Extended Coherent Point Drift Algorithm with Correspondence Priors and Optimal Subsampling

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Overview

- A first method for efficient embedding of prior correspondences into a probabilistic **non-rigid** point set registration algorithm
- An **extension** of the Coherent Point Drift [1] (CPD), hence the name Extended CPD (ECPD)
- ECPD allows to register **large point sets** (with **millions of points**) in reasonable time due to a two-step **acceleration technique** with a correspondence preserving subsampling (CPS)
- Prior correspondences are provided by point indexes and **weighted** according to their certainty

Details of the Approach

Prior correspondences are modelled by **a product of independent density functions**

$$P_c(N_c) = \prod_{(j,k) \in N_c} p_c(\mathbf{x}_j, \mathbf{y}_k)$$

with

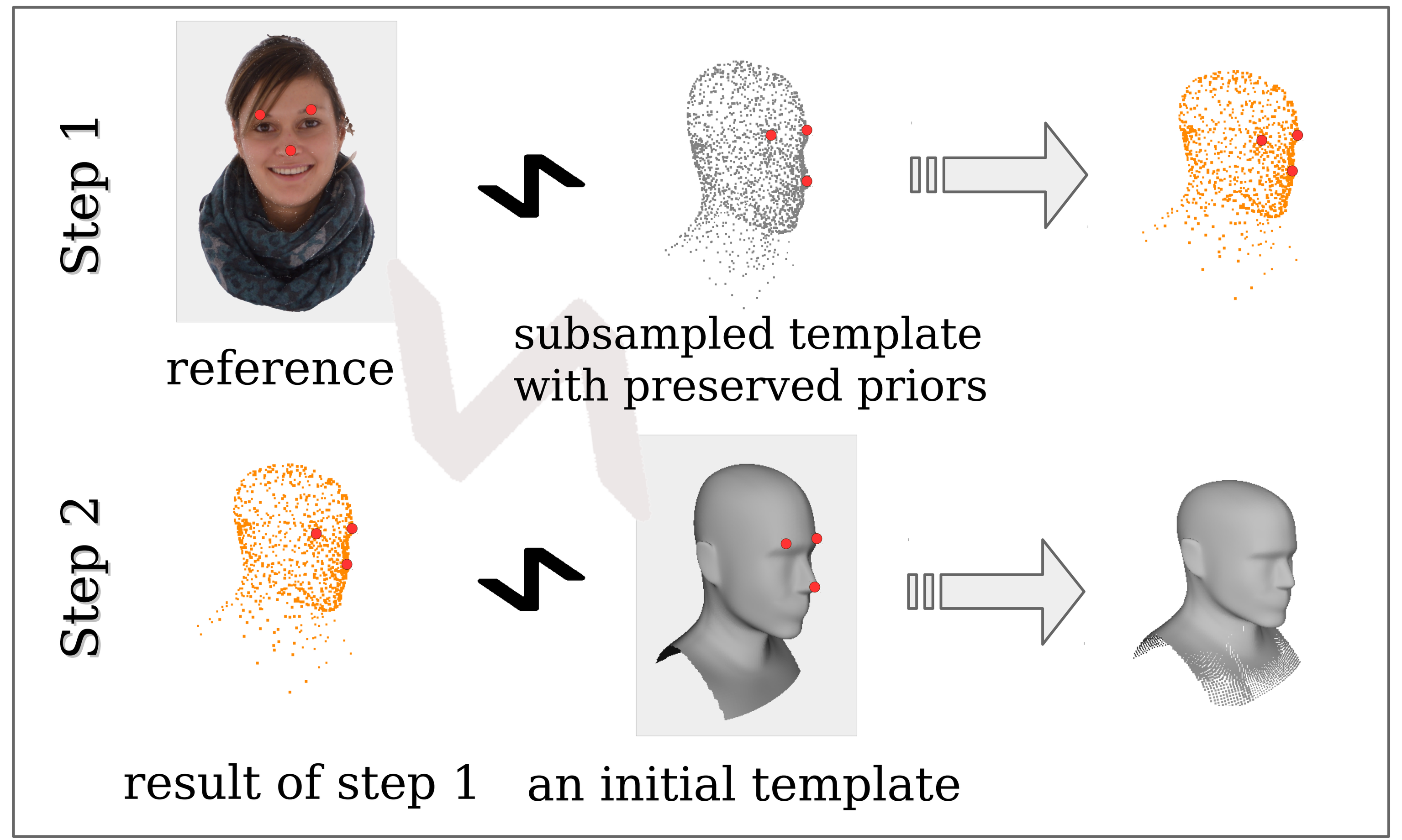
$$p_c(\mathbf{x}_j, \mathbf{y}_k) = \frac{1}{(2\pi\alpha)^{D/2}} \exp\left(-\frac{\|\mathbf{x}_j - T(\mathbf{y}_k, \theta)\|^2}{2\alpha^2}\right).$$

Further, we **superimpose** the original CPD [1] and the prior probabilities, obtain the modified Gaussian Mixture Model $\tilde{p}(\mathbf{x}) = P_c(N_c)p(x)$ and derive a modified energy function

$$\tilde{E}(\theta, \sigma^2) = E(\theta, \sigma^2) - \sum_{(j,k) \in N_c} \log(p_c(\mathbf{x}_j, \mathbf{y}_k)).$$

Similarly to CPD, we minimize the modified energy function using **Expectation-Maximization**.

Coarse-To-Fine Strategy



ECPD requires $T_{plain} = c_1 MN$ operations in the plain mode. Coarse-to-fine strategy requires only

$$T_{subs.} = c_2\left(M \cdot \frac{N}{t} + \frac{N}{t} \cdot N\right) = c_2 \frac{N(M+N)}{t}$$

operations, whereby t is the template subsampling factor. The theoretical speed-up is estimated as

$$s(m,n,t) = \frac{T_{plain}}{T_{subs.}} = \frac{c_1 MN}{\frac{c_2 N(M+N)}{t}} = c_s \frac{Mt}{M+N}.$$

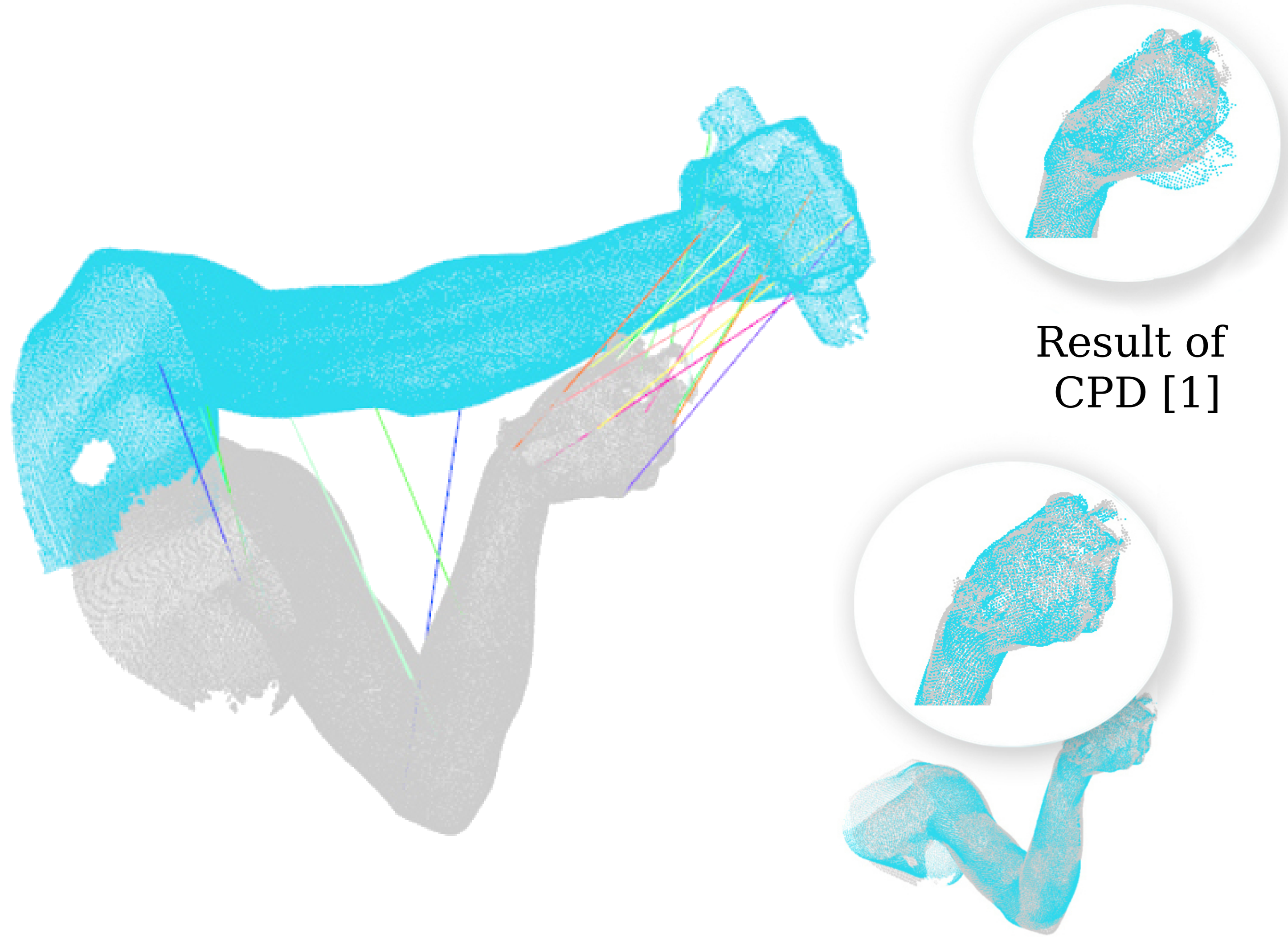
References

[1] A. Myronenko and X. Song. Point-set registration: Coherent point drift. T-PAMI, 2010.
[2] ARPACK - Arnoldi Package. http://www.caam.rice.edu/software/ARPACK/.
[3] B. Allen, B. Curless, and Z. Popovic. Articulated body deformation from range scan data. ACM SIGGRAPH 2002, 21(3):612–619, 2002.

Implementation

- ECPD is implemented in C++/CUDA C
- Arnoldi Iteration method (ARPACK [2]) is used
- The system takes advantage of a multicore CPU

Experiments on Real Data



Results of the experiment 1 (scans are taken from [3])

Acknowledgements

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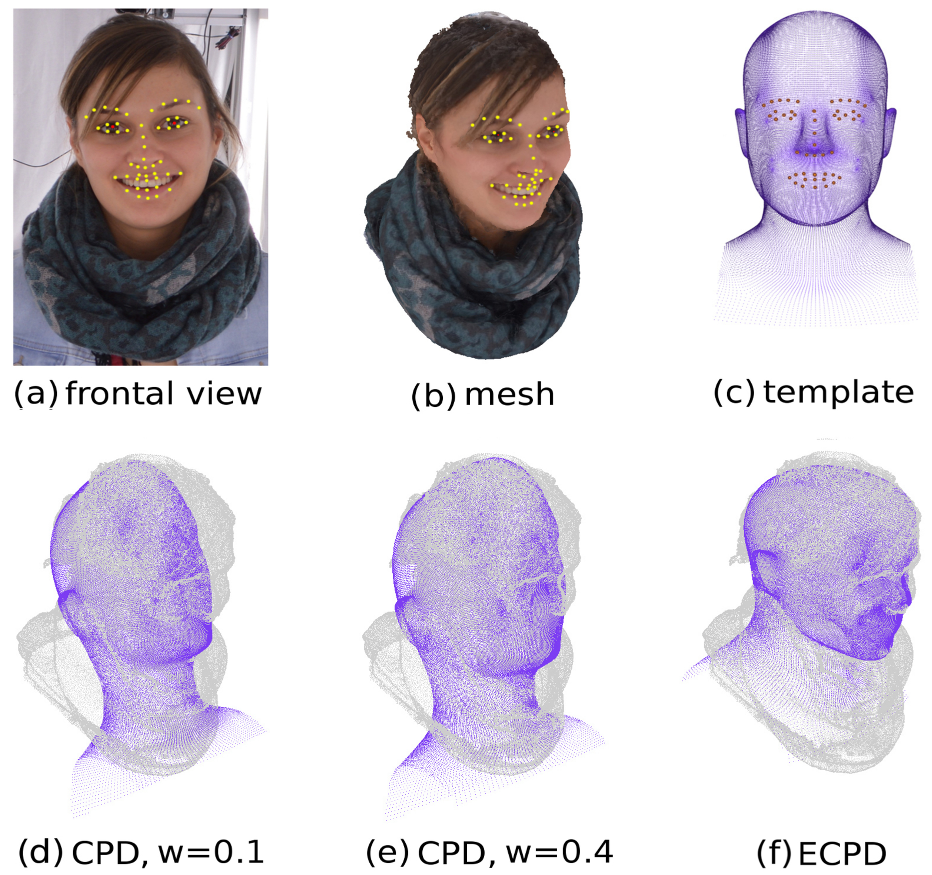
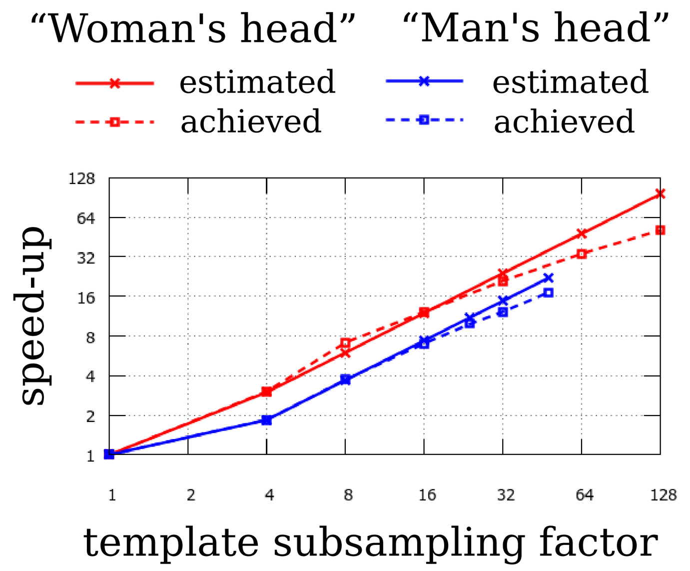
A multi-view system

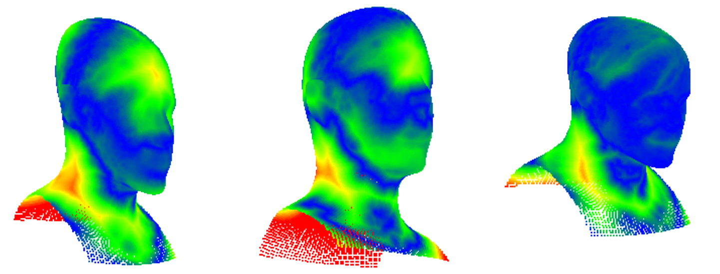
Data processing...

3D reconstruction examples



Results of the experiment 2





Cloud-to-cloud distances