

From Emotions to Action Units with Hidden and Semi-Hidden-Task Learning

Supplementary material

1. Cross-Database experiments: Individual Action Units performance

Figures 1, 2, 3 and 4 show the obtained results in cross-database experiments (Sec. 5.3) detailed for each individual Action Unit. Similar to the original paper, colors indicate the methods ranked according to their performance. Note that only AUs available in the training and test datasets are used to compute the AUC and F1-score. Overall, our cross-database experiments include 126 Action Unit detection sub-problems. In order to summarise the presented results, Figure 5 shows the percentage of times that each method achieves the best, second, third and worst result over the 126 sub-problems. Note that SHTL and HTL obtain the best and second performance more frequently than STL approaches. However, the number of cases in which HTL achieves the worst result is comparable to those in STL and SVM. Therefore, SHTL boosts performance in cases where either STL or HTL fail by combining information from Action Units and Facial expressions data.

AU	Test: CK+															
	Train: UNBC				Train: FERA				Train: DISFA				Train: DISFA			
	AUC		F1		AUC		F1		AUC		F1		AUC		F1	
	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL
1	-	-	-	-	-	-	-	-	80.7	79.7	84.4	83.9	54.6	53.9	62.8	61.9
2	-	-	-	-	-	-	-	-	86.5	86.5	79.9	74.2	58.3	57.7	47.6	45.1
4	76.9	76.9	88.2	92.4	45.1	46.8	71.9	81.6	74.8	69.6	92.5	92.4	58.0	54.6	80.2	81.6
5	-	-	-	-	-	-	-	-	85.2	85.3	93.4	93.0	55.1	55.1	76.6	74.8
6	66.3	81.2	87.5	85.6	32.5	51.9	62.9	58.7	72.9	71.9	85.2	85.6	43.4	41.4	57.7	58.7
7	77.9	78.1	78.5	60.2	44.3	44.6	44.4	32.7	81.6	81.5	71.7	60.2	53.4	52.9	44.9	32.7
9	85.9	85.7	90.0	90.3	34.8	32.2	46.4	48.7	83.3	80.7	92.3	90.3	24.0	8.7	53.5	48.7
10	56.7	61.2	67.4	63.7	8.5	7.3	11.0	10.2	68.5	67.7	73.2	63.7	10.8	9.8	14.9	10.2
12	94.6	95.5	97.2	97.2	76.8	80.1	85.4	85.2	92.0	92.0	96.7	97.2	72.7	73.1	84.6	85.2
15	-	-	-	-	-	-	-	-	69.8	52.3	89.4	86.3	29.6	9.2	54.0	48.6
17	-	-	-	-	-	-	-	-	65.8	78.8	88.5	86.7	24.8	33.7	70.0	67.5
20	71.5	74.4	68.8	63.3	30.6	31.0	22.1	16.0	56.1	59.4	60.5	63.3	18.4	20.1	19.3	16.0
25	88.4	90.0	89.1	79.6	70.1	77.8	77.5	70.1	87.8	85.5	86.9	79.6	70.0	55.4	76.3	70.1
26	62.8	60.8	68.6	72.2	18.8	19.0	20.9	22.1	67.8	66.2	73.2	72.2	9.0	8.6	23.8	22.1
Avg.	75.7	78.2	81.7	78.3	40.2	43.4	49.2	47.2	76.6	75.5	83.4	80.6	41.6	38.2	54.7	51.6

Figure 1. Individual AU performance testing on the CK+ dataset.

AU	Test: FERA															
	Train: CK+				Train: UNBC				Train: DISFA				Train: DISFA			
	AUC		F1		AUC		F1		AUC		F1		AUC		F1	
	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL
1	71.4	74.4	71.3	61.6	51.5	54.2	51.6	41.7	-	-	-	-	75.7	76.8	72.0	61.6
2	58.1	58.4	74.2	71.9	38.8	40.0	50.3	36.0	-	-	-	-	58.3	60.9	66.9	71.9
4	75.2	74.1	76.0	72.4	49.7	48.3	50.6	44.5	65.3	64.5	65.0	72.4	14.9	14.8	30.9	44.5
5	81.6	81.7	86.1	86.2	48.4	50.9	58.6	58.4	-	-	-	-	81.2	82.2	87.3	86.2
6	78.9	78.6	74.5	73.2	67.5	65.3	57.2	51.7	67.9	72.9	71.3	73.2	50.2	56.2	58.2	51.7
7	77.1	77.7	74.0	66.8	46.6	42.1	55.6	60.3	69.5	71.6	71.2	66.8	56.3	60.0	54.7	60.3
9	75.9	78.7	86.6	85.7	32.4	24.3	46.6	37.4	72.2	69.9	81.9	85.7	13.4	11.4	20.9	37.4
10	61.9	61.5	63.1	58.6	30.9	28.6	33.9	35.6	62.1	65.7	64.4	58.6	53.9	20.6	37.8	35.6
12	74.7	74.1	77.1	76.2	41.0	42.1	38.1	40.7	78.3	78.2	78.0	76.2	46.6	48.2	39.1	40.7
15	65.7	61.0	52.0	43.3	21.2	11.5	11.6	17.1	-	-	-	-	54.3	54.7	52.6	43.3
17	71.8	68.5	65.2	59.4	38.1	31.1	14.4	10.1	-	-	-	-	68.8	69.8	62.2	59.4
20	63.5	63.5	60.5	55.9	19.8	19.3	19.6	15.7	55.4	59.9	57.4	55.9	17.1	19.7	15.5	15.7
25	75.8	76.9	74.0	65.3	77.5	79.9	73.2	59.5	72.6	77.4	76.7	65.3	75.8	79.8	64.5	59.5
26	60.1	61.9	78.8	76.1	39.8	40.2	64.8	64.1	64.4	64.8	77.2	76.1	51.7	53.4	62.6	64.1
Avg.	70.8	70.8	72.4	68.0	43.1	41.3	44.7	40.9	67.5	69.4	71.5	70.0	42.2	40.5	42.7	45.5

Figure 2. Individual AU performance testing on the FERA dataset.

AU	Test: DISFA																											
	Train:CK+								Train:UNBC								Train:FERA											
	AUC				F1				AUC				F1				AUC				F1							
	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL
1	68.8	71.1	72.0	64.7	31.1	32.7	34.0	26.2	-	-	-	-	-	-	-	-	62.4	61.3	64.4	64.7	16.5	17.1	23.9	26.2				
2	65.5	64.9	69.3	65.5	22.9	24.5	20.6	15.8	-	-	-	-	-	-	-	-	65.5	69.6	64.7	65.5	13.4	16.1	16.2	15.8				
4	81.8	82.1	82.1	83.0	54.6	58.1	58.9	59.8	73.0	73.0	77.2	83.0	28.1	31.7	47.0	59.8	62.7	71.5	82.6	83.0	34.1	42.2	57.4	59.8				
5	82.9	87.3	86.9	88.5	19.2	27.1	37.7	36.8	-	-	-	-	-	-	-	-	77.6	76.8	87.3	88.5	11.2	10.9	38.7	36.8				
6	58.2	59.4	67.2	65.3	25.6	26.3	33.0	32.2	61.5	60.7	67.3	65.3	17.3	28.8	32.1	32.2	60.5	60.4	69.4	65.3	30.3	30.3	35.2	32.2				
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
9	64.5	66.8	73.5	78.0	8.3	15.2	20.8	23.6	67.1	66.7	71.1	78.0	13.7	10.4	22.9	23.6	65.9	69.5	77.3	78.0	10.5	5.1	26.1	23.6				
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
12	90.9	91.1	92.9	92.4	61.7	62.2	74.5	74.3	89.2	90.4	92.7	92.4	64.9	66.6	72.7	74.3	86.3	85.3	92.5	92.4	59.9	59.0	72.9	74.3				
15	66.4	66.1	68.5	69.2	13.8	17.5	28.8	18.9	-	-	-	-	-	-	-	-	66.3	62.2	68.5	69.2	11.5	8.2	23.4	18.9				
17	70.1	66.9	70.7	68.0	25.8	24.1	26.0	17.9	-	-	-	-	-	-	-	-	56.2	66.0	72.5	68.0	15.4	25.5	31.3	17.9				
20	62.7	62.8	65.6	60.4	11.1	11.2	10.7	8.8	49.3	50.6	48.6	60.4	7.0	6.0	5.8	8.8	55.6	57.8	61.8	60.4	0.4	0.4	9.0	8.8				
25	86.5	85.8	82.2	75.1	73.7	74.2	69.7	61.3	79.0	82.5	83.4	75.1	57.5	66.7	72.2	61.3	82.3	81.1	82.4	75.1	60.7	56.0	70.5	61.3				
26	61.9	66.5	80.9	82.5	21.4	29.2	55.1	58.0	68.5	68.3	77.4	82.5	38.6	39.9	52.2	58.0	82.1	82.0	83.5	82.5	39.0	35.2	57.8	58.0				
Avg.	71.7	72.6	76.0	74.4	30.8	33.5	39.1	36.1	69.7	70.3	74.0	76.7	32.4	35.7	43.5	45.4	68.6	70.3	75.6	74.4	25.2	25.5	38.5	36.1				

Figure 3. Individual AU performance testing on the DISFA dataset. AUs 7 and 10 are not available in this dataset.

AU	Test: UNBC																											
	Train: CK+								Train: FERA								Train: DISFA											
	AUC				F1				AUC				F1				AUC				F1							
	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL	SVM	STL	SHTL	HTL
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
4	78.8	78.0	81.3	86.3	9.4	7.7	7.6	8.3	60.0	73.6	83.4	86.3	6.1	13.6	8.7	8.3	82.3	81.7	81.9	86.3	11.4	11.2	7.1	8.3	-	-	-	
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	63.9	67.3	68.3	63.3	26.6	27.6	28.9	29.5	60.1	58.2	64.8	63.3	21.6	21.6	26.9	29.5	65.3	65.3	66.3	63.3	27.1	26.9	32.3	29.5	-	-	-	
7	68.1	68.6	66.5	63.2	19.4	20.1	19.9	17.2	58.4	56.9	57.8	63.2	15.6	13.9	16.5	17.2	-	-	-	-	-	-	-	-	-	-	-	
9	70.5	72.4	78.0	83.8	9.8	7.0	5.1	5.3	63.9	69.0	81.0	83.8	2.6	2.5	5.0	5.3	74.1	76.8	82.9	83.8	5.9	6.9	7.3	5.3	-	-	-	
10	61.8	60.3	69.2	82.7	3.1	2.3	4.6	8.5	73.6	68.2	83.7	82.7	3.8	2.8	5.4	8.5	-	-	-	-	-	-	-	-	-	-	-	
12	81.7	82.0	83.8	81.8	43.7	44.1	44.6	42.6	78.7	78.2	82.1	81.8	37.8	37.4	43.7	42.6	81.6	81.2	82.5	81.8	46.0	44.5	43.2	42.6	-	-	-	
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
20	60.8	59.0	44.1	31.1	5.1	5.7	2.1	1.5	39.8	40.7	30.6	31.1	0.0	0.0	1.3	1.5	35.0	35.5	32.5	31.1	1.6	1.4	1.6	1.5	-	-	-	
25	82.8	83.5	80.6	69.3	26.6	29.6	19.0	12.4	82.9	83.6	80.3	69.3	25.7	27.6	22.2	12.4	80.3	79.8	81.2	69.3	14.7	14.7	21.6	12.4	-	-	-	
26	45.6	44.5	55.8	66.1	8.2	8.3	10.0	15.0	57.1	58.4	66.5	66.1	3.1	2.8	12.0	15.0	51.0	51.7	57.0	66.1	7.6	7.5	13.0	15.0	-	-	-	
Avg.	68.2	68.4	69.7	69.7	16.9	16.9	15.8	15.6	63.8	65.2	70.0	69.7	12.9	13.6	15.7	15.6	67.1	67.4	69.2	68.8	16.3	16.2	18.0	16.4	-	-	-	

Figure 4. Individual AU performance testing on the UNBC dataset. AUs 1, 2, 5, 15 and 17 are not available in this dataset.

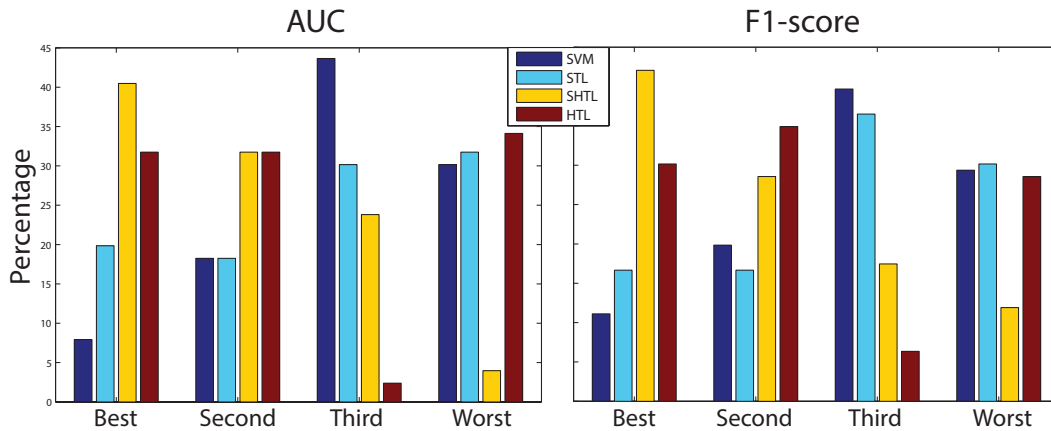


Figure 5. Percentage of times SVM, STL, SHTL and HTL achieves the best, second, third and worst performance in all the 126 AU classification problems in the cross-database experiments.