VideoClusterNet: Self-Supervised and Adaptive Face Clustering For Videos

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Character Face Clustering in Movies

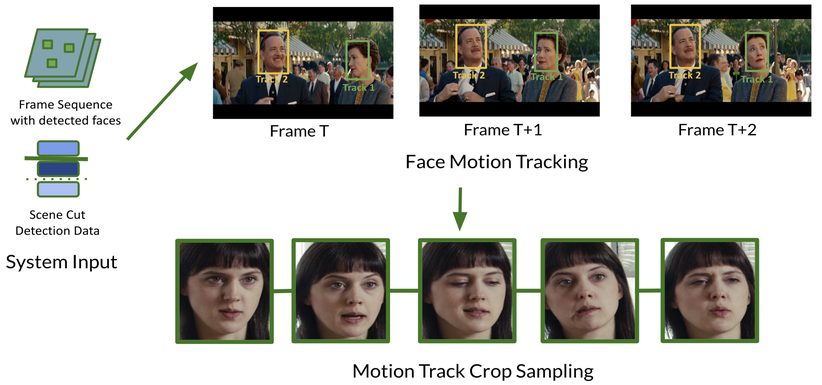
Objective: Given an entire movie sequence, cluster main character face tracks across common facial identities.

Movie domain specific challenges: Extreme variations across character face pose, lighting conditions, heavy occlusion, blur and facial appearance.

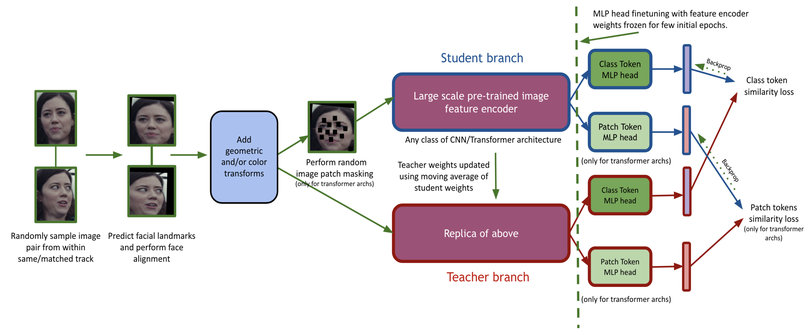
Contributions:

- A ***fully self-supervised video face clustering algorithm***, which progressively learns robust identity embeddings for all faces within a given video face dataset.
- A ***self-supervised model finetuning approach*** that removes any dependence on manual ground truth cluster labels.
- A ***deep learning-based similarity metric for face clustering***, which automatically adapts to a given model's learned embedding space.
- A ***novel video face clustering algorithm*** that does not depend on any user-input parameters.
- ***Release of a novel video face clustering benchmark dataset*** with extreme challenging face clustering scenarios in movie domain.

① Face Track Preprocessing



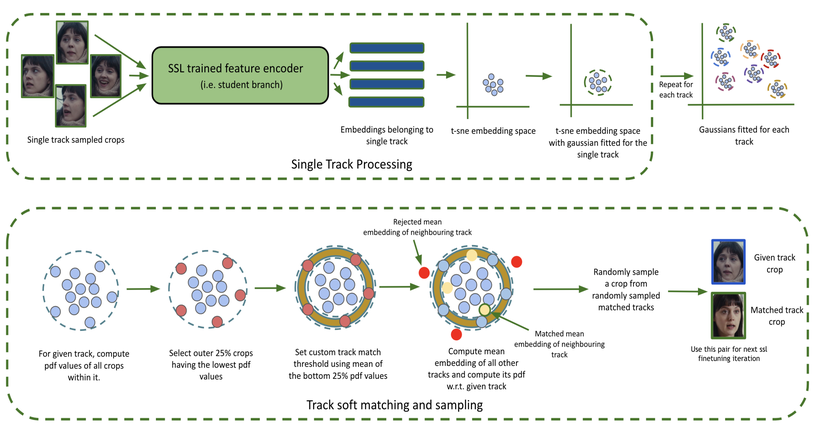
② Self-Supervised Face ID Model Finetuning



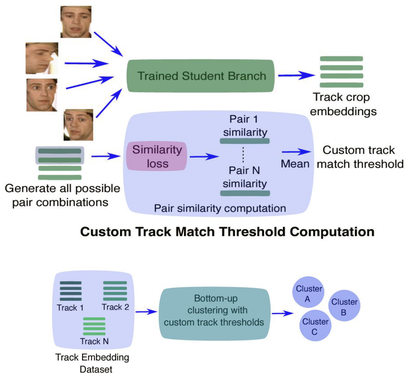
loss: -1*softmax(vec_1/temp_1)*log_softmax(vec_2/temp_2)

temp_* : softening temperature

③ Coarse Track Matching



④ Autonomous Face Clustering

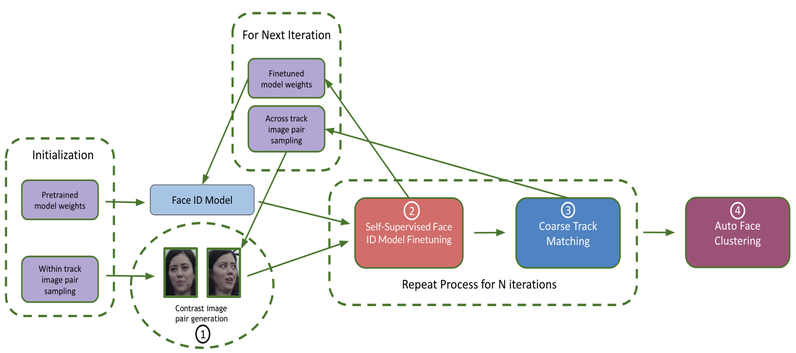


Algorithm 1: Face Track Clustering

Input:
Filtered Face Tracks $T = \{t_j | j = 1, 2, ..., N\}$ $\ni t_j = \{I_{t_1}, I_{t_2}, ...I_{t_n} | t_n = 12 * n + f_1\}$,
finetuned model θ_{ft}, **Similarity metric** S
Stage 3.1 (Compute track crop embedding set):
for t_j *in* T **do**
  for I_{t_n} *in* t_j **do**
    $E_{t_n} \longleftarrow \theta_{ft}(I_{t_n})$
  end
  $t_{jE} = \{E_{t_1}, E_{t_2}, ..., E_{t_n}\}$
end
$T_E = \{t_{1E}, t_{2E}, ...t_{NE}\}$
Stage 3.2 (Compute custom track threshold):
for t_{jE} *in* T_E **do**
  $Sim_{t_{jE}} = \{S(E_{t_j}, E_{t_m}) \; \forall (l, m) \in {}^nC_2\}$
  $Thres_{t_j} \longleftarrow mean(Sim_{t_{jE}})$
end
$T_{thres} = \{Thres_{t_1}, ..., Thres_{t_N}\}$

Stage 3.3 (Perform track clustering):
Initialize $i = 0, C = \{C_i = \{t_{jE}\} \forall j = 1, 2, ..., N\}$
repeat
  for C_j *in* C **do**
    for C_k *in* C *if* $k \neq j$ **do**
      $Sim_{jk} \longleftarrow mean(\{S(t_{iE_a}, t_{kE_b}) \; \forall (a, b) \in {}^nC_2\})$
      if $Sim_{jk} < Thres_{t_j}/Thres_{t_k}$ **then**
        $C_j \longleftarrow merge(C_j, C_k)$
      end
    end
  end
  $C = link\_merges(C)$
  $N_{C_i} = cluster\_count(C)$
  Repeat Stage 2 for new merged cluster set C
  $i = i + 1$
until $N_{C_i} - N_{C_{i-1}} = 0$;
Output: Clustered track IDs C

Central Idea



Results

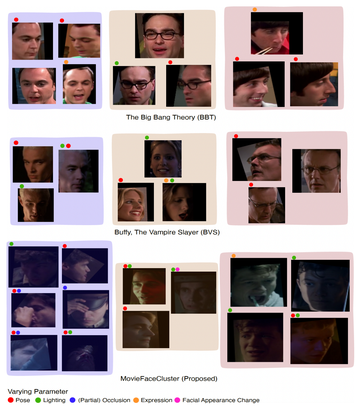
Literature Datasets: Big Bang Theory S01 & Buffy The Vampire Slayer S05

Method	BBT S01 Episode						
	S1E1	S1E2	S1E3	S1E4	S1E5	S1E6	Combined
SCTL [54]	66.48	-	-	-	-	-	-
TSiam [41]	96.4	-	-	-	-	-	-
SSiam [41]	96.2	-	-	-	-	-	-
MLR [4]	95.18	94.16	77.81	79.35	79.93	75.85	83.71
BCL [47]	98.63	98.54	90.61	86.95	89.12	81.07	89.63
CCL [42]	98.2	-	-	-	-	-	-
VCTRSF [53]	99.39	**99.84**	97.58	96.41	98.47	93.33	94.20
Ours⋆†	**99.70**	99.67	**98.60**	**98.80**	**99.10**	**97.10**	**98.70**

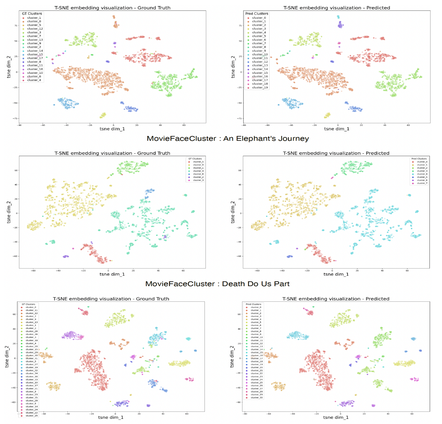
Method	BVS S05 Episode						
	S5E1	S5E2	S5E3	S5E4	S5E5	S5E6	Combined
HMRF [55]	-	50.3	-	-	-	-	-
WBSLRR [56]	-	62.7	-	-	-	-	-
TSiam [41]	-	92.46	-	-	-	-	-
SSiam [41]	-	90.87	-	-	-	-	-
CP-SSC [44]	-	65.2	-	-	-	-	-
MvCorr [43]	-	97.7	-	-	-	-	-
MLR [4]	71.99	61.27	66.60	67.07	69.59	61.72	66.37
BCL [47]	92.08	79.76	84.00	84.97	89.05	80.58	83.62
CCL [42]	-	92.1	-	-	-	-	-
Ours⋆†	**96.30**	**99.10**	**98.70**	**97.43**	**99.00**	**96.78**	**96.10**

Release of MovieFaceCluster Dataset

Literature Dataset Comparison



T-SNE Cluster Visualizations - Left Ground Truth, Right Predicted



Method	Movie								
	An Elephant's Journey (2019)	Armed Response	Angel Of The Skies	Death Do Us Part (2019)	American Fright Fest	The Fortress	Under The Shadow	The Hidden Soldier	S.M.A.R.T. Chase
	Weighted Cluster Accuracy (%) & Pred Cluster Ratio (Pred / GT)								
TSiam [41]	90.7 & 1.44	84.9 & 1.36	77.1 & 0.62	92.9 & 1.57	89.3 & 0.83	68.6 & 0.69	71.8 & 2.11	90.7 & 1.33	79.6 & 1.70
SSiam [41]	88.1 & 1.61	86.6 & 1.21	75.5 & 0.59	94.4 & 1.28	86.2 & 0.78	71.1 & 0.73	68.3 & 2.33	88.7 & 1.24	82.3 & 1.80
JFRAC [61]	91.4 & 1.33	85.2 & 1.50	73.4 & 0.62	90.8 & 0.71	91.5 & 0.86	65.3 & 0.77	73.1 & 2.00	92.6 & 1.19	85.8 & 1.70
CCL [42]	89.5 & N.A.†	89.7 & N.A.†	75.0 & N.A.†	95.4 & N.A.†	87.2 & N.A.†	62.7 & N.A.†	77.4 & N.A.†	84.0 & N.A.†	89.9 & N.A.†
VCTRSF [53]	96.3 & N.A.†	92.2 & N.A.†	77.7 & N.A.†	96.5 & N.A.†	91.3 & N.A.†	78.8 & N.A.†	78.7 & N.A.†	94.4 & N.A.†	88.4 & N.A.†
Ours	**97.2 & 1.11**	**94.1 & 0.93**	**85.9 & 0.72**	**98.0 & 1.14**	**97.6 & 0.92**	**89.3 & 1.02**	**82.5 & 1.88**	**98.5 & 1.04**	**93.8 & 1.50**