

3D Face Reconstruction From Radar Images

Supplementary Material

A. Additional Results

Additional Quantitative Results. In addition to the cosine similarity plots in Section 4 of the paper, we provide additional comparisons of the ground truth parameters, the encoder results, and the autoencoder results evaluated on synthetic data. Figure 9 shows the ground truth parameters in comparison and can, therefore, be used as best case comparison for the other cosine similarity plots. The Figures 10, 12, and 14 show the cosine similarity of the resulting parameters from the encoder, and Figures 11, 13, and 15 the same for the autoencoder results.

In Figure 16 we compare the results from the encoder models evaluated on real data and in Figure 17 for the results from the autoencoder models.

Additional Qualitative Results. We also provide additional qualitative results of our method. The Figures 18 and 19 display several image results for the autoencoder trained and evaluated on amplitude, depth and amplitude-depth images. In Figures 20 and 21 we show additional examples for the resulting meshes of the encoder and autoencoder models trained on amplitude, depth, and amplitude-depth images.

ids	0	1	2	3	4	5	6	7	8	9	Shape
0	1.000	0.401	0.378	0.261	0.271	-0.360	0.202	-0.401	0.067	0.193	
1	0.401	1.000	0.609	0.208	-0.128	-0.040	-0.048	0.096	-0.327	0.089	
2	0.378	0.609	1.000	0.227	0.613	-0.170	-0.249	0.031	-0.077	0.176	
3	0.261	0.208	0.227	1.000	0.145	-0.022	0.016	0.004	0.178	0.227	
4	0.271	-0.128	0.613	0.145	1.000	-0.256	0.025	-0.230	0.262	0.276	
5	-0.360	-0.040	-0.170	-0.022	-0.256	1.000	-0.373	0.064	0.266	0.655	
6	0.202	-0.048	-0.249	0.016	0.025	-0.373	1.000	-0.275	-0.175	-0.362	
7	-0.401	0.096	0.031	0.004	-0.230	0.064	-0.275	1.000	-0.092	-0.090	
8	0.067	-0.327	-0.077	0.178	0.262	0.266	-0.175	-0.092	1.000	0.398	
9	0.193	0.089	0.176	0.227	0.276	0.655	-0.362	-0.090	0.398	1.000	

(a) Shape parameters per shape instance.

ids	0	1	2	3	4	Expression
0	1.000	-0.249	-0.021	-0.750	-0.308	
1	-0.249	1.000	0.258	-0.120	-0.565	
2	-0.021	0.258	1.000	-0.312	-0.483	
3	-0.750	-0.120	-0.312	1.000	0.457	
4	-0.308	-0.565	-0.483	0.457	1.000	

(b) Expression parameters per expression instance.

Figure 9. Comparison of the cosine similarity of the shape parameters per shape instance (top) and expression parameters per expression instance (bottom) from the **synthetic ground truth parameters**. The plot can be used as a reference to the results shown in Figure 5.

ids	0	1	2	3	4	5	6	7	8	9	
0	0.292	0.303	0.123	-0.281	0.008	-0.194	-0.090	0.008	-0.327	-0.058	Shape
1	0.303	0.630	0.462	-0.399	-0.051	-0.074	-0.123	0.266	-0.161	0.007	
2	0.123	0.462	0.486	-0.220	0.032	-0.132	-0.004	0.108	-0.315	-0.149	
3	-0.281	-0.399	-0.220	0.530	-0.116	-0.083	0.408	-0.239	0.099	-0.070	
4	0.008	-0.051	0.032	-0.116	0.028	-0.058	0.049	-0.031	-0.115	-0.174	
5	-0.194	-0.074	-0.132	-0.083	-0.058	0.372	-0.336	0.271	0.462	0.286	
6	-0.090	-0.123	-0.004	0.408	0.049	-0.336	0.552	-0.185	-0.116	-0.303	
7	0.008	0.266	0.108	-0.239	-0.031	0.271	-0.185	0.459	0.401	0.232	
8	-0.327	-0.161	-0.315	0.099	-0.115	0.462	-0.116	0.401	0.757	0.383	
9	-0.058	0.007	-0.149	-0.070	-0.174	0.286	-0.303	0.232	0.383	0.208	
(a) Shape parameters per shape instance.											
ids	0	1	2	3	4						
0	0.366	0.331	0.182	-0.216	-0.045	Expression					
1	0.331	0.674	0.335	-0.201	0.012						
2	0.182	0.335	0.128	-0.110	0.019						
3	-0.216	-0.201	-0.110	0.117	0.189						
4	-0.045	0.012	0.019	0.189	0.339						
(b) Expression parameters per expression instance.											

Figure 10. Comparison of the cosine similarity of the shape parameters per shape instance (top) and expression parameters per expression instance (bottom) from the **encoder** trained on synthetic **amplitude images**.

	0	1	2	3	4	5	6	7	8	9	
0	0.583	0.489	0.214	-0.157	0.208	-0.383	0.039	0.093	-0.342	-0.114	Shape
1	0.489	0.717	0.551	-0.277	0.185	-0.197	-0.112	0.258	-0.199	-0.002	
2	0.214	0.551	0.678	-0.213	0.257	-0.031	-0.045	0.196	-0.178	-0.128	
3	-0.157	-0.277	-0.213	0.522	-0.121	-0.024	0.349	-0.137	0.060	-0.078	
4	0.208	0.185	0.257	-0.121	0.133	0.039	-0.023	0.058	-0.058	-0.037	
5	-0.383	-0.197	-0.031	-0.024	0.039	0.771	-0.502	0.165	0.464	0.371	
6	0.039	-0.112	-0.045	0.349	-0.023	-0.502	0.599	-0.090	-0.026	-0.282	
7	0.093	0.258	0.196	-0.137	0.058	0.165	-0.090	0.385	0.436	0.223	
8	-0.342	-0.199	-0.178	0.060	-0.058	0.464	-0.026	0.436	0.835	0.412	
9	-0.114	-0.002	-0.128	-0.078	-0.037	0.371	-0.282	0.223	0.412	0.299	
(a) Shape parameters per shape instance.											
ids	0	1	2	3	4						
0	0.311	0.038	-0.000	-0.114	-0.132	Expression					
1	0.038	0.635	0.387	-0.170	-0.165						
2	-0.000	0.387	0.363	0.057	-0.026						
3	-0.114	-0.170	0.057	0.297	0.210						
4	-0.132	-0.165	-0.026	0.210	0.195						
(b) Expression parameters per expression instance.											

Figure 11. Comparison of the cosine similarity of the shape parameters per shape instance (top) and expression parameters per expression instance (bottom) from the **autoencoder** trained on synthetic **amplitude images**.

ids	0	1	2	3	4	5	6	7	8	9
0	0.430	0.310	0.044	-0.133	0.238	-0.415	0.330	-0.079	-0.517	-0.359
1	0.310	0.757	0.537	-0.147	0.164	-0.381	0.209	0.200	-0.362	-0.347
2	0.044	0.537	0.602	-0.114	0.154	-0.229	0.059	0.086	-0.320	-0.299
3	-0.133	-0.147	-0.114	0.583	0.168	0.230	0.307	-0.091	0.266	-0.039
4	0.238	0.164	0.154	0.168	0.453	-0.161	0.290	-0.063	-0.196	-0.287
5	-0.415	-0.381	-0.229	0.230	-0.161	0.676	-0.525	0.145	0.501	0.588
6	0.330	0.209	0.059	0.307	0.290	-0.525	0.754	-0.175	-0.250	-0.603
7	-0.079	0.200	0.086	-0.091	-0.063	0.145	-0.175	0.304	0.254	0.181
8	-0.517	-0.362	-0.320	0.266	-0.196	0.501	-0.250	0.254	0.753	0.453
9	-0.359	-0.347	-0.299	-0.039	-0.287	0.588	-0.603	0.181	0.453	0.550

(a) Shape parameters per shape instance.

ids	0	1	2	3	4
0	0.095	0.084	0.040	-0.055	-0.027
1	0.084	0.401	0.101	-0.181	-0.182
2	0.040	0.101	0.158	-0.008	0.158
3	-0.055	-0.181	-0.008	0.068	0.173
4	-0.027	-0.182	0.158	0.173	0.292

(b) Expression parameters per expression instance.

Figure 12. Comparison of the cosine similarity of the shape parameters per shape instance (top) and expression parameters per expression instance (bottom) from the **encoder** trained on synthetic **depth** images.

ids	0	1	2	3	4	5	6	7	8	9
0	0.497	0.457	0.156	-0.319	0.263	-0.434	0.224	0.059	-0.505	-0.306
1	0.457	0.666	0.480	-0.271	0.222	-0.236	0.051	0.273	-0.332	-0.120
2	0.156	0.480	0.683	-0.137	0.171	-0.166	0.051	0.069	-0.305	-0.147
3	-0.319	-0.271	-0.137	0.583	-0.114	0.151	0.244	-0.113	0.311	-0.023
4	0.263	0.222	0.171	-0.114	0.083	-0.083	0.092	0.135	-0.154	-0.133
5	-0.434	-0.236	-0.166	0.151	-0.083	0.793	-0.586	0.284	0.641	0.625
6	0.224	0.051	0.051	0.244	0.092	-0.586	0.704	-0.176	-0.256	-0.601
7	0.059	0.273	0.069	-0.113	0.135	0.284	-0.176	0.468	0.354	0.227
8	-0.505	-0.332	-0.305	0.311	-0.154	0.641	-0.256	0.354	0.798	0.474
9	-0.306	-0.120	-0.147	-0.023	-0.133	0.625	-0.601	0.227	0.474	0.515

(a) Shape parameters per shape instance.

ids	0	1	2	3	4
0	0.333	-0.036	0.110	0.006	-0.076
1	-0.036	0.457	0.214	-0.196	-0.169
2	0.110	0.214	0.148	-0.025	0.055
3	0.006	-0.196	-0.025	0.142	0.158
4	-0.076	-0.169	0.055	0.158	0.292

(b) Expression parameters per expression instance.

Figure 14. Comparison of the cosine similarity of the shape parameters per shape instance (top) and expression parameters per expression instance (bottom) from the **encoder** trained on synthetic **amplitude-depth** images.

ids	0	1	2	3	4	5	6	7	8	9
0	0.585	0.561	0.242	-0.021	0.329	-0.552	0.433	-0.012	-0.438	-0.387
1	0.561	0.822	0.525	-0.054	0.295	-0.425	0.219	0.018	-0.516	-0.273
2	0.242	0.525	0.629	-0.037	0.343	-0.278	0.047	0.023	-0.302	-0.173
3	-0.021	-0.054	-0.037	0.618	0.242	0.149	0.294	0.048	0.243	0.002
4	0.329	0.295	0.343	0.242	0.399	-0.212	0.274	0.122	-0.120	-0.175
5	-0.552	-0.425	-0.278	0.149	-0.212	0.699	-0.573	0.056	0.476	0.561
6	0.433	0.219	0.047	0.294	0.274	-0.573	0.704	0.029	-0.146	-0.515
7	-0.012	0.018	0.023	0.048	0.122	0.056	0.029	0.222	0.277	0.077
8	-0.438	-0.516	-0.302	0.243	-0.120	0.476	-0.146	0.277	0.765	0.361
9	-0.387	-0.273	-0.173	0.002	-0.175	0.561	-0.515	0.077	0.361	0.438

(a) Shape parameters per shape instance.

ids	0	1	2	3	4
0	0.212	0.125	0.128	-0.172	-0.019
1	0.125	0.580	0.252	-0.320	-0.118
2	0.128	0.252	0.175	-0.078	0.055
3	-0.172	-0.320	-0.078	0.208	0.118
4	-0.019	-0.118	0.055	0.118	0.144

(b) Expression parameters per expression instance.

Figure 13. Comparison of the cosine similarity of the shape parameters per shape instance (top) and expression parameters per expression instance (bottom) from the **autoencoder** trained on synthetic **depth** images.

ids	0	1	2	3	4	5	6	7	8	9
0	0.647	0.465	0.180	-0.274	0.250	-0.588	0.337	-0.107	-0.339	-0.210
1	0.465	0.793	0.499	-0.230	0.139	-0.268	0.100	0.086	-0.358	-0.093
2	0.180	0.499	0.649	-0.208	0.283	-0.055	-0.026	0.071	-0.329	-0.145
3	-0.274	-0.230	-0.208	0.509	-0.142	0.160	0.112	-0.142	0.067	-0.064
4	0.250	0.139	0.283	-0.142	0.299	-0.201	0.158	0.161	-0.139	-0.189
5	-0.588	-0.268	-0.055	0.160	-0.201	0.822	-0.710	0.172	0.438	0.559
6	0.337	0.100	-0.026	0.112	0.158	-0.710	0.737	-0.149	-0.263	-0.556
7	-0.107	0.086	0.071	-0.142	0.161	0.172	-0.149	0.253	0.225	0.146
8	-0.339	-0.358	-0.329	0.067	-0.139	0.438	-0.263	0.225	0.734	0.462
9	-0.210	-0.093	-0.145	-0.064	-0.189	0.559	-0.556	0.146	0.462	0.540

(a) Shape parameters per shape instance.

ids	0	1	2	3	4
0	0.337	0.074	0.062	-0.058	-0.061
1	0.074	0.566	0.195	-0.246	-0.290
2	0.062	0.195	0.150	0.012	0.027
3	-0.058	-0.246	0.012	0.390	0.292
4	-0.061	-0.290	0.027	0.292	0.193

(b) Expression parameters per expression instance.

Figure 15. Comparison of the cosine similarity of the shape parameters per shape instance (top) and expression parameters per expression instance (bottom) from the **autoencoder** trained on synthetic **amplitude-depth** images.

ids	0	1	2	3	ids	0	1	2	3	4
0	0.436	-0.207	0.074	-0.080	0	-0.057	0.119	0.067	0.132	0.126
1	-0.207	0.545	-0.266	0.227	1	0.119	-0.000	-0.121	-0.082	0.042
2	0.074	-0.266	0.396	0.047	2	0.067	-0.121	0.231	0.152	0.031
3	-0.080	0.227	0.047	0.297	3	0.132	-0.082	0.152	0.153	0.122
					4	0.126	0.042	0.031	0.122	-0.174

(a) Comparison of the shape and expression parameters computed by the encoder evaluated on **real amplitude images**.

ids	0	1	2	3	ids	0	1	2	3	4
0	0.613	0.613	0.657	0.046	0	0.494	0.246	0.252	0.305	0.215
1	0.613	0.905	0.790	-0.125	1	0.246	-0.018	0.214	0.064	0.110
2	0.657	0.790	0.789	-0.043	2	0.252	0.214	0.214	0.296	0.118
3	0.046	-0.125	-0.043	0.192	3	0.305	0.064	0.296	0.347	0.146
					4	0.215	0.110	0.118	0.146	0.016

(b) Comparison of the shape and expression parameters computed by the encoder evaluated on **real depth images**.

ids	0	1	2	3	ids	0	1	2	3	4
0	0.394	0.479	0.569	-0.052	0	0.238	0.105	0.226	0.071	0.224
1	0.479	0.947	0.902	-0.004	1	0.105	-0.284	0.104	0.012	0.046
2	0.569	0.902	0.963	-0.130	2	0.226	0.104	0.309	0.220	0.025
3	-0.052	-0.004	-0.130	0.273	3	0.071	0.012	0.220	0.551	0.103
					4	0.224	0.046	0.025	0.103	-0.001

(c) Comparison of the shape and expression parameters computed by the encoder evaluated on the **real amplitude-depth images**.

Figure 16. Cosine similarity comparison between the shape and expression parameters from the **encoder** results derived from **real data**. The plots present the shape parameters (left) and expression parameters (right) grouped by instances of the same shape or expression, respectively.

ids	0	1	2	3	ids	0	1	2	3	4
0	0.452	-0.357	0.258	-0.023	0	0.361	0.251	0.149	-0.006	0.165
1	-0.357	0.431	-0.110	0.134	1	0.251	-0.001	0.102	-0.185	0.094
2	0.258	-0.110	0.601	0.130	2	0.149	0.102	0.104	-0.024	0.024
3	-0.023	0.134	0.130	0.206	3	-0.006	-0.185	-0.024	0.170	0.032
					4	0.165	0.094	0.024	0.032	-0.212

(a) Comparison of the shape and expression parameters computed by the autoencoder evaluated on **real amplitude images**.

ids	0	1	2	3	ids	0	1	2	3	4
0	0.519	0.202	0.710	0.471	0	0.318	0.275	0.281	0.068	0.271
1	0.202	0.782	0.107	-0.031	1	0.275	0.111	0.308	0.031	0.219
2	0.710	0.107	0.879	0.635	2	0.281	0.308	0.312	0.270	0.096
3	0.471	-0.031	0.635	0.539	3	0.068	0.031	0.270	0.169	-0.058
					4	0.271	0.219	0.096	-0.058	0.156

(b) Comparison of the shape and expression parameters computed by the autoencoder evaluated on **real depth images**.

ids	0	1	2	3	ids	0	1	2	3	4
0	0.372	0.274	0.574	0.144	0	0.027	0.222	-0.097	0.020	0.260
1	0.274	0.935	0.347	-0.135	1	0.222	0.413	0.050	-0.147	0.245
2	0.574	0.347	0.635	0.189	2	-0.097	0.050	0.217	-0.104	-0.101
3	0.144	-0.135	0.189	0.346	3	0.020	-0.147	-0.104	0.479	0.074
					4	0.260	0.245	-0.101	0.074	0.043

(c) Comparison of the shape and expression parameters computed by the autoencoder evaluated on the **real amplitude-depth images**.

Figure 17. Cosine similarity comparison between the shape and expression parameters from the **autoencoder** results derived from **real data**. The plots present the shape parameters (left) and expression parameters (right) grouped by instances of the same shape or expression, respectively.

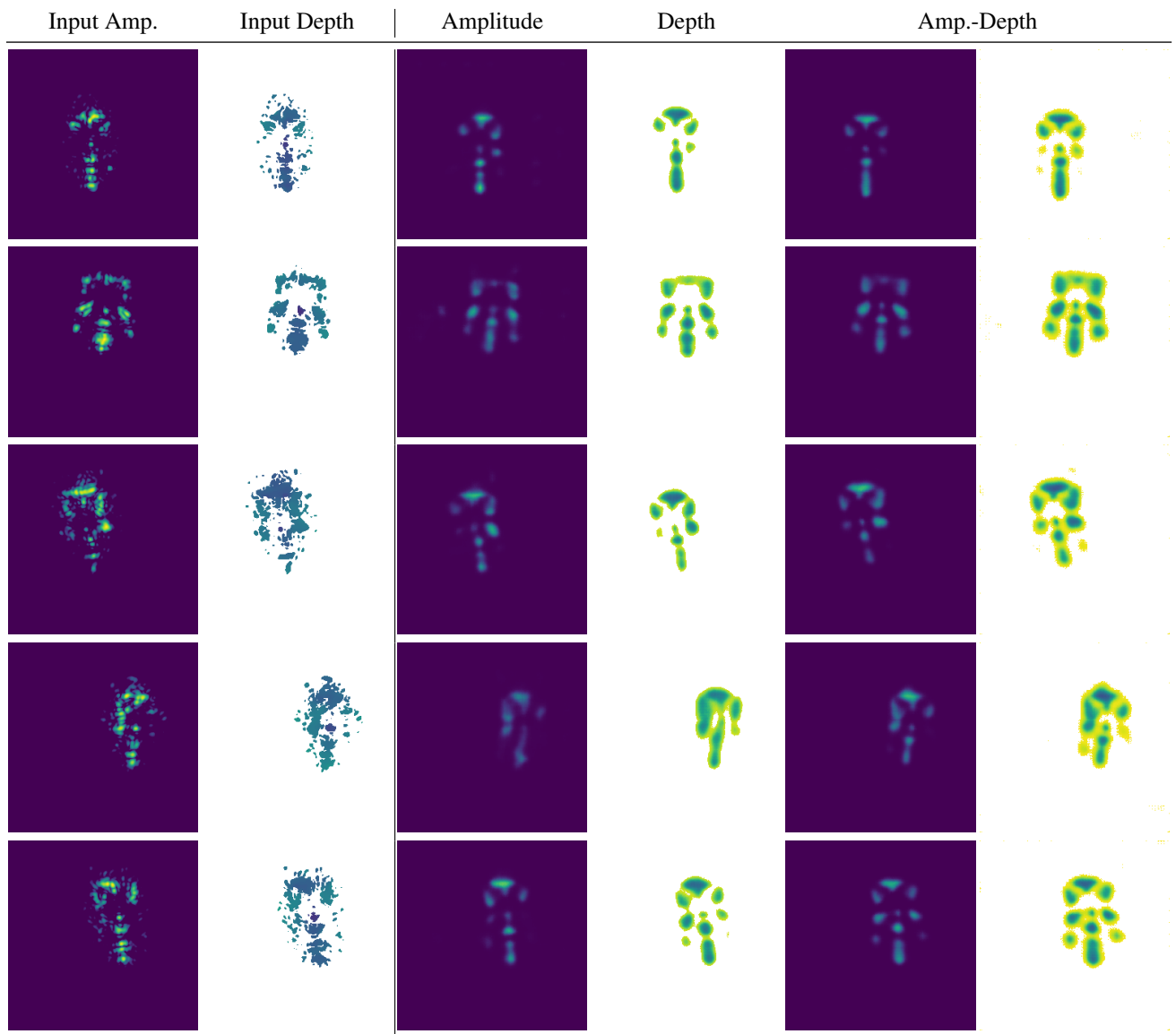


Figure 18. Resulting amplitude images of the **autoencoder** model trained on **amplitude**, **depth**, and **amplitude-depth** images for different **synthetic** face instances.

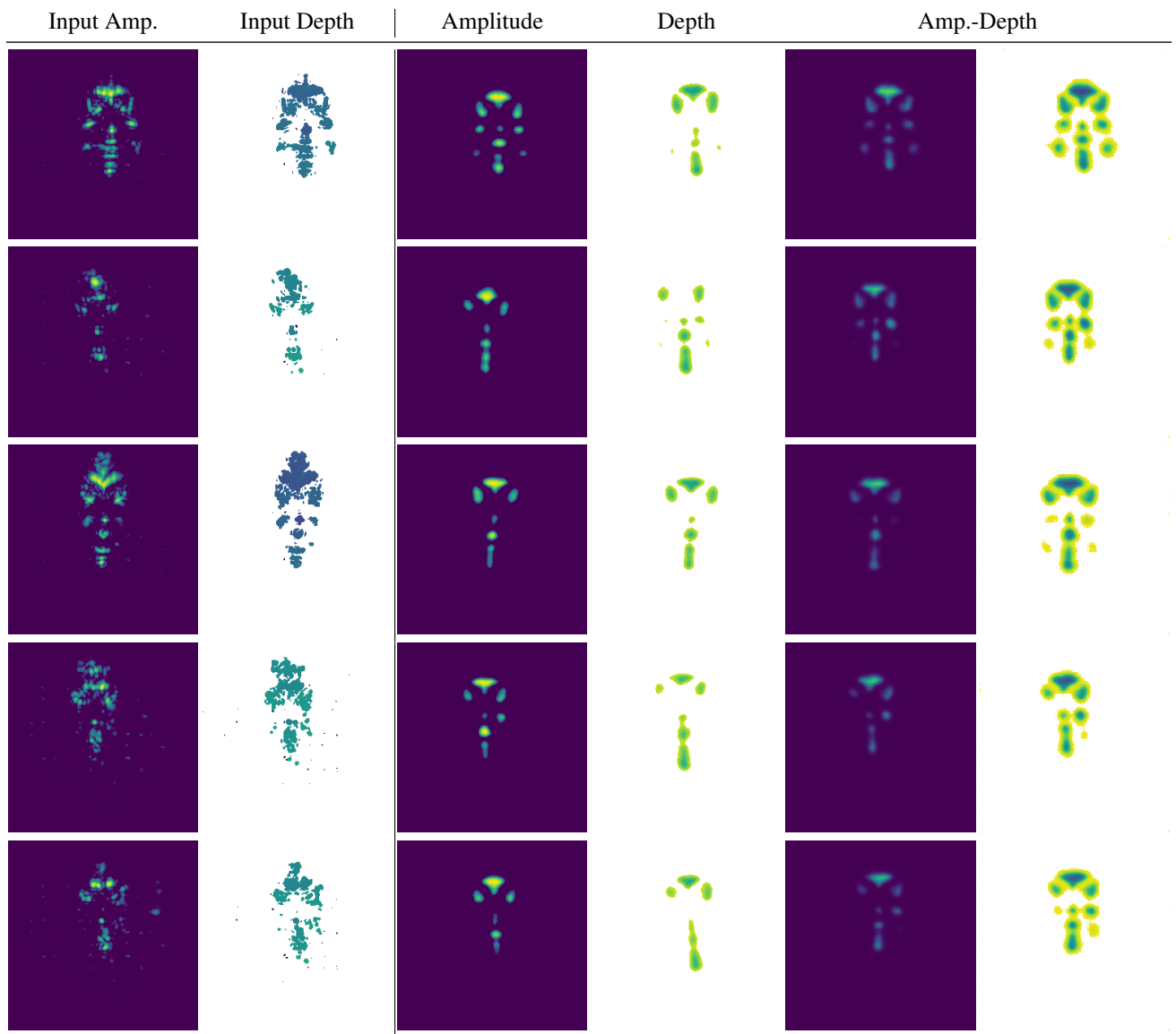


Figure 19. Resulting amplitude images of the **autoencoder** model trained on **amplitude**, **depth**, and **amplitude-depth** images for different **real** face instances.

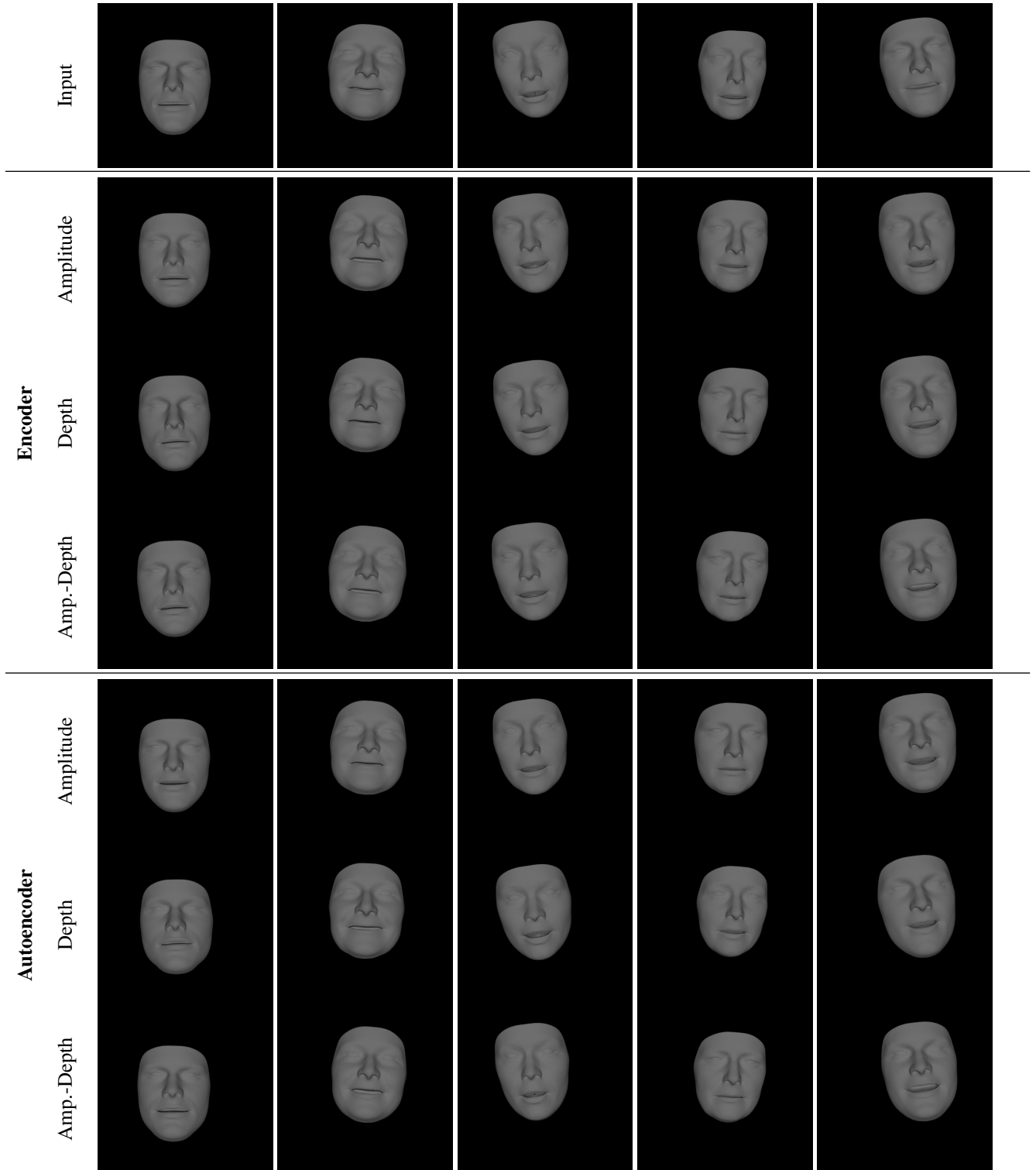


Figure 20. Mesh reconstructions of the results from the **encoder** and **autoencoder** models evaluated on **synthetic radar images**. Each column shows one face instance.

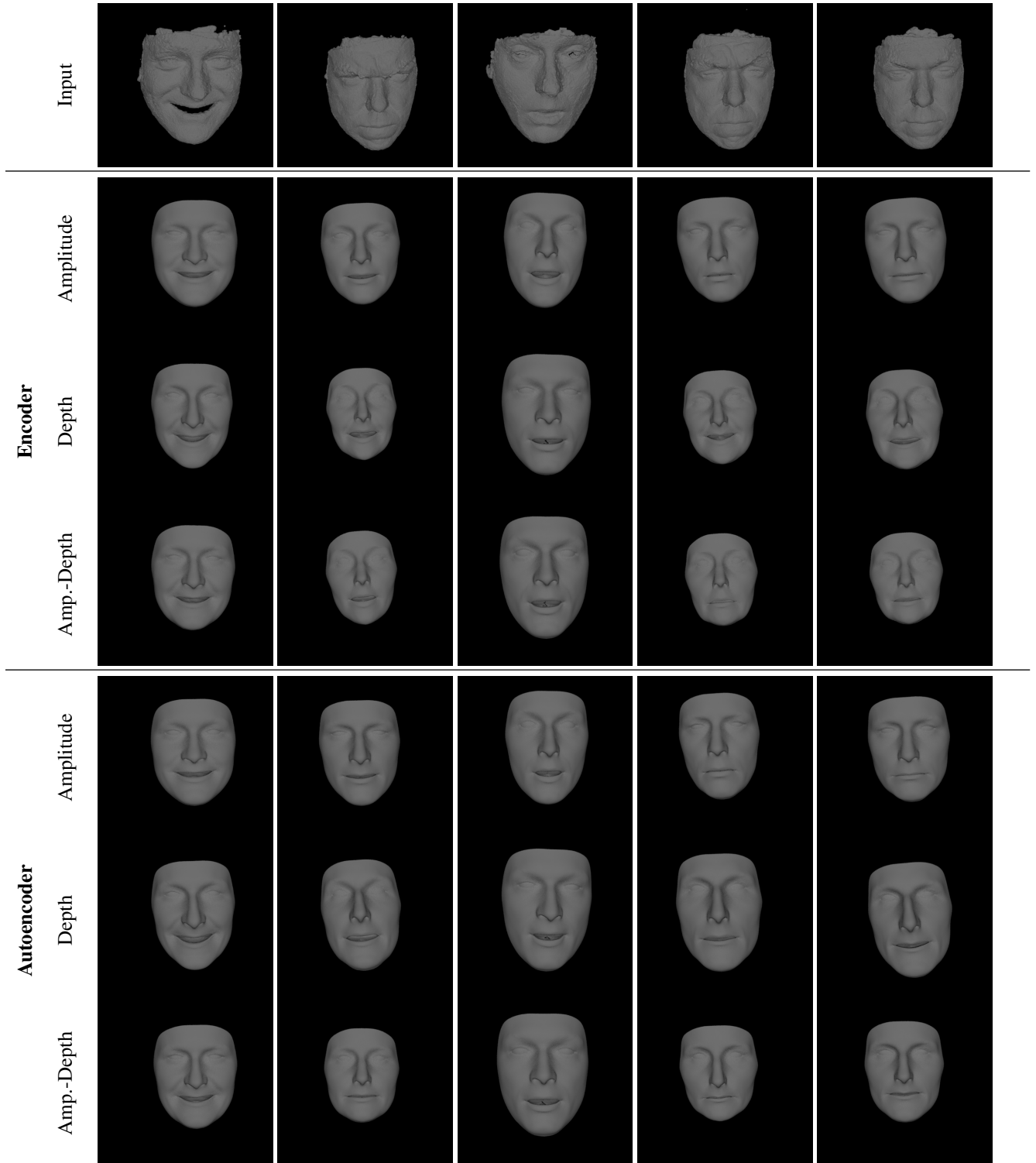


Figure 21. Mesh reconstructions of the results from the **encoder** and **autoencoder** models evaluated on **real radar images**. Each column shows one of the captured real persons with a different facial expression.