

# **Snímanie ľudského tela 3D kamerami do virtuálnej reality**

Martin Madaras  
madasar@sketex.xyz

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Predstav si, že sa chceš stretnúť s kamarátom vo virtuálnej realite. K tomu by sme potrebovali vedieť naskenovať 3D model človeka, v reálnom čase ho streamovať a realisticky renderovať. Ako fungujú 3D kamery? Ako z naskenovaných dát zrekonštruovať 3D model? Ako tento model čo najefektívnejšie streamovať online? Povieme si, ako k tomuto problému pristupujeme my vo firme, aké máme motivácie, čo sa nám podarilo a aké problémy stoja ešte pred nami.

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**Univerzita Komenského**  
**FMFI**  
**Katedra Aplikovanej Informatiky**



# Katedra aplikovanej informatiky, FMFI

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- ▶ Počítačová grafika
- ▶ Umelá inteligencia
- ▶ Softvérové inžinierstvo
- ▶ Didaktika informatiky

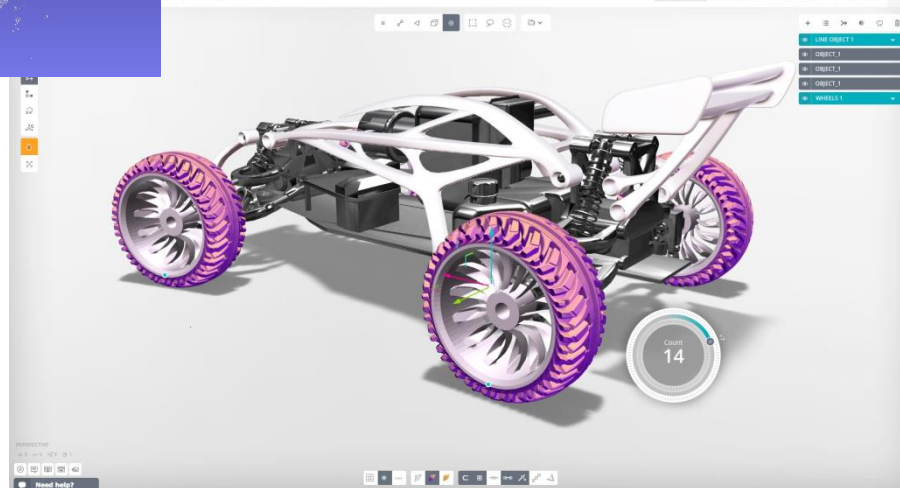
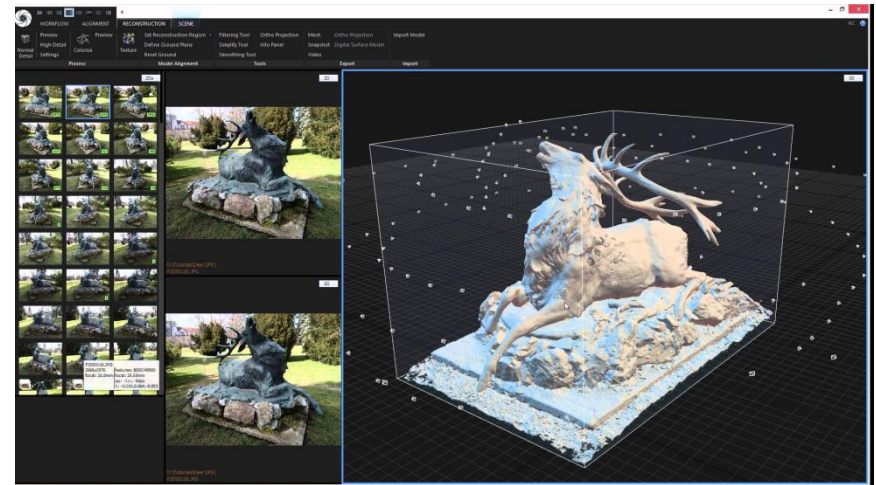
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## **Situácia na Slovensku**



# “The Danube Valley”

- ▶ Photoneo, Vectary, Capturing Reality, ...



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# Skeletex Research

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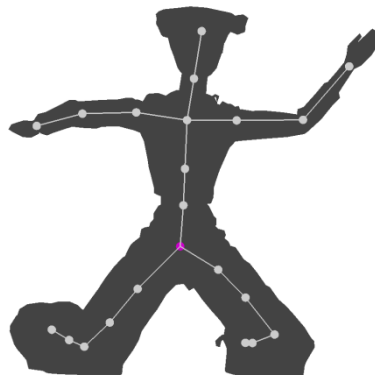
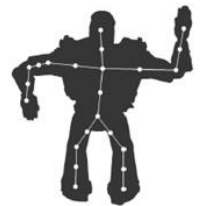
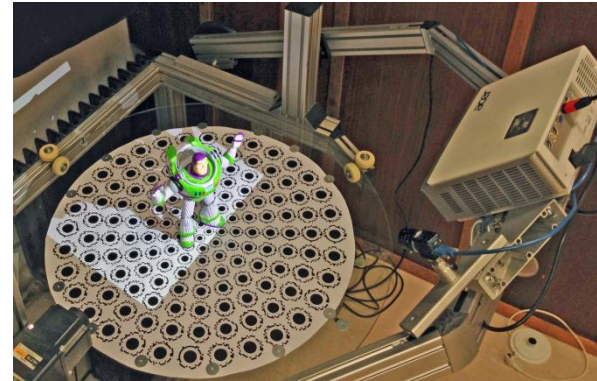
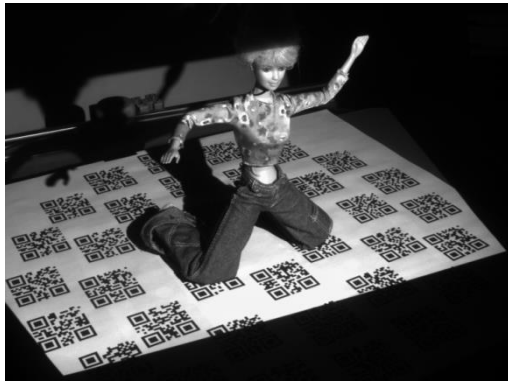
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- ▶ **Freelancing R&D skupina**
  - ▶ Martin Madaras
  - ▶ Adam Riečický
  - ▶ Michal Mesároš
  - ▶ Martin Stuchlík
  - ▶ Michal Piovarči
  
- ▶ Aktuálny aplikovaný výskum
- ▶ Spolupráca s poprednými tech firmami
  - ▶ Photoneo
  - ▶ Synertial



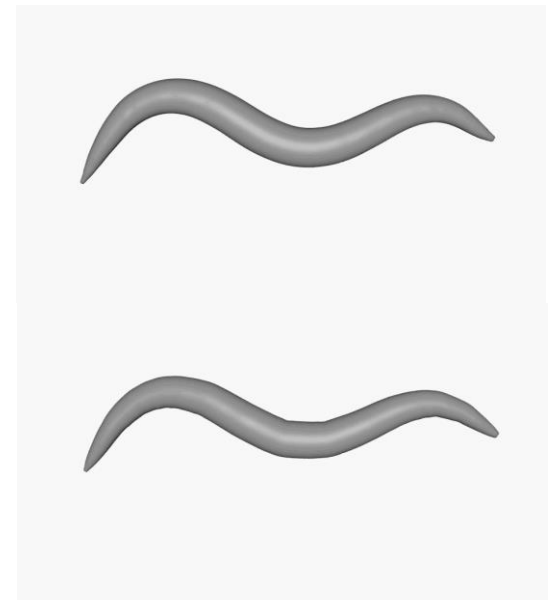
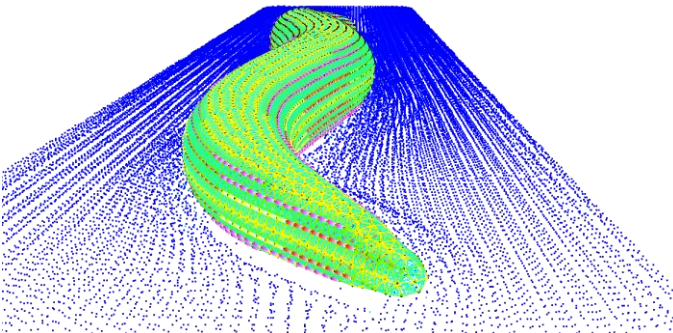
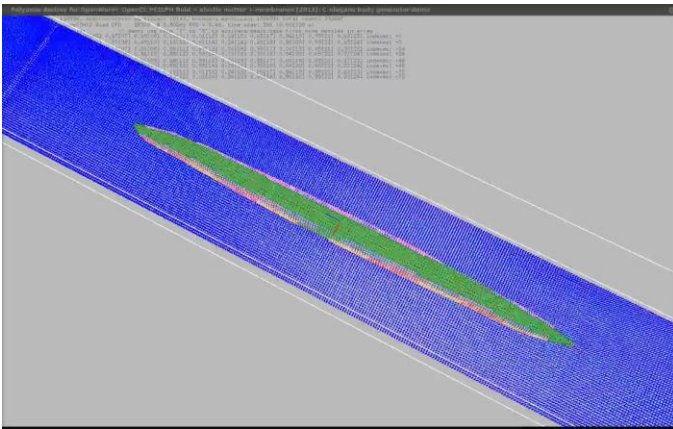
# Skeletex Research História

## ► Extrakcia kostier a aplikácie



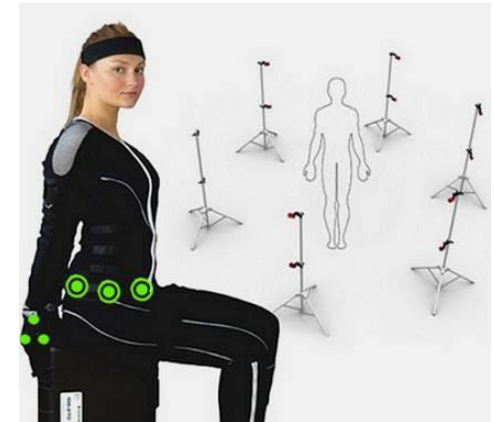
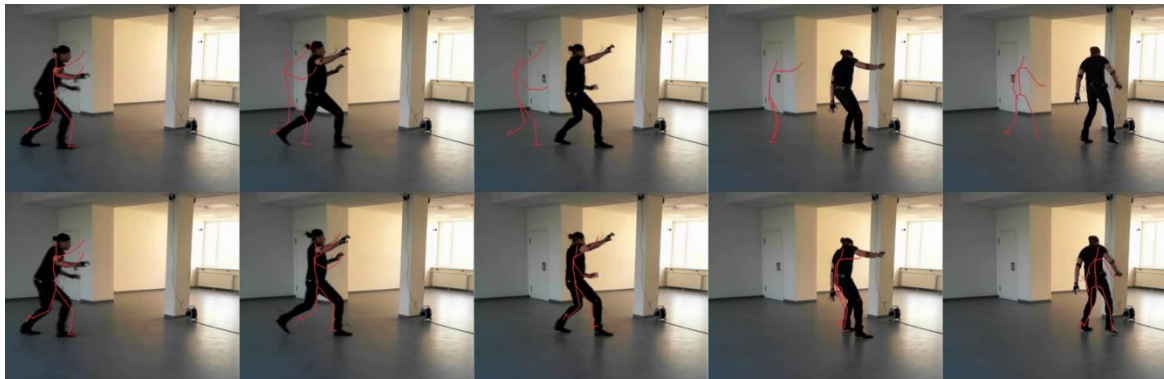
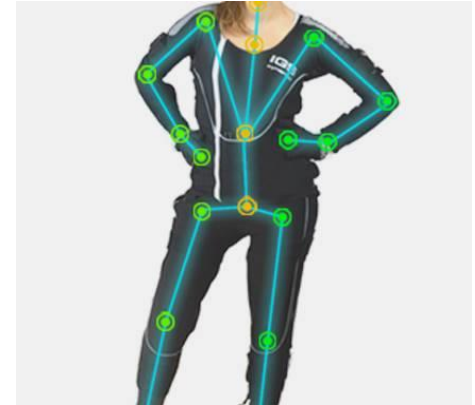
# Skeletex Research História

- ▶ Extrakcia kostier a aplikácie
- ▶ Openworm



# Skeletex Research História

- ▶ Extrakcia kostier a aplikácie
- ▶ Openworm
- ▶ Kinexact + Optinertial (Synertial)



# Skeletex Research História

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- ▶ Extrakcia kostier a aplikácie
- ▶ Openworm
- ▶ Kinexact + Optinertial (Synertial)
- ▶ Photoneo
- ▶ Univerzita



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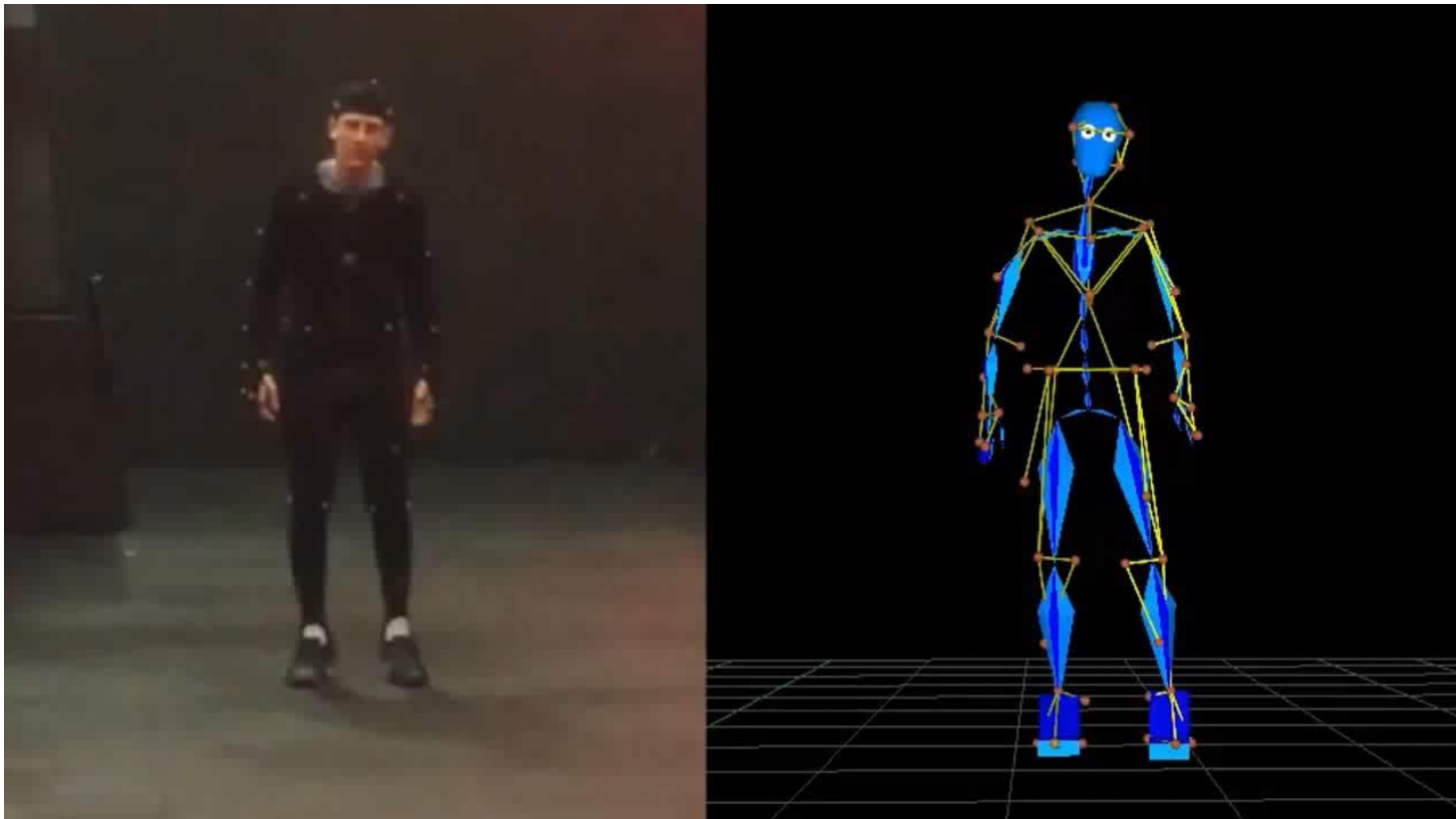
**“Motion Capture”**  
**MoCap obleky & rukavice**  
**Optinertial**



# “Motion Capture”

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- ▶ Snímanie pohybu herca
- ▶ Prirodzená animácia charakterov v PG



# Optický Mocap

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- ▶ Odhad pozície markerov



# Problémy Optického Mocapu

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- ▶ Komplikované nastavenie
- ▶ Problémy so zakrývaním častí
- ▶ Limitovaný priestor





# Inerčný Mocap

- ▶ Inertial Measurement Unit
- ▶ Rotácie kostí z IMU senzorov



# Problémy s Mocap Oblekmi

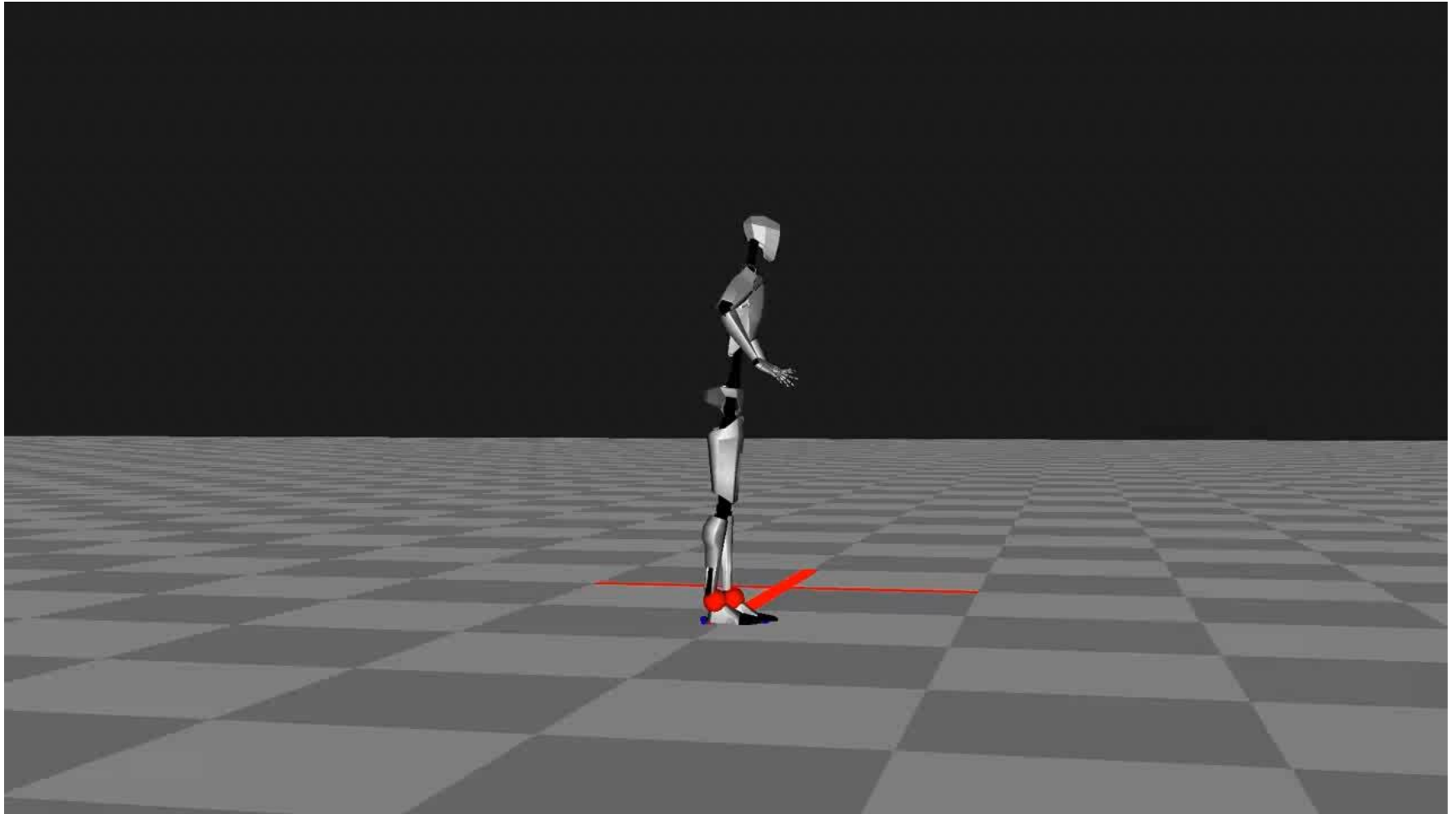
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- ▶ Vlastná implementácia chodiacich algoritmov
- ▶ Nepresné pre skákanie, kĺzanie a komplexné pohyby
- ▶ Potrebná neustála recalibrácia



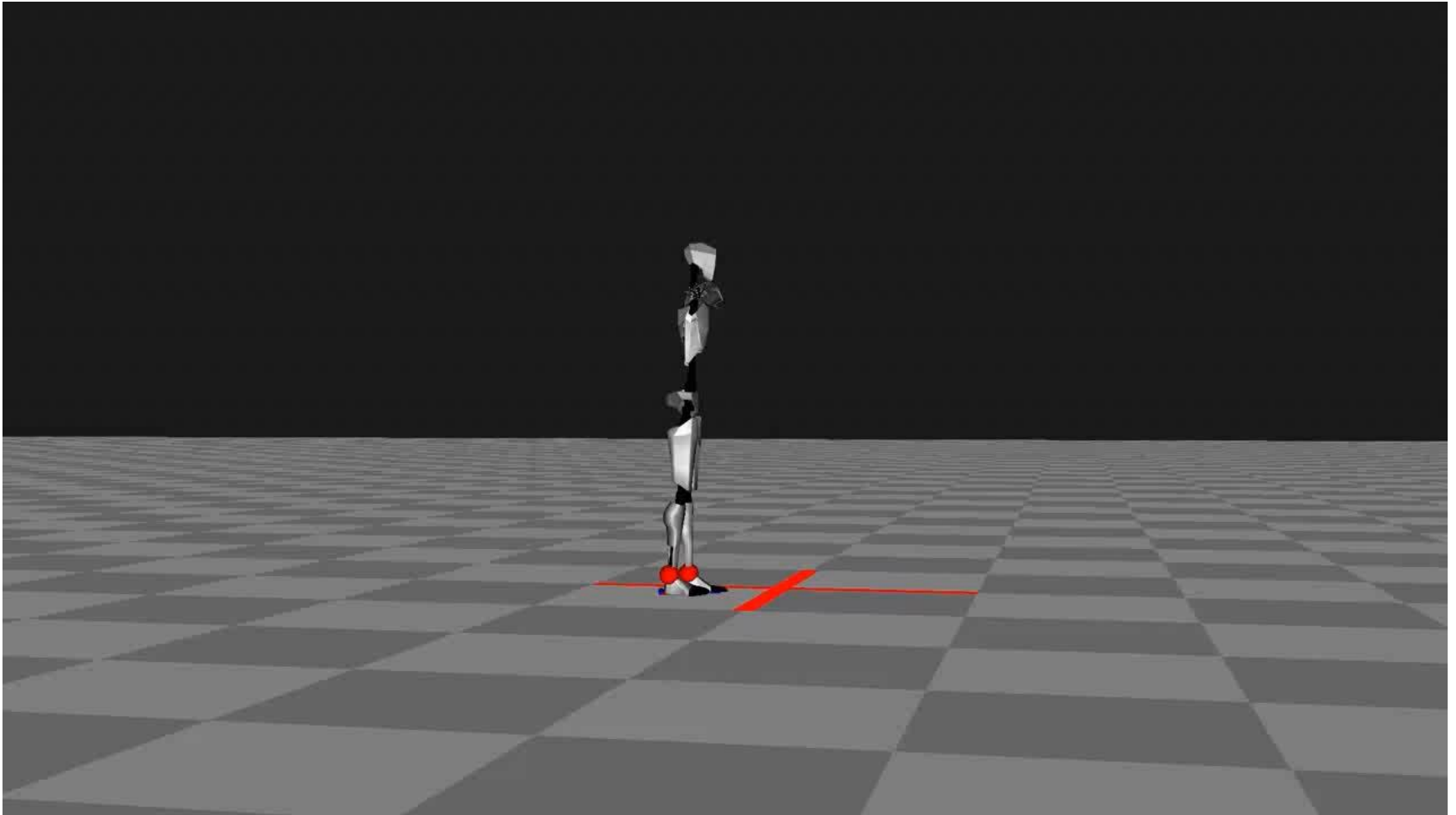
# Mocap Chodiaci Algoritmus

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# Chyba Chodiaceho Algoritmu

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# Hlavná Idea

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- ▶ **Synchronizovať inerčný mocap oblek s kamerou**
  - ▶ Rotácie kĺbov z obleku
  - ▶ Odhad pozície z kamery
- ▶ Obísť nevýhody oboch metód
- ▶ Získať spoľahlivú pozíciu a rotácie
  
- ▶ Ako synchronizovať a spojiť tieto dáta ?

# Naša Idea

MoCap suit input



Basemesh generation  
(in actor's pose)



Camera RGB input



Actor tracking  
and segmentation



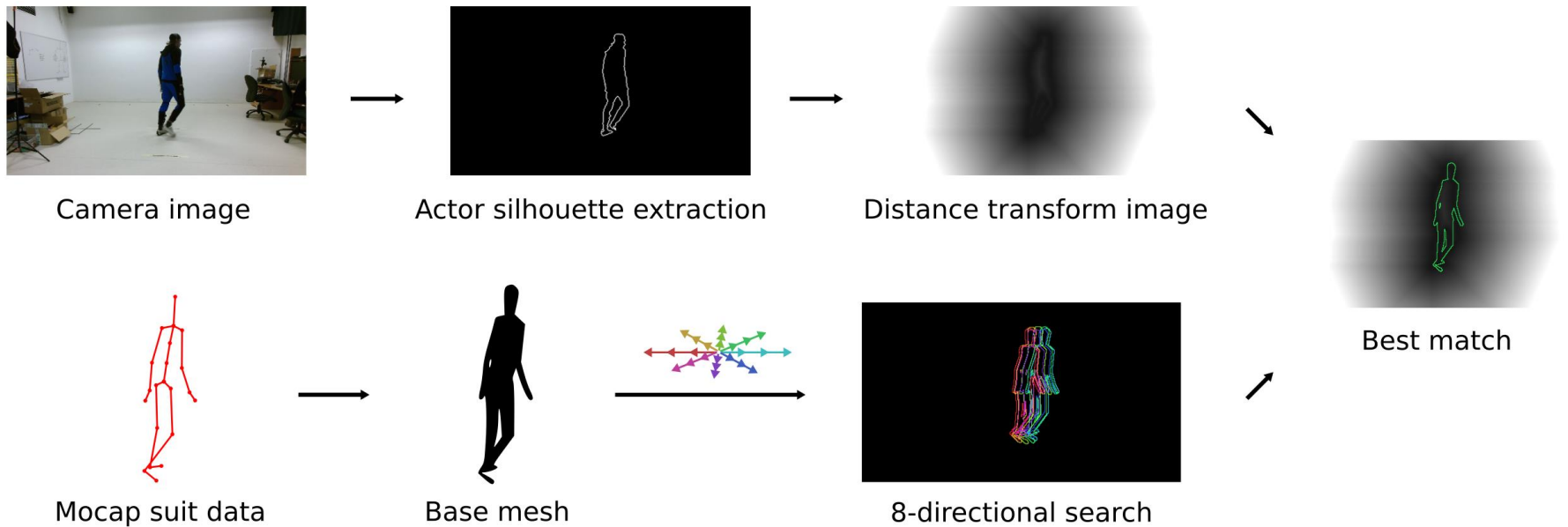
*Matching basemesh  
template to segmented  
actor silhouette in  
screen space*

3D actor position  
in a world space



# Optinertial

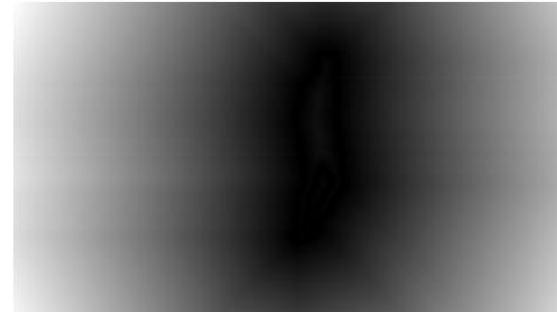
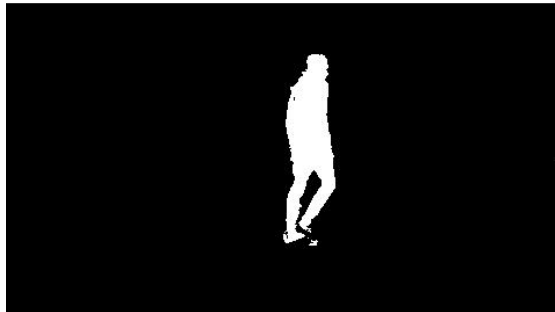
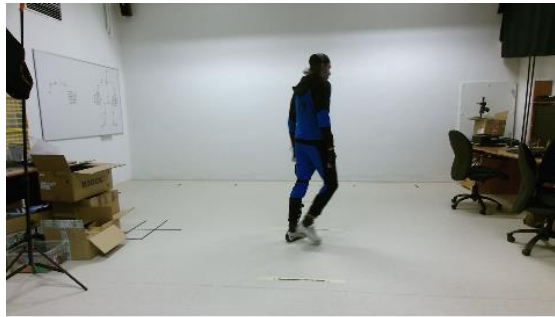
## ► Chamfer matching



# Obraz z Kamery

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- ▶ Distance transform image
- ▶ Odróatanie pozadia

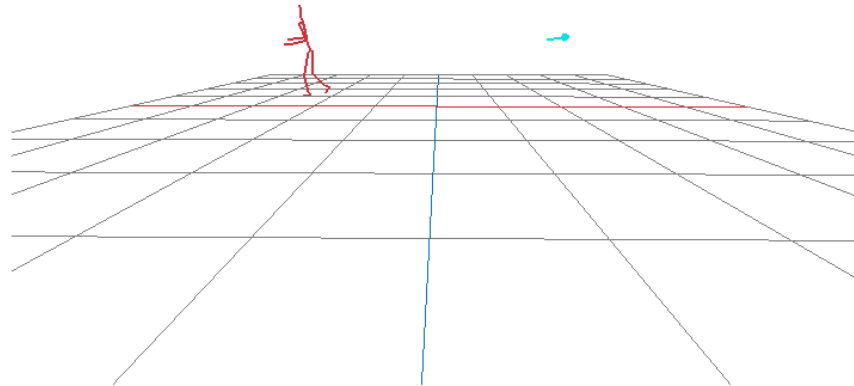




# Virtuálna Scéna

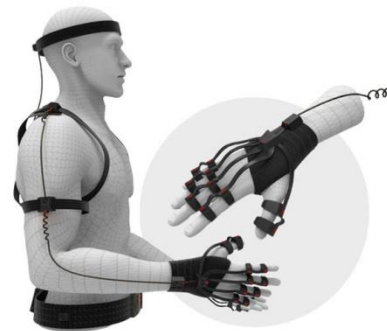
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- ▶ Updatovanie virtuálnej scény v reálnom čase
- ▶ Každý snímok sa vykreslí
- ▶ Kalibrácia kamery / odhad pozície



# Mocap Obleky

- Rôzne množstvo IMU senzorov vs. cena



Synertial

PERCEPTION  
NEURON™

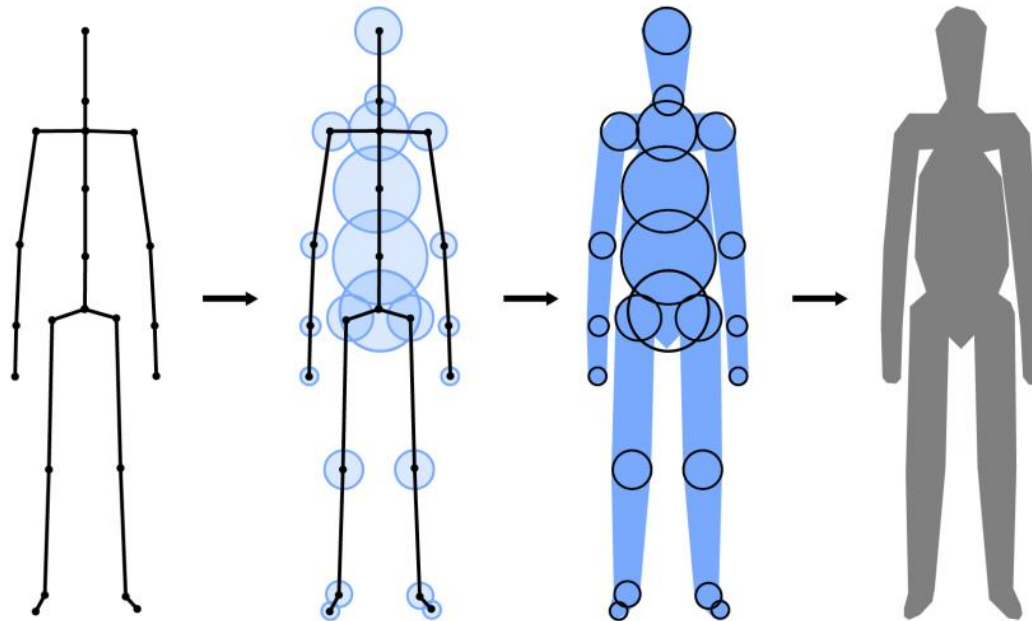


xsens

# Vykreslenie Základného Modelu

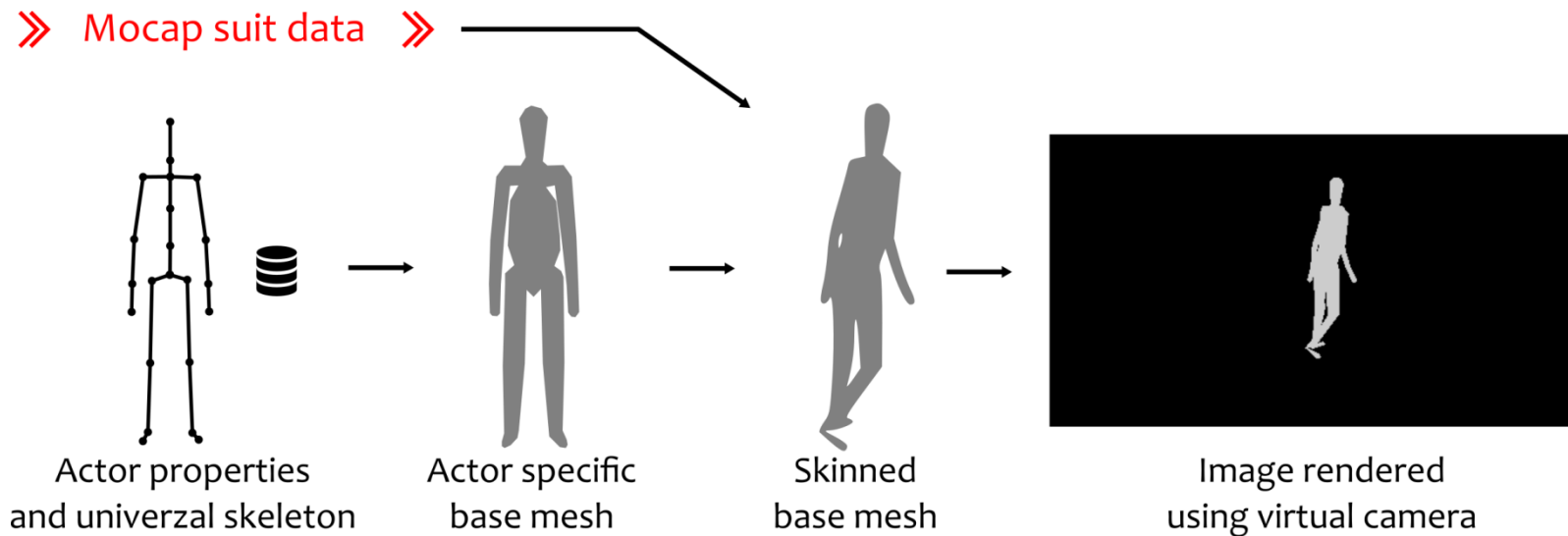
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- ▶ SQM algoritmus (kostra, rádiusy)
  - ▶ Baerentzen et al. 2012



# Vykreslenie Základného Modelu

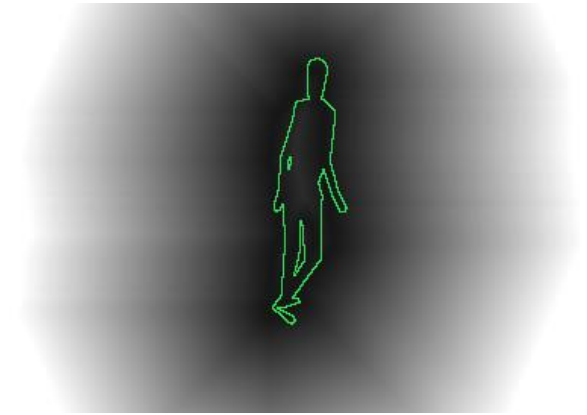
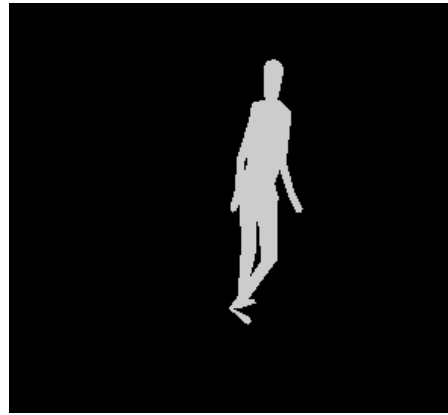
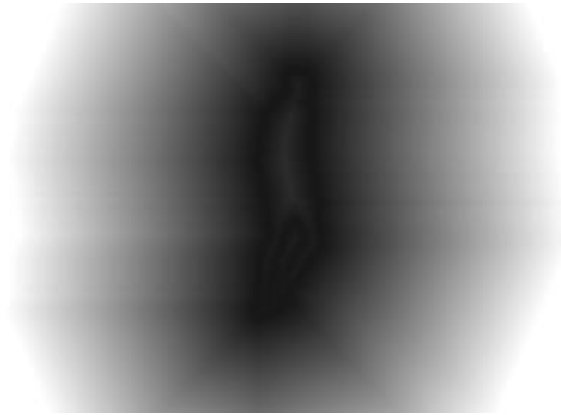
- ▶ Databáza vykreslených obrázkov
- ▶ Skinning základného modelu



# Detekcia Pohybu

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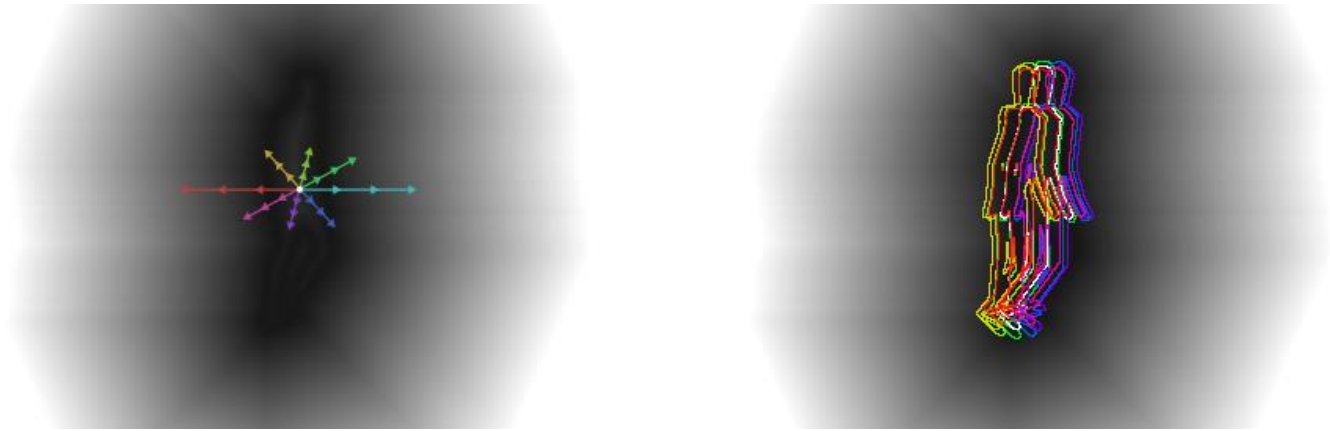
- ▶ Nájdienie najlepšieho posunu herca
- ▶ Distance transform minimalizácia



# Prehľadávanie Obrazového Priestoru

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## ► Silueta + integrácia



$$e_k = \iint_S DT(\mathbf{x}(s, t)) ds dt$$

# Výsledky - Video

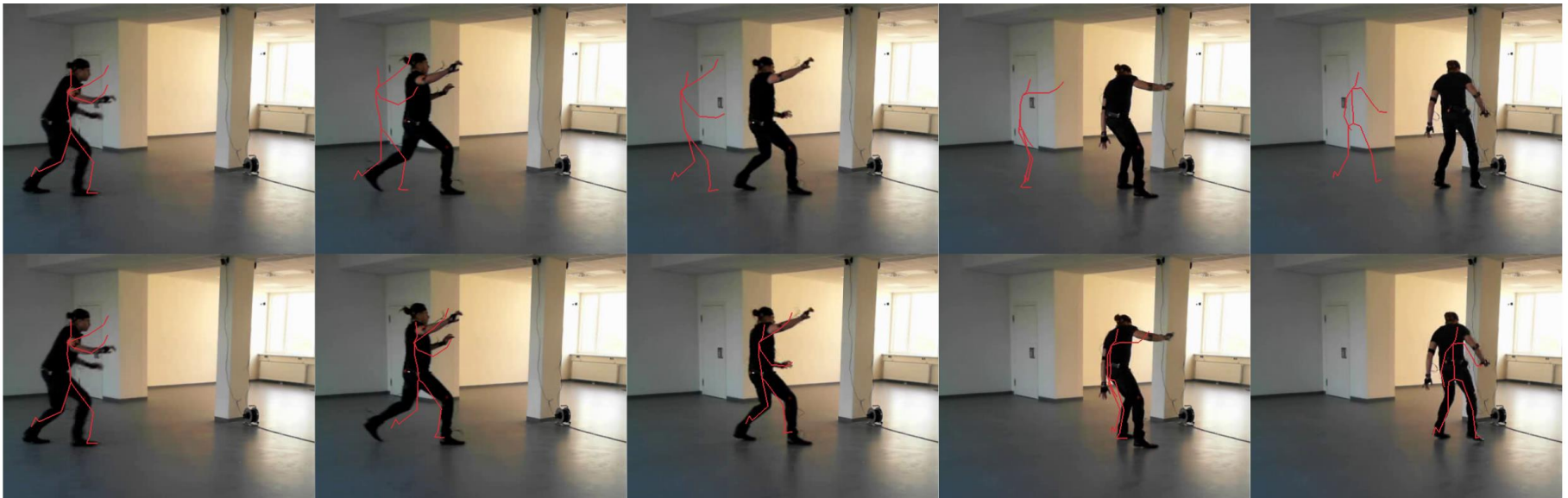
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Optical-Inertial Synchronization of MoCap Suit  
with Single Camera Setup  
for Reliable Position Tracking

# Výsledky – Vizualizácia

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## ► Sekvencia šmýkania





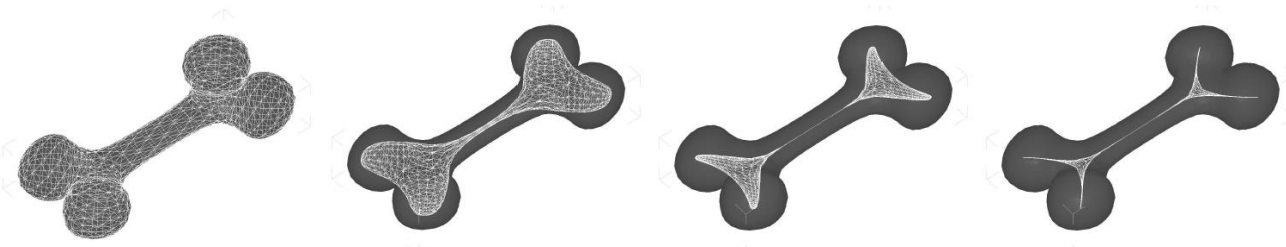
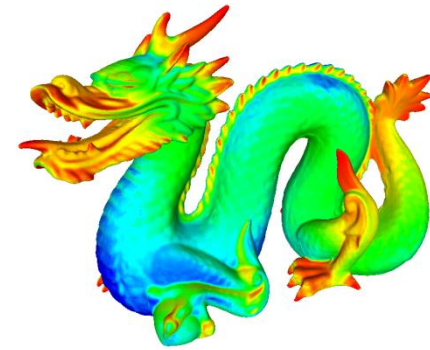
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# Aktuálny Výskum

# Náš Výskum

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- ▶ Spracovanie polygonálnych sietí
- ▶ Automatická extrakcia kostier
- ▶ Skenovanie modelov
- ▶ 3D rekonštrukcia
- ▶ MoCap
- ▶ Fitovanie kostry do človeka



# Ultimátny Cieľ

- ▶ Záznam pohybu človeka v reálnom čase a vykreslenie rekonštrukcie vo virtuálnej realite



# VR Proces

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- ▶ Sledovanie kostry a povrchu
- ▶ Fúzia spojitého povrchu
- ▶ Kompresia & streamovanie dát
- ▶ Rekonštrukcia povrchu z textúr a kostry
- ▶ Vykreslenie & aplikácie



Skeleton Displacement Mapping

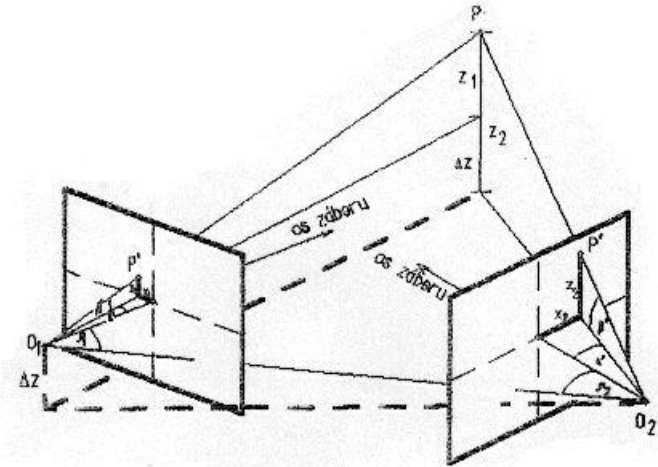
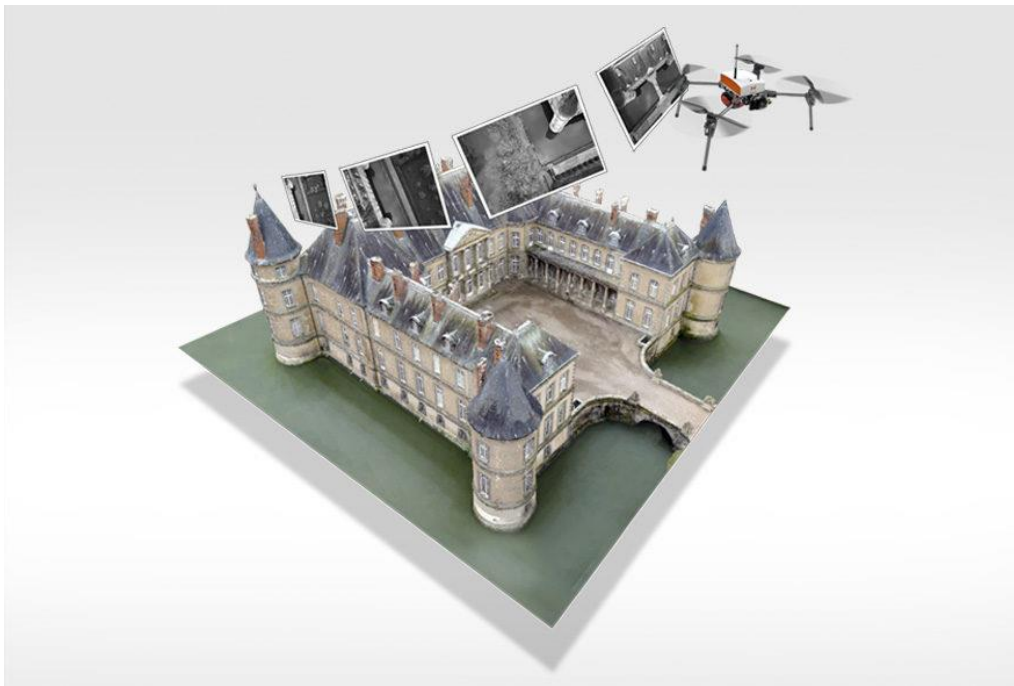
3D face scan reconstruction

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## **3D Kamery / Skenery**

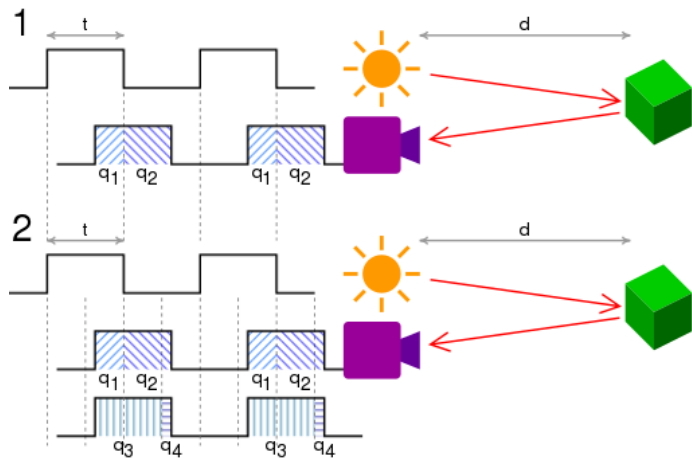
# “Stereo Vision”

- ▶ > 2 kamery
- ▶ Fotogrametria



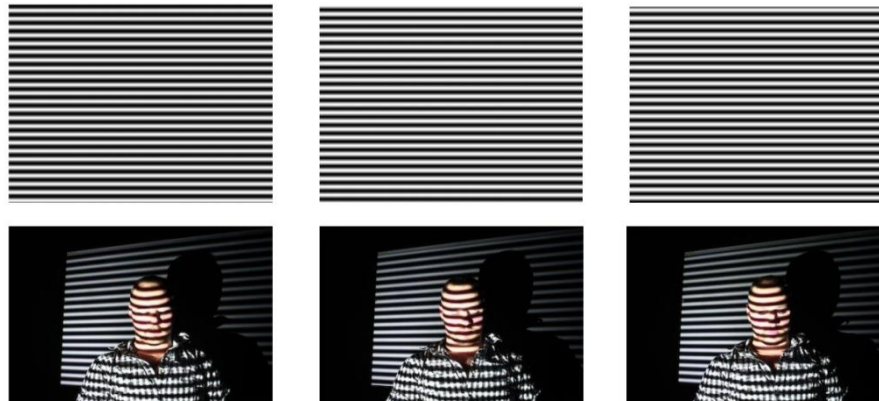
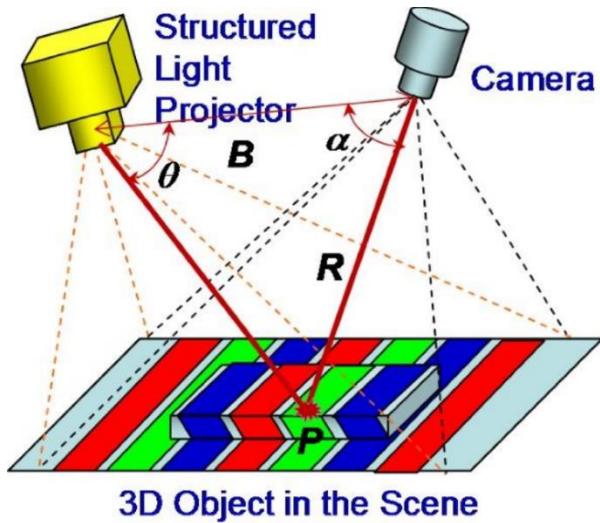
# “Time of Flight”

- Svetelné pulzy a odraz zachytený na fotodiódach



# “Structured Light”

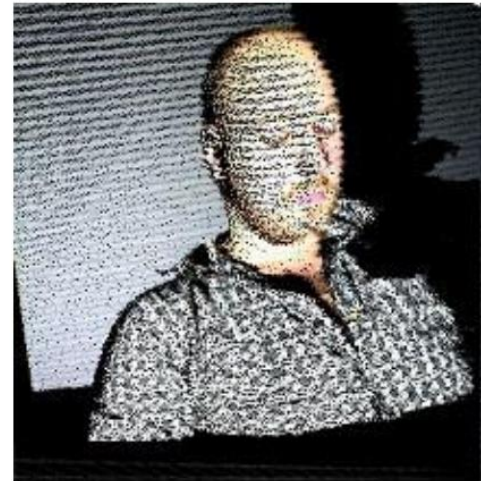
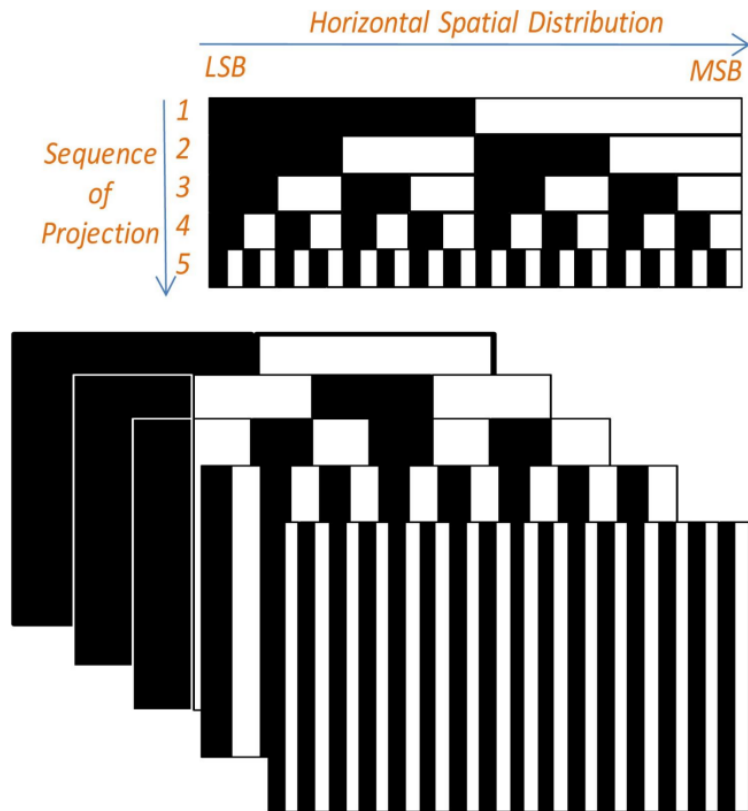
- Projekcia vzorov, snímanie kamerou – korešpondencia





# “Structured Light”

## ► Binárne sekvencie – pozícia



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# Sledovanie Kostry

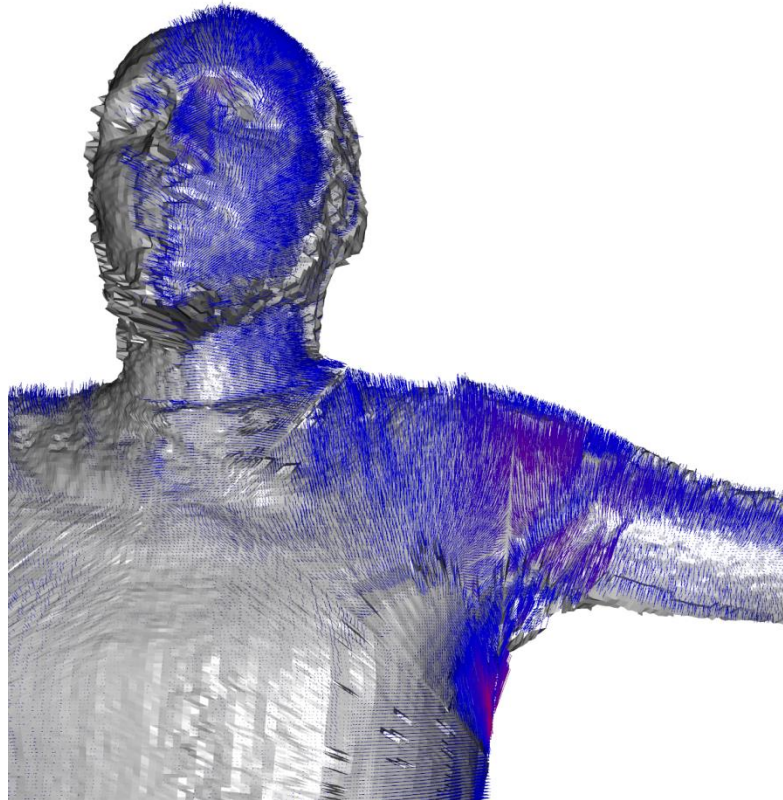
# Mračno Bodov & Sledovaná Kostra

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# Optický Tok

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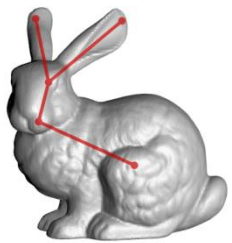


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# Skeletex Dátová Štruktúra

# Skeletex

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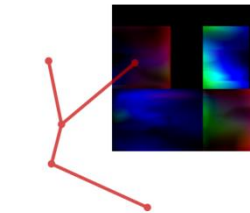
*Mesh and Skeleton*

## Conversion

Automatic segmentation



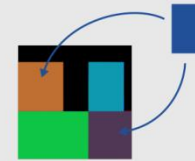
Parameterization and displacement extraction



*Skeletex - skeleton and displacement map*

## Rendering

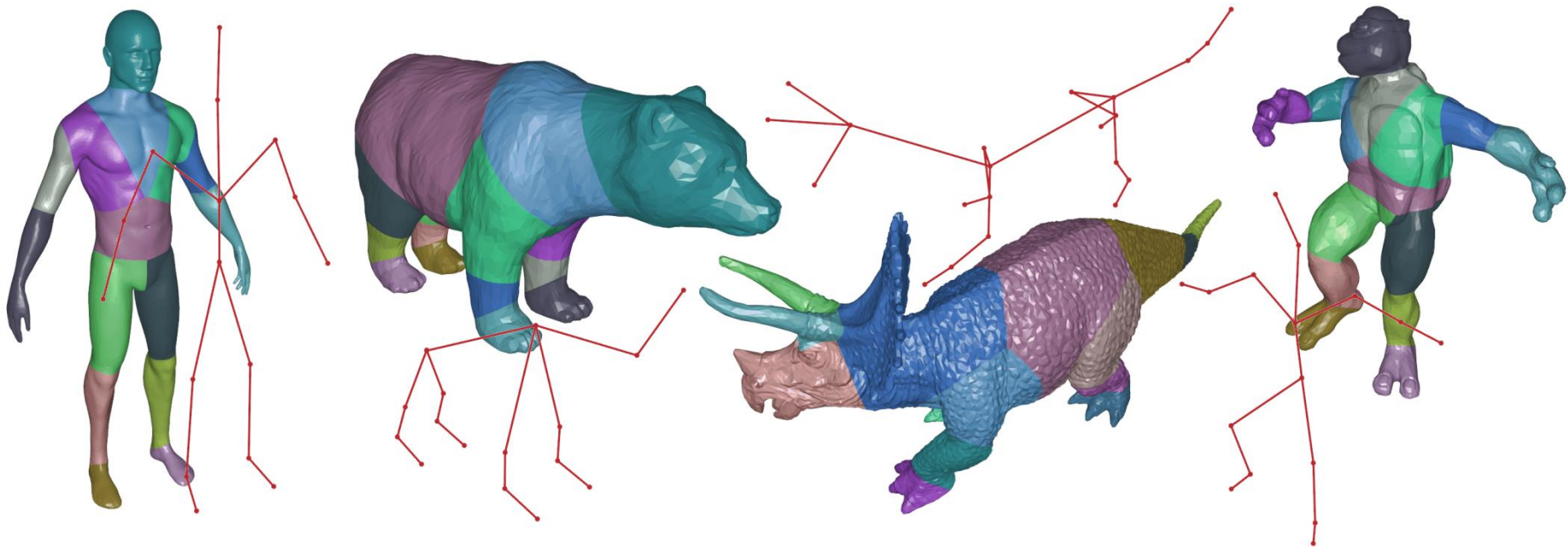
Possible modification



*Reconstruction*

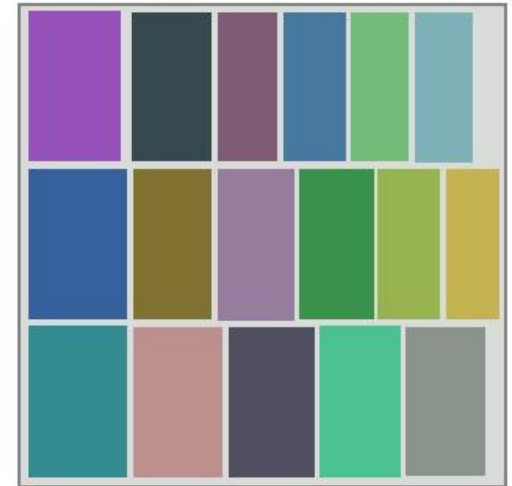
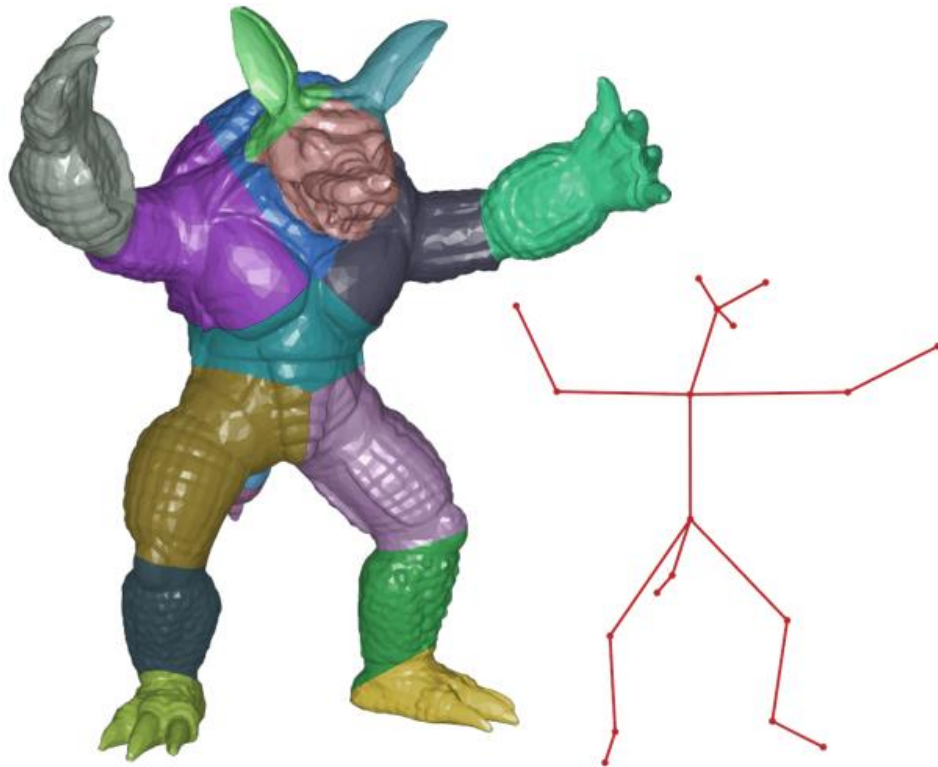
# Skeletex Segmentácia

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# Skeletex Rozloženie

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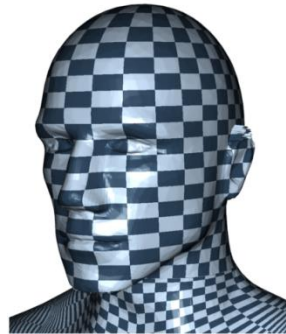


# Skeletex Parametrizácia

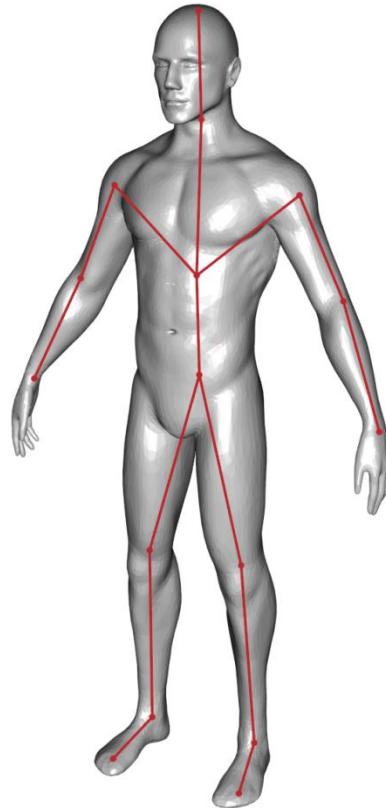
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VSM



SPD



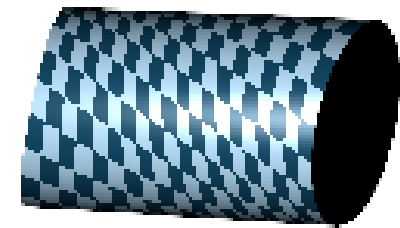
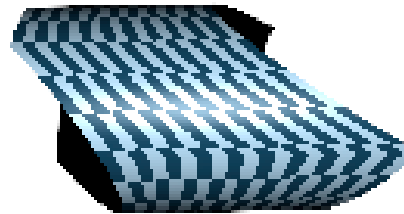
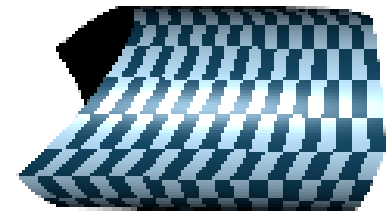
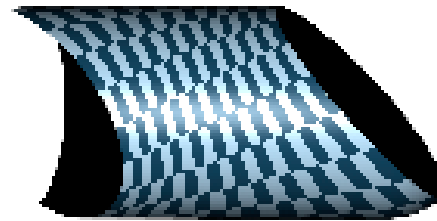
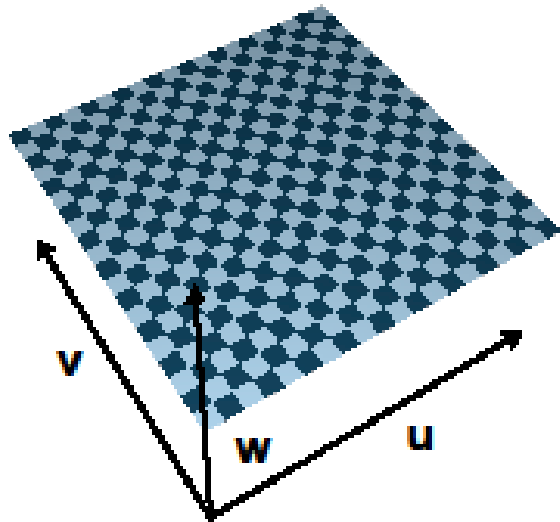
VSM



SPD

# Tangentný Priestor Kosti

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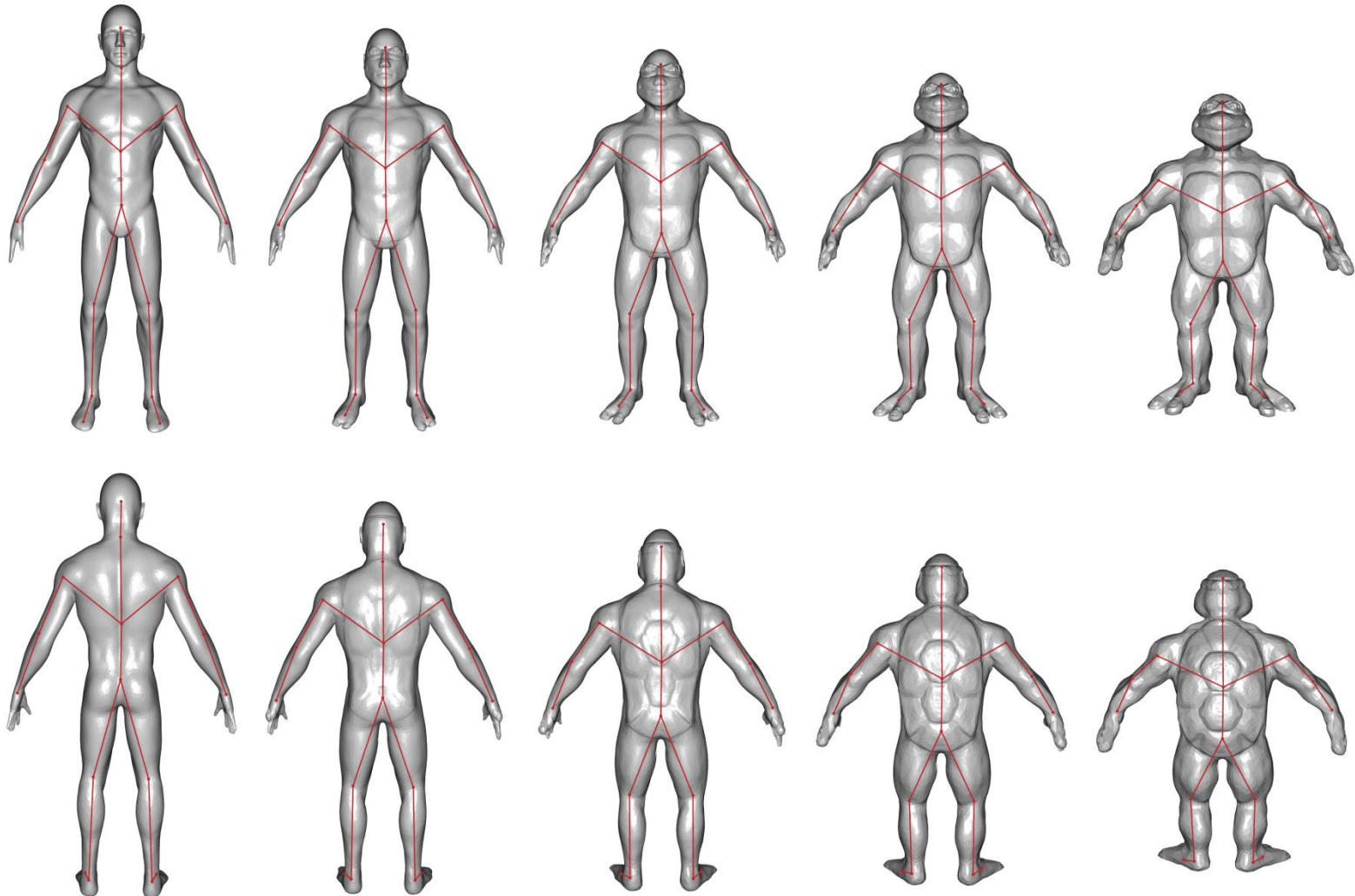
# Skeletex LoD

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# Textúrne Morfovanie

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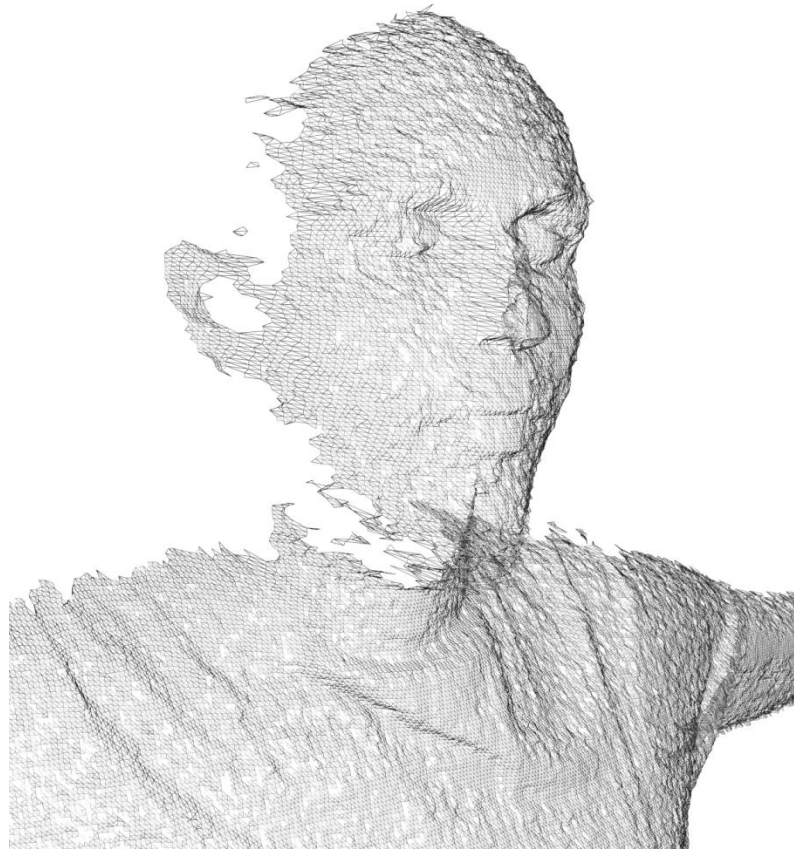


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# Skeletex Fúzia Povrchu

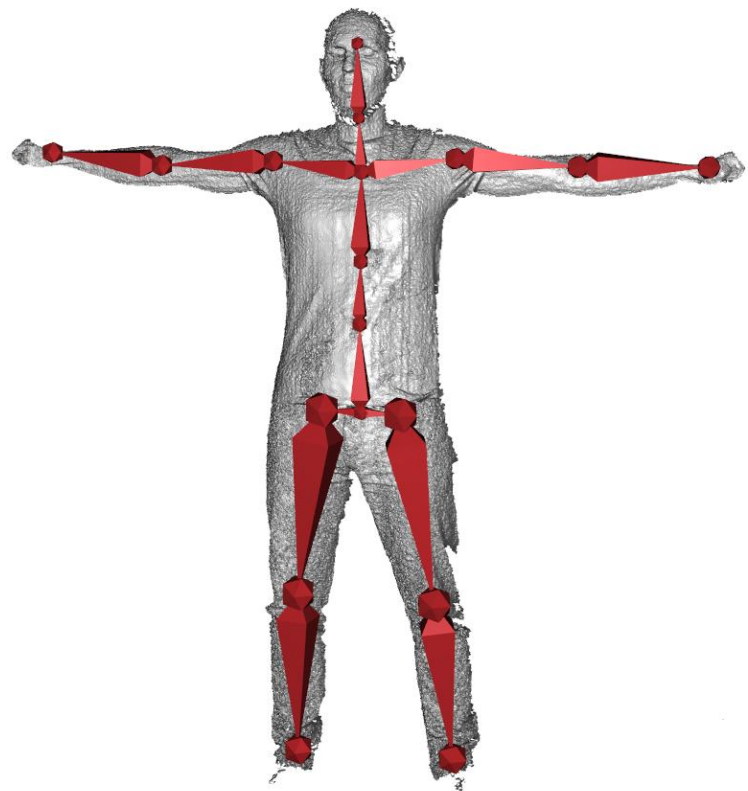
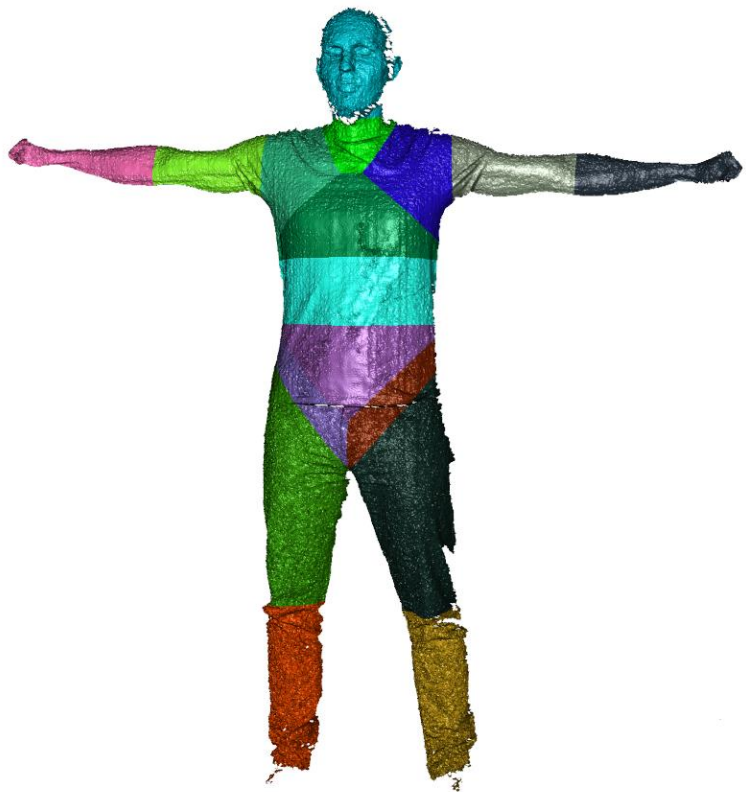
# Vstup z Kamery

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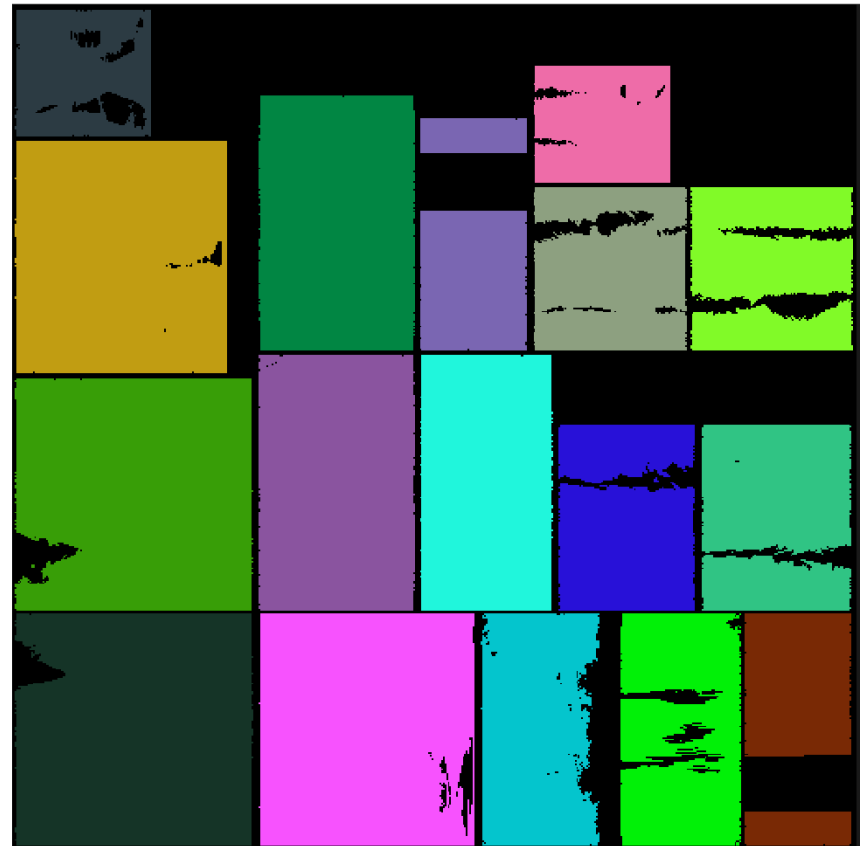
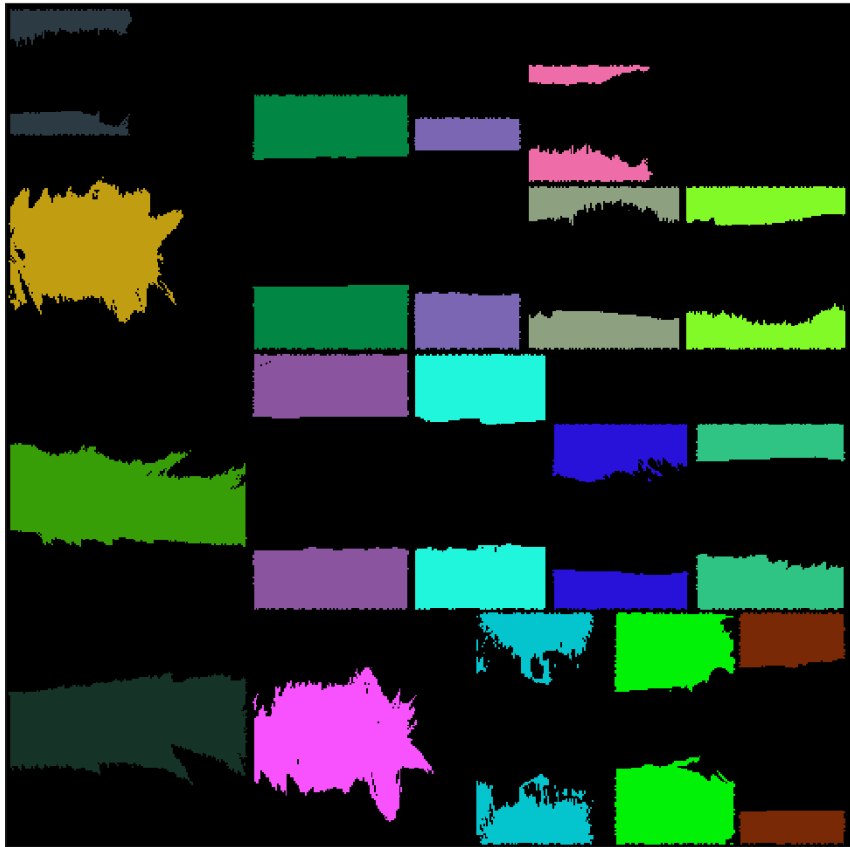
# Kostrová Segmentácia

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# Segmentačná Mapa

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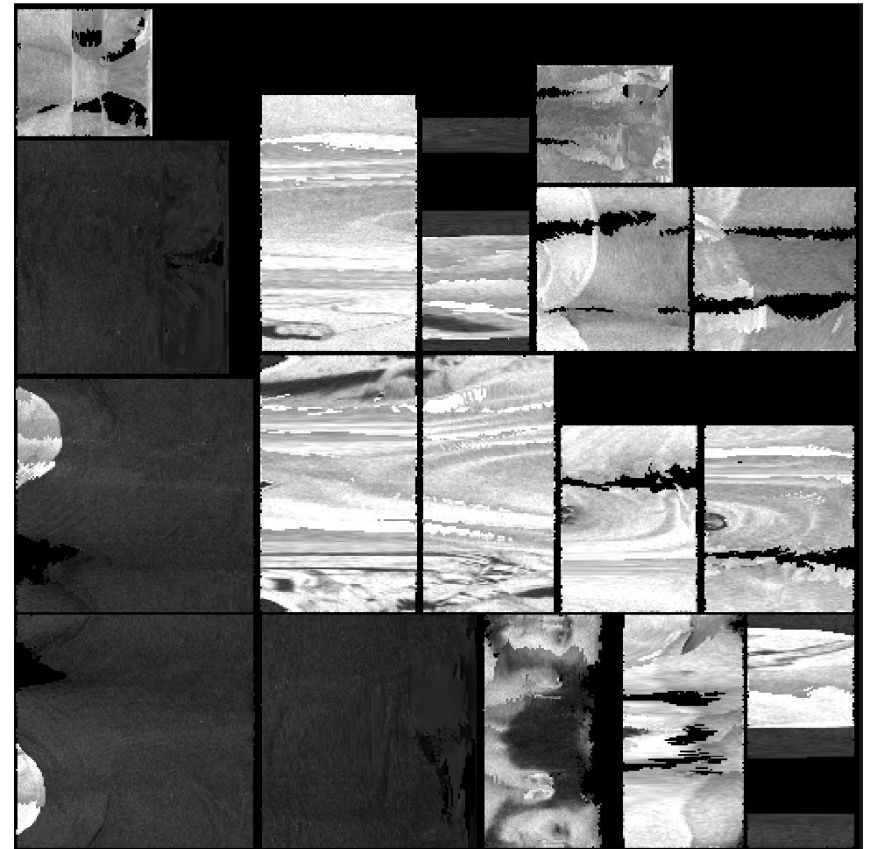
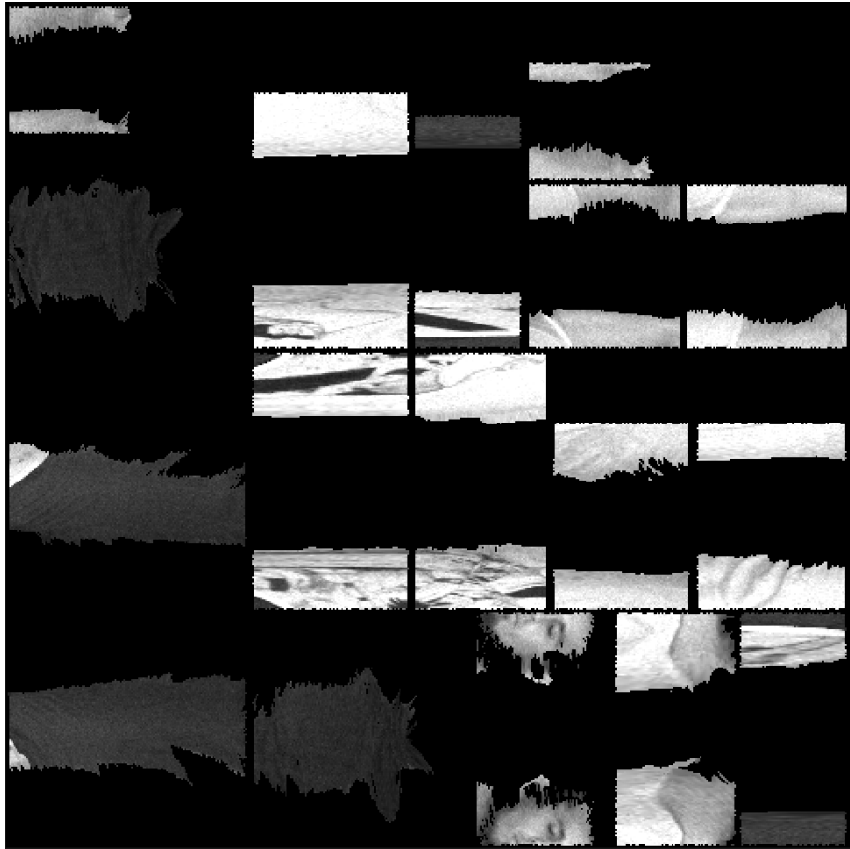
# Výšková Mapa

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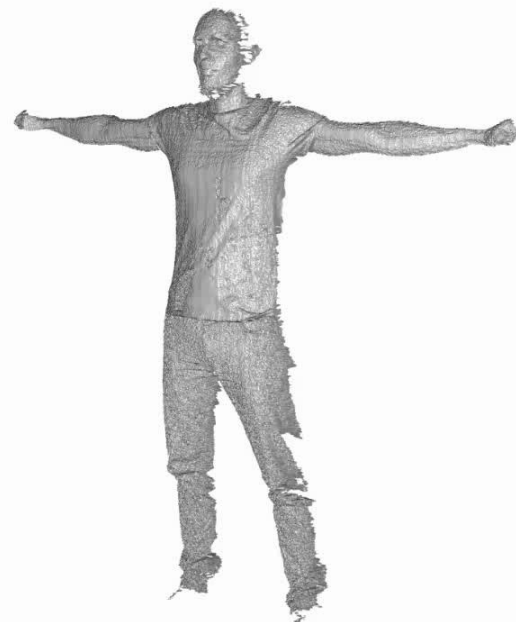
# Intenzitná Mapa

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# Fúzia Povrchu

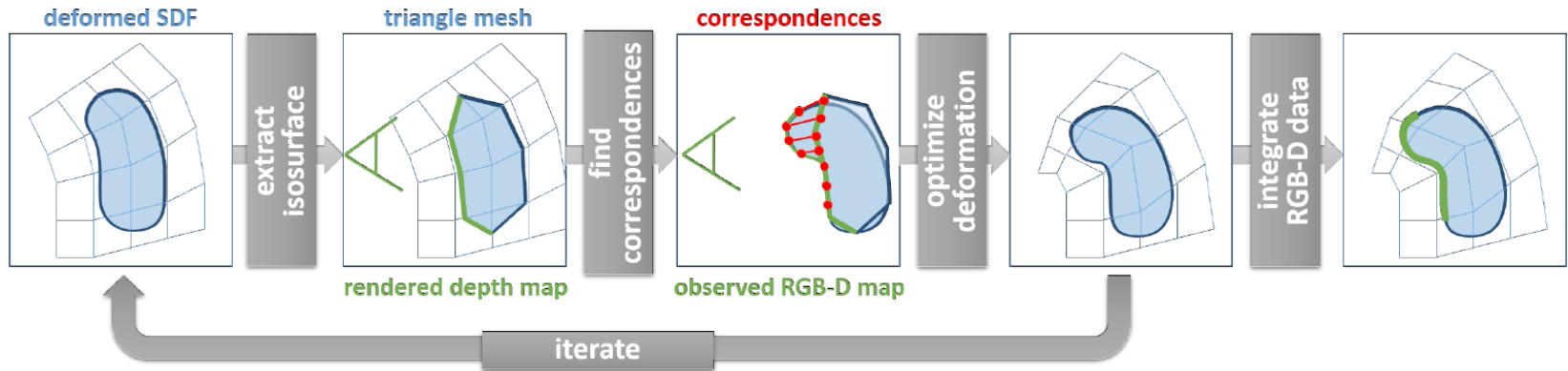
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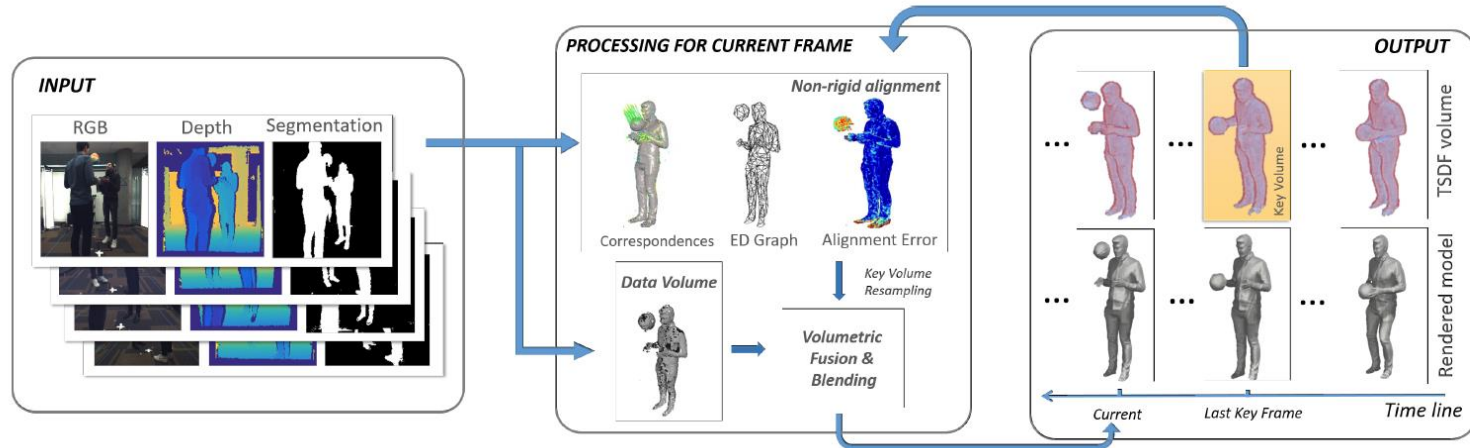
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# Aktuálne riešenia fúzie povrchu

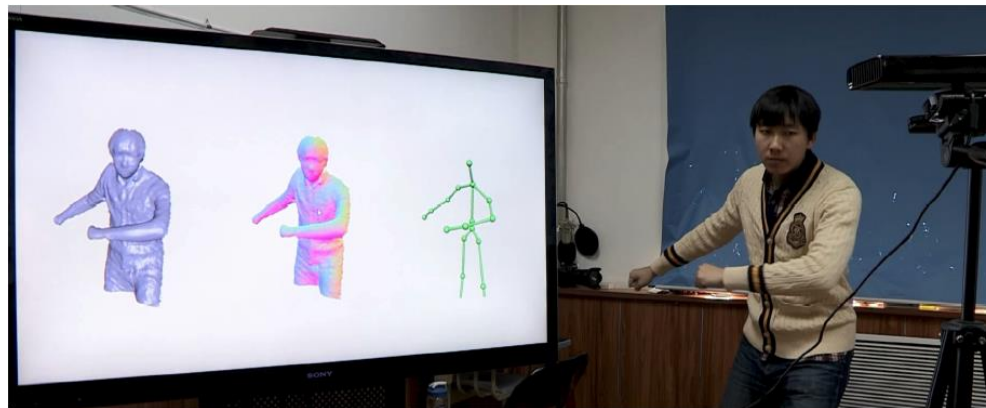
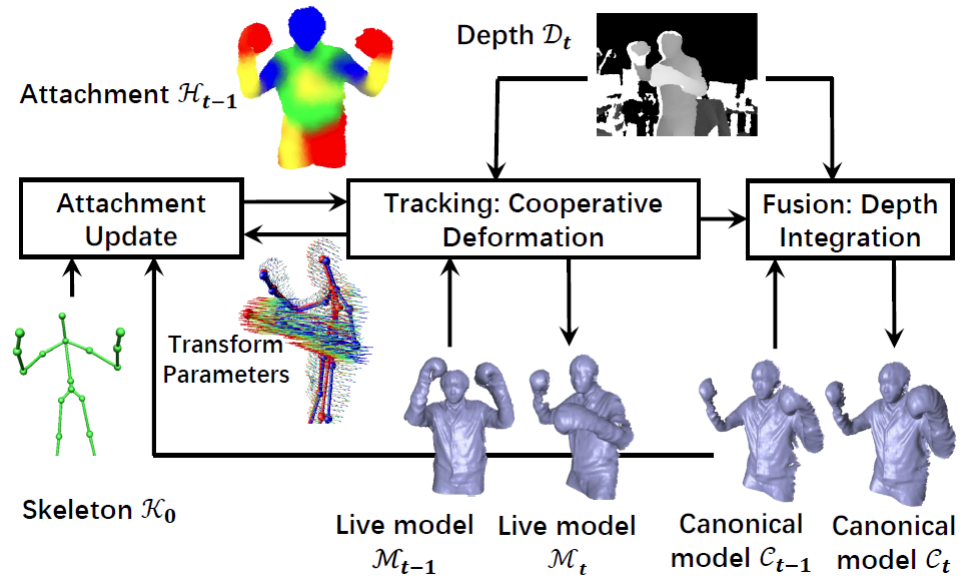
# VolumeDeform



# Fusion4D



# BodyFusion



# Naša Výhoda

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- ▶ Všetky ostatné metódy su volumetrické
- ▶ Štruktúra na fúziu je zároveň štruktúra na streamovanie
- ▶ Môžeme priamo použiť video kodek



# Na Záver

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- ▶ FMFI
- ▶ Počítačová grafika
- ▶ Skeletex research

# Partneri

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**Synertial**



**mpp**



# Vďaka !

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**Skeletex**  
R E S E A R C H

[www.skeletex.xyz](http://www.skeletex.xyz)  
[madaras@skeletex.xyz](mailto:madaras@skeletex.xyz)

MI13 --- FTLab