NICP: Neural ICP for 3D Human Registration at Scale

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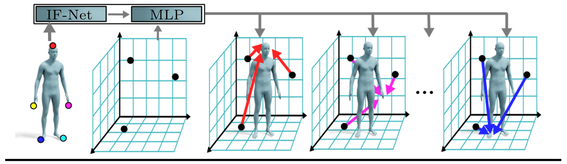
neural-icp.github.io

Goal

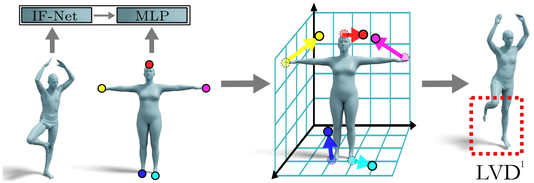
Registering a template to an input 3D Pointcloud

Neural 3D Registration

During the **training**, a network learns m neural fields, one for every template point. For any point in $\mathbb{R}^3$, it predicts the m offsets toward the target registration.



At **inference** time, it applies the offsets to the template vertices to deform it toward the target.



Problems

Lack of generalization causes **trivial misalignement.** Covering all the challenges within a training set is hard.

Neural Iterative Closest Point (NICP)

Points on the target surface should already be **close to the solution space.**

Hence, for every target point, **at least one predicted offset should have the norm close to zero.**

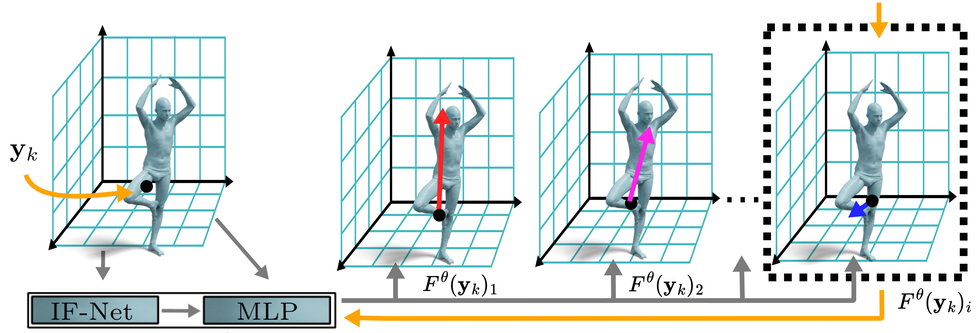
At inference time, fine-tune the Neural Fields in an ICP fashion, such that the prediction lies on the target.

(1) Query the Neural Field right on the target surface

(2) Select the offset with minimum norm.

$$\widetilde{i}_k = \arg\min_i \|F^{\tilde{\theta}}(\mathbf{y}_k)_i\|_2^2$$

(Update the correspondence)



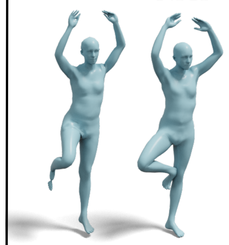
F^θ: $\mathbb{R}^3 \rightarrow \mathbb{R}^{m\times 3}$

(3) Update the Neural Field to minimize the selected offset

(Update the deformation)

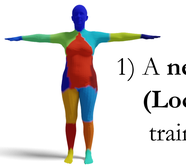
$$\widetilde{\theta} = \arg\min_\theta \sum_{k=1}^{n} \|F^\theta(\mathbf{y}_k)_{\widetilde{i}_k}\|_2^2$$

After 20 iterations (2-3 seconds)



Neural Scalable Registration (NSR)

NSR provides robust registration in ~1 minute.



1) A **new localized neural field (Localized Vertex Descent, LoVD)** trained on a large MoCap dataset (AMASS[2]).

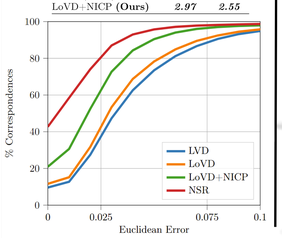
2) At inference time, we fine-tune the backbone with **NICP, a new self-supervised task.**

3) The output is spatially refined with Chamfer and local displacement optimizations.

NICP Analysis

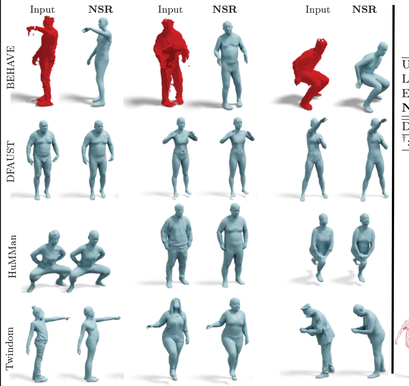
FAUST Training set

	FAUST_R	FAUST_S
OneShot	4.45	3.34
OneShot+NICP **(Ours)**	*3.64*	*3.15*
LVD	4.78	3.54
LVD+NICP **(Ours)**	*3.40*	*2.81*
LoVD **(Ours)**	**4.35**	**3.11**
LoVD+NICP **(Ours)**	***2.97***	***2.55***



ICP pairing in 3D is sensitive to outliers and artifacts. NICP correspondence is obtained by a robust data prior.

NSR: 3D Registration to go!



FAUST Challenge

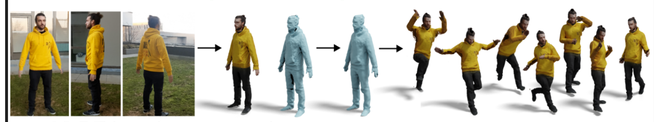
	INTRA	INTER
UD2E-Net	1.51	3.09
Loopreg	1.35	2.66
Elementary	1.74	2.58
NSR (Ours)	**1.06**	**2.26**
DVM (multi-view)†	1.19	2.37

†: Uses FAUST training set

Comparison

Train and test on CAPE	
IP-Net	2.59
PTF	2.05
LVD	1.98
NSR (Ours)	**1.70**

NSR is ready to animate your NeRF or GS asset!



1: Learned Vertex Descent: A New Direction for 3D Human Model Fitting, Corona et al., ECCV 2020 2: AMASS: Archive of Motion Capture As Surface Shapes, Mahmood et al., ICCV 2019