almost paracomplex Riemannian manifolds, i.e.  $\dim \mathcal{M} = 3$ .

Now, we recall some needed results from [19].

Let  $(\mathcal{M}, \phi, \xi, \eta, g)$  have the lowest dimension (i.e.  $\dim \mathcal{M} = 3$ ) and let the set of vectors  $\{e_0, e_1, e_2\}$  be a  $\phi$ -basis of  $T_p \mathcal{M}$  which satisfies the following conditions:

$$(5) \quad \begin{aligned} \phi e_0 &= 0, & \phi e_1 &= e_2, & \phi e_2 &= e_1, & \xi &= e_0, \\ \eta(e_0) &= 1, & \eta(e_1) &= \eta(e_2) &= 0, \end{aligned}$$

$$(6) \quad g(e_i, e_j) = \delta_{ij}, \quad i, j \in \{0, 1, 2\}.$$

The components of  $F$ ,  $\theta$ ,  $\theta^*$  and  $\omega$  with respect to a  $\phi$ -basis are denoted by  $F_{ijk} = F(e_i, e_j, e_k)$ ,  $\theta_k = \theta(e_k)$ ,  $\theta_k^* = \theta^*(e_k)$ ,  $\omega_k = \omega(e_k)$  and we have:

$$(7) \quad \begin{aligned} \theta_0 &= F_{110} + F_{220}, & \theta_1 &= F_{111} = -F_{122} = -\theta_2^*, \\ \theta_0^* &= F_{120} + F_{210}, & \theta_2 &= F_{222} = -F_{211} = -\theta_1^*, \\ \omega_0 &= 0, & \omega_1 &= F_{001}, & \omega_2 &= F_{002}. \end{aligned}$$

<sup>12</sup>M. MANEV AND V. TAVKOVA, On the almost paracontact almost paracomplex Riemannian manifolds, *Facta Univ. Ser. Math. Inform.*, **33** (2018), 637–657.

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अादिस संयोग निमित्त हेतुः परस्तिकालादकलोऽपिदृष्टः।  
तं विश्वरूपं भवभूतमीड्यम् देवं स्वचित्तस्थमुपास्य पूर्वम्।  
श्वेताश्वत्रोपनिषद् ६-५

वह मूल कारण, संयोग का निमित्त कारण तीनों कालों से परे, कला रहित  
भीजाना जाता है। उस विश्वरूप, उत्पत्तिस्थान स्तुति के योग्य उस पुरातन देव  
की जो सबके चित्तस्थ है हम उपासना करे।

THE BEGINING-HE, THE EFFICIENT CAUSE OF COMBINATIONS,  
AS BEYOND THE THREE TIMES, WITHOUT PARTS ALSO, IS HE TO  
BE SEEN AS THE MANIFOLD, THE SOURCE OF BEING, WORTHY  
OF PRAISE GOD IN ONE'S SELF ABIDING WORSHIP HIM - THE  
PRIMEVAL. SHWETASHWETARA UPANISHAD 6-5

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ZŞ Zerrin Şentürk (Guest)

ZE Zlatko Erjavec (Guest)

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## The second fundamental form

Let  $M$  and  $N$  be two Riemannian manifolds with Levi-Civita connections  $\overset{1}{\nabla}$  and  $\overset{2}{\nabla}$ . Suppose that  $F : M \rightarrow N$  is a map. There exists a unique pullback connection  $\overset{2}{\nabla}^F$  of  $\overset{2}{\nabla}$  along  $F$  such that for  $X \in \Gamma(TM)$  and  $Y \in \Gamma(TN)$

$$\overset{2}{\nabla}_X^F(Y \circ F) = \overset{2}{\nabla}_{F(X)}Y.$$

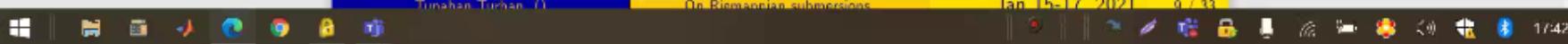
The second fundamental form of  $F$  is the map  $\nabla F_* : \Gamma(TM) \times \Gamma(TM) \rightarrow \Gamma(TN)$  defined by

$$(\nabla F_*)(X, Y) = \overset{2}{\nabla}_X^F F_*(Y) - F_*\left(\overset{1}{\nabla}_X Y\right) \quad (1)$$

[13].

Tunahan Tunahan (0) On Riemannian submersions Jan 15-17, 2021 9 / 33

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## Constant sectional curvature manifolds

We know that a totally umbilical submanifold  $M$  of a Riemannian manifold  $\bar{M}$  of constant sectional curvature  $\bar{c}$  has also constant sectional curvature  $\bar{c} + \|H\|^2$  for  $\dim M > 2$ . Thus, we can get the following corollary

**Corollary**

*Let  $i$  be a hyperelastic immersion between the submanifold  $M$  ( $\dim M > 2$ ) and a Riemannian manifold  $\bar{M}$  with constant sectional curvature  $\bar{c}$ . If  $M$  is an isotropic submanifold of  $\bar{M}$ , then  $M$  has also constant sectional curvature  $c = \bar{c} + \|H\|^2$ , where  $H$  is the mean curvature vector field.*

G. OZKAN TÜKEL (ISUBU) Hyperelastic immersions Jan 15-17, 2021 32 / 37

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Hyperelastic immersions

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## Nilmanifolds and totally geodesic subalgebras of nilpotent metric Lie algebras

Ágota Figula

University of Debrecen, Institute of Mathematics, Department of Geometry

RIGA conference, 15-17.01.2021



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Nilmanifolds, geodesic subalgebras of nilpotent metric Lie algebras

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## Preliminaries

## Definition

Let  $\mathfrak{g}$  be a Lie algebra and  $G$  be the corresponding connected and simply connected Lie group. A metric Lie algebra  $(\mathfrak{g}, \langle \cdot, \cdot \rangle)$  is a Lie algebra  $\mathfrak{g}$  together with a Euclidean inner product  $\langle \cdot, \cdot \rangle$  on  $\mathfrak{g}$ . This inner product  $\langle \cdot, \cdot \rangle$  on  $\mathfrak{g}$  induces a left invariant Riemannian metric on the Lie group  $G$ .

A connected Riemannian manifold  $M$  is called a Riemannian nilmanifold if its group of isometries contains a nilpotent Lie subgroup acting transitively on  $M$ . Denote  $\mathcal{OA}(\mathfrak{n})$  the group of orthogonal automorphisms of  $(\mathfrak{n}, \langle \cdot, \cdot \rangle)$ , which preserves the inner product.

E. Wilson in *Isometry groups on homogeneous nilmanifolds*, Geom. Dedicata 12 (1982), 337-346, proved that there is a unique nilpotent Lie subgroup  $N$  of the group of isometries acting simply transitively on  $M$ .

Dr. Figula Ágota

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On the structure of topological loops with solvable multiplication groups

Ameer Al-Abayechi  
supervised by  
Dr. Agota Figula

University of Debrecen  
Institute of Mathematics, Department of Geometry

RIGA Conference, 2021

Al-Abayechi Ameer Mohammedhussein Hasan

Ameer Al-Abayechi (Debrecen)

Topological loops with Mult( $L$ )

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Centrally nilpotency and classical solvability properties of  $L$

- The kernel of a homomorphism  $\alpha : (L, \cdot) \rightarrow (L', *)$  of a loop  $L$  into a loop  $L'$  is a normal subloop  $N$  of  $L$ .
- The centre  $Z(L)$  of a loop  $L$  consists of all elements  $z$  which satisfy the equations  $zx \cdot y = z \cdot xy$ ,  $x \cdot yz = xy \cdot z$ ,  $xz \cdot y = x \cdot zy$ ,  $zx = xz$  for all  $x, y \in L$ . If we put  $Z_0 = e$ ,  $Z_1 = Z(L)$  and  $Z_i/Z_{i-1} = Z(L/Z_{i-1})$ , then we obtain a series of normal subloops of  $L$ . If  $Z_{n-1}$  is a proper subloop of  $L$  but  $Z_n = L$ , then  $L$  is centrally nilpotent of class  $n$ .
- A loop  $L$  is called classically solvable if there is a series  $\{e\} = L_0 \leq L_1 \leq \dots \leq L_n = L$  of subloops of  $L$  such that,  $L_{i-1}$  is normal in  $L_i$  and the factor loop  $L_i/L_{i-1}$  is a commutative group.
- A real Lie group  $G$  is a group that is also a finite-dimensional real smooth manifold, in which the group operations of multiplication and inversion are smooth maps.

Ameer Al-Abayechi (Debrecen) Topological loops with Mult( $L$ ) RIGA Conference, 2021 3 / 29

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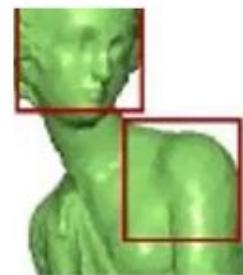
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## Data Structures in Applied Geometry



3D Scanner



Geom Proc



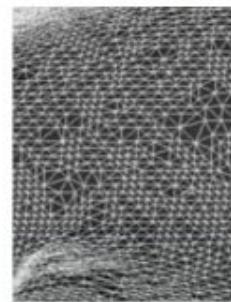
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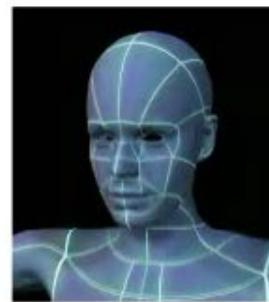
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Point set shapes



Triangle meshes



Low quality splines



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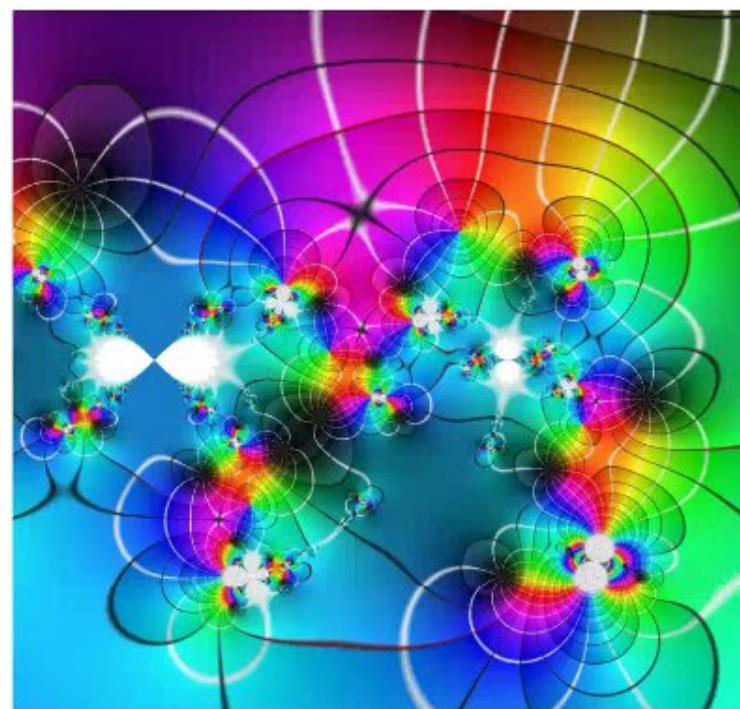
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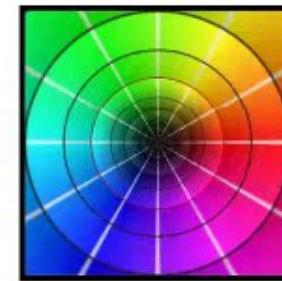
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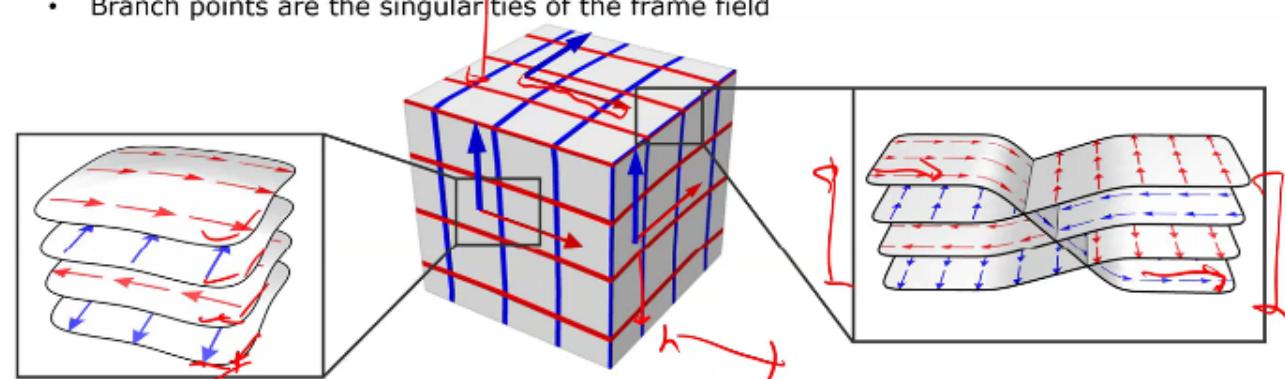
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## Lift Frame Field to Branched Covering Surface

Problem: Frame field has holonomy at singularities

Solution:

- Construct a 4-fold branched covering surface  $M^*$
- Branch points are the singularities of the frame field



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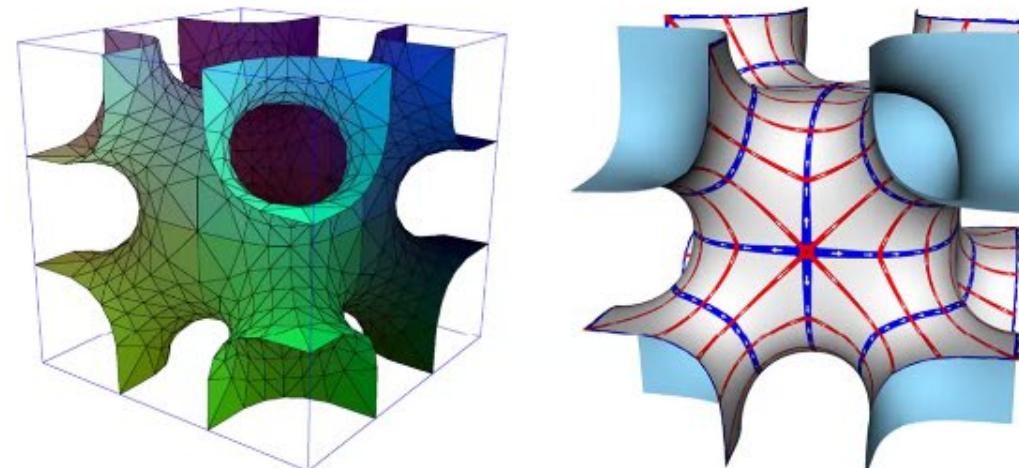
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## Parametrizing Minimal Surfaces



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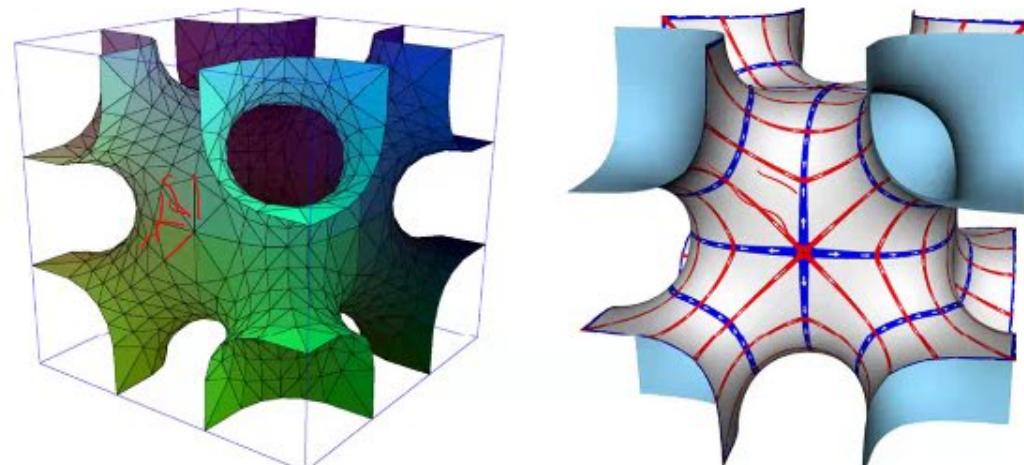
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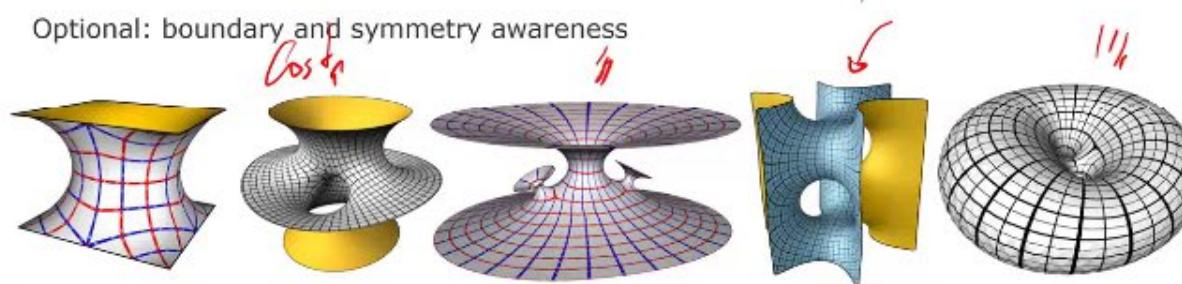
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## Parametrizing Minimal Surfaces



Optional: boundary and symmetry awareness



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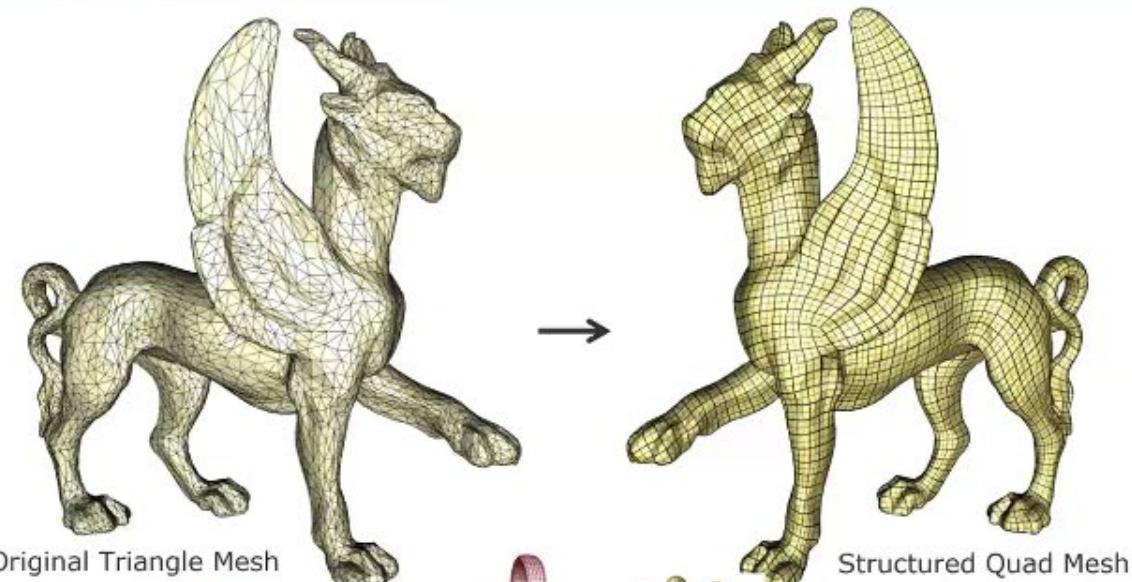
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## Automatic Generation of Quad Meshes



Original Triangle Mesh

Structured Quad Mesh

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