

De l'acquisition à la reconstruction

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Plan

- 1 Modélisation géométrique et traitements numériques
- 2 Un peu d'histoire
- 3 Traitements des nuages de points acquis
- 4 Les smartphones : outils d'acquisition et recalage à faible coût

Modélisation et traitements numériques

- Représentation de la géométrie et de la topologie
- Acquisition et reconstruction
- Maillages 3D : simplification, raffinement et remaillage
- Maillages "étanches" pour l'impression 3D

Illustrations de remaillage issue de [Y.Wang et al., 2017]

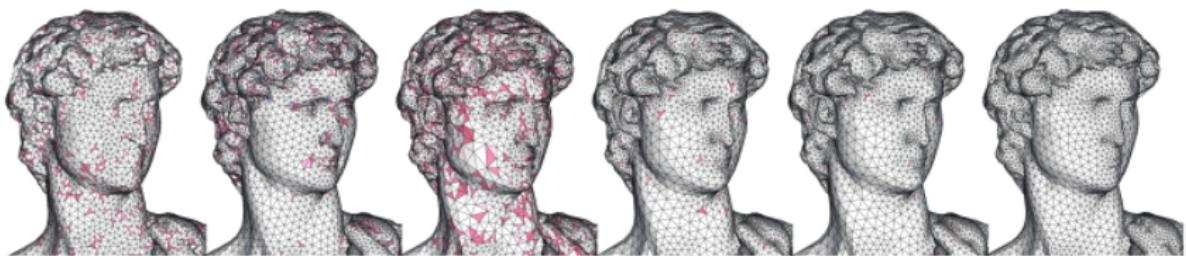


Figure 1: A comparison of different remeshing approaches. The input David's head model (60k vertices and 120k triangles) is remeshed with approximately 60k faces with each method. From left to right are results of MPS [Yan and Wonka 2013] ($\#_{obt} = 7k$), RAR [Dunyach et al. 2013] ($\#_{obt} = 7.2k$), MAI [Hu et al. 2017] ($\#_{obt} = 15.6k$), CVT [Yan et al. 2009] ($\#_{obt} = 1.4k$), NOB [Yan and Wonka 2016] ($\#_{obt} = 724$), and ours ($\#_{obt} = 0$). Obtuse triangles are colored in pink. Here, $\#_{obt}$ indicates the number of obtuse triangles after remeshing.

Communautés scientifiques

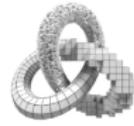
- Groupements De Recherche CNRS

GDR IFM Informatique Fondamentale et ses Mathématiques

GDR IG-RV Informatique Géométrique et graphique, Réalité virtuelle et Visualisation

GTMG Groupe de Travail de Modélisation Géométrique

La gazette du GT "Modélisation géométrique", n°13 - 19 mai 2025



La gazette du GT MG

- AFIG** Association Française d'Informatique Graphique

jFIG 2022



Communautés scientifiques

Int. Conf. on GMP Geometric Modelling and Processing

Conception, fabrication et impression 3D numériques

Géométrie et topologie numériques

Géométrie différentielle discrète

Modélisation et reconnaissance de caractéristiques géométriques

Fondements mathématiques de la conception géométrique assistée par ordinateur

Modélisation multirésolution et hétérogène

Représentation de formes et de solides

Optimisation de formes

...

Communautés scientifiques

SGP Symposium on Geometry Processing, Eurographics



Geometry Processing

The Eurographics Symposium on Geometry Processing (SGP) is the premier venue for disseminating new research ideas and cutting-edge results in geometry processing. In this research area, concepts from mathematics, computer science, and engineering are studied and applied to offer new insights and design efficient algorithms for acquisition, modeling, analysis, manipulation, simulation and other types of processing of 3D models and shape collections.

Communautés scientifiques

MIT Summer Geometry Initiative

SGP Summer School Presentations

la Pietà florentine de Michelangelo

F.Bernardini and H. Rushmeier,
2002

"The 3D Model Acquisition Pipeline"
Comp Gr Forum, 21 (2002), no 2,
149–172

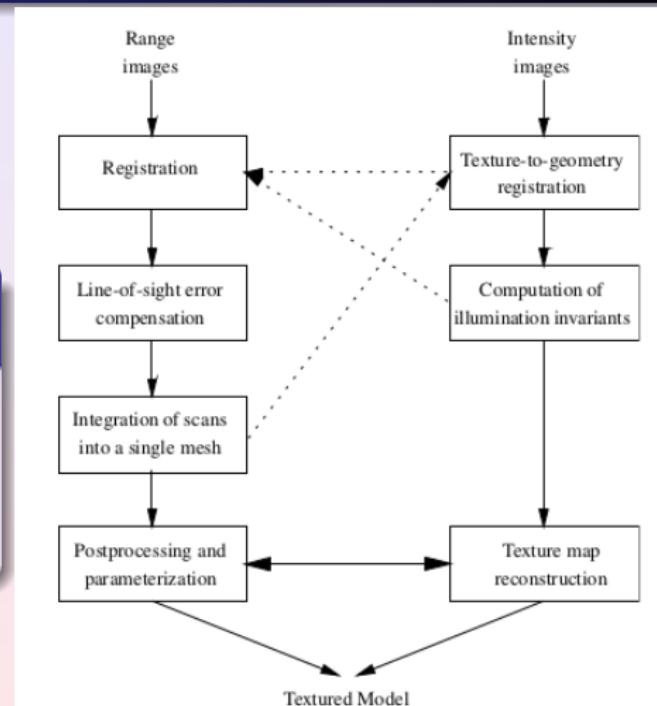


Figure 1: The sequence of steps required for the reconstruction of a model from multiple overlapping scans

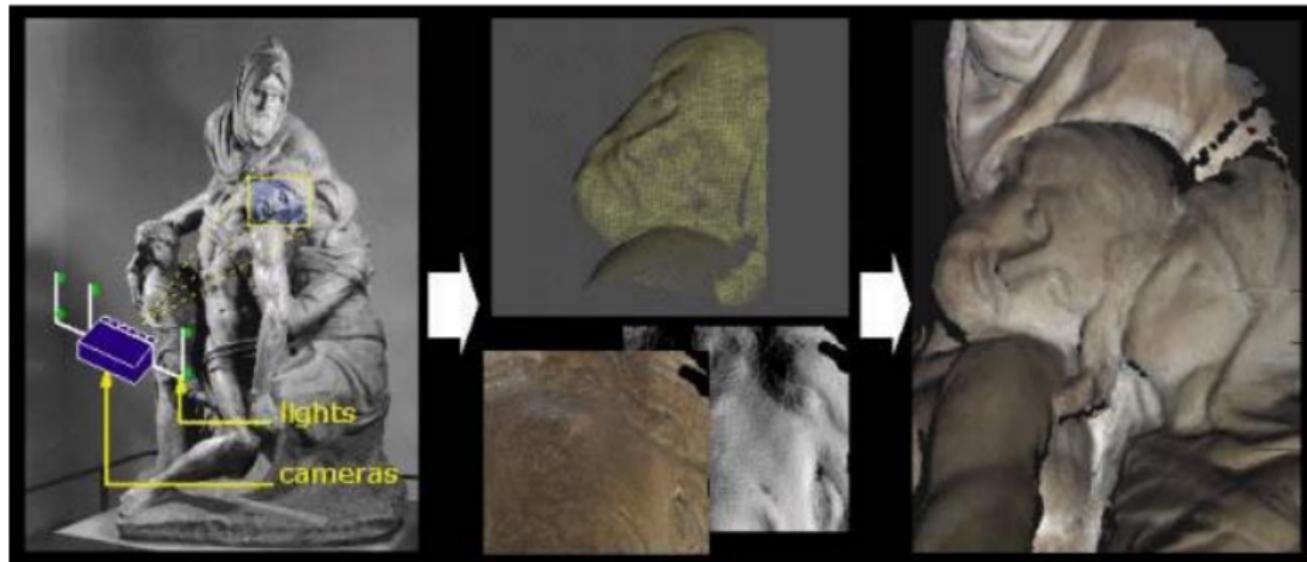
la Pietà florentine de Michelangelo



Fig. 1. (left) A photograph of Michelangelo's Florentine Pietà. (right) A syn-

F. Bernardini et al., 2002
"Building a digital model
of Michelangelo's
Florentine Pietà"
CGr&Appli 22(1), 2002,
59-67

la Pietà florentine de Michelangelo



3D capture methodology: (a) Multiple digital photos are taken. (b) Surface shape, color and details are computed for each scan. (c) Scans are merged into a single model.

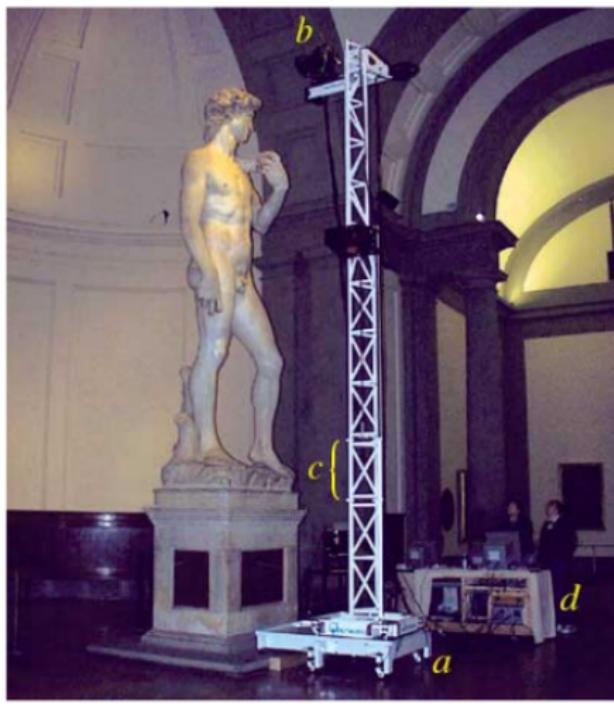
Projet numérique Michelangelo

M.Levoy et al., 2000

The Digital Michelangelo Project : 3D Scanning of Large Statues
SIGGRAPH 2000



Projet numérique Michelangelo



Projet numérique Michelangelo



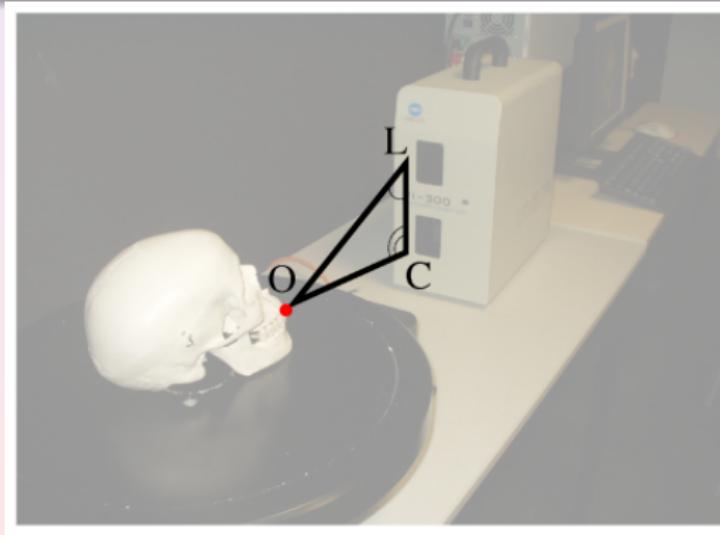
Figure 10: On the left is a photograph of Michelangelo's David. On the right is a rendering made from our model. Constructed at a resolution of 1.0 mm, the model is watertight and contains 4 million polygons. Its surface reflectance was computed from digitized color images as described in section 4.2. The photograph was taken under uncalibrated conditions, so its viewpoint and illumination differ slightly from those of the rendering. The raw data for this part of the statue was acquired at a resolution of 0.29 mm and contained 480 million polygons and 2,000 color images. Using one processor of an SGI Onyx2, it took 12 hours to align, merge, and map color onto this model.

Chaîne de traitements A2RI

R.Synave, 2009

"Reconstruction de solides à partir d'acquisitions surfaciques"

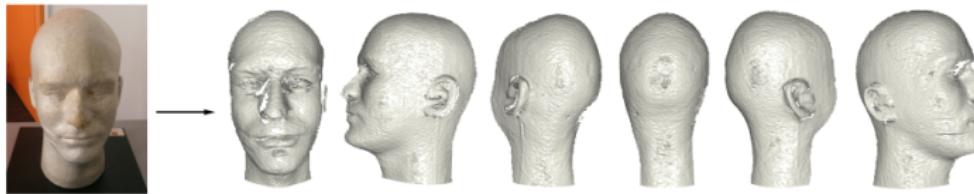
Thèse de doctorat, UB 2009, fig. 2-27, A2RI



Chaîne de traitements A2RI

R.Synave, 2009

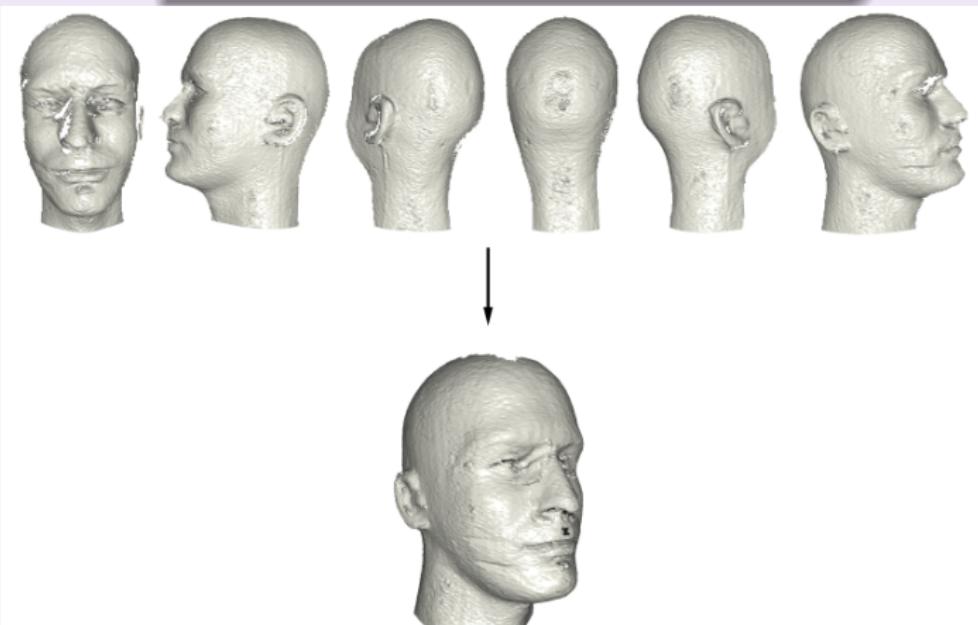
Thèse de doctorat, UB 2009, fig.2-25



Chaîne de traitements A2RI

R.Synave, 2009

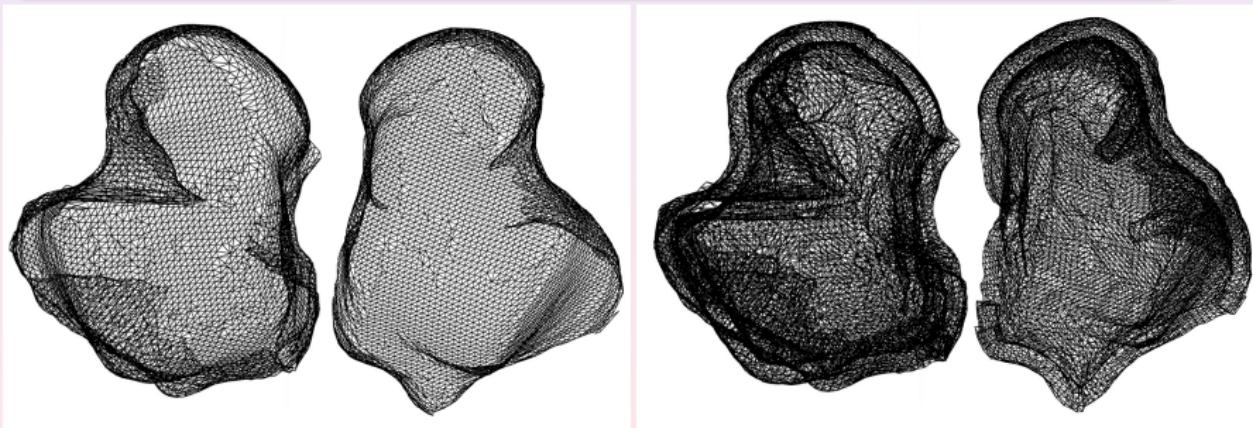
Thèse de doctorat, UB 2009, fig.3-54



De l'acquisition à l'impression 3D

Gueorguieva et al., 2010

"Teaching geometric modeling algorithms and data structures through laser scanner acquisition pipeline", ISVC, 2010



De l'acquisition à l'impression 3D

De l'acquisition à
l'impression 3D
d'un talus



Rétro-conception de maillages 3D : acquisition

Acquisition

- Scanner 3D Aquilon

<http://www.kreon3d.com/fr/scanners-3d/aquilon/>

- Bras de mesure Faro

<http://www.faro.com/fr-fr/produits/metrologie/>

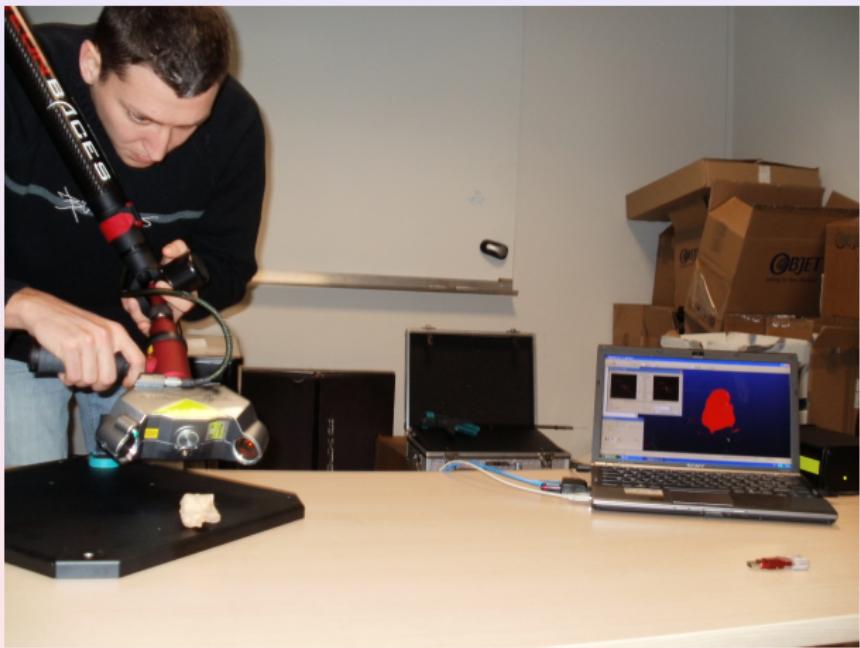
- Logiciel de rétro-conception Polygonia

<http://www.kreon3d.com/fr/solutions/logiciel-plug-in-polygonia/>
- acquisition de nuages de points avec affichage en temps réel ;
- mesure d'entités géométriques ;
- outils d'alignement ;
- génération de facettes ; - export des formats de fichiers :
IGES, ASCII, DXF, STL...

Rétro-conception de maillages 3D : acquisition

Acquisition

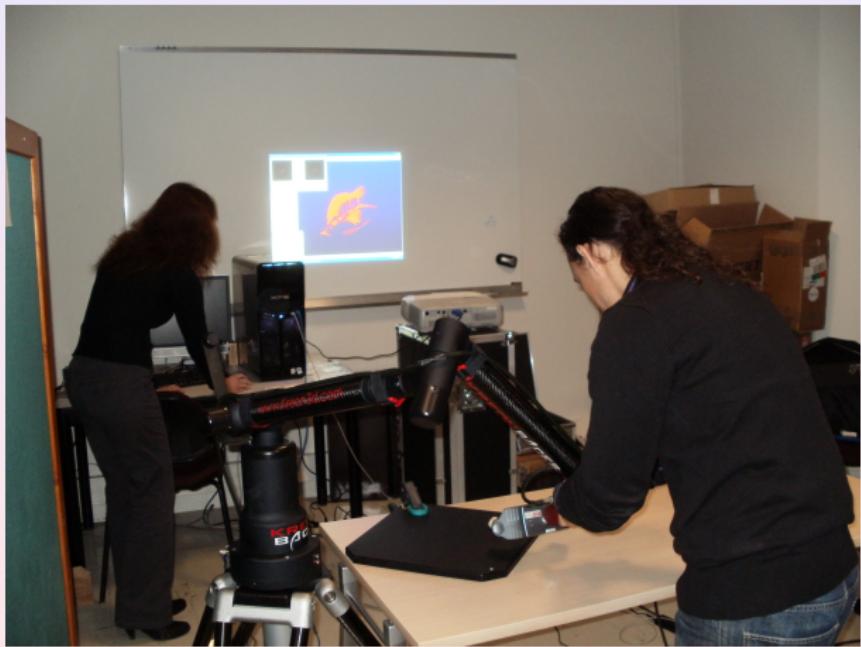
- Scanner laser 3D Aquilon
- Bras de mesure Faro
- Polygonia



Rétro-conception de maillages 3D : acquisition

Acquisition

- Scanner 3D Aquilon
- Bras de mesure Faro
- Polygonia



Rétro-conception de maillages 3D : reconstruction

- Geometric Studio

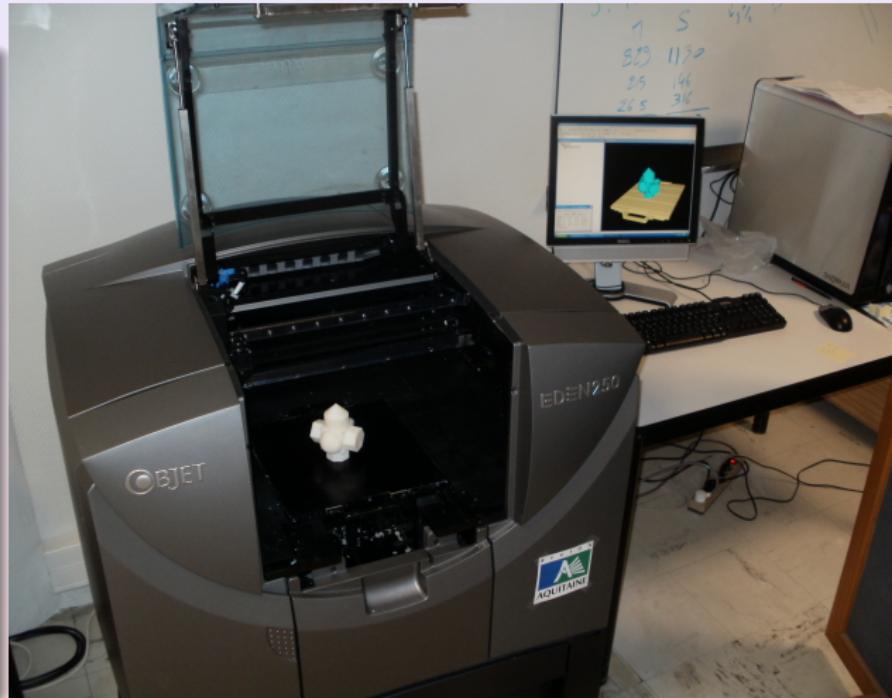
<http://www.geomagic.com/fr/>

The screenshot shows the official website for Geomagic. At the top, there's a navigation bar with links for PRODUITS, INDUSTRIES, COMMUNAUTAIRE, COMMENT ACHETER, SUPPORT & TRAINING, and A PROPOS DE GEOMAGIC. Below the navigation, there's a large banner for "Cx Geomagic® Control X™". The banner features a 3D model of a mechanical part with various measurement annotations and a screenshot of the software interface. Text on the banner reads: "Révolutionnez vos processus de mesure avec le logiciel leader de la métrologie industrielle". Below the banner is a button labeled "PLUS D'INFORMATIONS". To the right of the banner, there are three smaller boxes: one for "Geomagic Design X", one for "Geomagic Wrap", and one for "Geomagic Freeform". At the bottom of the page, there are three columns: "Solutions" (listing "Produits de conception 3D", "Produits de numérisation", "Produits de contrôle", "Produits tactiles", and "Tous les produits"), "Évaluations gratuites de logiciel" (listing "Geomagic Control X", "Geomagic Wrap", and "Geomagic Design X"), and "Support technique" (listing "Consultez nos centres de support", "Contacter le support", and "S'Inscrire à une formation"). The footer of the page includes a URL "geomagic.com/fr/products/freeform/overview" and a series of small navigation icons.

Rétro-conception de maillages 3D : impression

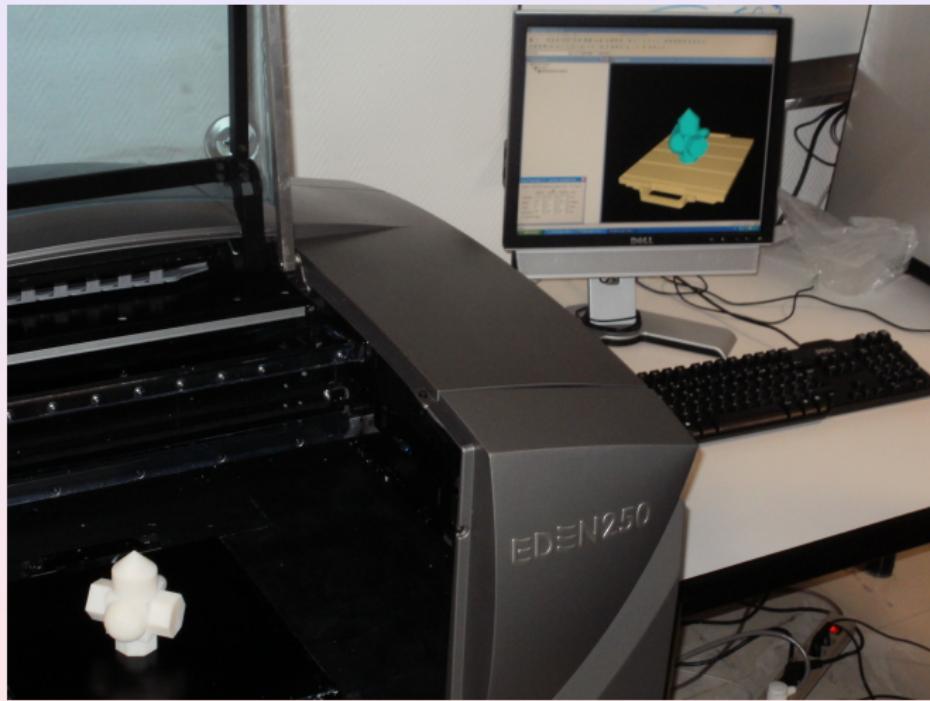
Impression 3D

OBJET, EDEN 250,
technologie Polyjet™
<http://arketyp3d.com/nos-produits/nos-gammes/eden-2-chambre-de-construction> : $260 \times 260 \times 200$ mm;
-précision : 0.1–0.2 mm en moyenne;
-format des fichiers : STL et SLC



Rétro-conception de maillages 3D : impression

OBJET,
EDEN 250



Recalage 3D ("Iterative Closest Point (ICP)")

P.J.Besl et N.D. McKay, 1992

"A method for registration of 3-D Shapes",

IEEE Tr. on Pattern Analysis and Machine Learning, 1992, Vol 14,
No 2

$$q_R = [q_0 q_1 q_2 q_3]^t, \quad q_0 \geq 0, \quad q_0^2 + q_1^2 + q_2^2 + q_3^2 = 1$$

R matrice de rotation générée par q_R

$$q_T = [q_4 q_5 q_6]^t$$

$$q = [q_R | q_T]^t$$

$P = \{p_i\}_{i=1}^{N_p}$, ensemble de points acquis

$X = \{x_j\}_{j=1}^{N_x}$, $N_p = N_m$, ensemble de points cible

On cherche à minimiser

$$f(q) = \frac{1}{N_p} \sum_{i=1}^{N_p} \| x_i - R(q_R)p_i - q_T \| ^2 \quad (1)$$

Recalage 3D ("Iterative Closest Point (ICP)")

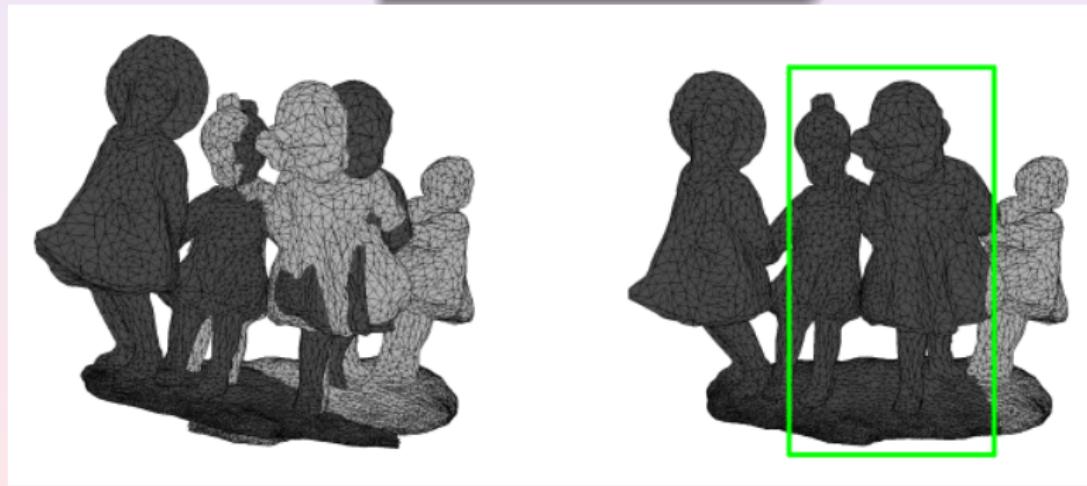
Besl, 1992

- ① $P_0 = P, q_0 = [1, 0, 0, 0, 0, 0, 0]^T, k = 0$
- ② Calculer les points les plus proches $Y = C(P_k, X)$
- ③ Calculer la transformation $(q, d) = Q(P_k, Y)$
- ④ Appliquer le recalage $P_{k+1} = q(P_k)$
- ⑤ Répéter (2), (3) et (4) tant que $d_k - d_{k+1} > \tau$, τ est le seuil d'erreur, $d_k = \min \|x - P_k\|, x \in X$

AuTrICP Automated Trimmed Iterative Closest Point

Synave, 2009

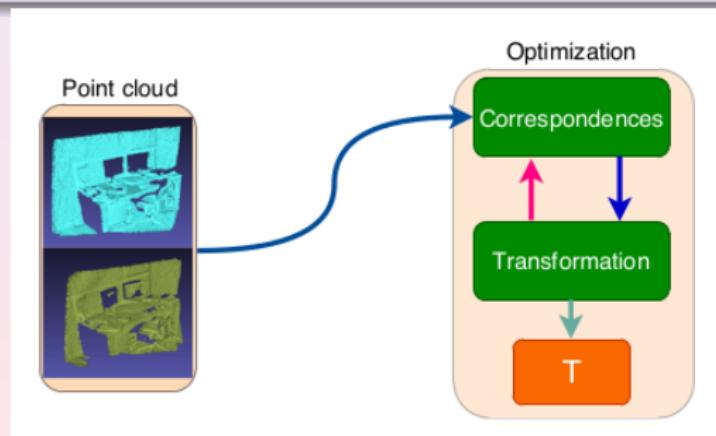
fig3-56



Recalage 3D de nuage de points

X.Huang et al., 2021

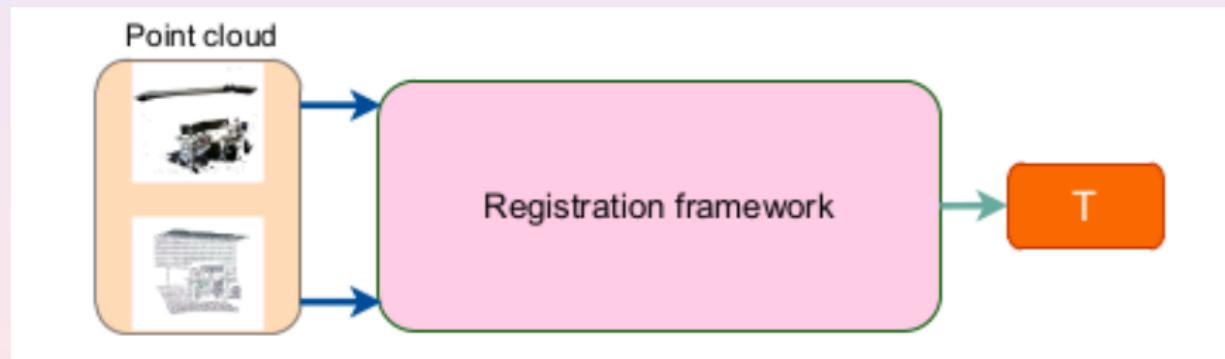
"A comprehensive survey on point cloud registration"
CoRR, abs/2103.02690, 2021, fig2a



Recalage 3D de nuage de points

X.Huang et al., 2021

fig2d

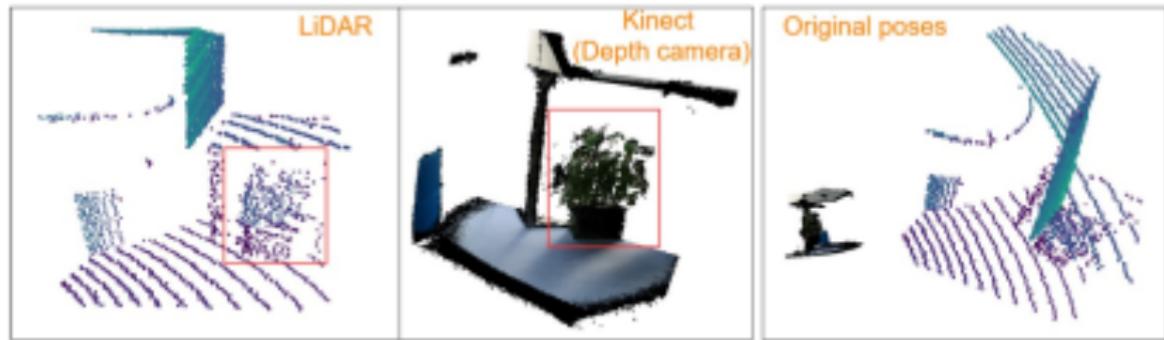


Recalage 3D de nuages de points multi-sources

X.Huang et al., 2023

"Cross-source point cloud registration : Challenges, progress and prospects", Neurocomputing, V 548, 2023, fig.1

Light Detection And Ranging



Large outliers

Density difference

Partial overlap

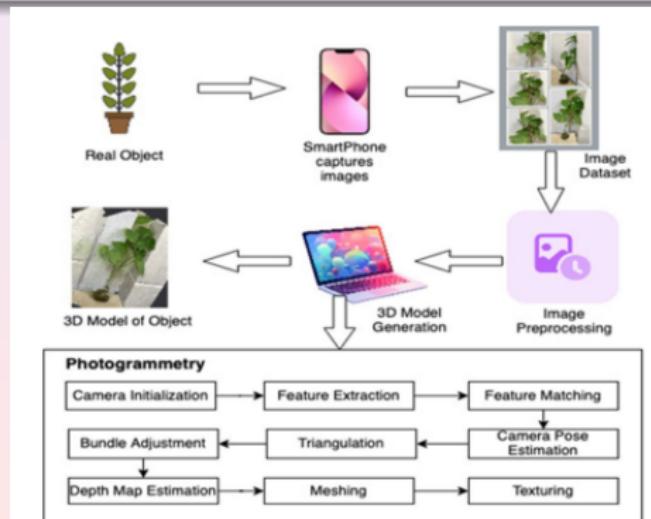
Large rotation

Scale difference

Photogrammétrie

T.Paul et al., 2025

"Improved 3D reconstruction pipeline for enhancing the quality of 3D model generation from multiview images"
 Sci Rep 15, 33231 (2025), <https://doi.org/10.1038/s41598-025-18318-x>



Photogrammétrie

T.Paul et al., 2025

Meshroom (2023.1.0) Software de photogrammétrie utilisé



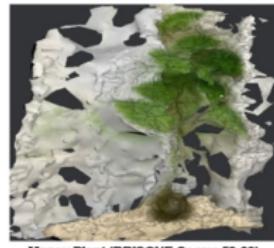
Money Plant (BRISQUE Score: 20.85)



Old Computer (BRISQUE Score: 29.17)
3D Model Generated using our Enhanced Pipeline



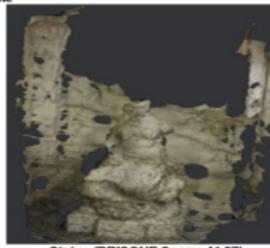
Statue (BRISQUE Score: 31.51)



Money Plant (BRISQUE Score: 59.60)



Old Computer (BRISQUE Score: 41.91)



Statue (BRISQUE Score: 41.97)

Photogrammétrie

A.Jasinska et al., 2025

"A simple way to reduce 3D model deformation in smartphone photogrammetry", Sensors, V 23, No 2, 2023



Photogrammétrie

A.Jasinska et al., 2025

Cloud Compare (V 2.13.Alpha)

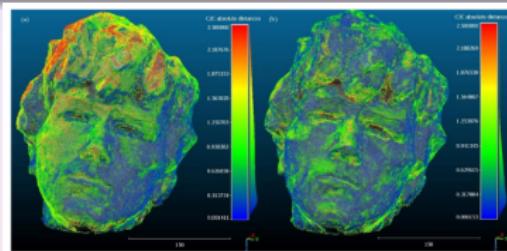


Figure 5. Deviations between the reference model and the model from Samsung Galaxy S10 images:
(a) with self-calibration, (b) with pre-calibration.

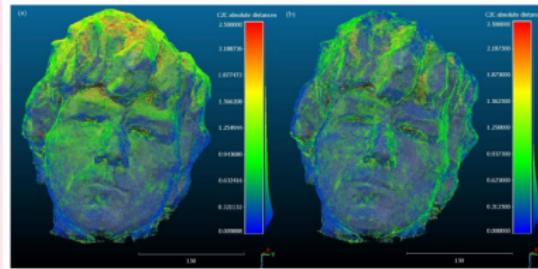


Figure 6. Deviations between the reference model and the model from Xiaomi Redmi Note 11S

3D : les meilleures applis de scan 3D (iPhone / Android)

All3DP

dernier accès 21/10/2025

Compatibilité Android

- [Kiri Engine](#)
- Dot3D
- MagiScan
- Widar
- [Polycam](#)
- PIX4Dcatch
- RealityScan
- ARPlan 3D

Uniquement iOS

- SureScan
- Recon-3D
- Scaniverse
- 3D Scanner App
- Metascan
- EM3D : Ethan Makes 3D Scanner
- ItSeez3D